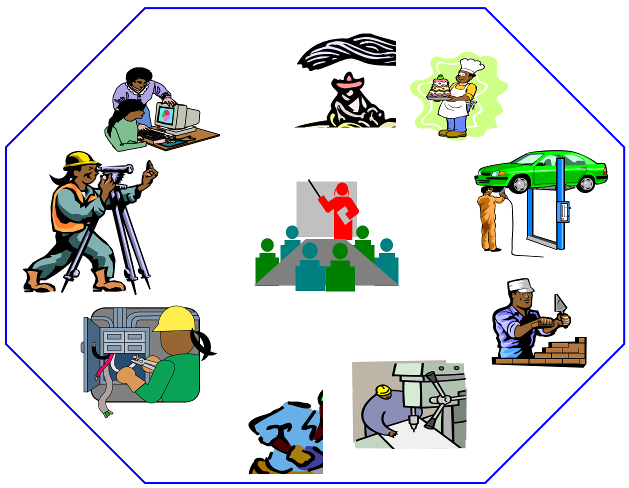
CROP PRODUCTION AND MARKETING MANAGEMENT

LEVEL IV

Based on March, 2018, Version 3 Occupational standards



Module Title: Participating to Develop a Soil Use Map for a Property

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East Africa Skills for Transformation and RegionalIntegration Project (EASTRIP)

Table of Contents

LG #64	LO #1- Collect information for soil mapping

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Using soil testing agencies to confirm soil samples
- Collecting the physical characteristics of the soil
- Collecting the chemical characteristics of the soil
- Collecting the biological characteristics of the soil
- Determining soil parameters for specified plants
- Collecting on cultural significance and habitats of biodiversity on the property
- Keeping record procedures accordance with enterprise

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Contact soil testing agencies to confirm soil samples
- Collect the physical characteristics of the soil
- Collect the chemical characteristics of the soil
- Collect the biological characteristics of the soil
- Undertake determination of soil parameters for specified plant
- Collect on cultural significance and habitats of biodiversity on the property
- Keep record procedures accordance with enterprise

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1- Using soil testing agencies to confirm soil samples

1.1. Introduction

The idea that one could test or analyze a soil and obtain some information about properties especially its acidity or alkalinity and its nutrient status is long established, and can be traced back to the beginning of scientific inquiry about the nature of soil. Analyses of plants to reflect the fertility status of the soil in which they grew is more recent, although visual crop observations are as old as the ancient Greeks, if not older. In the last few decades, spurred on by commercialization of agriculture and the demands for increased output from limited and even diminishing land resources, both soil and plant analysis procedures have been developed, and are still evolving.

With the advent of chemical fertilizers, the need to know nutrient status of a soil in order to use such expensive and limited inputs more effectively became all the more crucial. However, if soil testing is to be an effective means of evaluating fertility status of soils, correct methodology is absolutely essential.

Soil testing is now an intrinsic part of modern farming in the West, as well as in many developing countries. Tests primarily focus on the elements in most demand by crops which are supplied by fertilizers: nitrogen (N), phosphorus (P), and potassium (K). Depending upon the soil types, in some regions tests are also conducted for secondary nutrients: calcium (Ca), magnesium (Mg), and sulfur (S). In drier areas, micronutrients such as iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), and boron (B) are often measured, since deficiencies of these elements are more frequently associated with calcareous soils. Indeed such areas may also have excessive or toxic levels of some elements, such as B, and high levels of elements such as Na and Mg, which can adversely affect soil physical properties. As nutrient behavior in soils is governed by soil properties and environmental conditions, measurement of such properties is often required. These include pH, salinity, organic matter (OM), calcium carbonate ($CaCO_3$), and texture and aggregate stability. In drier areas, the presence of gypsum ($CaSO_4.2H_2O$) is also of concern.

1.2. Why soil sampling and testing

Soil testing is an essential component of soil resource management. Each sample collected must be a true representative of the area being sampled. Utility of the results obtained from the laboratory analysis depends on the sampling precision. Hence, collection of large number of samples is advisable so that sample of desired size can be obtained by sub-sampling. In general, sampling is done at the rate of one sample for every two hectare area. However, at-least one sample should be collected for a maximum area of five hectares. For soil survey work, samples are collected from a soil profile representative to the soil of the surrounding area.

1.3. Preparing tools and materials for collecting samples

- Materials required

1. Spade or auger (screw or tube or post hole type)
2. Core sampler
3. Sampling bags
4. Plastic tray or bucket

- Equipment for collecting soil samples
    - ✓ clean, residue-free plastic pail
    - ✓ soil probe, shovel, or trowel
    - ✓ permanent marking pen
    - ✓ sample boxes or plastic bags
    - ✓ Field Soil Submission Forms from Laboratory Services

1.4. Describing sample and sampling techniques

Four different methods or plans are available for soil sampling:

1. judgment sampling,
2. simple random sampling,
3. stratified random sampling,

4. Systematic sampling.

1. Judgment sampling

In this plan, the researcher or extension officer selects some part of the land which, in his/her judgment, is typical or representative of the field characteristics, and obtains the sample of the field from this typical part. Unless the researcher or extension officer is very skillful and experienced in selecting "typical" sites, this method has low precision; the selection of typical sites is difficult and time consuming; and the sampling method is inaccurate for large sample sites. However, if the sites are small and no estimate of accuracy is needed, this method is satisfactory. Generally, judgment sampling is used where soil or cropping differences are noticeable and where the focus of the survey is only a particular area of the field.

2. Simple random sampling

This sampling method is more precise and less subject to the bias of the sampler than the judgment sampling method. Sampling units are taken by selecting each sampling spot separately, randomly and independently of any spots previously taken. Thus each unit spot on the field has an equal chance of being selected as the sampling spot. Although the method is very precise, it is relatively cumbersome and time consuming. For this reason the method is not used in routine soil testing programs. It is more adaptable to research work, for sampling experimental plots.

3. Stratified random sampling

In this method, the field is divided into separate units (strata) based on observable differences in the field. The stratification may be based on soil types or series, land forms (slopes versus plain), soil drainage, crop growth pattern, differences in soil management history, erosion impact, etc. Each of the units is then sampled separately by random sampling.

This method has good precision as it is relatively faster and less cumbersome than the simple random sampling method. This is the method usually adopted in routine soil testing programs. Researchers or scientists also prefer this method in experimental plots because it allows the worker to

- Make a statement about each sub-population, i.e. stratum or sampling unit, separately, and
- Increase the accuracy of estimates over the entire field (population).

The details of the procedure for stratified random sampling are provided below.

Stratified random sampling is the preferred method in routine soil testing because:

- it is simple, relatively fast, and cost-effective;
- it allows different parts of the field to be evaluated separately;
- it minimizes measurement error due to soil variability;
- it has relatively good precision.

Preliminary planning

- Sketch a map of the field to be sampled.
- Outline on this map areas of the field which are observed to be different from other areas. These differences might be in soil types, degree of erosion, and degree of slope, drainage, crop growth performance or past management. Each area (stratum) is a sampling unit
- Obtain at least two composite samples from each sampling unit (stratum). Each composite sample should be from an area that is as uniform as possible. The number of composite samples depends on the size of each sampling unit (strata).

Sampling technique

- Take a minimum of 25 and maximum of 40 cores per 2 hectare field (depends on observed soil variability).
- Take at least two composite samples per sampling unit (stratum).
- Take a minimum of five cores per composite sample (the number depends on size of land represented by the composite sample, as well as the size of the sample container). Enough cores hould be taken to represent the whole sampling area adequately.

- If an area within a sampling unit (stratum) is quite obviously different from the rest of the stratum, but is too small to be of importance, do not sample it (i.e. ignore it). If it is large enough, take a composite sample from the area, but do not mix cores from this with cores from other areas in the stratum.
- Avoid sampling a fertilizer band if the position of the band is apparent.
- If possible sample when a crop, preferably a grain crop like maize, rice or wheat, is growing on the field. This enables variability in the field to be identified quite easily.
- Record the position of each composite sample on the map.
- Each core should be taken at the same soil depth so that core samples would be of the same soil volume. Select soil depth according to the purpose of sampling. For arable crops, sample at a depth of 0 to 15 cm. For perennial or tree crops, take deeper samples since tree crops often grow deep into the soil.

Sampling pattern

The sampling pattern for each composite sample should be random. The core samples are taken randomly in a zig-zag manner such that all points in the plot have an equal chance of being selected as a sampling point. One example for taking four composite samples of eight cores each from a field . Cores should not be taken close to the field boundaries, because these areas are frequently disturbed and different from the main field.

Take soil samples at about the same time of the year, e.g. just before land preparation or before planting. This will allow for comparison of soil test data over periods of time, as there seems to be seasonal variation in soil tests for some nutrients such as P and K. Put all core samples taken from one soil area together in a clean bucket, as a composite sample. Mix the sample thoroughly with your hand. Pour the soil sample into a clean plastic bag and tie it securely; label each bag properly for later identification.

4. Systematic sampling

This method is very simple to use, and it ensures better coverage of the population (field) than the three other methods. The basic characteristic of this method is that the selected sampling spots (units) are at regular intervals away from each other, either in one or in two dimensions, thereby forming a grid. The first sampling spot is selected at random, and the subsequent spots selected at uniform intervals.

1.4. Locating soil sample using site plans

Develop a soil sampling plan of your field. Samples should represent the area being tested, so collect samples from areas that are of the same soil type, appearance, or cropping history. Sample, problem areas separately, if needed. From this plan, count the number of samples you will collect.

1.5. Collecting and testing soil samples

The collection of samples from near-surface soil can be accomplished with tools such as spades, shovels, trowels, and scoops. The over-burden or over-lying surface material is removed to the required depth and a stainless steel or plastic scoop is used to collect the sample.

This method can be used in most soil types but is limited to sampling at or near the ground surface. Accurate, representative samples can be collected by this procedure depending on the care and precision demonstrated by the sample team member. A flat, pointed mason trowel to cut a block of the desired soil is helpful when undisturbed profiles are required. Tools plated with chrome or other materials must not be used.

These surface soil samples (zero to six inches) are typically used for conventional tests of organic matter, phosphorus, potassium, pH, and salt levels. Deep-rooted crops such as wheat and barley need deeper samples if nitrogen fertilizer recommendations are desired. Be sure to separate and discard surface litter.

Self-Check – 1	Written test

Name…………………………………………… ID………………………… Date…….

Direction: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers. (3.5 points each)

1. Discuss briefly the readiness assessment
2. What is the purpose of setting monitoring period
3. Discus briefly the importance of outcomes

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 5 points Unsatisfactory - below 5 points

Information Sheet 2- Collecting the physical characteristics of the soil

2.1 Soil texture

Soil is characterized by its physical, chemical and biological properties. The mineralogical properties are treated separately from the chemical properties. The focus of this chapter is the physical properties of soils. Physically, a mineral soil is a porous mixture of inorganic particles, decaying organic matter, air and water. There are a number of soil physical properties of which *texture* and *structure* are the most important ones as the others are directly or directly dependent upon them. Others, which will further be discussed, include:

- particle and bulk densities
- pore spaces
- soil color
- soil consistence
- soil water
- soil air and temperature

Soil texture is concerned with the size of mineral particles. It refers to the relative proportion of particles of various sizes in a given soil. Mineral particles are usually separated into convenient groups based on their size, for the ease of study. Such groups are called *soil separates*. Three primary soil separates are widely recognized: *sand, silt* and *clay.*

Mechanical composition of the soil: Mechanical composition of a soil refers to its solid phase composed of mineral fraction. Mineral soil particles are usually classified according to their size. The most commonly used classifications are those proposed by the United States Department of Agriculture (USDA) and the International Soil Science Society (ISSS), which are shown as follows:

1 **Table 1.Classification of Soils**

Fraction	Particle Diameter	
	USDA	**ISSS**
Gravel	>2mm	>2mm
Very Coarse Sand	1 to 2 mm	--
Coarse Sand	0.5 to 1mm	0.2 to 2 mm
Medium Sand	0.25 to 0.5 mm	--
Fine Sand	0.1 to 0.25 mm	0.02 to 0.2 mm
Very Fine Sand	0.05 to 0.1 mm	--
Silt	0.002 to 0.05 mm	0.002 to 0.02 mm
Clay	< 0.002 mm	< 0.002 mm

Soil textural class

Individual soil separates do not constitute a soil in the field. It is rather their mixture that constitutes a soil. Soil textural class names have become standardized to express the variation of soils in composition of the different sized particles (sand, silt and clay).

There are three basic soil textural names whose combination gave a total of twelve soil textural classes:

- SAND contains >70% sand by weight. It is not sticky and not heavy when ploughed. Textural classes of such soils are Sand and Loamy Sand.
- CLAY contains >35 or 40 % clay separate by weight. It feels sticky and heavy when ploughed.
  Textural classes: Clay, Silty Clay, and Sandy Clay.
- LOAM: Exhibits heavy and light properties in about equal proportions. It is agriculturally important soil.
- Textural classes: Loam, Sandy Loam, Silt Loam, Silty Clay Loam, Clay Loam, Sandy Clay Loam.

The following table shows the soil textural names based on the sequence of the variation in the field. The variation from sand to clay is very gradual and shows the very nature of field condition.

Table 3.2 General terms used to describe soil texture in relation to basic soil textural class names (USDA).

Common names	Texture	Basic soil textural class names
Sandy Soils	Coarse	Sandy
		Loamy sand
Loamy Soils	Moderately coarse	Sandy Loam
		Fine sandy Loam
	Medium	Very Fine Sandy Loam
		Loam
		Silt Loam
		Silt
	Moderately Fine	Clay Loam
		Sandy Clay Loam
		Silty Clay Loam
Clayey Soils	Fine	Sandy Clay
		Silty Clay
		Clay

Textural class name is normally given after the proportion of the different soil separates is known. For easy representation, soil textural triangle has been devised. Sand Silt and Clay take each of the sides of the triangle. After knowing the percentage of each of the soil separates their textural class name is sought in the textural triangle.
(A scanned map of textural triangle)

Textural Triangle

Steps to use the textural triangle:

1. Quantify this using soil sieves

- ✓ Pass soil through a series of progressively finer meshes by shaking
- ✓ Each mesh stops all grains > some specified diameter
- ✓ Weighing contents of each sieve to get "%-finer"
- ✓ Calculate the percentages of sand, silt, and clay in your soil, as determined by laboratory particle size analysis.
- ✓ Can be done wet or dry

2. Reading the Texture Triangle

- ✓ Locate the percentage of clay on the left side of the triangle and move inward horizontally, parallel to the base of the triangle.
- ✓ Follow the same procedure for sand, moving along the base of the triangle to locate your sand percentage
- ✓ Then, move up and to the left until you intersect the line corresponding to your clay percentage value.
- ✓ At this point, read the textural class written within the bold boundary on the triangle.

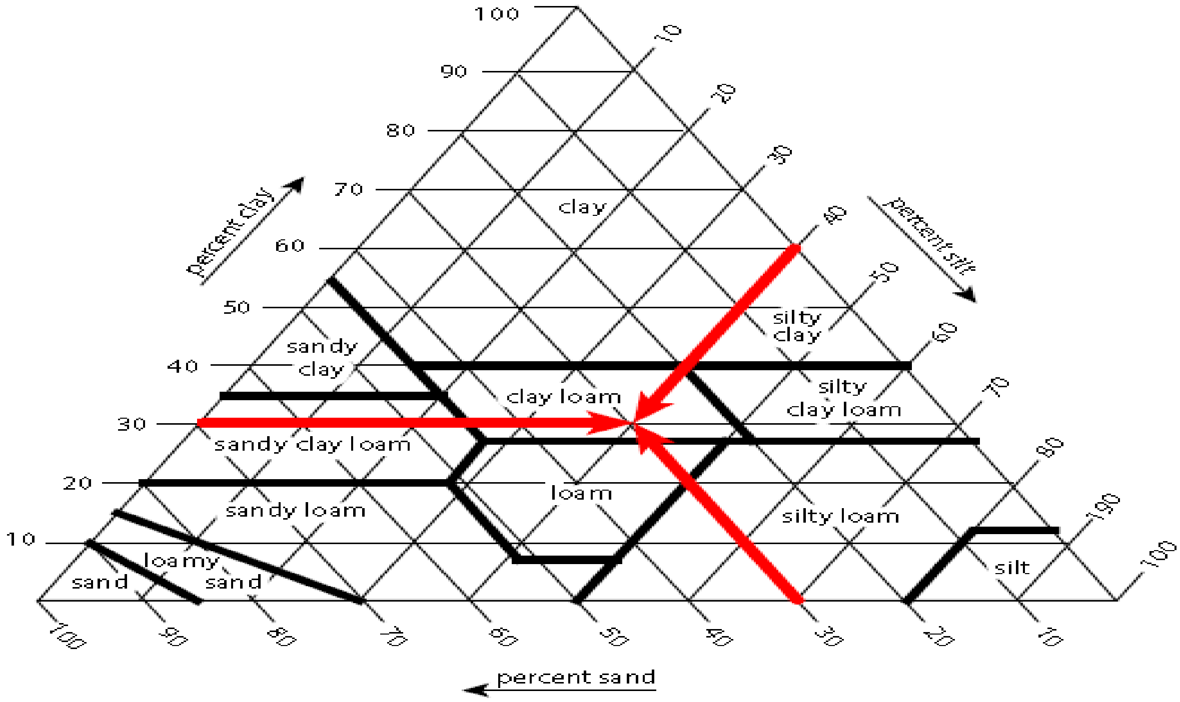


Figure 2. A soil textural classification triangle, showing a clay loam soil composed of 30 percent sand, 30 percent clay, and 40 percent silt.

1.2 Particle and bulk densities and pore space of soils

Density of Mineral soil

Density of a material is the mass of a unit volume of that material. This holds true for soils as well. However, the density of mineral soil is expressed in two different forms.

Particle density is the mass of a unit volume of soil solids (g/cm3). Particle Density depends on the type of the mineral that constitutes the soil and the organic matter content of the soil. Usually its value for mineral soils falls in the range between 2.6 and 2.75 g/cm3 for quartz, feldspar and colloidal silicates. However, if heavier minerals (magnetite, garnet, zircon, etc) are present, it may exceed 2.75 g/cm3. For topsoil the particle density may be as low as 2.4 g/cm3 due to its organic matter content. Pure organic matter has particle density of 1.2 –1.5g/cm3.

Where as, *Bulk density* is the mass of a unit volume dry soil. The volume in this case is the sum of the volume of the soil solids and the volume of the pore spaces. Bulk density of a soil depends on the Porosity and organic matter content of the soil. All other factors that affect the porosity of the soil do affect the bulk density of the soil. The higher the porosity, the lower is the bulk density. Similar relation is true for organic matter content as well.

E.g. soil densities: Let's say a block of moist soil has a volume of 1cm3 and it weighs 1.33g after drying it in an oven. The bulk density of this soil is, thus, 1.33g/1cm3=1.33g/cm3. Assume that 50% of the volume of the soil is occupied by pore spaces. Now assume that the soil is compressed and all the pore spaces are removed. What remains is only 0.5cm3. The particle density of this soil, therefore, 1.33g/0.5cm3= 2.66g/cm3.

Pore space of mineral soils

Pore space is that portion of a soil occupied by air and water. It is determined by the arrangement of the solid particles. Its volume is the difference between the total volume and the volume of soil solids.

$$\%\text{Solid space} = \frac{\text{bulk density}}{\text{Particle density}} * 100$$

$$\%\text{Pore space} = 100 - \%\text{solid space} = 100 - \frac{\text{bulk density}}{\text{Particle density}}$$

Porosity of a soil depends upon particle size, depth, organic matter content and management. Generally, sandy soils are less porous than clay soils. The higher the organic matter content of the soil, the higher its porosity. This is attributed to the granulation and aggregate stability of the soil which create pores in between the aggregates. As depth increases, porosity decreases as organic matter content decreases, and force of compaction increases due to the weight of the soil above it. Though cultivation increases porosity at the beginning, frequent cultivation lowers porosity as it destroys the granules and creates compaction.

Size of pores: Soil pores do not have uniform size. Depending on their size soil pores can be classified in to two groups. Macropores are large enough to characteristically allow the ready movement of air and percolating water. They are dominant in coarse textured soils. Whereas, in Micropores air movement is greatly impeded and water movement is restricted primarily to slow down capillary movement. The size of individual pores rather than their total volume is the important consideration as it determines the movement of air and water in the soil. In very fine soils, the micro pores fill themselves with water and there is poor aeration for root growth. Coarse textured soils with very high proportion of macro pores are prone to drought.

1.3 Soil consistence and soil color

Soil consistence is a term used to describe the physical condition of a soil at various moisture contents, as evidenced by the behavior of that soil towards mechanical stresses or manipulations. It is basically described at three moisture levels: wet, moist and dry.

- Wet: two parameters are used here, the *stickiness* (non-sticky, slightly sticky, sticky and very sticky) and the *plasticity* (non-plastic, slightly plastic, plastic and very plastic).
- Moist: is the most important since it best describes the condition of soils when they are tilled in the field. It is the measure of the resistance of the soil to crushing between the thumb and the forefinger. Terms used are:
- Loose ----------- non-coherent
- Very friable --- coherent but very easily crushed
- Friable------------easily crushed
- Firm ------------- crushed under moderate pressure
- Very firm -------- crushes only under strong pressure
- Extremely firm ---resists crushing between thumb and forefinger.

Texturally speaking sandy soils tend to be loose and clay soils tend to be extremely firm. However, moist consistence depends upon the moisture level.

- Dry Consistence: is related to the attraction of the particles to each other. The following terms are used:
- Loose ----- non-coherent
- Soft------- breaks under slight pressure between thumb and forefinger to a powdery mass.
- Slightly hard ----- breaks under moderate pressure
- Hard -------- breaks with difficulty under pressure
- Very hard --- very resistant to pressure; can not be broken between thumb and forefinger.
- Extremely hard ---- extreme resistance to pressure. Needs a hammer to break.

1.4. Soil Color

2. Soil color is an indication of soil conditions. It does not greatly affect the soil. Looking at the soil color some judgments may be made about the soil condition according to the following brief indications.

3. **Brown to black color:** results from organic matter or dark parent material. The cause may be specified from the odor of the soil, of course by an experienced expert. High level of organic matter in a waterlogged area has a sour, oily smell. In a well-drained area it has earthy smell. A dark parent material gives a faint chalky smell.
4. **White to light gray:** results when organic matter has been leached down of sandy soils and E-horizons can also be caused by the accumulation of lime, gypsum and other light materials.
5. **Yellow to Red:** Is due to iron oxides most commonly in warm areas. Red color is from iron (Fe^{+3}) oxides where there is good drainage for the aeration (oxygen supply). Yellow color results from an iron oxide that includes some water (limonite), i.e. slightly less well drained.
6. **Bluish gray:** results from unoxidized iron, indicates lack of oxygen

1.5. Soil Structure

Soil structure is a field term descriptive of the gross, overall aggregation, or arrangement of the primary soil separates. It influences water movement, heat transfer, aeration, bulk density and porosity.

Soil structure can be classified based on three parameters. *Type* describes the shape of the soil aggregates; *Class* describes the size of the peds; and, *grade* refers to how distinct and strong the peds are.

There are four primary *types* of soil structure:

A. **Platy-** aggregates are arranged in a relatively thin horizontal plates, leaflets, or lenses. It may our in any part of the soil but mainly at the surface. It is mainly laid down by water or ice and is common in E horizon.

B. **Prism-like-** Vertically oriented aggregates or pillars varying in length. Most commonly, it occurs in the B-horizons of arid and Semi arid Soils. They can be grouped in to two:

Columnar- when the tops are rounded. This occurs when the profile is changing and certain horizons are degrading.

Prismatic- when the tops are level plane and clean cut.

C. **Block-like** - aggregates have been reduced to block, six faced, with the 3 dimensions more or less equal. These can also be classified in to two:

Blocky - edges are sharp and the faces distinct.

