Part 618 - SOIL PROPERTIES AND QUALITIES

CONTENTS

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618.00 Definition and Purpose.

(a) Soil properties are measured or inferred from direct observations in the field or laboratory. Soil properties include, but are not limited to, particle-size distribution, cation exchange capacity, and salinity.

(b) Soil qualities are behavior and performance attributes that are not directly measured. They are inferred from observations of dynamic conditions and from soil properties. Soil qualities include, but are not limited to, corrosivity, natural drainage, frost action, and wind erodibility.

(c) Soil properties and soil qualities are the criteria used in soil interpretation rating guides, as predictors of soil behavior, and for classification and mapping of soils. The soil properties entered should be representative of the soil for the dominant land use for which interpretations will be based.

618.01 Policy and Responsibilities.

(a) Soil property data are collected, tested, and correlated as part of soil survey operations. These data are reviewed, supplemented, and revised as necessary.

(b) The soil survey project office is responsible for collecting, testing, and correlating soil property data and interpretive criteria.

(c) The MLRA office is responsible for the development, maintenance, quality assurance, correlation, and coordination of the collection of soil property data that are used as interpretive criteria. This includes all data elements listed in part 618.

(d) The National Soil Survey Center is responsible for the training, review, and periodic update of soil interpretation technologies.

(e) The state soil scientist is responsible for ensuring that the soil interpretations are adequate for the field office technical guide and that they meet the needs of federal, state, and local programs.

618.02 Collecting and Testing Soil Property Data.

The collection and testing of soil property data is based on the needs described in the soil survey memorandum of understanding for individual soil survey areas. The collection and testing must conform to the procedures and guides established in this handbook.

618.03 Soil Properties and Soil Qualities.

The following sections list soil properties and qualities in alphabetical order and provide some grouping for climatic and engineering properties and classes. A definition, classes, significance, method, and guidance for NASIS database entry are given. The listing includes the soil properties and qualities in the National Soil Information System. For specifics of data structure, attributes, and choices in NASIS, refer to http://nasis.nrcs.usda.gov/documents/metadata/5_1/

Previous databases of soil survey information used metric or English units for soil properties and qualities. The National Soil Information System (NASIS) transferred English units to metric units on conversion, except for crop yields in the database. All future edits and entries in NASIS will use metric units, except yields and acreage.

Ranges of soil properties and qualities, posted in the NASIS database for map unit components, may extend beyond the established limits of the taxon from which the component gets its name, but only to the extent that interpretations do not change. However, the representative value (RV) is within the range of the taxon.

618.04 Albedo, Dry.

(a) Definition. Albedo, dry, is the estimated ratio of the incident shortwave (solar) radiation that is reflected by the air-dry, less than 2 mm fraction of the soil surface to that received by it.

(b) Significance. Soil albedo, as a function of soil color and angle of incidence of the solar radiation, depends on the inherent color of the parent material, organic matter content, and weathering conditions.

Estimates of the evapotranspiration rates and for predicting soil water balances require the albedo. Evapotranspiration and soil hydrology models that are part of Water Quality and Resource Assessment programs require this information.

(c) Measurement. Instruments exist that measure albedo.

(d) Estimation. Approximate the values by use of the following formula:

Soil Albedo=0.069 x (Color Value} - 0.1l4. For albedo, dry, use dry color value. Surface roughness has a separate significant impact on the actual albedo. The equation above is the albedo of <2.0 mm smoothed soil condition, but if the surface is rough because of tillage, the albedo differs.

(e) Entries. Enter the high, low, and representative values of the map unit component using the above formula. Allowable entries range from 0.00 to 1.00, with 2 decimal places.

618.05 Available Water Capacity.

(a) Definition. Available water capacity is the volume of water that should be available to plants if the soil, inclusive of fragments, were at field capacity. It is commonly estimated as the amount of water held between field capacity and wilting point, with corrections for salinity, fragments, and rooting depth.

(b) Classes. Classes of available water capacity are not normally used except as adjective ratings that reflect the sum of available water capacity in inches to some arbitrary depth. Class limits vary according to climate zones and the crops commonly grown in the areas. The depth of measurement also is variable.

(c) Significance. Available water capacity is an important soil property in developing water budgets, predicting droughtiness, designing and operating irrigation systems, designing drainage systems, protecting water resources, and predicting yields.

(d) Estimates. The most common estimates of available water capacity are made in the field or the laboratory as follows:

(1) Field capacity is determined by sampling the soil moisture content just after the soil has drained following a period of rain and humid weather, after a spring thaw, or after heavy irrigation. The Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, provides more information.

(2) The 15-bar moisture content of the samples is determined with pressure membrane apparatus.

(3) An approximation of soil moisture content at field capacity is commonly made in the laboratory using 1/3-bar moisture percentage for clayey and loamy soil materials and 1/10-bar for sandy materials. Recently, some soil physicists have been using 1/10-bar instead of 1/3-bar for clayey and loamy soil materials and 1/20-bar for sandy soil materials.

(4) Measure the bulk density of the moist soil. The Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, provides more information.

(5) Calculate available water capacity (AWC) using the following formula:

$$AWC = \frac{(W_{1/3} - W_{15}) \times (Db_{1/3}) \times Cm}{100}$$

Where

AWC = volume of water retained in 1 cm^3 of whole soil between 1/3-bar and 15-bar tension; reported as
$cm\ cm^{-1}$, i.e., numerically equivalent to inches of water per inch of soil ($in\ in^{-1}$)

$W_{1/3}$ = weight percentage of water retained at 1/3-bar tension

W_{15} = weight percentage of water retained at 15-bar tension

$Db_{1/3}$ = bulk density of <2-mm fabric at 1/3-bar tension

$$Cm = \frac{\text{Vol moist <2-mm fabric } (cm^3)}{\text{Vol moist whole soil } (cm^3)}$$

Procedure 3B2 is used to determine Vol moist <2-mm fabric (cm^3).

AWC ($cm\ cm^{-1}$ horizon) or ($in\ in^{-1}$) = AWC ($cm\ cm^{-1}$) X horizon thickness or ($in\ in^{-1}$)

(6) If data are available, estimates are based on available water capacity measurements. If data are not available, data from similar soils are used as a guide. The relationship between available water capacity and other soil properties has been studied by many researchers. Soil properties that influence available water capacity are particle size; size, shape, and distribution of pores; organic matter; type of clay mineral; and structure.

(7) If roots are excluded from a layer, such as a duripan, petrocalcic horizon, or fragipan, the amount of water available to plants is nearly zero. Available water capacity values are zero for layers that exclude roots. If roots are restricted but not excluded, estimates of available water capacity are reduced according to the amount of dense material in the layers and the space available for root penetration. Depending on the ability of roots to enter the soil mass and utilize the water, values for the soils with these dense layers may be significantly less than for soils of similar texture that do not have pans. Entries are made for all soil layers below dense layers only if roots are present.

(8) Depending on their abundance and porosity, rock and pararock fragments reduce available water capacity. Nonporous fragments reduce available water capacity in proportion to the volume they occupy, for example, 50 percent nonporous cobbles reduces available water capacity as much as 50 percent. Porous fragments, such as sandstone, may reduce available water capacity to a lesser proportion.

(9) Several factors contribute to a lower amount of plant growth on saline soils. However, as a rough guide, available water capacity is reduced by about 25 percent for each 4 $mmhos\ cm^{-1}$ electrolytic conductivity of the saturated extract.

(10) Soils high in gibbsite or kaolinite, such as Oxisols and Ultisols, may have available water capacity values that are about 20 percent lower than those with equal amounts of 2:1 lattice clays.

(11) Soils high in organic matter have higher available water capacity than soils low in organic matter if the other properties are the same.

(e) Entries. Enter high, low, and representative values for available water capacity in cm per cm for each horizon. Enter "0" for layers that exclude roots. The range of valid data entries is 0.00 to 0.70 cm per cm.

618.06 Bulk Density, One-Tenth Bar or One-Third Bar.

(a) Definition. Bulk density one-tenth bar or one-third bar is the oven-dried weight of the less than 2 mm soil material per unit volume of soil at a water tension of 1/10 bar or 1/3 bar.

(b) Significance. Bulk density influences plant growth and engineering applications. It is used to convert measurements from a weight basis to a volume basis. Within a family particle size class, bulk density is an indicator of how well plant roots are able to extend into the soil. Bulk density is used to calculate porosity.

(1) Plant growth. Bulk density is an indicator of how well plant roots are able to extend into the soil. Root restriction initiation and root limiting bulk densities are shown below for various family particle size classes.

Family particle-size	**Bulk density (g cm^{-3})**	
Classes	**Restriction- initiation**	**Root- limiting**
Sandy	1.69	>1.85
Loamy		
coarse-loamy	1.63	>1.80
fine-loamy	1.60	>1.78
coarse-silty	1.60	>1.79
fine-silty	1.54	>1.65
Clayey*		
35-45% clay	1.49	>1.58
>45% clay	1.39	>1.47

* Oxidic and andic materials can initiate restriction at lower bulk densities.

(2) Engineering applications. Soil horizons with bulk densities less than those indicated below have low strength and would be subject to collapse if wetted to field capacity or above without loading. They may require special designs for certain foundations.

Family particle-size	**Bulk density (g cm^{-3})**
Sandy	<1.60
Loamy	
coarse-loamy	<1.40
fine-loamy	<1.40
coarse-silty	<1.30
fine-silty	<1.40
Clayey	<1.10

(c) Estimates. The weight applies to the oven-dry soil, and the volume applies to the soil at or near field capacity. For non-expansive soils, the 1/10-bar and 1/3-bar bulk densities are the same. Bulk density is a use dependent property. The entry should represent the dominant use for the soil.

(d) Entries. Enter bulk density at one tenth bar or one third bar with the low, high, and representative values for each horizon. The range of valid entries is 0.02 to 2.60 g cm^{-3}. Values should be estimated to the nearest 0.05 g cm^{-3}.

618.07 Bulk Density, 15 Bar.

(a) Definition. Bulk density 15 bar is the oven dry weight of the less than 2 mm soil material per unit volume of soil at a water tension of 15 bar.

(b) Significance. Bulk density, 15 bar, is necessary for resource assessment models such as Soil Hydrology, Water Budgets, Leaching and Nutrient/Pesticide Loading.

(c) Estimation. The value is derived by the following formula:

$$Db_{15} = [(\text{linear extensibility percent}/100) + 1]^3$$

where Db_{15} = bulk density 15 bar, and; linear extensibility is adjusted to a <2 mm basis.

(d) Entries. Enter the high, low, and representative value for each horizon. Valid entries range from 0.02 to 2.60 and 2 decimal places are allowed.

618.08 Calcium Carbonate Equivalent.

(a) Definition. Calcium carbonate equivalent is the quantity of carbonate (CO_3) in the soil expressed as $CaCO_3$ and as a weight percentage of the less than 2 mm size fraction.

(b) Significance. The availability of plant nutrients is influenced by the amount of carbonates in the soil. This is a result of the effect that carbonates have on soil pH and of the direct effect that carbonates have on nutrient availability. Nitrogen fertilizers should be incorporated into calcareous soils to prevent nitrite accumulation or ammonium-N volatilization. The availability of phosphorus and molybdenum is reduced by the high levels of calcium and magnesium which are associated with carbonates. In addition, iron, boron, zinc, and manganese deficiencies are common in soils that have a high calcium carbonate equivalent. In some climates, soils that have a high calcium carbonate equivalent in the surface layer are subject to wind erosion. This effect may occur in soils that have a calcium carbonate equivalent of more than 5 percent. Strongly or violently effervescent reaction to cold dilute HCL defines calcareous in the wind erodibility groups because of the significance of finely divided carbonates.

(c) Measurement. Calcium carbonate equivalent is measured by method 6E1 as outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS. It also may be measured in the field using calcimeters.

(d) Entries. Enter the high, low, and representative values for each horizon listed. Round values to the nearest 5 percent for horizons that have more than 5 percent $CaCO_3$ and to the nearest 1 percent for those with less than 5 percent. Enter 0 if the horizon does not have free carbonates.

618.09 Cation Exchange Capacity NH_4OAc pH7.

(a) Definition. Cation-exchange capacity is the amount of exchangeable cations that a soil can adsorb at pH 7.0.

(b) Significance. Cation-exchange capacity is a measure of the ability of a soil to retain cations, some of which are plant nutrients. Soils that have a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils that have a high cation-exchange capacity. Soils that have high cation-exchange capacity have the potential to retain cations, which reduces the risk of the pollution of ground water.

(c) Measurement. Cation-exchange capacity is measured by the methods outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004. The ammonium acetate method 5A8 gives the cation-exchange capacity value for soils that have pH ≥5.5 or that contain soluble salts. Cation-exchange capacity is expressed in milliequivalents per 100 grams (me $100g^{-1}$), of soil. If the pH is less than 5.5, use effective cation-exchange capacity (refer to part 618.17).

(d) Entries. Enter the high, low, and representative values of the estimated range in cation exchange capacity, in meq $100g^{-1}$, for each horizon with pH ≥5.5. Values in tenths are allowed. Valid entries range from 0.0 to 400.0.

618.10 Climatic Setting.

Climatic setting includes frost free period, precipitation, temperature, and evaporation. These elements are useful in determining the types of natural vegetation or crops that grow or can grow in an area and in planning management systems for vegetation. Climatic data are observed nationally by the National Weather Service Cooperative Network, which consists of approximately 10,000 climate stations. The records are available from the Climatic Data Access Facility (CDAF) at Portland, Oregon. Climatic data are delivered to the field through a Climatic Data Access Network. The Climatic Data Access Network consists of climatic data liaisons established in each state and at National Headquarters. Climatic data that are input into NASIS are obtained from the respective climatic data liaison. Climatic data may also be obtained from project weather stations or from the state climatologist. NRCS has selected the standard "normal" period of 1971 to 2000 for climate database entries. Always check with your state's climatic data liaison before using a climate station that has less than 30 years of records or that is located outside a county. Footnote the source of the data, the station, and the starting and ending year of record. Means are given as a range to represent the change of the climate over the geographic extent of the assigned soil.

(a) Frost-Free Period.

(1) Definition. Frost-free period is the expected number of days between the last freezing temperature (0° C) in spring (January-July) and the first freezing temperature (0° C) in fall (August-December). The number of days is based on the probability that the values for the standard "normal" period of 1971 to 2000 will be exceeded in 5 years out of 10.

(2) Entries. Enter the high, low, and representative values for the map unit component. Enter 365 for each value for taxa that are frost-free all year and 0 for those that have no frost-free period. Entries are rounded to the nearest 5 days.

(b) Precipitation, Mean Annual.

(1) Definition. Mean annual precipitation is the arithmetic average of the total annual precipitation taken over the standard "normal" period, 1971-2000. Precipitation refers to all forms of water, liquid or solid, that fall from the atmosphere and reach the ground.

(2) Entries. Enter the high, low, and representative values in millimeters of water, as integers to represent the spatial range for the map unit component.

(c) Air Temperature, Mean Annual.

(1) Definition. Mean annual air temperature is the arithmetic average of the daily maximum and minimum temperatures for a calendar year taken over the standard "normal" period, 1971-2000.

(2) Entries. Enter the high, low, and representative values as integers for the map unit component to represent the spatial range in degrees centigrade. Use a minus sign to indicate below zero temperatures.

(d) Daily Average Precipitation.

(1) Definition. Daily average precipitation is the total precipitation for the month divided by the number of days in the month for the standard "normal" period, 1971-2000.

(2) Entries. Enter the high, low, and representative value in mm. The range of allowed entries is 0 to 750 mm.

(e) Daily Average Potential Evapotranspiration

(1) Definition. Daily average potential evapotranspiration is the total monthly potential evapotranspiration divided by the number of days in the month for the standard "normal" period, 1971-2000.

(2) Entries. Enter the high, low, and representative value in mm. The range of allowed entries is 0 to 300 mm.

618.11 Corrosion.

Various metals and other materials corrode when they are on or in the soil, and some metals and materials corrode more rapidly when in contact with specific soils than when in contact with others. Corrosivity ratings are given for two of the common structural materials, uncoated steel and concrete.

(a) Uncoated steel.

(1) Definition. Risk of corrosion for uncoated steel is the susceptibility of uncoated steel to corrosion when in contact with the soil.

(2) Classes. The risk of corrosion classes are low, moderate, and high.

(3) Significance. Risk of corrosion on uncoated steel pertains to the potential soil-induced electrochemical or chemical action that converts iron into its ions, thereby dissolving or weakening uncoated steel.

(4) Guides. Exhibit 618-1 gives the relationsip of soil moisture, soil texture, acidity, and content of soluble salts (as indicated by either electrical resistivity at field capacity or electrolytic conductivity of the saturated extract of the soil) to corrosion classes.

(i) Soil reaction (pH) correlates poorly with corrosion potential; however, a pH of 4.0 or less almost always indicates a high corrosion potential.

(ii) Ratings, which are based on a single soil property or quality, that place soils in relative classes for corrosion potential must be tempered by knowledge of other properties and qualities that affect corrosion. A study of soil properties in relation to local experiences with corrosion helps soil scientists and engineers to make soil interpretations. Special attention should be given to those soil properties that affect the access of oxygen and moisture to the metal, the electrolyte, the chemical reaction in the electrolyte, and the flow of current through the electrolyte. A constant watch should be maintained for the presence of sulfides or of minerals, such as pyrite, that can be weathered readily and thus cause a high degree of corrosion in metals.

(iii) The possibility of corrosion is greater for extensive installations that intersect soil boundaries or soil horizons than for installations that are in one kind of soil or in one soil horizon.

(iv) Using interpretations for corrosion without considering the size of the metallic structure or the differential effects of using different metals may lead to wrong conclusions. Activities, such as construction, paving, fill and compaction, and surface additions, that alter the soil can increase possibility of corrosion by creating an oxidation cell that accelerates corrosion. Mechanical agitation or excavation that results in aeration and in a discontinuous mixing of soil horizons may also increase the possibility of corrosion.

(5) Entries. Enter the appropriate class of risk of corrosion for uncoated steel for the whole soil. The classes are LOW, MODERATE, or HIGH.

(b) Concrete.

(1) Definition. Risk of corrosion for concrete is the susceptibility of concrete to corrosion when in contact with the soil.

(2) Classes. The risk of corrosion classes are low, moderate, and high.

(3) Significance. Risk of corrosion on concrete pertains to the potential soil-induced chemical reaction between a base (the concrete) and a weak acid (the soil solution). Special cements and methods of manufacturing may be used to reduce the rate of deterioration in soils that have a high risk of corrosion. The rate of deterioration depends on (i) soil texture and acidity, (ii) the amount of sodium or magnesium sulfate present in the soil, singly or in combination, and (iii) the amount of sodium chloride (NaCl) in the soil. The presence of NaCl is one of the factors evaluated not because of its corrosivity of cement but because it is used to identify the presence of seawater. Seawater contains sulfates, which are one of the principal corrosive agents. A soil that has gypsum requires special cement. The calcium ions in gypsum react with the cement and weaken the concrete.

(4) Guides. Exhibit 618-2 gives the relationship of soil texture, soil acidity, sulfates, and NaCl to corrosion classes.

(5) Entries. Enter the appropriate class of risk of corrosion for concrete for the whole soil. The classes are LOW, MODERATE, or HIGH.

618.12 Crop Name and Yield.

(a) Definition. Crop name is the common name for the crop. Crop yield units is crop yield units per unit area for the specified crop.

(b) Classes. The crop names and the units of measure for yields that are allowable as data entries are listed in the data dictionary of the National Soil Information System. (http://nasis.nrcs.usda.gov/documents/metadata/4_1/home.shtml)

(c) Significance. Crop names and units of measure are important as records of crop yield. The crops and yield often are specific to the time when the soil survey was completed, but the ranking and comparison between soils within a soil survey is helpful. These crops and yield data are used to evaluate the soil productive capabilities, cash rent, and land values. Generally, only the most important crops are listed and only the best management is reflected.

(d) Estimates. Crop names and yields are specific to the soil survey area. The listing of crop names is not limited to any number but only the most important crops in the survey area should be used. The yields are derived in a number of ways but should represent a high level of management by leading commercial farmers, which tends to produce the highest economic return per acre. This level of management includes using the best varieties; balancing plant populations and added plant nutrients to the potential of the soil; controlling erosion, weeds, insects, and diseases; maintaining optimum soil tilth; providing adequate soil drainage; and ensuring timely operations.

Generally only a representative value is used for each map unit component for non MLRA soil survey areas. MLRA soil survey areas use the high and low representative value from map unit components of non MLRA soil survey areas. High and low values represent the range of representative values for a high level of management across the survey area or across several surveys.

(e) Entries. Enter the common crop name and units of measure. Enter the corresponding irrigated and/or nonirrigated yields as appropriate for the component. Yields can be posted as high, low, and representative values for the map unit component.

618.13 Diagnostic Horizon Feature Depth to Bottom.

(a) Definition. Diagnostic horizon feature depth to bottom is the distance from the top of the soil to the base of the identified diagnostic horizon or to the lower limit of the occurrence of the diagnostic feature.

(b) Measurement. Distance is measured from the top of the soil which is defined as the top of the mineral soil, or, for soils with "O" horizons, the top of any "O" layer that is at least partially decomposed. For soils that are covered by 80 percent or more rock or pararock fragments, the top of the soil is the surface of the fragments. See pages 63-64 in the *Soil Survey Manual* for a complete discussion.

(c) Entries. Enter the high, low, and representative values in whole centimeters. The high value represents either the greatest depth to which the base of the diagnostic horizon or feature extends or, for horizons for features extending beyond the limit of field observation, it is the depth to which observation was made (usually no more than 200 cm). In the case of the lithic contact, paralithic contact, and petroferric contact, the entries for depth to the bottom of the diagnostic feature will be the same as the entries for depth to the top of the feature, since the contact has no thickness.

618.14 Diagnostic Horizon Feature Depth to Top.

(a) Definition. Diagnostic horizon feature depth to top is the distance from the top of the soil to the upper boundary of the identified diagnostic horizon or to the upper limit of the occurrence of the diagnostic feature.

(b) Measurement. Distance is measured from the top of the soil, which is defined as the top of the mineral soil, or, for soils with "O" horizons, the top of any "O" layer that is at least partially decomposed. For soils that are covered by 80 percent or more rock or pararock fragments, the top of the soil is the surface of the fragments. See pages 63-64 in the *Soil Survey Manual* for a complete discussion.

(c) Entries. Enter the high, low, and representative values in whole centimeters.

618.15 Diagnostic Horizon Feature Kind.

(a) Definition. Diagnostic horizon feature kind is the kind of diagnostic horizon or diagnostic feature present in the soil.

(b) Significance. Diagnostic horizons and features are a particular set of observable or measurable soil properties that are used in Soil Taxonomy to classify a soil. They have been chosen because they are thought to be the marks left on the soil as a result of the dominant soil forming processes. In many cases they are thought to occur in conjunction with other important accessory properties. The utilization of diagnostic horizons and features in the classification process allows the grouping of soils that have formed as a result of similar genetic processes. The grouping, however, is done on the basis of observable or measurable properties, rather than speculation about the genetic history of a particular soil.

(c) Entries. The diagnostic horizons and features are listed in the latest Keys to Soil Taxonomy. Allowable codes are given in the NASIS data dictionary.

618.16 Drainage Class.

(a) Definition. Drainage class identifies the natural drainage condition of the soil. It refers to the frequency and duration of wet periods.

(b) Classes. The seven natural drainage classes are: (1) excessively drained, (2) somewhat excessively drained, (3) well drained, (4) moderately well drained, (5) somewhat poorly drained, (6) poorly drained, and (7) very poorly drained. Chapter 3 of the *Soil Survey Manual* provides a description of each natural drainage class.

(c) Significance. Drainage classes provide a guide to the limitations and potentials of the soil for field crops, forestry, range, wildlife, and recreational uses. The class roughly indicates the degree, frequency, and duration of wetness, which are factors in rating soils for various uses.

(d) Estimates. Infer drainage classes from observations of landscape position and soil morphology. In many soils the depth and duration of wetness relate to the quantity, nature, and pattern of redoximorphic features. Correlate drainage classes and redoximorphic features through field observations of water tables, soil wetness, and landscape position. Record the drainage classes assigned to the series.

(e) Entries. Enter the drainage class name for each map unit component. Utilize separate map unit components for different drainage class phases or for drained versus undrained phases where needed.

Drainage Class
Excessively
Somewhat excessively
Well
Moderately well
Somewhat poorly
Poorly
Very poorly

618.17 Effective Cation-Exchange Capacity

(a) Definition. Effective cation-exchange capacity is the sum of NH_4OAc extractable bases plus KCl extractable aluminum (method 5A3b, SSIR #42).

(b) Significance. Cation exchange capacity is a measure of the ability of a soil to retain cations, some of which are plant nutrients. Soils that have a low cation exchange capacity hold fewer cations and may require more frequent applications of fertilizer and amendments than soils that have a high cation exchange capacity. Soils that have high cation exchange capacity have the potential to retain cations. Effective CEC is a measure of CEC that is particularly useful in soils whose ion exchange capacity is largely a result of variable charge components such as allophane, kaolinite, hydrous iron and aluminum oxides, and organic matter, which results in the soil's CEC being not a fixed number but a function of pH. Examples of such soils might include some andic soils, Oxisols, and more weathered Utisols with kaolinitic mineralogy.

(c) Measurement. Effective cation exchange capacity is measured by the methods outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004. Method 5A3b gives the effective cation exchange capacity value for soils that have pH <5.5 and that are low in soluble salts. For soils that have a pH of 5.5 or greater, the ECEC equals the sum of NH_4OAc extractable bases.

(d) Entries. Enter the high, low, and representative values of the estimated range in effective cation exchange capacity at the field pH of the soil, in meq $100g^1$, for the horizon. Values in tenths are allowed. Valid entries range from 0.0 to 400.0.

618.18 Electrical Conductivity.

(a) Definition. Electrical conductivity is the electrolytic conductivity of an extract from saturated soil paste.

(b) Classes. The classes of salinity are:

Classes	**Electrical Conductivity (mmhos cm^{-1})**
Nonsaline	0-2
Very slightly saline	≥2-4
Slightly saline	≥4-8
Moderately saline	≥8-16
Strongly saline	≥16

(c) Significance. Electrical conductivity is a measure of the concentration of water-soluble salts in soils. It is used to indicate saline soils. High concentrations of neutral salts, such as sodium chloride and sodium sulfate, may interfere with the absorption of water by plants because the osmotic pressure in the soil solution is nearly as high or higher than that in the plant cells. Salts may also interfere with the exchange capacity of nutrient ions, thereby resulting in nutritional deficiencies in plants.

(d) Measurement. The electrolytic conductivity of a saturated extract is the standard measure used to express salinity as millimhos per centimeter (mmhos cm^{-1}) at 25 degrees C. The laboratory procedure used to measure is described in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.

(e) Estimates. Field estimates of salts are made from observations of free salt on structural faces or on the soil surface, from plant growth indicators, or from field salinity meters. The occurrences of bare spots, salt-tolerant plants, and uneven crop growth are used as indicators of salinity and high electrical conductivity. When keyed to measurements, these observations help to estimate the amount of salts.

(f) Entries. Enter the high, low, and representative values for the range of electrolytic conductivity of the saturation extract during the growing season for each horizon. Use the following classes: 0-2, 2-4, 4-8, 8-16, and 16-32; or use a combination of classes, for example, 2-8 for the high and low values. The allowable range is 0 to 99.

618.19 Elevation.

(a) Definition. Elevation is the vertical distance from mean sea level to a point on the earth's surface.

(b) Significance. Elevation, or local relief, exerts a modifying influence of the genesis of natural soil bodies. Elevation also may affect soil drainage within a landscape, salinity or sodicity within a climatic area, or soil temperature.

(c) Estimates. Elevation is normally obtained from U.S. Geological Survey topographic maps or measured using altimeters or global positioning systems.

(d) Entries. Enter the high, low, and representative values for each map unit component. The minimum entry is -300 meters and the maximum entry is 8550 meters. Record elevation to the nearest integer.

618.20 Engineering Classification.

(a) AASHTO group classification.

(1) Definition. AASHTO group classification is a system that classifies soils specifically for geotechnical engineering purposes that are related to highway and airfield construction. It is based on particle-size distribution and Atterberg limits, such as liquid limit and plasticity index. This classification system is covered in AASHTO Standard No. M 145-82 and consists of a symbol and a group index. The classification is based on that portion of the soil that is smaller than 3 inches in diameter.

