Notes for Testing Aquasol Criteria from USDA-NRCS Database Pedons

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Aquasols include mineral subaqueous soils, peraquic soils, and those soils where water is removed so slowly that the soil is wet at shallow depths (<30 cm from the soil surface) for sufficient duration to become strongly biochemically reducing and to express this morphologically. Free water is at or near the surface long enough during the growing season that hydrophytic vegetation are predominant and most mesophytic crops cannot be grown, unless the soil is artificially drained. These soils would correspond to those that are poorly-drained or wetter as defined in the Soil Survey Manual and in general have morphologies similar to those used to identify hydric soils.

The criteria to identify Aquasols were all assembled from definitions of aquic conditions, criteria for identifying strong gleying, or criteria used to identify Aqu suborders in Keys to Soil Taxonomy (Soil Survey Staff, 2022). There is one exception. The mucky modified texture modifier, which is used only in saturated soils as defined in the Field Book for Describing and Sampling Soils (Schoeneberger et al., 2012), is not found in Soil Taxonomy.

The current criteria for classification of soils into Aqu suborders vary depending on the soil order. In general, the concept is to have saturation and reducing conditions (aquic conditions) within 50 cm of the soil surface. All orders require aquic conditions in normal years for the defined depths and allow for the use of a positive reaction to alpha,alpha-dipyridyl to identify aquic conditions. Below are the basic requirements for the 9 soil orders that have Aqu suborders. **It should be noted that the criteria for Aquasols generally require wetter conditions (aquic conditions within 30 cm) than that required for Aquic suborders.**

Current criteria in Soil Taxonomy for aquic suborders

Spodosols: aquic conditions within 50 cm of the mineral soil surface and
1. A histic epipedon; *or*
2. Within 50 cm of the mineral soil surface, aquic conditions in an albic or a spodic horizon.

Andisols: aquic conditions at a depth between 40 and 50 cm and o*ne or more* of the following:
1) histic epipedon; or
2) 2 percent or more redox concentrations; *or*
3). A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less as either redox depletions on ped faces; or if there are no peds, at least 50% of the matrix is chroma 2 or less.

Entisols: *one or more* of the following:
1. Aquic conditions and sulfidic materials within 50 cm of the mineral soil surface; *or*
2. Permanent saturation with water and a reduced matrix in all horizons below 25 cm from the mineral soil surface; *or*

3. aquic conditions at a depth between 40 and 50 cm below the mineral soil surface and,
a. A texture class finer than loamy fine sand and, in 50 percent or more of the matrix, *one or more* of the following:
(1) Neutral colors with no hue (N) and zero chroma; *or*
(2) Chroma of 1 or less and a color value, moist, of 4 or more; *or*
(3) Chroma of 2 or less and redox concentrations; *or*
b. A texture class of loamy fine sand or coarser and, in 50 percent or more of the matrix, *one or more* of the following:
(1) Neutral colors with no hue (N) and zero chroma; *or*
(2) Hue of 10YR or redder, a color value, moist, of 4 or more, and chroma of 1; *or*
(3) Hue of 10YR or redder, chroma of 2 or less, and redox concentrations; *or*
(4) Hue of 2.5Y or yellower, chroma of 3 or less, and distinct or prominent redox concentrations; *or*
(5) Hue of 2.5Y or yellower and chroma of 1; *or*
(6) Hue of 5GY, 5G, 5BG, or 5B; *or*
(7) Any color if it results from uncoated sand grains;

