STATE OF CALIFORNIA
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
NORTH COAST REGION

SOIL EVALUATION FOR ON-SITE SEWAGE DISPOSAL

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INTRODUCTION

As the rural population of northern California continues to grow there is an ever increasing need for individual sewage disposal systems. These individual systems need to be properly located, in suitable soil material, to ensure their successful operation. Criteria for determining the suitability of soil and other site characteristics are established in the policies of the North Coast Regional Water Quality Control Board and other local regulatory agencies. This manual is intended to provide guidance in conducting inspections and interpreting soil characteristics and properties as called for in those policies.

To date, the standard method of judging a soil's suitability to accept effluent has been through percolation testing. Although in wide usage and fairly straight-forward, the percolation test has come under critical attack by many authorities because of the high variability in techniques and results. This manual focuses on the principles of soil science as an alternative method for determining a site's ability to accept effluent.

Another factor affecting successful operation of an individual system is the depth to groundwater or saturated soil. When the seasonal depth to groundwater or saturated soil is shallow there is an increased risk for system failure and/or pollution to groundwater. The usual method for determining the level of high groundwater or saturated soil has been by direct observation during winter. This method is rarely convenient and sometimes misleading. This manual describes a method of determining expected levels of soil saturation on the basis of basic soil science principles.

The soil evaluation procedures described herein have the following benefits: (1) The use of these alternate methods will provide a more accurate and reproducible determination of soil suitability for on-site sewage disposal than does sole reliance on percolation testing and winter time observance of groundwater. (2) These alternate methods are more convenient in that they may be conducted at any time of the year. (3) In most cases these alternate methods will be less costly because of the reduced amount of time and effort needed.

In addition to the description of soil science principles and methods, this manual contains detailed laboratory procedures, a list of references and a glossary of soil science terms.

SITE AND SOIL CRITERIA

In assessing a parcel for on-site sewage disposal, certain physical conditions must be recognized and evaluated. Minimum site criteria established by the Regional Board and local regulatory agencies are intended to guide this assessment. Compliance with those criteria are necessary to establish the suitability of a site and to serve also as a basis for design.

Setback Distances (feet)

"Facility	Well	Perennial Stream1/	Ephemeral Stream2/	Ocean, Lake or Reservoir3/	Cutbank or Natural Bluff
Septic Tank	100	100	50	50	25
Disposal Field	100	100	50	100	25 4/
Seepage Pit	150	100	50	100	25 4/

1/ Measured from line that demarcates the limit of a 10-year flood.
2/ Measured from the edge of the watercourse.
3/ Measured from the high-water line.
4/ Where soil depth or depth to groundwater is less than 5 feet below the bottom of the disposal trench, a minimum setback distance of 50 feet shall be required."

Setback requirements are necessary to ensure sufficient lateral movement of effluent in soil before wells and water courses are encountered. Additionally, setbacks serve as a buffer zone to allow containment of surfacing effluent should system failure occur. For the purpose of this criterion, intermittent streams are considered under the category of "perennial streams" since setback needs are of most concern (and system failure most likely) during the wet season when such streams are active.

Ground Slope

"Ground slope for all areas to be used for effluent disposal shall not be greater than 30%. Where less than 5 feet of soil exists below the trench bottom (see Soil Depth Criterion) ground slope shall not exceed 20%."

Ground slope limitations are imposed to ensure that sewage does not daylight down slope from the disposal field. The shallower and finer the soil, the more restrictive must be slope requirements.

Soil Depth

"Minimum soil depth immediately below the bottom of the disposal trench shall not be less than 5 feet. A minimum depth of 3 feet shall be permitted where ground slope is less than 20% and the soil is demonstrated to be of an acceptable texture (zone 2) according to the Soil Percolation Suitability Chart. Lesser soil depths may be granted only as a waiver or for Alternative Systems."

Sufficient soil depth beneath the disposal field is needed to provide filtration of contaminants and provide for lateral dispersion of wastewater. Recommendations of researchers and authorities range from 3 to 7 feet of soil depending upon soil texture. Recent research at the University of Wisconsin at Madison has indicated that when all other conditions are favorable, a minimum soil depth of 2 feet might be sufficient.

Depth to Ground Water

"Minimum depth to the anticipated highest level of ground water below the bottom of the leaching trench shall be determined according to soil texture and percolation rate as follows:

Soil Texture* Percent Silt + Clay	Depth to Ground Water Below Leaching Trench (ft)
5 or less	40
6 to 10	20
11 to 15	10
Greater than 15**	5
Greater than 15	2***

* Must exist for a minimum of three continuous feet between the bottom of the leaching trench and ground water

** Or a percolation rate slower than 5 mpi.

*** Granted only as a waiver or for Alternative Systems

Where ground water is determined to be non-usable (see definitions) and soils contain greater than 15% silt and clay or have a percolation rate slower than 5 mpi, a minimum depth to ground water of three feet below the leaching trench shall be permitted without need for waiver".

Silt and clay are the main soil constituents responsible for effluent filtration. As the percent of silt and clay in a soil decreases so does its ability to filter effluent, thus proportionately greater separation distances from ground water must be maintained.

Soil Percolation Suitability

Soil percolation suitability shall be determined by using the Soil Percolation Suitability Chart. This takes into account soil texture, bulk-density, gravel and cobble content. The way these properties affect percolation characteristics are discussed more fully in another section of this manual.

PREPARATION FOR SITE AND SOIL EVALUATION

Prior Reports

The first step in evaluating a site for a standard septic tank disposal field system is to study any existing reports or surveys of the parcel. These include soil surveys made by the USDA-Soil Conservation Service or the University of California, or engineering, geologic or hydrologic reports made by the U.S. Geological Survey or private firms. When examining reports one should be aware of the intensity at which the survey was made. This is a key to its accuracy and reliability. Because of broad scale and low intensity in surveying, most reports will not have all the information needed to make a complete site evaluation. For example, Soil Conservation Service soil surveys do not recognize areas smaller than about 5 acres in size. Whether or not a report can be relied on completely, it is useful to familiarize oneself with the landforms and soil types in the area. This gives a hint as to what might be expected when making on-site inspections.

Maps

Parcel maps and topographical maps should be compiled and used to ensure that minimum setback distances can be met. These include setbacks from streams, bodies of water and cutbanks or bluffs, as well as from structures, property lines or any other feature as designated by local regulatory agencies.

SITE EVALUATION

After the appropriate reports have been studied, and parcel and topographic maps have been compiled, an on-site inspection should be made.

Streams

All streams on or near a parcel may not be shown accurately, or at all, on the available maps. An on-site inspection is needed to identify and locate streams so that proper siting of the disposal field can be made. Perennial and intermittent streams are easy to recognize because of the obvious channel and riparian vegetation. Ephemeral streams are more obscure, but must also be recognized in the field. An ephemeral stream is defined as "...any observable water course that flows only as a direct response to precipitation." Periods of flow are usually less than one week following a rainfall event. Indicators of an ephemeral stream during periods of nonflow include scouring, hydrophytic vegetation and landscape position.

Ground Slope

Ground slopes need to be measured to ensure the proper placement of the leachfield system. Acceptable slopes are defined under Site Criteria. Several instruments can be used for measuring ground slope. Among them are the engineers' transit, level, Abney level, and clinometer. The latter two are the quickest and easiest to use.

When measuring slope it is important to maintain a parallel line of sight with the ground slope. This can be done by sighting to an object whose height above ground is the same as the instrument's. Keep in mind that a landform may have many different slopes with varying degrees of incline. The steepest slope most restricts the successful operation of a disposal field, so it is the one to be measured. (See Figure 1.)