(2) Classes. The AASHTO classification system identifies two general classifications: (i) granular materials having 35 percent or less, by weight, particles smaller than 0.074 mm in diameter and (ii) silt-clay materials having more than 35 percent, by weight, particles smaller than 0.074 mm in diameter. These two divisions are further subdivided into seven main group classifications. Exhibit 618-4 shows the criteria for classifying soil in the AASHTO classification system.

The group and subgroup classifications are based on estimated or measured grain-size distribution and on liquid limit and plasticity index values.

(3) Significance. The group and subgroup classifications of this system are aids in the evaluation of soils for highway and airfield construction. The classifications can help to make general interpretations relating to performance of the soil for engineering uses, such as highways and local roads and streets.

(4) Measurements. Measurements involve sieve analyses for the determination of grain-size distribution of that portion of the soil between a 3 inch and 0.074 mm particle size. ASTM methods D 422, C 136, and C 117 have applicable procedures for the determination of grain-size distribution. The liquid limit and plasticity index values (ASTM method D 4318) are determined for that portion of the soil having particles smaller than 0.425 mm in diameter (No. 40 sieve).

Measurements, such as laboratory tests, are made on most benchmark soils and on other representative soils in survey areas.

(5) Estimates. During soil survey investigations and field mapping activities, the soil is classified by field methods. This classification involves making estimates of particle-size fractions by a percentage of the total soil, minus the greater than 3-inch fraction. Estimates of liquid limit and plasticity index are based on clay content and mineralogy relationships. Estimates are expressed in ranges that include the estimating accuracy as well as the range of values for the taxon.

(6) Entries. Enter classes and separate them by commas for each horizon, for example, A-7, A-6. Acceptable entries are A-1, A-l-A, A-l-B, A-2, A-2-4, A-2-5, A-2-6, A-2-7, A-3, A-4, A-5, A-6, A-7, A-7-5, A-7-6, and A-8.

(b) AASHTO group index.

(1) Definition. The AASHTO group and subgroup classifications may be further modified by the addition of a group index value. The empirical group index formula was devised for approximate within-group evaluation of the "clayey granular materials" and the "silty-clay" materials.

(2) Significance. The group index is an aid in the evaluation of the soils for highway and airfield construction. The index can help to make general interpretations relating to performance of the soil for engineering uses, such as highways and local roads and streets.

(3) Measurement. The group index is calculated from an empirical formula:

$$GI = (F-35)\,[0.2 + 0.005\,(LL-40)] + 0.01\,(F-15)\,(PI-10)$$

where: F = Percentage passing sieve No. 200
(75 micrometer), expressed as a whole number

LL = Liquid limit

PI = Plasticity index

In calculating the group index of A-2-6 and
A-2-7 subgroups, only the PI portion of the formula is used.

(4) Entries. The group index is reported to the nearest integer. If the calculated group index is negative, the group index is zero (0). The minimum index value is 0 and the maximum is 120.

(c) Unified soil classification.

(1) Definition. The unified soil classification system is a system for classifying mineral and organic mineral soils for engineering purposes based on particle-size characteristics, liquid limit, and plasticity index.

(2) Classes. The Unified Soil Classification System identifies three major soil divisions: (i) coarse-grained soils having less than 50 percent, by weight, particles smaller than 0.074 mm in diameter; (ii) fine-grained soils having 50 percent or more, by weight, particles smaller than 0.074 mm in diameter, and (iii) highly organic soils that demonstrate certain organic characteristics. These divisions are further subdivided into a total of 15 basic soil groups. The major soil divisions and basic soil groups are determined on the basis of estimated or measured values for grain-size distribution and Atterberg limits. ASTM D 2487 shows the criteria chart used for classifying soil in the Unified system and the 15 basic soil groups of the system and the plasticity chart for the Unified Soil Classification System.

(3) Significance. The various groupings of this classification have been devised to correlate in a general way with the engineering behavior of soils. This correlation provides a useful first step in any field or laboratory investigation for engineering purposes. It can serve to make some general interpretations relating to probable performance of the soil for engineering uses.

(4) Measurement. The methods for measurement are provided in ASTM Designation D 2487. Measurements involve sieve analysis for the determination of grain-size distribution of that portion of the soil between 3 inches and 0.074 mm in diameter (No. 200 sieve). ASTM methods D 422, C 136, and C 117 have applicable procedures that are used where appropriate for the determination of grain-size distribution. Values for the Atterberg limits (liquid limit and plasticity index) are also used. Specific tests are made for that portion of the soil having particles smaller than 0.425 mm in diameter (No. 40 sieve) according to ASTM methods D 423 and D 424. Measurements, such as laboratory tests, are made on most benchmark soils and on other representative soils in survey areas.

(5) Entries for measured data. For **measured** Unified data, enter up to four classes for each horizon. ASTM D 2487 provides flow charts for classifying the soils. Separate the classes by commas, for example, CL-ML, ML. Acceptable entries are GW, GP, GM, GC, SW, SP, SM, SC, CL, ML, OL, CH, MH, OH, PT, CL-ML, GW-GM, GW-GC, GP-GM, GP-GC, GC-GM, SW-SM, SW-SC, SP-SM, SP-SC, and SC-SM.

(6) Estimates. The methods for estimating are provided in ASTM Designation D 2488. During all soil survey investigations and field mapping activities, the soil is classified by field methods. The methods include making estimates of particle-size fractions by a percentage of the total soil. The Atterberg limits are also estimated based on the wet consistency, ribbon or thread toughness, and other simple field tests. These tests and procedures are explained in ASTM D 2488. If samples are later tested in the laboratory, adjustments are made to field procedures as needed. Estimates are expressed in ranges that include the estimating accuracy as well as the range of values from one location to another within the map unit. If an identification is based on visual-manual procedures it must be clearly stated so in reporting.

(7) Entries for estimated soils. For **estimated** visual-manual Unified data, enter up to four classes for each horizon. ASTM D 2488 provides flow charts for classifying the soils. Separate the classes by commas, for example, CL, ML, SC. Acceptable entries are GW, GP, GM, GC, SW, SP, SM, SC, CL, ML, CH, MH, OL/OH, PT, GW-GM, GW-GC, GP-GM, GP-GC, SW-SM, SW-SC, SP-SM, and SP-SC.

618.21 Erosion Accelerated, Kind.

(a) Definition. Erosion accelerated, kind, is the type of detachment and removal of surface soil particles as largely affected by human activity.

(b) Significance. The type of accelerated erosion is important in assessing the current health of the soil, and in assessing its potential for different uses. Erosion, whether natural or induced by humans, is an important process that affects soil formation and may remove all or parts of the soils formed in the natural landscape.

(c) Classes.

Class
Water erosion, sheet
Water erosion, rill
Water erosion, gully
Water erosion, tunnel
Wind erosion

(d) Entries. Enter the appropriate class for each map unit component. Multiple entries are allowable, but a representative value should be indicated.

618.22 Erosion Class.

(a) Definition. Erosion class is the class of accelerated erosion.

(b) Significance. The degree of erosion that has taken place is important in assessing the health of the soil and in assessing the soil's potential for different uses. Erosion is an important process that affects soil formation and may remove all or parts of the soils formed in natural landscapes.

Removal of increasing amounts of soil increasingly alters various properties and capabilities of the soil. Properties and qualities affected include bulk density, organic matter content, tilth, water infiltration. Altering these properties affects the productivity of the soil.

(c) Estimation. During soil examinations, estimate the degree to which soils have been altered by accelerated erosion. The *Soil Survey Manual* describes the procedures involved.

(d) Classes.

Class
none - deposition
Class 1
Class 2
Class 3
Class 4

(e) Entries. Enter the appropriate class for each map unit component.

618.23 Excavation Difficulty Classes.

(a) Definition. Excavation difficulty is an estimation of soil layers, horizons, pedons, or geologic layers according to the difficulty in making an excavation into them. Excavation difficulty, in most instances, is strongly controlled by water state, which should be specified.

(b) Classes. The excavation difficulty classes are:

Classes	Definition
Low	Excavations can be made with a spade using arm-applied pressure only. Neither application of impact energy nor application of pressure with the foot to a spade is necessary
Moderate	Arm-applied pressure to a spade is insufficient. Excavation can be accomplished quite easily by application of impact energy with a spade or by foot pressure on a spade.
High	Excavation with a spade can be accomplished with difficulty. Excavation is easily possible with a full length pick, using an over-the-head swing.
Very high	Excavation with a full length pick, using an over-the-head swing, is moderately to markedly difficult. Excavation is possible in a reasonable period of time with a backhoe mounted on a 40 to 60 kW (50-80 hp) tractor
Extremely high	Excavation is nearly impossible with a full length pick using an over-the-head arm swing. Excavation cannot be accomplished in a reasonable time period with a backhoe mounted on a 40 to 60 kW (50-80 hp) tractor

(c) Significance. Excavation difficulty classes are important for evaluating the cost and time needed to prepare shallow excavations.

(d) Estimates. Estimates of excavation difficulty classes are made from field observations.

(e) Entries. Enter the appropriate class for each horizon. The allowable entries are Low, Moderate, High, Very high, and Extremely high.

618.24 Extractable Acidity.

(a) Definition. Extractable acidity is a measure of soil exchangeable hydrogen ions that may become active by cation exchange.

(b) Significance. Extractable acidity is important for soil classification and for certain evaluations of soil nutrient availability or of the effect of waste additions to the soil.

(c) Measurement. Extractable acidity is determined by method 6H5a, as outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.

(d) Entries. Enter the range of extractable acidity as milliequivalents per 100 grams (meq $100g^{-1}$) of soil for the horizon. Valid entries range from 0.0 to 250.0. Tenths are allowed.

618.25 Extractable Aluminum.

(a) Definition. Extractable aluminum is the amount of aluminum extracted in one normal potassium chloride.

(b) Significance. Extractable aluminum is important for soil classification and for certain evaluations of soil nutrient availability and of toxicities. An aluminum saturation of about 60 percent is usually regarded as toxic to most plants. It may be a useful measurement for assessing potential lime needs for acid soils.

(c) Measurement. Extractable aluminum is determined by method 6G9d, as in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS. Units of measure are milliequivalents per 100 grams (meq $100g^{-1}$).

(d) Entries. Enter the range of extractable aluminum as milliequivalents per 100 grams (meq $100g^{-1}$) of soil for the horizon. Valid entries range from 0.0 to 150.0. Tenths are allowed.

618.26 Flooding Frequency, Duration, and Month.

(a) Definition. Flooding is the temporary covering of the soil surface by flowing water from any source, such as streams overflowing their banks, runoff from adjacent or surrounding slopes, inflow from high tides, or any combination of sources. Shallow water standing or flowing that is not concentrated as local runoff during or shortly after rain or snow melt is excluded from the definition of flooding. Chapter 3 of the *Soil Survey Manual* provides additional information. Standing water (ponding) or water that forms a permanent covering is also excluded from the definition.

(b) Classes. Estimates of flooding class are based on the interpretation of soil properties and other evidence gathered during soil survey field work. Flooding hazard is expressed by (1) flooding frequency class, (2) flooding duration class, and (3) time of year that flooding occurs. Not considered here, but nevertheless important, are velocity and depth of floodwater. Frequencies used to define classes are generally estimated from evidence related to the soil and vegetation. They are expressed in wide ranges that do not indicate a high degree of accuracy. Flooding frequencies that are more precise can be calculated by performing complex analyses used by engineers. The class very frequent is intended for use on areas subject to daily and monthly high tides.

(1) Flooding frequency class. Flooding frequency class is the number of times flooding occurs over a period of time and expressed as a class. The classes of flooding are defined as follows:

Class	Definition
None	No reasonable possibility of flooding; near 0 percent chance of flooding in any year or less than 1 time in 500 years.
Very Rare	Flooding is very unlikely but possible under extremely unusual weather conditions; less than 1 percent chance of flooding in any year or less than 1 time in 100 years but more than 1 time in 500 years.
Rare	Flooding unlikely but possible under unusual weather conditions; 1 to 5 percent chance of flooding in any year or nearly 1 to 5 times in 100 years

Occasional	Flooding is expected infrequently under usual weather conditions; 5 to 50 percent chance of flooding in any year or 5 to 50 times in 100 years
Frequent	Flooding is likely to occur often under usual weather conditions; more than a 50 percent chance of flooding in any year or more than 50 times in 100 years, but less than a 50 percent chance of flooding in all months in any year.
Very Frequent	Flooding is likely to occur very often under usual weather conditions; more than a 50 percent chance of flooding in all months of any year.

(2) Flooding duration classes. The average duration of inundation per flood occurrence is given only for occasional, frequent, and very frequent classes.

Class	Duration
Extremely brief	0.1 to 4.0 hours
Very brief	4 to 48 hours
Brief	2 to 7 days
Long	7 days to 30 days
Very long	≥30 days

(3) Yearly flooding frequency classes are assigned to months to indicate the months of occurrence and not the frequency of the flooding during the month, except for the very frequent class. The time period expressed includes two-thirds to three-fourths of the occurrences. Time period and duration of the flood are the most critical factors that determine the growth and survival of a given plant species. Flooding during the dormant season has few if any harmful effects on plant growth or mortality and may improve the growth of some species. If inundation from flood water occurs for long periods during the growing season, the soil becomes oxygen deficient and plants may be damaged or killed.

(c) Significance. The susceptibility of soils to flooding is an important consideration for building sites, sanitary facilities, and other uses. Floods may be less costly per unit area of farmland as compared to that of urban land, but the loss of crops and livestock can be disastrous.

(d) Estimates. The most precise evaluation of flood-prone areas for stream systems is based on hydrologic studies. The area subject to inundation during a flood of a given frequency, such as one with a 1 percent or 2 percent chance of occurrence, generally is determined by one of two basic methods.

(1) The first method is used if stream flow data are available. In this method, the data are analyzed to determine the magnitude of floods of different frequencies. Engineering studies are made to determine existing channel capacities and flow on the flood plain by the use of valley cross sections and water surface profiles.

(2) The second method is used if stream flow data are not available. In this method, hydrologists make an estimate of flood potential from recorded data on rainfall. They consider such factors as (i) size, slope, and shape of the contributing watershed, (ii) hydrologic characteristics of the soil, (iii) land use and treatment, and (iv) hydraulic characteristics of the valley and channel system.

(3) With the use of either method, soil surveys can aid in the delineation of flood-prone areas. Possible sources of flooding information are (i) NRCS project-type studies, such as PL 556, FP, RB, or RC&D; (ii) flood hazard analyses; (iii) Corps of Engineers flood plain information reports; (iv) special flood reports; (v) local flood protection and flood control project reports; (vi) HUD flood insurance study reports; (vii) maps by USGS, NRCS, TVA, COE, NOAA; (viii) studies by private firms and other units of government; and (ix) USGS quadrangle sheets and hydrologic atlases of flood-prone areas and stream gauge data.

(4) General estimates of flooding frequency and duration are made for each soil. However, in intensively used areas where construction has materially altered the natural water flow, flood studies are needed to adequately reflect present flooding characteristics.

(5) Soil scientists collect and record evidence of flood events during the course of the soil survey. The extent of flooded areas, flood debris in trees, damage to fences and bridges, and other signs of maximum water height are recorded. Information that is helpful in delineating soils that have a flood hazard is also obtained. Hydrologists may have flood stage predictions that can be related to kinds of soil or landscape features. Conservationists and engineers may have recorded elevations of high flood marks. Local residents may have recollections of floods that can help to relate the events to kinds of soil, topography, and geomorphology.

(6) Certain landscape features have developed as the result of past and present flooding and include former river channels, oxbows, point bars, alluvial fans, meander scrolls, sloughs, natural levees, backswamps, sand splays, and terraces. Most of these features are easily recognizable on aerial photographs by comparing the photo image with on-the-ground observations. Different kinds of vegetation and soils are normally associated with these geomorphic features.

(7) The vegetation that grows in flood areas may furnish clues to past flooding. In central and southeastern United States, the survival of trees in flood-prone areas depends on the frequency, duration, depth, and time of flooding and on the age of the tree.

(8) Past flooding may sometimes leave clues in the soil, such as (1) thin strata of material of contrasting color or texture, or both; (2) an irregular decrease in organic matter content, which is an indication of a buried surface horizon; and (3) soil layers that have abrupt boundaries to contrasting kinds of material, which indicate that the materials were laid down suddenly at different times and were from different sources or were deposited from stream flows of different velocities.

Laboratory analyses of properly sampled layers are often helpful in verifying these observations. Organic carbon and particle-size analyses are particularly useful in verifying flood deposits. Microscopic observations may detect preferential horizontal orientation of plate-like particles; micro-layering, which indicates water-laid deposits; or mineralogical differences between layers.

(e) Entries. Flooding and frequency are posted for each month of the year for each map unit component.

(1) Enter the flooding frequency class name: none, very rare, rare, occasional, frequent, or very frequent.

(2) Enter the flooding duration class name that most nearly represents the soil: extremely brief, very brief, brief, long, or very long.

618.27 Fragments in the Soil

(a) Definition. Fragments are unattached cemented pieces of bedrock, bedrock-like material, durinodes, concretions, and nodules 2 mm or larger in diameter; and woody material 20 mm or larger in organic soils. Fragments are separated into three types: rock fragments; pararock fragments, which are separated based on cementation; and wood fragments.

Rock fragments are unattached pieces of rock 2 mm in diameter or larger that are strongly cemented or more resistant to rupture. Rock fragments from 2 mm to 75 mm (3 inches) are considered when estimating the percent passing sieves as discussed in part 618.43.

Pararock fragments are unattached, cemented bodies or pieces of material 2 mm in diameter or larger that are extremely weakly cemented to moderately cemented. These fragments are not retained on sieves because of the sample preparation by grinding.

Wood fragments are woody materials that cannot be crushed between the fingers when moist or wet and are larger than 20 mm in size. Wood fragments are only used in organic soils. They are comparable to rock and pararock fragments in mineral soils.

(b) Significance. The fraction of the soil 2 mm or larger has an impact on the behavior of the whole soil. Soil properties, such as available water capacity, cation exchange capacity, saturated hydraulic conductivity, structure, and porosity, are affected by the volume, composition, and size distribution of fragments in the soil. Fragments also affect the management of the soil and are used as interpretation criteria. Terms related to volume, size, and hardness of fragments are used as texture modifier terms.

Generally, the fraction of soil greater than 75 mm (3 inches) in diameter is not included in the engineering classification systems. However, it can be added as a descriptive term to the group name, for example, poorly graded gravel with silt, sand, cobbles, and boulders. Estimates of the percent of cobbles and boulders are presented in the soil descriptions for a group name. A small amount of these larger particles generally has little effect on soil properties. It may, however, have an effect on the use of a soil in certain types of construction. Often, the larger portions of a soil must be removed before the material can be spread in thin layers, graded, or compacted and graded to a smooth surface. As the quantity of this "oversized" fraction increases, the properties of the soil can be affected. If the larger particles are in contact with each other, the strength of the soil is very high and the compressibility very low. If voids exist between the larger particles, the soil will likely have high saturated hydraulic conductivity and may undergo some internal erosion as a result of the movement of water through the voids. Most of the smaller and more rapid construction equipment normally used in excavating and earthmoving cannot be used if the oversize fraction of a soil is significant.

(c) Measurement. The fraction from 2 to 75 mm may be measured in the field. However, 50-60 kg of sample may be necessary if an appreciable amount of fragments near 75 mm are present. An alternative is to visually estimate the volume of the 20-to 75-mm fraction, then sieve and weigh the 2-to 20-mm fraction. The fraction 75 mm (3 inches) or greater is usually not included in soil samples taken in the field for laboratory testing. Measurements can be made in the field by weighing the dry sample and the portion retained on a 3-inch screen. The quantity is expressed as a weight percentage of the total soil. A sample as large as 200 pounds to more than a ton may be needed to assure that the results are representative. Measurements of the fraction from 75 to 250 mm (3 to 10 inches) and the fraction greater than 250 mm (10 inches) are usually obtained from volume estimates.

(d) Estimates. Estimates are usually made by visual means and are on the basis of percent by volume. The percent by volume is converted to percent by weight, as shown in Exhibit 618.11, by using the average bulk unit weights for soil and rock. These estimates are made during investigation and mapping activities in the field. They are expressed as ranges that include the estimating accuracy as well as the range of values for a component.

Measurements or estimates of fragments less than strongly cemented are made prior to any rolling or crushing of the sample.

(e) Rock Fragments greater than 10 inches (250 mm).

(1) Definition. Rock fragment greater than 10 inches is the percent by weight of the horizon occupied by rock fragments greater than 10 inches (250 mm) in size. The upper limit is undefined, but for practical purposes it generally is no larger than a pedon, up to 10 meters square. For nonspherical material, the intermediate dimension is used for the 250 mm (10 inch) measurement. For example, a flat-shaped rock fragment that is 100 mm x 250 mm x 380 mm has an intermediate dimension of 250 mm, and is not counted as greater than 250 mm. A flat-shaped rock fragment that is 100 mm x 275 mm x 380 mm has an intermediate dimension of 275 mm, and is counted as greater than 250 mm.

(2) Entries. Enter the high, low, and representative values as whole number percentages for each horizon as appropriate.

(f) Rock fragments 3 to 10 inches (75 to 250 mm).

(1) Definition. Rock fragments 3 to 10 inches is the percent by weight of the horizon occupied by rock fragments 3 to 10 inches (75 to 250 mm) in size.

(2) Entries. Enter the high, low, and representative values as whole number percentages for each horizon as appropriate.

(g) Fragment kind.

(1) Definition. Fragment kind is the lithology/composition of the 2 mm or larger fraction of the soil.

(2) Entries. Enter the appropriate class name for the kind of fragment present. More than one choice may be entered. The class names can be found in the NASIS data dictionary.

(h) Fragment roundness.

(1) Definition. Fragment roundness is an expression of the sharpness of edges and corners of fragments.

(2) Significance. The roundness of fragments impacts water infiltration, root penetration, and macropore space.

(3) Classes. The fragment roundness classes are:

Angular
Subangular
Subrounded
Rounded
Well-rounded

(4) Entries. Enter the appropriate class name for the roundness class(es) present. A representative value may be designated.

(i) Fragment rupture resistance cemented.

(1) Definition. Fragment rupture resistance cemented is the rupture resistance of a fragment of specified size that has been air dried and then submerged in water.

(2) Measurements. Measurements are made using the procedures and classes of cementation that are listed with the rupture resistance classes in the *Soil Survey Manual*. Classes are described for block-like specimens about 25-30 mm on edge, which are air-dried and then submerged in water for at least 1 hour. The specimen is compressed between extended thumb and forefinger, between both hands, or between the foot and a nonresilient flat surface. If the specimen resists compression, a weight is dropped onto it from progressively greater heights until it ruptures. Failure is considered at the initial detection of deformation or rupture. Stress applied in the hand should be over a 1-second period. The tactile sense of the class limits may be learned by applying force to top loading scales and sensing the pressure through the tips of the fingers or through the ball of the foot. Postal scales may be used for the resistance range that is testable with the fingers. A bathroom scale may be used for the higher rupture resistance range.

(3) Significance. The rupture resistance of a fragment is significant where the class is strongly cemented or higher. These classes can impede or restrict the movement of soil water vertically through the soil profile and have a direct impact on the quality and quantity of ground water and surface water.

(4) Classes. The classes are:

Extremely weakly
Very weakly
Weakly
Moderately
Strongly
Very strongly
Indurated

(5) Entries. Enter the appropriate class name(s) for the fragments present. A representative value may be designated.

(j) Fragment shape.

(1) Definition. Fragment shape is a description of the overall shape of the fragment.

(2) Significance. Fragment shape is important for fragments that are too large to be called channers or flagstones.

(3) Classes. The classes are:

Flat
Nonflat

(4) Entries. Enter the appropriate class name for the class(es) present. Multiple entries may be made. A representative value may be designated.

k) Fragment size.

(1) Definition. Fragment size is the size based on the multiaxial dimensions of the fragment.

(2) Significance. The size of fragments is significant to the use and management of the soil. Fragment size is used as criteria for naming map units. It affects equipment use, excavation, construction, and recreational uses.

(3) Classes. Classes of fragment size are subdivided according to flat and non-flat fragments.

Flat fragment classes	Length (mm)
Channers	2-150
Flagstones	150-380
Stones	380-600
Boulders	≥ 600

Non-flat fragment classes	Diameter (mm)
Pebbles	2-75
fine pebbles	2-5
medium pebbles	5-20
coarse pebbles	20-75
Cobbles	75-250
Stones	250-600
Boulders	≥ 600

For fragments that are less than strongly cemented, "para" is added as a prefix to the above terms; i.e., paracobbles or fine parapebbles.

(4) Entries. Enter the minimum, maximum, and representative values in whole numbers of each size class being described. Entries are in millimeters and range from 2 to 3,000 mm.

(l) Fragment volume.

(1) Definition. Fragment volume is the volume percentage of the horizon occupied by the 2 mm or larger fraction.

(2) Significance. The volume occupied by the 2 mm or larger fraction is important for naming textural modifiers; i.e., gravelly, very gravelly, extremely paragravelly.

(3) Entries. Enter the high, low, and representative values, in whole numbers, for the percent volume present for each class of fragments being described.

618.28 Free Iron Oxides.

(a) Definition. Free iron oxides are secondary iron oxides, such as goethite, hematite, ferrihydrite, lepidocrocite, and maghemite. This form of iron may occur as discrete particles, as coatings on other soil particles, or as cementing agents between soil mineral grains. It is the iron extracted by dithionite-citrate from the fine earth fraction.

(b) Significance. The amount of iron that is extractable by dithionite-citrate is used in *Soil Taxonomy* in the Ferritic, Feruginous, Parasesquic, and Sesquic mineralogy classes. The ratio of dithionite-citrate (free) iron to total iron in a soil is a measure of the degree of soil weathering. Free iron oxides are important in the soil processes of podzolization and laterization and play a significant role in the phosphorous fixation ability of soils.

(c) Measurement. Free iron oxides are measured as the amount extracted by dithonite citrate using method 6C2b as outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.

(d) Entries. Enter high, low and representative values as percentages for each horizon for which data is available. Valid entries range from 0.00 to 99.99, and hundredths are allowed.

618.29 Frost Action, Potential.

(a) Definition. Potential frost action is the rating for the susceptibility of the soil to upward or lateral movement by the formation of segregated ice lenses. It rates the potential for frost heave and the subsequent loss of soil strength when the ground thaws.

(b) Classes. Classes are used in regions where frost action is a potential problem. Exhibit 618-5 provides more information. The classes are low, moderate, and high and are defined as follows:

Potential frost action classes	Definition
Low	Soils are rarely susceptible to the formation of ice lenses.
Moderate	Soils are susceptible to the formation of ice lenses, which results in frost heave and subsequent loss of soil strength.
High	Soils are highly susceptible to the formation of ice lenses, which results in frost heave and subsequent loss of soil strength.

(c) Significance. Damage from frost action results from the formation of segregated ice crystals and ice lenses in the soil and the subsequent loss of soil strength when the ground thaws. Frost heave damages highway and airfield pavements. It is less of a problem for dwellings and buildings that have footings which extend below the depth of frost penetration. In cold climates, unheated structures that have concrete or asphalt floors can be damaged by frost heave. Driveways, patios, and sidewalks can heave and crack. The thawing of the ice causes a collapse of surface elevation and produces free water perches on the still frozen soil below. Soil strength is reduced. Back slopes and side slopes of cuts and fills can slough during thawing. Seedlings and young plants of clover, alfalfa, wheat, and oats can be raised out of the soil or have their root systems damaged by frost heave.

(d) Estimates. Freezing temperatures, soil moisture, and susceptible soils are needed for the formation of segregated ice lenses. Ice crystals begin to form in the large pores first. Water in small pores or water that was adsorbed on soil particles freezes at lower temperatures. This super cooled water is strongly attracted to the ice crystals, moves toward it, and freezes on contact with them. The resulting ice lens continues to grow in width and thickness until all available water that can be transported by capillary has been added to the ice lens and a further supply cannot be made available because of the energy requirements.

Soil temperatures must drop below 0° C for frost action to occur. Generally, the more slowly and deeply the frost penetrates, the thicker the ice lenses are and the greater the resulting frost heave is. Exhibit 618-6 provides a map that shows the design freezing index values in the continental United States. The values are the number of degree days below 0° C for the coldest year in a period of 10 years. The values indicate duration and intensity of freezing temperatures. The 250 isoline is the approximate boundary below which frost action ceases to be a problem. Except on the West Coast, the frost action boundary corresponds closely to the mesic-thermic temperature regime boundary used in *Soil Taxonomy*. More information is provided in the U.S. Army Engineer School, Student Reference, 1967, Soil Engineering, Section I, Volume II, Chapters VI-IX, Fort Belvoir, Virginia.