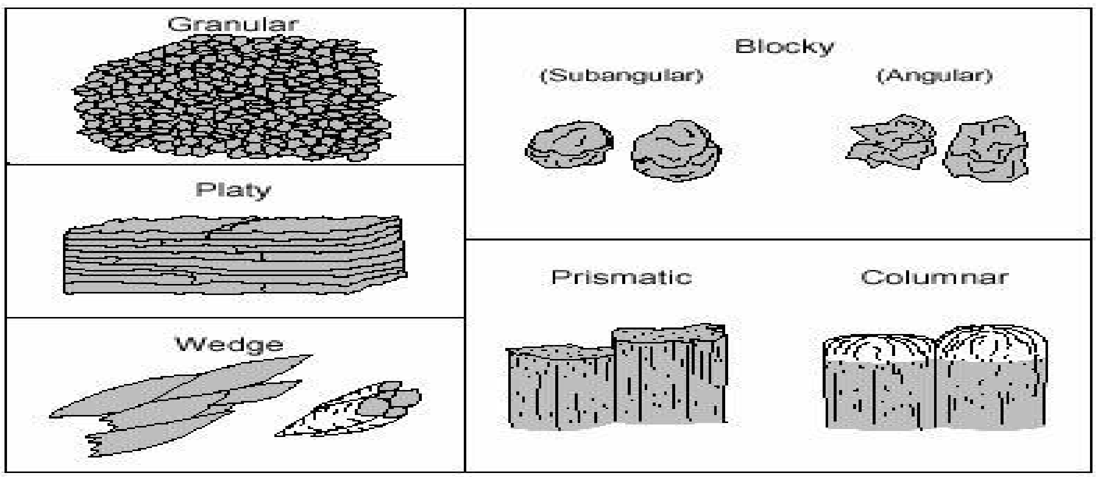
Sub-angular blocky - When sub-rounding has occurred. This type is confined to the subsoil.

D. Spheroidal - includes all rounded aggregates. Such types of structure lie loosely and are shaken apart easily. They are common in A-horizons that are high in organic matter content. Practical soil management like manuring can influence them. The different classes are:

Granular - Ordinary aggregates

Crumb - When the aggregates are especially crumb.

E. **Structure less soils:** Sand is a single grain and very porous with out any defined structural arrangement. Fine soils lacking structure are a solid mass stuck together like molding clay. Such soils are referred to as *massive* soils. They lack permeability and usually occur in C-horizon, may also occur in A-horizon if tilled in a wet condition.



Examples of Soil Structure

Self-Check – 2	Written test

Name…………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers. (2.5 points each)

1. Define and explain the difference between soil texture and soil structure.
2. Create a table that lists the sizes for sand, silt, and clay particles using USDA criteria.
3. What is a textural triangle?
4. What is the typical range of bulk density values for mineral soils? What is the range of bulk density values for an organic soil?

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

Information Sheet 3-Collecting the chemical characteristics of the soil

3.1. Assessing soil chemical characteristics

3.1.1.Major Elements

Eight chemical elements comprise the majority of the mineral matter in soils. Of these eight elements, oxygen, a negatively-charged ion **(anion)** in crystal structures, is the most prevalent on both a weight and volume basis. The next most common elements, all positively-charged ions **(cations)**, in decreasing order are silicon, aluminum, iron, magnesium, calcium, sodium, and potassium. Ions of these elements combine in various ratios to form different minerals. More than eighty other elements also occur in soils and the earth's crust, but in much smaller quantities.

Soils are chemically different from the rocks and minerals from which they are formed in that soils contain less of the water soluble weathering products, calcium, magnesium, sodium, and potassium, and more of the relatively insoluble elements such as iron and aluminum. Old, highly weathered soils normally have high concentrations of aluminum and iron oxides.

The organic fraction of a soil, although usually representing much less than 10% of the soil mass by weight, has a great influence on soil chemical properties. **Soil organic matter** is composed chiefly of carbon, hydrogen, oxygen, nitrogen and smaller quantities of sulfur and other elements. The organic fraction serves as a reservoir for the plant essential nutrients, nitrogen, phosphorus, andsulfur, increases soil water holding and cation exchange capacities, and enhances soil aggregation and structure.

The most chemically active fraction of soils consists of colloidal clays and organic matter. Colloidal particles are so small (< 0.0002 mm) that they remain suspended in water and exhibit a very large surface area per unit weight. These materials also generally exhibit net negative charge and high adsorptive capacity. Several different silicate clay minerals exist in soils, but all have a layered structure. Montmorillonite, vermiculite, and micaceous clays are examples of **2:1 clays**, while kaolinite is a **1:1 clay** mineral. Clays having a layer of aluminum oxide (octahedral sheet) sandwiched between two layers of silicon oxide (tetrahedral sheets) are called 2:1 clays. Clays having one tetrahedral sheet bonded to one octahedral sheet are termed 1:1 clays.

Cation Exchange

Silicate clays and organic matter typically possess net negative charge because of cation substitutions in the crystalline structures of clay and the loss of hydrogen cations from functional groups of organic matter. Positively-charged cations are attracted to these negatively-charged particles, just as opposite poles of magnets attract one another.

Cation exchange is the ability of soil clays and organic matter to adsorb and exchange cations with those in soil solution (water in soil pore space). A dynamic equilibrium exists between adsorbed cations and those in soil solution. Cation adsorption is reversible if other cations in soil solution are sufficiently concentrated to displace those attracted to the negative charge on clay and organic matter surfaces. The quantity of cation exchange is measured per unit of soil weight and is termed cation exchange capacity. Organic colloids exhibit much greater cation exchange capacity than silicate clays. Various clays also exhibit different exchange capacities. Thus, cation exchange capacity of soils is dependent upon both organic matter content and content and type of silicate clays.

Cation exchange capacity is an important phenomenon for two reasons:

1. Exchangeable cations such as calcium, magnesium, and potassium are readily available for plant uptake and

2. Cations adsorbed to exchange sites are more resistant to **leaching**, or downward movement in soils with water.

Movement of cations below the rooting depth of plants is associated with weathering of soils. Greater cation exchange capacities help decrease these losses. Pesticides or organics with positively charged functional groups are also attracted to cation exchange sites and may be removed from the soil solution, making them less subject to loss and potential pollution.

Calcium (Ca^{++}) is normally the predominant exchangeable cation in soils, even in acid, weathered soils. In highly weathered soils, such as oxisols, aluminum (Al^{+3}) may become the dominant exchangeable cation.

The energy of retention of cations on negatively charged exchange sites varies with the particular cation. The order of retention is: aluminum > calcium > magnesium > potassium > sodium > hydrogen. Cations with increasing positive charge and decreasing hydrated size are most tightlyheld. Calcium ions, for example, can rather easily replace sodium ions from exchange sites. This difference in replace ability is the basis for the application of gypsum ($CaSO_4$) to reclaim sodic soils (those with > 15% of the cation exchange capacity occupied by sodium ions). Sodic soils exhibit poor structural characteristics and low infiltration of water.

The cations of calcium, magnesium, potassium, and sodium produce an alkaline reaction in water and are termed bases or **basic cations**. Aluminum and hydrogen ions produce acidity in water and are called **acidic cat ions**. The percentage of the cation exchange capacity occupied by basic cations is called **percent base saturation**. The greater the percent base saturation, the higher the soil PH.

Soil pH

Soil pH is probably the most commonly measured soil chemical property and is also one of the more informative. Like the temperature of the human body, soil pH implies certain characteristics that might be associated with a soil. Since pH (the negative log of the hydrogen ion activity in solution) is an inverse, or negative, function, soil PH decreases as hydrogen ion, or acidity, increases in soil solution. Soil PH increases as acidity decreases.

A soil PH of 7 is considered neutral. Soil PH values greater than 7 signify alkaline conditions whereas those with values less than 7 indicate acidic conditions. Soil PH typically ranges from 4 to 8.5, but can be as low as 2 in materials associated with pyrite oxidation and acid mine drainage. In comparison, the PH of a typical cola soft drink is about 3.

Soil pH has a profound influence on plant growth. Soil pH affects the quantity, activity, and types of microorganisms in soils which in turn influence decomposition of crop residues, manures, sludge's and other organics. It also affects other nutrient transformations and the solubility, or plant availability, of many plant essential nutrients. Phosphorus, for example, is most available in slightly acid to slightly alkaline soils, while all essential micronutrients, except molybdenum, become more available with decreasing PH. Aluminum, manganese, and even iron can become sufficiently soluble at PH < 5.5 to become toxic to plants. Bacteria which are important mediators of numerous nutrient transformation mechanisms in soils generally tend to be most active in slightly acid to alkaline conditions.

Flow calorimetric, which is ideally suited for measuring reactions occurring at the liquid/solid interface, has been used to study the surface chemistry of many types of solids, but little use of it has been made in the study of surface reactions of soils

Self-Check – 3	Written test

Name…………………………………………… ID……………………….. Date…….

Directions: Answer the question listed below. Illustrations may be necessary to aid some explanations/answers. (2 point each)

1. Describe briefly the major element of soil chemical properties
2. Elaborate briefly PH
3. Define Cation Exchange Capacity
4. Write the importance of CEC

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 5 points Unsatisfactory - below 5 points

Information Sheet 4 – Collecting the biological characteristics of the soil

1.4. Biological properties of soil:

This includes all the activity of beneficial microorganisms. Bacteria that decompose soil organic matter are hindered in soils. This helps organic matter to breaking down, resulting in dispersion of organic matter and the tie up of nutrients, particularly nitrogen, that are held in the organic matter.

The biological component of the soil is perhaps the most intriguing attribute because it comprises both the living organisms and the dead organic materials they feed upon. It is important to note that bacteria, fungi, and many other living organisms in the soil, in association with living plants and dead organic matter, are the key drivers that maintain and even regenerate healthy soil functions. The soil food web is extremely complex, with different classes of organisms occupying different atrophic (feeding) levels . There are five trophic levels defined for the soil food web that transform nutrients from one form to another

At the bottom of the food web (Level 1) are materials produced from photosynthesis, such as dead plant parts that become organic matter that helps feed the soil communities. Root exudates also belong to this category since they are important in feeding microbial populations. Other materials that belong to Level 1 include animal waste products like manures and artificially created materials, such as composts, biochar, and many other biologically based soil amendments, all of which can be added to enrich the soil. The organic compounds found in plants, organic amendments, and waste byproducts supply energy and carbon for most of the soil organisms and provide a foundation for healthy soils.

The two most important components that enable effective functioning of the soil biological systems are soil organic matter and living roots in the soil. As discussed earlier, organic materials produced by photosynthesizing plants occupy the lowest level of the food web. Without these materials, the whole food web structure would break down. For example, due to the lack of organic material in beach sands, the activity of soil organisms is minimal.

Organic materials in agricultural soils are at various stages of decomposition due to diverse organisms that are involved in the process. Depending on the state of decomposition, organic materials in the soil are classified into three broad categories: “the living,” “the dead,” and “the very dead” .“The living” component consists of roots that are still alive and microbes and other soil organisms that are still functional in the soil. “The dead” component consists of recently shed plant parts like dead roots and leaves, manure, compost, and other biological materials added to the soil. The dead component can also be viewed as the active fraction of soil organic matter since these materials provide food for soil organisms to increase their rapid growth and population numbers in the soil. “The very dead” component is the product of organic matter decomposition that remains after the organic materials have undergone initial, rapid breakdown. Further decomposition is extremely slow because the material is so stable and resistant to further breakdown. The material that accumulates in the soil at this stage is called humus or humic substances. Unlike fresh plant residues, humus can absorb tremendous amounts of water and protects several plant nutrients, such as potassium, magnesium, and calcium, against leaching losses.

In addition to soil organic matter, soil organisms need plant roots to thrive. Most soil microorganisms are found near the plant roots in a region called the rhizosphere. There are 1,000–2,000 times more microorganisms associated with plant roots in the rhizosphere compared to the soils beyond this zone. Microbes are so abundant in rhizospheres due to the simple carbohydrates in root exudates that the plants produce, which microbes can use as food. An average of about 35% of the products formed during plant photosynthesis is released back into the soil as root exudates to stimulate microbial growth within the soil. Diverse plant species, like those found in rangelands or different cover crops planted in croplands, have diverse rooting depths, which support microbial diversity throughout the soil profile. That is why the presence of living roots is essential for maintaining good soil health.

Soil Biota

The soil environment is teeming with biological life and is one of the most abundant and diverse ecosystems on earth. Soil biota, including flora (plants), fauna (animals) and microorganisms, perform functions that contribute to the soil's development, structure and productivity. General characteristics and functions of these groups are presented below.

Soil Flora

Plants act on the soil environment by aiding in structure and porosity, and in supplying SOM via shoot and root residue. Root channels can remain open for some time after the root decomposes, allowing an avenue for water and air movement. Roots also act to stabilize soil through aggregation and intact root systems can decrease soil loss. The 'rhizosphere,' the narrow zone of soil directly surrounding plant roots, is the most biologically active region of the soil. It contains sloughed root cells and secreted chemicals (i.e., sugars, organic acids) that provide organisms with food

Soil Fauna

Soil fauna work as soil engineers, initiating the breakdown of dead plant and animal material, ingesting and processing large amounts of soil, burrowing 'biopores' for water and air movement, mixing soil layers, and increasing aggregation. Important soil fauna include *earthworms*, *insects*, *nematodes*, *arthropods* and *rodents.* Earthworms are considered one of the most important soil fauna. Through the process of burrowing, they provide channels that increase a soil's porosity, water holding capacity, and water infiltration. They also increase further biotic activity by breaking down large amounts of SOM through digestion and supplying nutrient-rich secretions in their casts. Furthermore, earthworms are able to build soil by moving between 1 to 100 tons of subsoil per acre per year to the surface, possibly helping offset losses by erosion.

Soil Microorganisms

Microorganisms (microbes) are invisible to the naked eye. However, their effect on numerous soil properties is far-ranging. Microorganisms represent the largest and most diverse biotic group in soil, with an estimated one million to one billion microorganisms per one gram of agricultural top soil. Microbes aid soil structure by physically surrounding particles and 'gluing' them together through the secretion of organic compounds, mainly sugars. This contributes to the formation of granular structure in the soil where microbial populations are greatest.

Soil microbes include *bacteria*, *protozoa*, *algae*, *fungi* and *actinomycetes* . Bacteria are the smallest and most diverse soil microbes. Bacteria are important in SOM decomposition, nutrient transformations and small clay aggregation. Some bacteria carry out very special roles in the soil, such as Rhizobia, the nitrogen-fixing bacteria associated with legume roots. Protozoa (e.g., amoebas, ciliates, flagellates) are mobile organisms that feed on other microbes and SOM. Algae, like plants, photosynthesize and are found near the soil surface. Fungi are a diverse group of microbes that are extremely important in the breakdown of SOM and large aggregate stability. Many fungi have long 'hyphae' or 'mycelia' (thin thread-like extensions) that can extend yards to miles underneath the soil surface and physically bind soil particles. Actinomycetes are a microbial group that are classified as bacteria, but have hyphae similar to fungi. They are important for SOM breakdown, particularly the more resistant fractions, and give soil much of its 'earthy' odor. Bacteria dominate in agricultural and grassland soils, whereas fungi are more prevalent in forest and acid soils.

An important relationship found in almost all soils and plants, including many crop species, are mycorrhizae. Mycorrhizae are a plant-fungal symbiosis (a relationship between two interacting species) in which fungi infect and live in, or on, a plant root. The fungus depends on the plant for energy, and in return, the fungus and its hyphae can take up nutrients for the plant, and possibly improve plant growing conditions. For instance, mycorrhizae associations have been shown to increase plant-water relations and reduce severity of some plant diseases, as well as improve soil aggregate stability due to the binding actions of hyphae and glomalin, a mycorrhizal secreted chemical. Ultimately, however, the full benefit of mycorrhizae to a plant will depend on the individual plant's needs and soil conditions. Commercial mycorrhizal inoculants are available. However, researches regarding their effectiveness on yields are variable, and they may only be economical for small-scale, high-value crops. Therefore, improving and maintaining existing mycorrhizal populations by increasing SOM content, reducing tillage and other soil disturbances, and eliminating long fallow periods may work best for encouraging mycorrhizal symbioses in agricultural.

Self-Check – 4	Written test

Name…………………………………………… ID……………………….. Date…….

Directions: Discuss all the questions listed below. Examples may be necessary to aid some explanations/answers. (2 point each)

1. Describe briefly the biological property of the soil (3 points)
2. Discuss about Soil Biota (3 points)
3. Discuss about Soil Fauna (4 Points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 5 points Unsatisfactory - below 5 points

Information Sheet 5 – Determining soil parameters for specified plants

1.5. When a variety of different soil types is found within one irrigation scheme, sprinkler or drip irrigation are recommended as they will ensure a more even water distribution. Different types of crop need different types of soils and the relations can shown as follow:-

Plants for clay and silt soils

Plants for clay and silt soils	Plant Type	Suitable for acid soils	Suitable for alkaline soils	Suitable for neutral soils	Extra features
Acer (Japanese Maple)	Tree	✔		✔	
Crab Apple	Tree	✔	✔	✔	
Laburnum	Tree				
Magnolia	Tree	✔	✔	✔	
Sorbus (Rowan)	Tree	✔		✔	
Berberis	Shrub	✔		✔	
Camellia	Shrub				
Hydrangea	Shrub	✔	✔	✔	
Lilac (Syringa)	Shrub	✔		✔	
Mahonia	Shrub	✔		✔	
Pyracantha	Shrub				
Rose	Shrub		✔	✔	
Sambucus	Shrub				
Vitis (Grape Vine)	Shrub				
Weigela	Shrub	✔	✔	✔	
Aconitum	Perennial	✔	✔	✔	
Aster novi-belgii	Perennial				
Astilbe	Perennial	✔	✔	✔	
Astrantia	Perennial		✔	✔	
Bluebells	Perennial				
Calamagrostis	Perennial				
Carex elata	Perennial	✔	✔	✔	
Deschampsia	Perennial	✔	✔	✔	
Filipendula	Perennial	✔	✔	✔	
Foxglove	Perennial				
Hosta	Perennial				
Ophiopogon	Perennial	✔	✔	✔	
Peony	Perennial	✔	✔	✔	
Rodgersia	Perennial	✔	✔	✔	
Rudbeckia	Perennial				
Solidago	Perennial	✔	✔	✔	
Prem Baboo					

Plants for sandy soils

Plants for sandy soils	Plant Type	Suitable for acid soils	Suitable for alkaline soils	Suitable for neutral soils	Extra features
Eucalyptus	Tree	✓		✓	
Hamamelis (Witch Hazel)	Tree	✓		✓	
Juniper	Tree				
Pinus (Pine)	Tree	✓	✓	✓	
Acacia (Mimosa)	Tree	✓	✓	✓	
Buddleja	Shrub	✓		✓	
Cotoneaster	Shrub				
Erica carnea	Shrub	✓	✓	✓	
Helianthemum	Shrub	✓	✓	✓	
Lavender	Shrub	✓		✓	
Perovskia	Shrub				
Pieris	Shrub		✓	✓	
Rhododendron	Shrub				
Rosemary	Shrub	✓	✓	✓	
Achillea	Perennial				
Allium	Perennial	✓	✓	✓	
Anthemis	Perennial	✓			
Dianthus	Perennial				
Echinops	Perennial	✓			
Eryngium	Perennial				
Festuca glauca	Perennial	✓	✓	✓	
Gaillardia	Perennial	✓	✓	✓	
Iris	Perennial				
Leymus arenarius	Perennial	✓	✓	✓	
Oenothera	Perennial	✓	✓	✓	
Osteospermum	Perennial		✓	✓	
Poppy	Perennial	✓	✓	✓	
Red Hot Poker	Perennial	✓	✓	✓	
Sage	Perennial	✓	✓	✓	
Salvia	Perennial	✓	✓	✓	
Sedum	Perennial				
Stipa	Perennial	✓		✓	
Thyme	Perennial				
Verbascum	Perennial	✓	✓	✓	
Wallflower	Perennial	✓	✓	✓	
Prem Baboo					

Self-Check – 5	**Written test**

Name…………………………………………… ID……………………….. Date…….

Directions: Answer the question listed below. Illustrations may be necessary to aid some explanations/answers.

1. Mention the types of crop suitable for both Saline and alkaline soil (3 points)
2. Mention the types of crops suitable for both Alkaline and neutral soil (3 points)
3. Mention the types of crops suitable for saline, alkaline and neutral soil in common (4 points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 5 points Unsatisfactory - below 5 points

Information Sheet 6 – Collecting on cultural significance and habitats

1.6 Understanding Cultural Features and habitat

The various mapping agencies of the United States Government have agreed on standard symbols for most cultural and natural ground features that are commonly identified on maps. Most of the symbols used on soil maps follow these standards. Some soil maps show special features that are not included in the standard list. The symbols for these must be compatible with symbols used by other mapping agencies. Different symbols are not used for the same feature, nor is the same symbol used for different features.

Conventional and special map symbols must be functional and readily identifiable on the map.

Conventional signs and symbols used in soil mapping are shown on figure 4-7. Some of these are described in the paragraphs that follow.

Boundaries of cultural features are shown on soil maps by standard conventional symbols. These include the boundaries of nations, states, counties or parishes, minor civil divisions, reservations (including Federal or State parks and forests), land grants, parks, and cemeteries.

U.S. Geological Survey (USGS) maps are the primary source of cultural boundaries. Where USGS maps are not available or must be supplemented, local sources are used. County or State assessors, planning and zoning officials, and reservation superintendents are authoritative sources. Boundary monuments are located in the field and boundaries are plotted during soil mapping only where boundary location cannot be plotted accurately from references. Boundaries are verified as a precaution against errors.

Where cultural boundaries of different classes coincide, the symbol of the major subdivision is used, for example where a State boundary coincides with a county boundary the State boundary has priority. Where a boundary obviously follows a stream or road for a short distance, the boundary symbol may be omitted. In some places, the road or stream may be labeled for clarity: "Road is county boundary" or "State boundary is center line of stream."

Township and range numbers are shown along the margins of field sheets for all lands that have been sectionized. Section lines are not shown. In some surveys all sections corners are shown; in others, only those that have been located are shown. In a published soil survey, section numbers are printed in the approximate center of each section. Published topographic quadrangle maps show the land grid, though some old ones may need correction. Soil scientists working in an area should be familiar with the local land survey system and its intricacies.

Cemeteries are outlined to scale on field sheets using dashed lines. The name is usually placed within the outline of a large cemetery and outside a smaller one, although the smallest cemeteries are usually indicated by a cross and not named. A feature such as a road or stream may serve as a boundary for a cemetery.

The identification of airports and landing fields is optional on field sheets. Boundaries of large municipal, commercial, and military airports and landing fields are shown by the symbol for a reservation. The runway pattern is not delineated if it is apparent on the aerial photograph. Small airfields can be shown by a dashed line symbol similar to that used for a cemetery, or the symbol for a "located object" can be used and labeled. Each airfield that is identified is labeled by its proper name or "airfield," if the name is not known.

Roads are identified on soil survey field sheets by symbol or name. In towns and cities only major roads are identified. Standard emblems are used to designate interstate, Federal, State, and other roads. Route numbers are placed in the emblems. If roads are shown, a simple and explicit classification is used.

The mapping of trails depends on their importance for proper map orientation and the help they will provide in locating specific areas on the map. In sparsely settled areas having few readily observable landmarks, important trails are shown and named. In more densely populated areas where roads are common, trails generally are not shown.

Railroads are shown on field sheets by conventional symbols. They may be labeled "railroad" or by the name of the line. Electric trolley lines both in urban areas and beyond city limits are shown by the standard railroad symbol and designated by operating name and type. In large railroad yards with parallel spur tracks and switches and sidings alongside single tracks, only the main track is shown.

Pipelines are shown on soil maps if they might be important as landmarks. A pipeline crossing a remote section of a survey area may be important. A similar pipeline in a populated area may be difficult to locate accurately and may have little value as a landmark. If shown, a pipeline must be accurately located.

Trunk power-transmission power lines are normally not shown on field sheets unless they have value as landmarks. They must be individually evaluated. Lateral distribution systems are not shown. The symbol for power-transmission lines, if used, begins and terminates at towns, power stations, and survey area boundaries.

Levees are indicated by short ticks. If a road or railroad is on the levee, the ticks extend from both sides of the road or railroad symbol.

Large permanent dams are shown to scale on field sheets. Thin lines are used to delineate the base of the dam. Smaller dams are indicated by single, heavy lines. A road following the top of a dam is shown in its correct place, and the road line on the upstream side is thickened to represent the dam. A dam symbol is inked to its scaled length. Important dams are named.

Permanent buildings.—rural dwellings, public buildings, and farm homes—are shown on most published soil maps but are optional. In some areas, buildings are constructed so rapidly that the map is out of date before it can be published. In such areas, omitting symbols for all buildings other than churches and schools is best. In most soil surveys, churches and schools are shown on the published map and may be named.

