NATIONAL SOIL JUDGING HANDBOOK

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PREFACE

Iowa State University and the Department of Agronomy are looking forward to welcoming you to Ames, Iowa.

This handbook provides information about the 2024 National Soil Judging Contest. This manual provides the rules, scorecard instructions, and additional information about the contest. This material has been adapted from previous handbooks, with some modification. Other references used to develop this handbook include *Soil Survey Manual* (Soil Division Staff, 1993), *Field Book for Describing and Sampling Soils v 3.0* (Schoeneberger et al., 2012), *Keys to Soil Taxonomy 12th edition* (Soil Survey Staff, 2014), *Soil Taxonomy 2nd edition* (Soil Survey Staff, 1999) and the *Illustrated Guide to Soil Taxonomy v 2* (Soil Survey Staff, 2015). In keeping with recent contests, emphasis is placed on fundamentals such as soil morphology, taxonomy, and soil-landscape relationships.

Soil Judging remains the most important experiential opportunity for soils students. In a short period of time, students gain a tremendous depth of experience in reading landscapes, describing soil profiles, and making use and suitability interpretations. In a much deeper sense, students learn to be bridge builders, connecting with people through a shared love of the land and the soil resource that crosses cultural, socioeconomic, and political boundaries. For this reason, Soil Judgers are world-changers, representing the heart and soul of our institutions.

We are appreciative of the support we are receiving in this planning process, particularly Dr. Mary Wiedenhoeft and the Agronomy Department at ISU, College of Agriculture and Life Sciences, ISU farm managers, private landowners, and former soil judgers that help make this event go smoothly.

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INTRODUCTION

Soil Judging provides an opportunity for students to study soils through direct experience in the field. Students learn to describe soil properties, identify different kinds of soils and associated landscape features, and interpret soil information for agriculture and other land uses. These skills are developed by studying a variety of soils formed from a wide range of parent materials and vegetation in different topographic settings. It is hoped that by learning about soils and their formation, students will gain an appreciation for soil as a natural resource. We all depend on soil for growing crops and livestock, building materials, replenishing water supplies, and waste disposal. It is increasingly clear that if we do not take care of our soils, loss of productivity and environmental degradation follow. By understanding more about soils and their management through activities like soil judging, we stand a better chance of conserving soil and other natural resources for future generations.

Students in soil judging participate in regional and national contests held annually in different states. These contests are an enjoyable and valuable learning experience, giving students an opportunity to get a first-hand view of soils and land use outside their home areas. As an activity within the American Society of Agronomy, soil judging in the United States is divided into seven regions. Our Region V includes universities from the states of Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota. Collegiate soil judging originated in the southeastern United States in 1956 and began in the Midwest in 1958 with a contest hosted by Kansas State University. Today, over 40 universities are involved with soil judging through the American Society of Agronomy.

This guidebook is organized into several sections that describe the format and content of the contest. The contest involves soil description and interpretation at sites by students, who record their observations on a scorecard. The content sections of this guidebook follow the organization of soil and related information given on the contest scorecard. Those sections include site characteristics, soil morphology, soil hydrology and profile properties, soil classification, and soil interpretations.

This guidebook contains information related to the 2024 National Soil Judging. Coaches are encouraged to consult other sources of information as well including the *Soil Survey Manual* (Soil Division Staff, 1993), *Field Book for Describing and Sampling Soils v 3.0* (Schoeneberger et al., 2012), Simplified version of *Keys to Soil Taxonomy 12th edition* (Soil Survey Staff, 2014), *Soil Taxonomy 2nd edition* (Soil Survey Staff, 1999) and the *Illustrated Guide to Soil Taxonomy v 2* (Soil Survey Staff, 2015) (provided). Other resources available for coaches to consult include web soil survey, official series descriptions, Google Earth, and traditional soil surveys for blockdiagrams and narratives. Specific sources of information for this contest are also included in the References section. Many portions of the text in this guidebook have been adapted from previous Region V contest guidebooks and we recognize that contributions of those writers to this effort.

CONTEST RULES, SCORING AND PROCEDURES

Table 1. Contest Events and Schedule

Date/Time	Activity	Location	Notes
Sunday, April 21	Practice pits	Ames area	Dinner provided with registration
Sunday, April 21	Geology talk		
Monday, April 22	Practice pits	Ames area	
Tuesday, April 23	Practice pits	Ames area	
Tuesday, April 23	Coaches meeting	TBD	
Wednesday, April 24	Practice Pits	Ames area	
Thursday, April 25	Individual contest	Ames area	7:30 am meet
Friday, April 26	Team contest	Ames area	Meet time and location will be provided to coach by Thursday
Friday, April 26	Awards	TBD	

Individual and Team Contests.

The individual contests will be held on **Thursday, April 25** and will consist of three individual-judged sites for the official designated members and two individually judged sites for the designated alternates. At each site, a pit will be excavated, and control area(s) will be designated for the measurement of horizon depths and boundaries. The control area will constitute the officially scored profile and must remain undisturbed and unblocked by contestants. A tape measure will be fixed within the control area.

The site number, number of horizons to be described, the profile depth to be described, and any additional information or laboratory data deemed necessary for correct classification will be provided to contestants. Typically, six horizons will be described at each pit. However, up to seven horizons could be required to give the best understanding of the parent materials for each pit. Some pits may also have less than six horizons. A marker (i.e. nail) will be placed at the base of the third horizon. A pit/site monitor at each site will enforce the rules, answer any questions, keep time limits, clean the soil from the base of the pit as needed and/or requested, and assure all contestants have an equal opportunity to judge the soil.

A team (for the individual portion of the contest) usually consists of four contestants from each school, but can be as few as three. A limited number of alternates may participate in the judging of the contest sites, depending upon space availability (check with contest leader(s) in advance). However, the coach must designate the four official contestants prior to the contest (by 7:00 PM Wednesday, April 24 to Amber). The individual scorecards of the alternates will also be graded, and winners recognized at the awards ceremony. Each school will be allowed one team for the "Team Judging" part of the contest.

The Team Judging portion of the contest will be held on Friday, April 26th. Two or three pits will be judged as a team, depending upon conditions.

General Grading Criteria

All scorecards will be graded by hand. To avoid ambiguity, all contestants are urged to write clearly and use only those abbreviations provided. Ambiguous or unrecognizable answers will receive no credit. Designated abbreviations or the corresponding, clearly written terminology will be graded as correct responses. Scorecards will be graded by a minimum of two coaches, assistant coaches or contest personnel from different schools. A coach or assistant coach cannot be the first to grade a scorecard from their own students. Coaches and assistant coaches may be the second to grade scorecards from their own students if necessary.

Contest Equipment and Materials

Contestants provide the following materials for their own use:

- clipboard
- calculator
- water bottle
- hand lens
- knife
- rock hammer
- tape measure
- acid bottle (10% HCl)
- clinometer or Abney level
- pencils (number 2 pencil is required) *
- Soil Color Charts
- containers for soil samples
- 2mm sieve
- hand towel

*A number 2 pencil is required because of the waterproof paper used for the official scorecards. An ink pen will not work when the scorecards are wet.

This will be an "open book" contest. Any relevant written materials (including this handbook and practice sheets) will be allowed in the contest. A clinometer, knife, and color book will be provided at each pit for emergency situations as well as extra water, acid (10% HCl), and blank scorecards. Contestants are not allowed to have mobile phones during the contest under any circumstances. If a contest official sees one, that contestant will be disqualified for both the individual and team events.

Each site will have its own scorecard designated by a unique border color. Each individual or team contestant will be given a packet during the contest that contains color scorecards corresponding to each site. Since this is an open book contest, an extra set of abbreviations will not be provided, and contestants should use the set of abbreviations in their handbook.

Student Scorecard Responsibilities.

Students must correctly enter the pit number and nail depth on their scorecard. Scorecard entries must be recorded according to the instructions for each specific feature to be judged (see following sections of the handbook). Only one response should be entered in each blank, unless otherwise specified. The official judges may decide to recognize more than one correct answer to allow partial credit for alternative answers. Entries for soil morphology may be recorded using the provided abbreviations or as a complete word.

Contest Timing.

Contestants will be allowed sixty (60) minutes to judge each individual site. The time in and out of the pit for the individually-judged sites will be as follows: 5 minutes in/out, 5 minutes out/in, 10 minutes in/out, 10 minutes out/in, 5 minutes in/out, 5 minutes out/in, and 20 minutes free time for all to finish. The contestants who are first "in" and "out" will switch between the pits. Two members of each team will describe the left pit face and other two team members will describe the right pit face. NOTE: This timing schedule may be modified depending on the number of teams and contestants participating. However, each individual will have at minimum 60 minutes at each site.

For team judging, the tentative timing will be 10 minutes in, 10 minutes out, 10 minutes in, 10 minutes out, 10 minutes in, 10 minutes to finish. Time will start when a team enters a pit, and teams will not alternate in first/out first as in the individual contest for the sake of time. Each team will have a minimum of 60 minutes at each site, including 30 minutes alone at the control section. This timing may change if coaches request and agree upon a change.

Team Scoring.
The overall team score will be the aggregate of the top three individual scores at each individually-judged site plus the team-judged sites. In the case where a team is comprised of only three members, all individual scores will count towards the team's overall score. Individual scores will be determined by summing the three site scores for each contestant (Table 2).

Table 2. Example team score calculation for individual sites.

Contestant	Individual Site 1	Individual Site 2	Individual Score
1	212	196	408
2	230	204	434
3	190	183	373
4	200	174	375
Team Score	642*	583*	

*Top three scores added for team score for each site. The final team score will consist of scores from the two-three team judged pits plus the top three scores for the individually judged pits.