Water necessary for the formation of ice lenses may come from a high water table or from infiltration at the surface. Capillary water in voids and adsorbed water on particles also contribute to ice lens formation; but unless this water is connected to a source of free water, the amount generally is insufficient to produce significant ice segregation and frost heave.

The potential intensity of ice segregation is dependent to a large degree on the effective soil pore size and soil saturated hydraulic conductivity, which are related to soil texture. Ice lenses form in soils in which the pores are fine enough to hold quantities of water under tension but coarse enough to transmit water to the freezing front. Soils that have a high content of silt and very fine sand have this capacity to the greatest degree and hence have the highest potential for ice segregation. Clayey soils hold large quantities of water but have such slow saturated hydraulic conductivity that segregated ice lenses are not formed unless the freezing front is slow moving. Sandy soils, however, have large pores and hold less water under lower tension. As a result, freezing is more rapid and the large pores permit ice masses to grow from pore to pore, entombing the soil particles. Thus, in coarse-grained soils, segregated ice lenses are not formed and less displacement can be expected.

Estimates of potential frost action generally are made for soils in mesic or colder temperature regimes. Exceptions are on the West Coast, where the mesic-thermic temperature line crosses below the 250 isoline, as displayed in Exhibit 618-6, and along the East Coast, where the soil climate is moderated by the ocean. Mesic soils that have a design freezing index of less that 250 degree days should not be rated because frost action is not likely to occur. The estimates are based on bare soil that is not covered by insulating vegetation or snow. They are also based on the moisture regime of the natural soil. The ratings can be related to manmade modifications of drainage or to irrigation systems on an on site basis. Frost action estimates are made for the whole soil to the depth of frost penetration, to bedrock, or to a depth of 2 meters (6.6 feet), whichever is shallowest. Exhibit 618-5 is a guide for making potential frost action estimates. It uses the moisture regimes and family textures as defined in Soil Taxonomy.

(e) Entries. Enter one of the following: LOW, MOD, or HIGH for the whole soil. If frost action is not a problem, enter NONE.

618.30 Gypsum.

(a) Definition. Gypsum is the percent, by weight, of hydrated calcium sulfates in the <20 mm fraction of soil.

(b) Significance. Gypsum is partially soluble in water and can be dissolved and removed by water. Soils with more than 10 percent gypsum, may collapse if the gypsum is removed by percolating water. Gypsum is corrosive to concrete. Corrosion of concrete is most likely to occur in soils that are more than about 1 percent gypsum when wetting and drying occurs.

(c) Measurement. Gypsum is measured by method 6F4, as outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.

(d) Entries. Enter the high, low, and representative values to represent the range in gypsum content as a weight percent of the soil fraction less than 20 mm in size. Round values to the nearest 5 percent for layers that are more than 5 percent gypsum and to the nearest 1 percent for layers that are less than 5 percent gypsum, for example, 0-1, 1-5, 5-10. If the horizon does not have gypsum, enter "0". Entries range from 0 to 120.

618.31 Horizon Depth to Bottom.

(a) Definition. Horizon depth to bottom is the distance from the top of the soil to the base of the soil horizon.

(b) Measurement. Distance is measured from the top of the soil, which is defined as the top of the mineral soil, or, for soil with "O" horizons, the top of any "O" layer that is at least partially decomposed. For soils that are covered by 80 percent or more rock or pararock fragments, the top of the soil is the surface of the fragments. See pages 63-64 in the *Soil Survey Manual* for a complete discussion. Measurement should be estimated to at least 25 cm below a lithic contact. For most soils, including those that have a root restricting contact such as a paralithic contact, the lowest horizon bottom should extend to a depth of at least 150 cm.

(c) Entries. Enter the high, low, and representative values in whole centimeters. The high value represents either the greatest depth to which the base of the horizon extends or, for horizons extending beyond the limit of field observation, it is the depth to which observation was made (usually no more than 200 cm but at least 150 cm).

618.32 Horizon Depth to Top.

(a) Definition. Horizon depth to top is the distance from the top of the soil to the upper boundary of the soil horizon.

(b) Measurement. Distance is measured from the top of the soil, which is defined as the top of the mineral soil, or, for soils with "O" horizons, the top of any "O" layer that is at least partially decomposed. For soils that are covered by 80 percent or more rock or pararock fragments, the top of the soil is the surface of the fragments. See pages 63-64 in the *Soil Survey Manual* for a complete discussion.

(c) Entries. Enter the high, low, and representative values in whole centimeters. Refer to the discussion under "horizon designations" as to how to list E/B and E and Bt type horizons.

618.33 Horizon Designation.

(a) Definition. Horizon designation is a concatenation of three kinds of symbols used in various combinations to identify layers of soil that reflect the investigator's interpretations of genetic relationships among layers within a soil.

(b) Significance. Soils vary widely in the degree to which horizons are expressed. The range is from little or no expression to strong expression. Layers of different kinds are identified by symbols. Designations are provided for layers that have been changed by soil formation and for those that have not. Designations are assigned after comparison of the observed properties of the layer with properties inferred for the material before it was affected by soil formation. Designations of genetic horizons express a qualitative judgment about the kind of changes that are believed to have taken place. A more detailed discussion can be reviewed in the *Soil Survey Manual*, Chapter 3.

(c) Entries. Enter combinations of symbols. Each horizon identified in a soil description can be entered or, if there are no significant differences in other data elements between two horizons, they may be combined. Enter only what the documentation can support. For example, if the only horizons that the data identify are an A, B, and C, then only enter those horizons. If, on the other hand, an Ap, A1, A2, Bt1, Bt2, Btk, C1, and C2 are documented, then enter those horizons. If the Bt1 and Bt2 horizons in the above example have no significant differences in the data element values, then they can be combined into a Bt horizon. For E/Bt and E&Bt horizon types, it is necessary to enter the horizons designations twice since each part will have a different set of data elements values associated with that portion of the horizon. This procedure is addressed in Chapter 7 of the Pedon Description Program User's Guide. Allowable codes are listed in the NASIS data dictionary. Further discussion of rules for use can be found in the *Soil Survey Manual*, Chapter 3, and the *Keys to Soil Taxonomy*, Ninth Edition, 2003.

618.34 Horizon Thickness.

(a) Definition. Horizon thickness is a measurement from the top to bottom of a soil horizon throughout its areal extent.

(b) Measurement. Soil horizon thickness varies on a cyclical basis. Measurements should be made to record the range in thickness as it normally occurs in the soil.

(c) Entries. Enter the high, low, and representative values in whole centimeters. The minimum allowable entry is 1 cm. For horizons extending beyond the limit of field observation, thickness is calculated only to the depth to which observation was made.

618.35 Hydrologic Group.

(a) Definition. Hydrologic group is a group of soils having similar runoff potential under similar storm and cover conditions. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonally high water table, and saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate . The influence of ground cover is treated independently.

(b) Classes. The soils in the United States are placed into four groups, A, B, C, and D, and three dual classes, A/D, B/D, and C/D. In the definitions of the classes, infiltration rate is the rate at which water enters the soil at the surface and is controlled by the surface conditions. Transmission rate is the rate at which water moves in the soil and is controlled by soil properties. Definitions of the classes are as follows:

A. (Low runoff potential). The soils have a high infiltration rate even when thoroughly wetted. They chiefly consist of deep, well drained to excessively drained sands or gravels. They have a high rate of water transmission.

B. The soils have a moderate infiltration rate when thoroughly wetted. They chiefly are moderately deep to deep, moderately well drained to well drained soils that have moderately fine to moderately coarse textures. They have a moderate rate of water transmission.

C. The soils have a slow infiltration rate when thoroughly wetted. They chiefly have a layer that impedes downward movement of water or have moderately fine to fine texture. They have a slow rate of water transmission.

D. (High runoff potential). The soils have a very slow infiltration rate when thoroughly wetted. They chiefly consist of clay soils that have a high swelling potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. They have a very slow rate of water transmission.

(1) Dual hydrologic groups, A/D, B/D, and C/D, are given for certain wet soils that can be adequately drained. The first letter applies to the drained condition, the second to the undrained. Only soils that are rated D in their natural condition are assigned to dual classes. Soils may be assigned to dual groups if drainage is feasible and practical.

(2) Chapter 7 of the NRCS National Engineering Handbook-4, Hydrology, discusses specific hydrologic groups of soils. Refer to:
ftp://ftp.wcc.nrcs.usda.gov/downloads/hydrology_hydraulics/neh630/hydro_soil_groups.pdf

(c) Significance. Hydrologic groups are used in equations that estimate runoff from rainfall. These estimates are needed for solving hydrologic problems that arise in planning watershed-protection and flood-prevention projects, for planning or designing structures for the use, control, and disposal of water. They pertain to the minimum steady ponded infiltration under conditions of a bare wet surface.

(d) Measurements. The original classifications assigned to soils were based on the use of rainfall-runoff data from small watersheds and infiltrometer plots. From these data, relationships between soil properties and hydrologic groups were established.

(e) Estimates. Assignment of soils to hydrologic groups is based on the relationship between soil properties and hydrologic groups. Wetness characteristics, water transmission after prolonged wetting, and depth to very slowly permeable layers are properties that assist in estimating hydrologic groups.

(f) Entries. Enter the soil hydrologic group, such as A, B, C, D, A/D, B/D, or C/D.

618.36 Landform.

(a) Definition. Landform is any physical, recognizable form or feature of the earth's surface, having a characteristic shape and produced by natural causes.

(b) Significance. Geographic order suggests natural relationships. Running water, with weathering and gravitation, commonly sculptures landforms within a landscape. Over the ages, earthy material has been removed from some landforms and deposited on others. Landforms are interrelated. An entire area has unity through the interrelationships of its landform.

Each landform may have one kind of soil present, or several. Climate, vegetation, and time of exposure to weathering of the parent materials are commonly about the same throughout the extent of the landform, depending on the relief of the area. Position on the landform may have influenced the soil-water relationships, microclimate, and vegetation.

The proper identification of the landform is an important part of understanding the formative history of the soil and the materials from which they formed. This aids in the development of the soil mapping model, and in the transfer of information between areas.

Landform terms are also used as phase criteria for separating mapping components or phases of a soil taxon.

(c) Classes. The allowable list of landform terms are included in the NASIS data dictionary. Definitions of the terms are included in part 629 of this handbook.

(d) Entries. Enter the appropriate class name for the landform(s) on which each map unit component occurs. A representative value (term) may be indicated. The capability is provided for indicating the presence of one landform occurring on another landform, i.e., a dune on a floodplain.

618.37 Linear Extensibility Percent.

(a) Definition. Linear extensibility percent is the linear expression of the volume difference of natural soil fabric at 1/3 bar or 1/10 bar water content and oven dryness. The volume change is reported as percent change for the whole soil.

(b) Classes. Shrink-swell classes are based on the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. If this change is expressed as a percent, the value used is LEP, linear extensibility percent. If it is expressed as a fraction, the value used is COLE, coefficient of linear extensibility. The shrink-swell classes are defined as follows:

Shrink-swell Class	**LEP**	**COLE**
Low	<3	<0.03
Moderate	3-6	0.03 - 0.06
High	6-9	0.06 - 0.09
Very High	≥9	≥0.09

(c) Significance. If the shrink-swell potential is rated moderate to very high, shrinking and swelling can damage buildings, roads, and other structures. The high degree of shrinkage associated with high and very high shrink-swell potentials can damage plant roots.

(d) Measurement. Coefficient of linear extensibility is measured directly as the change in clod dimension from moist to dry conditions and is expressed as a percentage of the volume change to the dry length:

$$\text{COLE} = \frac{\text{moist length - dry length}}{\text{dry length}}$$

When expressed as LEP (linear extensibility percent):

$$\text{LEP} = \text{COLE X } 100$$

Linear extensibility may be determined by any of the following methods:

(1) For the core method of measurement, select a sample core from a wet or moist soil. Carefully measure the wet length of the cores and set the core upright in a dry place. If the core shrinks in a symmetrical shape without excessive cracking or crumbling, its length can be measured and linear extensibility percent calculated. If the core crumbles or cracks, measurements cannot be accurately determined by this method.

(2) In the coated clod method of measurement, shrink-swell potential can be estimated from the bulk density of soil measured when moist and when dry. The coated clod method is widely used and is the most versatile procedure for determining bulk density of coherent soils. Procedures and calculations are given in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS, which is obtainable from the National Soil Survey Center.

(3) Linear extensibility percent can be calculated from bulk density moist (Dbm) and bulk density dry (Dbd) using the following formula:

$$LEP = 100\,[(Dbd/Dbm)^{1/3} - 1]\,[1 - (\text{Volume } \% > 2\text{ mm}/100)]$$

This equation is used to simplify the determination of shrink-swell potential classes. The classes are as follows:

Dbd / Dbm	Shrink-Swell Potential
<1.10	Low
1.10-1.20	Moderate
1.20-1.30	High
≥1.30	Very High

(e) Estimates. Field estimates of shrink-swell potential can be made by observing desiccation cracks, slickensides, gilgai, soil creep, and leaning utility poles. Shrink-swell potential correlates closely with the kind and amount of clay. The greatest shrink-swell potential occurs in soils that have high amounts of 2:1 lattice clays, such as smectites. Illitic clays are intermediate, and kaolinitic clays are least affected by volume change as the content in moisture changes.

(f) Entries. Enter the low, high, and representative linear extensibility percent values. The high and low values are to correspond to the high and low limits of the appropriate class. The range of valid entries is 0.00 to 30.00 percent.

618.38 Liquid Limit.

(a) Definition. Liquid limit is the water content of the soil (passing 40 sieve) at the change between the liquid and the plastic states.

(b) Significance. The plasticity chart, given in ASTM D 2487, is a plot of liquid limit (LL) versus plasticity index (PI) and is used in classifying soil in the Unified Soil Classification System. The liquid limit is also a criterion for classifying soil in the AASHTO Classification System, as shown in Exhibit 618-4. Generally, the amount of clay- and silt-size particles, the organic matter content, and the type of minerals determine the liquid limit. Soils that have a high liquid limit have the capacity to hold a lot of water while maintaining a plastic or semisolid state.

(c) Measurement. Tests are made on thoroughly puddled soil material that has passed a No. 40 (425 mm) sieve, and is expressed on a dry weight basis, according to ASTM method D 4318. This procedure requires the use of a liquid limit device, a special tool designed to standardize the arbitrary boundary between a liquid and plastic state of a soil. Estimates of liquid limit are made on soils during soil survey investigations and mapping activities. The liquid limit is usually inferred from clay mineralogy and clay content. If soils are tested later in the laboratory, adjustments are made to the field estimates as needed. Generally, experienced personnel can estimate these values with a reasonable degree of accuracy.

(d) Estimates. The formula in Exhibit 618-7 is used within the National Soil Information System to provide default calculated values if no measurements are available.

(e) Entries. Enter the high, low, and representative values as a range of percentages. Entries are allowed to tenths of a percent; however, entries should be rounded to the nearest 10 except where they are measured. Enter "0" for nonplastic soils.

618.39 Organic Matter.

(a) Definition. Organic matter percent is the weight of decomposed plant and animal residue and expressed as a weight percentage of the soil material less than 2 mm in diameter.

(b) Significance. Organic matter influences the physical and chemical properties of soils far more than the proportion to the small quantities present would suggest. The organic fraction influences plant growth through its influence on soil properties. It encourages granulation and good tilth, increases porosity and lowers bulk density, promotes water infiltration, reduces plasticity and cohesion, and increases the available water capacity. It has a high cation-adsorption capacity and is important to pesticide binding. It furnishes energy to micro-organisms in the soil. As it decomposes, it releases nitrogen, phosphorous, and sulfur. The distribution of organic carbon with depth indicates different episodes of soil deposition or soil formation.

Soils that are very high in organic matter have poor engineering properties and subside upon drying.

(c) Measurement. Measurements are made using total combustion to determine total carbon. Carbonate carbon is then determined and subtracted to provide an estimate of organic carbon. The results are given as the percent of organic carbon in dry soil. To convert the figures for organic carbon to those for organic matter, multiply the organic carbon percentage by 1.724. The detailed procedures will be outlined in the next version of Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, USDA, NRCS.

(d) Estimates. Color and "feel" are the major properties used to estimate the amount of organic matter. Color comparisons in areas of similar materials can be made against laboratory data so that a soil scientist can make estimates. In general, black or dark colors indicate high amounts of organic matter. The contrast of color between the A horizon and subsurface horizons is also a good indicator.

(e) Entries. Enter the high, low, and representative values to represent the range for each horizon. Use whole numbers for entries that are 1 and above; use tenths for those that are less than 1.

618.40 Parent Material, Kind, Modifier, and Origin.

Parent material is the unconsolidated material, mineral or organic, from which the soil develops. The soil surveyor uses parent material to develop a model used for soil mapping. Soil scientists and specialists in other disciplines use parent material to help interpret soil boundaries and project performance of the material below the soil. Many soil properties relate to parent material. Among these properties are proportions of sand, silt, and clay; chemical content; bulk density; structure; and the kinds and amounts of fragments. These properties affect interpretations and may be criteria to separate soil series. Soil properties and landscape information infer parent material. Three data elements -- parent material kind, parent material modifier, and parent material origin describe parent material.

(a) Parent Material Kind.

(1) Definition. Parent material kind is a term describing the general physical, chemical and mineralogical composition of the material, mineral or organic, from which the soil develops. Mode of deposition and/or weathering may be implied or implicit.

(2) Classes. The list of allowable entries are included in the NASIS data dictionary. Definitions of many of these terms are included in Part 629 of this handbook.

(3) Entries. Enter the applicable class name(s) for each map unit component. Multiple entries are permissible. Multiple layers of parent materials may also be indicated for a single component, such as loess over till over residuum.

(b) Parent Material Modifier.

(1) Definition. Parent material modifier is the general description of the texture of the parent material. Class limits correspond to those of textural groupings defined in *Soil Survey Manual* and family particle-size classes of Soil Taxonomy.

(2) Classes. The classes of parent material modifiers are:

Clayey	Loamy
Coarse-loamy	Sandy
Coarse-silty	Sandy and gravelly
Fine-loamy	Sandy and silty
Fine-silty	Silty
Gravelly	Silty and clayey

(3) Entries. Enter the appropriate class name to modify the corresponding layer of parent material kind as desired.

(c) Parent Material Origin.

(1) Definition. Parent material origin is the type of bedrock from which the parent material was derived.

(2) Classes. The allowable class names are included in the NASIS data dictionary and are the same as for the "bedrock kind" data element.

(3) Entries. Enter the appropriate "parent material origin" class name(s) to correspond with each "parent material kind" as desired. This data element is intended to be used when "residuum" is the chosen parent material kind. However, it may also be used with other kinds of parent material.

618.41 Particle Density.

(a) Definition. Particle density is the mass per unit of volume of the solid soil particle, either mineral or organic. Also known as specific gravity.

(b) Significance. Particle density is used in the calculation of weight and volume for soil (porosity). The relationship of bulk density, percent pore space, and the rate of sedimentation of solid particles in a liquid depends on particle density. The term particle density indicates wet particle density or specific gravity.

(c) Measurement. The standard methods of measurement for particle density are the ASTM Standard Test Method for Specific Gravity of Soils, ASTM designation D 854-92, which uses soil materials passing a No. 4 sieve; the method described by Blake and Hartge in Methods of Soil Analysis, Part 1, Agronomy 9; or the method for volcanic soils described by Bielders and others in Soil Sci. Soc. Am. J. 54: 822-826.

(d) Estimates. Particle density is often assumed to be 2.65 g cm^{-3}; however, many minerals and material of various origins exhibit particle densities less than or greater than this "standard." Particle density (Dp) may be calculated using the extractable iron and the organic carbon percentages in the following formula:

$$Dp = \frac{100}{\frac{(1.7 \times OC)}{Dp1} + \frac{(1.6 \times Fe)}{Dp2} + \frac{100 - [(1.7 \times OC) + (1.6 \times Fe)]}{Dp3}}$$

OC is the organic carbon percentage and Fe is the extractable iron determined by method 6C2 (Soil Survey Laboratory Staff, 1992) or by an equivalent method. The particle density of the organic matter (Dp1) is assumed to be 1.4 g cm^{-3}; that of the minerals from which the extractable iron originates (Dp2) is assumed to be 4.2 g cm^{-3}, and that of the material exclusive of the organic matter and the minerals contributing to the extractable Fe (Dp3) is assumed to be 2.65 g cm^{-3}.

(e) Entries. Enter the representative value. The range of valid entries is 1.0 to 6.0 g cm^{-3}. Hundredths are allowable.

618.42 Particle Size.

(a) Definition. Particle size is the effective diameter of a particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific, effective diameter class limits. The broad classes are clay, silt, and sand, ranging from the smaller to the larger of the less than 2 mm mineral soil fraction. It includes fragments of weathered or poorly consolidated fragments that disperse to particles less than 2 mm.

(b) Significance. The physical behavior of a soil is influenced by the size and percentage composition of the size classes. Particle size is important for most soil interpretations, for determination of soil hydrologic qualities, and for soil classification.

(c) Measurement. Particle size is measured by sieving and sedimentation. The method used is Method 3A1, which is outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.

(d) Classes. The United States Department of Agriculture uses the following size separates for the <2 mm mineral material:

USDA Particle size separates	Size (mm)
Clay, total	<0.002
Silt, total	0.002 - 0.05
Silt, fine	0.002 - 0.02
Silt, coarse	0.02 - 0.05
Sand total	0.05 - 2.00
Very fine sand	0.05 - 0.10
Fine sand	0.10 - 0.25
Medium sand	0.25 - 0.50
Coarse sand	0.50 - 1.00
Very coarse sand	1.00 - 2.00

Exhibit 618-8 compares the USDA system with the AASHTO and Unified Soil Classification System and shows the U.S. standard sieve sizes.

(e) Clay percentage.

(1) Definition. Total clay percentage is the weight percentage of the mineral particles less than 0.002 mm in equivalent diameter in the less than 2 mm soil fraction. Most of the material is in one of three groups of clay minerals or a mixture of these clay minerals. The groups are kaolinite, smectite, and hydrous mica, the best known member of which is illite.

(2) Significance. Physical and chemical activities of a soil are related to the kind and amount of clay minerals. Clay particles may have thousands of times more surface area per gram than silt particles and nearly a million times more surface area than very coarse sand particles. Thus, clay particles are the most chemically and physically active part of mineral soil.

Clay mineralogy and clay percentage have a strong influence on engineering properties and the behavior of soil material when it is used as construction or foundation material. They influence linear extensibility, compressibility, bearing strength, and saturated hydraulic conductivity.

The kind and amount of clay influence plant growth indirectly by affecting available water capacity, water intake rate, aeration, cation exchange capacity, saturated hydraulic conductivity, erodibility, and workability. Up to a certain point, an increase in the amount of clay in the subsoil is desirable. Clay can increase the amount of water and nutrients stored in that zone. By slightly slowing the rate of water movement, it can reduce the rate of nutrient loss through leaching. If the amount of clay is great, it can impede water and air movement, restrict root penetration, increase runoff and, on sloping land, result in increased erosion.

Clay particles are removed by percolating water from surface and subsurface horizons and deposited in the subsoil horizons. The amount of clay accumulation and its location in the profile provide clues for the soil scientist about soil genesis. Irregular clay distribution as related to depth may indicate lithologic discontinuities, especially if accompanied by irregular sand distribution.

(3) Measurement. Clay content is measured in the laboratory by the pipette or hydrometer methods after the air-dry soil is pretreated to remove organic matter and soluble salts. Field estimates of clay content are made by manual methods. The way a wet soil ribbons, or develops a long continuous ribbon, when pressed between the thumb and fingers gives a good idea of the amount of clay present. Excessive amounts of sodium can toughen the soil, making the soil feel more clayey. Care should be taken not to overestimate the amount of clay in sodic soils. Accuracy depends largely on frequent and attentive observation. Texture reference samples determined in the laboratory are used by soil scientists to calibrate the feel of soils with various percentages of clay.

(4) Entries. Enter the high, low, and representative values of the clay total separate as a percent of the material less than 2 mm in size for each horizon. Enter a "0" if amount is not significant, as in organic layers or in some andic soil materials. The representative value should equate to the representative (clay total separate) "texture class" posted for each horizon.

(f) Sand Percentage.

(1) Definition. Sand percentage is the weight percentage of the mineral particles less than 2 mm and greater than or equal to 0.05 mm in equivalent diameter in the less than 2 mm soil fraction. The sand separates recognized are very coarse, coarse, medium, fine, very fine, and total. Respective size limits are shown in paragraph 618.42(d) above. Much of the sand fraction is composed of fragments of rocks and primary minerals, especially quartz. Therefore, the sand fraction is quite chemically inactive.

(2) Significance. Physical properties of the soil are influenced by the amounts of total sand and of the various sand fractions present in the soil. Sand particles, because of their size, have a direct impact on the porosity of the soil. This influences other properties, such as saturated hydraulic conductivity, available water capacity, water intake rates, aeration, and compressibility related to plant growth and engineering uses.

(3) Measurement. Sand content is measured in the laboratory by the wet sieving method and then fractionated by dry sieving. Field estimates are made by manual methods. The degree of grittiness in a wet soil sample, when worked between the thumb and forefinger, gives an estimate of the sand content. The size of sand grains may be observed with the naked eye or with the aid of a hand lens.

(4) Entries. Enter the high, low, and representative value of each sand size separate (sand coarse separate, sand fine separate, sand medium separate, sand very coarse separate, sand very fine separate, sand total separate) as a percent of the material less than 2 mm in size for each horizon. Enter a "0" if amount is not significant, as in organic layers or in some andic soil materials. The representative value should equate to the representative "texture class" posted for each horizon.

(g) Silt Percentage.

(1) Definition. Silt percentage is the weight percentage of the mineral particles greater than or equal to 0.002 mm but less than 0.05 mm in the less than 2 mm soil fraction. The silt separates recognized are fine, coarse, and total. The respective size limits are listed in paragraph 618.42 (d) above. The silt separate is dominated by primary minerals, especially quartz, and therefore has a low chemical activity.

(2) Significance. The silt separate possesses some plasticity, cohesiveness, and absorption, but to a much lesser degree than the clay separate. Silt particles act to slow water and air movement through the soil by filling voids between sand grains. A very high content of silt in a soil may be physically undesirable for some uses unless supplemented by adequate amounts of sand, clay, and organic matter.

(3) Measurement. The silt content is measured in the laboratory in two phases. The fine silt is measured using the pipette method on the suspension remaining from the wet sieving process. Aliquots of the diluted suspension are removed at predetermined intervals based on Stokes Law. The aliquots are then dried and weighed. The coarse silt fraction is the difference between 100 percent and the sum of the sand, clay, and fine silt percentages.

The silt content may be estimated in the field using the ribbon test as described for clay. The content of silt is usually estimated by first estimating the clay and sand portions and then subtracting that number from 100 percent. Silt tends to give the soil a smooth feel.

(4) Entries. Enter the high, low, and representative value of each silt size separate (silt coarse separate, silt fine separate, silt total separate) as a percent of the material less than 2 mm in size for each horizon. Enter a "0" if amount is not significant, as in organic layers or in some andic soil materials. The representative value should equate to the representative "texture class" posted for each horizon.

618.43 Percent Passing Sieves.

(a) Definition. The percent passing sieve numbers 4, 10, 40, and 200 is the weight of material that passes these sieves, based on the material less than 3 inches (75 mm) in size, expressed as a percentage.

(b) Significance. Data for the percent passing sieves are used to classify the soil in the engineering classifications and to make judgments on soil properties and performance. Many soil characteristics are influenced by the depth distribution of grain size for the soil as well as its mode of deposition, stress history, density, and other features.

(c) Measurement. Measurements involve sieve analysis for the determination of grain size distribution of that portion of the soil having particle diameters between 3 inches and 0.074 mm (No. 200 sieve). ASTM methods D 422, C 136, and C 117 have applicable procedures that are used where appropriate. Measurements are made on most benchmark soils and other representative soils in survey areas.