Symbols for individual houses are commonly not shown in urban areas. Prominent landmark buildings—large schools and large churches—may be shown, but they are not drawn to scale and are identified by the conventional symbols.

The cross or pennant of a church or school symbol is oriented at right angles to a nearby roadway. A building used as both a school and a church is marked by the school symbol. If churches or schools are omitted from large urban area but mapped in rural areas, the notation "omitted in urban areas" is made on the legend of conventional symbols.

Open pits, mines, and quarries smaller than the minimum area for delineation are shown only by conventional symbols. Larger areas are delineated, classified, and correlated as kinds of soil or miscellaneous areas.

Producing oil and gas wells may be shown. Where the number of wells is so large that the symbols are closely spaced on the map, the approximate outline of the field may be shown by dashed lines and the delineated area identified as "oil field" or "gas field" without the conventional symbol.

Streams and rivers are shown on the field sheets, and perennial and intermittent streams are clearly differentiated. The pattern of drainage and the classification of the drainage must be complete. If the main drainage courses are identified by stereoscopic study of aerial photographs, the lines must be confirmed and the drainage classified in the field. Most distinct drainage courses more than 1 cm long on the field sheets are shown. Drainage courses are mapped to scale if wide enough to be shown legibly or by single lines if narrow.

A perennial stream is one in which water flows constantly except during periods of unusual drought. That a stream is perennial must be verified, especially in semiarid and arid regions where the water in streams and waterholes is vitally important.

Mapping large rivers that change course and width from time to time is difficult. The shorelines shown on a soil map generally mark the areas covered with water for so long that little or no vegetation grows during low water and unvegetated riverwash persists from year to year. Areas that are covered by flood water for only short periods are excluded. Areas that are uncovered only during very low water stages are included.

The level of river stages varies widely, depending on characteristics of the river in relation to the climate of its watershed and other factors. Where the flow of rivers, though active for brief periods, dwindles or ceases altogether for many months, the normal stage is very low. Thus rivers, such as the Platte and much of the Rio Grande, are normally braided, and the boundaries of the river are usually placed at the outer limits of the area of braided channels. Unstabilized sediment that is washed and rewashed and supports little or no vegetation but persists from year to year may be identified as riverwash. Areas within a flood plain that can support vegetation are shown as soil.

Some streams, especially in areas underlain by limestone, enter abruptly into caverns and may flow for long distances through subterranean channels. The points where the streams enter and emerge are located accurately, but only the surface drainage is shown.

An intermittent stream is dry each year for extended periods, usually for more than three months. In arid and semiarid regions especially, intermittent streams are distinguished from perennial streams because they are not reliable sources of water.

Poorly defined water courses are not shown. Aggraded flats or valley floors without well-defined stream channels or scars are shown as soil.

Canals and ditches, whether for navigation, irrigation, or drainage, are plotted to scale if they are wide enough. Otherwise they are shown by the single-line symbol. Arrows indicate the direction of flow. Generally, both the main ditches and important laterals of irrigation systems are shown. Large canals and ditches are named on the field sheets if they have names. On the map, canals and ditches must be distinguishable from roads.

Lakes, ponds, and reservations are delineated to scale on field sheets. The boundary marks the normal water level, which may not be the shoreline observed and recorded at the time of the survey. Normal water level may be marked by a line of permanent land vegetation, but many lakes are bounded by wave-washed beaches above the normal water level. Many reservoirs are bounded by areas that are submerged when the water level is high. The shore line that is evident on aerial photographs may be used to delineate the normal stage of a lake, pond, or reservoir. If a high water level other than wave-washed beaches can be identified, it is shown on the map by the intermittent water symbol and is identified. The area between high water level and normal water level can be defined as a soil map unit if the area warrants it. The intermittent water symbol is not used in these areas. The intermittent water cover is described in the map unit description.

Reservoirs surrounded by an impounding structure are outlined. Some reservoirs have flood-pool lines that are determined from available sources. They are shown on the map by a dashed line and given an appropriate label, such as "approximate flood-pool line."

The shoreline of an island is determined at the same water stage as the adjoining mainland shoreline. Islands exposed at a lower stage are not shown.

Tidal shorelines present special problems. The mean high tide level (determined excluding the semimonthly highest tides) can be used where the land rises to elevations well above high tide within a short distance from the shore. Where broad marshes mark the transition from sea to land, the shoreline is the outer boundary of the area that supports plants. The soil boundaries extend to that line.

The shoreline of a body of water is not broken for wharves, piers, and similar structures that may be built over the water. Seawalls and retaining walls that are part of a shoreline are shown as the shoreline.

Intermittent lakes are shown on the field sheets as kinds of soil or miscellaneous areas. The dashed line symbol shows the area covered by water part of the year.

Marshes and swamps are mapped as soil unless they are too small to be delineated. If too small, they are shown by the conventional marsh or swamp symbol.

Springs are shown on the soil map if they are important in the area. Springs of all kinds are shown in arid and semiarid regions. In humid regions, only large and dependable springs are shown. Some springs have names, which may be printed on the soil map. In arid regions, intermittent springs or springs that have salty or otherwise impotable water are so identified by notes on the map. Walled-in springs are shown by circles, like those for wells. A spring that is a source of a stream is shown by a circle where the stream symbol starts.

Artesian wells and wells for irrigation are shown on soil maps where they are important sources of water, as in arid and semiarid regions. Artesian wells are designated by a conventional symbol, whether or not they flow at the surface. In regions of few wells, all are shown; but in thickly settled areas that have many nonflowing artesian wells, they can be explained in the report without being shown on the map.

A wet spot is an area of wet soil that is too small to delineate. It is usually somewhat poorly drained or wetter and at least one drainage class wetter than the soil around it. Wet spot symbols are not placed within areas that are mapped as a wet soil.

Special symbols are used to identify small areas of various kinds of soil, miscellaneous areas, and special soil features. These are commonly used for areas that are too small to delineate but large enough to significantly influence use and management. If a specific kind of area is shown by special symbols, all such areas of that land are shown; the symbols are not to be used haphazardly. The symbols must be defined in terms of the kinds and size of areas each symbol represents.

In some places, the pattern of mappable areas is so complex that symbols and leaders clutter the map. Special symbols used with moderation reduce the congestion of lines and symbols, although many special symbols in a small area reduce legibility. It may be preferable to map as complexes many areas of intricately associated kinds of soil.

Special symbols show relief features that are too small to show as map units; for example, bedrock escarpements, short steep slopes, and gullies. Natural depressions or sinks such as those common to limestone areas, may be shown by the depression or sink symbol. Small areas of rock outcrop in an area of otherwise deep soil are obstacles to tillage and should be shown. In addition, small areas of saline soil and very stony soil, in areas otherwise suitable for crops should be shown. Special symbols are used for small areas of some kinds of soil that contrast sharply with surrounding soils in their management needs or productivity, even though they are suited to the same uses. Small areas of gravelly soil in gravel-free areas, sand spots in areas of finer textured soil, and small areas of severely or moderately eroded soil in areas of noneroded soil are examples.

Self-Check – 6	Written test

Name………………………………………… ID………………………… Date……

Directions: Answer the question listed below. Illustrations may be necessary to aid some explanations/answers. (2.5 points each)

1. Discuss briefly Keeping records of field sheets
2. Explain step by step in on Collecting on cultural significance and habitats

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 5 points Unsatisfactory - below 5 points

1.7 Preparing recording format

Soil sample information sheet

1. Name of farmer---------------------------------- Date----------------
2. Address--
   Village--------------------------------------- P.O.--------------------------------
   Block-- District --------------------------
   State---

1. Sample No. ------------- 2. Depth of sampling (cms)----------------
3. Area (in hectare)----------------- 4. Slope or topography- level/sloping/ undulating
5. Elevation ------------------------- Up land/ low land
6. Drainage-------------------------- Well drained/ moderate/ impeded
7. Irrigation ------------------------- Irrigated/unirrigated (rain fed)
8. Source of irrigation -----------------Well /tube well/ canal/ pond
9. Type of soil --------------------------- Sandy/loamy/ clayey
10. Special soil conditions--------------- Hardpan layer/rocky subsoil/ concentration
11. Cropping Details -----------------------------

Crop variety	Seed rate (kg/ha)	Yield kg/ha

For previous years

1.

2.

For proposed years

1.

2.

14. Fertilizer and manuring history

Year	Crop	Manure/fertilizer	Quantity /applied (kg/ha)
20			
20			

15. Any other information to be furnished

16. Other remarks (if any)

Signature---------------------------

Self-Check – 7	Written test

Name…………………………………………… ID…………………………
Date…….

Directions: Answer the question listed below. Illustrations may be necessary to aid some explanations/answers.

1. What are Sources of data to conduct performance monitoring & evaluation? (2.5 points)
2. Briefly elaborate the step to be conducted in the data collection process.(2.5 points)
3. Compare and contrast quantitative and qualitative data (5 points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 5 points Unsatisfactory - below 5 points

Operation Sheet 1- Undertake Collection and preparation of soil samples

ROCEDURE

1. The soil sampling is done when there is no crop in the field i.e., before the growing the next crop and also prior to application of manures and fertilizers. Rainy season should be avoided for sampling work.
2. The root penetration is important for crop growth, therefore, for cearls, vegetables and another seasonal crops the sample should be drawn from 0-15cm i,e., plough layer.
3. For deep rooted crops like sugarcane, cotton or under dry farming conditions, obtain samples from different depths. For plantation crops or fruit trees samples should be collected from 0-30, 30-60, and 60-100 cm depth.
4. In case of saline alkali soils, salt crust if visible on the soil surface should be sampled separately and record the depth of sampling. Generally, the sample may be drawn up to 15 cm depth from surface for testing.
5. Ten-fifteen soil samples collected from homogeneous sampling units are mixed and smaller sample is drawn which represents the entire sampling unit is known as composite sample. A field can be treated as a single unit if it is appreciably uniform and 0.5 ha is take as one sampling unit.
6. Mobilize tools and Materials
7. Divide the field on the basis of variations in slope, colour, texture, crop growth and management practices.
8. Scrap away the surface litter without much disturbing soil.
9. Take 15 soil samples randomly distributed over each area using a soil auger/tube and place them in clean bucket(Fig.1.3A &B). A khurpi or spade can be also used if auger is not available. In this case, make a V shaped cut up to 15 cm thick slice of soil from top to bottom, moving in a zig-zag manner from each sampling unit and place the samples in a clean bucket.

10. From fields having standing crops in rows draw samples in between rows(Fig.1.4)
11. Mix thoroughly the soil sample taken from each area on a clean piece of cloth or polythene sheet by hand(Fig.1.5)
12. Reduce the bulk of soil sample to about 500g by quartering process in which the entire soil is spread, divided in four equal parts; two opposite ones are discarded and remaining two are remixed. Repeat this procedure until about half kilogram of the soil is left. Put the soil in a clean cloth/ polythene bag free from any contamination of fertilizer, salt etc.
13. Prepare two labels, one to be put inside the bag
14. Fill out an information sheet for each composite sample. The information should be as complete and accurate as possible.
15. Pack the soil sample bags along with information sheet in a clean and dry gunny bags.

Operation Sheet 2- Undertaking Processing of Soil Samples for Analysis

1. Air dries the soil samples in shade.
2. Crush the soil clods lightly and grind with the help of wooden pestle and mortar.
3. Pass the entire quantity through 2 mm stainless steel sieve.
4. Discard the plant residues, gravels and other material retained on the sieve.
5. If the gravel content is substantial, record as per cent of the sample(w/w)
6. For certain type of analysis (organic carbon), grind the soil further so as to pass it through 0.2 to 0.5 mm sieves.
7. Remix the entire quantity of sieved soil thoroughly before analysis
8. Draw the soil samples from uniform piece of land. Sample should never be collected either from hills or depressions in the field as these do not represent the natural conditions of the field.
9. Do not draw any sample from extreme corners of the field, areas recently manured or fertilized, old bunds, marshy spots, manure piles and non-representative areas.
10. Avoid contact of samples with chemicals, fertilizers and manures.
11. Use steel augers instead of rusted iron khurpi or kassi for sampling of micro-nutrient analysis.
12. Do not take less than 0.5 kg of composite sample
13. Do not dry the soil directly under sunlight or by artificial heating. Air dry the sample under shade.
14. Store the samples preferably in a clean cloth or polythene bags.
15. Use glass, porcelain or polythene jar for long duration storage

LAP TEST	Performance Test

Name………………………………. ID……………………………..

Date…………………………………….

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 8 hour. The project is expected from each student to do it.

Task-1 Go to the demonstration area of your college ,by Collecting and Colleting the necessary land use data, undertake Collection and preparation of soil samples, write a report and present it.

Task-2 Go to the demonstration area of your college, by Collecting and Colleting the necessary land use data, undertake Processing of Soil Samples for Analysis, write a report and present it.

LG #65	LO #2- Participate to analyse soil information

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Undertaking classification of soil
- Establishing parameters for proposed land use and production.
- Evaluating Soil Characteristics to Determine the Land Use Need
- Determining Readily Available Water (RAW) values for irrigation sites

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Undertake classification of soil
- Establish parameters for proposed land use and production.
- Evaluate Soil characteristics to determine the land use need
- Determine readily available water (RAW) values for irrigation sites

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following

“Operation sheets” ,

8. If your performance is satisfactory proceed to the next learning guide,

9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1- Undertaking classification of Soil

2.1. Soil Classification

Soil classification is the grouping of the objects in some orderly and logical manner in to compartments.

Purpose of soil classification

1. To organize knowledge leading to economy of thoughts.
2. To recognize properties of the objects classified.
3. To bring out and understand relationship among individuals and classes of the population being classified.
4. To establish groups or subdivisions of the objects under study in a manner useful for practical and applied purposes in:
   - Predicting their behavior
   - Identifying their potential uses
   - Estimating their productivity
   - Providing objects for research and
   - Transferring agro-technology from research farm to cultivators fields.
   - The latest comprehensive classification system is known as 'Soil Taxonomy', based on the properties of the soils as they are found today. The soil taxonomy permits classification of soils rather than soil forming processes.

There are six categories of classification in Soil Taxonomy: (a) Order (the broadest category)

(b) Suborder (c) Great group (d) Sub group (e) Family (f) Series (most specific category). The nature and kind of differentiating characteristics used in these six categories are given in the

Preparation of samples for analysis

Drying: Wet soil sample should not be stored as changes may occur in the chemical nature of certain ions and organic matter. Samples are generally air dried at temperature (25-35 0C) and relative humidity (20-60%) then after are stored. Fresh samples from the field without any drying are required. For certain determinations such as ammonium and nitrate N, exchangeable K, acid extractable P and ferrous iron fresh sample from the field without any drying are required. Results of soil analysis are expressed on oven dry weight basis. This necessitates determination of moisture percentage by drying a small sample in an oven at 105 0C for 2 hours.

Sieving: Field moist samples prior to drying can be made to pass through a 6 mm sieve (about 4 meshes per inch) by rubbing with fingers. The practice seems of much advantage in case of heavy soils. Soil in the right moisture condition can be passed through a 2 mm sieve (about 10 mesh per inch). The common practice of sieving a portion of the gross sample through a 2 mm sieve and discarding the rest is undesirable as it increase the concentration of most of the elements involved in soil fertility. When the gravels in the soil exceeds 2% limit over a 2 mm sieve their exact percentage should be recorded.

Grinding: A roller, rubber pestle in an agate mortar, or a motorized grinder is commonly used. Crushing of the gravel or primary sand particles should be avoided for heavy soils, it is better to pass these through a 2 mm sieve before allowing them to get completely air dried.

Mixing: Sample should be thoroughly mixed by rolling procedure. Place the dried ground and sieved sample on a piece of cloth. Hold all the four corners of the cloth and then up the one corner and down the other corner across the sample alternatively. Now repeat the process in the reverse direction to roll the soil from one corner to another. Continue this until thorough mixing is assured.

Storage: Store the soil in paper carton (soil sample box) using a polythene bag as in inner lining. Label the carton mentioning cultivators name, plot number, date of sampling and initials.

2.2. **Soil Analysis**

Soil is the main source of nutrients for crops. Soil also provides support for plantgrowth in various ways. Knowledge about soil health and its maintenance is criticalto sustaining crop productivity. The health of soils can be assessed by the qualityand stand of the crops grown on them. However, this is a general assessmentmade by the farmers. A scientific assessment is possible through detailed physical,chemical and biological analysis of the soils.Essential plant nutrients such as N, P, K, Ca, Mg and S are called macronutrients,while Fe, Zn, Cu, Mo, Mn, B and Cl are called micronutrients. It is necessary toassess the capacity of a soil to supply nutrients in order to supply the remainingamounts of needed plant nutrients (total crop requirement - soil supply). Thus,soil testing laboratories are considered nerve centres for nutrient management andcrop production systems.

Soil testing is often performed by commercial labs that offer a variety of tests, targeting groups of compounds and minerals. The advantages associated with local lab is that they are familiar with the chemistry of the soil in the area where the sample was taken. This enables technicians to recommend the tests that are most likely to reveal useful information.

The amount of plant available soil phosphorus is most often measured with a chemical extraction method, and different countries have different standard methods. Just in Europe, more than 10 different soil P tests are currently in use and the results from these tests are not directly comparable with each other (Jordan-Meille et al 2012).

Soil testing is used to facilitate fertilizer composition and dosage selection for land employed in both agricultural and horticultural industries.

Prepaid mail-in kits for soil and ground water testing are available to facilitate the packaging and delivery of samples to a laboratory. Similarly, in 2004, laboratories began providing fertilizer recommendations along with the soil composition report.

Lab tests are more accurate and often utilize very precise flow injection technology, though both types are useful. In addition, lab tests frequently include professional interpretation of results and recommendations. Always refer to all proviso statements included in a lab report as they may outline any anomalies, exceptions, and shortcomings in the sampling and/or analytical process/results.

Some laboratories analyze for all 13 mineral nutrients and a dozen non-essential, potentially toxic minerals utilizing the "universal soil extractant" (ammonium bicarbonate DTPA).

2.3. Procedure for Analysis of selected soil properties

The following procedures are employed in standard soil laboratories to determine the following soil properties:

- The particle size distribution is determined by soil textural triangle .
- Bulk density is measured by core method (and Porosity was computed from bulk density and particle density.
- Soil pH is determined potentiometrically in 1:25 soil liquid ratio
- Organic carbon is determined using method described by, Nelson and Sommers methods and the result of organic carbon multiplied by 1.724 to determine the organic matter content.
- Total available phosphorus is determined using Bray II method .
- Total Nitrogen is determined using Kjeidal Digestion and Technicon/Auto analyzer method.
- Exchangeable bases are determined by extraction of ammonia acetate (NH4OAC) at pH 7.0 known as extractant in determining calcium, magnesium while sodium and potassium are determined using flame photometer.
- The exchangeable acidity is determined using extraction of exchangeable H+ and Al3+with KCl and titrated as outlined by .
- The effective cation capacity was estimated by the summation of all the exchangeable base and acidity.

The most important phase of soil analysis takes place not in the laboratory but in the field where the soil is sampled. Soils vary from place to place. In view of this, efforts should be made to take the samples in such a way that they are fully representative of the field. Composite sampling can be performed by combining soil from several locations prior to analysis. This is a common procedure, but should be used judiciously to avoid skewing results.

In general, the following estimations are generally carried out in a service-oriented soil testing laboratory: soil texture, soil structure, cation exchange capacity (CEC), soil moisture, water holding capacity, pH,lime requirement, electrical conductivity, gypsum requirement, organic C, total N, mineralizable N, inorganic N, available P, available K, available S, calcium, calcium plus magnesium, micronutrients – available Zn, Cu, Fe, Mn, B and Mo.

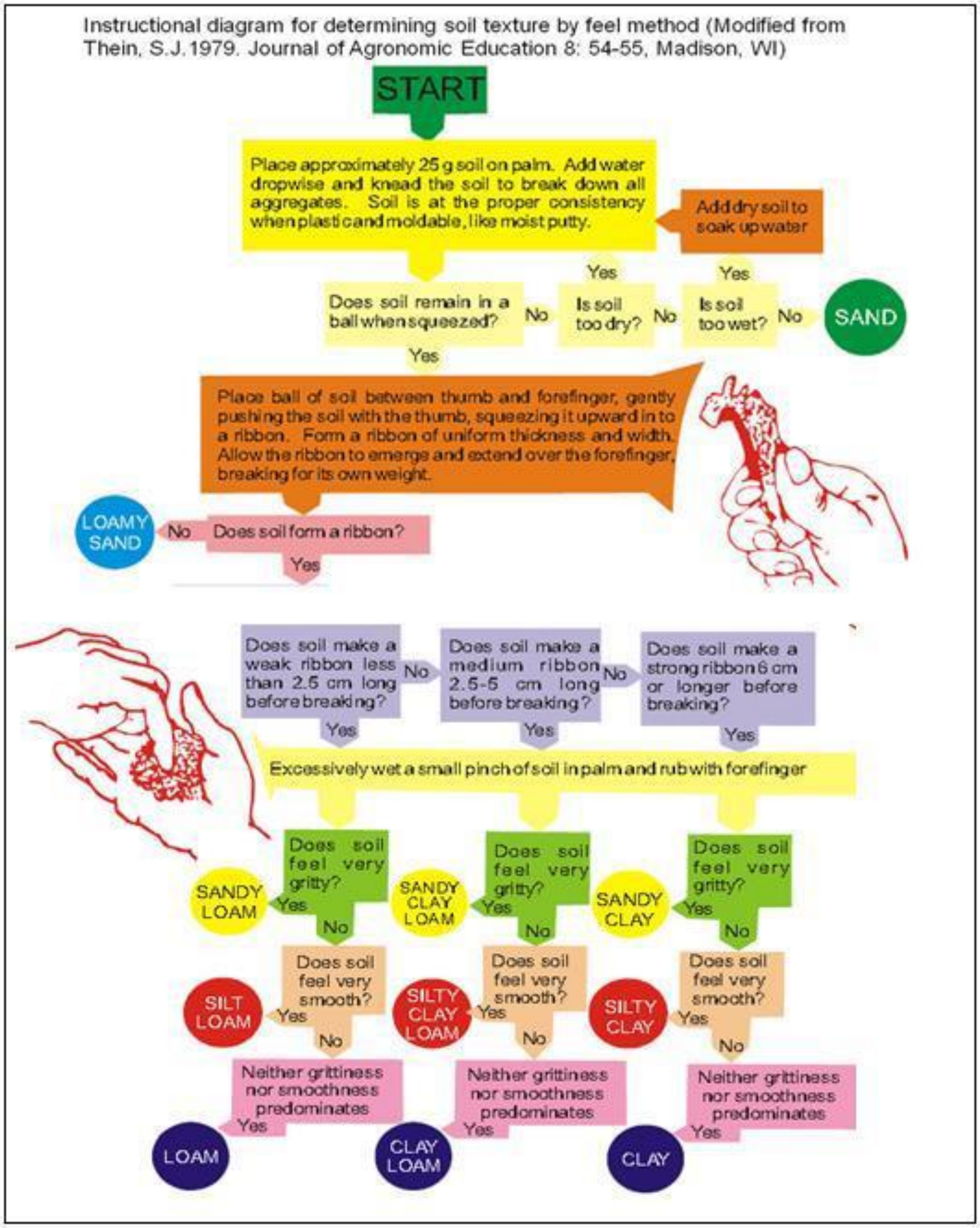


Figure determination of soil texture by fill and appearance method

Self-Check – 1	Written test

Name………………………………………… ID……………………… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (5.Points each)

1. Discuss briefly about analysis of soil sample by feel and appearance method
2. Discuss briefly about analysis of soil sample by textural method

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 3 points   Unsatisfactory - below 3 points

Information Sheet2- Establishing parameters for land use and production

2.2. Local Relative Placements

If interpretations are locally made, it becomes feasible to rank soils on a strictly relative basis and to introduce local knowledge about soil behavior that may have been excluded from more general national ratings. The term soil potential has been used to describe locally controlled numerical ratings that give the relative ranking of soils for a given use. This is in contrast to the national specific-use interpretative system which emphasizes criteria that apply nationwide and thus are more general than rankings based on local data that include costs to overcome limitations and costs to maintain a system.