Tie-Break Rules.
The clay content of one horizon at one of the individually-judged sites will be used to break ties in team and individual scores. In order to break a tie in team scores, the mean clay content will be calculated from the estimates provided by all the contestants of a given team. The team with the mean estimate closest to the actual value will receive the higher placing. If this method does not break the tie, the next lowest horizon of the same site will be used in the same manner until the tie is broken. In the event of a tie in individual scores, the clay content of the tie breaker horizon will be compared to that estimated by each individual. The individual with the estimate closest to the actual value will receive the higher placing. If this does not break the tie, the next horizon at the same site will be used in the same manner until the tie is broken.

Contest Results.
Final contest results will be announced at a ceremony on Friday, April 26, 2024. Every effort will be made to avoid errors in determining the contest results. However, the results presented at the awards ceremony are final.

Scorecard Instructions

The scorecard (attached at the end of this guidebook) consists of five parts:

A. Site Characteristics
B. Soil Morphology
C. Soil Hydrology and Profile Properties
D. Soil Classification
E. Site Interpretations

Numbers in parentheses after each item in a section indicate the points scored for one correct judgment. If a pedon has more than one parent material, diagnostic subsurface horizon, or applicable subgroup, five points will be awarded for each correct answer. In these sections of the scorecard, negative credit (minus 5 points for each incorrect answer, with a minimum score of zero for any section) will be used to reduce guessing. More than one entry in other items of the scorecard will be considered incorrect and will result in no credit for that item. Official judges, in consultation with coaches involved in grading, have the prerogative of giving full or partial credit for alternative answers to fit a given site or condition (e.g., hydraulic conductivity where 3 points are given if the answer is close to the correct answer).

A. SITE CHARACTERISTICS

A-1. LANDFORM

A landform is a physical, recognizable form or feature of the Earth's surface that usually has a characteristic shape and is produced by natural causes. Parent materials are commonly associated with particular landforms. The landforms recognized for this contest are:

Upland: These areas dominate central Iowa, and are commonly associated with both till and loess deposits.

Depression: These localized areas collect water, as they are not fully integrated into the drainage system. While glacial till or loess may underly the soil profile, hillslope sediments can likely be found at the surface in depressional areas.

Floodplain: A nearly level alluvial plain that borders a stream and is subject to flooding unless artificially protected. The floodplain refers to the lowest level or levels associated with a stream valley and is sometimes referred to as bottom soil, stream bottom, or first bottom. Sediments may or may not be stratified. Soils found in a floodplain position normally have little profile development beneath the A horizon other than a structure or color horizon. If coarse fragments are present, they are normally rounded or subrounded.

Lake plain: These broad, flat areas (under 2% slope), were former lake beds, now drained. Drainage is common across the state for agricultural purposes. Materials in these areas will be fine in texture and may contain varves, or fine stratification layers in repeated patterns correlated with seasonal fluctuations in water flow.

Stream Terrace: A step-like surface or platform along a stream valley that represents a remnant of an abandoned floodplain. Where occurring in valley floors, this landform is commonly smooth, having low relief, and may or may not be dissected by an under-fitted stream. It consists of a relatively level surface, cut or built by a stream and a steeper descending slope (scarp or riser).

Constructed: These areas have been significantly human modified, so determining original landscape is no longer possible.

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A-2. PARENT MATERIAL

Parent material refers to the sediment in which soils form. Parent materials include bedrock, various kinds of unconsolidated sediments, and "pre-weathered" materials. Soils may be developed in more than one parent material and this should be indicated on the scorecard. For this contest, a parent material should be ≥ 30 cm thick if it is on the surface or ≥ 10 cm thick if at least 30 cm below the soil surface to be indicated on the scorecard.

Aeolian sand: These well-sorted, fine to very fine sands are generally found down-wind of a river valley or body of water. Interbedding, or layers of deposition that may intersect and may look like alluvial stratified materials, but are at angles.

Alluvium: Alluvium consists of sediment transported and deposited by running water and is associated with landforms such as floodplains and stream terraces. As running water sorts sediment by particle size, these materials are often stratified. Rock fragments are often rounded in shape. Alluvium may occur on terraces above present streams (old alluvium) or in the normally flooded bottomland of existing streams (recent alluvium). The sediments may be of either a general or local origin. Stratification may or may not be evident.

Colluvium: A general term applied to **any loose, heterogeneous, and incoherent mass of soil material** and/or rock fragments deposited by rainwash, sheetwash, or slow, continuous downslope creep, usually collecting at the base of gentle slopes or hillsides. Agricultural activities have influenced the landscape across most of Iowa, so local hillslope sediments may exist in the footslope on top of the previous soil surface. This local hillslope sediment will also be included in this option for this contest.

Glacial Till: Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Lacustrine Sediments: Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Loess: Loess consists of fine-textured, wind-deposited sediment that is dominantly of silt size. Loess may contain significant amounts of clay, depending on the distance from the loess source. Silt loam and silty clay loam textures are commonly found in the loess of this area.

Outwash: Mainly sandy or coarse textured material of glaciofluvial origin. While it may occur by itself, you may find a layer of outwash-like material at the top of a glacial till deposit. Therefore, this material is lumped with Glacial Till.

Residuum: This material is left, or residual, as bedrock is weathered. Residuum is rare at the surface in this part of Iowa due to the glacial and loess depositional events that have occurred.

A-3. SLOPE

Slope refers to the inclination of the ground surface and has length, shape, and gradient. Gradient is expressed in percent slope and is the difference in elevation, in length units, for each one hundred units of horizontal distance. Slope may be measured by an Abney level or by a clinometer. Slope classes are based on the gradient. Stakes or markers will be provided at each site for determining slope and the slope should be measured between these two markers. It is the responsibility of the contestant to make sure that markers are at the same height**.** If the slope measurement falls on the boundary between two slope classes, contestants should mark the steeper class on thescorecard. Contestants may want to write the actual slope value in the margin of the scorecard to aid in the completion of the interpretations section.

A-4. HILLSLOPE POSITION

The slope positions given below and shown in the diagram (from Ruhe, 1969) represent geomorphic segments of the topography in which the soil is located. These slope components have characteristic geometries and greatly influence soils through differences in slope stability, water movement, and other slope processes. **Slope positions at the contest site should be determined by the dominant position between the slope markers**.

Summit: The highest level of an upland landform with a relatively gentle slope. It is often the most stable part of a landscape. If the site is on a summit and has a slope < 2%, the summit should be selected on the scorecard.

Shoulder: The rounded (convex-up) hillslope component below the summit. It is the transitional zone from the summit to the backslope and is erosional in origin.

Backslope: The slope position that forms the principal segment of many hillslopes. It is commonly linear along the slope and is also erosional in origin. It is located between the shoulder and footslope positions.

Footslope: The slope position at the base of a hillslope that is commonly rounded, concave-up along the slope. It is transitional between the erosional backslope and depositional toeslope. Accumulation of sediments often occurs at this slope position. If the site is on a footslope and has a slope of < 2%, the footslope should be selected on the scorecard.

None: This designation will be used when slope at the site is < 1% and the site is not in a well-defined example of one of the slope positions given above. This includes toeslope positions, or broad nearly level positions on upland plains, lacustrine plains, stream terraces, or floodplains.

B. Soil Morphology

B-1. Designations for Horizons and Layers

For entering answers in the morphology section of the scorecard, the provided standard abbreviations may be used or the word(s) may be written out. Abbreviations or words that are ambiguous or may be interpreted as an incorrect answer will not receive credit. The Munsell color notation (e.g., 10YR 4/2) should be used and not the color names. If spaces on the scorecard for the soil morphology section do not require an answer (e.g., if no concentrations are present in a horizon), a dash or blank in those spaces will be considered correct. The Field Book for Describing and Sampling Soils (version 3.0, 2012), Chapter 3 of the Soil Survey Manual (1993) entitled, "Examination and Description of Soils", and Chapter 18 of Keys to Soil Taxonomy 12th Edition (2014) entitled "Designations for Horizons and Layers" should be used as a guide for horizon symbols and descriptions.

The number of horizons to be described and the total depth of soil to judge will be provided on an information card at each site. Narrow transition horizons (< 8 cm thick) should be regarded as a gradual boundary and the center used as the measuring point for the boundary depth. Horizons that can be thinner than 8 cm and should be described are O, A or E. These horizons must be at least 2 cm thick to be described.

Three kinds of symbols are used in various combinations to designate horizons and layers in Section A of the contest scorecard: capital letters, lower case letters, and Arabic numerals. Capital letters are used to designate master horizons (or in some cases, transition horizons). Lower case letters are used as suffixes to indicate specific characteristics of the master horizon and layers. Arabic numerals are used both as suffixes to indicate vertical subdivisions within a horizon or layer and as prefixes to indicate lithologic discontinuities.

<u>Prefix</u>: Lithologic discontinuities will be shown by the appropriate Arabic numeral(s). A dash or a blank will receive credit where there is no prefix on the master horizon.

<u>Master</u>: The appropriate master horizon (O, A, E, B, C, R), as well as any transitional horizons (e.g., BC) or combination horizons having dual properties of two master horizons (e.g., B/E), should be entered as needed.

<u>Horizon Suffixes</u>: Enter the appropriate lower case letter or letters. For this contest you should be familiar with the following letter suffixes: a, b, d, e, g, i, k, p, r, ss, t, u, w, y, and z. If more than one is needed, all must be indicated for full credit. If a horizon suffix is not applicable, enter a dash or leave the space blank.

<u>Number:</u> Arabic numerals are used as suffixes to indicate vertical subdivisions within a horizon or layer. Sequential subhorizons having the same master horizon and suffix letter designations should be numbered to indicate a vertical sequence. For other horizons, enter a dash or leave the space blank.

<u>Primes</u>: Primes are used when the same designation is given to two or more horizons in a pedon, but where the horizons are separated by a different kind of horizon. The prime is used on the lower of the two horizons having identical letter designations and should be entered with the capital letter for the master horizon (e.g., Ap, E, Bt, E', B't, Btk, C).