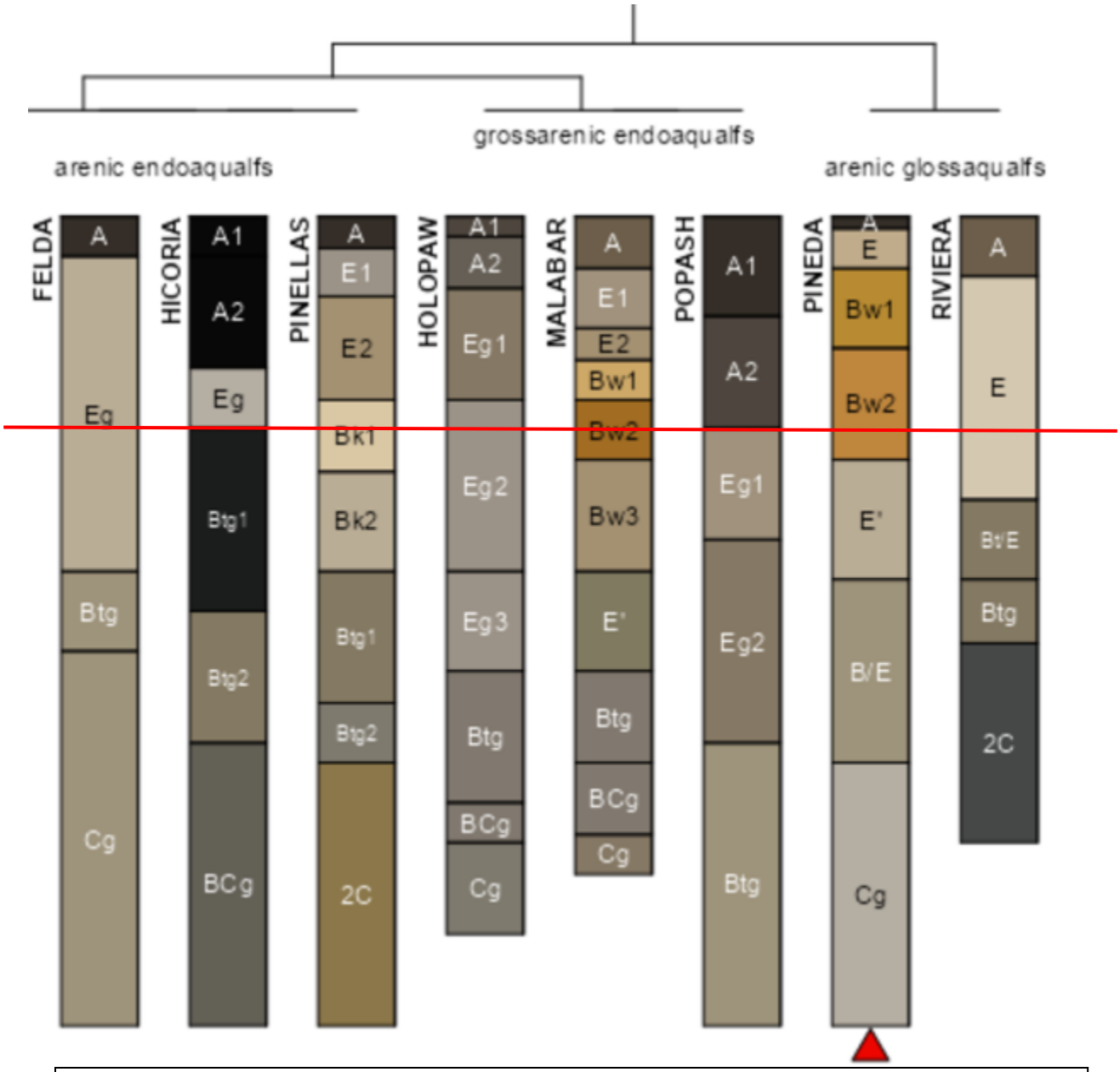
Mollisols: aquic conditions within a layer between 40 and 50 cm from the mineral soil surface, and a mollic epipedon where within 30 cm of the mineral soil surface, or bottom of the mollic if it is shallower, a chroma <=2, and one or more of the following:

1. Contains distinct or prominent redox concentrations, or

2. immediately under the mollic a horizon where >50% of the soil (on ped faces or within peds) has one of these combinations of Munsell hue, value, chroma and redox concentrations if noted

Hue	Value	Chroma	Redox Concentrations
10YR or redder*	>=4	1	Yes
2.5Y or yellower**	>=4	1	No
10YR or yellower	>=4	2	Yes
5Y or yellower	>=4	3	Yes
Neutral (N)	>=4	0	No

Ultisols and Alfisols: in one or more horizons within 50 cm of the mineral soil surface *aquic conditions; and* redoximorphic features in all layers between 25 cm and 40 cm; *and* within the upper 12.5 cm of the argillic, natric, glossic, or kandic horizon 50 percent or more chroma 2 colors or less in the matrix or faces of peds and redox concentrations. The figure below shows the variation in morphologies that can exist in these soils and the range in depth to horizons with strongly reducing colors (Eg or Btg).



Range of soil profiles of Aqualfs commonly mapped in the same vicinity. The horizontal red line is 50 cm from the soil surface. Note the range in depth to horizons that meets the criteria: "argillic, natric, glossic, or kandic horizon 50 percent or more chroma 2 colors or less in the matrix or faces of peds and redox concentrations."