The process of determining a soil potential requires an evaluation of the capacity of the soil to produce a crop or support a given structure or activity at a cost expressed in economic, social, and environmental units. Determination of potentials usually cannot be accomplished by soil scientists working alone. In particular, identification of corrective measures requires other disciplines.

Soil potentials for a soil survey area are of greatest value in local planning of specific tracts of land. If comparative ratings of every soil in a specific tract for a particular use are available, then a rational decision can be made whether to proceed, to change the plans, or to find another area that has soils with higher potential. The best soils in the specific tract for the particular use may be among those with low potential in the soil survey area overall, although this fact has no bearing on the relative evaluation for the specific tract.

The extent to which a given property is limiting and, in many cases, the practices that can be used to overcome the limitation are influenced by other properties of the soil. An example is the low strength of some soils in coarse-silty families. Such soils may not be limiting for dwelling foundations if the shallowest depth of free water exceeds 2 m. If, however, the shallowest depth of free water is within 25 to 50 cm of the base of the foundation, then these soils may be decidedly limiting for foundations. The process of determining soil potentials, which involves the interaction of knowledgeable local people, makes it possible to use more sophisticated criteria than is feasible for the national specific-use program.

Soil potentials are presented either as a set of qualitative, relative classes or in a numerical scale. The first step is to identify for a particular use the soil properties of significance. These properties may be the same as the basic soil interpretative attributes but are not limited to these properties. C ritical values for each property are defined and may include properties that are not limiting. For example, the occurrence of free water below 60 cm may not interfere with the production of soybeans; but the critical depth may be 120 cm for the production of alfalfa. Thus, soil potentials are crop and property specific. practice to include interrelated practices.

Alternative practices can commonly be substituted. For example, dwellings can be built without basements on integral slab foundations and avoid the necessity of reinforced basement walls.

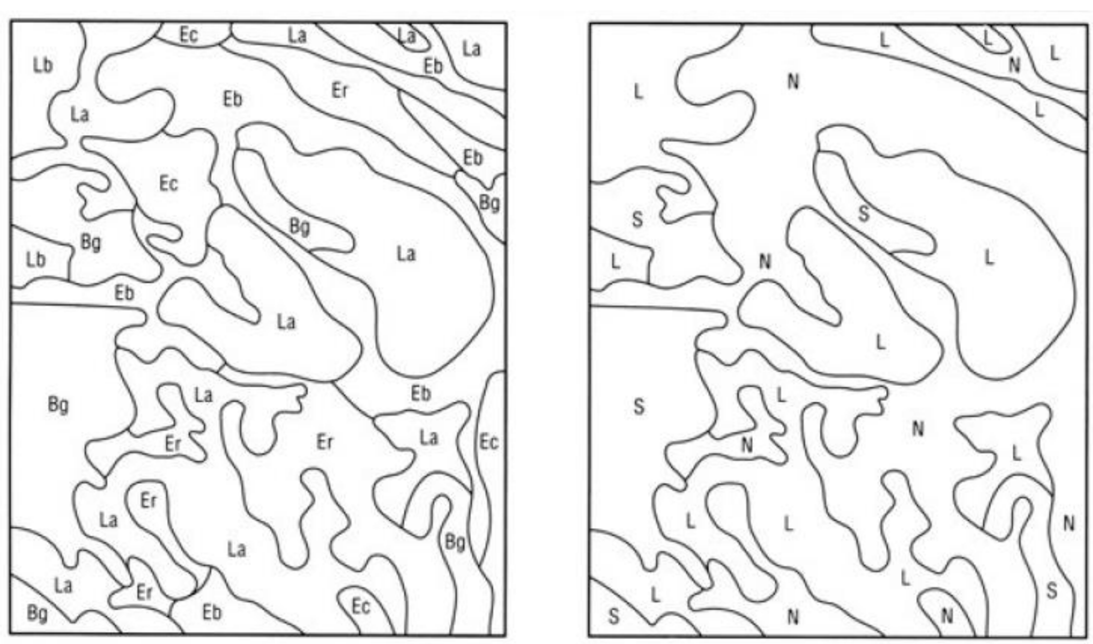
The third step in rating soil potential is to determine the cost or difficulty of overcoming soil limitations. Relative rather than absolute costs of corrective measurements are generally desirable. If the cost of overcoming the limitation is judged to be prohibitive, the soil is rated to have low potential for that use. Information on cost provides a guide to landowners and local planners.

The fourth step is to identify the limitation that would exist after the corrective measures have been installed. Certain practices are fully successful in overcoming limitations on some soils. Performance is as good as that of soils that do not have the limitations or even better. For other soils and uses, however, no corrective measures are available at an acceptable cost. For many situations, practices may substantially lessen the effects of soil properties, but problems still remain.

To express soil potentials numerically, values are assigned to those soil properties and site conditions that influence performance. Some approaches assign penalty points to limiting soil properties or site conditions, and others assign points based on favorable properties or conditions.

Interpretive Soil Properties

Soil survey interpretations are provided for specific soil uses. Interpretations for each soil use are based on a set of interpretative soil properties. These properties include site generalities such as slope gradient, measurements on individual horizons (e.g., particle size distribution), temporal repetitive characteristics that pertain to the soil as a whole (e.g., depth to free water), and potential for diastrophic events (e.g., down-slope movement). Most of the interpretative soil properties are included in the description text and are on the tables associated with a particular map unit



Section of a detailed soil map on the left and its interpretations on the right. The map units have been rated slight (L), moderate (N), or severe (S) for a specific use.

Self-Check – 2	Written test

Name…………………………………………… ID……………………… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (5. points each)

1. Why you establish parameters for land use production
2. Discuss about Interpretive Soil Properties

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Information Sheet 3- Evaluating soil characteristics

2.3. Introduction

The problem soils are those which owing to land or soil characteristics cannot be economically used for cultivation of crops. These soils require remedial measures and management practices for satisfactory crop production.

Types of problem soils:

The problem soils have been classified in two main categories on the basis of nature of constraints.

1. Physical nature: a) Highly eroded soils, ravines and soils on sloping lands b) Soil physical constraints

2. Chemical nature: i) Saline soils ii) Saline alkali soils iii) Alkali soils and iv) Acid soil

Physical nature:

Highly eroded soils, ravines and soils on sloping lands: The areas affected by this problem and in steep slopes of hilly areas. The erosion is mainly caused by wind, water and landslides.

Wind erosion: It occurs in arid and semiarid areas devoid of vegetation due to high wind velocity. Soil particles are lifted and blown off and when the velocity of the dust bearing wind is retarded, coarser soil particles are deposited in the form of dunes and thus fertile lands are unfit for cultivation.

Water erosion: Water removes a thin covering of soil from large area uniformly during every rain which produces runoff. Its existence can be detected by muddy colour of the runoff from the fields. This is called sheet erosion. Later on , the silt laden runoff forms a well defined but minute finger shaped grooves over the entire field. Such thin channeling is known as rill erosion. The tiny grooves develop in to wider and deeper channels which may assume a huge size is known as gully erosion.

Land slides or slip erosion: The outward and downward movement of the slope forming material composed of natural rocks, soil etc. is known as land slides or slip erosion. The main cause of land slides are topography, geological structure, type of rocks and their physical characteristics.

Agronomic measures for soil and water conservation:

Interception of rain drops reduces the splash effect. The overland runoff can be reduced through use of contour cultivation, mulches, dense growing crops, strip cropping and mixed cropping.

A simple practice of farming across the slope, keeping the same level as for as possible is called contour farming. It reduces runoff, soil erosion and loss of plant nutrients and increases crop yields.

Surface mulches are used to prevent soil from being blown and washed away to reduce evaporation, increase infiltration, check weeds, improved soil structure and eventually to increase crop yields.

Grow the crop which can provide and reduce runoff and soil losses. Legume furnishes better cover and hence provides better protection to cultivated land against erosion than ordinary crops.

Grow the crops in strips of suitable width across the slopes by alternating the strips of soil protecting and erosion resisting crops.

Soil physical constraints:

1. Permeable soils:

Highly permeable coarse textured soils:

The high permeability of these soils are associated with their sand and loamy sand texture.

The soils has low bulk density and high hydraulic conductivity and infiltration rate which results in to high permeability and low water retention capacity.

The fertilizer and water use efficiency is very low and nutrient losses are very high. Soil compaction and clay mixing should be done to improve these type of soils.

Slowly permeable soils:

The infiltration rate and hydraulic conductivity is low which results in to slow permeability of the soil and possibility of submergence during rainy season.

The prevailing anaerobic conditions cause the accumulation of carbon dioxide and other by products which restrict the plant growth.

These soils are associated with black clay soils. The black soils are sticky when moist, therefore, could be cultivated only within limited soil moisture range.

These type of soils can be reclaimed by growing crops on raised beds, broad beds with drainage furrow in between, deep tillage through ploughing and chiseling to break the hard pan in sub-soil.

Crusting soils:

When the rain drop strikes the exposed dry soil surface, there is disintegration and dispersion of soil aggregates.

The finer clay particles moves down along with infiltrating water and clog the soil pores.

As the water evaporates and soil dries, a thin layer of hard crust of soil is formed. The crust present a serious barrier for seedling emergence.

Crusting of alluvial soils is a serious problem

Application of farm yard manure or green manuring will improve these type of soils.

Chalka soils:

The red sandy loam soils “Chalka soils” which cover a large area become very hard on drying with the result that growth of the crops are adversely affected.

Incorporation of slow decomposing crop residues and other materials such as powdered ground nut shell, paddy husk improves these type of soils. **Sandy Soils:**

Sandy soils are weakly developed because of slow chemical weathering in dry and hot climate.

The coarse texture of sandy soils causes a low water holding capacity and high infiltration rate which represents the main production constraint.

Nutrient content and nutrient retention are normally low, thus causing a low inherent fertility status of the soil.

The poor soil structure makes the soil very susceptible to wind erosion. The agricultural potential of sandy soils depends on the availability of sufficient water for crop cultivation and the provision of nutrients.

If appropriately managed sandy soils can be highly productive.

2.3. Nature of the problem

1. Salt affected soils:

Some amounts of the salts are always present in soil. When concentration of these salts are low, they are not harmful but with the increase in the salt content the plant growth is adversely affected which in turn decrease the productivity.

Salt affected soils have been classified in to three categories viz. Saline soils, Saline alkali soils and alkali or sodic soils.

2.Saline soils:

Soils containing excess of neutral soluble salts dominated by chlorides and sulphates so as to affect plant growth. High osmotic pressure of soil solution hinders the water uptake by roots of plants.

These soils are characterized by EC more than 4.0 dS m-1 , pH less than 8.5 and exchangeable sodium percentage (ESP) less than 15.0 .

These soils are characterized by saline efflorescence or white encrustation of salts at the surface. In India, these soils are known as ‘reh’ and in others as ‘thur’.

3.5 Management:

Removal of excess salt to a desired level in the rooting zone is the basic principle in the reclamation of saline soils.

Leaching with water of good quality and adequate drainage are the two essential components.

The addition of organic matter improves physical conditions of the soil and increase the water holding capacity, hence keeps the salt in diluted form.

Rice is considered a satisfactory crop during initial year of reclamation. After rice, growing of legume is suitable for the production. Cultivation of salt tolerant crops (Table-1) is the other management practices.

$$\mathrm{Soil} - \mathrm{Na2} + \mathrm{CaSO4} \rightleftarrows \mathrm{Ca} - \mathrm{Soil} + \mathrm{Na_2SO4}$$

The above reaction is reversible therefore sodium sulphate formed needs to be removed by leaching.

The fertilizers which have acidic residual effect should be used. The preferential order is

$NH_3 > NH_4Cl > (NH_4)_2SO_4 >$ Urea.

The addition of organic matter is always good in improving soil physical conditions viz. aeration, water holding capacity, infiltration, pulverization.

- It is advisale to grow tolerant and medium tolerant crops.
- Tolerant crops: Rice, Sugarbeet, Dhanicha
- Medium tolerant crops: Wheat, Barely, Oats, Millets
- Sensitive crops: Legume, Maize, Ground nut **Saline – alkali soils:**
- These soils are characterized by EC more than 4.0 dSm-1, pH more than 8.5, ESP more than 15.0.

- Such soils have characteristics of both saline and alkali soils. Therefore, soils showing high salinity and ESP should be reclaimed for both but first for salinity and later for excessive exchangeable Na.

Acid Soils

- The leaching of bases is the main cause of the formation of acid soils though parent acidic rock is also contributing factor.
- These soils are high in exchangeable Al3+ and H+ with a pH value less than 5.5 and respond to lime application.
- The adverse effect of acid soils on plant growth is mainly related to presence of aluminum, Manganese and iron in toxic concentration, deficiency of calcium and magnesium, nutrient imbalance and microbial imbalance.
- The aluminium toxicity has multiple effects, of which the inhibition of root growth is perhaps the most important.
- The manganese (below pH 5.0) toxicity interferes with plant metabolism.
- The acid soils are generally low in available phosphorus and have high P fixation capacity.
- The status of available micronutrient elements, except molybdenum, is generally adequate in these soils.
- The population of bacteria and actinomycetes are lower, and those of fungi are higher.
- The acid soils cover a large area of about 47 mha in the states of Assam, Tripura, Mnipur, W.Bengal, Bihar, Orissa, Karnataka, Tamil Nadu, Himachal Pradesh and Kerala.

Management:

- Acid soils can be managed in two ways viz. either by growing crops suitable for a particular soil pH or by ameliorating the soils through the application of amendments which will conteract soil acidity.
- The acid soils are made more suitable for agriculture use by liming which raises the pH.

- The common practice of liming is to apply ground limestone to soil. When liming materials are added to the soil they get hydrolysed and release hydroxyl ions which neutralize hydrogen ions (cause of acidity). This process can be represented by the following equations: $CaCO_3 + H_2O$ -------- > $Ca^{++} + HCO_3^- +$ OHH+

  (soil solution) + OH^- ----- > H_2O

  Table2: Liming material and their neutralizing value

Liming material	Chemical formula	Neutralizing value
Burnt lime	CaO	179
Slacked lime	$Ca(OH)_2$	136
Dolomite	$Ca\,Mg(CO_3)_2$	109

- The crop species which are more tolerant to soil acidity and problems associated with it should be grown.
- Sensitive Crops: Arhar, soybean, cotton, oats
- Semi-tolerant crops: Gram, maize, sorghum, peas, wheat, barley
- Tolerant crops: Paddy, potato, tea, millets.

Self-Check – 3	Written test

Name………………………………………… ID……………………… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (5 points each)

1. What are the steps to be conducted before providing backstopping cases?
2. Elaborate briefly the feedback process for undertaking monitoring and evaluation

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Information Sheet 4 - Determining readily available water (RAW)

The Readily Available Water (RAW) values for irrigation sites are determined in line with optimum industry standards.

1.4. Determination of readily available water (RAW)

Irrigation is normally required to keep the soil water content between FC and θc. This range is called RAW. In irrigation system design, net irrigation requirement is interchangeably used with RAW. It is calculated as:

NIR = RAW = (FC – θc).Dz

= MAD. TAW

= MAD. (FC – PWP).Dz

MAD = maximum allowable depletion = 0.50 for most crops. However, irrigation amount should account unavoidable water losses in application such as runoff and deep percolation. Thus, the NIR needs to be increased by an overall irrigation efficiency of the system, E. Therefore, the actual irrigation amount to be applied is called Gross Water Requirement which is given by:

A. How much water to Apply?(Irrigation depth)

Irrigation is normally required to keep the soil water content between FC and θc. This range is called RAW. In irrigation system design, net irrigation requirement is interchangeably used with RAW. It is calculated as:

NIR = RAW = (FC – θc).Dz

= MAD. TAW

= MAD. (FC – PWP).Dz

MAD = maximum allowable depletion = 0.50 for most crops. However, irrigation amount should account unavoidable water losses in application such as runoff and deep percolation. Thus, the NIR needs to be increased by an overall irrigation efficiency of the system, E. Therefore, the actual irrigation amount to be applied is called Gross Water Requirement which is given by:

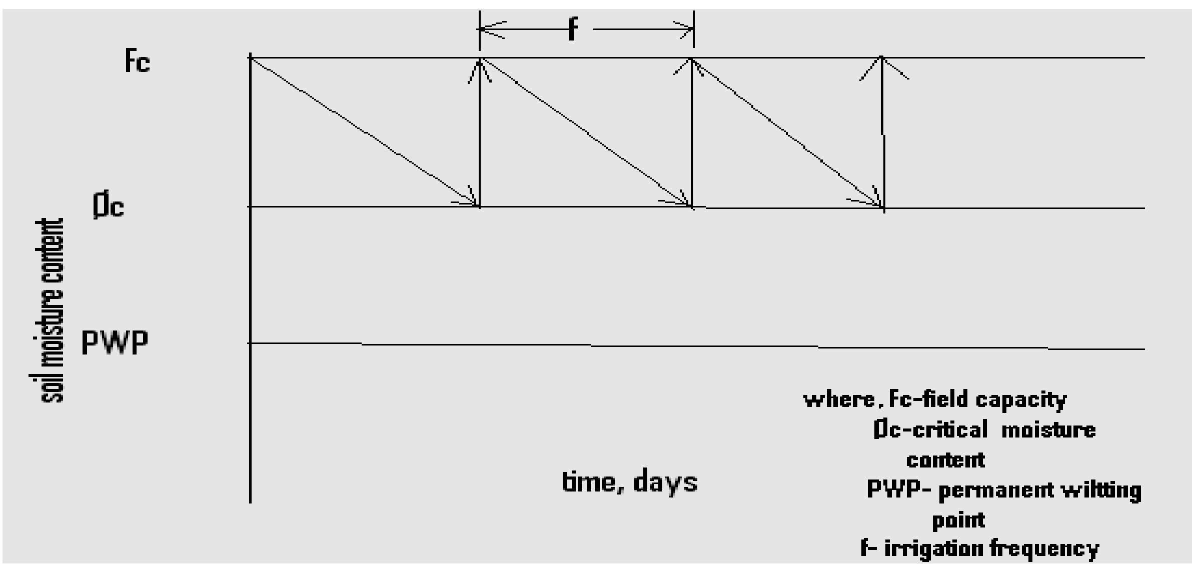
GIR = NIR/Ea

B) When to Apply? (Frequency of irrigation)

This refers to the irrigation interval which is the number of days between two successive irrigation applications. It is given by:

f = NIR/ETc

- Irrigation frequency therefore depends upon both soil and crop properties.
- For shallow soil having shallow rooted crops, irrigation frequency will be small and water will need be applied more often
- During germination and flowering stage, crop must be irrigated frequently as permissible depletion would be small.



Example 1.

How much water must be added to a field of area 3 ha to increase the volumetric water content of the top 40cm from 16% to 28%? Assume all water added to the field stays in the top 40cm.

Solution

Volume = A*dw

dw= (PWP-FC)*di

(28%-16%)*0.4 = 0.048m

Volume =A*dw

= 30,000m^2 * =.048m

= 1440m^3

Example 2.

Compute the depth and frequency of irrigation required for a certain crop with data given below.

Crop: wheat, Average daily CU: 1.2cm D rz: 1.20m, Application efficiency: 75%

FC: 17%, PWP: 5%, Bulk density: 1.72 gm/cm^3, ***Answer: d = 24.77cm; f = 10days***

a. **RAW= NIR = (Fc-PWP) * Dr * ρb * MAD**

(17%-5%) * 120cm * 1.72 * 0.5 = 12.384cm

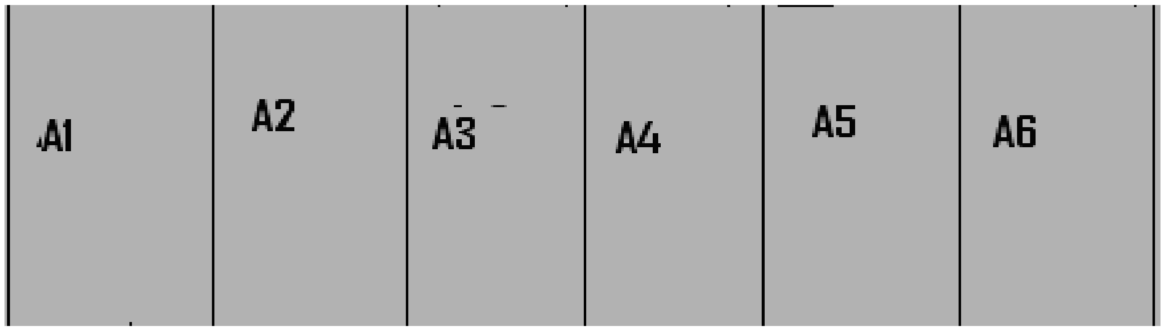
Cu = 1.2cm/day

Frequency, f , = NIR/Cu = 12.384cm/1.2cm/day = 10 days

C) Irrigation Period:

- It is the number of days allowed to complete one irrigation cycle in a given area.
- Irrigation period can not be greater than the irrigation interval.

Example: if the calculated irrigation interval is 7 days and if an irrigated area is divided into 6 sub-areas to be irrigated in shift. The irrigation period is 6 days.



And it can be calculated by:

$$IP= \frac{f*GIWR*A}{0.36Q_m}$$

Where: IP- irrigation period in hour

f- Irrigation interval in day

GIWR- gross irrigation requirement of the plant in mm/day

A - Area of irrigated farm in hectare

Q_m - manageable discharge in liter/sec.

Exercise:

Calculate irrigation interval (f) & Irrigation period (IP) under the following condition.

CWR (ET_C) =10mm/day, root depth=1m, FC=24%, PWP=8%,

Q_M =150L/Se, A=0.5ha, GIWR = 70% and Depletion=50% , Bulk Density 1.5g/cm3

Solution

ETc= 10mm/day Dr= 1m =100cm FC = 24% PWP = 8%

Q = 150 lt /sec = 150m3/1000 sec = 0.15 m3/sec

Irrigation efficiency = η = 70% MAD = 50% **ρ_b= 1.5 gm/cm^3**

a) Frequency of irrigation

$$F= \frac{NIR}{ETc}$$

But, NIR = di * MAD

$$di= \left(\frac{FC-PWP}{100}\right) * Dr_8 * \rho_b$$

di = $di= \left(\frac{24-8}{100}\right)*100 * 1.5$

di= 24cm

NIR = di * MAD = 24cm * 50/100= 12cm

Therefore $F = \frac{NIR}{ETc}$

$= \frac{12cm}{10mm/day}$

$= \frac{120mm}{10mm/day}$, F= 12 days

a) Time of irrigation, t

Q * t = A * GIWR

$t\ (sec) = \frac{A * GIWR}{Q}$

A= 5000m^2, Q = 0.15 m^3/sec

$GIWR = \frac{NIR}{\eta}$ = 12 CM/0.7 = 17.143 CM

GIWR = 0.17143m

$t\ (sec) = \frac{A * GIWR}{Q}$ = $t\ (sec) = \frac{50000m^2 * 0.17143m}{15m^3/sec}$

t= 5714.333 sec = 1.59 hr = 1.6 hr

Self-Check – 4	Work out

Name………………………………………… ID………………………… Date…….

Directions: Show Your steps clearly and neatly

1. How much water must be added to a field of area 5ha to increase the volumetric water content of the top 50cm from 16% to 28%? Assume all water added to the field stays in the top 50cm.
2. Compute the depth, RAW, and frequency of irrigation required for a certain crop with data given below.

   Crop: wheat, Average daily CU: 1.5cm D rz: 1.40m, Application efficiency: 70%

   FC: 17%, PWP: 5%, Bulk density: 1.72 gm/cm^3
3. Calculate irrigation interval (f) & Irrigation period (IP) under the following condition. CWR (ET_C) =12mm/day, root depth=1.5m, FC=24%, PWP=8%, Q_M =0.03m^3/s, A=1.5ha, GIWR = 70% and Depletion=50%

You can ask you teacher for the copy of the correct answers.

***Note:* Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

Operation Sheet 1- Analyzing Irrigation water demand

ROCEDURE

1. determine the moisture status of the soil using gravimetric method and depth of the soil, permanent wilting point, field capacity and dry bulk density based on standard method
2. collect the type of crops growing in the area
3. determine the discharge of the water source
4. determine reference evapotranspiration based on the available data
5. determine the growing season and crop factors
6. determine effective rainfall
7. determine actual evapotranspiration or (CWR
8. determine the total area of the farm that will be irrigated
9. determine irrigation efficiencies
10. determine depth of irrigation
11. Determine maximum allowable depletion (MAD)
12. Determine net irrigation requirement
13. Determine growth irrigation requirement
14. Determine frequency of irrigation or irrigation interval
15. Determine time of irrigation

LAP TEST	Performance Test

Name………………………………. ID……………………………..