B-2. Boundary

B-2-1. Depth of Lower Boundary

Boundary depths are determined (in centimeters) from the soil mineral surface to the middle of the lower boundary of each horizon. For reference there will be a nail in the thirdhorizon, with that depth posted on the pit card or information sheet. If the total soil profile depth corresponds to the lower boundary of the last horizon, the horizon boundary depth should be described. Otherwise, a dash or the total soil profile depth with a + sign (e.g., 100+) should be enteredon the scorecard. Boundary depths should be judged from the tape measure anchored to the pit face and vertical to the nail within the control section. Therefore, for horizons with wavy boundaries, the boundary depth at the tape should be recorded rather than an estimate of the middle of the wavy boundary across the control section.

Boundary measurements should be made at the center of the boundary separating the two horizons, particularly when the boundary distinctness is not abrupt. Answers for lower boundary depths will be considered correct if within the following limits above or below the depth determined by the official judges: for **abrupt** boundaries +/- 1 cm; for **clear** boundaries +/- 2 cm; for **gradual** boundaries +/- 4 cm; and for **diffuse** boundaries +/- 8 cm. Partial credit for depth measurements may be given at the discretion of the officialjudges where the boundary is not smooth.

If a lithic or paralithic contact occurs at or above the specific judging depth, the contact should be marked as a subsurface feature of the scorecard and should be considered in evaluating the hydraulic conductivity,effective rooting depth, and water retention to 150 cm. Otherwise, the lowest horizon should be mentally extended to a depth of 150 cm for making all relevant evaluations. When a lithic or paralithic contact occurs within the specified judging depth, the contact should be considered as one of the requested horizons, and the appropriate horizon nomenclature should be applied (e.g., Cr or R). However, morphological features of Cr or R horizons need not be provided in Part B of the scorecard. If the contestant gives morphological information for a designated Cr or R horizon, the information will be ignored and will not count against the contestant's score.

B-2-2. Distinctness of Boundary

The distinctness of boundaries separating various horizons must be described if they fall within the designated profile depth indicated by the judges for each site. Categories of distinctness of boundaries are:

Table 3. Soil horizon boundary distinctness category.

Boundary	Abbreviation	Boundary Distinctness
Abrupt	**A**	< 2 cm
Clear	**C**	2.1 to 5 cm
Gradual	**G**	5.1 to 15 cm
Diffuse	**D**	> 15 cm

There will be no distinctness category given for the last horizon, unless a lithic or paralithic contact exists at the lower boundary. A dash or a blank is acceptable for distinctness of the last horizon to be described when a lithic or paralithic contact is not present.

B-3. STRUCTURE

Soil structure refers to the aggregation of primary soil particles into secondary compound groups or clusters of particles. These units are separated by natural planes, zones, or surfaces of weakness. Dominant shape and grade of structure for each horizon are to be judged. If the horizon lacks definite structural arrangements or if there is no observable aggregation, "**structureless**" should be recorded in the grade column and either "**massive**" or "**single grain**" (whichever is appropriate) should be recorded in the type column.

If various types of structure exist within the horizon, contestants should record the type and grade of structure that is most dominant. Compound structure (e.g., prismatic parting to angular or subangular blocky structure) is common in some soils. In this case, structure having the stronger grade should be described. If the structures are of equal grade, the structure type with the largest peds should be described. **The term "blocky" always requires a modifier, either angular or subangular blocky**. Blocky will not receive full credit if used alone.

B-3-1. Grade

The grade of structure is determined by the distinctness of the aggregates and their durability. Expression of structure grade is often moisture dependent and so may change with drying of the soil.

Table 4. Structural Grades

Grade	Code	Description
Structureless	0	The condition in which there is no observable aggregation or no definite, orderly arrangement of natural lines of weakness.
Weak	1	The soil breaks into very few poorly formed, indistinct peds, most of which are destroyed in the process of removal. The shape of structure is barely observable in place.
Moderate	2	The soil contains well-formed, distinct peds in the disturbed soil when removed by hand. They are moderately durable with little unaggregated material. The shape of structure observed in the undisturbed pit face may be indistinct.
Strong	3	Durable peds are very evident in undisturbed soil of the pit face with very little or no unaggregated material when peds are removed from the soil. The peds adhere weakly to one another, are rigid upon displacement, and become separated when the soil is disturbed.

B-3-2. Type

Types of soil structure are described below, modified from the *Field Book for Describing and Sampling Soils, version 3.0,2012.*

Table 5. Structural Types

Type	Abbreviation	Description
Granular	GR	Spheroids or polyhedrons bound by curved planes or very irregular surfaces which have slight or no accommodation to the faces of surrounding peds. The aggregates may or may not be highly porous.
Platy	PL	Plate-like with the horizontal dimension significantly greater than the vertical dimension. Plates are approximately parallel to the soil surface.
Subangular Blocky	SBK	Polyhedron-like structural units that are approximately the same size in all dimensions. Peds have mixed rounded and flattened faces with many rounded vertices. These structural units are casts of the molds formed by the faces of the surrounding peds
Angular Blocky	ABK	Similar to subangular blocky but block-like units have flattened faces and many sharply angular vertices.
Prismatic	PR	Prism-like with the two horizontal dimensions considerably less than the vertical. Vertical faces are well defined and arranged around a vertical line with angular vertices. The structural units have angular tops or caps.
Columnar	COL	Same as prismatic but with rounded tops or caps.
Massive	MA	No structure is apparent, and the material is coherent.
Single-Grained	SGR	No structure is apparent, and soil fragments and single mineral grains do not cohere (e.g., loose sand).

B-3-3. Structure Source

While structure has historically been limited to pedogenically formed features, other consistent planes of weakness can be found in soil. When present, they can significantly impact water movement and root growth in the layer. Therefore, we will recognize geologic structure (GS) and human impacted (HI) influences in this contest, in addition to the traditionally described structure (pedogenic, P).

Pedogenic Structure (P): This category recognizes soil shapes formed due to soil development.

Geologic Structure (G): These unaltered depositional layers may break out in plate-like shapes (alluvial or aeolian sand) or unweathered glacial till that breaks out with sharp corners/edges due to decompression. These structures are associated with a “C” horizon.

Human impact (HI): This category includes soils with significant compaction and/or structure degradation due to intensive or poorly managed agricultural tillage or construction. Strength of structures associated with these impacts may be decreased in the case of compaction, or primary shape modified.

B-4. COLOR

Soil color charts are used to determine the moist soil matrix color for each horizon described. Color must be designated by hue, value, and chroma. Space is provided to enter the hue, value, and chroma for each horizon separately on the scorecard. At the discretion of the official judges, more than one color may be given full credit. Color is to be judged for each horizon by selecting soil material to represent that horizon. The colorof the surface horizon will be determined on a moist, rubbed (mixed) sample. For lower horizons (in some soils this may also include the lower portion of the epipedon) selected peds should be collected from near the central part of the horizon and broken to expose the matrix. If peds are dry, they should be moistened before the matrix color is determined. Moist color is that color when there is no further change in soil color when additional water is added. For Bt horizons with continuous clay films, care should be taken to ensure that the color of a ped interior rather than a clay film is described for the matrix color. For neutral colors (N hues), the chroma is 0.

B-5. REDOXIMORPHIC FEATURES

Redoximorphic (redox, RMF) features are caused by the reduction and oxidation of iron and manganese associated with soil wetness/dryness and not rock color. Characteristic color patterns are created by these processes. Redox features are colors in soils resulting from the concentration (gain) or depletion (loss) of pigment when compared to the soil matrix color. Reduced iron (Fe^{2+}) and manganese (Mn^{2+}) ions may be removed from a soil if vertical or lateral fluxes of water occur. Wherever iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions and nodules. Redox features are used for identifying aquic conditions and determining soil wetness class.

The color of redox features must differ from that of the soil matrix by at least one color chip to be described, except in the case of a depleted matrix in which case the matrix is a redox feature. Colors associated with the following mottled features will not be considered as redox features: carbonates, krotovina, rock colors (lithochromic colors), roots, or mechanical mixtures of horizons such as B horizon materials in an Ap horizon.

Movement of iron and manganese as a result of redox processes in a soil may result in redoximorphic features that are defined as follows:

Redox Concentrations – These are zones of apparent pedogenic accumulation of Fe-Mn oxides, and include: nodules and concretions (firm, irregular shaped bodies with diffuse to sharp boundaries; masses (soft bodies of variable shapes in the soil matrix; zones of high chroma color ("red/orange" for Fe and "black"/purple for Mn); and pore linings (zones of accumulation along pores). Dominant processes involved are chemical dissolution and precipitation; oxidation and reduction; and physical and/or biological removal, transport, and accrual.

If redox concentrations are present, contestants should mark the scorecard indicating the presence of concentrations using the following classes and abbreviations:

Present: (F, C, M)
- **Few (F): redox concentrations cover under 2% of the soil surface area**
- **Common (C): concentrations cover 2 to up to 20% of the soil surface area**
- **Many (M): concentrations cover 20 percent or more of the soil surface area**

Absent: (N or dash) redox concentrations are not present

Redox Depletions - These are zones of apparent pedogenic translocation or loss of Fe-MN oxides. For determination of a seasonal high water table, depletions with a chroma of 2 or less and value of 4 or more must be present. Low chroma (≤ 2) in the soil may be due to drainage, parent material, or other features. However, parent material variations and other such features should not be considered in evaluating soil wetness or soil drainage characteristics.

Present: (F, C, M)
- **Few (F): redox depletions cover under 2% of the soil surface area**
- **Common (C): depletions cover 2 to up to 20% of the soil surface area**
- **Many (M): depletions cover 20 percent or more of the soil surface area**

Absent: (N or dash) redox depletions are not present

Depleted Matrix – This is a soil matrix that has low chroma (2 or less) and values of 4 or more. Low chroma matrix colors caused by dark colors (values of 3 or less), especially those close to the surface, are assumed to be due to organic matter, except when iron concentrations are present in the same horizon. A depleted matrix is indicated by using the "g" suffix designation. This feature is an exaggerated form of redox depletions; thus, the Redox Depletion column should be marked as many if a depleted matrix is present. This feature is not included separately on the scorecard.