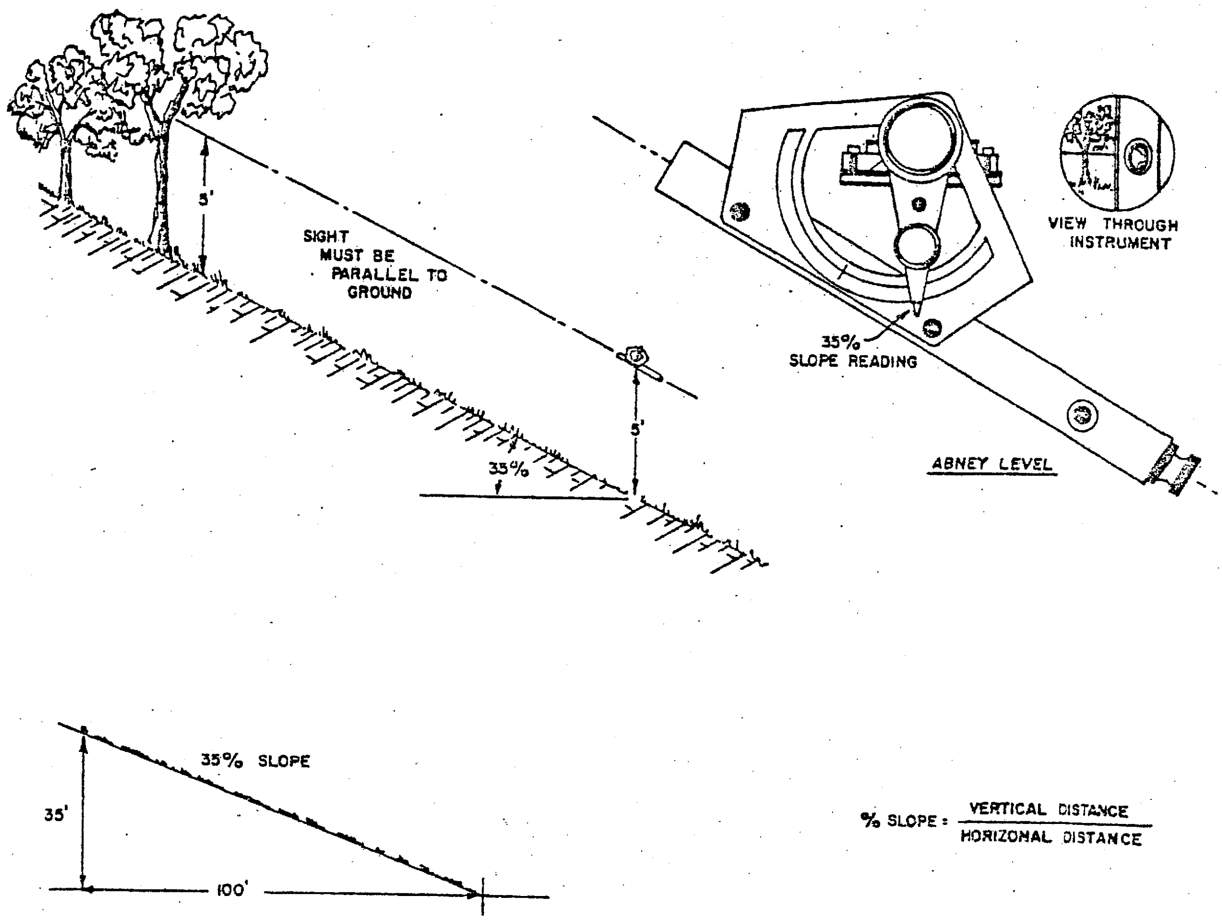


Figure 1. Use of Abney level

SOIL EVALUATION

There are many different kinds of soil. They are the product of the five soil-forming factors; parent material, living organisms, climate, topography, and time. Together, the soil forming factors control the weathering of rocks and soil material. They affect the gains, losses, or alterations that occur in the soil profile. Since these factors occur in varying degrees and ways, different soils display a wide variety of properties and characteristics. For example, a soil that has formed on the Russian River flood plain in sandy alluvium and under a mediterranean environment, would be expected to, and does, behave quite differently than a soil formed over shale parent material in a cool, wet environment. Both soils are typical of the north coast area of California.

Some soil forms can be expected to behave favorably when used for a sewage disposal system while others cannot. Favorable behavior may be thought of as the ability of a soil to accept septic effluent at a suitable rate, and to effectively filter it. In order to determine if a soil will behave favorably when used as a disposal field a soil profile inspection must be made.

The Soil Profile

The usual soil profile consists of the surface soil (commonly called topsoil), the subsoil, and the substratum or parent material. These layers are parallel to the ground surface.

The surface soil is rich in humus from decomposed plants, worms, and micro-organisms. This humus gives the soil its characteristic dark color.

The subsoil, which lies directly under the surface soil, is a zone of accumulation or alteration. As rain percolates down through the surface soil it may carry some clay with it. The clay, then, settles in the subsoil causing it to have a finer texture than the overlying surface soil. This process is called illuviation. Percolating rain can also carry other agents. When silica or calcium carbonate are carried in solution they may precipitate in a layer and chemically cement it. These cemented layers, commonly called hardpans, are known as duripans (cemented by silica) or petrocalcic layers (cemented by calcium carbonate).

The substratum or parent material lies under the subsoil. It may be hard rock such as granite or slate, or it may be unconsolidated rock material such as decomposed granite or ancient sand dunes. It shows little or no soil development as caused by loss, gain, or alteration of materials. (See Figure 2).

On floodplains the soils have been deposited so recently that they have not had time to develop. These soils are usually stratified, having several layers that may be different and unrelated to any of the other layers. (See Figure 3).

Soil Inspection

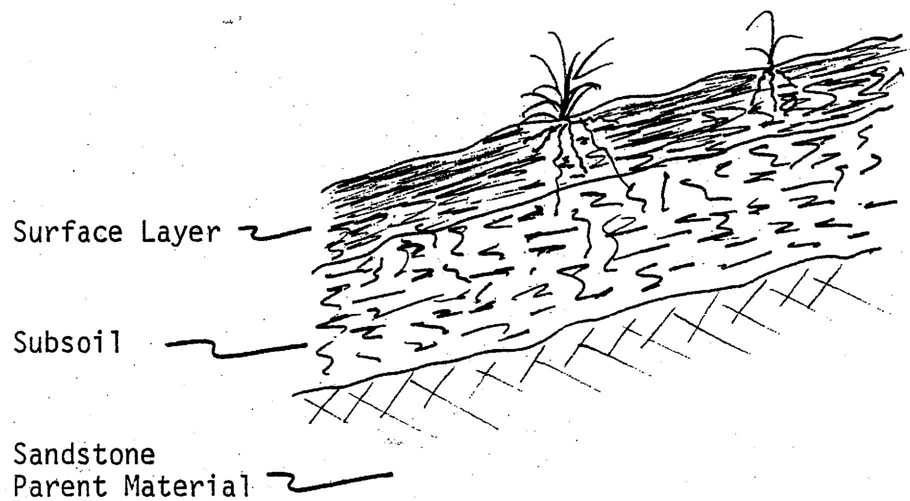
Since there are so many different possible profiles, a soil evaluation should be made for every proposed disposal field. The most satisfactory way to evaluate a soil is by excavating pits to expose the zone that will be used as the filtering medium. This zone is considered to extend to 5 feet below the trench bottom. For example, if the bottom of the septic trenches is to be 3 feet deep, then the inspection pits should be 8 feet deep. All pits should be large enough to allow comfortable entry and exit. One end should be gently sloping or stair-stepped so ladders need not be used for entry.

IMPORTANT: Safety must be maintained at all times, and regulations set forth by the Occupational Safety and Health Administration (OSHA) followed. This means shoring up side walls for excavations deeper than 5 feet.

Shoring may be required of excavations less than 5 feet in depth if conditions are unstable. One end of the pit is to be sloping or stair-stepped, at a horizontal to depth ratio of 3/4 to 1, if entry is anticipated (See Figure 4). At no time should entry to a depth of greater than 5 feet be exercised. Whenever possible, inspection and sampling of the soils should occur at the time of the excavation, so as to eliminate the need for entry.