Date…………………………………….

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **5.**hour. The project is expected from each student to do it.

Task-1 Go to the demonist ration farm of your college and nearby metreological station &Collect and Collet the necessary data, undertake determination of irrigatin water and recommend the type of soil and crop , write a report and present it.

LG #66	LO #3- Participate to plot topography and soil survey data on property map

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Establishing format to map interpreted results
- Identifying potential uses of the soil for purposes of land classing land capability.
- Defining property boundaries and property features
- Identifying irrigation area
- Plotting contour or spot level information
- Plotting soil sampling sites on map
- Describing soil profile and irrigation characteristics for each irrigation area
- Mapping the readily available water (RAW) values for irrigation sites
- Describing specific areas are plotted on the map

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Establish format to map interpreted results
- Identify potential uses of the soil for purposes of land classing land capability.
- Define property boundaries and property features
- Identify irrigation area
- Plot contour or spot level information
- Plot soil sampling sites on map
- Describe soil profile and irrigation characteristics for each irrigation area
- Map the readily available water (RAW) values for irrigation sites
- Describe specific areas are plotted on the map

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

3.1. Soil Mapping

Soil mapping can be defined as the process of delineating natural bodies of soils, classifying and grouping the delineated soils into map units, and capturing soil property information for interpreting and depicting soil spatial distribution on a map. The repetitive patterns imprinted in soils by the soil-forming factors can be observed at scales ranging from continental to microscopic. These patterns are the basis for soil identification and mapping at different scales. A system of terminology, definitions, and operations can be ascribed to the various scales. Hierarchical systems of classes and subclasses are established to produce groupings at the different scales. Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. Some boundaries are sharp, where soils change over a few meters, while others are more gradual. Soil scientists can observe only a limited number of pedons. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil and to determine their boundaries.

1. Maps of agronomic application. As has been previously stated, maps of agronomic applications can be very different, both in their detail and scale, but they must be based on a soils map established on an identical or larger scale.

Mapping Unit

A soil mapping unit can be defined as a collection of soil delineations (on the map) that comprise similar soils or soil combinations (depending on the scale of the survey and the intricacy of the soil pattern) Soil mapping units are designed to efficiently deliver soil information to meet the need of user and for effective management and land use decisions. Mapping units can appear as individual areas (i.e., polygons), points, or lines on a map. Each map unit differs in some respect from all others in a survey area and is uniquely identified on a soil map. Each individual area on the map is a *delineation*. A map unit is a collection of areas defined and named the same in terms of their soil components, miscellaneous areas, or both (components and miscellaneous areas are described below). Each map unit differs in some respect from all others in a survey area and is uniquely identified on a soil map. A map unit description is a written characterization of the component within a map unit and the relationship of one map unit to another.A delineation of a map unit generally contains the dominant components in the map unit name, but it may not always contain a representative of each kind of inclusion. A dominant component is represented in delineation by a part of a polypedon, a complete polypedon, or several polypedons.

Important facts to know

- A soil mapping unit can be defined as a collection of soil delineations (on the map) that comprise similar soils or soil combinations.
- Soil mapping units are designed to efficiently deliver soil information to meet the need of user and for effective management and land use decisions.
- Each map unit differs in some respect from all others in a survey area and is uniquely identified on a soil map.
- A few delineations of some map units may not contain any of the dominant components named in the map unit description, but contain very similar soils.
- The kinds of map units used in a survey depend primarily on the purposes of the survey and the pattern of the soils and miscellaneous areas in the landscape.
- It must be remembered that soil interpretations are made for areas of land and the most useful map units are those that group similarities.

A map unit is a collection of areas defined and named the same in terms of their soil components or miscellaneous areas or both. Each map unit differs in some respect from all others in a survey area and is uniquely identified on a soil map. Map units consist of one or more components. An individual component of a map unit represents the collection of polypedons or parts of polypedons that are members of the taxon or a kind of miscellaneous area. Classes of miscellaneous areas are treated the same as soil taxa in soil surveys. A taxonomic unit description describes the ranges in soil properties exhibited in the polypedon for the maps in a survey area that are referenced by that taxonomic unit.

Soil boundaries can seldom be shown with complete accuracy on soil maps, hence parts and pieces of adjacent polypedons are inadvertently included or excluded from delineations.A few delineations of some map units may not contain any of the dominant componentsnamed in the map unit description, but contain very similar soils. In most survey areas there are a few soils that occur as mappable bodies, but they have very limited total extent. They are normally included with other map units, if, for all practical purposes, interpretations are the same.

Aggregated data capture the ranges of various physical and chemical properties of soil map units as a whole and individual soil map unit components. They include the descriptions of each soil map unit and map unit component; the detailed physical, chemical, and morphological attributes of each soil; and descriptions of the relationship of one soil map unit to another on the landscape. Aggregated soil property data generally are the data used to generate interpretive ratings for each map unit and its components.

Self-Check – 1	Written test

Name…………………………………………… ID……………………… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (5points each)

1. What do you mean by undertaking readiness assessment?
2. What are the models that pose key readiness questions?

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

1.2 Conducting preliminary research

The soil survey party leader should arrive in the area before soil mapping begins and generally before the other party members do. This allows the party leader time to become familiar with the area, review preliminary data, investigate the major soils and their pattern of occurrence, review the stated purposes of the survey, check the adequacy of the base map material, and prepare a preliminary mapping legend. During the general premapping appraisal of the survey area, the party leader also assembles the information needed to schedule survey operations.

A well-established principle of research is to assemble the existing information about a subject first. Time and effort are saved and costly errors are avoided if what is already known is used. The time required to find and appraise existing information is usually small relative to the time required to compensate for failure to use the information. Even for areas about which little is thought to be known, a diligent search usually uncovers useful information. In addition, information about adjacent areas can often be applied to the survey area.

If an older soil survey has been made, it is generally the most important reference available. Soil surveys made in the United States before 1920 emphasized the character of the parent material. The maps commonly provide some of the best information available for dividing the survey area into sections within which parent material is reasonably uniform. Many soil surveys made between 1920 and 1930 provide most of the information needed to broadly characterize the area and its soils. Those made between 1930 and 1940 provide a very important part of the information needed for identifying map units. The earlier surveys are also useful for identifying map units, but they must be used in conjunction with a systematic preliminary field study. It is helpful to examine mapping and examples of established soil series in nearby areas that have been recently surveyed.

Unpublished soil surveys of scattered farms are another source of information about the area. The value of this information depends on the quality of the legend and consistency of mapping over long periods. Regardless of the quality of the legend, the scattered farm mapping should not be made a part of the modern soil survey without careful field checking.

A soil survey is a study of the geography of soil. Maps detail geographic information. Aerial photographs, topographic maps, and other maps are useful references whether or not they are used as the mapping base. Each kind of map shows features that the others do not.

Topographic maps are the best references for appraising relief for most areas. Maps and texts on geology for many areas have been published by the U.S. Geological Survey and by comparable State agencies. The publications are on various subjects, such as bedrock geology, surficial deposits, and water or mineral resources. The maps were made at various scales and degrees of detail. Almost all contain important information about the parent material of soils and related factors. Although not as extensive as for geology, maps showing vegetation have been published for many areas. The U.S. Forest Service and State agencies are likely sources. In addition, climatic maps that are commonly at small scale and general in nature are available. The cartographic staff of the Soil Conservation Service, local libraries, and university libraries are good sources of information about what has been published and where it can be obtained.

Local sources—libraries of local schools, universities, municipals, historical societies, State agencies—are sources of published material on soils, agriculture, geology, geomorphology, hydrology, climate, engineering, biology, history, and related subjects. If a university is located within reasonable distance of a survey area, graduate theses may provide significant material. Local weather stations can provide data on temperature, precipitation, and other weather events. Reports of the Bureau of the Census and of USDA's Economic Research Service and National Agricultural Statistics Service are authoritative references on land use and crop production. A computerized bibliographic search service can also provide references for publications about the survey area.

Faculty members of universities often have information that is not available in published form or know of published information that the party leader has not found. The local representatives of the Cooperative Extension System, area and district conservationists of SCS, and vocational agriculture teachers may also be sources of knowledge that is not generally available. Representatives of planning boards, sanitation departments, highway departments, and the like are knowledgeable about matters that are important for interpreting soils and designing map units. Strong working relationships with the office of the State geologist and with geologists working in the survey area are very important. They can provide much information that is helpful in understanding soil-rock relationships.

Some information not directly related to soils is also helpful in planning, organizing, and conducting a soil survey. Questions that should be answered include:

1. What is the present land-use pattern? Is it relatively uniform or a mixture of conflicting uses and intensities? Are there political or economic problems associated with present land uses?
2. Is there a land-use policy or plan for the area? Is it active and effective? What changes in land use does it outline?
3. What is the general ownership pattern? Is it expected to change?
4. Are mineral rights important in the area? Who owns them?
5. Are water rights, either ground or surface, controlled? Does water supply limit land use and continued growth and development? What is the quality of the water?
6. What cultural, social, or economic factors influence or control land use?
7. What qualities of the area (climate, soils, mineral, and so forth) are unique, valuable, or limiting for some uses?

Not all of these questions are universally important, nor is the list complete. The answer to these questions, however, can be important in satisfying the needs for the soil survey.

Promising sources of reference material have been mentioned. The amount and significance of existing information varies widely, but in most parts of the United States it is substantial. Preliminary research can provide much, if not most, of the information about the soils of the area and their geography that is needed to start field studies and prepare a preliminary mapping legend. Preliminary research provides the basic data for interpreting the soils.

Self-Check – 2	Written test

Name………………………………………… ID……………………… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (2 points each)

4. Briefly elaborate the steps to be conducted in initiating readiness assessment (10 points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 3 points   Unsatisfactory - below 3 points

Information Sheet 3- Defining property boundaries and property features

1.3. Preparing the Mapping Legend

Preparing the mapping legend is the principal duty of the party leader after preliminary field studies have been completed. The purposes of the survey having been stated in the memorandum of understanding, the party leader consults with other specialists and determines what soil areas are significant. Soils and map units that can be consistently identified and mapped are then described, and names and symbols are proposed for them.

The mapping legend is composed of two parts: (1) the descriptive legend, which contains descriptions and classification of the soils, the identification legend, the legend of conventional and special symbols, and the general soil map and (2) mapping aids such as a genetic key, table of soil characteristics, and notes about individual soils or map units. The mapping legend contains the primary references and the principal guides for each survey party member. It is designed to serve the purposes of the soil survey and is unique to each area.

Preliminary studies are made in a survey area to identify sets of soil properties that are repeated in characteristic landscapes and are mappable. Not all of the soil map units needed for the complete survey can be anticipated at the start. An initial mapping legend is prepared after preliminary investigations and test mapping. The initial mapping legend should include only the descriptive legend and mapping aids for those soils, map units, and other features that have been definitely identified as needed. The number of map units in the initial legend depends on the scope of the initial studies, complexity of the area, and intensity of the survey. Map units must be defined and described carefully. These descriptions are the guidelines for mapping soils and the standards against which possible additional map units are evaluated as the survey progresses. The mapping legend should be made available to each member of the party before mapping begins. It is revised as needed during the soil survey.

As the survey progresses, other material is added to the mapping legend. This makes a soil handbook for the survey area. The soil handbook contains all of the information and other related facts about the genesis, morphology, classification, and interpretation of the soils of the survey area. By the time mapping is completed, the soil handbook should contain all of the material needed for the published soil survey.

1 Field Operations

Soil mapping is a technical art. It requires sound training in soil science and familiarity with the principles of the earth sciences. A skilled soil scientist is a perceptive observer and understands the significance of landscape. Subtle differences in slope gradient or configuration, in landform, and in vegetation can be important indicators of soil boundaries. The soil scientist must learn to associate sets of landscape features with sets of internal soil properties to be able to visualize the pattern of the soils. A skilled mapper is able to abstract the essentials of the soil pattern and sketch this pattern on a map.

Above all, a good soil scientist strives for accuracy and is truthful about the reliability of the maps. The demanding standards for soil mapping must be maintained throughout such a survey regardless of vegetative cover.

Even though the map scale is adequate and the legend is well designed, the legibility and usefulness of the maps depends on the skill and judgement used in applying the legend. Some soil boundaries are more important than others and require greater accuracy. Time and effort must be spent to delineate small areas of soil that contrast with neighboring soils. In mapping consociations, for example, boundaries between highly contrasting soils, such as a wet soil and a dry soil or a clayey soil and a sandy soil, must be located as correctly as possible.

The greatest time and effort is spent delineating dissimilar soils that are more limiting for use than nearby soils. Small areas of some soils are deliberately mapped with their more extensive neighbors if the two kinds perform similarly for the purpose of the survey. Useless detail is avoided. Special symbols are used to indicate significant areas too small to be delineated. The skill and judgment of the mapper are part of the art of separating the landscape into meaningful units of soil and then recording the units on a map.

Using Aerial Photographs.—Aerial photographs provide important clues about kinds of soil from the shape and color of the surface and the vegetation. The relationships between patterns of soil and patterns of images on photographs can be learned for an area. These relationships can be used to predict the location of soil boundaries and kinds of soil within them.

Light and dark tone on panchromatic photographs and color differences on color photographs, for example, are records of light reflected when the photographs were taken. These records must be interpreted by relating the visual pattern on the photographs to soil characteristics found by inspection on the ground. Using the aerial photographs of an area, a soil scientist learns many relationships between the photographic images and soil and landscape features, but many uncertainties inevitably remain. Awareness of the factors that affect an image is required to interpret the aerial photographs as fully as possible.

The techniques used to predict specific kinds of surface features, landforms, attributes of soils, and soil boundaries from photographs are continually being refined. Published material provides information about the techniques and the kinds of clues used by photo interpreters. Some publications provide helpful illustrations of specific features. Nevertheless, reliable predictions of many features in a particular area require experience in relating the images on the photographs to what is actually on the ground.

Such features, as roads, railroads, buildings, lakes, rivers, field boundaries, and many kinds of vegetation can be recognized on aerial photographs.

Relief can be perceived by stereoscopic study. Shadows and differences in tone between slopes that faced the sun and those that did not at the time of photography also help show relief. Relief features help locate many soil boundaries on the map. Relief also identifies many kinds of landforms which are commonly related to kinds of soil.

Many landforms—terraces, flood plains, sand dunes, kames, eskers—can be identified and delineated reliably from their shapes, relative heights, and slopes. Their relationship to streams and other landforms provide additional clues. The soil scientist must understand geomorphology to take full advantage of photographic imagery.

Some landforms are less easily identified, but most images contain clues that narrow the choices of the kinds of landforms represented. Experience in interpreting tone patterns, configuration of relief, and patterns of drainageways commonly permits correlation of these patterns with kinds of geologic deposits and geomorphic features in an area. As the survey progresses, experience generally increases the reliability of predictions.

Differences in tone or color may reflect soil differences. Differences caused by man-imposed land use usually can be recognized by the angular shapes and abrupt boundaries of the areas. Other tonal differences may reflect differences in vegetation that relate to soil or differences in the surface of bare soil. Certain patterns of tone or color may reflect local soil patterns within areas that can be mapped in one day. Different soil associations have distinctive patterns that can be recognized on photographs. These patterns serve as bases for drawing tentative soil boundaries and for predicting kinds of soils. These predictions of soils and boundaries must be verified in the field.

Accurate soil maps cannot be produced solely by interpretation of aerial photographs. Time and place influence the clues on the photographs. Shades of gray commonly reflect the state of the soil moisture when the photograph was taken; but the soil moisture changes with time. Clues to soil boundaries that are evident on photographs taken at one time are not necessarily evident at another time. The activities of man have changed patterns of vegetation and confounded their relationships to soil patterns. The clues must be correlated with soil attributes for each set of photographs, and predictions of soil properties from such clues must be verified in the field. The accuracy of maps improves as fieldwork and experience increase.

Stereoscopic examination.—Before an area is surveyed, making a careful stereoscopic study is helpful (fig. 4-1 (no longer available)). The area is scanned with a stereoscope for a general impression of farming, relief, geology, landforms, kinds of soils to be expected, soil moisture states, and so forth. Important features that can be accurately identified are sketched lightly on the photograph. Some features can be determined with more certainty than others. Images that help identify obscure features can be marked. The following steps are commonly used in preliminary studies.

1. Drainage ways, streams, and ponds are tentatively sketched.
2. Roads, buildings, and other location references are identified.
3. If soils have been mapped along the match line with an adjacent photograph, the soil boundaries are transferred to the outside edge of the match line. Some soil boundaries can be tentatively extended onto the unmapped sheet.

4. Additional features can be lightly penciled if they can be identified with confidence: boundaries of flood plains and stream terraces, boundaries of wet areas and water, prominent landforms such as escarpments and areas of rock outcrop, gravel and borrow pits, ridge lines, sinkholes and wet spots.

Routes of traverse can be placed during these preliminary studies. Obstacles can be identified and plans made to avoid them. Enough field checking is planned to ensure maximum accuracy with a minimum of walking per unit of area mapped.

As experience is gained in an area, many soil boundaries and kinds of soil can be tentatively predicted on the photographs. These predictions must be verified in the field, but preliminary interpretation can increase the quality of mapping. During such preliminary studies, a map should not be cluttered with conjectures. Only features that can be predicted with confidence are marked.

After fieldwork, mapped sheets are examined again while the landscapes are fresh in the mind and can be related to the stereoscopic images. If considerable time elapses, details may be forgotten. Questions that the examination may raise become more difficult to resolve, and a special trip to the field may be needed. Because dense vegetation or other conditions may obscure the image on a photograph, some drainageways, slope breaks, and soil boundaries that are observed in the field may be impossible to place accurately on a photograph. These features can be sketched tentatively in the field, and their locations later checked by stereoscopic study for necessary revision. Thorough stereoscopic study of areas that have been mapped commonly reveals places where soil boundaries or stream symbols need to be refined to conform to relief. The traces of roads in heavily forested areas may be obscure on single photographs but evident under the stereoscope. If some boundaries inadvertently were not closed during field mapping, they can often be closed with confidence on the basis of stereoscopic study.

In the field, roads, houses, streams, field boundaries, individual trees or bushes, and the like are used to identify locations on the ground with points on the base map. The photograph can be oriented so that the relative position of its images corresponds to the relative position of ground features from the vantage point of the surveyor. The photographic images of surface features that mark soil boundaries can be followed in the sketches of the boundaries. Boundaries that are not evident on the photograph can be sketched in relation to identifiable ground features.

In some areas a stereoscope used in the field with stereoscopic pairs of photographs is helpful. A pocket stereoscope can be used on the hood of a vehicle or on a dropleaf shelf . It can be carried while walking. The stereoscope and pairs of photographs can be used to relate the landscape features to the stereoscopic images. Kinds of soils and the location of boundaries can be predicted from the stereoscopic image. Boring or digging is needed to identify soils positively and to verify predictions, but stereoscopic study commonly reduces the number of borings that are needed to locate the boundaries of an area.

Plotting soil boundaries.—a soil scientist plans the day's work as a series of trips across the area to be mapped. Proceeding along these routes, the soil scientist predicts soil areas, the kinds of soil in the areas, and the boundaries that separate different kinds of soil. These predictions are checked as the areas are crossed. Finally, boundaries and kinds of soils are plotted on the map. Thus, fieldwork consists of a sequence of predictions and verifications.

To the extent feasible, mapping is scheduled to proceed systematically across contiguous areas. When mapping is resumed each day, the mapping of the previous day provides points of reference. The boundaries that were projected tentatively the day before are predictions to be verified. The soil patterns and the clues for interpreting the landscape are already understood. Mapping systematically across contiguous areas contributes greatly to both efficiency and quality of the work.

Ground traverses are planned to cross as many soil areas as possible. Soil areas generally conform to the orientation of relief, which is commonly related to drainage courses. Consequently, most soil areas and most soil boundaries can be crossed by traveling at an angle to the secondary or tertiary drainage courses. The traverses are spaced so that the boundaries that are identified and projected on one traverse can be identified and continued on the next. Traverse spacing depends on the complexity of the soil pattern, visibility, and amount of detail required by the survey objectives. In fairly detailed surveys, for example, traverses are planned to pass within 200 to 400 meters of every point in the area, thereby permitting detection of small areas of contrasting soils.

Where aerial photographs are used as the mapping base, a predetermined line of traverse need not be followed consistently if there are sufficient reference points for accurate location. A traverse can deviate from a planned route to cross landscape features that may be marks of soil boundaries. Wandering from place to place at random, however, should be avoided. Aerial photographs assist in avoiding obstacles on the route. If boundaries are observed to run in a different direction than had been anticipated, the plan can be adjusted.

From any point of observation, the soil scientist looks along the projected route and predicts the kinds of soils on the landscape ahead. A break in slope gradient, a change from convex to concave slope configuration, a change in the color of the surface of a plowed field, the margin of a swamp or forest, the edge of a stony area, a change in kind or vigor of crops—these observable features can be related to soil boundaries. If possible, these features are identified on the aerial photograph. Some may already have been marked during the stereoscopic examination. If soil boundaries follow identifiable features, they are lightly traced on the photograph in pencil. Boundaries that are not evident on the photograph are sketched on the map in relation to identifiable features. Most features must be located and sketched by estimating location in relation to the point of observation and other known points. Tentative soil boundaries are sketched for perhaps 100 to 200 meters ahead and on either side of the point of observation. Natural and cultural features that are immediately ahead, such as a stream or drainageway, are also sketched on the aerial photograph.

Some soil boundaries are sharply defined (fig. 4-3). Others are plotted as lines midway in zones of gradual transition from one soil to another (fig. 4-4). A judgment is made about whether a broad transition zone is a discrete mappable soil unit or should be split and its parts included with the soils on either side. Every part of the mapped area must be enclosed in a boundary and assigned a symbol.

After predictions are made about the soil areas and boundaries are sketched on the map, the soil scientist walks across the predicted boundaries. The course is adjusted as necessary to investigate the transitional zone and any unusual features. Slope gradient is estimated or measured with an Abney level or a clinometer. As a predicted soil boundary is approached, especially in a broad transitional zone, the soil is examined to locate the significant changes in soil properties.

As a projected delineation is crossed, the distribution of microdepressions, microknolls, tiny areas of different vegetation, convexities and concavities, and other features too small to delineate are observed. The soil is examined at a place where the microfeatures suggest that the predicted dominant soil should be best expressed; and this portion of the delineation is identified positively. The prediction may be confirmed, or a different kind of soil may be found. Where microfeatures suggest important inclusions, additional observations are made to ensure that the evaluation of the whole delineation is good. Sites for examination are not chosen at random if reasons exist for dividing the projected delineation into parts that are the predicted soils and parts that are not.

FIGURE 4-3

Sharply defined boundary between sand soils on a high terrace (at right) and loamy soils on a lower terrace.

FIGURE 4-4

Broad transition zones between contrasting soils. Dark areas are Brookston soils; light areas are Crosby soils.

The number of places at which observations are made depends on the certainty of the predictions and the objectives of the survey. If predictions about the kind of landscape under examination have been valid many times before, soils need be examined in only a few places. If the landscape features have not been consistently related to kinds of soils, many places must be examined. The depth of the examinations depends on the depth of differentiating criteria for the map unit and on the confidence in the predictions about the kind and uniformity of soil material at a given depth. The examination itself is rapid and is mostly a search for a few properties that identify the soil. A small sample of a pedon is observed; seldom is an entire pedon studied.

After a delineation has been identified and crossed, the soil scientist turns and looks back on the landscape from a new vantage point. A final judgement is made on the boundaries and symbols. If mapping is done on an aerial photograph, the photographic images are checked against the landscape features before the final boundaries are sketched.

Soil boundaries are projected on either side of the traverse as far as they can be seen and identified with reasonable certainty. The ends of their projections are checked from the next traverse. Many boundaries can be seen throughout their lengths. Other boundaries can be predicted on the aerial photographs with a high degree of certainty. In forests, for example, visibility may be a few tens of meters or less; but, where a slope break that marks a soil boundary can be seen under the stereoscope, the boundary can be plotted much more accurately by a study of the photographs than by an observation on the ground. A soil boundary that is found at one point to correspond to a change in color on the photograph is commonly continued along the change on the photograph even though the boundary itself is not visible on the ground during mapping. In detailed soil mapping many boundaries between traverses are drawn on the basis of variations in the photographic image.