Vertisols: aquic conditions in one or more horizons within 50 cm of the mineral soil surface, and *one or both* of the following:
1. In more than half of each pedon, either on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:
a. 2 or less if redox concentrations are present; *or*
b. 1 or less; *or*

Inceptisols: aquic conditions within a layer at a depth between 40 and 50 cm from the mineral soil surface and *one or more* of the following:
a. A histic epipedon; *or*
b. A sulfuric horizon within 50 cm of the mineral soil surface; *or*
c. A layer directly under the epipedon, or within 50 cm of the mineral soil surface, that has, on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:
(1) 2 or less if there are redox concentrations; *or*
(2) 1 or less; *or*

Oxisols:

1. A histic epipedon; *or*
2. An epipedon with a color value, moist, of 3 or less and, directly below it, a horizon with chroma of 2 or less; *or*
3. Distinct or prominent redox concentrations within 50 cm of the mineral soil surface, an epipedon, and, directly below it, a horizon with *one or both* of the following:
a. 50 percent or more hue of 2.5Y or yellower; *or*
b. Chroma of 3 or less.

For those testing the criteria for Aquasols, keep in mind that many of the soils in the USDA-NRCS databases were described and sampled in the 1960's, 70's, and 80's. Up until 1985, the USDA was providing incentives for farmers to drain wet soils for agriculture suggesting a lack of understanding of the importance of these systems functions and values. Consequently, in 1985 the International Committee for the Aquic Moisture Regime (ICOMAQ) began work in earnest to better understand and define the morphological effects of saturation and reducing conditions in soils and the application in Soil Taxonomy (Ditzler, 2017). Thus, not until 1992 were aquic conditions and redoximorphic features defined and applied in the Keys to Soil Taxonomy. Prior to 1992, redoximorphic features were referred to as red and gray mottles. Red mottles were what is currently understood as redox concentrations (e.g. masses, nodules, pore linings). Gray mottles are what is currently understood as redox depletions. See Fanning and Fanning (1989) for further discussion of mottling patterns in soils.

Many of the soils that occur in the massive NRCS soil database were sampled and described in the 1950's, 1960's, and 1970's. Over time, the National Cooperative Soil Survey (NCSS) used different horizon designations. For example, prior to 1982 E horizons were designated A2, BC transitional horizons were designated B3, and instead of an Arabic numeral placed before a

master horizon to indicate a discontinuity (e.g. 2C) a roman numeral was used (e.g. IIC, see Guthrie and Witty (1982). Below is a summary of the changes between 1951 and 2010 for master horizon designations (Schoeneberger et al., 2012). See Schoeneberger et al. (2012) for changes in subordinate distinctions.

HORIZON AND LAYER DESIGNATIONS CONVERSION CHARTS—(***NOTE:*** Gray boxes indicate the year the convention was first adopted.)

Master Horizons, Layers, or Combinations				
1951 [1]	**1962** [2] **1975** [3]	**1982** [4]	**1998** [5]	**2006** [6], **2010** [7]
Aoo or Ao	O	O	O	O
Aoo	O1	Oi and/or Oe	Oi and/or Oe	Oi and/or Oe
Ao	O2	Oe and/or Oa	Oe and/or Oa	Oe and/or Oa
—	—	Oi	Oi	Oi
—	—	Oe	Oe	Oe
—	—	Oa	Oa	Oa
A	A	A	A	A
A1	A1	A	A	A
A2	A2	E	E	E
A3	A3	AB or EB	AB or EB	AB or EB
AB	AB	—	—	—
A&B	A&B	A/B or E/B	A/B or E/B	A/B or E/B
AC	AC	AC	AC	AC
—	—	E and Bt	E and Bt	E and Bt
B	B	B	B	B
B1	B1	BA or BE	BA or BE	BA or BE
B&A	B&A	B/A or B/E	B/A or B/E	B/A or B/E
B2	B2	B or Bw	B or Bw	B or Bw
G	g [8]	Ag, Bg, Cg	Ag, Bg, Cg	Ag, Bg, Cg
B3	B3	BC or CB	BC or CB	BC or CB
—	—	B/C, C/B, C/A	B/C, C/B, C/A	B/C, C/B, C/A
C	C	C	C	C
Cca	Cca	*Bk*	*Bk*	*Bk, Bkk* [6]
Ccs	Ccs	*By, Cy*	*By, Cy*	*By* or *Byy*, *Cy* or *Cyy* [7]
D	—	—	—	—
Dr	R	R	R	R
—	—	—	L [3, 6]	L
—	—	—	—	M [6]
—	—	—	W	W

[1] Soil Survey Staff, 1951.