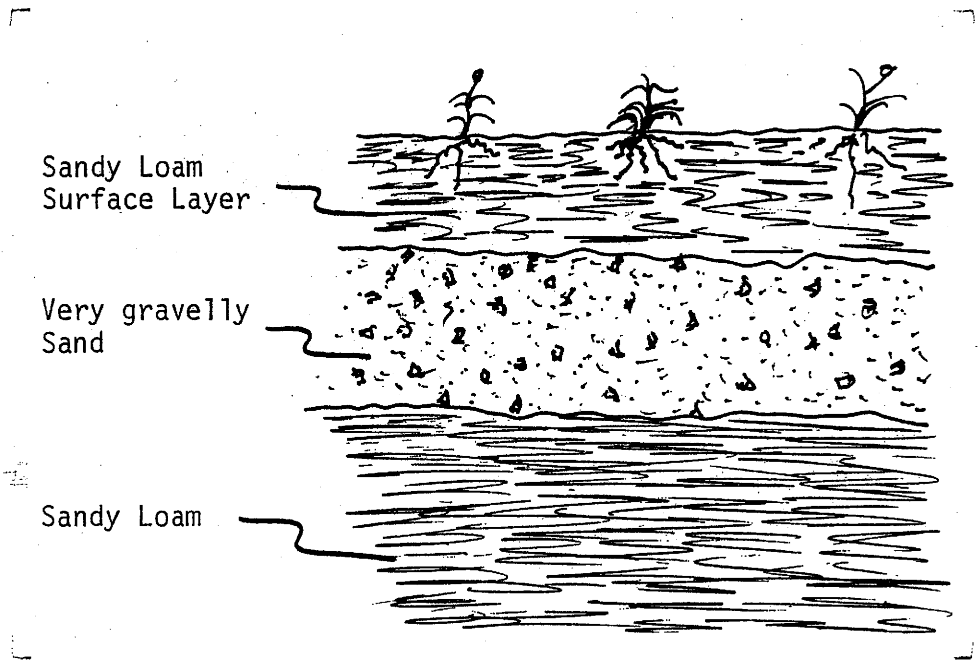
Inspection pits of this type and size are most easily dug with a backhoe. The advantage of having large inspection pits is that they offer a view of the soil profile, *in situ*. By observing the soil profile *in situ*, an accurate soil evaluation can easily be made.

In some areas that have had a sufficient number of previous soil evaluations, backhoe pits may not always be necessary. In areas such as these the soil types are predictable and need only to be confirmed. Confirmation can be made by such hand implements as a soil auger or core sample. One disadvantage to using hand implements is that rock fragments in the soil may make these implements very difficult to use and time consuming.



This typical upland soil has a darkened surface layer about 10 inches thick. (The upper 2 inches are very dark.) The subsoil, which has a finer texture is about 30 inches thick. The sandstone parent material is visible starting at a depth of about 40 inches.

Figure 2. Typical profile of an upland soil



This floodplain soil exhibits typical stratification. The surface layer is sandy loam about 2 feet thick. The underlying material is very gravelly sand about 2 feet thick and sandy loam about 4 feet thick.

Figure 3. Typical profile of a floodplain soil

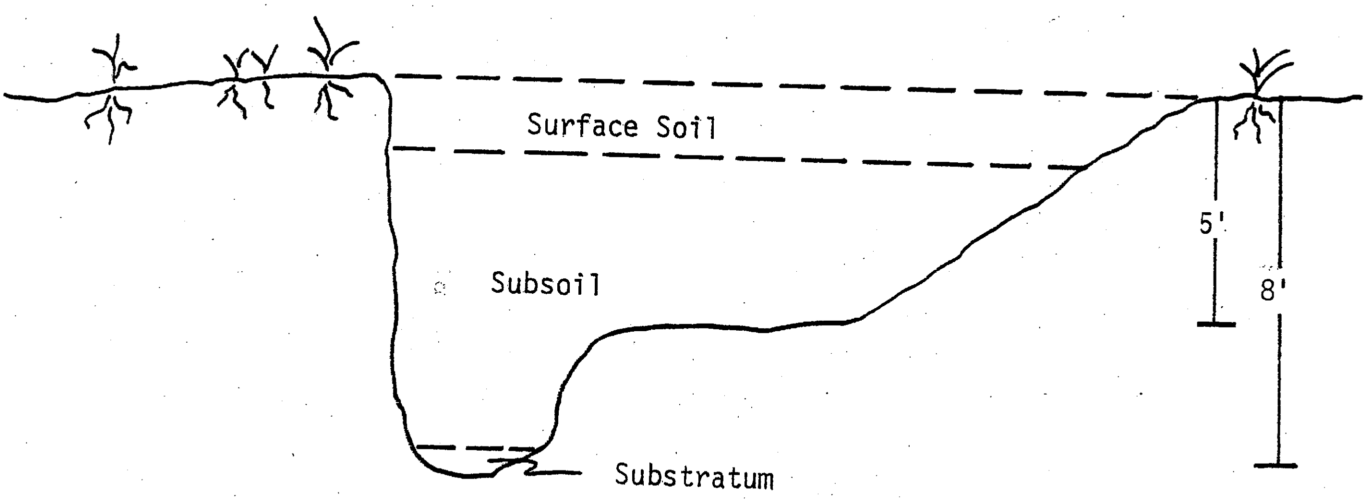


Figure 4. Cross section of inspection pit

Soil inspections may also be made in conjunction with geologic or hydrologic investigations. In a case when men and equipment are already in the process of making a survey for purposes other than soil inspection, it is advantageous to make a concurrent soil inspection.

The number of inspections required to make a suitable soil evaluation in a previously unexplored area is dependent on the topographic complexity of the area. Complex areas are likely to have more than one landform (i.e., uplands with intermountain valleys), thus more than one type of soil. It is necessary that all the soils in a porposed disposal field be inspected, so that an accurate evaluation can be made. Areas with a uniform geographic appearance and uniform vegetation would be expected to have similar soil types, and can be characterized with fewer inspection pits.

Evaluation Methods

To evaluate a soil for use as a disposal field the following properties and characteristics should be noted:

(A) Depth to rock or cemented or impervious soil material.

(B) Depth or indicated depth to high (seasonal) groundwater or saturated soil.

(C) Estimated percolation and filtration characteristics of the soil profile.

(A) Rock and Cemented Soil Material:

Rock and cemented soil material lack enough fine soil particles to provide acceptable filtration, and should not be considered for use as a filtering medium. Fine soil particles contribute to sewage filtration and removal in several ways: (1) they act as a mechanical filter; (2) they harbor and supply mineral nutrients that are beneficial to bacteria that decompose sewage constituents; and (3) they provide exchange sites for ions in solution.

Rock, whether solid, fractured or weathered, is easily recognized. Though weathered rock may be quite soft, it still exhibits its original structure and orientation, and still retains enough cementation to prevent it from slaking in water.

Cemented soil is more difficult to recognize since it lacks any rock structure or orientation. To determine if a soil aggregate is cemented, it can be placed in water to see if it slakes. If the soil doesn't slake in water it is cemented. Also, cemented soil has a brittle consistency. When pressure is applied to an aggregate the aggregate does not deform slowly, but fractures or crushes.

(B) High Ground Water and Saturated Soil

Even before a high ground water and depth to saturated soil determination is made there are some clues that can be used to identify suspect areas. (1) Landscape position. Swale and basin areas collect runoff from surrounding higher areas, usually giving them a higher ground water level. (2) Hydrophytic vegetation. Certain plants grow abundantly only where the soil is saturated for months at a time. A few examples are rushes (Juncus), sedges (Carex), and docks (Rumex).

Determination of high ground water levels can be most conveniently made through the observation of soil mottling in a soil profile inspection pit. Such observations can be made at any time of the year. The highest level at which mottling occurs is considered to represent the anticipated highest level of ground water. An exception occurs in some soils when the texture is so fine that water is held too tightly to exist as free (and usable) ground water. Mottling in these soils is indicative of saturated soil conditions but not always high ground water. Although effluent contact with saturated soil does not necessarily pose a threat to ground water quality, it does act as a barrier to percolating effluent and a constraint on the siting of a disposal field. Direct observation of ground water during wet weather conditions is necessary in such cases to distinguish between free ground water and saturated soil.

Soil color is caused by organic matter and iron and other compounds. Without these coloring agents soil would appear white or grayish as is washed sand. Organic matter causes the surface soil, where it accumulates the most, to be darkened to a black or dark brown color. Iron and other elemental compounds that are contributed by the parent material cause soils to have a characteristic brown to reddish color below the darkened surface layer. Because these compounds vary in kind and proportion soils vary in color.