(d) Estimates. Estimates of the content of sand, silt, clay, and rock fragments that are made for soils during soil survey investigations and mapping activities are used to estimate percent passing sieves. If samples are tested later in a laboratory, adjustments are made to the field estimates as needed. Generally, experienced personnel can estimate these values with a high degree of accuracy. Estimates for percent passing sieves can be made from soil texture using the following general guidance:

Percent passing #200 = clay + silt + 1/2 very fine sand

Percent passing #40 = 1/2 very fine sand + fine sand + 1/2 medium sand + percent passing #200

The percent passing #10 equals the less than 2 mm fraction, and soil texture is based on the less than 2 mm fraction. Since sieves represent the less than 3-inch fraction, the #40 and #200 sieve estimates must be adjusted when the percent passing #10 is less than 100 percent. The percent passing #40 and #200 that is determined above by texture must be adjusted by multiplying the percent passing #40 and percent passing #200 by the percent passing #10. Pararock fragments are not cemented strongly enough to be retained on sieves. They are crushed and estimated into percent passing sieves.. ASTM procedures use a roller crusher as a pretreatment of the soil material prior to sieving . Field estimates should try to replicate this procedure.

(e) Entries. Enter the high, low, and representative values to represent the range of percent passing each sieve size for each horizon. The range includes the estimating accuracy as well as the range of values for a soil. Entries are allowable as tenths of a percent and range from 0 to 100 percent.

618.44 Plasticity Index.

(a) Definition. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It is the range of water content in which a soil exhibits the characteristics of a plastic solid. The plastic limit is the water content that corresponds to an arbitrary limit between the plastic and semisolid states of a soil.

(b) Significance. The plasticity index, when used in connection with the liquid limit, serves as a measure of the plasticity characteristics of a soil. The plasticity chart, given in ASTM D 2487, is a plot of the liquid limit (LL) versus the plasticity index (PI) and is used in classifying soil in the Unified Soil Classification System. The plasticity index is also a criterion for classifying soil in the AASHTO Classification System, as shown in Exhibit 618-4. Soils that have a high plasticity index have a wide range of moisture content in which the soil performs as a plastic material. Highly and moderately plastic clays have large PI values.

(c) Measurements. Tests are made on that portion of the soil having particles passing the No. 40, (425 micrometer) sieve, according to ASTM Method D 423. Measurements are made on most benchmark soils and on other representative soils in survey areas. Estimates of plasticity index are made on all soils during soil survey investigations and mapping activities. The plasticity index is usually not estimated directly, but a position on the plasticity chart in ASTM D 2487 is estimated. The plasticity index can then be determined from the chart. If soils are later tested in the laboratory, adjustments are made to the field procedures as needed. Generally, experienced personnel can estimate these values with a reasonable degree of accuracy. Estimates are expressed in ranges that include the estimating accuracy as well as the range of values from one location to another within the map unit.

(d) Estimates. The formula in Exhibit 618-7 is used within the National Soil Information System to provide default calculated values if no measurements are available.

(e) Entries. Enter the high, low, and representative values to represent the range for each horizon. Round to the nearest 5 percent unless the values are measured. Entries may range from 0 to 130. Enter "0" for nonplastic soils.

618.45 Ponding Depth, Duration, Frequency Class, and Month.

Ponding is standing water in a closed depression. The water is removed only by deep percolation, transpiration, or evaporation or by a combination of these processes. Ponding of soils is classified according to depth, frequency, duration, and the beginning and ending months in which standing water is observed.

(a) Ponding depth.

(1) Definition. Ponding depth is the depth of surface water that is ponding on the soil.

(2) Entries. Enter the high, low, and representative values for the ponding depth, in centimeters, for the map unit component. Entries are whole numbers that range from 0 to 185 centimeters.

(b) Ponding frequency class.

(1) **Definition**. Ponding frequency class is the number of times ponding occurs over a period of time.

(2) **Classes**. The ponding frequency classes are:

Ponding Frequency Class	Definition
NONE	No reasonable possibility of ponding, near 0 percent chance of ponding in any year
RARE	Ponding unlikely but possible under unusual weather

	conditions; from nearly 0 to 5 percent chance of ponding in any year or nearly 0 to 5 times in 100 years
OCCASIONAL	Ponding is expected infrequently under usual weather conditions; 5 to 50 percent chance of ponding in any year or nearly 5 to 50 times in 100 years
FREQUENT	Ponding is likely to occur under usual weather conditions; more than 50 percent chance in any year or more than 50 times in 100 years

(3) Entries. Enter NONE, RARE, OCCASIONAL, or FREQUENT as appropriate for the map unit component.

(c) Ponding duration class.

(1) Definition. Ponding duration class is the average duration, or length of time, of the ponding occurrence.

(2) Classes. The ponding duration classes are:

Ponding Duration Class	**Duration of the ponding occurrence**
VERY BRIEF	Less than 2 days
BRIEF	2 to 7 days
LONG	7 to 30 days
VERY LONG	≥30 days

(3) Entries. Enter VERY BRIEF, BRIEF, LONG, or VERY LONG for the map unit component. Only use entries if ponding occurs more often than rare.

(d) Ponding month.

(1) Definition. Ponding month is the calendar month(s) in which ponding is expected.

(2) Classes. The time of year when ponding is likely to occur is expressed in months for the expected beginning to expected end of the ponding period. The time period expressed includes two-thirds to three-fourths of the occurrences.

(3) Entries. Enter the name of each month of the year in which ponding is expected.

(e) Significance. The susceptibility of soils to ponding is important for homes, building sites, and sanitary facilities. Time and duration of the ponding are critical factors determining plant species. Ponding during the dormant season has few if any harmful effects on plant growth or mortality and, may even improve growth.

(f) Estimates. Generally, estimates of ponding frequency and duration can be made for each soil. Where the natural infiltration, saturated hydraulic conductivity, and surface and subsurface drainage of soils is altered, ponding studies are needed to reflect present ponding characteristics.

(1) Evidence of ponding events should be gathered during soil survey field work. High water lines and other signs of maximum water height are recorded. Other records may also exist.

(2) Certain landform features are subject to ponding. These features are characteristics of closed drainage systems and include potholes, playas, sloughs, and backswamps. Most of these features are recognizable when correlating features on aerial photographs with ground observations. Different kinds of vegetation and soils are normally associated with these geomorphic features.

(3) The vegetation that grows in ponded areas may furnish clues to past ponding and indicate the potential for ponding in the future. Generally, native vegetation in ponded areas consists of obligate and facultative wet hydrophytes. Some plant species are intolerant of ponding and do not grow in areas that are ponded.

(4) The soil provides clues to past ponding, but characteristics vary according to climate and soil conditions. Some of the clues are (i) a dark surface horizon or layer overlying a gleyed subsoil; (ii) many prominent redoximorphic features that have low value and chroma; (iii) capillary transport and concentrations of carbonates or sulfates, or both, in the upper soil horizons; and (iv) dark colors and high levels of organic matter throughout the profile or any combination of these features.

618.46 Pores.

Pore space is a general term for voids in the soil material. The term includes matrix, nonmatrix, and interstructural pore space. For water movement at low suction and conditions of satiation, the nonmatrix and interstructural porosity have particular importance.

Matrix pores. Matrix pores are formed by the agents that control the packing of the primary soil particles. These pores are usually smaller than nonmatrix pores. Additionally, their aggregate volume and size would change markedly with water state for soil horizons or layers with high extensibility.

Nonmatrix pores. Nonmatrix pores are relatively large voids that are expected to be present when the soil is moderately moist or wetter, as well as under drier states. The voids are not bounded by the planes that delimit structural units. Nonmatrix pores may be formed by roots, animal, action of compressed air, and other agents. The size of the distribution of nonmatrix pores usually bears no relationship to the particle size distribution and the related matrix pore size distribution.

Interstructural pores. Interstructural pores are delimited by structural units. Inferences as to the interstructural porosity may be obtained from the structure description. Commonly, interstructural pores are at least crudely planar.

Nonmatrix pores are described by quantity, size, shape, and vertical continuity--generally in that order.

(a) Pore quantity.

(1) Definition. Pore quantity is the classes that pertain to the number of a selected size of pores per unit area of undisturbed soils--1 cm^2 for very fine and fine pores, 1 dm^2 for medium and coarse pores, and 1 m^2 for very coarse pores.

(2) Classes. The pore quantity classes are:

Pore Quantity Class	Number of pores per unit area
Few	<1
Common	≥1-5
Many	≥5

(3) Entries. Enter pore quantity as pores/area. Enter the high, low, and representative values as a whole number between 0 and 99 for the horizon.

(b) Pore size.

(1) Definition. Pore size is the average diameter of the pore.

(2) Classes. The pore size classes are:

Pore Size Class	Pore Size (mm)
Very fine	<1
Fine	1-2
Medium	2-5
Coarse	5-10
Very Coarse	≥ 10

(3) Entries. Enter a single class or a combination of size classes for the horizon. Acceptable entries for pore size class are very fine, very fine and fine, very fine to medium, very fine to coarse, fine, fine and medium, fine to coarse, medium, medium and coarse, coarse, and very coarse.

(c) Pore shape.

(1) Definition. Pore shape is a description of the multiarial shape of the pore. Most nonmatrix pores are either vesicular (approximately spherical or elliptical) or tubular (approximately cylindrical and elongated). Some are irregularly shaped and referred to as interstitial. Additionally, the following designations are utilized:

Continuous--if nonmatrix pore extends vertically through the thickness of the horizon or layer.

Discontinuous--the nonmatrix pore does not extend vertically through the thickness of the horizon or layer.

Constricted--the tubular pores are plugged with clay.

Dendritic--the tubular pores branch out of a main stem.

(2) Classes. The pore shape classes are:

Constricted tubular	Interstitial and tubular
Continuous tubular	Tubular
Dendritic tubular	Vesicular
Discontinuous tubular	Vesicular and tubular
Filled with coarse material	Void between fragments
Interstitial	

(3) Entries. Enter one of the choices from the class list for the horizon.

(d) Vertical continuity.

(1) Definition. Vertical continuity is the average vertical distance through which the minimum pore diameter exceeds 0.5 mm when the soil layer is moist or wetter.

(2) Classes. The vertical continuity classes are:

Vertical Continuity Class	Vertical distance (cm)
Low	< 1
Moderate	1-10
High	≥ 10

(3) Entries. Enter one of the vertical continuity classes.

618.47 Reaction, Soil (pH).

(a) Definition. Soil reaction is a numerical expression of the relative acidity or alkalinity of a soil.

(b) Classes. The descriptive terms for reaction and their respective ranges in pH are:

Reaction Class	Range in pH
Ultra acid	1.8-3.4
Extremely acid	3.5-4.4
Very strongly acid	4.5-5.0
Strongly acid	5.1-5.5
Moderately acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral	6.6-7.3
Slightly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strongly alkaline	8.5-9.0
Very strongly alkaline	9.1-11.0

(c) Significance. A principal value of soil pH is the information it provides about associated soil characteristics. Two examples are phosphorus availability and base saturation. Soils that have a pH of approximately 6 or 7 generally have the most ready availability of plant nutrients. Strongly acid or more acid soils have low extractable calcium and magnesium, a high solubility of aluminum, iron, and boron, and a low solubility of molybdenum. In addition, these soils have a possibility of organic toxins and generally have a low availability of nitrogen and phosphorus. At the other extreme are alkaline soils. Calcium, magnesium, and molybdenum are abundant with little or no toxic aluminum, and nitrogen will be readily available. If pH is above 7.9, the soils may have an inadequate availability of iron, manganese, copper, zinc, and especially of phosphorus and boron.

Soil reaction is one of several properties used as a general indicator of soil corrosivity or its susceptibility to dispersion. In general, soils that are either highly alkaline or highly acid are likely to be corrosive to steel. Soils that have pH <5.5 are likely to be corrosive to concrete. Soils that have pH >8.5 are likely to be highly dispersible, and piping may be a problem.

(d) Measurement. The most common soil laboratory measurement of pH is the 1:1 water method. A crushed and sieved soil sample is mixed with an equal amount of water, and a measurement is made of the suspension using a pH meter. Another method used, especially for Histosols, is the 0.01M calcium chloride method. In NASIS these two methods are shown as separate data elements.

(1) The pH values derived from water suspension are affected by field applications of fertilizer or other salts in the soil, the content of carbon dioxide in the soil, and even moisture content at the time of sampling. The 0.01M calcium chloride method reduces these influences.

(2) The laboratory methods are described in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.

(e) Estimates. A variety of field test kits are available for determination of pH in the field. The methods include a water-soluble dye, which is mixed with soil and thus produces a color that is compared with a chart; a dye-impregnated paper, which changes color according to differences in pH; and portable glass electrodes. Each state office can recommend a suitable pH method for the soils in the state. If requested, the Soil Survey Laboratory makes suggestions for suitable methods for field measurements and furnishes NRCS soil scientists with the proper chemicals.

(f) Entries. Soil reaction (pH) is time and moisture dependent, and water pH can vary up to a whole unit during the growing season. The range of pH should reflect the variations. The 1:1 water method generally is used except for Histosols, which are measured in 0.01M calcium chloride. Separate entries are made for "pH 1 to 1 water" and "pH 0.1M calcium chloride", depending on whether the horizon is mineral or organic. Enter the high, low, and representative values of the appropriate estimated pH range for each horizon. The high and low values are to correspond with the class limits as follows:
1.8-3.4, 3.5-4.4, 4.5-5.0, 5.1-5.5, 5.6-6.0, 6.1-6.5, 6.6-7.3, 7.4-7.8, 7.9-8.4, 8.5-9.0, 9.1-11.0; or enter a combination of classes, for example, 4.5-5.5.

618.48 Restriction Kind, Depth, Thickness, and Hardness.

Identify and describe restrictive soil layers in the field. Observe, measure, and record restriction kind, hardness, depth, and thickness.

When describing pedons, if possible, identify types or kinds of restrictions by suffix symbols, such as "d," "f," "m," "r," "v," or "x;" or by the master layer "R."

(a) Restriction kind.

(1) Definition. Restriction kind is the type of nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly reduce the movement of water and air through the soil or that otherwise provide an unfavorable root environment. Cemented layers, dense layers, frozen layers, abrupt or stratified layers, strongly contrasting textures, and dispersed layers are examples of soil layers that are restrictions.

(2) Classes. The choices for restriction kind are:

Abrupt textural change	Petrocalcic
Bedrock (lithic)	Petroferric
Bedrock (paralithic)	Petrogypsic
Cemented horizon	Placic
Dense material	Plinthite
Duripan	Salic
Fragipan	Strongly contrasting textural stratification

Natric
Ortstein
Permafrost
Sulfuric
Undefined

(3) Entries. Enter the appropriate choice for the horizon or layer.

(b) Restriction depth.

(1) Definition. Restriction depth is the vertical distance from the soil surface to the upper and to the lower boundary of the restriction.

(2) Entries. Enter the high, low, and representative values for upper and lower restriction depths in centimeters using whole numbers.

(c) Restriction thickness.

(1) Definition. Restriction thickness is the distance from the top to the bottom of a restrictive layer.

(2) Entries. Enter the high, low, and representative values for the thickness in whole centimeters using whole numbers from 1 to 999.

(d) Restriction hardness.

(1) Definition. Restriction hardness is the rupture resistance of an air-dried, then submerged block-like specimen of mineral material. Ice is not applicable.

(2) Classes. Restriction hardness is rated using the following classes and operation descriptions:

Restriction hardness class	**Operation description**
Not applicable	Specimen not obtainable
Noncemented	Fails under very slight force applied slowly between thumb and forefinger (<8N).
Extremely weakly cemented	Fails under slight force applied slowly between thumb and forefinger (8 to 20N).
Very weakly cemented	Fails under moderate force applied slowly between thumb and forefinger (20 to 40N).
Weakly cemented	Fails under strong force applied slowly between thumb and forefinger (about 80N maximum force can be applied) (40 to 80N).
Moderately cemented	Cannot be failed between thumb and forefinger but can be failed between both hands or by placing specimen on a nonresilient surface and applying gentle force underfoot (80 to 160N).
Strongly cemented	Cannot be failed in hands but can be failed underfoot by full body weight (about 800N) applied slowly (160 to 800N).
Very strongly cemented	Cannot be failed underfoot by full body weight but can be failed by <3J blow (800N to 3J).
Indurated	Cannot be failed by blow of 3J (≥ 3J).

Both force (Newtons, N) and energy (joules, J) are employed. The number of Newtons is 10 times the kilograms of force. One joule is the energy delivered by dropping a 1 kg weight a distance of 10 cm.

(3) Measurement. For measurements of the restriction hardness, use the procedures and classes of cementation that are listed with the rupture resistance classes. Classes are described for like specimens about 25-30 mm on edge which are air-dried and then submerged in water for at least 1 hour. Compress the specimen between extended thumb and forefinger, between both hands, or between the foot and a nonresilient flat surface. If the specimen resists compression, drop a weight onto it from progressively greater heights until it ruptures. Failure is the point of the initial detection of deformation or rupture. Stress applied in the hand should be over a 1-second period. Learn the tactile sense of the class limits by applying force to top loading scales and sensing the pressure through the tips of the fingers or through the ball of the foot. Use postal scales for the resistance range that is testable with the fingers. Use a bathroom scale for the higher rupture resistance range.

(4) Entries. Enter the appropriate class name without the word "cemented"; i.e., use "moderately" for moderately cemented.

(e) Significance. Restriction layers limit plant growth by restricting the limits of the rooting zone. They also impede or restrict the movement of soil water vertically through the soil profile and have a direct impact on the quality and quantity of ground water and surface water. Restriction hardness and thickness have a significant impact on the ease of mechanical excavation. Use excavation difficulty classes to evaluate the relationships of restriction layers to excavations.

(f) Measurements. Use measurements or observations made throughout the extent of occurrence of a soil as a base for estimates of restriction kind, depth, thickness, and hardness.

618.49 Runoff (Index Surface Runoff).

(a) Definition. Index surface runoff class is the runoff potential class for the soil.

(b) Significance. Surface runoff refers to the loss of water from an area by flow over the land surface. The estimation of the amount of runoff is important to hydrologic models in assessing the stream flow and water storage.

(c) Estimation. Estimate the runoff classes by using the table below (ref. SSM table 3-10). This table uses a combination of surface slope and the saturated hydraulic conductivity (Ksat) representative value (RV) of the upper 1 meter of soil material including bedrock or other restrictive material as criteria. Determine the minimum Ksat of the upper 1 meter of material. If that minimum Ksat is at or above .5 meters, use the table below as shown. If the minimum Ksat of the upper 1 meter of material occurs between .5 and 1 meter, use the table below but reduce the runoff by one runoff class (from medium to low, for example). For soils with seasonal free water within 50 cm of the soil surface, use a Ksat of <0.01 $\mu m\ s^{-1}$ in the table.

The concept indicates relative runoff for very specific conditions. (1) The soil surface is assumed to be bare and surface water retention due to irregularities in the ground surface is low. (2) Steady ponded infiltration rate is the applicable infiltration stage. (3) Ice is assumed to be absent unless otherwise indicated. (4) Both the maximum bulk density in the upper 25 cm and the bulk density of the uppermost few centimeters are assumed within the limits specified for the mapping concept. (5) The concept assumes a standard storm or amount of water addition from snowmelt of 50 mm in a 24-hour period with no more than 25 mm in any single 1-hour period. (6) The soil moisture state is assumed to be *very moist* or *wet* to the base of the soil, to 1/2 m, or through the horizon or layer with minimum Ksat within 1 meter, whichever is the greatest depth.

Index Surface Runoff Classes

Slope Pct.	**Saturated Hydraulic Conductivity ($\mu m\ s^{-1}$) Ksat**					
	≥100	**<100-10**	**<10-1.0**	**<1.0-0.1**	**<0.1-0.01**	**<0.01**
Concave	N	N	N	N	N	N
<1	N	N	N	L	M	H
1-5	N	LV	L	M	H	HV
5-10	LV	L	M	H	HV	HV
10-20	LV	L	M	H	HV	HV
≥20	L	M	H	HV	HV	HV

(d) Classes. The index surface runoff classes and their abbreviations are:

N	Negligible
LV	Very low
L	Low
M	Medium
H	High
HV	Very high

(e) Entries. Enter the appropriate index surface runoff class for each map unit component. Only one class may be listed.

618.50 Saturated Hydraulic Conductivity

(a) Definition. Saturated hydraulic conductivity is the amount of water that would move vertically through a unit area of saturated soil in unit time under unit hydraulic gradient

(b) Significance. Saturated hydraulic conductivity is used in soil interpretations. It is also known as Ksat.

(c) Measurement. Means, such as the Amoozemeter and double ring infiltrometers, provide some basis for estimation of saturated hydraulic conductivity. but no method has been accepted as a standard. Since measurements are difficult to make and are available for relatively few soils, estimates of saturated hydraulic conductivity are based on soil properties.

(d) Estimates. The soil properties that affect saturated hydraulic conductivity are distribution, continuity, size, and shape of pores. Since the pore geometry of a soil is not readily observable or measurable, observable properties related to pore geometry are used to make estimates of saturated hydraulic conductivity. These properties are texture, structure, pore size, density, organic matter, and mineralogy. Exhibit 618-9 provides a guide for estimating saturated hydraulic conductivity from soil texture and bulk density with a guide for use with overriding conditions.

(1) In making estimates, the soil characteristic that exerts the greatest control for many soils is texture.

(2) The general relationships in Exhibit 618-9 are adjusted up or down depending on bulk density. Structure, pore size, organic matter, clay mineralogy, and other observations within the soil profile, such as consistency, dry layers in wet seasons, root mats or absence of roots, and evidence of perched water levels or standing water are good field indicators for adjusting estimates.

(3) Water movement through lithic and paralithic materials can be estimated from the guide in Exhibit 618-10.

(e) Entries. Enter the high, low, and representative values of saturated hydraulic conductivity for each horizon. The range of valid entries for saturated hydraulic conductivity is 0.00 to 705.00 $\mu m\ s^{-1}$. Four decimal places are allowed.

618.51 Slope Aspect.

(a) Definition. Slope aspect is the direction toward which the surface of the soil faces.

(b) Significance. Slope aspect may affect soil temperature, evapotranspiration, winds received, and snow accumulation.

(c) Measurement. Slope aspect is measured clockwise from true north as an angle between 0 and 360 degrees..

(d) Entries. Enter the slope aspect counter-clockwise, slope aspect clockwise, and slope aspect representative for each map unit component. The minimum is 0 degrees and the maximum is 360 degrees.

Slope aspect counter-clockwise is one end of the range in characteristics for the slope aspect of a component. This end of the range is expressed in degrees measured clockwise from true north, but in the direction counter-clockwise from the representative slope aspect.

Slope aspect clockwise is one end of the range in characteristics for the slope aspect of a component. This end of the range is expressed in degrees measure clockwise from true north, and in the direction clockwise from the representative slope aspect.

Slope aspect representative is the common, typical, or expected direction toward which the surface of the soil faces, measured in degrees clockwise from true north.

618.52 Slope Gradient.

(a) Definition. Slope gradient is the difference in elevation between two points and is expressed as a percentage of the distance between those points. For example, a difference in elevation of 1 meter over a horizontal distance of 100 meters is a slope of 1 percent.

(b) Significance. Slope gradient influences the retention and movement of water, the potential for soil slippage and accelerated erosion, the ease with which machinery can be used, soil-water states, and the engineering uses of the soil.

(c) Measurement. Slope gradient is usually measured with a hand level or clinometer. The range is determined by summarizing data from several sightings.

(d) Entries. Enter the high, low, and representative values to represent the range of slope gradient as a percentage for the map unit component. Entries for high and low are whole number integers and range from 0 to 999. Entries for representative values below 1 percent can be given in tenths of a percent.

618.53 Slope Length.

(a) Definition. Slope length is the horizontal distance from the origin of overland flow to the point where either the slope gradient decreases enough that deposition begins or runoff becomes concentrated in a defined channel. Reference Agriculture Handbook 703.

(b) Significance. Slope length has considerable control over runoff and potential accelerated water erosion. Slope length is combined with slope gradient in erosion prediction equations to account for the effect of topography on erosion.

(c) Measurement. Slope length is measured from the point of origin of overland flow to the point where the slope gradient decreases enough that deposition begins or runoff becomes concentrated in a defined channel. In cropland defined channels are usually ephemeral gullies, in rare instances, near a field edge they may be a classic gully or stream. Surface runoff will usually concentrate in less than 400 feet (120 meters), although longer slope lengths of up to 1,000 feet are occasionally found. The maximum distance allowed in erosion equations is 1000 feet (305 meters). Conversion to the horizontal distance is made in the conversion process within the equation model.

Assume no support practices. Ignore practices such as terraces or diversions. Slope length is best determined by pacing or measuring in the field. Do not use contour maps to estimate slope lengths unless contour intervals are one foot or less. Slope lengths estimated from contour maps are usually too long because most maps do not have the detail to indicate all ephemeral gullies and concentrated flow areas that end the slope lengths. Refer to figures 4-1 through 4-10 within Ag. Handbook 703 for more landscape guidance.

(d) Entries. Enter the high, low, and representative values for the range for each map unit component. Enter a whole number that represents the length in meters from the point of origin of overland flow to the point of deposition or concentrated flow of the slope on which the component lies. The slope length may be fully encompassed within one map unit or it may cross several map units. The minimum value is 0, and the maximum value used in erosion equations is 305 meters.

618.54 Sodium Adsorption Ratio.

(a) Definition. Sodium adsorption ratio (SAR) is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration. SAR is calculated from the equation:

$$SAR = Na / [(Ca + Mg)/2]^{0.5}$$

(b) Significance. Soils that have values for sodium adsorption ratio of 13 or more may have an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure.

(c) Measurement. The concentration of Na, Ca, and Mg ions is measured in a water extract from saturated soil paste. The procedure is method 5 described in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.

(d) Entries. Enter the high, low, and representative values to represent the range of sodium adsorption ratio as integers for each horizon. Enter "0" where the SAR is negligible. Entries range from 0 to 9999.

618.55 Soil Erodibility Factors, USLE, RUSLE2.

(a) Definition. Soil erodibility factors (Kw) and (Kf) quantify soil detachment by runoff and raindrop impact. These erodibility factors are indexes used to predict the long-term average soil loss, from sheet and rill erosion under crop systems and conservation techniques. Factor Kw applies to the whole soil, and Kf applies only the fine-earth fraction, which is the <2.0 mm fraction. The procedure for determining the Kf factor is outlined in Agriculture Handbook No. 703, Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE), USDA, ARS, 1997. The K factors in Hawaii and the Pacific Basin were extrapolated from local research. The nomograph was not used.

(b) Classes. Experimentally measured Kw factors vary from 0.02 to 0.69. For soil interpretations, the factors are grouped into 14 classes. The classes are identified by a representative class value as follows: .02, .05, .10, .15, .17, .20, .24, .28, .32, .37, .43, .49, .55, and .64.

(c) Significance. Soil erodibility factors Kw or Kf are used in erosion prediction equations USLE and RUSLE. Soil properties that influence rainfall erosion are (1) those that affect infiltration rate, movement of water through the soil, and water storage capacity and (2) those that affect dispersion, detachability, abrasion, and mobility by rainfall and runoff. Some of the most important properties are texture, organic matter content, structure size class, and subsoil saturated hydraulic conductivity.

(d) Estimates. The Kw factor is measured by applying a series of simulated rainstorms on freshly tilled plots. Direct measurement of the Kw is both costly and time consuming and has been conducted only for a few selected soils.

Reliable Kf estimates are obtained from the soil erodibility nomograph on page 11 of Agricultural Handbook 537, which is reproduced in Exhibit 618-12, or by using the soil erodibility equation. The nomograph integrates the relationship between the Kf factor and five soil properties: (1) percent silt plus very fine sand, (2) percent sand greater than 0.10 mm, (3) organic matter content, (4) structure, and (5) saturated hydraulic conductivity. The soil erodibility equation which follows also provides an estimate of Kf.

$$K\ factor = \{2.1 \times M^{1.14} \times 10^{-4} \times (12-a)+3.25 \times (b-2)+2.5 \times (c-3)\}/100$$

where:

M = (percent si + percent vfs) X (100 - percent clay)

For a soil with 29.0% silt, 12.3% very fine sand, and 36% clay

M = (29.0+12.3) X (100-36) = 2,643.20.

a = percent organic matter (nearest whole value) (use worse case organic matter assuming long term cultivation) (0, 1, 2, 3, or 4)
b = structure code (1, = very fine granular, 2, = fine granular, 3, = med or coarse granular, or 4 = blocky, platy, or massive)
c = profile saturated hydraulic conductivity code (1, 2, 3, 4, 5, or 6). Use the layer with the lowest Ksat range. Note that the codes were initially established using the 1951 Soil Survey Manual. The codes correspond to the following saturated hydraulic conductivity ranges:

Profile Permeability Class Code	Permeability Class of 1951	Saturated hydraulic conductivity range µm/sec
6	Very slow	<0.30
5	Slow	0.30 to <1.20
4	Slow to Mod.	1.20 to <5.00
3	Moderate	5.00 to <15.00
2	Mod. to Rapid	15.00 to <30.00
1	Rapid	≥ 30.00

Rock or pararock fragments are not taken into account in the nomograph or the equation. If fragments are substantial, they have an armoring effect, and the Kf factor should be adjusted downward. Pararock fragments are assumed to break down with cultivation.