In mapping, a pattern of soils and landscapes is conceived, rather than a group of individual map units. Certain soils are typically found together. The number of soils in any locality is usually small.

In most places landscape features mark the kinds of soils. But landscape features do not identify soils everywhere, and by no means can all internal soil properties that are used to define map units be correlated with external features. Where soil boundaries cannot be predicted with confidence, they may be identified by direct examination of the soil.

In some areas, important attributes of the subsoil or substratum are not related to surface features. Depth to bedrock, layers of contrasting texture, salt in the substratum, and similar attributes may have no visible relationship to the vegetation or other natural features but may be important when the soil is used. When desert is irrigated, when wet soils are drained, or when highways are built, soil differences that are not reflected in landscape variations may become important.

Conditions of this kind occur in most survey areas. If common mapping techniques are used, the predictions frequently turn out to be inaccurate for some areas. Unless the mapper can reappraise the landscape and reliably predict the extent of the soil, the boundaries must be determined by actual examination.

In large areas where landscape has low predictive value, geologic history and geomorphology may provide guides to stratigraphy, depth, and distribution of the kinds of rocks that are related to specific soils. The general hydrology of an area may indicate where salt-charged water has moved and where the salt has concentrated. Streams and their traces help in locating areas that have layers that differ in texture. As much preliminary information as possible is assembled to help determine the pattern and scale of soil variability. This information helps in planning the route and spacing of traverses and the spacing of samples within the traverses.

In survey areas that are to be irrigated, samples of critical layers may be taken for special field-testing or examination to determine boundaries. These samples may be taken at points on a predetermined grid or at predetermined points along lines of a traverse.

Where internal properties of soils are used for locating boundaries, a predetermined line of traverse is generally followed. Side trips are made wherever landscape features or experience with the soil pattern indicates that there is probably a significant soil change between traverses. Generally, the soil is examined at some standard interval along the traverse to locate important differences. If properties deep in the soil are important, the plan may require observations at fixed depth-intervals to a certain depth, such as 1 meter, and with layer depth intervals to greater depth.

In most areas, some feature of the landscape or some aspect of the pattern of soils already mapped on an adjacent traverse provides a basis for predicting the location of soil boundaries. As evidence of change is observed, preliminary observations are made.

Where the evidence indicates an important soil boundary, the soil is examined in more detail or to a greater depth to verify the prediction.

Where power equipment can be moved freely across the countryside, it can be used to examine the soil to considerable depth at close spacing. Map units that are based on soil properties deep below the surface can be delineated with increased accuracy and the rate of progress can be greater if the geographic distribution of these properties is consistent with the scale of mapping.

Neither standard intervals between traverses nor intervals for investigating the soil within traverses can be specified with certainty. The plan is adjusted to the direction and scale of the soil boundaries and the variability of the important properties. This kind of evidence is commonly obtained as the survey progresses, and the mapping plan can be altered to fit the accumulated evidence.

A great deal of skill and judgement is required in areas of low predictability. Rarely are the soils at two sample sites exactly alike. Study of a single site is not enough to identify a significant area. Map units are defined to include the variability within areas large enough to be meaningful for the objectives of the survey. Using preconceived ideas of significant limits of definitive properties to define map units without regard to their geographic distribution generally results in unmappable units. Meaningless boundaries may result. Delineations should show the pattern and scale of orderly variation of soils. The kinds of variability over short distances should be noted in the descriptions of the map units.

In all soil surveys distinctive landscapes are outlined on the map first. In surveys where most map units are fairly large and contain more than one kind of soil, landscape patterns are identified mainly by interpretation of aerial photographs, by aerial observation, and by study of topographic maps, geologic maps, land-use maps, and other available information. The size of the outlined areas depends on the objectives of the survey and the landscape pattern. Preliminary areas are of course no smaller than the smallest delineation that will appear on the soil map. They are often much larger. In 3rd-, 4th-, and 5th-order surveys, however, most map units are made up of more than one kind of soil or miscellaneous area and usually coincide with the landscapes outlined in preliminary work.

Traverses of the preliminary delineations may be desirable, depending on the level of generalization required for the survey and the complexity of the soil patterns. The plan of traverses usually is based on interpretations of photographs, but this plan should be tested in the field.

In areas of low accessibility, roads or trails may be traveled; but the mapper must understand that roads and trails commonly follow the easiest routes and avoid the steepest slopes, the wettest areas, and the other places that are difficult to cross. Such places are integral parts of soil associations and should be observed by the mapper on the ground.

Transects are commonly used to determine the composition of map units. In transecting, a planned line of travel is followed as closely as possible and the soils are observed at predetermined regular intervals.

In transecting, routes of travel are systematically planned to give a valid sample of the area. Taxa phases and other features are identified and recorded. Distances or number of points along the route identified by each taxon provides estimates of the composition of the map units. In surveys without easily predictable patterns, soils are sampled most efficiently if the transect lines are selected at random. Lines oriented to cross the drainage pattern often provide the most information about the pattern of soils.

Sample blocks, instead of transects, are used in some surveys to determine the composition of map units. Blocks do not replace transects, however, they permit one to observe spatial patterns not always evident from transects. Sampling by transects is usually more efficient than block sampling for estimating map unit composition.

Methods for sampling by blocks vary among soil surveys. One method imposes a grid of appropriate divisions on the entire area. Grid segments are numbered, and sample blocks are selected by drawing numbers at random. Each sample block is remapped in greater detail, and the area of each kind of soil is measured. These data provide estimates of the kinds and proportions of soils in each map unit. The number of blocks and their sizes are determined by statistical principles with consideration of mapping scale, the limits of confidence required for the survey, the general pattern of soils, and the relative size of soil areas.

Mapping of organic soils follows the same general principles as mapping of mineral soils. Organic soils, however, have some special relationships to landscape and vegetation. These relationships affect mapping of organic soils at all levels.

In preparing the mapping legend, systematic investigation of organic soils is required as for other kinds of soils. A thorough knowledge of the genesis of organic soils is required, as well as high-quality imagery and appropriate tools.

The kind of organic soil in many areas is closely related to the kind and pattern of native vegetation. Since many areas of organic soils are comparatively undisturbed, reliable relationships between soils and plant communities can be established. Thus, high-quality imagery from aerial photography and other forms of remote sensing can be very useful in preparing legends and in mapping these soils.

Where organic soils have formed directly on a mineral substratum, the environment may be rather uniform over extensive areas. Although the kind of organic material can vary with depth because of changes in climate over the period in which the soils have formed and because of differences in rate of decomposition that result from the accumulation of the organic material, such variations commonly are uniform over large areas. The properties of a large area of organic soils, therefore, can be accurately estimated from the properties of a small sample.

Organic soils are not uniform in some areas that have microrelief of hummocks and swales. The hummocks commonly contain fibric material, and the swales contain hemic and sapric material. In such landscapes, many more sites must be examined to determine the nature of the soils.

These relationships and processes generally apply where organic soils are formed by lake filling. Each basin in which organic soils have formed has a unique local environment, and the organic soils in adjacent basins may differ considerably. This is particularly true in irregular glacial moraines. For example, limnic materials may be covered by only a thin mantle of organic material in some basins and by several meters of organic material in others.

Areal relationship must be kept in mind when estimating the extent of the different soil components within basins, particularly small basins. For example, one kind of organic soil occupying a rather narrow fringe of a bog may cover a greater area than the organic soil in the center.

In northern glaciated areas in particular, organic soils may form around the edges of swamps that have open water in the center while adjacent swamps lack surface water.

In some areas, a layer of water can underlie the organic soils at a relatively shallow depth. Such areas may not support much weight and should be investigated with caution.

Organic soils of some coastal wetlands lack distinctive landscape features and, additionally, are poorly accessible. In these areas, the soil scientist relies on other features to predict kinds of soils. Patterns and kinds of soils in many coastal areas can be related to the position of such natural features as shores, deltas, streams, and adjoining higher lands. The soil scientist must have a thorough knowledge of the geomorphic history of the area in order to make reasonable predictions related to such features and to determine the places where transects and other field checks will best verify the predictions.

2 Completing Field Sheets

Most soil survey field sheets are individual photographs or compiled photobase maps. As each field sheet is completed it is joined with adjacent sheets and checked for errors.

Joining field sheets.—Each pair of adjacent field sheets shares a common match line. During mapping, soil boundaries are commonly extended beyond the match line to be transferred to the adjacent sheet; but when the field sheet is completed, soil boundaries and other features may be discontinued at the match line. The mapping on each field sheet should be carefully matched with that on adjacent sheets to check boundaries and delineations. Roads and streams also should be continuous from one sheet to another. Special care is needed at the corners where four field sheets join.

If soil boundaries are sketched on overlays, field sheets are matched before soil lines are transferred to the soils overlay. Matching should be completed while the photographic background is available.

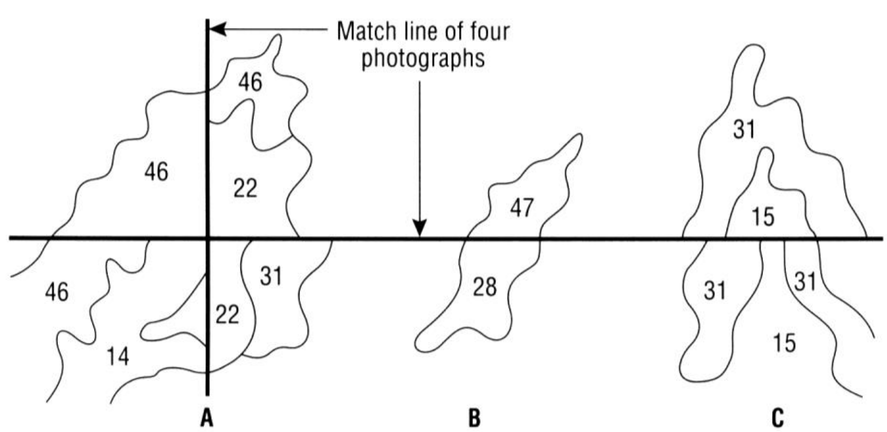
The mapping on one field sheet can be matched with that on an adjacent sheet in several ways. For aerial photographs, the mapped field sheet and an adjoining unmapped field sheet can be placed under the stereoscope and the images meshed. The soil boundaries and other features on both sides of the match line can then be transferred from the completed field sheet to the unmapped sheet.

Another method, that is particularly useful if adjoining sheets vary in scale, is to transfer boundaries by reference to the photographic images. The relationship of the soil boundaries to images of isolated trees, clumps of bushes, field corners, and the like are observed along the match-line. Images of the same features are located along the match line of the adjoining photograph, and the boundaries are transferred or checked in relation to the images.

When the second field sheet is mapped, boundaries of delineations that cross the match-line may be altered. Consequently, the boundaries at the match-line must be rechecked after both field sheets have been completed. If different individuals map adjacent field sheets independently and the completed sheets are joined, a match indicates the uniformity of fieldwork.

If there is no systematic method of joining sheets, errors are easily made that may require additional fieldwork before the final map can be compiled. Figure 4-5 illustrates

FIGURE 4-5



Failure to join adjacent field sheets: *A,* boundaries do not match where four field sheets join; *B,* boundaries match but symbols do not; *C,* symbols match but boundaries do not.

some errors on unmatched field sheets.

Inking field sheets.—After mapping has been completed on each field sheet, it may be inked to provide a permanent record and to provide a map from which copies can be made (fig. 4-6). All soil boundaries and symbols and important drainage features should be inked. Cultural features needed on the soil maps are determined before mapping starts and are specified in the legend.

Inks or leads that are reproducible photographically and are readable by automatic scanning equipment are preferred. The ink or lead used should be compatible with the base material, and the lines should be opaque. Several kinds of inks and leads are suitable. Commonly, pens that store carbon-base ink in a reservoir are used.

Several pens that make uniform lines of different thickness are needed for inking different features and for lettering. Line widths recommended for different features are indicated in the list of conventional symbols on fig. 4-7.

Different groups of features generally are inked in separate operations. Drainage is inked first and inspected to see that individual streams are properly joined, matched, and classified. Then, culture is inked. The classification of roads and other features is checked at the same time.

FIGURE 4-6

Example of a field sheet

Soil boundaries and symbols are inked next. Finally, the place names are lettered. In some surveys, however, certain features may not be inked. For example, if the photographic image of all roads is pronounced, they do not need to be inked.

If photobase map sheets are used as field sheets, the inking can be done on transparent overlays. As many as three overlays can be used: one for culture and drainage, one for soil boundaries, and one for symbols. Together these form a composite overlay and can be used in printing the final map. The individual overlays can be used in printing special purpose maps. Adhesive-backed, clear stripping film with printed symbols can be applied to the overlay to save handwork.

In inking soil boundaries, a good procedure is to close each boundary within one section of the field sheet. When the boundary of a small area is closed, its symbol is placed as near the center of the area as practical. More than one symbol is placed in areas that extend for long distances and in those that have intricate shapes.

Mapping along the match lines may be left in pencil until the field sheets have been joined.

Soil symbols on all sheets should be positioned to be read horizontally, or as nearly so as possible, when the map is oriented in one direction. Usually, north is toward the top of the map. If an area is too small to contain a symbol, the symbol may be placed outside it and a leader used to indicate the area to which the symbol applies. The leader should be so placed that it cannot be confused with a soil boundary.

Place names should be inked last so that they may be placed where they will not obscure soil symbols and other details. Place names should be arranged so that they clearly identify their features. Names of features expressed as lines on the map are oriented parallel to the lines. Names of other features are usually oriented horizontally, with north at the top. Important features that serve as landmarks should be named on each sheet. Names of streams should be so positioned that no confusion arises about which branch is meant. Incorrect and correct placement of names are illustrated in figure 4-8.

Self-Check – 3	Written test

Name………………………………………… ID……………………… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (5 points each)

1. Discuss the reasons behind program redesigning
2. Write the steps conducted to undertake program redesigning.

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Information Sheet 4- Identifying Irrigation Area

2.1. Irrigation Project

Can also be defined as a set of inputs and outputs required to achieve a particular goal. Projects can range from simple to complex and can be managed by one person or a hundred. Projects are often described and delegated by a manager or executive. They go over their expectations and goals and it's up to the team to manage logistics and execute the project in a timely manner. Sometimes deadlines can be given or a time limitation. For good project productivity, some teams break the project up into individual tasks so they can manage accountability and utilize team strengths.

1.1 Conducting reconnaissance survey

Once it is decided to prepare irrigation scheme for any region the first issue to be decided is about its location. Before undertaking **reconnaissance**, an office study of the proposal is made on the basis of the available topographical maps and other data to explore prima-facie feasibility of a project. In these studies a very rough scope of the project and its tentative location can also be decided.

Reconnaissance surveys on a small scale i.e. 1:100 000 to 1:250 000 are useful for broad resource inventory, the identification of promising areas for development, and to provide a basis for more detailed study. Mapping units are usually compound and provide only estimates of the **proportions** of the conditions for the various land suitability categories. The 'land system' method of survey is often used and it may suffice to broadly distinguish land which is promising for specific kinds of irrigated agriculture from land which is not. Economic studies at this, stage broadly indicate levels of production and income.

Reconnaissance survey: is the process of obtaining information about existing and past land use practices by sending out small group of professionals or using air craft e.t.c. As describe bove, the primary objective of reconnaissance survey is to review the previous land use practice and made decision on what type of land us
e practice has to be use.

The data that has to be assessed during Reconnaissance survey are;

- Topographic data of the area
- Rainfall data of the area
- soil survey data of the area
- water resource potential of the area
- socio economic data

1.1. Planning irrigation project

Proper system planning and design is essential to Irrigation Water Management (IWM) and requires the thoughtful consideration of many elements. Selecting a system must include the following major items: Management, water, soil, and crops.

1. Management – The irrigator and planner need to collaborate in order to develop the best plan. The discussion of desired system type needs to include an understanding of management, operation, and maintenance requirements.

2. Water – The source, whether surface or ground, and the quantity, quality, availability, and flow rate, is needed to determine the type of system that is appropriate. Most sources of ground water require power, no matter which type of system is planned. With micro irrigation, a ground water source might only need an inline screen to clean the water while a surface water source would require a sophisticated filtration system. Some sources, due to high salinity (EC), may not be suitable for sprinkler irrigation. A micro irrigation system works best with a constant source while a surface system can operate on a longer interval between water applications. A surface system, in turn, requires a relatively high flow for most efficient application, while sprinkler or micro irrigation systems can function well at a lower rate of application.

3. Soil – Many soil qualities are important when planning an irrigation system. Soil texture is a good indicator of water holding capacity (whc), permeability, and transmissivity. Whc is particularly important when considering a surface system, due to intervals between irrigations. Permeability plays a key role in surface system design, and to a lesser extent, sprinklers. Transmissivity, the ability of water to move through the soil, is important when considering a point source of irrigation, such as with drip emitters. The water needs to be able to move into and through the root zone.

4. Crops – Selection of crops to be grown can be limited due to water quality and quantity. High salinity (EC) can cause yield reduction and even crop failure, depending upon the crop planted.

Other important considerations should include growing season and location.

1. Growing season - The length of growing season is important for crop selection and also is important for justifying the expense for any system planned

2. Location - System structures and hardware must be able to withstand climate extremes of temperature, humidity, precipitation, or wind. Proximity to wildlife, cattle, and humans also suggest necessary precautions to consider.

Proper planning can help ensure that the best system will be installed.

1.1. 2 surveying existing land use

An inventory of current land uses in the community is an important first step. It isimportant to find out if a land use inventory for your community or GIS layers that could be used for this task are available from an agency within your community, such as the engineering office or your county or regional planning commission. The information gathered in this step is used to produce a map of current uses by amount and type (e.g., residential, commercial, institutional). Typical methods for determining current land use involve windshield (conducted from a vehicle) and walking surveys. A windshield survey is useful for large areas such as rural or suburban areas. In an urban area, where land uses are more dense a walking survey may be best. Surveys may be supplemented by aerial photo interpretation, assessment records from your local assessor and field checks. Aerial photos can also provide building footprints and assist in locating other landscape features. In addition web resources, such as WISCLAND (DNR) can be useful for rural areas. An evaluation of current land use conditions is necessary in preparing the land use element. Evaluating the current land use patterns, densities and relationships will assist you in determining land available to meet your community's future land use needs.

1.2. Assessing Water resource proximity

In planning and developing an irrigation project, source(s) of water should be identified so as to ensure continuous water supply. In water resource development, harmonization of the different demands for water, establishment of irrigation priority rights between upstream and downstream users, and consideration of the rights of the existing users of water from flood, which may be modified by dams, is essential. It requires a formal institutional approach based on local experience. If the project is based on groundwater resource, sustainability of the resource should be considered.

The water needed to supply an irrigation scheme is taken from a water source. The most common sources of water for irrigation include rivers, reservoirs and lakes, and groundwater.

You should also examine the location of your field relative to possible water sources. Consider both the distance and elevation difference between field and water source. There will be a cost to convey water from a distant source to the field, and there will be an annual operating cost to pump water from a lower elevation to a higher one. Try to estimate the total cost of pumping and delivering water from each source to your field before making a choice. For example, it may be cheaper to drill a well at the field to be irrigated than to pump water from a distant river or lake.

The volume of water available for irrigation must be determined. After establishing the hydrological availability, the suitability of the water sources and competing water needs within the basin should be assessed. The quality of the water also helps determine the suitability of the water source.

Investigations of water resources should be considered an integral part of the land resources evaluation process. The activities of those involved (hydrologists, hydrogeologists, engineers, agriculturists and economists) should be appropriately scheduled. Costly water resources surveys in areas where the land later proves unsuitable for irrigation are wasteful; vice versa, detailed land and soil surveys for irrigated agriculture can be wasteful in areas where water supplies later prove inadequate.

The volume of water obtainable for irrigation will depend on the outcome of hydrological studies of surface water, and hydro geological studies of groundwater (subsurface water). These are the water supply aspects. The water demand aspects include studies and field work to estimate irrigation water requirements and crop water requirements.

An important part of the evaluation is the matching of water supplies and water demand (requirement) by mutual adjustments involving cooperative work between water resources specialists, engineers and agriculturists.

i. Hydrological studies: Studies may be carried out at national level, at river basin level, at the project development level, and at farm or field level. Surface water resources may be progressively developed, first using diversion structures to regulate run-off-river stream flow, secondly, with the addition of storage, and later, to full control, including flood control.

Existing data, and data collected during the investigations from stream measuring devices (e.g. stage posts, formula-calibrated weirs, current meters and velocity-area rated stations) can be used to estimate run-off and catchment yields, divertible volumes of water, amounts of water for storage, subsurface flows of water, flood peaks and volumes, etc.

ii. Hydro geological studies: Investigations of groundwater resources are generally carried out at the level of the whole hydro geological basin or aquifer. The studies include observations of water levels and quality in existing open wells and tube wells, and specially drilled observation wells.

iii. Irrigation water requirements: Meteorological data and field studies are usually necessary to estimate crop water requirement, effective precipitation, run-on, groundwater contribution, soil water storage, run-off, seepage and percolation, conveyance losses, and leaching requirements. Irrigation water supplies and their control often determine water volumes used by farmers, therefore water management may be as important as physical factors in matching the available supply to the requirements.

iv. Water quality data: Water quality for agricultural use can be evaluated using field and laboratory analyses. The electrical conductivity of, and other simple tests on, samples of irrigation water can be measured in the field using portable conductivity bridges, pH meters and testing kits. For example, having tools-of-the-trade for the testing of groundwater in wells obviates the need for transporting water samples. Local analyses of carbonate, bicarbonate and nitrate may be required where storage of samples may lead to chemical changes and inaccurate results.

In arid and semi-arid areas it will be necessary to predict the salt balance and the water balance for a project area to evaluate leaching requirements, and the drainage needed to maintain the land in a productive condition. In rehabilitation projects, water samples may be analyzed at different points of the network.

Water for drip irrigation and for other techniques where there is a potential clogging problem can be evaluated on the basis of measurements of the suspended solids and chemical or biological properties of the water.

1.3. Delineating Command area

Mapping: Existing maps (topographic maps) and aerial photographs are intensively used in the irrigation planning process (i.e. delineating the Command area). In addition, for example, women and men farmers' detailed local knowledge could be mapped for information on: existing water sources and water use; hydrological units and drainage system; agricultural lands, crop varieties and locations; and soil characteristics.

Command Area Development

envisaged execution of on-farm development works like field channels, land leveling, field drains and conjunctive use of ground and surface water; the rotational system of water distribution to ensure equitable and timely supply of water to each holding; and evolving and propagating crop patterns and water management practices appropriate to each command area. Other ancillary activities like construction of link roads, go downs and market centers, arrangements for supply of inputs and credits, agricultural extension and development of ground water for conjunctive use are also taken up as part of the relevant sectoral programs in the State Plan. Initially, the emphasis of the programme was on the development of infra-structure required to deliver the water to the farmers' field. At the time of formulating the Plan, the progress in implementing the full package of on- farm development works was found to be very limited. A variety of constraints were identified. These included: absence of up-to-date land records, resistance of farmers to land consolidation, inadequate flow of institutional credit and organizational weaknesses. Experience had also shown that once the farmers are assured of timely and adequate supply of water, they take up some of the OFD works such as land leveling.

Self-Check – 4	Written test

Name... ID............................ Date.......

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (5 points each)

1. Why site reconnaissance survey is important for irrigation project plane?(7pt)
2. What are the major essential items used for Proper system planning and design to Irrigation Water Management (6pt)
3. How to Assess proximity of water resource for irrigation development plane ?(5pt)
4. How to be Delineate command area based on land use map of the area?(6pt)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Contour line (also isocline, isopleth, or isarithm) of a function of two variables is a curvealong which the function has a constant value, so that the curve joins points of equal value. It is a plane section of the three-dimensional graph of the function *f*(*x*, *y*) parallel to the *x*, *y* plane. In cartography, a contour line (often just called a "contour") joins points of equal elevation (height) above a given level, such as level. A contour map is a map illustrated with contour lines, for example a topographic map, which thus shows valleys and hills, and the steepness or gentleness of slopes. The contour interval of a contour map is the difference in elevation between successive contour lines.