In soils that are saturated anaerobic conditions are present. Under anaerobic conditions certain bacteria exist to decompose and oxidize organic material. Unlike aerobic living bacteria which use oxygen to decompose organic material, the anaerobic bacteria must use certain insoluble forms of iron and other elements. When iron is used in this way it becomes chemically reduced and mobilized. It is able to move with water. When iron moves away from an area it leaves the area gray in color. This is because the brown, oxidized iron, which is the coloring agent, is either absent or is masked by grayish and greenish, reduced forms of iron.

It takes a few weeks of anaerobic conditions for this process to advance to the point that gray colors begin to be visible. At first they are so faint that they cannot easily be recognized. As times goes on the original soil color fades and the gray becomes more pronounced. If the saturated soil is allowed to drain, and oxygen is re-introduced, some of the reduced iron will immediately be re-oxidized. The oxidized iron will assume a reddish yellow or rust color, and it will be immobilized. As more of the still reduced, mobile iron reaches the area where oxygen is present, it becomes oxidized and settles on the already oxidized iron. In this way the oxidized areas collect iron, immobilize and oxidize it, and become progressively stronger in their reddish yellow color.

A zone of soil that is subject to seasonal groundwater fluctuations will exhibit a mixture of gray or grayish background colors due to wintertime anaerobic conditions and reddish yellow patches due to summertime oxidation. Since some of the gray color is due to iron being absent in any form, it will remain gray even though it has dried out. This mixture of gray and reddish yellow patches of color is called mottling. Mottles caused by water-soil relationships are irregular in shape, although sometimes they follow pores or cracks. They do not appear to have any structure or orientation with respect to decomposing parent material. They range in size from a few millimeters to a few centimeters.

Soil zones that are subject to fluctuating ground water will, over the years, assume a progressively more mottled condition. The mottles will become more prominent and easy to see. In the same way, soil zones that are saturated for many months during the year will have mottles more prominent than soils that are saturated for just a few weeks. Another factor affecting the prominence of mottles is the amount of iron compounds in the soil. Finer textured soils usually have more iron than coarse textured soils, thus they have more strongly expressed mottles.

This relationship between soil and water makes it possible to make an accurate estimation of seasonal high ground water by noting the depth of occurrence of gray and reddish yellow mottles. It is particularly convenient that this evaluation can be done at any time of the year.

The shortcomings of this procedure are few, but they should be pointed out. Some soils have developed in materials that do not contain enough iron compounds to allow mottles to form. (An example is the soils that have formed in volcanic parent material in the intermountain valleys of the Cascade Range.) It is possible for a soil of this type to be saturated every year for long periods of time and never assume a mottled condition. Fortunately, these soils are rare, and can be located with the help of a soil or geology map. When this type of soil is encountered a wintertime determination of high ground water must be made.

Another source of possible confusion stems from mottles caused by the weathering of rocks or parent material. When rocks become so decomposed as to lose their structural integrity they may break apart the way soil does, and appear to be water-caused mottles. To distinguish between water-caused mottles and weathered rock mottles, color and orientation must be carefully scrutinized. Water-caused mottles are gray and reddish yellow, and have no structural orientation. Weathered rock mottles may be almost any color, and do have orientation as related to their original rock structure. Weathered rock mottles also may be of a different texture than the surrounding soil, whereas mottles caused by water have the same texture as the surrounding soil.

(C) Percolation and Filtration Characteristics

Percolation characteristics are dependent on pore size distribution, which is the relative volumes of various sizes of pores in the soil. Water or effluent percolates through soils having large pores more rapidly than it does through soils having small pores. This is because the large pores offer less resistence to moving water.

Pore size distribution is nearly impossible to measure directly. There is, however, a good way to estimate pore sizes and thus evaluate a soil's percolation characteristics. This is by making a particle size analysis, also known as a textural analysis or hydrometer analysis. In most soils there is a direct correlation between particle size distribution (hereafter referred to as texture) and pore size distribution. For example, a soil with a silty clay texture may have an average pore size of 2 microns, whereas a soil with a loamy sand texture may have an average pore size of 200 microns. Since the loamy sand soil has larger pores than the silty clay soil it offers less restriction to the movement of water.

Appendix 2 contains a detailed procedure for particle size analysis. Briefly, the analysis is designed to measure the relative proportions of sand, silt, and clay in the soil. A weighed sample, without coarse fragments, is placed in a 1 liter cylinder with a dispersing solution. It is vigorously agitated to get all the soil particles in suspension. Soil particles immediately begin to fall out of suspension as soon as the agitation is stopped. At designated time intervals, a hydrometer is inserted into the cylinder and a reading is made. The reading is the number of grams per liter remaining in suspension. Since coarse particles with low surface area to volume ratios fall more quickly than fine particles with high surface area to volume ratios, carefully timed readings give the relative proportions of sand, silt, and clay in the soil. One reading is taken when the sand has settled and another is taken when the silt has settled.

Soil Percolation Suitability Chart:

The Soil Percolation Suitability Chart is a modified Soil Textural Classification Triangle as used by the U.S. Department of Agriculture and the University of California. The textural triangle uses the relative percentages of sand, silt and clay to determine soil texture. Research conducted by the USDA-Soil Conservation Service has correlated permeability rates with areas on the triangle. The slower permeabilities being toward the clay corner, and the faster permeabilities being toward the sand corner. Through continuing research being conducted by the staff of the North Coast Water Quality Control Board a strong correlation has been made between soil texture and percolation rates. The Soil Percolation Suitability Chart uses four texture zones to indicate soil suitability for use in a standard sewage disposal system.

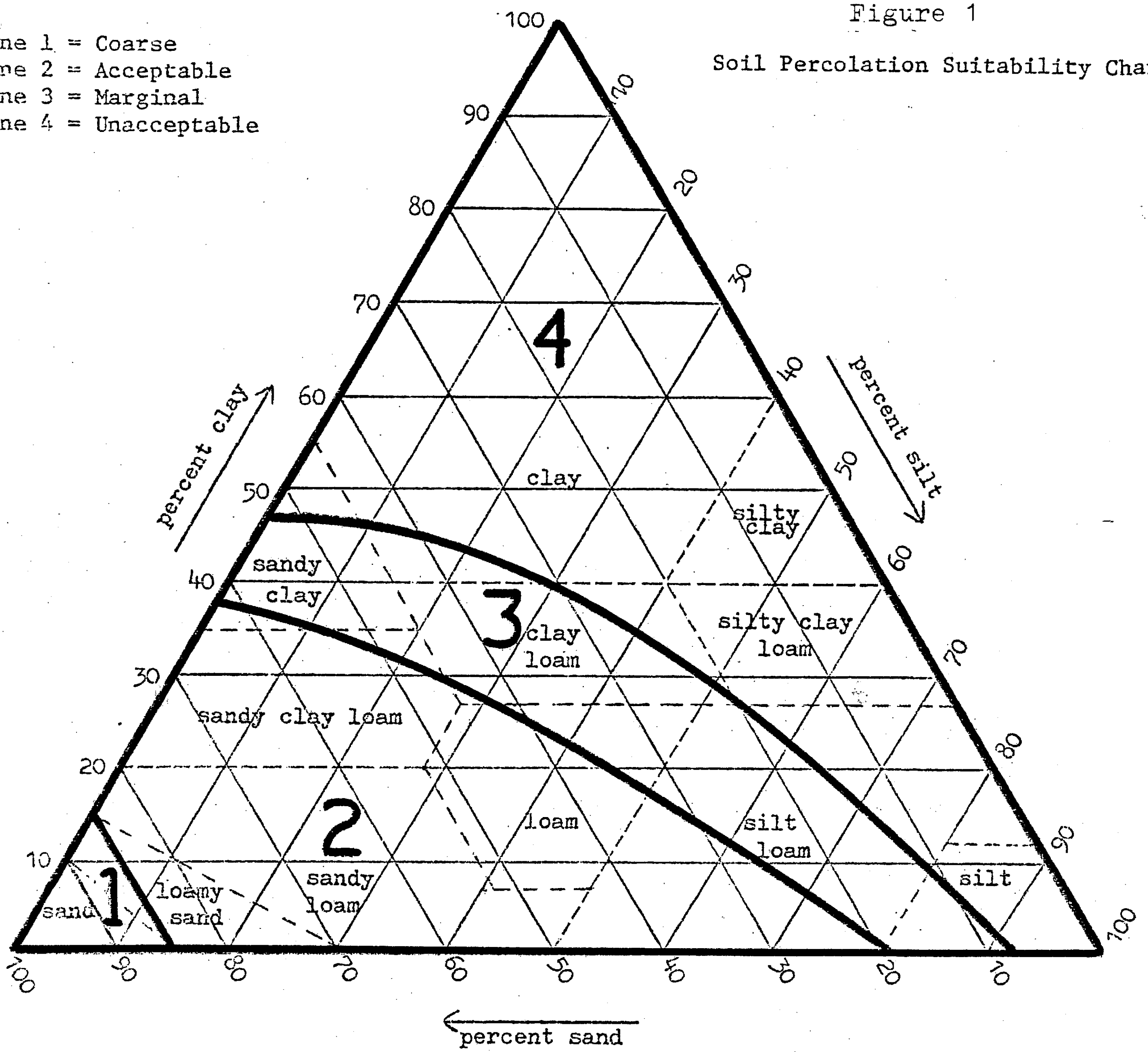
Zone 1 - Soils in this zone are very high in sand content. They readily accept effluent, but because of their low silt and clay content they provide minimal filtration. These soils demand greater separation distances from ground water.