[2] Soil Survey Staff, 1962; same content used in *Soil Taxonomy* (Soil Survey Staff, 1975), except for addition of Limnic (L) horizon. [3]

[3] Soil Survey Staff, 1975. Limnic materials and limnic layer were recognized in 1975, formally dropped in 1985 (National Soil Taxonomy Handbook 615.30); master L horizon was formally adopted in 2006. [6]

[4] Guthrie and Witty, 1982.

[5] Soil Survey Staff, 1998.

[6] Soil Survey Staff, 2006.

[7] Soil Survey Staff, 2010a.

[8] Master horizon G (1951) was changed to a horizon suffix (g) that can be used with master horizon A, B, or C; e.g., *Bg*.

Although the term peraquic moisture regime appears in the current version of Soil Taxonomy, a proper definition is not apparent. The NCSS is currently debating the following definition of peraquic soils. Peraquic conditions: Soils that have continuous or permanent saturation (unless artificially drained) possess peraquic conditions. These soils are biochemically reduced when conditions are favorable (i.e. during the growing season). Soils that have peraquic conditions are saturated by ground water or have water tables that are either above, at or very close to the surface, in normal years. The level of the ground water remains nearly constant and shows minimal fluctuation with the seasons unlike most soils with aquic conditions. Peraquic soils often have long-term inundation, or periods of flooding or ponding (both temporal conditions) in normal years. Soils with peraquic conditions can be described as having a peraquic soil moisture regime. Examples of landscape with peraquic soils include tidal marshes, closed depressions, and spring-fed wetlands such as fens.

Answers to the following questions should be provided in any assessment of the criteria.

1) What year was the soil described and sampled?
2) Is the soil being reviewed the modal pedon (available online at the OSD page)?
3) If it is not the modal pedon, is it correlated (classified in current Soil Taxonomy) the same as the modal pedon?
4) Are either Eg, Bg, Btg, or Cg horizons described in the upper 30 cm or directly under an umbric or mollic epipedon?
5) Is the soil poorly or very poorly drained, and how are the drainage classes defined.
6) Is there any reference made to peraquic conditions, peraquic moisture regime, or aquic conditions or seasonal saturation in the description within 30 cm?

WHY ARE THESE QUESTIONS IMPORTANT?

Answering these 6 questions assists in understanding the context of when these soils were described. The year the soil was described and sampled is important because of the many changes in horizon nomenclature that have occurred since the release of the 7th Approximation (1960). Many of the OSDs and soils correlated to specific series were described in the 1960's and 1970's – prior to 1982 when many of the major horizon designations were changed. Andisols were not introduced into Soil Taxonomy until 1990. The morphological specifications for Aquands do not require chromas of 2 or less to be dominant on ped faces or in the matrix as in most Aquic suborders (Parfitt and Clayden, 1991). This is because "soils that developed entirely from ash rarely have the low chroma of Aquepts, no matter how wet they may be..." (Soil Survey Staff, 1975, p. 237). The relevance of the functions and values of wet soils has changed since the 7th Approximation. In the 1960's, 1970's, and early 1980's the federal government was still providing incentives for farmers and silviculturists to drain wet soils. Thus, the focus was on soil properties related to lowering the water table instead of a focus on what morphological properties are indicative of saturation and reducing conditions. Consequently, not until 1985 did the National Cooperative Soil Survey (NCSS) focus on identifying wet soil

morphological properties that eventually turned into the concepts of aquic conditions and redoximorphic features (1992).

The criteria developed for Aquasols were based on the concept of those soils where water is removed so slowly that the soil is wet at shallow depths (<30 cm from the soil surface) for sufficient duration to become strongly biochemically reducing and to express this morphologically. These soils would correspond to those that are poorly-drained or wetter as defined in the Soil Survey Manual. Our focus in developing criteria for Aquasols has been on soils recognized as poorly and very poorly drained under the series concept of Official Soil Descriptions (OSDs). These OSDs, approved as a standard for classification by the NCSS, represent the modal concept of that particular soil type. Thus, any assessment should focus on OSDs or associated correlated soils (meaning soils that meet the range and characteristics) that are poorly or very poorly drained. Particular attention should be given to horizon designations indicative of strong gleying (i.e. Eg, Bg, Btg, Cg) representing saturation and strongly biochemically reducing conditions. Aquic conditions within 30 cm of the mineral soil surface are a requirement for Aquasols (like the requirements for all current Aqu suborders except at a shallower depth). Thus, depth of seasonal or long-term saturation and presence of aquic conditions should be noted.