If a depleted matrix, contestants should use the **"g" suffix designation** for that horizon as well.

B-6. TEXTURE

Texture refers to the proportion of sand, silt, and clay-sized particles in soil. These proportions are expressed on a percentage basis, with sand, silt, and clay always adding up to 100%. Textural classes, shown in the USDA texture triangle (see Appendix), group soil textures that behave and are managed similarly.

B-6-1. Rock Fragment Modifier

Modifications of texture classes are required whenever rock fragments > 2 mm occupy more than 15% of the soil volume. If rock fragments are present, the percentage should be recorded in the corresponding box, even if the soil contains under 15% rock fragments. Credit will be given for within +/- 5% of the value.

For this contest, the terms "gravelly, cobbly, stony, bouldery, channery, and flaggy" will be used (Table 5, following page). For a mixture of sizes (e.g., both gravels and stones present), the largest size class isnamed. A smaller size class is named only if its quantity (%) exceeds 2 times the quantity (%) of a larger size class. The total rock fragment volume is used (i.e. sum of all the separate size classes) to determine which modifier goes with the fragment term (none, very, or extremely). For example, a horizon with 30% gravel and 14% stones (44% total fragments) would be named very gravelly (**GRV**), but only 20% gravel and 14% stones (34% total fragments) would be named stony (**ST**).

Table 6. Rock fragment modifier size and shape requirements and symbols

Size (Diameter)	Adjective	Symbol
Rounded, Subrounded, Angular, Irregular		
0.2 cm - 7.5 cm **7.6 cm - 25.0 cm** **25.1 cm - 60.0 cm** **> 60.0 cm**	Gravel Cobbly Stony Bouldery	GR CB ST BD
Flat (length measured along longest axis)		
0.2 cm - 15 cm **15.1 cm - 38.0 cm** **38.0 cm - 60 cm** **> 60 cm**	Channery Flaggy Stony Bouldery	CH FL ST BD

Additional requirements for rock fragment modifiers based upon percent of soil volume occupied are listed in Table 6 below.

Table 7. Modifiers by percent rock fragment (> 2 mm) present by volume

Percent Rock by Volume	Rock Fragment Modifier
< 15%	No special term used with the soil texture class. Enter a dash or leave blank.
15 - 35%	Use "gravelly", "cobbly", "stony", "bouldery", "channery" or "flaggy" as a modifier of the texture term (e.g. gravelly loam or GR-L)
35 - 60%	Use "very (V) + size adjective" as a modifier of the texture term (e.g. very cobble fine sandy loam or CBV-FSL).
60 - 90%	Use "extremely (X) + size adjective" as a modifier of the texture term (e.g.. extremely stony clay loam or STX-CL)
> 90%	Use "coarse fragment noun" as the coarse fragment term (e.g. boulders or BD) and dash or leave blank the soil texture class and the % clay boxes.

B-6-2. Texture Classes

Soil texture classes are those defined in the Soil Survey Manual (2017). Any deviation from the standard nomenclature will be considered incorrect (e.g., loamy silt). Sandy loam, loamy sand, and sand should be further specified (see textures and abbreviations listed in Table 4 on the following page) if the soil is dominated by a particular size of sand other than medium sand. Include very coarse sand with coarse sand.

Table 8. Textural Classes and Abbreviations

Texture	Symbol	Texture	Symbol
Coarse sand	COS	**Sandy Loam**	SL
Sand	S	**Loam**	L
Fine Sand	FS	**Sandy Clay Loam**	SCL
Very Fine Sand	VFS	**Silt Loam**	SIL
Loamy Coarse Sand	LCOS	**Silt**	SI
Loamy Sand	LS	**Silty Clay Loam**	SICL
Loamy Fine Sand	LFS	**Clay Loam**	CL
Loamy Very Fine Sand	LVFS	**Sandy Clay**	SC
Coarse Sandy Loam	COSL	**Silty Clay**	SIC
Fine Sandy Loam	FSL	**Clay**	C
Very Fine Sandy Loam	VFSL		

Contestants will determine soil texture classes by hand. The official judges will use field estimates along with laboratory data on selected samples to determine the soil texture class.

B-6-3. Sand Percentage

Sand percentage estimates should be entered in the space provided. Answers within ± 5% of the official value will be given credit.

B-6-4. Clay Percentage

Clay percentage estimates should be entered in the space provided. Answers within ± 3% of the official value will be given credit.

B-7. EFFERVESCENCE

Calcium carbonate is an important constituent of parent materials in Iowa. Small differences in elevation can lead to significant differences in water movement and carbonate accumulation. Floodplains or closed depressional areas can have calcium carbonate accumulations due to water movement and evaporation.

Additionally, erosion of the loess materials can mean till, outwash, or unweathered loess parent material are now within the crop rooting zone, impacting production but not necessarily being a clear or obvious cause.

Carbonates may be visible as whitish material in the field or they may be disseminated and not visible. Dilute hydrochloric acid (10% or 1M HCl) is used to test for carbonates in the field. Calcite effervesces when treated with the HCl. To avoid problems with variability, presence or absence of carbonate as judged by visible effervescence will be determined, rather than classes of effervescence as given in the Soil Survey Manual. Team members should have their own acid bottles for this determination.

Presence: Yes (Y) – Effervescence in any degree
Absence: No (N, -, or blank) – No effervescence

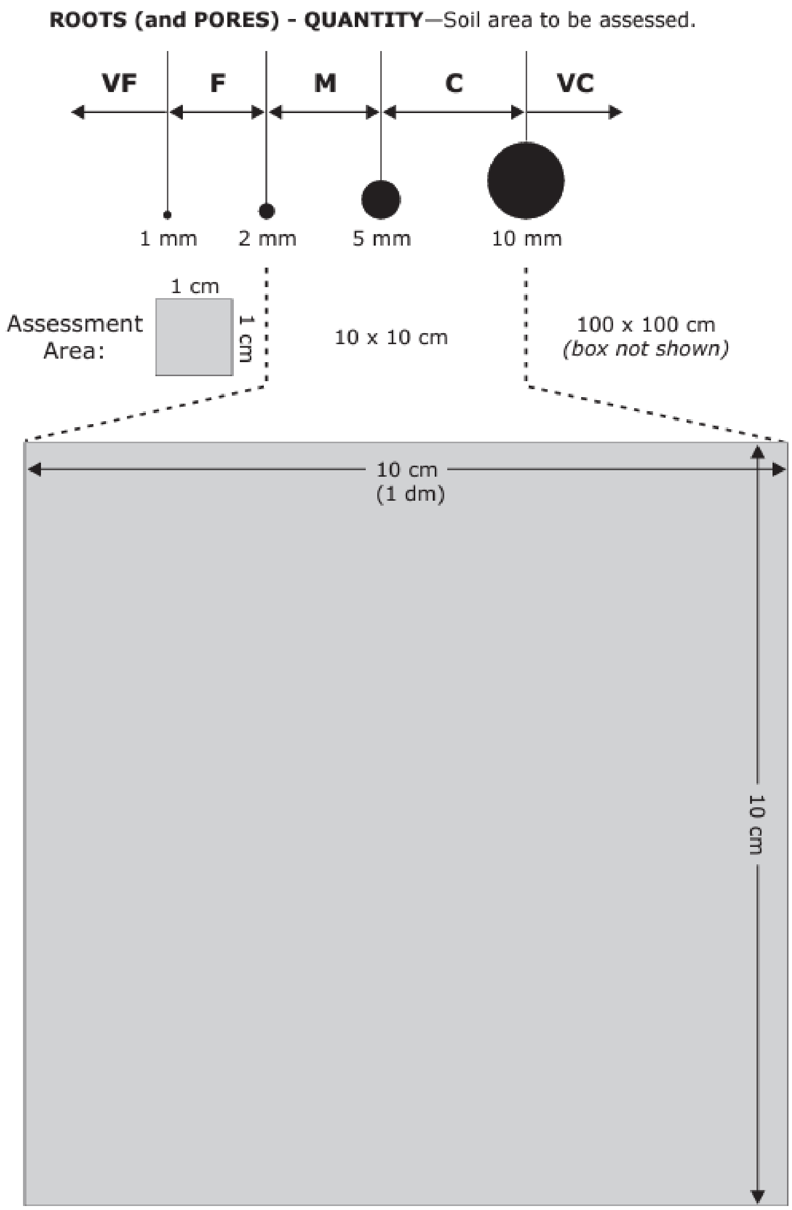
B-8. ROOT ABUNDANCE

Healthy root growth is a positive indicator that soil processes are properly functioning. Healthy roots are associated with better soil physical properties, decreased nutrient loss, higher biological activity, and decreased erosion. Root abundance is influenced by soil properties and cropping or management decisions. They will be described using the following table:

Table 9: Root Abundance and Descriptions

Root Abundance	Description
Many (M)	≥5 per area*
Common (C)	1 to <5 per area
Moderately Few (MF)	0.2 to <1 per area
Very Few (F)	<0.2 per area

*Area assessed is 1 cm^2 for fine roots, 1 dm^2 for medium or coarse roots, see NRCS field book 2-71 or following page if printed on an 8.5x11 sheet.