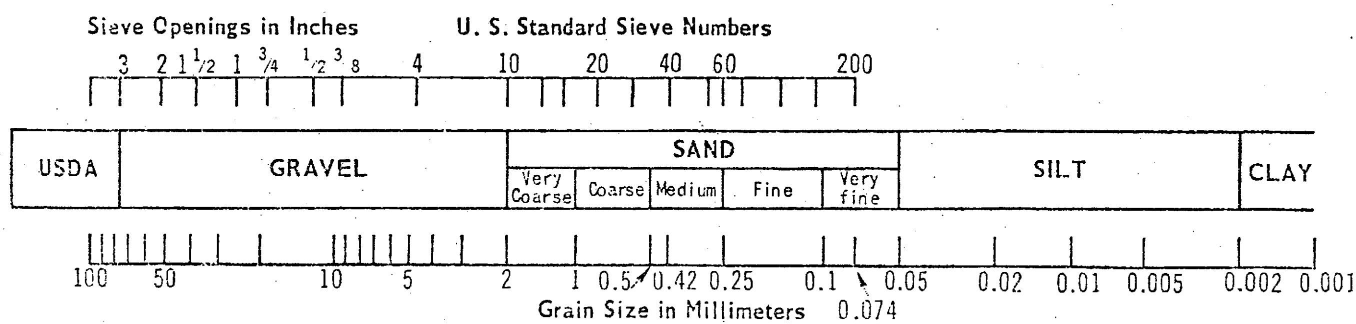
Zone 2 - Soils in this zone provide adequate percolation rates and filtration to effluent. They are suitable for use of a conventional system, without further testing.

Zone 1 = Coarse
Zone 2 = Acceptable
Zone 3 = Marginal
Zone 4 = Unacceptable

Figure 1

Soil Percolation Suitability Chart





Instructions:

1. Plot texture on triangle based on percent sand, silt, and clay as determined by hydrometer analysis.

2. Adjust for coarse fragments by moving the plotted point in the sand direction an additional 2% for each 10% (by volume) of fragments greater than 2mm in diameter.

3. Adjust for compactness of soil by moving the plotted point in the clay direction an additional 15% for soils having a bulk-density greater than 1.7 gm/cc.

Note: For soils falling in sand, loamy sand or sandy loam classification bulk density analysis will generally not affect suitability and analysis not

Zone 3 - Soils in this zone are expected to provide good filtration of effluent, but their ability to accept effluent at a suitable rate is questionable. These soils require wet-weather percolation tests to verify their suitability for effluent disposal by conventional leachfield methods.

Zone 4 - Soils in this zone are unsuitable for a conventional leachfield because of their severe limitations for accepting effluent.

To determine what zone a soil is in, the percent of sand, silt and clay need to be plotted on the chart. The point at which the sand, silt and clay amounts intersect determines the zone. For example, if the soil has 15% clay, 25% silt and 60% sand, it will plot in Zone 2, and have a sandy loam texture.

There are some other soil properties that have an effect on soil percolation. They affect percolation to a lesser degree than does soil texture, but they should be taken into account. (1) Coarse fragment content. When fragments ranging from 2mm to 10 inches in diameter are present in sufficient number the percolation rate will be increase. (2) Bulk-density. When a soil is overly compact the pore size distribution is decreased giving the soil a slower percolation rate.

Generally, the coarser the texture of a soil the greater the bulk-density. Values exceeding1.7 gm/cc are not uncommon for sands and loamy sands, but the effect on percolation characteristics should not make such soils unsuitable for effluent disposal. Soils having a finer texture are not likely to have bulk-density values exceeding 1.7 gm/cc unless they have been significantly compacted. This high degree of compaction causes a marked decrease in percolation, consequently reducing the suitability for effluent disposal. For this reason, 1.7 gm/cc is considered a reasonable indicator value for adjusting the estimate of a soil's percolation suitability.

Coarse fragment content and bulk-density can be measured quantitatively, and used to adjust the plotted texture determination on the Soil Percolation Suitability Chart. When the texture determination point has been adjusted, the zone within which the point falls will indicate the soil's suitability for effluent disposal.

There are other soil factors that may affect percolation, but their effect is usually minor or not expected to occur in the soils of the North Coast Region. These include excess sodium, soil structure, excess pore size, minerology and organic matter.

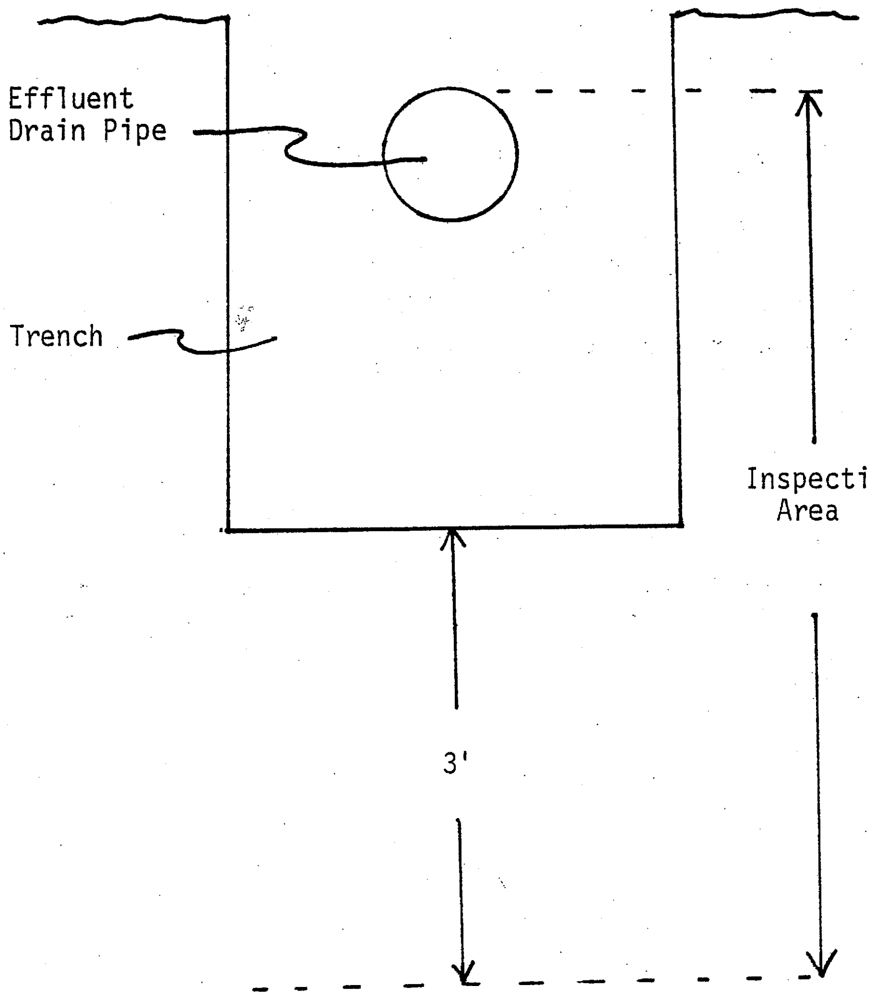
SAMPLING METHOD

The way in which soils are sampled for analysis is extremely important. Incorrect sampling methods are likely to yield unrepresentative data, and lead to a misinterpretation of the soil's suitability. For example, if a loam surface soil is sampled for texture analysis and plots in Zone 2 on the Soil Percolation Suitability Chart, the soil would be deemed suitable for effluent disposal. It may, however, be underlain by a more restrictive silty clay loam subsoil, in which case the soil suitability determination based on the topsoil would be misleading. On the other hand, if a thin, silty clay overwash is sampled for analysis, but under it are strata of sandy loam and loam extending to great depth, the soil may incorrectly be judged unsuitable for effluent disposal. These two cases illustrate why samples must be taken from each layer within the filtering zone.