The nomograph and the equation accuracy has been demonstrated for a large number of soils in the United States. However, the nomograph and the equation may not be applicable to some soils having properties that are uniquely different from those used in developing the nomograph. For example, the nomograph does not accurately predict Kf factors for certain Oxisols in Puerto Rico or the Hawaiian Islands. In these cases, Kf factors are estimated from the best information at hand and knowledge of the potential for rainfall erosion.

When using the nomograph and the equation, care should be taken to select the organic matter curve that is most representative of the horizon being considered, assuming long term cultivation. For horizons that have organic matter >4 %, use the 4 % curve. Do not extrapolate between whole values when using the equation.

If a soil has fragments, the Kw factor should reflect the degree of protection afforded by those fragments. Guidelines for determining Kw factors are as follows:

(1) Use the nomograph in Exhibit 618-12 or the equation to determine the Kf factor for material less than 2 mm in diameter.

(2) Use Exhibit 618-11 to convert the weight percentage of the material greater than 3 inches and of the material less than 3 inches, which is retained on the #10 sieve, to a volume percent of the whole soil that is rock fragments, specifically rock fragments >2 mm in diameter. First, find the volume percentage greater than 3 inches on the whole soil basis by taking the midpoint of the weight percentage of material greater than 3 inches and comparing the weight percentage in column 2 to the volume percentage in column 1. On that same line, move to the right to the weight percent passing #10 sieve column to find the volume percent gravel, specifically rock fragments that are 2 to 75 mm in size, on a whole soil basis. Then add the volume greater than 3 inches from column 1 and the volume gravel to find the volume percent of the whole soil that is rock fragments. Add in the percent pararock fragments on noncultivated areas.

(3) Use Exhibit 618-13 to convert the Kf value of the fraction less than 2 mm derived from the nomograph in Exhibit 618-12 or from the equation, to a Kw factor adjusted for volume of rock fragments.

If the soil on site contains more or less rock fragments than the mean of the range reported, adjustments can be made in Kf by using Exhibit 618-13. Convert the estimates of rock fragments from weight percentages to volume percentages using Exhibit 618-11, then enter Exhibit 618-13 in line with this volume percentage and find in that line the nearest value to the Kf factor. Within that column, read the Kw factor on the line with the percentage of rock fragments of the soil for which you are making the estimate. Round the factor to the closest factor class. This is the new Kw factor adjusted for rock fragments on site.

(e) Entries. Enter the coordinated Kw and Kf classes for each horizon posted, except organic horizons.

Acceptable entries for Kw and Kf are .02,. 05, .10, .15, .17, .20, .24, .28, .32, .37, .43, .49, .55, and .64. Soil textures that do not have rock fragments have equal Kw and Kf factors. Where rock fragments exist, Kw is always less than Kf. For example:

Depth (in)	USDA Texture	Kw	Kf
0-5	GR-L	.20	.32
0-5	L	.32	.32
0-5	GRV-L	.10	.32
5-46	CL	.28	.28
46-60	SL	.20	.20

Soils that have similar properties and erosivity should group in similar K classes.

618.56 Soil Erodibility Factors for WEPP.

Soil erodibility factors for WEPP include Interrill Erodibility (K_i), Rill Erodibility (K_r), and Critical Hydraulic Shear (T_c). These erodibility factors for the WEPP erosion model quantify the susceptibility of soil detachment by water. These erodibility factors predict the long-term average soil loss, which results from sheet and rill erosion under various alternative combinations of crop systems and conservation techniques.

Soil erodibility factors K_i, K_r, and T_c are factors in a continuous simulation computer model which predicts soil loss and deposition on a hillslope. Reference the NSERL Report No. 9, USDA, ARS National Erosion Research Laboratory, August 1994, documentation version 94.7. This procedure does not include data for oxidic and andic materials.

These values are quantitative and calculated using experimental equations. They are different than soil erodibility factors for USLE and RUSLE.

(a) Interrill erodibility (K_i).

(1) Definition. Interrill erodibility (K_i) is the susceptibility of detachment and transport of soil by water. It is the susceptibility of the soil to movement to a rill carrying runoff.

(2) Significance. Interrill erodibility (K_i) is a measure of sediment delivery rate to rills as a function of rainfall intensity. The K_i values for soil need to be adjusted for factors that influence the resistance of soil to detachment, such as live and dead root biomass, soil freezing and thawing, and mechanical and livestock compaction.

(3) Measurement. Interrill erodibility (K_i) measurements result from rainfall simulation experiments. These experiments require specialized equipment and specialized measurement techniques in a research setting.

(4) Calculations. Use the following equations:

For cropland soils with 30 percent or more sand:

K_i = 2,728,000 + 192,100 X (% very fine sand)

Very fine sand must be less than or equal to 40 percent; if very fine sand is greater, use 40 percent.

For cropland soils with less than 30 percent sand:

K_i = 6,054,000 - 55,130 X (% clay)

Clay must not exceed 50 percent: if clay is greater, use 50 percent.

(5) Entries. The computer generates entry values using the above formulas. Allowable Ki values range from 2,000,000 to 11,000,000.

(b) Rill erodibility (K_r).

(1) Definition. Rill erodibility (K_r) is a measure of the susceptibility of a soil to detachment by flowing water. As a rule as rill erodibility (K_r) increases, rill erosion rates increase.

(2) Significance. Rill erodibility (K_r) is a measure of soil susceptibility to detachment concentrated flow, and is often defined as the soil detachment per unit increase in shear stress of clear water flow. Rate of soil detachment in rills varies because of a number of factors including soil disturbance by tillage, living root biomass, incorporated residue, fragments, soil consolidation, freezing and thawing, and wheel and livestock compaction.

(3) Measurement. Rill erodibility (K_r) measurements result from simulated rainfall and simulated flow in a research setting. These experiments require specialized equipment and specialized measurement techniques.

(4) Calculations. Use the following equations:

For cropland soils with 30 percent or more sand:

K_r = 0.00197 + 0.00030 X (% very fine sand) + 0.03863 X *EXP*(-1.84 X ORGMAT)

Organic Matter (ORGMAT) is the organic matter in the surface soil (assuming that organic matter equals 1.724 times organic carbon content). Organic matter must exceed 0.35 percent; if less, use 0.35 percent.

Very fine sand must be less than or equal to 40 percent; if greater, use 40 percent.

For cropland soils with less than 30 percent sand:

K_r = 0.0069 + 0.134 X *EXP*(-0.20 X % Clay)

Clay must be 10 percent or greater; if less, use 10 percent.

(5) Entries The computer generates the value by using the above formulas. Allowable K_r values range from 0.002 to 0.045 s/m.

(c) Critical shear stress (T_c).

(1) Definition. Critical shear stress (T_c) is the hydraulic shear that must be exceeded before rill erosion can occur.

(2) Significance. Critical shear stress (T_c) is an important term in the rill detachment equation, and is the shear stress below which no soil detachment occurs. Critical shear stress (T_c) is the shear intercept on a plot of detachment by clear water versus shear stress in rills.

(3) Measurements. Critical hydraulic shear (T_c) is a derived variable measured in a specialized research project.

(4) Calculations. Use the following equations:

For cropland soils with 30 percent or more sand:

T_c = 2.67 + 0.065 X (% clay) - 0.058 X (% very fine sand)

Very fine sand must be less than or equal to 40 percent; if greater, use 40 percent.

For cropland soils with less than 30 percent sand:

Tc = 3.5

(5) Entries. No manual entry is needed. The value will be computer generated using the above formulas. Allowable T_c values range from 1 and 6 N/m^2.

618.57 Soil Moisture Status.

(a) Definition. Soil moisture status is the mean monthly soil water state at a specified depth.

(b) Classes. The water state classes used in soil moisture status are dry, moist, and wet. These classes are defined as follows:

Water State Class	**Definition**
Dry	≥15 bar suction
Moist	< 15 bar to ≥ 0.0 bar (moist plus nonsatiated wet)
Wet	< 0.0 bar; free water present (satiated wet)

(c) Significance. Soil moisture status is a recording of the generalized water states for a soil component. Soil moisture greatly influences vegetation response, root growth, excavation difficulty, albedo, trafficability, construction, conductivity, soil chemical interactions, workability, chemical transport, strength, shrinking and swelling, frost action, seed germination, and many other properties, qualities, and interpretations. Soil moisture states are significant to soil taxonomic classification, wetland classification, and other classification systems. The recording of soil moisture states helps to document the soil classification as well as convey information for use in crop and land management models.

(d) Measurement. Soil water status can be measured using tensiometers or moisture tension plates. Soil water status also can be field estimated. Chapter 3 of the *Soil Survey Manual* provides more information. It is important to note that the 3 water state classes and 8 subclasses described in the *Soil Survey Manual* are used to describe the moisture state at a point in time for individual pedons (spatial and temporal point data), while the water state classes discussed here are used for estimating the mean monthly aggregated moisture conditions for a map unit component. As a consequence, only 3 classes are used, and the definitions for the moist and wet classes are modified from the *Soil Survey Manual* definitions. The wet class used here includes only the satiated wet class and corresponds to a free water table. The moist class is expanded to include the nonsatiated wet class of the *Soil Survey Manual*.

Dry is separated from moist at 15 bar suction. Wet satiated has a tension of 0.0 bar or less (zero or positive pore pressure)

Changes in natural patterns of water movement from dams and levees **are** considered in evaluating and entering soil moisture status. Infiltration, saturated hydraulic conductivity, and organic matter, which affect soil moisture movement, are strongly impacted by land cover and land use. Land use/land cover should be given consideration as a mapping tool in separating map units or map unit components. The differences in soil moisture status from land use/land cover differences constitute a difference in soil properties. However, conservation practices, such as irrigation and fallow, alter the soil moisture status but are not considered in the map unit component data. Use-dependent databases may allow entries for these altered states in the future.

Permanent installations, such as drainage ditches and tile, affect soil moisture status, and the drained condition should be reflected in the soil moisture status entries for map unit components that are mapped as “drained.” Undrained areas are mapped as “undrained” components and the entries for soil moisture status reflect the undrained condition.

Irrigation and drainage canals are shown on soil maps; their effects on the soil should be shown in the properties of the soils in mapping and in the property records. Soils that are now wet because of excessive irrigation and leaking canals should be mapped, and their properties should reflect the current soil moisture status.

(e) Guiding Concepts

- The intent is to describe a mean moisture condition, by month, for a soil component. Layer depths may or may not be the same as horizon depths in the component horizon table. Layers define the zone having the same soil moisture state. If the soil is wet throughout 0 to 200 cm, then one entry (wet) is made for 0 to 200 cm for that month.
- For frozen soils enter the appropriate soil moisture state that the soil would have if thawed. For example, if the soil is frozen and you determine it is wet when thawed, enter wet.
- The layers can be subdivided into various soil moisture states as needed, but remember that these are monthly averages for the extent of the component across the landscape.
- The entries are expected to come from the best estimates that local knowledge can provide. If local knowledge is supported by data, so much the better. The information as aggregated data is not expected to be exact but to be generalized and to reflect an average condition.
- Entries for RV are to reflect the conditions of a “normal year."
- Make entries for each month by layer. Enter the condition that dominates for the month. This is the condition for more than 15 days on the long-term average. The low and high values represent the depth range within the component for the normal year; they are not to represent the extremes, such as years of drought.
- If the depth to free-water fluctuates during the month, use the depth for the average between the high and low level.

Exhibit 618-18 contains examples of entries.

(f) Entries. Enter the soil moisture status with dry, moist, or wet, for each soil layer for each month. Enter only one soil moisture state within a given layer. The number of layers depends upon the number of changes of soil moisture status in the profile.

Enter the value for soil moist depth to top that represents the distance, in whole centimeters, from the soil surface to the top of each soil layer for each month.

618.58 Soil Slippage Hazard.

(a) Definition. Soil slippage hazard is the observation of surface slippage features that indicate a mass of soil will possibly slip when the vegetation is removed and soil water is at or near saturation or when the slope is undercut. Saturating a slope with water from altered drainage or irrigation has an effect on slippage hazard but is not considered when making these ratings.

The publication "Landslides Investigation and Mitigation Special Report 247 Transportation Research Board National Research Council 1996" provides additional information on landscape slippage.

(b) Significance. Slippage is an important consideration for engineering practices, such as constructing roads and buildings, and for forestry practices.

(c) Estimates. Soil slippage hazard classes are estimated by observing slope; lithology, including contrasting lithologies; strike and dip; surface drainage patterns; and occurrences of such features as slip scars and slumps.

(d) Guides. Use Exhibit 618-17 "Key Landforms and Their Susceptibility to Slippage" as a guide for rating soil slippage hazard.

(e) Entries. Enter one of the following classes:

High - (Unstable)
Medium - (Moderately unstable)
Low - (Slightly unstable to stable)

618.59 Soil Temperature.

(a) Definition. Soil temperature is the mean monthly soil temperature at the specified depth. (The average of the daily high and daily low temperature for the month.)

(b) Significance. Soil temperature is important to many biological and physical processes that occur in the soil. Plant germination and growth are closely related to soil temperature. Cold soil temperatures effectively create a thermal pan in the soil. Roots cannot uptake moisture or nutrients below the threshold temperatures specific to plant species. Chemical reactions are temperature sensitive. Pesticide breakdown, residue breakdown, microbiological activity in the soil, and nutrient conversions relate to soil temperature. Soil temperature gradients affect soil moisture and salt movement. Soil temperatures below freezing especially affect soil saturated hydraulic conductivity, excavation difficulty, and construction techniques. Soil temperature is used in soil classification and hydric soil determinations. Additional information is provided in Chapter 3 of the *Soil Survey Manual*.

(c) Estimates. Soil temperature according to depth can be estimated from measured soil temperatures in the vicinity. Air temperature fluctuations, soil moisture, aspect, slope, color, snow cover, plant cover, and residue cover affect soil temperature. Estimates of soil temperature should take these factors into account when soil temperatures are extrapolated from one soil map unit component to another.

(d) Measurement. Soil temperature can be measured by many types of thermometers, including mercury, bimetallic, thermisters, and thermocouples. Many types of thermometers can be configured for remote, unattended operation.

(e) Entries. Each soil temperature layer consists of a zone bounded by a five degree increment; e.g., 0-5, 5-10, 10-15. The allowable range is -10.0 to 50.0 degrees Celsius. The number of layers depends upon the number of changes of soil temperature status in the profile.

Enter the value for soil temperature mean monthly using the average soil temperature Celsius increment that corresponds to each soil temperature layer for each month.

Enter the value for soil temperature depth to top that represents the distance, in centimeters, from the soil surface to the top of each soil temperature layer for each month. Enter the value for soil temperature depth to bottom that represents the distance, in centimeters, from the soil surface to the bottom of each soil temperature layer for each month.

618.60 Subsidence, Initial and Total.

(a) Definition. Subsidence is the decrease in surface elevation as a result of the drainage of wet soils that have organic layers or semifluid, mineral layers. Initial subsidence is the decrease of surface elevation that occurs within the first 3 years of the drainage of these wet soils. Total subsidence is the potential decrease of surface elevation as a result of the drainage of these wet soils.

(b) Significance. The susceptibility of soils to subsidence is an important consideration for organic soils that are drained. If these soils are drained for community development, special foundations are needed for buildings. Utility lines, sidewalks, and roads that lack special foundations may settle at different rates, thus causing breakage, high maintenance costs, and inconvenience. If the soils are drained for farming, the long-term effects of subsidence, the possible destruction of land if it subsides below the water table, and possible legal implications if the soils are in wetlands must be considered.

Subsidence, as a result of drainage is attributed to (1) shrinkage from drying, (2) consolidation because of the loss of ground-water buoyancy, (3) compaction from tillage or manipulation, (4) wind erosion, (5) burning, and (6) biochemical oxidation. The first three factors are responsible for the initial subsidence that occurs rapidly, specifically, within about 3 years after the water table is lowered. After the initial subsidence, a degree of stability is reached and the loss of elevation declines to a steady rate primarily because of oxidation. The oxidation and subsidence continues at this slower rate until stopped by the water table or underlying mineral material. The rate of subsidence depends on (1) ground-water depth, (2) amount of organic matter, (3) kind of organic matter, (4) soil temperature, (5) pH, and (6) biochemical activity.

(c) Estimates. A number of studies have been made to measure actual subsidence. Other useful studies have measured the bulk density of organic soils after drainage. Based on these studies, some general guidelines can be given for initial and total subsidence.

Initial subsidence, generally is about half of the depth to the lowered water table or to mineral soil, whichever is shallower. It occurs within about 3 years after drainage. Total subsidence is the total depth to the water table or the thickness of the organic layer, whichever is shallower. It is rarely reached except where organic layers are thin or where drainage systems have been installed for a long time.

(d) Measurement. After organic soils have been drained and cultivated for a number of years, they reach a nearly steady rate of subsidence that is reflected by the rather stable bulk density. Unpublished studies by the Soil Survey Laboratory, have shown that the bulk density of the organic component, such as that with the percent mineral calculated out, stabilizes at around 0.27 g/cc for surface layers and 0.18 g/cc for subsurface layers. These values can be used to calculate the amount of subsidence at some time in the future as compared to the thickness of soil at the time of observation or measurement. The procedure is as follows:

(1) Sample the surface and subsurface layers for field state bulk density. Methods are described in the Handbook of Soil Survey Investigations Field Procedures, I 4-2, 1971, USDA, SCS, and Method 4A as described in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.

(2) Calculate out the weight contribution of the mineral component to obtain the bulk density of the organic component (DbOM). This manipulation allows bulk densities to be on a common base so that various layers can be compared. The formula for the computation is as follows:

DbOM = Db (1 - percent mineral/100), where Db is the field state bulk density.

(3) Calculate the subsidence percent (SP) for surface and subsoil horizons as follows:

For surface horizons:

SP = 100 - [(DbOM/0.27) x 100]

For subsurface horizons:

SP = 100 - [(DbOM/0.18) x 100]

Where DbOM is obtained from step (2).

(4) Convert initial subsidence percent to depth of subsidence in inches as follows:

Where:

S	=	SPsur x Tsur + SPsub x Tsub
S	=	depth of subsidence in inches
SPsur	=	subsidence percent of the surface horizon
Tsur	=	thickness of the surface horizon
SPsub	=	subsidence percent of the subsurface horizon
Tsub	=	thickness of the subsurface horizon above the water table or the mineral soil, whichever is shallower

(e) Entries. Enter the high, low, and representative values, in whole numbers that represent the range for initial and total subsidence in centimeters for the map unit component. Allowable entries range from 0 to 999. If subsidence is not a concern, enter "0".

618.61 Surface Fragments.

(a) Definition. Surface fragments are unattached, cemented pieces of bedrock or bedrock-like material 2 mm or larger that are exposed at the surface of the soil.

Surface fragments can be either rock fragments or pararock fragments, which are defined in part 618.27. Vegetal material is not included.

(b) Surface fragment cover percent.

(1) Definition. Surface fragment cover percent is the percent of ground covered by fragments 2 mm or larger.

(2) Significance. Fragments on the soil surface are used as map unit phase criteria and greatly affect use and management of the soil. They affect equipment use, erosion, excavation, and construction. They act as a mulch, slowing evaporation and armoring the soil from rainfall impact. They also affect the heating and cooling of soils.

(3) Estimates. An estimation of cover by surface fragments can be made visually without quantitative measurement, by transect techniques, or by some combination of visual and quantitative measures. Chapter 3 of the *Soil Survey Manual* provides more information.

(4) Entries. Enter the high, low, and representative values for the percent of the surface covered by each size class and the kind of fragment described for each map unit component.

(c) Surface fragment kind.

(1) Definition. Surface fragment kind is the lithology/composition of the surface fragments 2mm or larger.

(2) Significance. Fragments vary according to their resistance to weathering. Consequently, fragments of some lithologies are more suited than others for use as building stone, road building material, or riprap to face dams and stream channels.

(3) Entries. Enter the appropriate class name for the kind of fragment present. More than one choice may be entered. The class names can be found in the NASIS data dictionary.

(d) Surface fragment size.

(1) Definition. Surface fragment size is the size based on the multiaxial dimensions of the surface fragments.

(2) Significance. The size of surface fragments is significant to the use and management of the soil. The adjective form of fragment size is used as phase criteria for naming map units. It affects equipment use, excavation, construction, and recreational uses.

(3) Classes. Classes of surface fragment size are subdivided according to flat and non-flat fragments.

Flat fragment classes are:

Flat fragment class	**Length of fragment (mm)**
Channers	2-150
Flagstones	150-380
Stones	380-600
Boulders	≥600

Non-flat fragment classes are:

Non-flat fragment class	**Diameter (mm)**
Pebbles	2-75
Fine pebbles	2-5
Medium pebbles	5-20
Coarse pebbles	20-75
Cobbles	75-250
Stones	250-600
Boulders	≥600

For fragments that are less than strongly cemented, "para" is added as a prefix to the above terms; i.e., paracobbles.

(4) Entries. Enter the minimum, maximum, and representative values, in whole numbers, of each size class described. Entries are in millimeters and range from 2 to 3,000 mm.

(e) Mean distance between rocks.

(1) Definition. Mean distance between rocks is the average distance between surface stones and/or boulders.

(2) Significance. The mean distance between rocks is a field clue for naming stony or bouldery map units. The closer the distance, the more equipment limitations for harvesting forestland or soil cultivation.

(3) Estimates. Table 3-12 of the *Soil Survey Manual* shows the distance between stones and boulders if the diameter is 0.25 m, 0.6 m, or 1.2 m. This table should be used with caution because stones and boulders will rarely be equally spaced or have the same diameter.

(4) Entries. Enter the high, low, and representative values for the mean distance in hundredths of meters.

(f) Surface fragment roundness.

(1) Definition. Surface fragment roundness is an expression of the sharpness of edges and corners of surface fragments.

(2) Classes. The surface fragment roundness classes are:

Angular
Subangular
Subrounded
Rounded
Well-rounded

(3) Entries. Enter the appropriate class name for the roundness class(es) present. A representative value may be designated.

(g) Surface fragment rupture resistance cemented.

(1) Definition. Surface fragment rupture resistance cemented is the rupture resistance of a surface fragment of specified size that has been air dried and then submerged in water.

(2) Measurements. Procedures and classes of cementation are listed with the rupture resistance classes. Classes are described for similar specimens about 25-30 mm on edge, which are air-dried and then submerged in water for at least 1 hour. The specimen is compressed between extended thumb and forefinger, between both hands, or between the foot and a hard flat surface. If the specimen resists compression, a weight is dropped onto it from progressively greater heights until it ruptures. Failure is considered at the initial detection of deformation or rupture. Stress applied in the hand should be over a 1-second period. The tactile sense of the class limits may be learned by applying force to top loading scales and sensing the pressure through the tips of the fingers or through the ball of the foot. Postal scales may be used for the resistance range that is testable with the fingers. A bathroom scale may be used for the higher rupture resistance range.

(3) Significance. The rupture resistance is significant where the class is strongly cemented or higher. These classes can impede or restrict the movement of soil water vertically through the soil profile and have a direct impact on the quality and quantity of ground water and surface water.

(4) Classes. The classes are:

Extremely weakly
Very weakly
Weakly
Moderately
Strongly
Very strongly
Indurated

(5) Entries. Enter the appropriate class name(s) for each class of fragment present. A representative value may be designated.

(h) Surface fragment shape.

(1) Definition. Surface fragment shape is a description of the overall shape of the surface fragment.

(2) Classes. The surface fragment shape classes are:

Flat
Nonflat

(3) Entries. Enter the appropriate class name(s) for each class present. Multiple entries may be made. A representative value may be designated.

618.62 T Factor.

(a) Definition. The T factor is the soil loss tolerance (in tons per acre). It is defined as the maximum amount of erosion at which the quality of a soil as a medium for plant growth can be maintained. This quality of the soil to be maintained is threefold in focus. It includes maintaining (1) the surface soil as a seedbed for plants, (2) the atmosphere-soil interface to allow the entry of air and water into the soil and still protect the underlying soil from wind and water erosion, and (3) the total soil volume as a reservoir for water and plant nutrients, which is preserved by minimizing soil loss. Erosion losses are estimated by USLE and RUSLE2.

(b) Classes. The classes of T factors are 1, 2, 3, 4, and 5.

(c) Significance. Soil loss tolerances commonly serve as objectives for conservation planning on farms. These objectives assist in the identification of cropping sequences and management systems that will maximize production and also sustain long-term productivity. T factors represent the goal for maximum annual soil loss.

(d) Guidelines. Conservation objectives for soil loss tolerance include on maintaining a suitable seedbed and nutrient supply in the surface soil, maintaining an adequate depth and quality of the rooting zone, and minimizing unfavorable changes in water status throughout the soil. A single T factor is assigned to each map unit component.

(e) Estimates. The T factor is assigned to soils without respect to land use or cover. T factors are assigned to compare soils and do not imply differences to vegetation response directly. Many of the factors used to assign a T factor are also important to vegetation response, but the T factor is not assigned to imply vegetation sensitivity to all vegetation. The general guideline given in

Exhibit 618-14 is used to assign T factors but more specific criteria is used to select limiting soil properties.

(f) Entries. The estimated soil loss tolerance should be calculated from the soil properties and qualities posted in the database for each map unit component based generally on the guideline, given in Exhibit 618-14. Acceptable values are 1, 2, 3, 4, or 5.

618.63 Taxonomic Family Temperature Class.

(a) Definition. The soil temperature classes are part of the family level in *Soil Taxonomy*. They differ from "Soil temperature regimes," (Data Element: taxonomic temp regime), in that the "cryic", and "pergelic" temperature regimes are divided between the frigid and isofrigid classes based on differences in mean winter and mean summer soil temperatures. Soil temperature classes are based on mean annual and mean seasonal soil temperatures using the Celsius (centigrade) scale and taken either at a depth of 50 cm from the soil surface or at a lithic or paralithic contact, whichever is shallower.

For soil families that have a difference of 5°C or more between mean summer (June, July, and August in the northern hemisphere) temperature and mean winter (December, January, and February in the northern hemisphere) temperature, the soil temperature classes, defined in terms of the mean annual soil temperature, are as follows:

Frigid	Lower than 8°C
Mesic	8°C to 15°C
Thermic	15°C to 22°C
Hyperthermic	22°C or higher

For soil families that have a difference of less than 5°C between the mean summer and mean winter soil temperatures, the soil temperature classes, defined in terms of the mean annual soil temperature, are as follows:

Isofrigid	< 8°C
Isomesic	8°C to 15°C
Isothermic	15°C to 22°C
Isohyperthermic	22°C or higher

(b) Significance. All soils have a taxonomic soil temperature class. Soil temperature classes are used as family differentiae in all orders in *Soil Taxonomy*. The names are used as part of the family name unless the criteria for a higher taxon carry the same limitation. The frigid or isofrigid class is implied in all boric and cryic suborders and great groups, but the class is not used as part of the family name because it would be redundant.

(c) Estimates. Estimates of soil temperature classes are made with models that use climatic data including mean annual and mean seasonal air temperatures, precipitation, and evapotranspiration. Some models include snow cover, topographic, and vegetative inputs.

(d) Measurement. The Celsius (centigrade) scale is the standard. It is assumed that the temperature is that of a nonirrigated soil. The soil temperature classes are based on long term averages of mean annual and mean seasonal soil temperatures taken either at a depth of 50 cm from the soil surface or at a lithic or paralithic contact, whichever is shallower.

(e) Entries. Enter the appropriate soil temperature class from the following list:

Frigid	Hyperthermic
Isofrigid	Isomesic
Isothermic	Isohyperthermic
Mesic	Thermic

618.64 Taxonomic Moisture Class.

(a) Definition. Soil moisture classes refer to the moisture regimes defined in soil taxonomy. Soil moisture regimes are defined by the presence or absence either of ground water or of water held at a tension of less than 1500 kPa, in the soil or in specific horizons, by periods of the year.