ROOTS (and PORES) - QUANTITY—Soil area to be assessed.
VF
F
M
C
VC
1 mm
2 mm
5 mm
10 mm
1 cm
Assessment Area:
1 cm
10 x 10 cm
100 x 100 cm
(box not shown)
10 cm
(1 dm)
10 cm

C. Soil Hydrology and Soil Properties

C-1. Effective Soil Depth

The depth of soil to a restrictive layer, or effective soil depth, is the depth of soil that can be easily penetrated by plant roots. Soil materials must be loose enough so that roots do not experience severe physical resistance and yet fine enough to hold and transmit moisture. Horizons that provide physical impediments to rooting limit the effective depth of the soil. For this contest, materials considered restrictive to plant roots include: lithic and paralithic contacts. Soils that are clayey throughout, abrupt textural changes, and seasonal high-water tables do not restrict the depth of rooting. For this contest, a natric horizon will be considered as a root restrictive layer.

The depth to a restricting layer is measured from the soil surface (excluding O horizons). Besides its direct importance for plant growth, this property also relates to key factors such as water relationships and nutrient supplying capacity. The presence or absence of roots may be helpful in determining the effective soil depth, but it is not always the sole indicator. In many cases, the plants growing at the site may be shallow rooted or, conversely, a few roots may penetrate the restrictive layer, particularly along fractures or planes of weakness. At all sites, actual profile conditions should be considered and observed. A soil is considered very deep if no root-restricting layers appear in the upper 150 cm (Table 11). If the profile is not visible to a depth of 150 cm, or if you are requested to describe a soil only to a shallower depth, then you may assume that the conditions present in the last horizon described extend to 150 cm.

Table 10. Effective Soil Depth Classes

Depth Class	Depth to Restricting Layer
Very Deep	> 150 cm
Deep	100.1 – 150 cm
Moderately Deep	50.1 – 100 cm
Shallow	25.1 – 50 cm
Very Shallow	< 25 cm

C-2. Hydraulic Conductivity

In this contest, the vertical, saturated hydraulic conductivity of the surface horizon (Hydraulic Conductivity/ Surface Layer) and the most limiting horizon (Hydraulic Conductivity/Limiting Layer) within the depth specified to be described by the official judges will be estimated. "Limiting layer" refers to the horizon or layer with the slowest hydraulic conductivity. If lithic or paralithic contact occurs at or above the specified judging depth, the hydraulic conductivity for the limiting layer is very low. In some soils, thesurface horizon is the limiting horizon with respect to saturated hydraulic conductivity. In this case, the surface conductivity would be reported in two places on the scorecard. The presence of a natric horizon at or above thespecified judging depth will move the hydraulic conductivity class to the next lower class. In some soils, the surface horizon is the limiting horizon for saturated hydraulic conductivity. In this case, the surface hydraulic conductivity would be reported in two places on the scorecard. For a discussion of factors affecting hydraulic conductivity, refer to the *Field Book for Describing and Sampling Soils (2012)* and *Soil Survey Manual (1997).* **The contest scoring will be 5 points for the correct response and 3 points if the adjacent category (higher or lower) is selected.**

Table 11. Hydraulic Conductivity Classes

Class	Hydraulic Conductivity	Description
Very High	> 100 µm/s (> 36.0 cm/hr)	Usually includes textures of coarse sand, sand, and loamy coarse sand. It also includes textures of loamy sand and sandy loam if they are especially "loose" because of high organic matter content. Horizons containing large quantities of rock fragments with insufficient fines to fill many voids between the fragments are also in this class.
High	10 to 100 µm/s (3.7 to 36.0 cm/hr)	Usually includes textures of fine sand, very fine sand, loamy sand, loamy fine sand, loamy very fine sand, coarse sandy loam, sandy loam, and fine sandy loam.
Moderately High	1 to 10 µm/s (0.36 to 3.6 cm/hr)	Includes textures of very fine sandy loam, sandy clay loam, loam, silt loam, and silt.
Moderately Low	0.1 to 1 µm/s (0.36 to 3.6 cm/hr)	Includes textures of sandy clay, clay loam, silty clay loam. It also includes a texture of silt loam if it has a low organic matter content (< 2%) and a high clay content (24-27%).
Low	0.01 to 0.1 µm/s (0.0036 to 0.036 cm/hr)	Usually includes textures of clay and silty clay that have moderate structure and a moderate organic matter content as well as low to moderate shrink-swell potential (mixed or kaolinitic mineralogy).
Very Low	< 0.01 µm/s (< 0.0036 cm/hr)	Usually includes textures of clay and silty clay with a low organic matter content (< 2%) and weak or massive structure or clay or silty clay textures with moderate to high shrink-swell potential (montmorillonitic mineralogy). Mark very low on the scorecard if a lithic or paralithic contact occurs at or abovethe specified judging depth.

C-3. SURFACE RUNOFF

Surface runoff refers to the relative rate at which water flows over the ground surface. The rate and amount of runoff are determined by soil characteristics, management practices, climatic factors (e.g., rainfall intensity), vegetative cover, and topography. For this contest, we will use the six runoff classes described in the Soil Survey Manual (Soil Survey Division Staff, 1993). The following table, which illustratesthe relationship between soils with various slopes and surface hydraulic conductivity (infiltration), will be usedto determine the surface runoff class. The amount of vegetative cover should also be considered. **Where thereis good vegetative cover or an O horizon at the surface, use the next lower surface runoff class. Vegetative cover should be judged between the slope stakes.** Students should mark "Negligible" for sites in topographic depressions with no surface runoff (i.e., sites subject to ponding).

Table 12. Surface Runoff Classes

Slope %	Saturated Hydraulic Conductivity Class					
	Very High	High	Moderately High	Moderately Low	Low	Very Low
< 2%	Negligible	Negligible	Negligible	Low	Medium	High
2 - 5%	Negligible	Very Low	Low	Medium	High	Very High
5 - 9%	Very Low	Low	Medium	High	Very High	Very High
9 - 18%	Very Low	Low	Medium	High	Very High	Very High
> 18%	Low	Medium	High	Very High	Very High	Very High

C-4. WATER RETENTION DIFFERENCE

Water retention difference (WRD) refers to the soil water held between 0.033 MPa (field capacity) and 1.5 MPa tension (permanent wilting point), which approximates the range of available water for plants. WRD depends on the effective depth of rooting, the texture of the fine earth fraction (< 2 mm) (Table 12), and the content of rock fragments in the soil. The amount of available water stored in the soil is calculated for the top 150 cm of soil or to a root-limiting layer, whichever is shallower. Total WRD is calculated by summing the amount of water held in each horizon (or portion of a horizon if it extends below 150 cm). If a horizon or layer is restrictive (all except natric horizons) to roots, this and all horizons below should be excluded from WRD calculations. For natric horizons and all horizons below the natric horizons, the available water content is reduced by 50%. If the depth that is designated for describing soil morphology is less than 150 cm, contestants should assume that the water retention properties of the last horizon extend to 150 cm or to the top of a lithic or paralithic contact if either of these is observed at a depth shallower than 150 cm.

Rock fragments are assumed to hold no water that is available for plant use. Therefore, if a soil contains rock fragments, the volume occupied by the rock fragments must be estimated, and the water retention difference corrected accordingly. For example, if a silt loam A horizon is 25 cm thick and contains coarse fragments which occupy 10% of this volume, the available water-holding capacity of that horizon would be 4.5 cm of water rather than 5.0 cm.

Once the water retention difference is calculated for the appropriate soil profile depth, the water retention class can be determined using Table 13. An example water retention difference calculation and classification for a theoretical soil profile can be found on the following page.

Table 13. Texture and Water Retention Difference Relationships

Texture Class or Material Type	cm water/cm soil
All sands, loamy coarse sand	0.05
Loamy sand, loamy fine sand, loamy very fine sand, coarse sandy loam	0.10
Sandy loam, fine sandy loam, sandy clay loam, sandy clay, silty clay, clay	0.15
Very fine sandy loam, loam, silt loam, silt, silty clay loam, clay loam	0.20

Table 14. Water Retention Difference Classes

Water Retention Difference Class	cm of available water
Very Low	< 7.5 cm of available water
Low	7.5 to 14.9 cm of available water
Medium	15.0 to 22.5 cm of available water
High	> 22.5 cm of available water

Example of calculation of water retention difference (WRD) for the following soil:

Horizon	Depth (cm)	Texture Class	Rock fragment %
A	20	SL	5
Bt1	60	CL	10
Bt2	80	L	10
2C	150	S	50

Calculation:

Horizon	Thickness		Texture WRD		Rock Frag Correction		cm H_2O/horizon(s)
A	20	x	0.15	x	0.95	=	2.9
Bt1/Bt2	60	x	0.20	x	0.90	=	10.8
2C	70	x	0.05	x	0.50	=	1.8
							Total: 15.5 cm WRD

The water retention class in this example is **MEDIUM (15.0 to 22.5 cm of available water)**.

C-5. SOIL WETNESS CLASS

Soil wetness is a reflection of the duration of water remaining in the soil. Position, slope, infiltration rate, surface runoff, hydraulic conductivity (permeability), texture, and soil bulk density features are significant factors influencing the soil wetness class. The shallowest depth of either:

1) distinct or prominent chroma ≤ 2 and value ≥ 4 redoxfeatures (i.e. redox depletions) due to wetness. **For the purposes of this contest, redox will be assumed to be active (not relict).**
2) color value and chroma of 2/1, 2.5/1 or 3/1 containing distinct or prominent redox concentrations and occurring contiguously above a horizon with a reduced matrix, defined as chroma ≤2 and value ≥4 OR color value and chroma of 2/1, 2.5/1, or 3/1 containing distinct or prominent redox concentraitons occurring contiguously above a horizon with a reduced matrix.

Table 15. Soil Wetness Classes

Class	Depth to Wetness features (from soil surface)
1	> 150 cm
2	100.1 – 150 cm
3	50.1 – 100 cm
4	25 – 50 cm
5	< 25 cm

D. SOIL CLASSIFICATION

D-1. CLASSIFICATION INFORMATION PROVIDED AND EPIPEDON

Each contest profile will be classified using Soil Taxonomy and a simplified set of criteria and options as explained herein and via additional supplements. Family classification will only identify textural class. Classification criteria for each Order, Suborder, Great Group and Subgroup possible for this contest are considerably simplified. These simplified classification criteria are the official ones for this contest. Ambiguities will be clarified during discussion at the Coaches meetings.