Procedure

When sampling, keep in mind the area of soil that will be used for sewage disposal. This is the area from the top of the effluent drain pipes to 3 feet below the bottom of the trenches. It is the area through which effluent must pass. Each soil layer occurring within this zone should be sampled for analysis. This will allow full characterization of soil conditions in the disposal area.

To take a soil sample a blunt knife or trowel can be used to remove soil from the desired layer of the soil profile. The soil samples should be about 1 or 2 lbs. If possible, they should be in the form of undisturbed soil aggregates. If soil aggregates are crushed or compacted, the bulk-density analysis cannot be done. The amount of soil required for all analyses are as follows: (1) Particle size analysis, 50-100 gm. (2) Bulk-density analysis, 50-100 gm. (3) Coarse-fragment determination, 300-500 gm. The soil samples can be put in plastic bags during transportation to a laboratory.



The area between the top of the effluent drain pipes and 3 feet below the bottom of the trenches should be inspected. Each soil layer in this area should be sampled for analysis.

Figure 7. Inspection area

Field Method for Textural Estimation

Sometimes it may be useful to compare soil texture characteristics prior to conducting laboratory analyses. The following simple method can be used in the field. It consists of comparing the way the different layers feel.

To feel a soil, it must be moistened. Take a small amount of the soil, about the size of a golf ball. If it is dry, break it up into small pieces the size of pea gravel. Add water, a little at a time, until it assumes the consistency of putty. (A plastic squeeze bottle is convenient for adding water.) This is necessary because aggregated clay particles may feel like sand or silt when dry. Work the moistened soil vigorously between your thumb and forefingers. Also, try sliding your thumb against the soil and notice how the soil feels and adheres to your fingers.

Clay feels quite sticky and plastic when moist. There is no gritty or floury feel. It can be formed into a long wire or ribbon without breaking.

Silt feels soft and floury. It is not gritty or sticky. It may be slightly plastic. A short wire or ribbon can be formed, but is easily broken.

Sand feels very gritty. The individual grains can be seen with the unaided eye. It is non-sticky and non-plastic, and no wire or ribbon can be formed.

Since soil is a mixture of sand, silt, and clay, it is likely that a combination of their characteristics will be noted. The layer that most exhibits the characteristics of clay will be the most limiting layer to percolating effluent.

SUMMARY OF INSPECTION PROCEDURE

1. Review any reports that have been made covering the parcel in question.

2. See that the parcel meets requirements for setback distances and maximum slopes.

3. Dig soil inspection pits in areas proposed for system installation.

4. Observe depth to rock or other unsuitable filtering medium.

5. Observe depth or indicated depth to ground water.

6. Sample each soil layer in filtering zone for analyses.

7. Plot results of analyses on Soil Percolation Suitability Chart to determine soil suitability.

APPENDICES

A. GLOSSARY

B. LABORATORY PROCEDURES

C. REFERENCES AND SUGGESTED READING

GLOSSARY

Abney Level
: Hand held instrument, utilizing a pivoting bubble level, used for measuring slope.

Alluvium
: Soil material deposited on land by streams.

Anaerobic Conditions
: Conditions in soil such that oxygen is absent. Usually caused by sautration by water.

Bedrock
: Solid rock, which may have fractures, that lies beneath soils and other unconsolidated material. Bedrock may be exposed at the surface or have an overburden several hundred feet thick.

Bulk-density
: The mass of dry soil per unit bulk volume. The bulk volume is determined before drying to a constant weight at 105°C.

Clay
1. A soil particle less than 2 microns in size.
2. A soil texture classification containing more than 40 percent clay particles, less than 45 percent sand and less than 40 percent silt.

Clay Loam
: A soil texture classification containing between 27 and 40 percent clay, and between 20 and 45 percent sand.

Clinometer
: A hand held instrument, utilizing a weighted wheel, used for measuring slope.

Coarse Fragments
: Pieces of rock greater than 2 mm. in diameter. For the purpose of this manual coarse fragments include gravel and cobbles. The upper limit in diameter is 10 inches.

Cobbles
: Pieces of rock ranging in diameter from 3 inches to 10 inches.

Cut Bank
: A man-made excavation of the natural terrain in excess of three feet.

Daylight
: Sewage is said to daylight when it moves laterally and reaches the ground surface downhill of the leachfield without being effectively treated.

Ephemeral Stream

Any observable watercourse that flows only in direct response to precipitation. It receives no water from springs and no long-continued supply from melting snow or any other source. Its stream channel is at all times above the local water table. Any watercourse that does not meet this definition is considered to be a perennial stream for the purposes of this manual.

Excess Sodium

A condition in which sodium ions greatly outnumber other di- or trivalent cations in soil. This condition leads to clay becoming overly electro-negative and repelling each other, thus clogging soil pores.

Flood Plain

A nearly level alluvial plain that borders a stream, and is subject to flooding unless artificially protected.

Gravel

Pieces of rock ranging in diameter from 2 mm to 3 inches.

Ground Slope

The degree of slope of land expressed in percent. Rise over run times 100 equals percent.

Ground Water

Any subsurface body of water which is beneficially used or is usable. It includes perched water if such water is used or usable, or is hydraulically continuous with used or usable water.

Hardpan

An irreversibly hardened soil layer caused by the cementation of soil particles. The cementing agent may be silica, calcium carbonate, iron, or organic matter.

Hydrometer

Instrument used for measuring the density of a soil suspension. Bouyoucous scale reads grams per liter.

Hydrophytic Vegetation

Water-loving plants, growing in or around very wet areas.

Impermeable Soil Layer

Any layer of soil having a percolation rate slower than 120 mpi or an "unacceptable" soil texture (zone 4) according to the Soil Percolation Suitability Chart contained in this manual.

Intermittent Stream

A stream that is expected to flow seasonally because of snow-melt or watershed drainage, but usually dries up at some time during the year. Considered a perennial stream for the purposes of this manual.

Landform

An easily recognizable natural configuration of land. Examples are mountains, terraces, and floodplains.

Limiting Soil Layer

The portion of the soil profile that because of percolation characteristics most restricts the successful operation of a leachfield.

Loam

A soil texture classification that contains between 7 and 27 percent clay, between 28 and 50 percent silt, and less than 52 percent sand.

Loamy Sand

A soil texture classification that contains at the upper limit between 85 and 90 percent sand, and the percentage of silt plus 1.5 times the percentage of clay is not less than 15; at the lower limit it contains not less than 70 to 85 percent sand, and the percentage of silt plus 1.5 times the percentage of clay does not exceed 30.

Mediterranean Climate

A climate characterized by cool, moist winters and warm, dry summers. Snow is rare, as are temperatures greater than 100°F.

Minerology

Refers to the kinds and proportions of clay minerals in soils.

Mottles (Soil Mottling)

Irregular spots of different colors that vary in size and number. Mottling in soil usually indicates poor aeration and lack of drainage.

Non-Usable Ground Water

Any subsurface water which cannot reasonably be expected to be used for withdrawal and beneficial use due to natural factors related to quality and quantity of supply.