(b) Significance. All soils have a soil moisture regime. Soil moisture regimes are used as differentiae in all orders, except Histosols, in soil taxonomy. The moisture regime is used for making interpretations for wildlife habitat. The moisture regime of some soils is not apparent in the classification given in soil taxonomy. Ustolls and Xerolls, for example, can have an aridic moisture regime. Some soils can have more than one moisture regime. An example is a soil that meets the requirements of the aquic moisture regime in the wet season and also meets the requirements of the ustic regime.

(c) Estimates. Estimates of soil moisture regimes are made with models that use climatic data, including mean annual and mean seasonal air temperatures, precipitation, and evapotranspiration. Some models include topographic and vegetative inputs. The soil moisture control section, also defined in soil taxonomy, is used to facilitate estimation of soil moisture regimes.

(d) Measurement. The soil moisture regimes are based on annual and seasonal soil moisture measurements taken in the soil moisture control section. The soil should not be irrigated or fallowed or influenced by other moisture altering practices.

(e) Entries. Enter the appropriate soil moisture regimes from the following list:

Aquic	Peraquic
Aridic (torric)	Udic
Perudic	Ustic
Xeric	

618.65 Taxonomic Moisture Subclass. (Subclasses of soil moisture regimes.)

(a) Definition. Subclasses of soil moisture regimes are defined at the subgroup level in soil taxonomy. The criteria differ among the great groups. For example aquic, aridic, and udic are subclasses of the soil moisture regime in Haplustalfs. A subclass is entered for all soils in a great group that meet the subclass criteria, even if the subclass is not part of the taxonomic classification. For example, aquic, aridic, udic, or typic should be used as a subclass of the soil moisture regime in Lithic Haplustalfs if the criteria are met.

(b) Significance. Subclasses of soil moisture regimes are used at the subgroup level in all orders in Soil Taxonomy except Histosols. They typically indicate an intergrade between two moisture regimes that affect the use and management of the soil. Subclasses of soil moisture regimes are used for making interpretations for wildlife habitat.

(c) Estimates. Estimates of subclasses of soil moisture regimes are made with models that use climatic data, including mean annual and mean seasonal air temperatures, precipitation, and evapotranspiration. Some models include topographic and vegetative inputs. The soil moisture control section, also defined in soil taxonomy, is used to facilitate estimation of some subclasses of soil moisture regimes.

(d) Measurement. The subclasses of soil moisture regimes are based on annual and seasonal soil moisture measurements taken in the soil moisture control section. The soil should not be irrigated or fallowed or influenced by other moisture altering practices.

(e) Entries. Enter the appropriate subclass of soil moisture regimes from the following list:

Aeric	Anthraquic
Aquic	Aridic (torric)
Oxyaquic	Typic

Udic Ustic
Xeric

618.66 Taxonomic Temperature Regime. (Soil Temperature Regimes.)

(a) Definition. Soil temperature regimes refer to the temperature regimes as defined in soil taxonomy.

(b) Significance. Soil temperature regimes are used as differentiae above the family level in all orders in soil taxonomy. (Soil temperature classes, defined above, are used as family differentiae.) Soil temperature regimes greatly affect the use and management of soils, particularly for the selection of adapted plants. They are used for making interpretations for wildlife habitat.

(c) Estimates. Estimates of soil temperature regimes are made with models that use climatic data including mean annual and mean seasonal air temperatures, precipitation, and evapotranspiration. Some models include topographic and vegetative inputs.

(d) Measurement. The soil temperature regime is based on mean annual and seasonal soil temperatures using the Celsius (centigrade) scale and taken either at a depth of 50 cm from the soil surface or at a lithic or paralithic contact, whichever is shallower.

(e) Entries. Enter the appropriate soil temperature regimes from the following list:

Pergelic	Cryic
Frigid	Mesic
Thermic	Hyperthermic
Isofrigid	Isomesic
Isothermic	Isohyperthermic

618.67 Texture Class, Texture Modifier, and Terms Used in Lieu of Texture.

(a) Definition. Texture class refers to the soil texture classification used by the U.S. Department of Agriculture as defined in the *Soil Survey Manual*. Soil texture is the relative proportion, by weight, of the particle separate classes finer than 2 mm in equivalent diameter. The material finer than 2 mm is the fine-earth fraction. Material 2 mm or larger is rock or pararock fragments.

(b) Significance. Soil texture influences engineering works and plant growth and is used as an indicator of how soils formed. Soil texture has a strong influence on soil mechanics and the behavior of soil when it is used as construction or foundation material. It influences such engineering properties as bearing strength, compressibility, saturated hydraulic conductivity, shrink-swell potential, and compaction. Engineers are also particularly interested in rock and pararock fragments. Soil texture influences plant growth by its affect on aeration, the water intake rate, the available water capacity, the cation exchange capacity, saturated hydraulic conductivity, erodibility, and workability. Changes in texture as related to depth are indicators of how soils formed. When texture is plotted with depth, smooth curves indicate translocation and accumulation. Irregular changes in particle-size distribution, especially in the sand fraction, may indicate lithologic discontinuities, specifically, differences in parent material.

(c) Measurement. USDA texture can be measured in the laboratory by determining the proportion of the various size particles in a soil sample. The analytical procedure is called particle-size analysis or mechanical analysis. Stone, gravel, and other material 2 mm or larger are sieved out of the sample and do not enter into the analysis of the sample. Their amounts are measured separately. Of the remaining material smaller than 2 mm, the amount of the various sizes of sand is determined by sieving. The amount of silt and clay is determined by a differential rate of settling in water. Either the pipette or hydrometer method is used for the silt and clay analysis. Organic matter and dissolved mineral matter are removed in the pipette procedure but not in the hydrometer procedure. The two procedures are generally very similar, but a few samples, especially those with high organic matter or high soluble salts, exhibit wide discrepancies. The detailed procedures are outlined in Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004, USDA, NRCS.

(d) Estimates. The determination of soil texture of the less than 2 mm material is made in the field mainly by feeling the soil with the fingers. The soil must be well moistened and rubbed vigorously between the fingers for a proper determination of textural class by feel. This method requires skill and experience but good accuracy can be obtained if the field soil scientist frequently checks his or her estimates against laboratory results. Many NRCS offices collect reference samples for this purpose. The content of particles larger than 2 mm cannot be evaluated by feel. The content of the fragments is determined by estimating the proportion of the soil volume that they occupy. Fragments in the soil are discussed in part 618.27.

Each soil scientist must develop the ability to determine soil texture by feel for each genetic soil group according to the standards established by particle-size analysis. Soil scientists must remember that soil horizons that are in the same texture class but are in different subgroups or families may have a different feel. For example, natric horizons generally feel higher in clay than "non-natric" horizons. Laboratory analysis generally shows that the clay in natric horizons is less than the amount estimated from the field method. The scientist needs to adjust judgment and not the size distribution standards.

A detailed discussion of field determination of soil texture is on page I-2.5-1 in the Handbook of Soil Survey Investigations Field Procedures, USDA, Natural Resources Conservation Service.

(e) Entries. Texture is displayed by the use of five data elements in NASIS -- texture class, texture modifier, texture modifier and class, stratified texture flag, and terms used in lieu of texture.

As many as four entries can be made for each horizon for each of these data elements. However, only one texture for a surface horizon should be entered for each component. Only use multiple textures if they interpret the same for the horizon. Only textures that represent complete horizons should be entered. A representative value is also identified for each horizon. This choice should match the representative values of the various soil particle size separates posted elsewhere in the database.

(f) Texture class.

(1) Definition. Texture class is an expression, based on the USDA system of particle sizes, for the relative portions of the various size groups of individual mineral soil grains less than 2 mm equivalent diameter in a mass of soil.

Each texture class has defined limits for each particle separate class of mineral particles less than 2 mm in effective diameter. The basic texture classes, in the approximate order of increasing proportions of fine particles, are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further subdivided into coarse, fine, or very fine. The basic USDA texture classes are given graphically in Exhibit 618-8 as a percentage of sand, silt, and clay. The chart at the bottom of the figure shows the relationship between the particle size and texture classes among the AASHTO, USDA, and Unified Soil Classification systems.

(2) Entries. Enter the texture class code(s) for each horizon using Exhibit 618-15.

(g) Terms used in lieu of texture.

(1) Definition. Terms used in lieu of texture are substitute terms applied to materials that do not fit into a texture class because of organic matter content, size, rupture resistance, solubility, or another reason. Examples include muck, duripan, gravel, and bedrock. Exhibit 618-15 provides a list of these terms and their codes. Some of these terms may be modified with terms from the list of texture modifiers.

(2) Application.

(i) The codes HPM, MPM, and SPM, which are used for decomposed plant material, should only be used to describe thin surface horizons composed of forest or other plant material in various stages of decomposition. They should not be used to describe histic epipedons, or organic horizons in Histosols, except for Folists.

(ii) Material, which uses the code MAT, is generic and requires the use of a texture modifier. Texture modifier terms, such as ashy, coprogenous, gypsiferous, and marly, are used to describe material.

(3) Entries. Enter the applicable code(s) for each horizon as appropriate.

(h) Texture modifier.

(1) Definition. Texture modifier is a term used to denote the presence of a condition or component other than sand, silt, or clay.

(2) Application. Texture modifier terms may apply to both texture and terms used in lieu of texture. Some may apply to both, others only apply to one or the other. Combinations of some texture modifiers are allowed. A list of allowable texture modifier terms and their codes is given in Exhibit 618-15. Some rules of application are given below.

(i) If the content of fragments exceeds 15 percent by volume, texture modifiers are used. An example is gravelly loam or parachannery loam. The terms very and extremely are used when the content of fragments exceeds about 35 and 60 percent, by volume, respectively.

(ii) Mucky and peaty are used to modify mineral soils if the organic matter content is more than 10 percent. An example is mucky loam.

(iii) Compound texture modifiers may be used, such as a term used to indicate the presence of fragments and another used to indicate some non-fragment condition. The term used to indicate fragments should be listed first. An example is very gravelly mucky silt loam or paragravelly ashy loam.

(iv) Texture modifiers, such as paragravelly and paracobbly, are used to identify the presence of pararock fragments. The size, shape, and amounts of pararock fragments required for these terms are the same as for rock fragments.

(v) When a horizon includes both rock and pararock fragments, use the following for selecting textural modifiers:

--Describe the individual kinds and amounts of rock and pararock fragments.

--Do not use a fragment textural modifier when the combined volume of rock and pararock fragments is less than 15 percent.

--When the combined volume of rock and pararock fragments is more than 15 percent, and the volume of rock fragments is less than 15 percent, assign pararock fragment modifiers based on the combined volume of fragments. For example, use paragravelly as a textural modifier for soils with 10 percent rock and 10 percent pararock gravel sized fragments.

--When the volume of rock fragments is 15 percent or greater, use the appropriate textural modifier for rock fragments (Exhibit 618-11), regardless of the volume of pararock fragments. (Do not add the volume of rock and pararock fragments to determine the textural modifier).

(vi) The following definitions of texture modifiers guide their usage:

<u>Hydrous</u> -- material that has andic soil properties and an undried 15 bar water content of 100 percent or more of the dry weight.

<u>Medial</u> -- material that has andic soil properties and has a 15 bar water content of less than 100 percent on undried samples and of 12 percent or more on air-dried samples.

<u>Ashy</u> -- material that is neither hydrous nor medial, and the fine earth fraction contains 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is composed of volcanic glass; and the [(aluminum plus 1/2 iron percent by ammonium oxalate) times 60] plus the volcanic glass percent is equal to or more than 30.

<u>Gypsiferous</u> -- material that contains 15 percent or more by weight gypsum.

(vii) Woody, grassy, mossy, and herbaceous texture modifiers are only used to modify muck, peat, or mucky peat terms (Histosols or histic epipedons).

<u>Woody</u> -- any material that contains 15 percent or more wood fragments larger than 2 cm in size; or

-- organic soil materials, other than SPM, MPM, or HPM, that contains 15 percent or more fibers that can be identified as wood origin and contain more wood fibers than any other kind of fiber.

Grassy -- organic soil material that contains more than 15 percent fibers that can be identified as grass, sedges, cattails, and other grass-like plants and contains more grassy fibers than any other kind of fiber.

Mossy -- organic soil material that contains more than 15 percent fibers that can be identified as moss and contains more moss fibers than any other kind of fiber.

Herbaceous -- organic soil material that contains more than 15 percent fibers that can be identified as herbaceous plants other than moss and grass or grass-like plants and more of these fibers than any other kind of fiber.

(viii) Some materials can be described by utilizing an apparent texture, even though they do not fit the requirements of texture. These materials use a texture modifier. Examples are marly silt loam and gypsiferous sand.

(ix) Limnic materials are used as modifiers to texture to describe the origin or the material. These materials were deposited in water by precipitation or through the action of aquatic organisms or derived from plants and organisms. These modifiers are used to indicate presence and origin without respect to any set amount. Refer to the Keys to Soil Taxonomy for complete definitions of limnic materials.

Coprogenous -- Coprogenous-earth or sedimentary peat is limnic layer which contains many very small (0.1 to .001mm) fecal pellets..

Diatomaceous -- Diatomaceous-earth is a limnic layer composed of diatoms.

Marly -- Marl is a limnic layer that is light colored and reacts with HCl.

(xi) Permanently frozen -- Term applied to soil layer in which the temperature is perennially at or below 0 degrees C, whether its consistence is very hard or loose.

(3) Entries. Enter the applicable texture modifier code(s). Multiple texture modifiers may be used in some cases.

(i) Texture modifier and class.

(1) Definition. Texture modifier and class is a concatenation of texture modifier and texture class.

This data element indicates the full texture classification of the horizon. If texture modifiers are used, they are attached to the texture class by a hyphen, for example, GR-SL. If a layer is stratified, enter SR as a texture modifier and the end members of the textural range and connect them by hyphens, for example, SR-C-L and SR-GR-S-GR-C.

(2) Entries. Enter the appropriate designation for each horizon.

(j) Stratified texture flag.

(1) Application. Stratified texture flag is used to identify stratified textures.

(2) Entries. An entry of "yes" indicates the textures are stratified. The default entry is "no."

618.68 Water One-Tenth Bar.

(a) Definition. Water one-tenth bar is the amount of soil water retained at a tension of 1/10 bar, expressed as a percentage of < 2 mm, oven-dry soil weight.

(b) Significance. Water retained at one-tenth bar is significant in the determination of soil water-retention difference, which is used as the initial estimation of available water capacity for some soils.

(c) Measurement. Measurement in the laboratory is done on natural clods using method 4B1c. Measurement for nonswelling soils, loamy sand or coarser soils, and some sandy loams is done using method 4B1a.

(d) Entries. Enter the low, high, and representative values for the horizon. The range of valid entries is 0.00 to 999.00 percent. Tenths of a percent are allowable.

618.69 Water One-Third Bar.

(a) Definition. Water one-third bar is the amount of soil water retained at a tension of 1/3 bar, expressed as a percentage of < 2 mm, oven-dry soil weight.

(b) Significance. Water retained at one-third bar is significant in the determination of soil water-retention difference, which is used as the initial estimation of available water capacity for some soils.

(c) Measurement. Measurement in the laboratory on natural clods uses method 4B1c. Measurement for nonswelling soils, loamy sand or coarser soils, and some sandy loams is done using method 4B1a.

(d) Entries. Enter the low, high, and representative values for the horizon. The range of valid entries is 0.00 to 999.00 percent. Tenths of a percent are allowable.

618.70 Water 15 Bar.

(a) Definition. Water 15 bar is the amount of soil water retained at a tension of 15 bars, expressed as a percentage of < 2 mm, oven-dry soil weight.

(b) Significance. Water retained at 15 bar is significant in the determination of soil water-retention difference, which is used as the initial estimation of available water capacity for some soils. Water retained at 15 bar is an estimation of the wilting point. It is also used to estimate clay in poorly dispersed soils in soil taxonomy.

(c) Measurement. Measurement in the laboratory is done using method 4B2a.

(d) Entries. Enter the low, high, and representative values for the horizon. The range of valid entries is 0.00 to 220.00 percent. Tenths of a percent are allowable.

618.71 Water, Satiated.

(a) Definition. Water, satiated, is the estimated volumetric soil water content at or near zero bar tension, expressed as a percentage of the less than 2 mm fraction of the soil.

(b) Significance. Water, satiated, represents the total possible water content of the soil, including the amount in excess of field capacity, and is used to estimate the amount of water available for leaching and translocation. Satiated water content approximates the water content for the fine-earth fraction at saturated conditions. It is used in such resource assessment tools as Soil Hydrology, Water Budgets, Leaching, and Nutrient/Pesticide Loading models. Correction for fragments may be needed when applied to various models since the entry is for the < 2mm fraction.

(c) Estimation. The values are derived by the following formula:

Satiated water % = total porosity % - entrapped air %
Total porosity % = 100(1-bulk density moist/particle density)
Assume approximately 3% entrapped air.

(d) Entries. Enter the high, low, and representative values, as whole integers for the horizon. The range of valid entries is 25 to 80 percent.

618.72 Wind Erodibility Group and Index.

(a) Definition. A wind erodibility group (WEG) is a grouping of soils that have similar properties affecting their resistance to soil blowing in cultivated areas. The groups indicate the susceptibility to blowing. The Wind Erodibility Index (I), used in the wind erosion equation, is assigned using the wind erodibility groups.

(b) Significance. There is a close correlation between soil blowing and the size and durability of surface clodiness, fragments, organic matter, and the calcareous reaction. The soil properties that are most important with respect to soil blowing are (1) soil texture, (2) organic matter content, (3) effervescence due to carbonate reaction with HCl, (4) rock and pararock fragment content, and (5) minerology. Soil moisture and the presence of frozen soil also influence soil blowing.

(c) Estimates. Soils are placed into wind erodibility groups on the basis of the properties of the soil surface layer. Exhibit 618-16 lists the wind erodibility index assigned to the wind erodibility groups. The wind erodibility index values are assigned because the dry soil aggregates are very use dependent on crop management factors.

(d) Entries. Enter the wind erodibility group and wind erodibility index values for surface layer(s) only. The range of valid entries for wind erodibility group data is 1, 2, 3, 4, 4L, 5, 6, 7, and 8. The lowest valid entry for wind erodibility index data is 0, and the highest is 310. The index values should correspond exactly to their wind erodibility group.

Exhibit 618-1 Guides for Estimating Risk of Corrosion Potential for Uncoated Steel. 1/

Property	Limits		
	Low	**Moderate**	**High**
Drainage class and texture	Excessively drained, coarse textured or well drained, coarse to medium textured soils; or moderately well drained coarse textured, soils; or some- what poorly drained, coarse textured soils	Well drained, moderate y fine textured soils; or moderately well drained, medium textured soils; or somewhat poorly drained, moderately coarse textured soils; or very poorly drained soils with stable high water table	Well drained, fine textured or stratified soils; or moderately well drained, fine and moderately fine textured or stratified soils; or somewhat poorly drained, medium to fine textured or stratified soils; or poorly drained soils with fluctuating water table
Total acidity 2/(meq/100g)	<8	8-12	≥12
Resistivity at saturation(ohm/cm) 3/	≥5,000	2,000-5,000	<2,000
Conductivity of saturated extract(mmhos cm^{-1}) 4/	<0.3	0.3-0.8	≥0.8

1/ Based on data in the publication "Underground Corrosion," table 99, p. 167, Circular 579, U.S. Dept. of Commerce, National Bureau of Standards.
2/ Total acidity is roughly equal to extractable acidity (as determined by Soil Survey Laboratories Method 6Hla, Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004).
3/ Roughly equivalent to resistivity of fine-and medium-textured soils measured at saturation (Method 8E1, Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004). Resistivity at saturation for coarse-textured soil is generally lower than when obtained at field capacity and may cause the soil to be placed in a higher corrosion class.
4/ Method 8Ala, Soil Survey Investigations Report No. 42, Soil Survey Laboratory Methods Manual, Version 4.0, November 2004. The relationship between resistivity of a saturated soil paste (Method 8E1) and electrical conductivity of the saturation extract (Method 8A1a), is influenced by variations in the saturation percentage, salinity, and conductivity of the soil minerals. These two measurements generally correspond closely enough to place a soil in one corrosion class.

Exhibit 618-2 Guide for Estimating Risk of Corrosion Potential for Concrete.

Property	**Limits 1/**		
	Low	**Moderate**	**High**
Texture and reaction	Sandy and organic soils with pH>6.5 or medium and fine textured soils with pH>6.0	Sandy and organic soils with pH5.5-6.5 or medium and fine textured soils with pH 5.0 to 6.0	Sandy and organic soils with pH<5.5 or medium and fine textured soils with pH<5.0
Na and/or Mg sulfate (ppm)	Less than 1000	1000 to 7000	More than 7000
NaCl (ppm)	Less than 2000	2000 to 10000	More than 10000

1/ Based on data in National Handbook of Conservation Practices, Standard 606, Subsurface Drain, 1980.

Exhibit 618-3 Crop Names and Units of Measure.

(Refer to the data dictionary of the National Soil Information System for crop_names and crop_yield_units in: http://nasis.nrcs.usda.gov/documents/metadata/5_1/n51clr.pdf)

Exhibit 618-4 Classification of Soils and Soil-Aggregate Mixtures for the AASHTO System.

General Classification	Granular Materials (35% of less passing No. 200)							Silt-Clay Materials (More than 35% passing No. 200)			
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve analysis, % passing No. 10 No. 40 No 200	 50 max 30 max 15 max	 - 50 max 25 max	 - 51 max 10 max	 - - 35 max	 - - 35 max	 - - 35 max	 - - 35 max	 - - 36 min	 - - 36 min	 - - 36 min	 - - 36 min
Characteristics of fraction passing No. 40 Liquid limits Plasticity index	- 6 max		- NP	40 max 10 max	41 max 10 max	40 max 11 min	41 min 11 min	40 max 10 max	41 min 10 max	40max 11 min	* 41 min 11 min
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to good					Fair to good					

* Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plastaicity index of A-7-6 subgroup is greater than LL minus 30.

Exhibit 618-5 Potential Frost Action.

Soil moisture regime	**Frost action classes 1/**		
	Low	**Moderate**	**High**
Aquic	Cindery, Fragmental, Pumiceous	Sandy, Sandy-skeletal	Coarse-loamy, Fine-loamy, Coarse-silty, Fine-silty, Loamy-skeletal, Clayey and clayey skeletal, Organic soil materials, Ashy, ashy-pumiceous, and ashy-skeletal, Medial, medial- pumiceous, and medial-skeletal, Hydrous- pumiceous, Hydrous-skeletal, Hydrous
Udic, Xeric, Ustic (when irrigated), Aridic (when irrigated)	Fragmental, Cindery, Sandy, Sandy-skeletal, Pumiceous	Coarse-loamy, Fine-loamy, Loamy-skeletal, Clayey, Clayey-skeletal, Ashy-pumiceous, Ashy-skeletal, Hydrous-skeletal, Medial-skeletal, Medial-pumiceous	Coarse-silty, Fine-silty, Ashy Medial, Hydrous- pumiceous, Hydrous
Ustic, Aridic	Fragmental, Sandy, Sandy-skeletal, Clayey, Clayey-skeletal, Cindery, Ashy, ashy-pumiceous, and ashy-skeletal, Medial and medial-skeletal, Pumiceous	Coarse-loamy, Fine-loamy, Coarse-silty, Fine-silty, Loamy-skeletal, Medial-pumiceous, Hydrous-pumiceous, Hydrous-skeletal, Hydrous	

1/ Family texture classes apply to the whole soil to the depth of frost penetration.

Exhibit 618-6 Distribution of Design Freezing Index Values in the Continental United States.

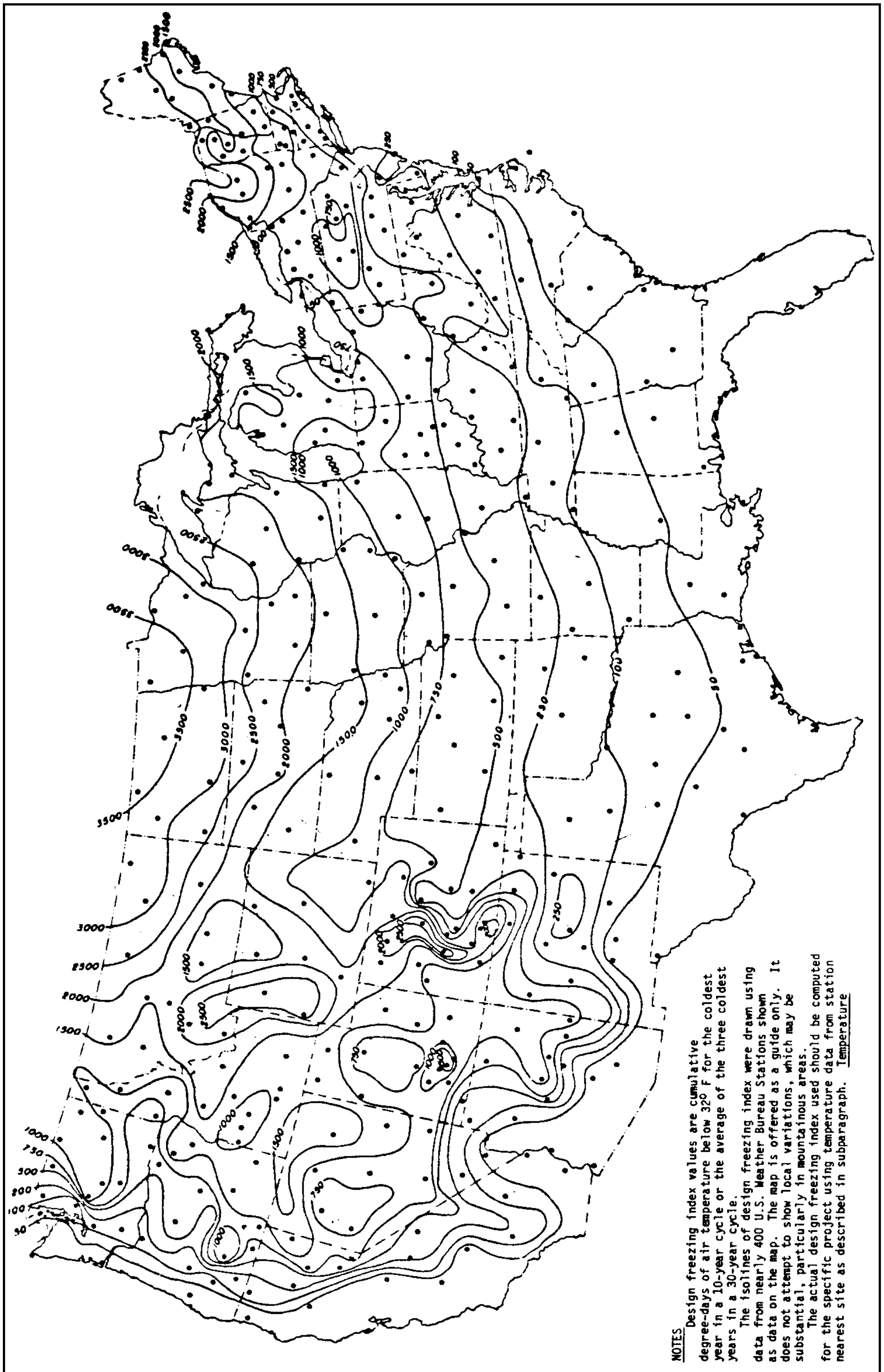


Exhibit 618-7 Estimating LL and PI from Percent and Type of Clay.

The following two formulas provide estimates of liquid limit and plasticity index. These calculations are included in the National Soil Information System and provide default values to LL and PI.

LL = 11.60 + [1.49 x 15 bar water %] + [1.35 x org. carbon %] + [0.6 x LEP]
+ [0.26 x non-carbonate clay %]*

where LL is liquid limit
LEP is Linear Extensibility Percent

PI = -1.86 + [0.69 x 15 bar water %] - [1.19 x organic carbon %] +[0.13 x LEP]
+[0.47 x non-carbonate clay %]*

where PI is Plasticity Index
LEP is Linear Extensibility Percent

* When the calculated PI < 0.5, the PI is set to zero (nonplastic). When the calculated LL < 15 or PI < 0.5, the LL is set to zero.

Exhibit 618-8 Texture Triangle and Particle-Size Limits of AASHTO, USDA, and Unified Classification Systems.