Flooding and ponding conditions as well as USLE T value will be given at each site. On a horizon by horizon basis the following laboratory information will be given for each practice and contest profile: weight percentage of calcium carbonate equivalent (CCE), percentage base saturation (BS), electrical conductivity (EC), weight percentage of gypsum (G), and weight percentage of organic carbon (OC). Exchangeable sodium percentage (ESP) will be given in some cases. Please note, some of this information will be measured using standard laboratory methodologies and some will be estimated based upon prior data.

The following are the classification options and their definitions as used in this contest. Epipedon options are Mollic, Umbric and Ochric. Options for diagnostic subsurface horizons and features are Albic, Argillic, Calcic, Cambic, Lithic or Paralithic Contact, Lithologic Discontinuity, Natric, Slickensides, Wetness features (depletion or depleted matrix),and None.

Mollic Epipedons are thick, black organic rich epipedons. Mollic epipedons have 25 cm or more thick that throughout have moist value/chroma of 3/3 or darker, 0.6% or more OC and 50% or more base saturation. The upper boundary of a Mollic epipedon must be within 25 cm of the soil surface. This can occur in the case where there has been significant upslope recent erosion. Mollic epipedons are allowed to be "split" by an albic E horizon.

Umbric epipedons have the same criteria as the Mollic except base saturation is less than 50%.

Note, it is possible there will be profiles with – say – 60 cm with "mollic" colors and OC content but only part of that thickness will have BS at or above 50%. In this case the distinction between Umbric and Mollic epipedons will be whether or not there is 25 cm of cumulative thickness with BS at or above 50%.

Ochric epipedons are those that do not meet all the criteria of Mollic or Umbric.

D-2. DIAGNOSTIC SUBSURFACE HORIZONS AND FEATURES

Diagnostic subsurface horizons form below the soil surface. They can be exposed at the surface rarely due to truncation. Typically, diagnostic subsurface horizons are B horizons, but may include parts of A or E horizons. Indicate all diagnostic subsurface horizons and characteristics that are present. More than one may be present. If none is present, mark "none" for full credit. Remember that negative credit will be given for incorrect answers to **discourage** guessing (although a total score for one answer will never be less than zero). Possible diagnostic horizons or features include: **albic, argillic, calcic, cambic, lithic/paralithic contact, lithologic discontinuity, natric, slickensides/pressure faces, or none**.

Albic horizons are "white" E horizons. Hence, they must be exhibit clay loss relative to one or more horizon above them and they must have moist value of 5 or more and chroma of 2 or less. In order to facilitate separating these horizons from gleyed B horizons and calcite-enriched B horizons in this contest, an Albic horizon must occur such that Mollic colors are present above and below it and the albic has platy structure. The minimum thickness of an albic horizon is 8 cm.

Argillic horizons are diagnostic subsurface pedogenic horizons of phyllosilicate enrichment, not due to parent material change, and are most commonly identified as "Bt or Btg or Btk" but other possibilities exist especially with multiple parent materials and such. Argillic must have clay films, organoclay coatings and/or clay bridging. Argillic horizons must contain clay content that is ≥ 1.2-times the minimum amount of some horizon above it. The minimum thickness of an argillic horizon is 8 cm.

Calcic horizons ("Bk" and such) are diagnostic subsurface pedogenic horizons of calcite enrichment. The CCE content of a Calcic horizon must be ≥ 1.15-times that of an underlying horizon. Typical field evidence of a Calcic horizon is apparent calcite precipitates and very strong to violent effervescence although neither of these are requirements. The minimum thickness of a calcic horizon is 8 cm.

Cambic horizons ("Bw" and such) are subsurface diagnostic horizons where there is enough color and/or structure change to no longer be a C horizon but not so much pedogenic change to classify as one of the other diagnostic horizons herein. This cannot be used in the same profile as an albic, argillic, calcic, or natric. The minimum thickness of a calcic horizon is 8 cm

Lithic or Paralithic Contact refers to the depth where "rock" begins; more specifically, a R or Cr horizon begins. A lithic contact is rock hard enough that a rock hammer is needed to chip it while a paralithic contact is one where a spade can be used to dig in it. Paralithic, rather than lithic, contacts are the norm in Iowa with shale, limestone, sandstone and the other sedimentary rock strata.

Lithologic Discontinuity refers to any change in parent material including alluvial strata stacked on alluvial strata provided the depositional environment of the two strata resulted in a significant difference in texture (including coarse fragment content) or organic matter content. A couple of the common lithological discontinuities in the contest region include (a) loess over till or outwash or aeolian sands; (b) colluvium – both natural and human-induced - over alluvium, loess, till or outwash.

Natric horizons are argillic horizons that in addition to meeting all the requirements of the argillic horizon (above) also have both prismatic structure and ESP ≥ 15 for a thickness of at least 8 cm.

Slickensides or pressure faces refer to morphological features produced when aggregates containing high content of expanding phyllosilicates slide past each as swelling occurs as the soil wets.

None is an option only if none of these are present in the profile.

D-3. ORDER, SUBORDER, GREAT GROUP, AND SUBGROUP

Orders (select 1):
Vertisol: Profile containing more than 35% clay throughout the solum with all or part of the B-horizon having slickensides or pressure faces.
Mollisol: Profile with a mollic epipedon and greater than 50% base saturation throughout the solum.
Alfisol: Profile with an argillic horizon having greater than 35% base saturation.

Inceptisol: Profile with other B horizons.
Entisol: Profile lacking in B horizons.

Suborders (select 1):
"Alb-" is used with Mollisol profiles that contain an Albic horizon.
"Aqu-" is used for all profiles with Soil Wetness Class 4 or 5.
"Fluv" is used for all profiles exhibiting fluvial bedding planes within 50 cm of the surface.
"Orth" is used with Entisol profiles with Soil Wetness Class 1, 2 or 3 and family particle size class of loamy, coarse loamy, fine loamy, coarse silty, fine silty, clayey, fine, very fine, loamy-skeletal, clayey-skeletal or contrasting.
"Psamm-" is used with Entisol profiles having family particle size class of sandy or sandy-skeletal.
"Ud-" is used for all profiles with Soil Wetness Class of 1, 2 or 3 and either (a) lack a calcic horizon within 90 cm of the surface or (b) have a calcic horizon between 50 and 90 cm using the Ustic-Udic "Decision Diagram" in the contest manual.
"Ust-" is used for all other profiles.

Great groups (select 1):
"Natr-" is used with Mollisol and Alfisol suborders having natric horizons.
"Argi-" is used with Mollisol suborders having argillic horizons.
"Calci-" is used with Vertisol, Mollisol, Alfisol and Inceptisol suborders having calcic horizons.
"Hapl-" is used with Udert, Udoll, Ustoll, Udalf, Ustalf, Udept, Ustept suborders.
"Endo-" is used with Aquerts, Aquolls, Aqualfs, Aquepts, and Aquents wherein the redoximorphic features formed due to reducing water tables originating from within the profile.
"Epi-" is used with Aquolls, Aqualfs, Aquepts, and Aquents wherein the redoximorphic features formed due to reducing water tables originating from ponding or flooding having long duration residence times.
"Fluv-" is used with Inceptisol and Entisol profiles having fluvial bedding planes not recognized in the Subgroup level.
"Dystr-" is used with Orthent, Aquent, Udept and Aquept profiles having base saturation less 60% at any point below 25 cm depth.
"Eutr-" is used with Orthent, Aquent, Udept, and Aquept profiles having base saturation equal to or greater than 60% at all points greater than 25 cm depth.
"Ud-" is used in all other cases.

Subgroups (select all that apply to a given profile):
"Aquic" is used for all profiles with Soil Wetness Class 3.
"Cumulic" is used to designate Mollisols having Mollic epipedons deeper than 60 cm.
"Fluventic" is used to designate evidence of fluvial deposition that was not recognized at the suborder or great group level.
"Mollic" is used when Ochric epipedons that have all the properties of a Mollic epipedon to at least 18 cm depth.
"Pachic" is used to designate Mollisols having Mollic epipedon thickness between 50 and 60 cm.
"Typic" is used to designate profiles that have no other subgroups.
"Udic" is used with "ustic" suborder profiles having a calcic horizon that begins between 50 and 90 cm using the "Decision Diagram" below in the contest manual.
"Vertic" is used with profiles that have more than 35% clay not associated with an argillic or natric horizon in part – but not all – of the upper 75 cm depth (not allowed on a vertisol).

D-4. PARTICLE SIZE CONTROL SECTION AND FAMILY PARTICLE SIZE CLASS

Determine the family particle-size class control section for the soil; calculate the weighted percentage sand, silt, clay, and, if needed, rock fragment content in the control section; and determine the family particle-size class.

For soils with contrasting particle-size classes, just mark that this is the case on the scorecard without specifying the class.

D-4-1. Depth of Particle-Size Control Section

Contestants should select the proper depth of the family particle-size control section based on the soil properties present in the judged profile from those listed below.