Perennial Stream

Any stretch of stream that can be expected to flow continuously.

Sand

1. Soil particle ranging from 50 microns to 2 mm. in diameter.
2. A soil textural classification that contains at least 85 percent sand, and the percentage of silt, plus 1.5 times the percentage of clay does not exceed 15.

Sandy Clay

A soil textural classification that contains at least 35 percent clay and at least 45 percent sand.

Sandy Clay Loam

A soil textural classification that contains 20 to 35 percent clay, less than 28 percent silt, and at least 45 percent sand.

Sandy Loam

A soil textural classification that contains either 20 percent clay or less, and the percentage of silt plus twice the percentage of clay exceeds 30, and at least 52 percent sand; or less than 7 percent clay, less than 50 percent silt, and between 43 and 52 percent sand.

Saturated Soil

The condition of soil when all available pore space is occupied by water and the soil is unable to accept additional moisture. In fine textured soils a free water surface may not be apparent. The extent of saturated soil conditions can be estimated by the extent of soil mottling.

Silt

1. A soil particle ranging from 2 microns to 50 microns in size.
2. A soil textural classification that contains at least 80 percent silt and less than 12 percent clay.

Silt Loam

A soil textural classification that contains either at least 50 percent silt, and 12 to 27 percent clay; or 50 to 80 percent silt, and less than 12 percent clay.

Silty Clay

A soil textural classification that contains at least 40 percent clay and at least 40 percent silt.

Silty Clay Loam

A soil textural classification that contains 27 to 40 percent clay and less than 20 percent sand.

Slake

A soil aggregate slakes when it is placed in water and begins to fall apart as a result of the water destroying its structural integrity.

Soil

The unconsolidated material on the surface of the earth that exhibits properties and characteristics that are a product of the combined factors of parent material, climate, living organisms, topography, and time.

Soil Depth

The combined thickness of adjacent soil layers that are suitable for effluent filtration. Soil depth is measured vertically to bedrock, hardpan, an impermeable soil layer, or saturated soil.

Soil Texture - USDA

The relative amounts of sand, silt, and clay as defined by the classes of the soil textural triangle. Textural classes may be modified when coarse fragments are present in sufficient number, i.e., gravelly sandy loam, cobbly clay, etc.

Soil Structure

The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. The principal forms of soil structure are platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are either single grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans).

Standard System

Any system using a standard septic tank for treatment and standard leaching trenches or seepage pit for effluent disposal.

System Failure

The ineffective treatment and disposal of waste resulting in the surfacing of sewage effluent and/or the degradation of surface or ground water quality.

Texture Analysis

Apparatus

Pint jars
Wash bottle
No. 10 sieve
Volumetric cylinders, 1000 ml.
Hydrometer, Bouyoucous scale
Agitating plunger
Asbestos sleeves for cylinders
Stop watch

Reagents

Demineralized water
Sodium hexametaphosphate [$(NaPO_3)_6$], 5% solution. Dissolve 50 grams of dry reagent in 1 liter of demineralized water. It should all dissolve in less than 1 hour. This solution is subject to deterioration and should be made afresh monthly.

Procedure

Determining cementation

Carefully drop an undisturbed sample into a beaker of water. Observe whether or not the sample remains intact.

Determining coarse particle content

Sample should be at least 1 kilogram. Break-up and dry in oven at 105°C for 4 hours. Weigh sample to nearest gram. Use No. 10 sieve to separate coarse particles. Do not include particles greater than 3 inches. Weigh coarse particles to nearest gram. Retain soil that passes through No. 10 sieve for texture analysis.

Determining fine particle size distribution

Weigh to the nearest 0.1 gram a portion of soil passing the No. 10 sieve. Sample size should be approximately 50 grams if loamy or finer, 75 grams if sandy loam or 100 grams if sand.

Dispersing sample

Pour 100 ml. of 5% sodium hexametaphosphate solution into pint jar. Add weighed sample. Cover securely. Shake vigorously about one minute. Let soak for 5 days, shaking twice each day.

Determining texture

Transfer dispersed sample with dispersing solution to 1000 ml. cylinder. Use wash bottle filled with demineralized water to get all soil particles transferred from jar and lid. Add demineralized water to cylinder to 1000 ml. mark. Use plunger to agitate solution. Agitation must be sufficient to get entire sample into suspension, but gentle enough to prevent loss from splashing. Cease agitation and immediately begin timing. At 15 seconds, gently place hydrometer in cylinder. At 40 seconds read hydrometer at meniscus. Record temperature of solution. Remove hydrometer and rinse it. Gently place hydrometer in suspension just before two hours. At two hours read hydrometer at meniscus and record temperature of suspension.

Calculations

Texture

Correcting hydrometer readings for temperature and dispersing solution density

The Bouyoucous hydrometer reads grams per liter at 68°F. If the temperature is above or below 68°F, a correction of 0.2 must be made for each degree. For temperatures above 68°F 0.2 should be added to the reading. For temperatures below 68°F 0.2 should be subtracted from the reading. The dispersing solution, alone, at 0.5% should read 6.5 at 68°F. To get true solution density a composite correction should be made for temperature and dispersing solution density. See attached chart.

% sand = 100 - [(Corrected 40 sec. reading ÷ sieved sample weight) x 100]

% clay = (Corrected 2 hr. reading ÷ sieved sample wt.) x 100

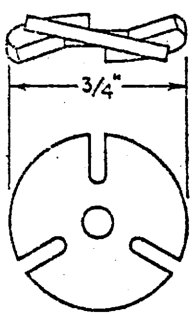
% silt = 100 - (%sand + %clay)

Coarse particle content

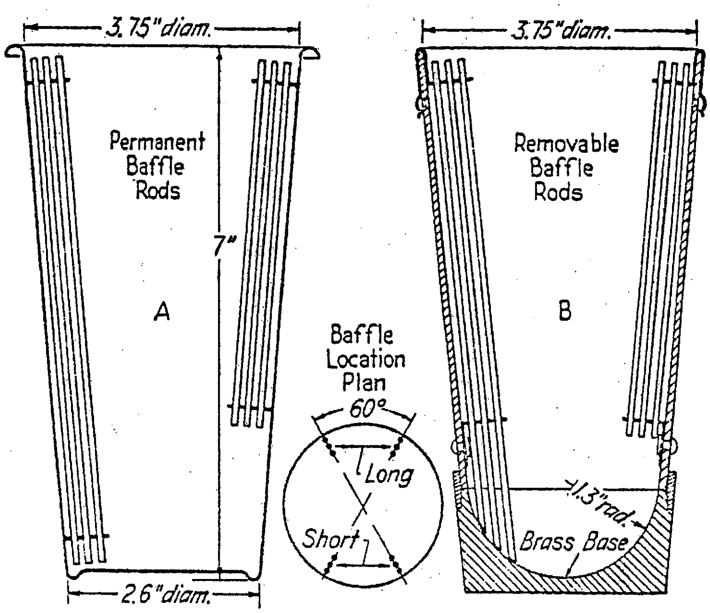
$$\% \text{ coarse particles} = \frac{\text{wt. coarse particles retained in No. 10 si}}{\text{wt. of total sample, oven dry}} \times 100$$

Note: An alternative procedure for dispersing the sample may be used. This requires a mechanically operated stirring device in which a suitably mounted electric motor turns a vertical shaft at a speed of not less than 10,000 rpm without load. The shaft is equipped with a replaceable stirring paddle made of metal, plastic, or hard rubber, as shown below. The shaft is of such a length that the stirring paddle will operate not less than 3/4 inch nor more than 1-1/2 inches above the bottom of the dispersion cup. A special dispersion cup conforming to either of the designs shown below is provided to hold the sample while it is being dispersed.

Place the weighed sample in a 250 ml. beaker and cover with 125 ml. of sodium hexametaphosphate solution. Stir until the soil is thoroughly wetted. Allow to soak for at least 16 hours. Transfer the soil-water slurry from the beaker into the dispersion cup, washing any residue from the beaker into the cup with demineralized water. Add demineralized water, if necessary, so that the cup is more than half full. Stir for a period of 1 minute.