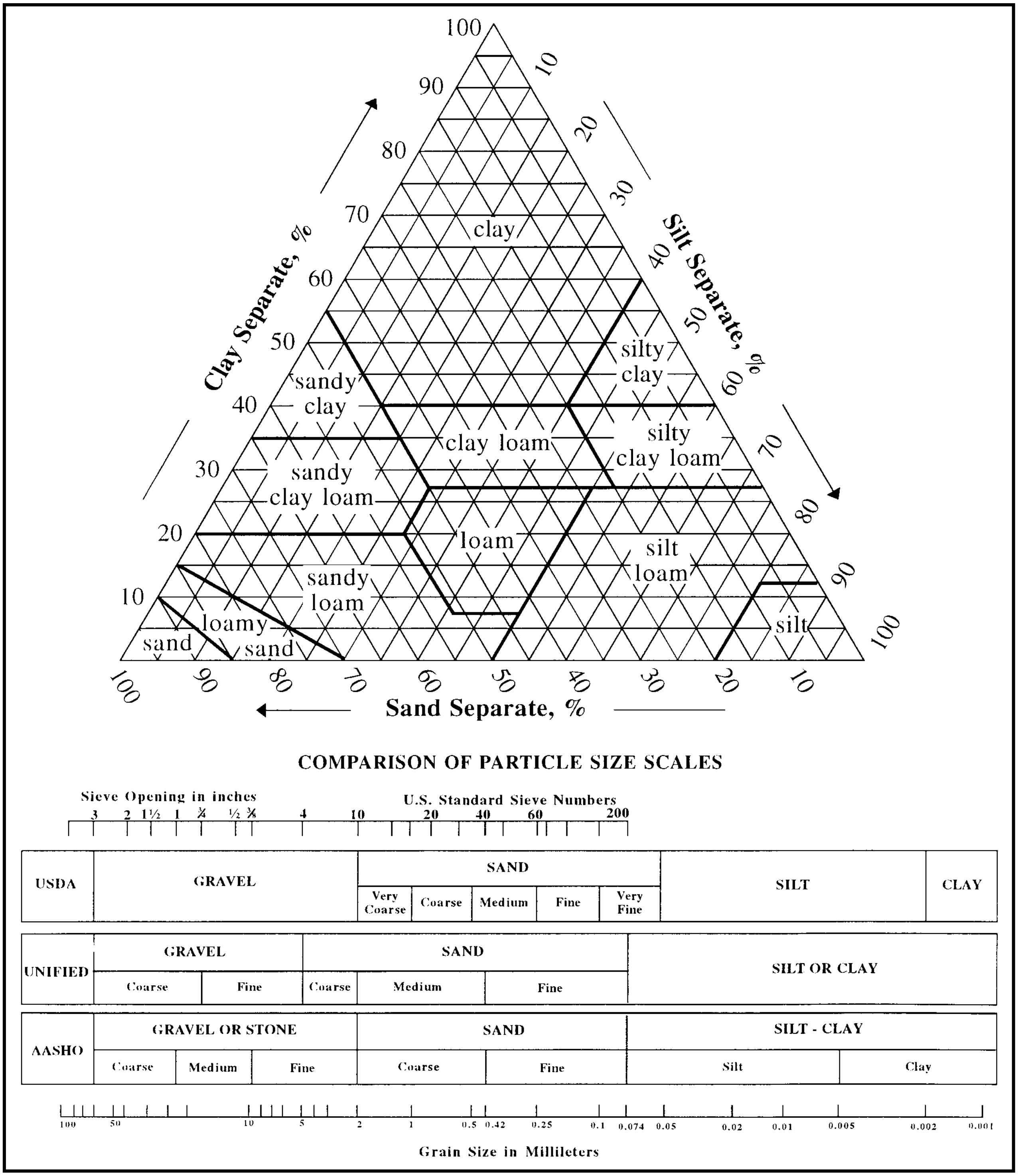
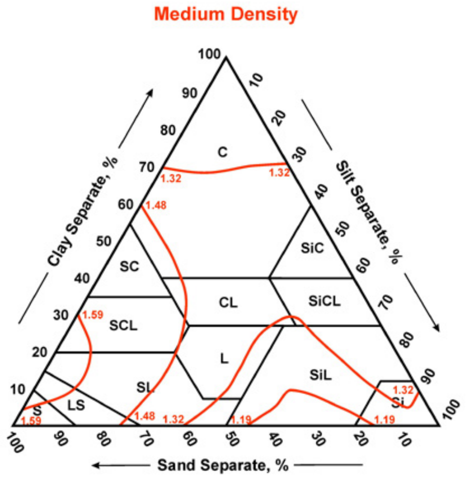
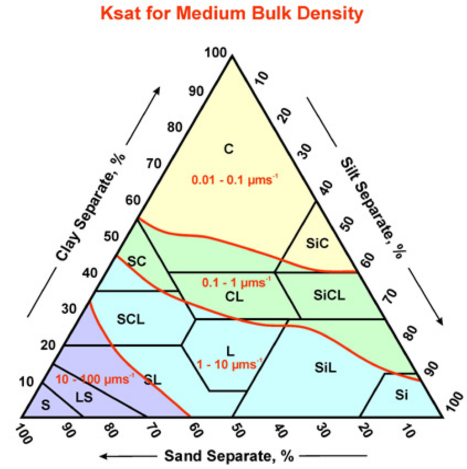
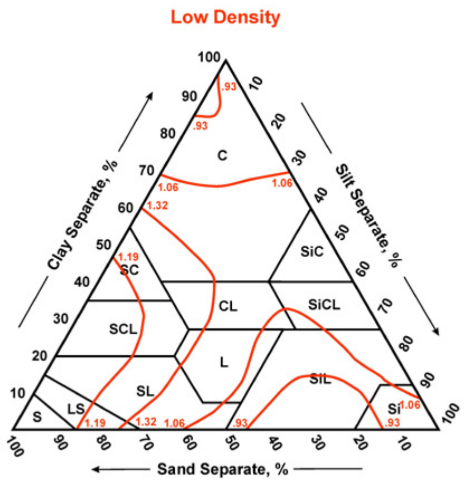


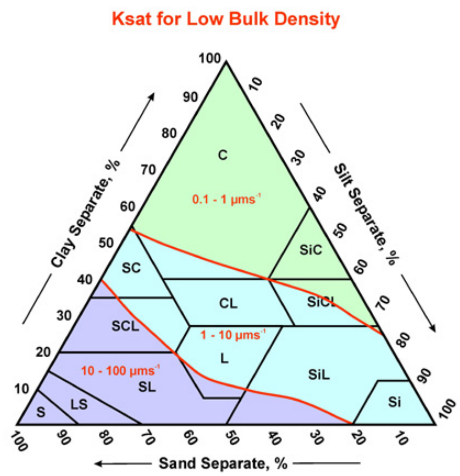
Exhibit 618-9 Guide for Estimating Ksat from Soil Properties.

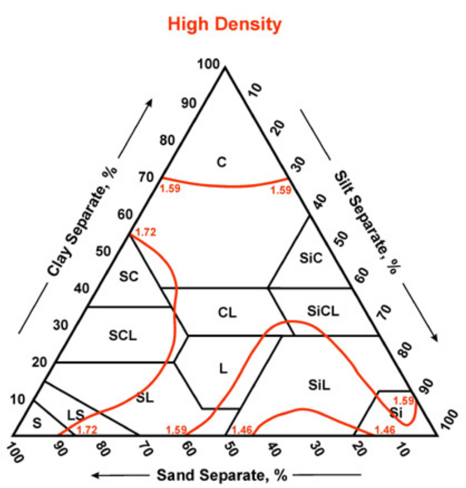
Estimate saturated hydraulic conductivity (Ksat) from soil texture by first selecting the bulk density class of medium, low or high. Then use the corresponding textural triangle to select the range of saturated hydraulic conductivity in μms^{-1}. Use non-carbonate clay. Overrides on next page.











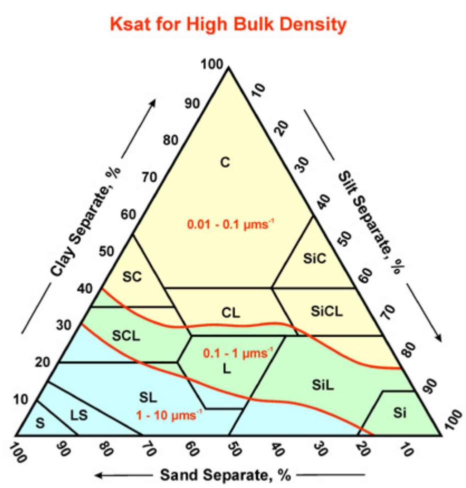


Exhibit 618-9 (continued)

Use these overrides in lieu of the textural guide above when these conditions exist. A single property statement is sufficient for an override from the textural guide.

Overriding condition	**Saturated hydraulic conductivity (μm s^{-1})**
All fragmental, cindery or pumiceous	≥ 100
Many medium or coarser vertical pores that extend through the layer.	≥ 100
Medial-pumiceous, medial-skeletal, ashy-pumiceous, ashy-skeletal, hydrous-pumiceous that is very friable, friable, soft, or loose.	10 - 100
When moderately moist or wetter, structure that is moderate or strong granular, strong blocky or prismatic smaller that is very coarse and no stress surfaces or slickensides.	10 - 100
Common medium or coarser vertical pores that extend through the layer.	10 - 100
Strong very coarse blocky or prismatic and no stress surfaces or slickensides.	1 - 10
≥ 35 percent clay, soft, slightly hard, very friable or friable, no stress surfaces or slickensides and the clay is subactive after subtracting the quantity (2 x (OC x 1.7))	1 - 10
Few stress surfaces and/or slickensides.	0.1 - 1
Massive and very firm or extremely firm, or weakly cemented.	0.1 - 1
Continuously moderately cemented.	0.1 - 1
Common or many stress surfaces and/or slickensides.	0.01 - 0.1
Continuously indurated or very strongly cemented.	< 0.01

Exhibit 618-10 Guide to Estimating Water Movement Through Lithic and Paralithic Materials. 1/ 2/

Material	Water Movement µm s^{-1}
Sandstone	
unfractured	<10
fractured	10-100
weathered	10-100
Limestone	
unfractured	<1
fractured	<10
weathered	<10
Limestone, Karst	>100
Shales and Mudstones	
consolidated	<1
weathered	<10
Igneous and Metamorphic Rocks	
unfractured	<1
fractured	1-100
weathered	<1

1/ This table is to be used as a guide and may be adjusted to reflect local, regional, or state bedrock permeability data. Fracturing may increase hydraulic conductivity of consolidated rock by a factor of 10^4 to 10^6, which is dependent on the degree and interconnection of fracturing. (Freeze and Cherry, 1979; Legget and Karrow, 1983).
2/ This table assumes that materials are level bedded. Tilted beds of some materials may have rapid rates of water movement that goes directly to an aquifer.
3/ Haan, C.T., Barfield, B.J., and Hayes, J.C.; Design Hydrology and Sedimentaology for Small Catchments.

Exhibit 618-11 Percent By Volume Conversion to Percent by Weight.

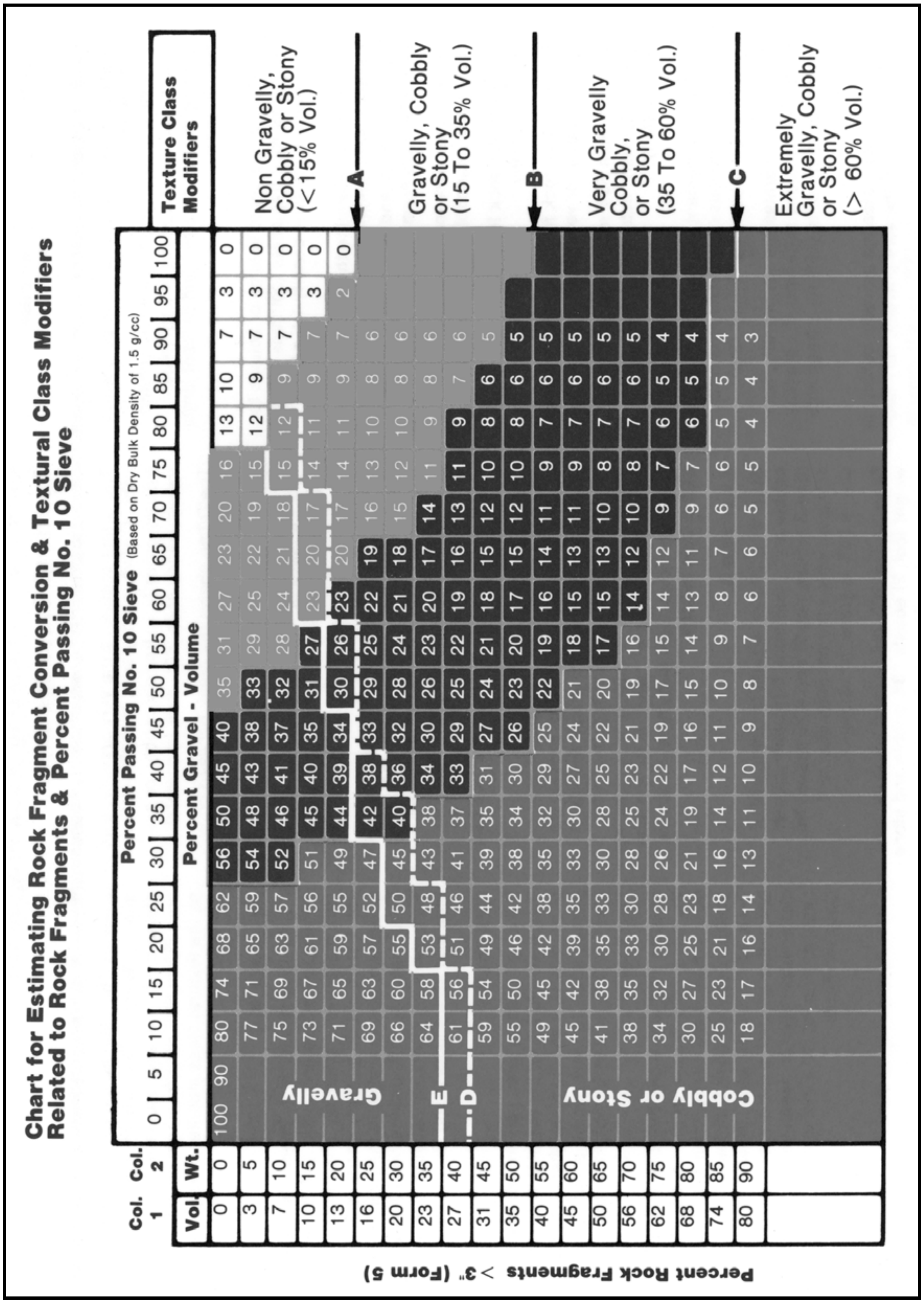


Chart for Estimating Rock Fragments and Textural Class Modifer

Exhibit 618-11 Percent By Volume Conversion to Percent by Weight. (continued)

Instructions--This chart can be used to:
1. Estimate the percent gravel by volume from estimates of percent of rock fragments passing the No. 10 sieve and percent larger than 3 inches.
2. Convert weight to volume or volume to weight for fragments (columns 1 and 2), based on dry bulk density 1.5 g cm^{-3}.
3. Check or determine the texture modifier that coincides with percent passing No. 10 sieve and percent larger than 3 inches.
(a) less than 15 percent fragments-nongravelly, noncobbly, or nonstony
(b) 15 to 35 percent fragments - gravelly, cobbly, or stony
(c) 35 to 60 percent fragments - very gravelly, very cobbly, or very stony, and
(d) more than 60 percent fragments - extremely gravelly, extremely cobbly, or extremely stony.
4. Estimate percent passing No. 10 sieve (weight) for various combinations of rock fragment percentages by volume (top).
The A line separates the nongravelly, noncobbly, or nonstony soils from the gravelly, cobbly, or stony soils (15 percent fragments by volume).
The B line separates the gravelly, cobbly, or stony soils from the very gravelly, very cobbly, or very stony soils (35 percent fragments by volume).
The C line separates the very gravelly, very cobbly, or very stony soils from the extremely gravelly, extremely cobbly, or extremely stony soils (60 percent fragments).
The D line shows the break between gravelly size and cobbly size texture modifiers--2.0 times or more as much gravel as cobble to use gravelly if more than 35 percent fragments, and 1.5 times or more as much gravel as cobble to use gravelly if 15 to 35 percent fragments.
The E line shows the break between gravelly size and stony size texture modifiers--2.5 times or more as much gravel as stone to use gravelly if more than 35 percent fragments, and 2.0 times or more as much gravel as stone to use gravelly if 15 to 35 percent fragments.

TEXTURE MODIFIER GUIDE [i] Substitute channers for gravel, flagstones for cobbles, etc. where applicable

Total Rock Fragments (%)	GR + CB > GR + ST	MODIFIER		GR + CB ≤ GR + ST
≥ 15 < 35	GR:CB ≥ 1.5	Gravelly		GR:ST ≥ 2
		Gravelly		
	GR:CB < 1.5	Cobbly	Stony	GR:ST < 2
≥ 35 < 60	GR:CB ≥ 2	Very Gravelly		GR:ST ≥ 2.5
		Very Gravelly		
	GR:CB < 2	Very Cobbly	Very Stony	GR:ST < 2.5
≥ 60 < 90	GR:CB ≥ 2	Extremely Gravelly		GR:ST ≥ 2.5
		Extremely Gravelly		
	GR:CB < 2	Extremely Cobbly	Extremely Stony	GR:ST < 2.5

All conversion of fragments from volume to weight and percent passing No. 10 sieve are based on dry bulk density of 1.5 g cm^{-3}. If desired, adjustments can be made in estimates by adding to subtracting 3 percent for each 0.2 g cm^{-3} change in bulk density. Add for lower bulk density; subtract for higher bulk density.

EXAMPLE A

Step 1: If 20 percent by weight is composed of cobble and stone (fragments greater than 3 inches, col. 2) and 40 percent passing No. 10 sieve, where the columns intersect shows 39 percent is gravel by volume.
Step 2: The 20 percent cobble and stone by weight (col. 2) equals 13 percent cobble and stone by volume (col. 1). And 13 percent cobble and stone (vol.) + 39 percent gravel (vol.) (step 1) equals 52 percent fragments by volume.
Step 3: The intersection of 13 percent cobble and stone and 39 percent gravel by volume is above the D line, and occurs in the blue area (35 to 60 percent fragment by volume), so the texture modifier is very gravelly.

EXAMPLE B

If field estimates for fragments show 10 percent cobble and stone and 30 percent gravel (vol.), enter the chart from 10 percent col. 1 (15 percent col. 2) go horizontally to 31 (closest to 30 percent gravel) and then vertically to estimate that 50 percent passes No. 10 sieve. This soil is very gravelly because it is in the blue and above lines D and E.

EXAMPLE C

If the soils is designated as very gravelly then it should fall within the blue color and above line D, it should show that 0 to 55 percent passes a No. 10 sieve, and it should show that 0 to 30 percent or less by weight is larger than 3 inches.

Exhibit 618-12 Soil Erodibility Nomograph.

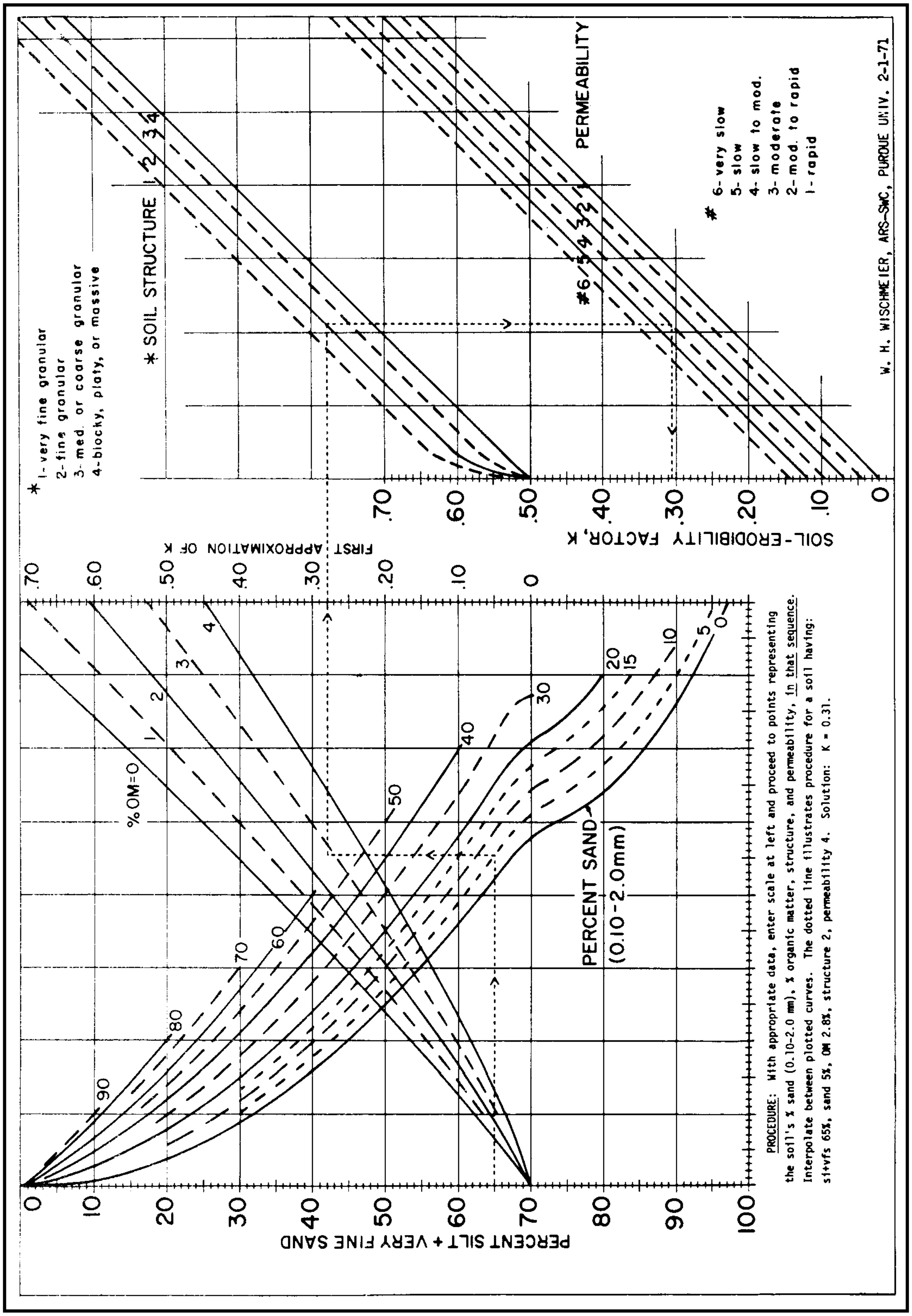


Exhibit 618-13 Kw Value Associated with Various Fragment Contents.

Fragment vol. %	**Mulch factor 1/**	**Kf value classes of less than 2 mm soil fraction**										
		.10	.15	.20	.24	.28	32	37	.43	.49	.55	64
5	.90	.09	.14	.18	.22	.25	.29	.33	.39	.44	.50	.58
10	.77	.08	.12	.15	.18	.22	.25	.28	.33	.38	.42	.49
15	.68	.07	.10	.14	.16	.19	.22	.25	.29	.33	.37	.43
20	.61	.06	.09	.12	.15	.17	.20	.23	.26	.30	.37	.39
25	.54	.05	.08	.11	.13	.15	.17	.20	.23	.26	.30	.35
30	.48	.05	.07	.10	.12	.13	.15	.18	.21	.24	.26	.31
35	.43	.04	.06	.09	.10	.12	.14	.16	18	.21	.24	.28
40	.38	.04	.06	.08	.09	.11	.12	.14	.16	.19	.21	.24
45	.34	.03	.05	.07	.08	.10	.11	.13	.15	.17	.19	.22
50	.30	.03	.05	.06	.07	.08	.10	.11	.13	.15	.17	.19
55	26	.03	.04	.05	.06	.07	.08	.09	.11	.13	.12	.14
60	.22	.02	.03	.04	.05	.06	.07	.08	.09	.11	.12	.14
65	.19	.02	.03	.04	.05	.05	.06	.07	.08	.09	.10	.12
70	.16	.02	.02	.03	.04	.04	.05	.06	.07	.08	.09	.10
75	.13	.01	.02	.03	.04	.04	.04	.04	.06	.06	.07	.08
80	.10	.01	.02	.02	.02	.03	.03	.04	.04	.05	.06	.06
85	.08	.01	.02	.02	.02	.02	.03	.03	.03	.04	.04	.05
90	.06	.01	.01	.01	.01	.02	.02	.02	.03	.03	.03	.04
95	.04	.01	.01	.01	.01	.01	.01	.02	.02	.02	.02	.03
100	.03	.01	.01	.01	.01	.01	.01	.01	.01	.02	.02	.02

1/ Mulch factor is the ratio of the soil loss from soils with the specified fragment volumes to that from soils with no fragments. The table was constructed from the zero canopy curve, figure 6, page 19 in AH 537 (USDA-SEA 1978).

Exhibit 618-14 General Guidelines for Assigning Soil Loss Tolerance "T".

Soil loss tolerance "T" is assigned according to properties of root limiting subsurface soil layers. The designation of a limiting layer implies that the material above the layer has more favorable plant growth properties. As limiting or less favorable soil layers become closer to the surface, the relative ability of a soil to maintain its productivity through natural and managed processes decreases.

Criteria for assigning "T" are estimated from:

1. The severity of physical or chemical properties of subsurface layers.
2. The climatically influenced properties of soil moisture and temperature.
3. The economic feasibility of utilizing management practices to overcome limiting layers or conditions.

The following general guide was used with specific soil properties and conditions to write criteria statements for programming "T" factors at Iowa State University Statistical Laboratory.

Depth to limiting layer	Group 1	Group 2	Group 3
(inches)	Annual soil loss tolerance in tons/acre		
0 - 10	1	1*	3
10 - 20	1	2	3
20 - 40	2	3	4
40 - 60	3	4	4
>60	5	5	5

Group 1--The limitations are significant or have permanent layers of root limitation.
Group 2--The limitations are of moderate root restriction, or have a less than permanent loss to productivity in a given climate.
Group 3--The limitations can be overcome in a given climate, through natural or managed processes to achieve the productivity level of the non-eroded soil.

*Some soils are assigned with soil loss tolerance of 2.

Exhibit 618-14 "T" Criteria (continued).

"T" CRITERIA
3/11/1995

Soil Characteristic		Definition	Depth Limit (inches)	T Value
1. Bedrock	A.	Soils in all Land Resource Regions except W, X, and Y having SOFT identified in the Bedrock soil property block or MARL (marl layers) with the beginning depth of:	<10 10-20 20-40 40-60 >60	1 2 3 4 5
		OR		
	B.	Soils having HARD identified in the Bedrock soil property block or layers identified as ICE with the beginning depth of:	<20 20-40 40-50 >60	1 2 3 5
		OR		
	C.	Soils in only Land Resource Regions W, X, and Y having SOFT identified in the Bedrock soil property block or MARL (marl layers) with the beginning depth of:	<20 20-40 40-60 >60	1 2 3 5
2. Cemented pans [1/]				
	A.	Soils in all Land Resource Regions except W, X, and Y having duripan, petrocalcic, petrogypsic, petroferric with THIN in Cemented Pan block and CEM in lieu of texture OR THIN or THICK if IND or CEM are not shown in lieu of texture with the beginning depth of:	<20 20-40 40-60 >60	2 3 4 5
		OR		
	B.	Soils in all Land Resource Regions except W, X, and Y having duripan, petrocalcic, petrogypsic, petroferric with THICK in Cemented Pan block and CEM and/or IND in lieu of texture or THIN in Cemented Pan Block and IND in lieu of texture with the beginning depth of:	<20 20-40 40-60 <60	1 2 3 5
	C.	Soils in only Land Resource Regions W, X, and Y having duripan, petrocalcic, petrogypsic, petroferric with THIN in Cemented Pan block and CEM in lieu of texture OR THIN or THICK if IND or CEM are not shown in lieu of texture with the beginning depth of:	<20 20-40 40-60 >60	1 2 3 5
3. Fragmental/Cindery				
	A.	Soils in all Land Resource Regions except W, X, and		

[1] Where cemented pan is effectively ripped causing an increase in rooting depth, assign T according to new depth to restrictive material, if present (e.g., any restrictive underlying material).