A topographic map is a type of map characterized by large-scale detail and quantitative representation of relief, usually using contour lines, but historically using a variety of methods. Traditional definitions require a topographic map to show both natural and man-made features. A topographic survey is typically published as a map series, made up of two or more map sheets that combine to form the whole map. A contour line is a line connecting places of equal elevation.

Tape meter, line level, theodolite, tripod, chaining pins, ranging pole, staff, clinometers, Global positioning system, compass, Auger, core sampler, spatula, oven, pressure apparatus, sensitive balance, sieve, soil grinder, hydro meter, shaker and measuring cylinder, thermometer, stop watch.

2.4.2. Interpretation of topographic map

Contour lines on a map show topography or changes in elevation. They reveal the location of slopes, depressions, ridges, cliffs, height of mountains and hills, and other topographical features. A contour line is a brown line on a map that connects all points of the same elevation. They tend to parallel each other,each approximately the shape of the one above it and the one below it. In Figure 2-15, compare thetopographic map with the landscape perspective.

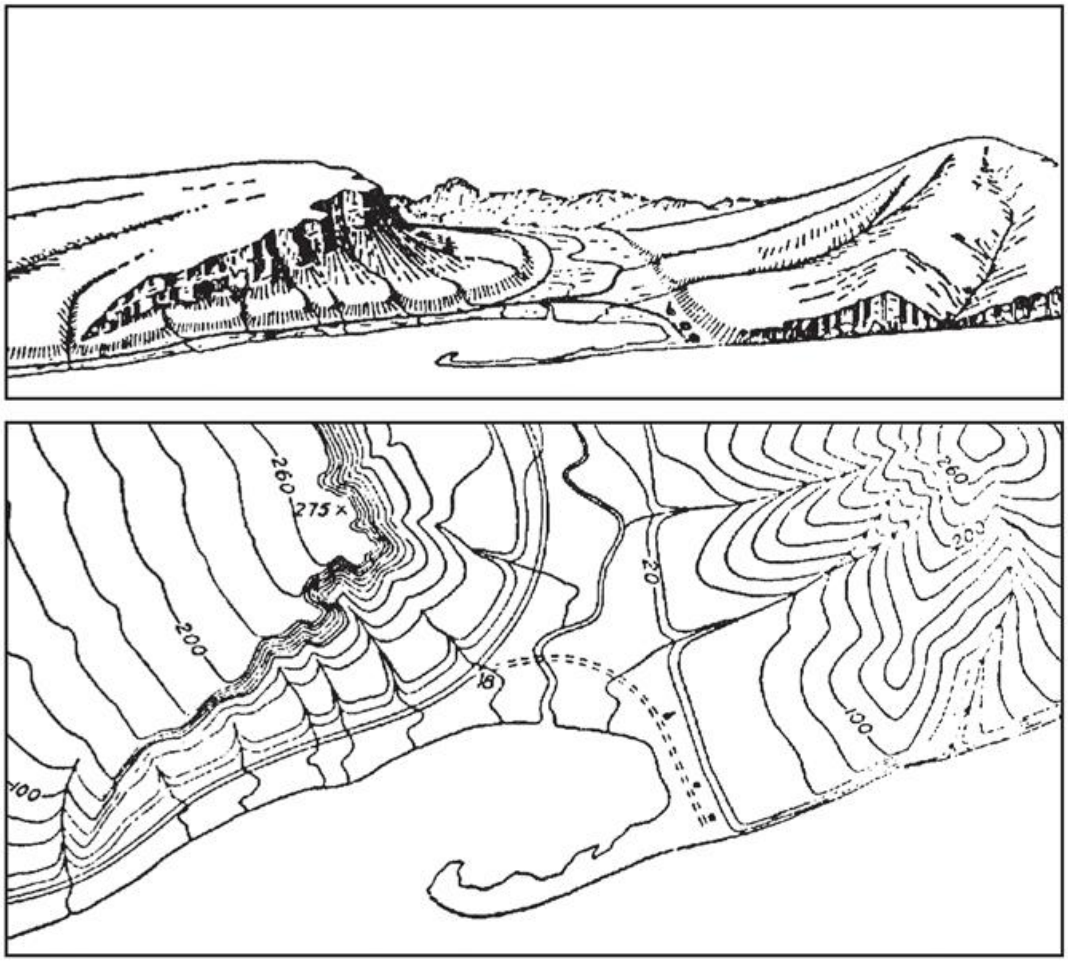


Figure 2-15. A contour map and what it looks like from alandscape perspective. Note that contour lines are far apartor level land and almost touch for cliffs.

Contour Characteristics

Contours have general characteristics; some of which are illustrated in Figures 2-16 and 2-17.

- ✓ Concentric circles of contour lines indicate a hill.
- ✓ Evenly spaced contours indicate uniform slope.
- ✓ Widely spaced contours indicate a gentle slope.
- ✓ Widely spaced contours at the top of a hill indicate flat hilltop.
- ✓ Close together contours indicate steep slope, wall, or cliff.
- ✓ Close together contours at the top of a hill indicate a pointed hilltop.
- ✓ Crossing or touching contours indicate overhanging cliff.

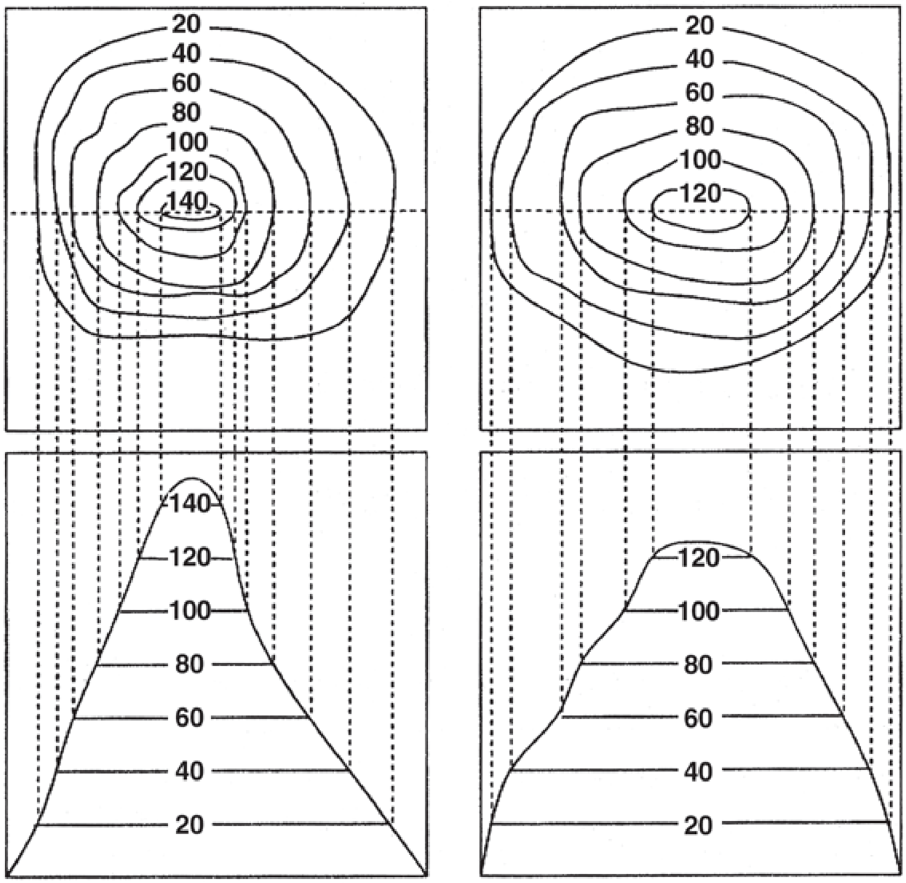


Figure 2-16. Evenly and widely spaced contours indicate type of slope and shape of hilltop.

- ✓ Jagged, rough contours indicate large outcrops of rocks, cliffs, and fractured areas.
- ✓ "V" shape contours indicate stream beds and narrow valleys with the point of the "V" pointing uphill or upstream.
- ✓ "U" shape contours indicate ridges with the bottom of the "U" pointing down the ridge. A saddle is a ridge between two hills or summits.
- ✓ "M" or "W" shape contours indicate upstream from stream junctions.
- ✓ Circles with hachures or hatch lines (short lines extending from the contour line at right angles) indicate a depression, pit, or sinkhole.
- ✓ Spot elevations (height of identifiable features) such as mountain summits, road intersections, and surfaces of lakes may also be shown on the map.

How to read a topo map...

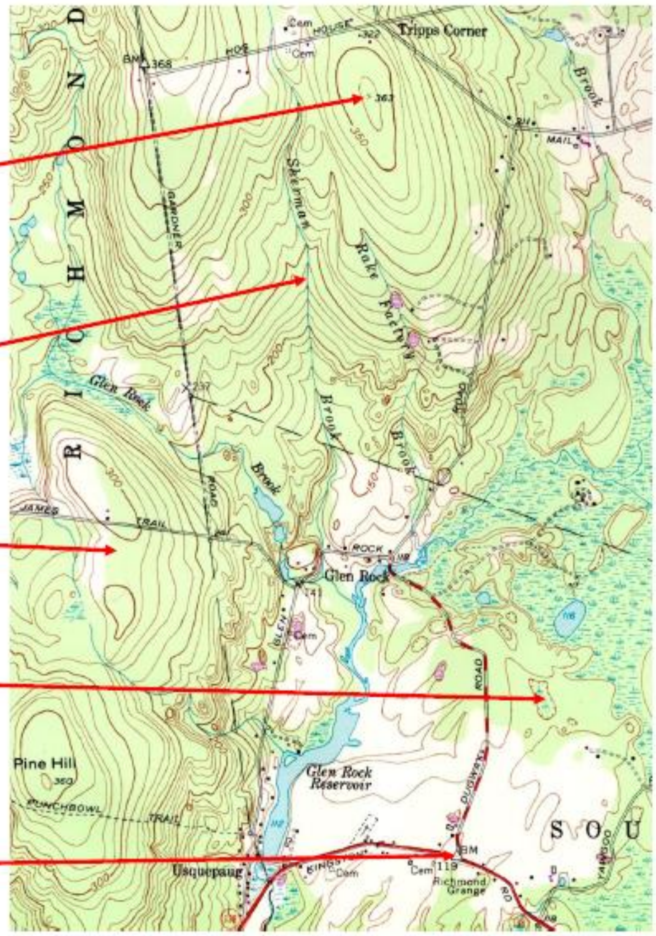
- A **spot elevation** is a point with a known elevation.

- When contour lines cross a stream, they form a "**V**" that always points **uphill**.

•A **saddle** is a lower area, often on a ridge, between two areas of higher elevation.

•**Depressions** are indicated by closed contours with inward-pointing ticks.

•A **benchmark (BM)** is a point of known position & elevation used as a point of reference for surveys



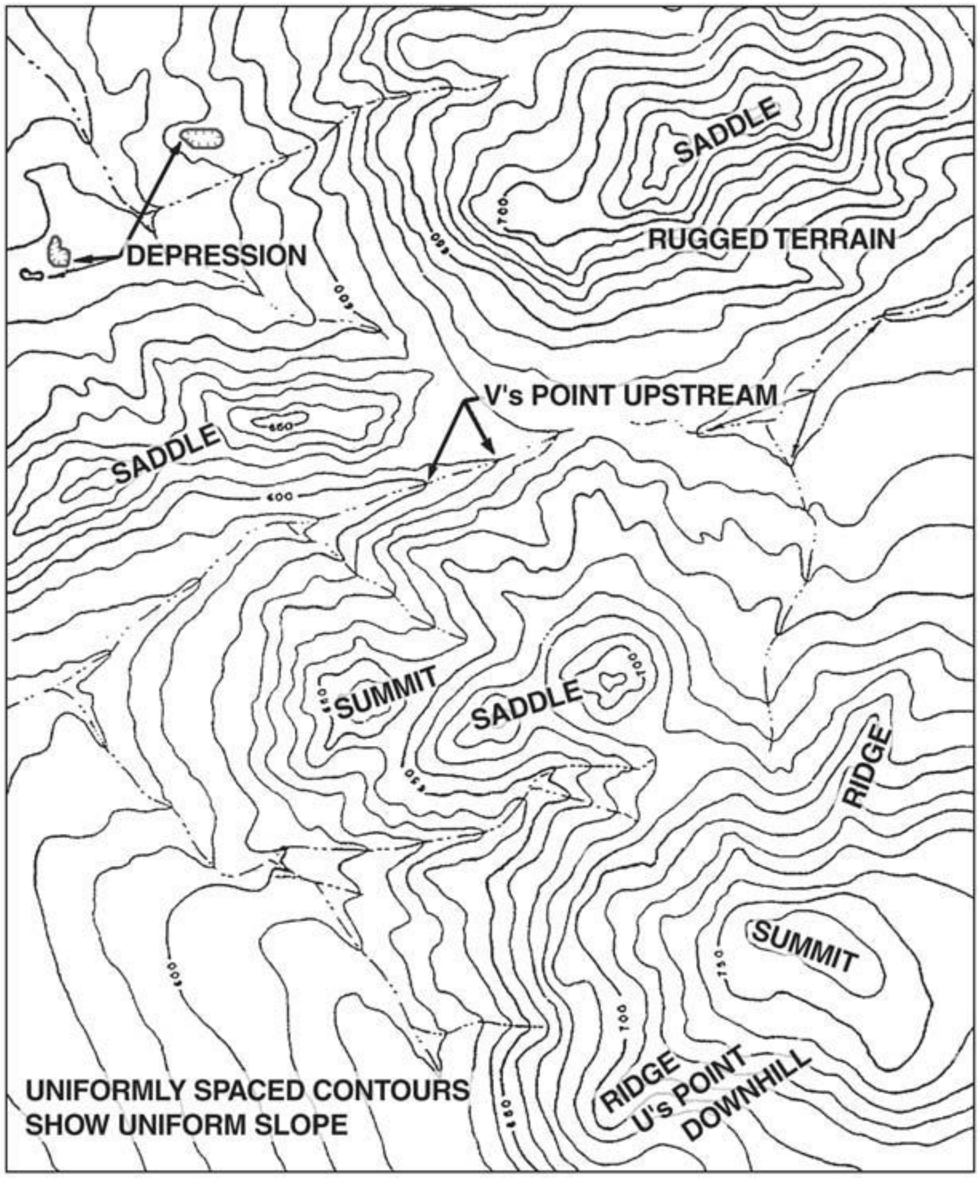


Figure 2-17. Contour lines and topographic features

Contour Interval: Contour interval is the difference in elevation between two adjacent contour lines. On USGS maps,contour intervals are usually 1, 5, 10, 20, 40, and 80 feet. Occasionally you will find a map with a25 foot contour interval or metric units, but not often. To make the contours easier to read, every fifth one is the index contour which is printed darker and has the elevation in feet from mean sea level marked on the line (Figure 2-18). The thinner or lighter colored contour lines are called intermediate contours.

Self-Check – 5	Written test

Name…………………………………………… ID……………………….. Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (5 points each)

1. List out the tools and equipment used for drawing countur line ?
2. Explain the characteristics of conture lines (10 pts)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 3 points   Unsatisfactory - below 3 points

Information Sheet 6- Plotting soil sampling sites on map

3.1. Soil sampling sites are plotted on map.

Soil survey data on the property map --May include, but not limited to:

- Topsoil types, Soil profiles and Readily Available Water (RAW).

Type of maps developed	May include contour maps and aerial photomaps and may include the use of overlays to indicate various categories of data.

3.6. Soil Mapping

Soil mapping can be defined as the process of delineating natural bodies of soils, classifying and grouping the delineated soils into map units, and capturing soil property information for interpreting and depicting soil spatial distribution on a map. The repetitive patterns imprinted in soils by the soil-forming factors can be observed at scales ranging from continental to microscopic. These patterns are the basis for soil identification and mapping at different scales. A system of terminology, definitions, and operations can be ascribed to the various scales. Hierarchical systems of classes and subclasses are established to produce groupings at the different scales. Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. Some boundaries are sharp, where soils change over a few meters, while others are more gradual. Soil scientists can observe only a limited number of pedons. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil and to determine their boundaries.

3.6.1 Agronomic application of soil map

As has been previously stated, maps of agronomic applications can be very different, both in their detail and scale, but they must be based on a soils map established on an identical or larger scale.

- Maps of soil resources are established at smaller scales (such as the 1:500,000map of Upper Volta), and they are analytical in nature. They include delineation of agro-climatic zones and emphasize texture, primarily that of the surface horizon, but also that of the lower horizon to the extent that it affects plant performance. Taxonomic units are indicated with respect to the principal kinds of improvements proposed for various characteristic features: drainage conditions, actual water consumption, organic matter content, exchangeable bases, physical properties (particularly unfavorable ones), and the presence of toxic elements. Some subunits are defined by the association of different component units in a zone or "spot" of the soils map, as this had been indicated in the units of the pedological map. In northern climatic zones, cultivatable lands have been separated into areas suitable for dry land and irrigated agriculture and rangelands. On the map itself, a table will be compiled that indicated the order of the units and subunits as assembled on the pedological map, and these units were given values characteristic of the various land uses for each of the retained fertility factors.
- At medium and detailed scales (1:100,000)or larger, synthesized maps of optimum agricultural utilization or suitability for cultivation are assembled. The legend includes units of "universal agricultural value" and the principal possible uses.
- As a function of the soil characteristics themselves (their type of evolution, parent material. depth, etc.) and also as a function of their environment, slope, degree of erosion, etc. The most interesting system, as previously mentioned, indicates for each unit of land the relative fertility for each of the principal kinds of use or possible cultivation groupings, and the principal for seen improvements. It is of

course indispensable that these documents be prepared with collaboration of an agronomist.

- Maps of cultivation constraints have been rarely established as many of the previous map types include in their taxonomic description's constraints such as "utilizable depth" or various other unfavorable physical properties. However, maps have been made for to analyze depth, texture, profile differentiation, insufficiency or excess of available water, and degree and danger of erosion. The limiting factors arc primarily the slope and the depth of usable land, and extreme textures, the excess of calcareous materials and any fertility or chemical insufficiencies.
- Purely thematic maps are also established at very detailed scales with regard to drainage operations or for particular irrigated cultivations The maps compiled at very small scales (1:1,000,000 or 1:5,000,000) concerning the dangers of desert formation and the degradation of soils.

Self-Check – 6	Written test

Name…………………………………………… ID……………………….. Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (2 points each)

1. Define soil map
2. What can you do to construct accurate soil map
3. Discuss briefly he agronomic application of soil map

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 3 points   Unsatisfactory - below 3 points

Information Sheet 7- Describing soil profile and irrigation characteristics

7.1. Undertaking soil profile description

Soil profile descriptions are basic data in all soil surveys. They provide a major part of the information required for correlation and classification of the soils of an area. They are essential for interpreting soils and for coordinating interpretations across State and regional boundaries. The soil descriptions and the soil map are the parts of a published survey having the longest useful life.

Field descriptions of soil profiles range from partial descriptions of material removed by a spade or by an auger to complete descriptions of pedons seen in three dimensions from intersecting pits as horizontal layers are removed sequentially from the surface downward. Most field descriptions of soil profiles are the former, so care in making them is essential.

Field descriptions should include:

- Observed external attributes of the area, such as landform and characteristics of slope;
- Inferred attributes of the area, such as parent material and soil-water states;
- Observed internal properties of the profile, such as horizon thickness, color, texture, structure, and consistence;
- Inferred attributes of the profile, such as horizon designations and parent material;
- Inferred soil drainage class;
- Classification of the profile in the lowest feasible category;
- Location of the site relative to geographic markers and in terms of landscape position;
- Plant cover or use of the site;
- Date, time of day, and weather conditions;
- Name of the describer

Field Data:

Soil profile description

Profile No.:		**Parent Material:**
Investigator:		**Field Drainage:**
Location: {Coordinates, GPS}		**Principal Drainage:**
Elevation:		**Irrigation Source:**
Geomorphic Unit:		**Irrigation Efficiency:**
Topography:		**Surface:**
Slope:		**Salts:**
Vegetation:		**Human Influence:**
Water Table:		**Soil Classification:**
Depth (cm)	**Description**	
	Colour (Dry/Moist), Texture, Stones/Gravels, Structure, Porosity, Consistency, Roots (Organic Matter), concretions (reaction with Acid, H Cl), Water Conditions, Boundary	

7.2. Characterizing irrigation

Important considerations for the design of irrigation systems are feasible water application rates, ease of land leveling and the resultant effect on the soils, possibility of erosion by irrigation water, physical obstructions to use of equipment, and susceptibility to flooding. To meet these considerations, an Order 1 soil survey may be needed to include both deeper than customary observations and measurements of infiltration rates. Soil properties that may be the basis for the interpretations are saturated hydraulic conductivity, available water capacity, erodibility, slope, stoniness, effective rooting depth, salinity, sodium adsorption ratio (SAR), gypsum, and properties that may affect the level of response

Regarding soil productivity, the soils were classified into six classes. The soils of classes 1 and 2 are considered as productive soils while the soils of classes 3 and 4 are considered moderate to poor productive ones. On the other hand, soils of classes 5 and 6 are bare soils or up-build areas.

The following is the description of the productivity classes of cultivated soil:

Class 1: These soils are high productive soils. The crop production of these soils is much higher than the general average of the country. The costs of the agricultural practices are relatively low. They are characterized by natural drainage where they drain in the River Nile, availability of irrigation water, and non-saline and non-sodic through the soil profile. These soils are clay loams or loams, with moderate to rapid water permeability and have no water table to a depth of 150 cm.

Class 2: These soils are good productive soils. The crop production is higher than the general average of the country. The costs of the agricultural practices are normal. They are characterized by the availability of irrigation water, and they are non-saline and non-sodic through the soil profile except in small scattered areas where medium salinity or sodicity respectively appear in the sub-surface layers or along the soil profile. These soils are clays and have no water table to a depth of 150 cm.

Class 3: These soils give the general average of the crop production of the country. The costs of the agricultural practices are similar to the national average. They are characterized by poor drainage in most cases and at times by poor levelling resulting in the appearance of the water table at depths less than 150 cm from the soil surface. They are mostly characterized also by the appearance of medium or high salinity along the soil profile or in some of its layers. Other characteristics in some of these soils include sodicity, appearing either along the soil profile or in some of its layers. In some soils, the soil texture is coarse sandy and of calcareous nature, especially those immediately next to the borders of the valley and delta.

Class 4: These soils give a poor production far below the general average of the crop production of the country. The reasons for the poor production are the same as in class 3.

Self-Check – 7	Written test

Name…………………………………………… ID……………………….. Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (5 points each)

1. Discuss the field description of soil
2. Discuss about the class of soil with respect to irrigation suitability.

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Information Sheet 8- Relating the readily available water (RAW) with soil type

8.1. Determining the readily available values

8.1.1. Assessing soil moisture

Soil moisture is always being subjected to pressure gradients and vapor pressure differences that cause water to move. Thus it cannot be constant at any pressure. But for particularly significance in agriculture, same soil moisture constants are used. These are;

- saturation capacity
- Moisture equivalent
- Available water
- field capacity
- permanent writing point

Saturation capacity: - when all the pores in the soil are filled with water. The tension of water at this Level is almost zero and it is equal to free water surface.

Field capacity:-soil moisture content after draining excess water and it is relatively stable. The soil moisture tension at field capacity varies from soil to soil, but ranges from 1/10 to 1/3 atmospheres.

Moisture equivalent: the amount of water retained by a sample of initially saturated soil material after being subjected to a center fugal force of 1000times that of gravity for a definite period of time, usually hour in hour.

Permanent wilting percentage /pwp: - soil moisture content at which plant cannot longer obtain

Enough moisture to meet transpiration requirement, and remain wilted unless water is added to the soil. The moisture tension here ranges from 7 to 32 atmospheres.

Available water: - soil moisture between Fc and pwp. It is moisture available for plant use. In general, fine texture soil has a wide range of water b/n Fc and pwp than course textured soil.