Detail of Stirring Paddle



Dispersion Cups

WORK SHEET FOR SOIL TEXTURE

Sample Location ____

Sample number				
Depth				
A. Ovendry wt. (gm)				
B. Starting time (hr:min:sec)				
C. Temp @ 40 sec (^{o}F.)				
D. Hydrometer reading @ 40 sec (gm/l)				
E. Composite correct (gm/l)				
F. True density @ 40 sec (gm/l)D.-E.				
G. Temp @ 2 hrs. (^{o}F.)				
H. Hydrometer reading @ 2 hrs. (gm/l)				
I. Composite Correction (gm/l)				
J. True density @ 2 hrs. (gm/l) H.-I.				
K. % Sand=100 - [(F÷A) x 100]				
L. % Clay = (J. ÷ A.) x 100				
M. % Silt = 100 - (k.+L.)				

USDA texture ____________________

Soil Percolation Suitability Chart zone ________________

COMPOSITE CORRECTIONS*
to be applied to readings of
standard soil hydrometers
when floating in a 0.5%
solution of $(NaPO_3)_6$

Temperature of Solution	Correction (Minus)
Degrees F.	GM./L
60	-8.1
61	-7.9
62	-7.7
63	-7.5
64	-7.3
65	-7.1
66	-6.9
67	-6.7
68	-6.5
69	-6.3
70	-6.1
71	-5.9
72	-5.7
73	-5.5
74	-5.3
75	-5.1
76	-4.9

Explanation:

Volume of solution increases as temperature increases, therefore density decreases. Correction factor should be subtracted from hydrometer stem reading after determining temperature of soil solution.

Example:

When reading is 24 grams on stem reading and temperature of soil solution in cylinder is 72°F, subtract 5.7 grams from 24 grams, for a corrected reading of 18.3 grams.

*Involves the density of a 0.5% $Na(PO_3)_6$ solution between 60-76°F. Method should not be performed when temperature of solution is less than 60°F or more than 76°F. Correction table adapted from Hydrometer Method Improved for Making Particle Size Analyses of Soils, by G. J. Bouyouces, Agron. Journal Vol. 54, No. 5, Sept.-Oct. 1962.

Bulk-Density Analysis

Density is defined as mass per unit volume. Soil density differs from most densities in that the mass of the liquid phase is excluded. Also, the volume over which the weight is determined includes interparticle space. Because of these irregularities, soil density has been called bulk density, Db, to distinguish it from the more usual density that is based on intraparticle volume only.

Sampling Procedure

Collect natural clods of about 50 to 200 cc. Chip a piece of soil larger than the clod from the face of the inspection pit. From this piece remove two clods by gently breaking of protruding peaks and any areas that may have been compacted. Cut off any roots. Because of moisture content and texture some soils are easier to sample than others. This procedure may be adapted to ensure a satisfactory sample is obtained. Carefully pack the sample to protect it while en route to the laboratory.

Laboratory Procedure

1. Air dry both clods at 90°F until a constant weight is reached. Weigh the clods.

2. Sieve the first clod and weigh those particles greater than 2mm (wt. greater than 2mm). Determine the volume of the particles greater than 2mm by water displacement (vol. greater than 2mm).

3. Tie a thread around the second clod and immerse it in paraffin melted at 100-110°C for about 15 seconds. Measure the volume of the clod by water displacement.

Calculations

$$\text{Vol. first clod} = \frac{(\text{Vol. second clod})\ (\text{Wt. first clod})}{\text{Wt. second clod}}$$

$$\text{Db} = \frac{\text{Wt. first clod} - \text{wt.} > 2\text{mm}}{\text{Vol. first clod} - \text{vol.} > 2\text{mm}}$$

Where

Db = bulk density of air-dry soil particles smaller than 2mm.

Note: A core sampling procedure may be used to determine bulk-density. This method may be used when the core contains no coarse fragments more than 10 to 20mm in diameter and when there are no large cracks in the horizon.

Procedure

To collect the cores, prepare a flat surface in the sampling pit, either horizontal or vertical, at the desired depth. Press the core sampler into the soil, using caution to prevent compaction. Remove the core in the aluminum liner and place both in a moisture can for transport to the laboratory. If the soil is too loose to remain in the core, use the core sampler without the liner and deposit the entire sampler in a moisture can.

Calculations

$$\text{Bulk-density (g/cc)} = \frac{\text{oven dry wt. core (g)}}{\text{vol. core (cc)}}$$

WORK SHEET FOR SOIL BULK-DENSITY

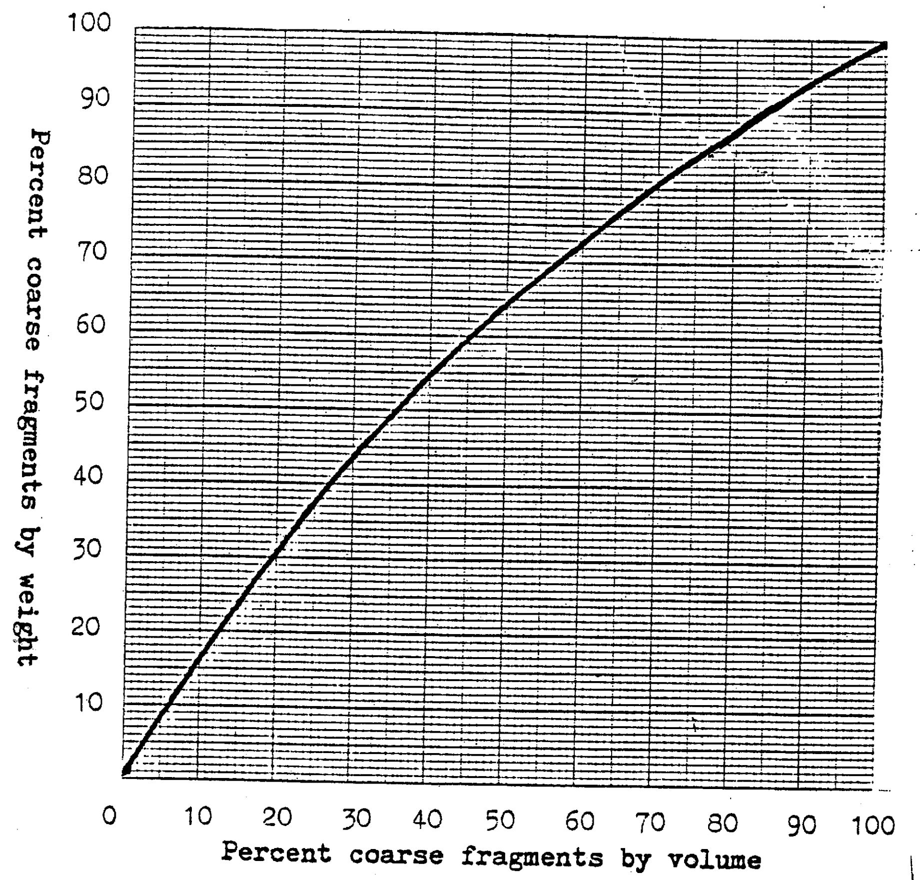
Sample Location ______________________________

____

Sample number						
Depth						
A. 90°F - dry wt. before paraffin coating (gm)						
B. Paraffin coated clod wt. in water (gm)						
C. 90°F - dry vol. (cc) A. - B.						
D. Ovendry wt. (gm)						
E. >2mm. particle wt. (gm)						
F. Vol. of water displaced by >2mm. particles (cc)						
G. Db_{ad} = (D. - E.) ÷ (C. - F.)						

Coarse Fragment Weight to Volume

Conversion Curve



To convert the amount of coarse fragments from a weight to a volume percentage;

1) locate the percent, by weight, on the vertical axis,
2) move horizontally to the right and intersect the conversion curve,
3) move straight down to the horizontal axis and read percent by volume.

Conversion curve based on the formula:

$$W = \frac{2.7V}{1.5(100-V)+(2.7V)}$$ where

W = percent coarse fragments, by weight
V = percent coarse fragments, by volume
2.7 = average specific gravity of coarse fragments
1.5 = average bulk-density of soil without coarse fragments

APPENDIX C

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