		Y having an upper layer that has a texture term other than SG, G, FRAG, or CIND immediately above a layer of G, FRAG or CIND beginning at depth of:	<10 10-20 20-40 40-60 >60	1 2 3 4 5
B. Soils in Land Resource		Regions W, X, and Y having an upper layer that has a texture term other than SG, G, FRAG, or CIND immediately above a layer of G, FRAG or CIND beginning at depth of:	<20 20-40 40-60 >60	1 2 3 5
4. Fragipan		Soils having a FRAGI great group. Layer selected has the greatest bulk density inflection, (layer selected has the maximum change which was determined by evaluating all adjacent layers that change from a lower bulk density to a higher bulk density) and a permeability less than or equal to 0.2 inches per hour, beginning at a depth of:	<20 20-60 >60	3 4 5
5. Natric	A.	Soils designated in great groups of Natraquolls or Natraqualfs or subgroups of Natric Duraquolls but exclude subgroups of Glossic in the great group of Natraqualfs; and have a natric horizon (to find the natric horizon: search for a subsoil, subsurface, layer with the slowest permeability [<0.2 inches/hour] above a layer, if present, with UWB, WB, CEM, or IND and use the upper depth of that layer to assign depth to natric horizon) beginning at a depth of:	<20 20-40 40-60 >60	2 3 4 5
	B.	Use criterion B in MLRA's 48A, 48B, 49, 52, 53A, 53B, 53C, 54, 55A, 55B, 55C, 56, 58A, 58B, 58C, 58D, 60A, 60B, 61, 62, 63A, 63B, 64 through 79, 8OA, 8OB, 81, 82, 83A, 83B, 83C, 83D, 84A, 84B, 84C, 85, 86, 87, 102A, and 102B. Soils designated in great groups of Natralbolls, Natriborolls, Natrustolls, *Natriborals, Natrustalfs Natrargids, Nadurargids, or subgroups of Natric Durustolls but exclude subgroups of Glossic in great groups of Natriborolls, Natrustolls, Natriboralfs, Natrustalfs, and Natrargids; and have a natric horizon (to find the natric horizon: search for a subsoil, subsurface, layer with the slowest permeability (<0.2 inches/hour] above a layer, if present, with UWB, WB, CEM, or IND and use the upper depth of that layer to assign depth to natric horizon) beginning at a depth of: *At present, Natriboralfs are rare in the United States, and subgroups have not been developed.	<20 20-40 40-60 >60	2 3 4 5
	C.	Soil designated in great group with "NA" and suborder "UD" and a subsurface natric horizon with a slow or very slow permeability (to find the	<20 20-60 >60	3 4 5

			natric horizon: search for a subsoil, subsurface, layer with the slowest permeability [<0.2 inches/hour] and use the upper depth of that layer to assign depth to natric horizon) beginning at a depth of:		
		D.	Soils in Land Resource Regions A, B, C, D, and E except MRLA's 48A, 48B, and 49 having a subsurface natric horizon with equal to or greater than 35 percent clay; slow or very slow permeability (to find the natric horizon: search for a subsoil, subsurface, layer with the slowest permeability [<0.2 inches/hour and equal to or more than 35 percent clay] and use the upper depth of that layer to assign depth to natric horizon); and with aridic or xeric soil moisture regime and in great groups designated as Nadurargids, Natrixerolls, Natrargids, or Natrixeralfs or subgroups of Natric Durixeralfs or Aridic Natrixerolls with the slow or very slow permeability beginning at a depth of:	<20 20-40 40-60 >60	2 3 4 5
6.	Sandy or Sandy Skeletal Substratum	A.	Soils in all Land Resource Regions except A, B, C, D, E, W, X , and Y and MLRA's 52, 58A, 60B, 101, 140 141,142, 143, 144A, 144B 145, and 146 having sandy substratum layer(s) of SG, COS, S, LS, FS, or LCOS (with or without rock fragment modifiers); or SR with these textures; that extend to a depth of 60 inches or more; with a permeability equal to or greater than 6 inches per hour (A) immediately below a layer or layers that have (1) a permeability of less than 6 inches per hour, (2) less than 50 percent fine or coarser sand separates in the fine earth fraction, and (3) a combined thickness of equal to or more than 10 inches; OR (B) immediately below a layer or layers that have (1) CE, DE, FB, HM, MPT, MUCK, PEAT, or SP in lieu of texture, and (2) a combined thickness of equal to or more than 10 inches. With a substratum beginning at a depth of:	10-20 20-60 >60	3 4 5
			OR		
		B.	Soils in Land Resource Regions A, B, C, D, and E and MLRA's 52, 58A, 60B, 101, 140, 141, 142,143, 144A, 144B 145, and 146 having sandy substratum layer(s) of SG, COS, S, LS, FS, or LCOS (with or without rock fragment modifiers); or SR with these textures; that extend to a depth of 60 inches or more; with a permeability equal to or greater than 6 inches per hour (A) immediately below a layer or layers that have (1) a permeability of	10-20 20-40 40-60 >60	2 3 4 5

	less than 6 inches per hour, (2) less than 50 percent fine or coarser sand separates in the fine earth fraction, and (3) a combined thickness of equal to or more than 10 inches; OR (B) immediately below a layer or layers that have (1) CE, DE, FB, HM, MPT, MUCK, PEAT, or SP in lieu of texture, and (2) a combined thickness of equal to or more than 10 inches. With a substratum beginning at a depth of:		
	OR		
	C. Soils in Land Resource Regions W, X, and Y having sandy substratum layer(s) of SG, COS, S, LS, FS, or LCOS (with or without rock fragment modifiers); or SR with these textures; that extend to a depth of 60 inches or more; with a permeability equal to or greater than 6 inches per hour (A) immediately below a layer or layers that have (1) a permeability of less than 6 inches per hour, (2) less than 50 percent fine or coarser sand separates in the fine earth fraction; and (3) a combined thickness of equal to or more than 10 inches; OR (B) immediately below a layer or layers that have (1) CE, DE, FB, HM, MPT, MUCK, PEAT, or SP in lieu of texture, and (2) a combined thickness of equal to or more than 10 inches. With a substratum beginning at a depth of:	10-20 20-40 40-60 >60	1 2 3 5
7. Abrupt Textural Change	A. Soils in orders of Alfisols, Aridisols, Mollisols, or Ultisols and (1) all Pale great groups of those orders, Albaqualfs or Argialbolls; or (2) soils in xer, bor, alb, arg, aqu, or argi suborders with great groups of alb, argi, eutro, dur, or cry with subgroups of Abruptic, Abruptic Aridic, Abruptic Cryic or Abruptic Xerollic; or (3) Alfic Haploxerands or Alfic Vitrixerands with an argillic horizon with equal to or greater than 35 percent clay; AND having an adjacent upper layer with a permeability of more than 0.6 inches/hour overlying and adjacent to a lower layer having more than 35 percent clay with a permeability of less than 0.2 inches/hour OR having an adjacent upper layer with permeability greater than 0.2 inches per hour overlying and adjacent to a lower layer having equal to or more than 35 percent clay with a permeability of less than 0.06 inches per hour beginning at a depth of: Criteria A. will be used in the	<20 20-60 >60	3 4 5

following MLRA's 1, 2, 3, 4, 5, 6, 8 through 10, 10A, 11, 11A, 11B, 12 through 15, 17 through 27, 28A, 28B, 29 through 32, 34, 35, 37, 39, 40, 41, 43, 44, 47, 48A, 48B, 52, 53A, 54, 58A, 58B, 60A, 60B, and 67.

B. Soils in orders of Alfisols, Mollisols, or Ultisols and; (1) Albaqualfs with subgroups of Udollic, Aeric, Mollic, or Typic; or (2) Hapludalfs with subgroups of Albaquultic or Albaquic; or (3) Typic Argialbolls; (4) Abruptic Argiaquolls; or (5) Albaquults with subgroups of Typic or Aeric with an argillic horizon with equal to or more than 35 percent clay; AND having an adjacent upper layer with a permeability of more than 0.6 inches/hour overlying and adjacent to a lower layer having more than 35 percent clay with a permeability of less than 0.2 inches/hour OR having an adjacent upper layer with permeability greater than 0.2 inches per hour overlying and adjacent to a lower layer having equal to or more than 35 percent clay with a permeability of less than 0.06 inches per hour beginning at a depth of:	<20	3
	20-60	4
	>60	5

Criteria B. will be used in the following MRLA's: 71, 73, 74, 75, 76, 102B, 106, 107, 108, 109, 111, 112, 113, 114, and 115.

C. Soils in orders of Alfisols and Mollisols with an argillic horizon with equal to or more than 35 percent clay: AND having an adjacent upper layer with permeability greater than 0.6 inches per hour overlying and adjacent to a lower having equal to or more than 35 percent clay with a permeability of less than 0.2 inches per hour; OR having an adjacent upper layer with permeability greater than 0.2 inches per hour overlying and adjacent to a lower layer having equal to or more than 35 percent clay with a permeability of less than 0.06 inches per hour beginning at a depth of:	<20	3
	20-60	4
	>60	5

Criteria C. will be used in the following MLRA's 108, 109, 110, 113, 114, 115, 115A, 115B, and 115C.

8. Dense Layer

A. Soils having a layer whose upper boundary begins at the depths indicated and has the following average bulk density for layer soil textural class(s); and with permeability difference of 2 classes between dense layer and upper adjacent layer. (excluding Vertisols, and Vertic subgroups) (not used in Land Resource Regions R, W, X, and Y and MLRA's 100 and 101):

Layer Soil Textural Class [1/]	Moist Avg.BD	Layer Depth	T Value

COS, S, LCOS, LS, FS, LFS	>1.80	<20	3
		20-60	4
		>60	5
VFS, LVFS, FSL, COSL VFSL, SL, with average <18 percent clay.	>1.75	<20	3
		20-60	4
		>60	5
COSL, VFSL, FSL, SL, or CL and average 18 to 35 percent clay or L or SCL	>1.7	<20	3
		20-60	4
		>60	5
SI, SIL, or SICL and average <35 percent clay.	>1.6	<20	3
		20-60	4
		>60	5
CL, SC, C, SICL, SIC and clay average within 35 to 60 percent clay.	>1.55	<20	3
		20-60	4
		>60	5
C with average clay value 60 percent or more clay (exclude Soil Orders of Andisols and Oxisols).	>1.35	<20	3
		20-60	4
		>60	5

OR

B. Soils in Land Resource Regions W, X, and Y for soils having a layer whose upper boundary begins at the depths indicated and has the following average bulk density for layer soil textural class(s); and with permeability difference of 2 classes between dense layer and upper adjacent layer. (excluding Vertisols, and Vertic subgroups):

Layer Soil Textural Class[2]	Moist Avg.BD	Layer Depth	T Value
COS, S, LCOS, LS, FS, LFS	>1.80	<20	1
		20-40	2
		40-60	3
		>60	5
VFS, LVFS, FSL, COSL, VFSL, or SL with average <18 percent clay.	>1.75	<20	1
		20-40	2
		40-60	3
		>60	5
COSL, VFSL, FSL, SL, or CL and average 18 to 35 percent clay or L or SCL	>1.7	<20	1
		20-40	2
		40-60	3
		>60	5
SI, SIL, or SICL and average <35 percent clay.	>1.6	<20	1
		20-40	2
		40-60	3
		>60	5
CL, SC, C, SICL, SIC and average within 35 to 50 percent clay.	>1.55	<20	1
		20-40	2
		40-60	3
		>60	5
C with average clay value 60 percent or more clay (exclude Soil Orders of Andisols and Oxisols).	>1.35	<20	1
		20-40	2
		40-60	3
		>60	5

C. Soils in Land Resource Region R and MLRA's 100 and 101 having a layer whose upper boundary begins at the depths indicated and has the following average bulk density for layer soil textural class(es):

Layer Soil Textural Class [1/]	Moist Avg.BD	Layer Depth	T Value
COS, S, LCOS, LS, FS,	>1.75	<20	2

[2] Layer soil textural class - excludes the surface layer.

	LFS		20-40	3
			40-60	4
			>60	5
	VFS, LVFS, FSL, COSL VFSL, or SL with average <18 percent clay.	>1.75	<20	2
			20-40	3
			40-60	4
			>60	5
	COSL, VFSL, FSL, SL, or CL and average 18 to 35 percent clay or L or SCL	>1.7	<20	2
			20-40	3
			40-60	4
			>60	5
	SI, SIL, or SICL and average <35 percent clay.	>1.6	<20	2
			20-40	3
			40-60	4
			>60	5
	CL, SC, C, SICL, SIC and average 35 to 60 percent clay.	>1.55	<20	2
			20-40	3
			40-60	4
			>60	5
	C with average 50 percent or more clay	>1.35	<20	2
			20-40	3
			40-60	4
			>60	5
	D. Soils in Land Resource Regions W, X, and Y that have a combined surface layer of 10 inches or more thick with a bulk density less than 1.10 and 95percent or more material passing the #10 sieve overlying a layer with soil textural modifiers of CB, CBV, CBX, ST, STV, or STX or less than 85 percent passing the #10 sieve:		<20	1
			20-40	2
			40-60	3
			>60	5
9. Rock Fragments	If state equals CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT VA, and WV, use only the 2mm - 10 inch rock fragment fraction for the surface layer.			
	A. Soils in all Land Resource Regions except W, X, and Y having layer(s) with a combined thickness of equal to or more than 10 inches with (1) Texture with no rock fragment modifier, or (2) texture modified by BY, CB, GR, ST, CN, OR FL (in the Northeast states, this layer has 0 to 50 percent rock fragments by weight; texture modifiers are not used.), or (3) CE, DE, FB, HM, MPT, MUCK, PEAT, SP, VAR over a layer that extends to a depth of 60 inches or more that has a texture (exclude SG, COS, S, LS, FS, or LCOS) modified by BYX, CBX, GRX, STX, CNX, or FLX or over bedrock, CEM, or IND if texture modified by BYX, CBX, GRX, STX, CNX, or FLX extends to less than 50 inches, beginning at a depth of:		<20	3
			20-60	4
			>60	5
	OR			
	B. Soils in Land Resource Regions W, X, and Y having layer(s) with a combined thickness of equal to or more than 10 inches with (1) Texture with no rock fragment modifier, or (2)		<20	1
			20-40	2
			40-60	3
			>60	5

			texture modified by BY, CB, GR, ST, CN, OR FL (in the Northeast states, this layer has 0 to 50 percent rock fragments by weight; texture modifiers are not used.), or (3) CE, DE, FB, HM, MPT, MUCK, PEAT, SP, VAR over a layer that extends to a depth of 60 inches or more that has a texture (exclude COS, S, SG, LS, FS, or LCOS) modified by BYX, CBX, GRX, STX, CNX, or FLX or over bedrock, CEM, or IND if texture modified by BYX, CBX, GRX, STX, CNX, or FLX extends to less than 60 inches, beginning at a depth of:		
		C.	Soils in all Land Resource Regions except W, X, and Y having layer(s) with a combined thickness of equal to or more than 10 inches with (1) Texture with no rock fragment modifier, over a layer that extends to a depth of 60 inches or more that has a texture (exclude SG, COS, S, LS, FS, or LCOS) modified by BYV, CBV, GRV, STV, CNV, or FLV or over bedrock, CEM, or IND if texture modified by BYV, CBV, GRV, STV, CNV, or FLV extends to less than 60 inches, beginning at a depth of:	<20 20-60 >60	3 4 5
			OR		
		D.	Soils in Land Resource Regions W, X, and Y having layer(s) with a combined thickness of equal to or more than 10 inches with (1) Texture with no rock fragment modifier over a layer that extends to a depth of 60 inches or more that has a texture (exclude COS, S, SG, LS, FS, or LCOS) modified by BYV, CBV, GRV, STV, CNV, or FLV or over bedrock, CEM, or IND if texture modified by BYV, CBV, GRV, STV, CNV/ or FLV extends to less than 60 inches, beginning at a depth of:	<20 20-40 40-60 >60	1 2 3 5
10.	High gypsum		Soils having a gypsiferous material layer designated as GYP at a beginning depth of:	<20 20-40 40-60 >60	2 3 4 5
11.	Organic	A.	Soils (excludes Land Resource Regions W, X, and Y) that are Histosols having organic soil material; and <u>not</u> lithic or limnic or terric or hydric subgroup (e.g., Terric, Hemic Terric, etc.), then "T" is		3
			OR		
		B.	Soils that are Histosols having a lithic, hydric, or limnic subgroup, then "T" is		1
			OR		
		C.	Soils that are Histosols having a terric subgroup (e.g., Terric, Hemic Terric, etc.), then "T" is		2
			OR		
		D.	Soils in Land Resource Regions W, X, and Y that are Histosols having organic soil material; and <u>not</u>		

		lithic or limnic or terric or hydric subgroup (e.g., Terric, Hemic Terric, etc.), then "T" is		5
12.	High Carbonates	Criteria will be used after October 1, 1994. States will need to review and possibly need to update soil properties to generate appropriate "T" value using Criteria A and B.		
		A. Soils in Land Resource Regions B, C, D, E, W, X, and Y having a surface layer with equal to or less than 15 percent calcium carbonate (CaC03) equivalent and have a subsurface layer with more than 25 percent (average) CaC03 equivalent OR having a surface layer with more than 15 percent calcium carbonate (CaC03) equivalent and a subsurface layer that exceeds the surface layer in calcium carbonate (CaC03) equivalent by 20 percent or more beginning at a depth of:	<20 20-40 40-60 >60	2 3 4 5
		B. Soils (excludes Land Resource Regions B, C, D, E, W, X, and Y) having a surface layer with equal to less than 15 percent calcium carbonate (CaC03) equivalent and have a subsurface layer with more than 25 percent (average) CaC03 equivalent OR having a surface layer with more than 15 percent calcium carbonate (CaC03) equivalent and a subsurface layer that exceeds the surface layer in calcium carbonate (CaC03) equivalent by 20 percent or more beginning at a depth of:	<20 20-60 >60	3 4 5
13.	Severely Eroded	Soils designated on the Soil Interpretations Record (SIR) as having a severely eroded unit modifier or have severely eroded shown in Class Determining Phase in Capability and Yields Per Acre of Crops and Pasture and have reduced productivity. These SIR's manually are adjusted 1 class of "T" value lower than the non-eroded SIR or Class Determining Phase.		

Exhibit 618-15 Texture Class, Texture Modifiers, and Terms Used in Lieu of Texture.

Texture Modifiers**

ASHY	Ashy
BY	Bouldery
BYV	Very bouldery
BYX	Extremely bouldery
CB	Cobbly
CBV	Very cobbly
CBX	Extremely cobbly
CEM	Cemented
CN	Channery
CNV	Very channery
CNX	Extremely channery
COP	Coprogenous
DIA	Diatomaceous
FL	Flaggy
FLV	Very flaggy
FLX	Extremely flaggy
GR	Gravelly
GRC	Coarse gravelly
GRF	Fine gravelly
GRM	Medium gravelly
GRV	Very gravelly
GRX	Extremely gravelly
GS	Grassy
GYP	Gypsiferous
HB	Herbaceous
HYDR	Hydrous
MEDL	Medial
MK	Mucky
MR	Marly
MS	Mossy
PBY	Parabouldery
PBYV	Very Parabouldery
PBYX	Extremely Parabouldery
PCB	Paracobbly
PCBV	Very Paracobbly
PCBX	Extremely Paracobbly
PCN	Parachannery
PCNV	Very Parachannery
PCNX	Extremely Parachannery
PF	Permanently frozen
PFL	Paraflaggy
PFLV	Very Paraflaggy
PFLX	Extremely Paraflaggy
PGR	Paragravelly
PGRV	Very Paragravelly
PGRX	Extremely Paragravelly
PST	Parastony
PSTV	Very Parastony
PSTX	Extremely Parastony
PT	Peaty
ST	Stony
STV	Very stony
STX	Extremely stony
WD	Woody

Texture Class

C	Clay
CL	Clay loam
COS	Coarse sand
COSL	Coarse sandy loam
FS	Fine sand
FSL	Fine sandy loam
L	Loam
LCOS	Loamy coarse sand
LFS	Loamy fine sand
LS	Loamy sand
LVFS	Loamy very fine sand
S	Sand
SC	Sandy clay
SCL	Sandy clay loam
SI	Silt
SIC	Silty clay
SICL	Silty clay loam
SIL	Silt loam
SL	Sandy loam
VFS	Very fine sand
VFSL	Very fine sandy loam

Terms used in lieu of texture

BR	Bedrock
BY	Boulders
CB	Cobbles
CN	Channers
FL	Flagstones
G	Gravel
HPM	Highly decomposed plant material
MAT	Material
MPM	Moderately decomposed plant material
MPT	Mucky peat
MUCK	Muck
PBY	Paraboulders
PCB	Paracobbles
PCN	Parachanners
PEAT	Peat
PFL	Paraflagstones
PG	Paragravel
PST	Parastones
SPM	Slightly decomposed plant material
ST	Stones
W	Water

** "Texture Modifiers" may apply to both "texture class" and "terms used in lieu of texture". Some apply to both, others only apply to one or the other. Refer to part 618.67.

Exhibit 618-16 Wind Erodibility Groups (WEG) and Index.

WEG [1] [3] [4] [5]	Properties of soil surface layer	Dry soil aggregates more than 0.84 mm (wt.%)	Wind erodibility index (I) (tons/ac/yr)
1	Very fine sand, fine sand, sand or coarse sand[2]	1 2 3 5 7	310 250 220 180 160
2	Loamy very fine sand, loamy fine sand, loamy sand, loamy coarse sand; very fine sandy loam and silt loam with 5 or less percent clay and 25 or less percent very fine sand; and sapric soil materials (as defined in Soil Taxonomy); except Folists	10	134
3	Very fine sandy loam, fine sandy loam, sandy loam, coarse sandy loam, and noncalcareous silt loam that has 20 to 50 percent very fine sand and 5 to 12 percent clay	25	86
4	Clay, silty clay, noncalcareous clay loam that has more than 35 percent clay, and noncalcareous silty clay loam that has more than 35 percent clay. All of these do not have sesquic, parasesquic, ferritic, ferruginous, or kaolinitic mineralogy (high iron oxide content).	25	86
4L	Calcareous [6] loam, calcareous silt loam, calcareous silt, calcareous sandy clay, calcareous sandy clay loam, calcareous clay loam and calcareous silty clay loam	25	86
5	Noncalcareous loam that has less than 20 percent clay; noncalcareous silt loam with 12 to 20 percent clay; noncalcareous sandy clay loam; noncalcareous sandy clay; and hemic materials (as defined in Soil Taxonomy).	40	56
6	Noncalcareous loam and silt loam that have more than 20 percent clay; noncalcareous clay loam and noncalcareous silty clay loam that has less than 35 percent clay; silt loam that has parasesquic, ferritic, or kaolinitic mineralogy (high iron oxide content)	45	48
7	Noncalcareous silt; noncalcareous silty clay, noncalcareous silty clay loam, and noncalcareous clay that have sesquic, parasesquic, ferritic, ferruginous, or kaolinitic mineralogy (high content of iron oxide) and are Oxisols or Ultisols; and fibric material (as defined in Soil Taxonomy)	50	38
8	Soils not susceptible to wind erosion due to rock and pararock fragments at the surface and/or wetness; and Folists	---	0

[1] For all WEGs except sands and loamy sand textures, if percent rock and pararock fragments (>2mm) by volume is 15-35, reduce "I" value by one group with more favorable rating. If percent rock and pararock fragments by volume is 35-60, reduce "I" value by two favorable groups except for sands and loamy sand textures which are reduced by one group with more favorable rating. If percent rock and pararock fragments is greater than 60, use "I" value of 0 for all textures except sands and loamy sand textures which are reduced by three groups with more favorable ratings. An example of more favorable "I" rating is next lower number - "I" factor of 160 to "I" factor of 134 or "I" factor of 86 to "I "factor of 56.

[2] The "I" values for WEG 1 vary from 160 for coarse sands to 310 for very fine sands. Use an "I" of 220 as an average figure.

[3] All material that meets criterion 2 in the requirements for andic soil properties in Soil Taxonomy, regardless of the fine earth texture, are placed in WEG 2.

[4] All material that meets criterion 1 in the requirements for andic soil properties in Soil Taxonomy, regardless of the fine earth texture, are placed in WEG 6 except for medial classes of Cryic Spodosols having MAAT < 40 degrees F. which are placed in WEG 2.

[5] Surface layers or horizons that do not meet andic soil properties criteria but do meet Vitrandic, Vitritorrandic, and Vitrixerandic subgroup criteria (thickness requirement excluded) move one group with less favorable rating.

[6] Calcareous is a strongly or violently effervescent reaction of the fine-earth fraction to cold dilute (1N) HCL; a paper "Computing the Wind Erodible Fraction of Soils" by D. W. Fryear et.al (1994) in the J. Soil and Water Conservation 49 (2) 183-188 raises a yet unresolved question regarding the effect of carbonates on wind erosion.

Exhibit 618-17 Key Landforms and Their Susceptibility to Slippage.

Topography	Landform or Geologic Materials	Slippage Potential [a/]
I. Level Terrain		
A. Not elevated	Floodplain, Till plain, Lake bed	3
B. Elevated		
1. Uniform Tones	Terrace, Lake bed	2
2. Surface irregularities, sharp cliff	Basaltic plateau	1
3. Interbedded-porous over impervious layers	Lake bed, coastal plain,	1
II. Hilly terrain		
A. Surface drainage not well integrated		
1. Disconnected drainage	Limestone	3
2. Deranged drainage, overlapping hills, associated with lakes and swamps (glaciated areas only)	Moraine	2
B. Surface drainage well integrated		
1. Parallel ridges		
a. Parallel drainage, dark tones	Basaltic hills	1
b. Trellis drainage, ridge-and-valley topography, banded hills	Downslope tilted sedimentary rock	1
c. Pinnate drainage, vertical-sided gullies	Loess	2
2. Branching ridges, hilltops at common elevation		
a. Pinnate drainage, vertical sided gullies	Loess	2
b. Dendritic drainage		
(1) Banding on slopes	Flat-lying sedimentary rocks	2
(2) No banding on slopes		
(a) Moderately to highly dissected ridges, uniform slopes	Clay Shale	1
(b) Low ridges, associated with coastal features	Dissected coastal plains	1
(c) Winding ridges connecting conical hills, sparse vegetation	Serpentinite	1

3. Random ridges or hills		
a. Dendritic drainage		
(1) Low, rounded hills meandering streams	Clay shale	1
(2) Winding ridges connecting conical hills, sparse vegetation	Serpentinite	1
(3) Massive, uniform, rounded to A-shaped hills	Granite	2
(4) Bumpy Topography (glaciated areas only)	moraines	2
III. Level to hill terrain		
A. Steep slopes	Talus, colluvium	1
B. Moderate to flat slopes	Fan, delta	3
C. Hummocky slopes with scarp at head	Old slide	1

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a/ 1 = susceptible to slippage (Unstable);
2 = susceptible to slippage under certain conditions (Moderately unstable);
3 = not susceptible to slippage except in vulnerable locations (Slightly unstable to stable).

Exhibit 618-18 Example Worksheets for Soil Moisture State by Month and Depth

SOIL MOISTURE STATE BY MONTH AND DEPTH

Aridic Thermic

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)	10	10	8	4	6	2	8	10	6	4	8	8
0 **SOIL** DEPTH 200 cm	M D	M D	M D	M D	D	D	D	D	D	D	D	M D

Xeric Mesic

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)	180	140	110	60	40	30	10	20	40	80	170	200
0 **SOIL** DEPTH 200 cm	M W	M W	M W	M	M	D M	D M	D M	M D M	M	M	W

Ustic Mesic

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)	10	15	50	60	80	100	70	70	70	40	25	15
0 **SOIL** DEPTH 200 cm	M D M	M D M	M D M	M	M	M	D M	D M	D M	M D M	M D M	M D M

Udic Mesic

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)	50	60	80	80	100	100	110	90	70	50	80	70
0 **SOIL** DEPTH 200 cm	M W	M W	M W	M W	M W	M	M	D M	D M	M	M W	M W

SOIL MOISTURE STATE BY MONTH AND DEPTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)												
0 SOIL DEPTH 200 cm												

SOIL MOISTURE STATE BY MONTH AND DEPTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)												
0 SOIL DEPTH 200 cm												

SOIL MOISTURE STATE BY MONTH AND DEPTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)												
0 SOIL DEPTH 200 cm												

SOIL MOISTURE STATE BY MONTH AND DEPTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ppt (mm)												
0 SOIL DEPTH 200 cm												

[i] Substitute channers for gravel, flagstones for cobbles, etc. where applicable.