Bulk density is the ratio of the mass of dried particle to total volume of soil (including particles and pores)

RAW= (FC-PWP) X Dr X bulk density

Thus, RAW is affected by

- Type of soil
- Soil pore space
- Soil voids
- Depth of root zone
- Soil structure

Self-Check – 8	Written test

Name…………………………………………… ID……………………….. Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (1 point each)

1. Define the following briefly

- saturation capacity
- Moisture equivalent
- Available water
- field capacity
- permanent writing point

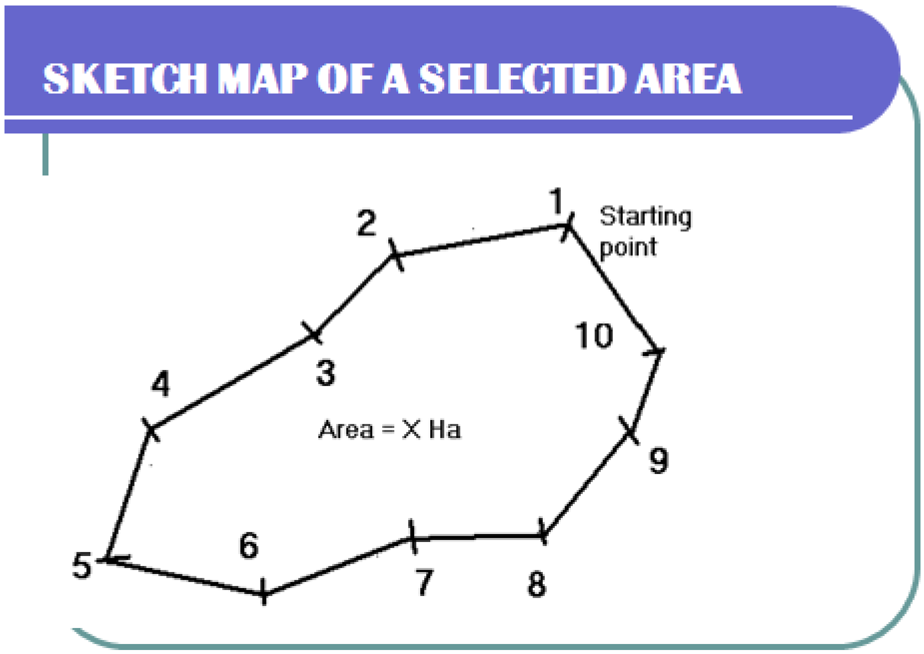
You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 3 points   Unsatisfactory - below 3 points

Information Sheet 9- Describing specific areas are plotted on the map

9.1. Undertaking plotting a specific areas on the map

Steps 1



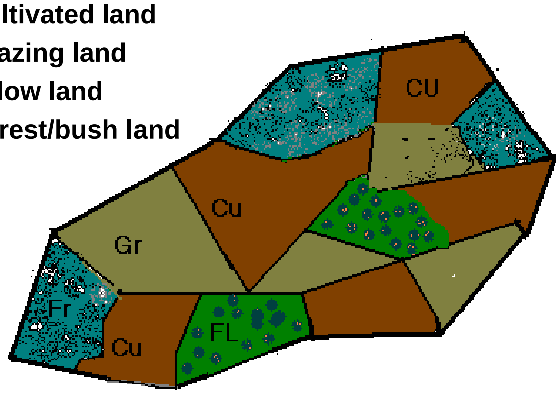
MAKING A SKETCH MAP WITH A COMPASS

Stations	Degrees	Slope (%)	Distance, m
1-2	271 NW	3	215
2-3	239 SW	8	210
3-4	259 SW	5	200
4-5	80 NE	10	230
5-6	110 SE	15	150
6-7	100 NE	15	160
7-8	70 NE	10	200
8-9	330 NW	15	100
9-10	70 NE	5	160
10-1	5 NE	10	80

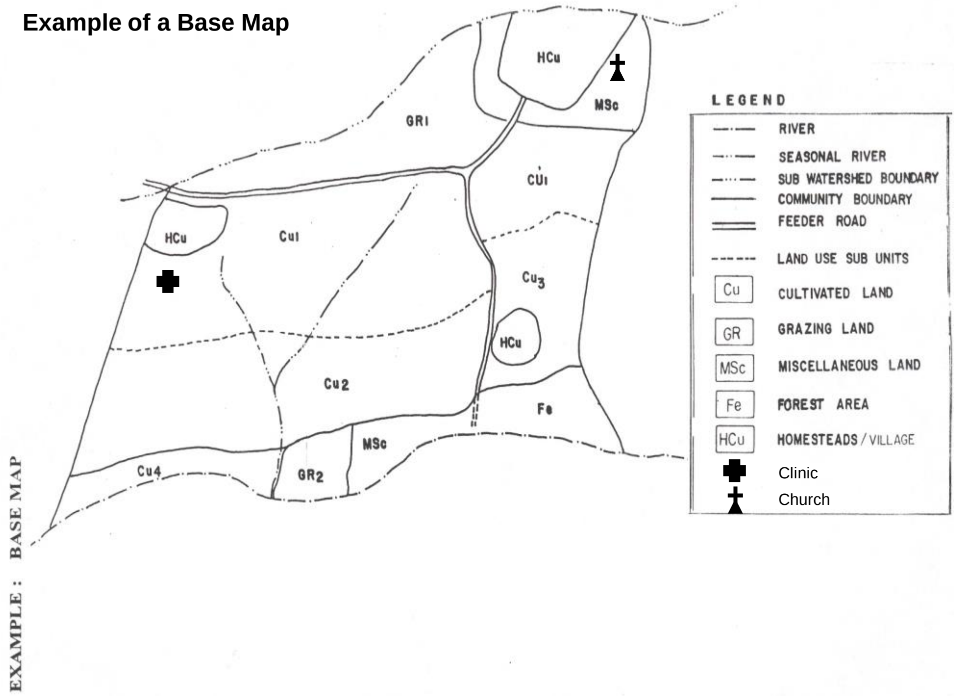
SKETCH MAP SHOWING PRESENT LAND USE

Legend

Cu - cultivated land
Gr - Grazing land
Fl - Fallow land
Fe - Forest/bush land



Example of a Base Map



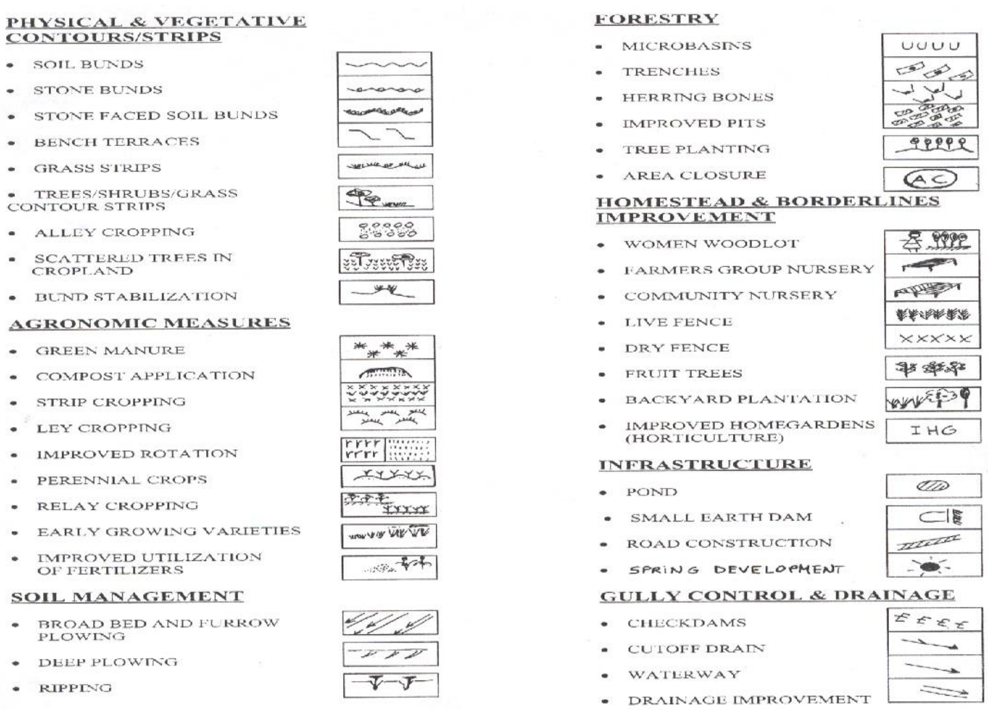
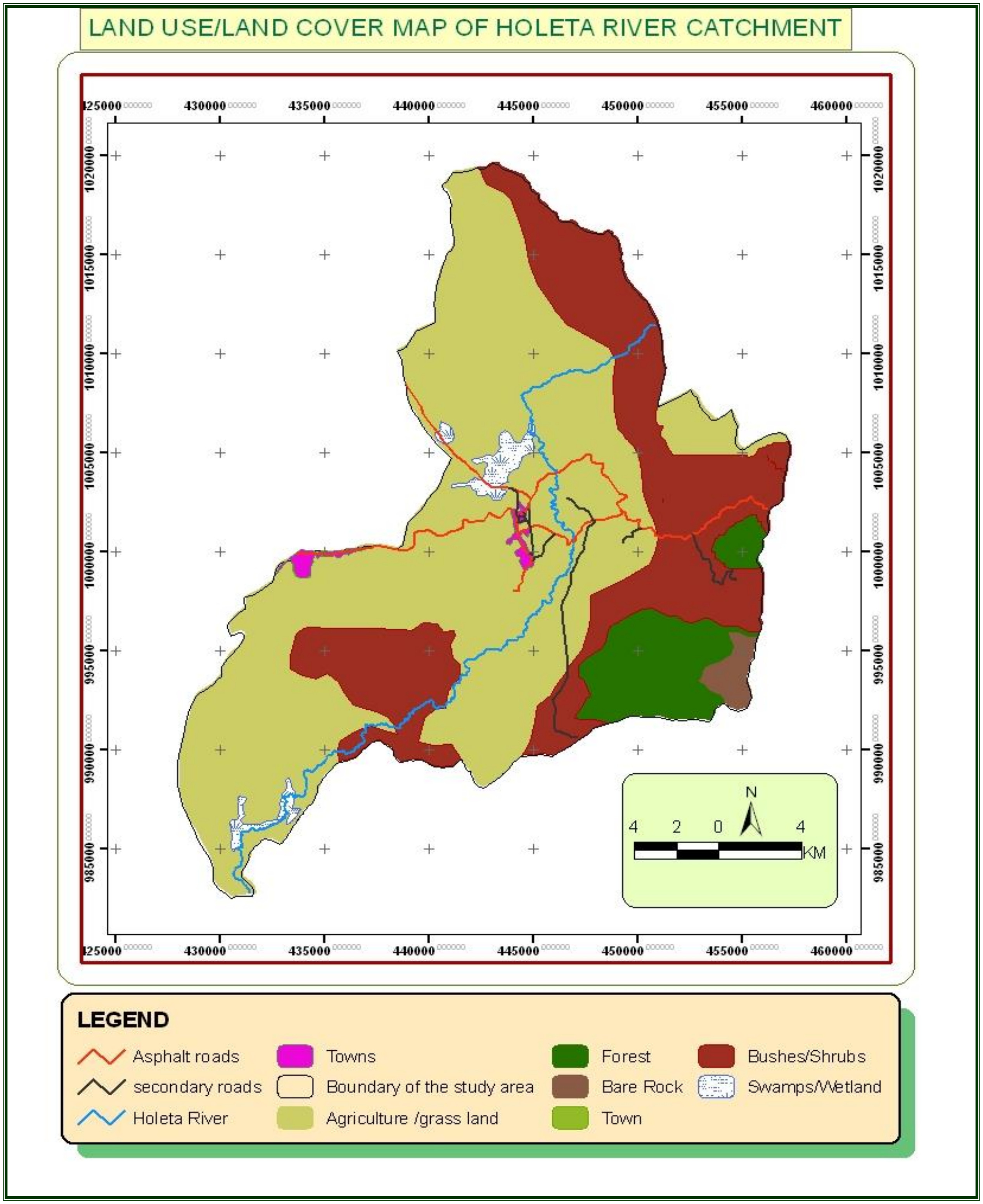
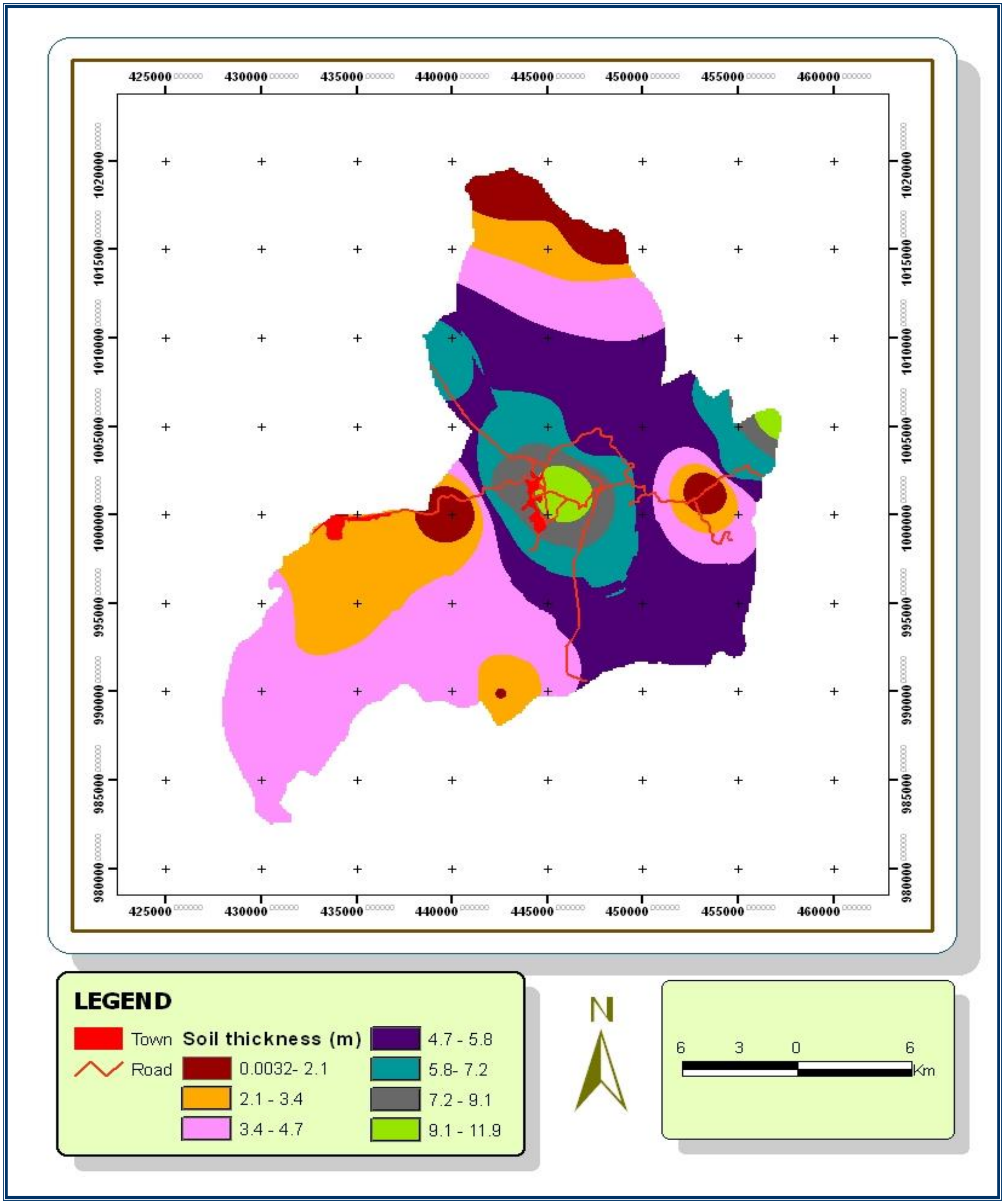


Table 2.2 Land use/Land cover of Holeta River Catchment.

No.	Land use/Land cover	Area(km^2)	Area (%)
1	Agriculture/ grass land	325.96	63.95
2	Forest	32.9	6.46
3	Bare Rock	5.55	1.09
4	Town	3.50	0.69
5	Bushes/Shrubs	133.20	26.13
6	Wetland	8.57	1.68
Total		**509.68**	**100**



LAND USE/LAND COVER MAP OF HOLETA RIVER CATCHMENT
425000
430000
435000
440000
445000
450000
455000
460000
1020000
1015000
1010000
1005000
1000000
995000
990000
985000
N
4 2 0 4
KM
LEGEND
Asphalt roads
secondary roads
Holeta River
Towns
Boundary of the study area
Agriculture /grass land
Forest
Bare Rock
Town
Bushes/Shrubs
Swamps/Wetland


425000
430000
435000
440000
445000
450000
455000
460000
1020000
1015000
1010000
1005000
1000000
995000
990000
985000
980000
LEGEND
Town
Road
Soil thickness (m)
0.0032- 2.1
2.1 - 3.4
3.4 - 4.7
4.7 - 5.8
5.8- 7.2
7.2 - 9.1
9.1 - 11.9
N
6
3
0
6
Km

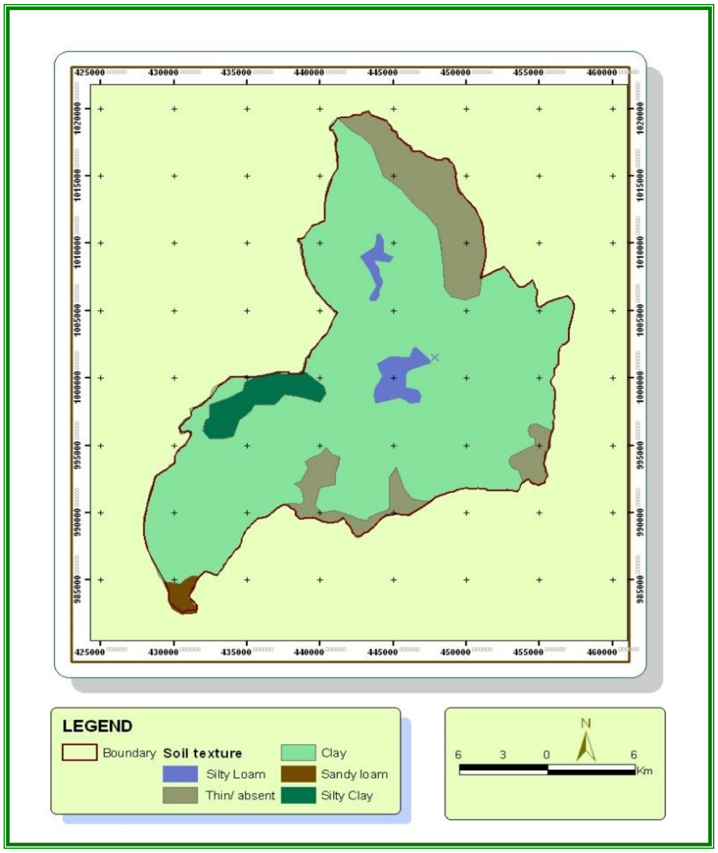


Figure 2.8 Soil Texture map

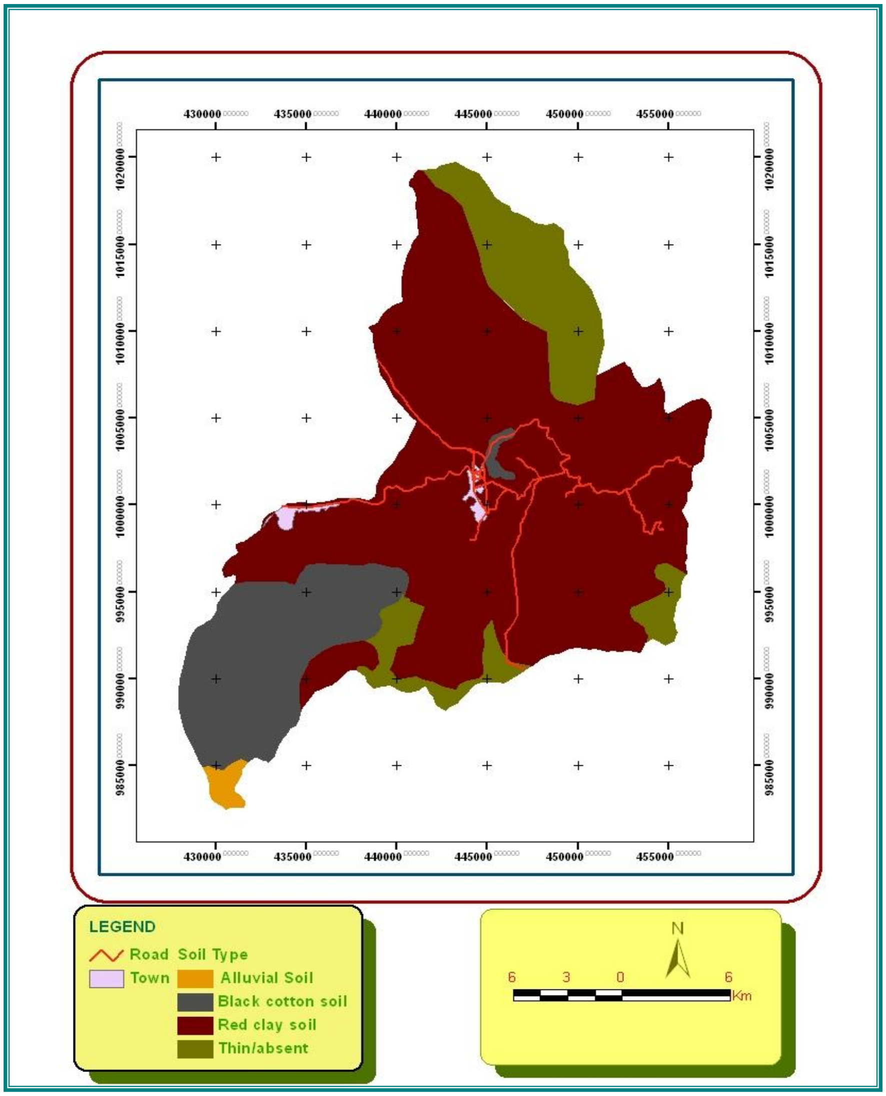


Figure2.9 Soil Type Map

Self-Check – 9	Written test

Name…………………………………………… ID……………………….. Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (5 points each)

1. What is the first step in drawing map
2. What are the possible features found on map

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Operation Sheet 1- Undertake developing soil map

PROCEDURE:

1. Collect the necessary materials
2. Subtle differences in slope gradient or configuration, in landform, and in vegetation since it is important indicators of soil boundaries
3. Using Aerial photographs provide important clues about kinds of soil from the shape and color of the surface and the vegetation. The relationships between patterns of soil and patterns of images on photographs can be learned for an area. These relationships can be used to predict the location of soil boundaries and kinds of soil within them.
4. Before an area is surveyed, making a careful stereoscopic study
5. Look for Important features that can be accurately identify are sketch lightly on the photograph. Some features can be determined with more certainty than others. mark Images that help identify obscure Use the following steps as a preliminary study.
6. Sketch Drainage ways, streams, and ponds
7. Identify Roads, buildings, and other location references.
8. If soils have been mapped along the match line with an adjacent photograph, the soil boundaries are transfer to the outside edge of the match line. Some soil boundaries can be tentatively extended onto the unmapped sheet.
9. Additional features can be lightly penciled if they can be identified with confidence: boundaries of flood plains and stream terraces, boundaries of wet areas and water, prominent landforms such as escarpments and areas of rock outcrop, gravel and borrow pits, ridge lines, sinkholes and wet spots.
10. Plotting soil boundaries.
11. After a delineation has been identified and crossed, the soil scientist turns and looks back on the landscape from a new vantage point. A final judgement is made on the boundaries and symbols. If mapping is done on an aerial photograph, the photographic images are checked against the landscape features before the final boundaries are sketched.

LAP TEST	Performance Test

Name………………………………. ID……………………………..
Date…………………………………….

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **3** hour. The project is expected from each student to do it.

Task-1 Go to the rural kebele area proximity to your college &Collect and Collet the necessary data, undertake plot topography and soil survey data on property map, write a report and present it.

Reference Materials

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WEB ADDRESSES

1. Soil http://www.geolab.nrcan.gc.ca/geomag/e_cgrf.html
2. http://www.navcen.uscg.gov/gps/default.htm.
3. FAO):http://home.gdbc.gov.bc.ca/
4. PME Ltd (subscription based):http://www.terrapro.bc.ca
5. Soil map implementation http://www.nrcan.gc.ca/gsc

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This Teaching, Training and Learning Materials (TTLM) was developed on September, 2021 at Adama, Pan- Africa Hotel.

The trainers who developed the learning guide

No	Name	Qualification	Educational background	Region	Tel.no	E-mail
1	DerejeSeyoum	B	Agr. Engineering	Oromia	0911776191	derejeseyoum99@yahoo.com
2						
3						
4						