1. 0 cm to a root limiting layer (where the root limiting layer is less than 36 cm deep)
2. 25 to 100 cm
3. 25 cm to a root limiting layer (where the root limiting layer is between 36 and 100 cm)
4. Upper 50 cm of the argillic
5. Upper boundary of the argillic to 100 cm (contrasting particle size class)
6. All of the argillic where it is less than 50 cm thick

D-4-2. Family Particle-Size Class

Once the family particle-size class control section for the soil profile has been determined, contestants should calculate the weighted percentage sand, silt, clay, and, if needed, rock fragment content within that control section. The family particle-size class can then be determined using the guide listed below (also see textural triangles in Appendix). Contestants should know when to select only the three broad particle size classes, the skeletal classes, and when to use the seven more specific particle size classes. If two or more strongly contrasting particle-size classes are present within the control section, name the two most contrasting classes. ***Subclasses of the loamy and clayey particle size classes will always be used unless a root limiting layer occurs within 50 cm.***

1. Sandy: texture is S or LS
2. Loamy: texture is LVFS, VFS, or finer with clay < 35%
    a. Coarse-loamy: ≥ 15% FS or coarser + < 18% clay
    b. Fine-loamy: ≥ 15% FS or coarser + 18-34% clay
    c. Coarse-silty: < 15% FS or coarser + < 18% clay
    d. Fine-silty: < 15% FS or coarser + 18-34% clay
3. Clayey: ≥ 35% clay
    a. Fine: 35- 59% clay
    b. Very-fine: ≥ 60% clay
4. Sandy-skeletal: ≥ 35% coarse fragments + sandy particle size class
5. Loamy-skeletal: ≥ 35% coarse fragments + loamy particle size class
6. Clayey-skeletal: ≥ 35% coarse fragments + clayey particle size class
7. Contrasting particle size classes - transition zone < 12.5 cm thick
    a. Loamy-skeletal over clayey: absolute difference of 25% clay of the fine earth fraction

E. Soil Interpretations

This section illustrates applications of soil information to land use and ecological site suitability. Soil interpretations involve the determination of the degree of limitation within each soil for a specified use. The most restrictive soil property determines the limitation rating. In cases where the base of the pit does not extend to the depth indicated in the following tables (i.e. 180 cm for some criteria), assume that the lowest horizon in the pit extends to the depth of interest.

E-1. Septic Tank Absorption Fields

The following table is used for evaluating limitations for septic tank absorption fields. The soil between the depths of 60 cm and 180 cm should be considered in making septic tank ratings. If the profile is not visible to 180 cm, assume the last visible horizon continues to 180 cm.

Table 16. Septic Tank Absorption Fields

Criteria	Limitations		
	Slight	**Moderate**	**Severe**
Hydraulic Conductivity of the most limiting layer (60 – 180 cm)	Moderately High, Moderately Low	---	Very High, High, Low, or Very Low
Wetness Class	1	2	3, 4, 5
Average Rocks > 7.5 cm diameter (60 – 180 cm)	< 15%	15 – 35%	> 35%
Depth to Bedrock	> 180 cm	100 – 180 cm	< 100 cm
Slope	< 9%	9 – 14%	> 14%
Flooding/Ponding	None	---	Any

Most limiting layer is defined as the one that would be most limiting for this use, so a loamy sand and clay loam within the profile would be limited (for septic) by the filtering capacity of the loamy sand and should be rated severe due to this property.

E-2. Local Roads and Streets

The following table is used for evaluating soil limitations for local roads and streets. The soil between the depths of 25 cm and 100 cm should be considered for local roads and streets. If the profile is not visible to 100 cm, assume the last visible horizon continues to 100 cm.

Table 17. Local Roads and Streets

Criteria	Limitations		
	Slight	**Moderate**	**Severe**
Texture of the most limiting horizon (25 – 100 cm)	S, LS, SL	L, SCL	SI, SIL, SICL, SIC, CL, SC, C
Average Rocks > 7.5 cm diameter (60 – 180 cm)	< 25%	25 – 50%	> 50%
Wetness Class	1, 2	3, 4	5
Depth to Hard Bedrock (R)	> 100 cm	50 – 100 cm	< 50 cm
Depth to Soft Bedrock (Cr)	> 50 cm	< 50 cm	---
Slope	< 9%	9 – 14%	> 14%
Flooding/Ponding	None	Rare	Occasional or More

E-3. Dwellings with Basements

The following table is used for evaluating soil limitations for dwellings with basements. The soil between the depths of 25 cm and 150 cm should be considered for dwellings with basements.

Table 18. Dwellings with Basements

Criteria	Limitations		
	Slight	**Moderate**	**Severe**
Texture of the most limiting horizon (25 – 100 cm)	S, LS, SL	≤ 35% clay	>35 clay
Average Rocks > 7.5 cm diameter (60 – 180 cm)	< 15%	15 – 35%	> 35%
Wetness Class	1, 2	3	4, 5
Depth to Hard Bedrock (R)	≥ 150 cm	150 – 100 cm	< 100 cm
Depth to Soft Bedrock (Cr)	> 100 cm	50-100 cm	< 50 cm
Slope	< 9%	9 – 14%	> 14%
Flooding/Ponding	None	N/A	Any flooding

E-4. CSR2

CSR2

CSR2 is an inherent soil productivity rating. It is used across Iowa's 99 counties for rural land assessment. "CSR2" stands for "corn suitability rating," calculated using a 2^{nd} generation iteration of the original CSR equation. The CSR2 formula is built around standard "soil judging" (pedological) knowledge. Please note, CSR2 is about the soil profile and its location on the landscape. It is not designed to directly predict "yield" in no small part because yield in Iowa is dependent on the soil, the weather and how farmers manage their fields. The one field management assumption built into CSR2 is that all farmland in Iowa is appropriately managed for long term agronomic success. This means it is assumed that all soils that need artificial drainage have it and that all soils are appropriately fertilized for the crop being grown. The "perfect corn producing" soil gets a CSR2 rating of 100. Most soils have ratings that are lower. The formula used in this contest for calculating CSR2 is:

CSR2 = S-M-W-F-D

Where:

S is the <u>taxonomic subgroup class</u> created from order, suborder, great group and subgroup.
M is the <u>family particle size class</u>,
W is the <u>available water holding capacity</u>
F is the <u>"field" characteristics.</u> It has two components: slope (F_{sl}) and standing water (F_{sw}).
D is the <u>effective soil depth</u>

<u>Notes</u>

(a) If a contestant finds more than one subgroup classification is possible based on their scorecard (Section D) then the "best" subgroup S factor should be used.
(b) "Standing water" can arise from either flooding or ponding. The degree of standing water – whether from flooding or ponding – will be given at all pits where either occurs.
(c) If a soil ends up with a "negative" CSR2 value it is scored as having a "very low" CSR2 value. That is because under normal CSR2 use there is a lower limit of 5.
(d) Values +/- 5 will be given credit

Table 19. S factors used in the CSR2 formula.

Taxonomic Subgroup:	**S factor**		**Taxonomic Subgroup:**	**S factor**		**Taxonomic Subgroup:**	**S factor**
Aquic Argiudolls	85		Mollic Endoaqualfs	85		Typic Fluvaquents	80
Aquic Cumulic Hapludolls	93		Mollic Epiaqualfs	80		Typic Hapludalfs	89
Aquic Hapludolls	100		Mollic Fluvaquents	83		Typic Hapludolls	100
Aquic Pachic Argiudolls	96		Mollic Hapludalfs	95		Typic Natraquerts	40
Aquic Pachic Hapludolls	98		Mollic Paleudalf	89		Typic Udifluvents	95
Aquic Udifluvents	98		Mollic Udifluvents	88		Typic Udipsamments	58
Aquic Udipsamments	60		Pachic Argiudolls	100		Typic Udorthents	72
Aquic Udorthents	84		Pachic Hapludolls	100		Udertic Haplustolls	80
Aquollic Hapludalfs	90		Pachic Haplustolls	78		Udic Haplustolls	80
Aquolls	50		Typic Albaqualfs	87		Udic Ustorthents	74
Argiaquic Argialbolls	80		Typic Argialbolls	80		Udifluvents	50
Cumulic Endoaquolls	84		Typic Argiaquolls	80		Vertic Argialbolls	80
Cumulic Hapludolls	99		Typic Argiudolls	100		Vertic Argiaquolls	84

Cumulic Haplustoll	83		Typic Calciaquolls	78		Vertic Endoaquepts	78
Cumulic Vertic Endoaquolls	79		Typic Calciudolls	84		Vertic Endoaquolls	75
Cumulic Vertic Epiaquolls	81		Typic Endoaqualfs	66		Vertic Epiaqualfs	81
Dystric Eutrudepts	97		Typic Endoaquerts	55		Vertic Epiaquolls	79
Fluventic Hapludolls	85		Typic Endoaquolls	94		Vertic Fluvaquents	67
			Typic Eutrudepts	78			

Table 20. M and W factors used in the CSR2 formula.

Family Particle Size Class	**M factor**		**Available Water Holding Capacity**	**W factor**
Sandy	35		Very Low	24
Loamy	6		Low	12
Coarse Loamy	9		Medium	8
Fine Loamy	4		High	0
Coarse Silty	4			
Fine Silty	0			
Clayey	10			
Fine	10			
Very Fine	12			
Sandy-skeletal	30			
Loamy-skeletal	20			
Clayey-skeletal	25			
Contrasting	25			

Table 21. F factors used in the CSR2 formula.

Slope %	**F_{sl} factor**			
0 to < 2	0			
2 to <5	5			
5 to <9	10			
9 to <14	20			
14 or >	25			
Flooding conditions:	**F_{sw}**		**Ponding conditions:**	**F_{sw}**
frequency is none,	0		Frequency is	0
frequent brief	25		frequent brief	20
frequent very brief	20		frequent very brief	20
occasional brief	20		occasional brief	20
occasional very brief	20		occasional very brief	20
occasional long	25		frequent long	50
frequent extremely brief	25		frequent very long	50
occasional very long	40		occasional long	50
occasional extremely brief	5		occasional very long	50

Table 22. D values used in CSR2.

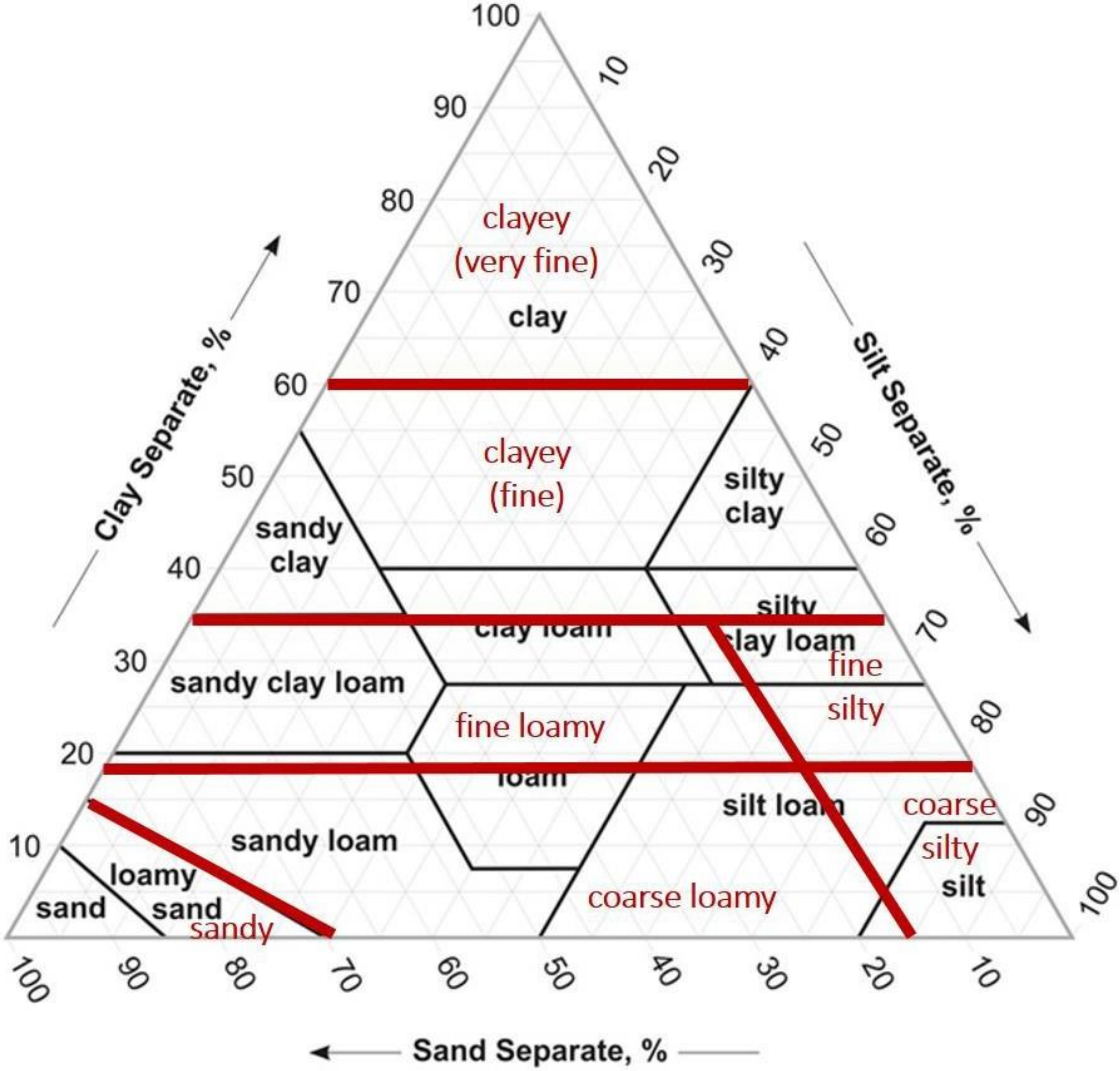
Effective Soil Depth	**D factor**
Very Shallow	40
Shallow	30

Moderately Deep	20
Deep	10
Very Deep	0

ABBREVIATIONS AND USDA TEXTURAL TRIANGLE

Abbreviations are provided in Tables throughout this guidebook. A sheet of abbreviations will be given to contestants on the day of the contest.

Combined USDA Soil Textural Triangle (black) and Family Particle-Size Classes (red).



Site Information and Rotation

<u>Example of Information to be Posted at Each Judging Site</u>

SITE #

Describe 6 horizons between the surface shown by the top of the ruler and a depth of 150 cm.
The yellow scorecard will be used at this site. (Any additional instructions or data will be indicated here.)

Note: Identification of horizons, diagnostic horizons and characteristics, and taxa will primarily be based on morphology. If morphological criteria are met, assume lab-determined criteria are too, unless lab data are given. For example, if the soil meets the moist color, base saturation, thickness, lack of stratification, and organic carbon criteria for a mollic epipedon, it can be assumed that all other criteria for the mollic epipedon and Mollisols are met. Lab data will be provided.

<u>Site and Rotation Procedures</u>:

Each site will have its own color-marked scorecard. Each contestant will be given a packet at the beginning of the contest that has scorecards, but should bring their own copy of this guidebook. Extra copiesof the scorecard will be available at each site for emergencies. The information posted at each site will include scorecard color information. Rotation may be changed due to participant numbers or weather conditions.

<u>Individual Sites</u>:

An example of a full contestant number is as follows: 1AL-In. The “1” is the team number and the “A” is the contestant number. Each contestant ID number will contain either an “L” or an “R”. This tells whether the left or the right face is to be judged. Finally, there is an “-In” or an “-Out”. This designates whether the contestant starts in or out of the judging pit first at the first site. If a contestant starts in the judging pit at the first site, that contestant will start out of the judging pit at the second site, and vice versa.

Each contestant will be in the pit first one time and out of the pit first one time during the individual part of the contest. In addition, two team members of each team will describe the left face and two team members will describe the right face. Alternates will be assigned to even out contestant numbers at each site.

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APPENDIX

Region V and National Soil Judging Contest Dates and Locations
(Most information compiled by M.D. Ransom and O.W. Bidwell, Kansas State University).

Date	Region V Location	National Location	Region Host
1958	Manhattan, KS	---	---
1959	Brainerd, MN	---	---
1960-61	Lincoln, NE	Lexington, KY	2
1961-62	None	St. Paul, MN	5
1962-63	None	Lubbock, TX	4
1963-64	None	Madison, WI	3
1964-65	None	Raleigh, NC	2
1965-66	Ames, IA	Las Cruces, NM	6
1966-67	Manhattan, KS	Ithaca, NY	1
1967-68	St. Paul, MN	Manhattan, KS	5
1968-69	Lincoln, NE	Stillwater, OK	4
1969-70	Rolla, MO	Lansing, MI	3
1970-71	Ames, IA	Tucson, AZ	6
1971-72	Manhattan, KS	Blacksburg, VA	2
1972-73	St. Paul, MN	University Park, MD	1
1973-74	North Platte, NE	Boone, IA	5
1974-75	Fargo, ND	College Station, TX	4
1975-76	Columbia, MO	Urbana, IL	3
1976-77	Brookings, SD	Clemson, SC	2
1977-78	Manhattan, KS	Las Cruces, NM	6
1978-79	Ames, IA	Bozeman, MT	7
1979-80	Brainerd, MN	State College, PA	1
1980-81	Brookings, SD	Lincoln, NE	5
1981-82	Manhattan, KS	Fayetteville, AR	4

1982-83	Ames, IA	Columbus, OH	3
1983-84	Elba, MN	San Luis Obispo, CA	6
1984-85	Lincoln, NE	Knoxville, TN	2
1985-86	Lake Metigoshe, ND	Fort Collins, CO	7
1986-87	Lake of the Ozarks, MO	Ithaca, NY	1
1987-88	Rock Springs Ranch, KS	Near Brookings, SD	5
1988-89	Roaring River State Park, MO	Stephenville, TX	4
1989-90	Boone County, IA	West Lafayette, IN	3
1990-91	Long Lake Conservation Camp, MN	Murray, KY	2
1991-92	Aurora, NE	Davis, CA	6
1992-93	Brookings, SD	Corvallis, OR	7
1993-94	Rock Springs, KS	Near College Park, MD	1
1994–95	Poplar Bluff, MO	Lake of the Ozarks, MO	5
1995-96	Near Ames, IA	Stillwater, OK	4
1996-97	Camp Ihduhapi, Minnesota	Madison, WI	3
1997-98	Holt County, Nebraska	Athens, GA	2
1998-99	Brookings, SD	Tucson, AZ	6
1999-2000	Manhattan, KS	Moscow, ID	7
2000-2001	Mt. Vernon, MO	University Park, PA	1
2001-2002	Decorah, IA	Red Wing, MN	5
2002-2003	Lake Shetek, MN	College Station, TX	4
2003-2004	Columbia, MO	Normal, IL	3
2004-2005	Norfolk, NE	Auburn, AL	2
2005-2006	Sturgis, SD	San Luis Obispo, CA	6
2006-2007	Manhattan, KS	Logan, UT	7
2007-2008	Griswold, IA	West Greenwich, RI	1
2008-2009	Cloquet, MN	Springfield, MO	5
2009-2010	Columbia, MO	Lubbock, TX	4
2010-2011	North Platte, NE	Bend, OR	7
2011-2012	Pierre, SD	Morgantown, WV	2

2012-2013	Maryville, MO	Platteville, WI	3
2013-2014	Springfield, MO	Delaware Valley College, PA	1
2014-2015	Ames, IA	Monticello, AR	4
2015-2016	Grand Rapids, MN	Manhattan, KS	5
2016-2017	Lincoln, NE	DeKalb, IL	3
2017-2018	Redfield, SD	Martin, TN	2
2018-2019	Manhattan, KS	San Luis Obispo, CA	6
2019-2020	Grand Island, NE	Columbus, OH* *cancelled due to COVID-19	N/A
2020-2021	University of Missouri – Virtual* *virtual due to COVID-19	Virtual* *virtual due to COVID-19	N/A
2021-2022	Crookston, MN	Columbus, OH	1
2022-2023	Okoboji, IA	Woodward, OK	4
2023-2024	Sturgis, SD	Ames, IA	5