Aquasol Testing Summary

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For testing the criteria for identifying a soil as a Aquasol we examined soils currently classified at the suborder level as Aqualfs, Aquands, Aquents, Aquepts, Aquerts, Aquoxs Aquods, Aquolls, and Aquults. Our initial focus was on the wettest of these soils, which we took to be those designated as very poorly drained (VPD) and poorly drained (PD) soils. This was the group that we anticipated should be included within Aquasols. Using a database search, we identified all soil series in the US that met these criteria (were in aquic suborders and were VPD or PD.) These series were sorted based on the aerial extent (number of acres mapped). We selected the 10 most extensive of these VPD-PD series for testing. Each was examined based on the Aquasol morphological criteria to see whether or not the Official Series Description (OSD modal pedon) met the criteria. We documented any notes (if present) indicating the depth of saturation or aquic conditions. We also examined the range in characteristics (RIC) for each series to assess whether the morphological properties included in the RIC may vary outside the bounds of the criteria for an Aquasol. If the modal pedon of the series met the criteria, but the RIC suggested that soils may vary such that they didn't meet the criteria, we examined descriptions of actual pedons that had been described, sampled, and correlated within this same series from the NASIS/Kellogg database. Some series had many correlated pedons and some had none. We selected as many as 10 correlated pedons to assess and focused on those correlated after 1981 if possible. This effort was made to determine whether the series RIC that varied beyond the morphology of the Aquasol criteria were commonly, rarely, or never actually described. Data for the series evaluated are included in Table 1 and Fig. 1.

Table 1. Extent of PD and VPD series in aquic suborders and of those evaluated.

PD and VPD soils					
Suborder	total acres	acres in top 10	M acres	M acres	%
Aquolls	49,135,383	13,930,584	49.1	13.9	28%
Aquepts	27,994,086	7,635,119	28.0	7.6	27%
Aqualfs	24,904,095	7,646,913	24.9	7.6	31%
Aquults	15,453,635	8,265,883	15.5	8.3	53%
Aquents	15,284,894	6,488,811	15.3	6.5	42%
Aquods	10,703,132	7,025,283	10.7	7.0	66%
Aquerts	8,536,803	5,379,865	8.5	5.4	63%
Aquand	225,667	189,745	0.226	0.190	84%
Aquox	4,674	4,674	0.005	0.005	100%
Total	152,242,369	56,566,877	152.2	56.6	37%

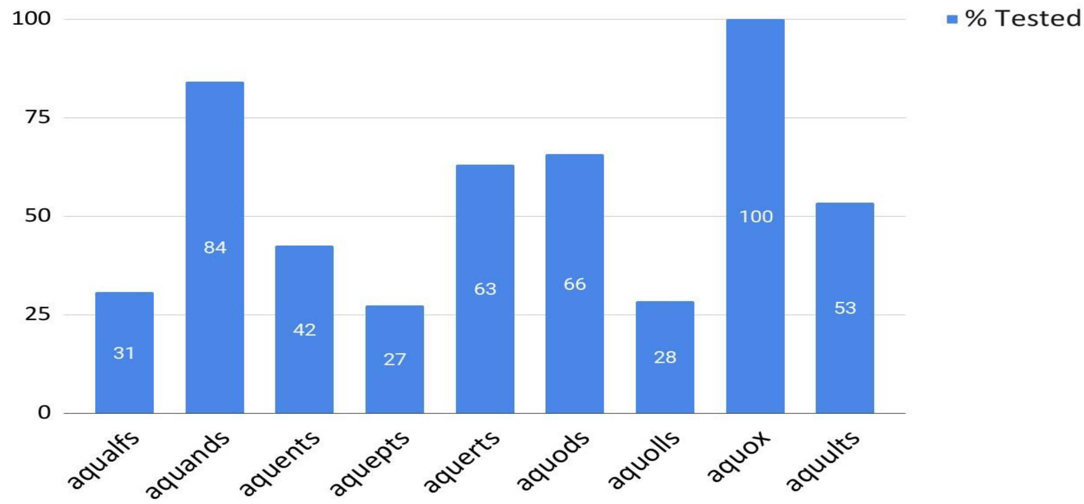

Figure 1: Percent by area the top ten poorly and very poorly series based on the area of each relative to the total area of those PD and VPD soils in the associated Aqu suborder.

In total, the series evaluated represented 152 M acres, which is 37% of the total area covered by series in aquic suborders that are PD or VPD. For a given order, this percentage ranged from 27% (for Aquepts) to 100% (for Aquox).

The testing described above was to evaluate whether the soils that we expected to meet the Aquasol criteria did, in fact, meet it. This was to ensure that the Aquasol criteria captured those soils that should be in the proposed Aquasol soil order. Those VPD and PD soils that did not meet the criteria would be considered a "Type 1" error. We were also concerned whether the Aquasol criteria might also "capture" soils that we would not expect to be (should not be) an Aquasol (which might be considered a "Type 2" error). In order to evaluate this, we also examined those soils in aquic suborders that were drier than PD (mostly SWPD). We would not expect these soils to be Aquasols and so our hope and expectation was that the Aquasol criteria would exclude these soils.

Using a database search, we identified all soil series in the US that met these criteria (were in aquic suborders and were not PD or VPD). These series were sorted based on the aerial extent (number of acres mapped). We selected the 10 most extensive of these SWPD series for testing. Each OSD was examined based on the Aquasol morphological criteria to see whether or not the modal pedon of the OSD met the criteria and, if present, we documented any notes indicating the depth of saturation or aquic conditions. We also examined the range in characteristics (RIC) for each series to assess whether the morphological properties included in the RIC may vary outside the bounds of the criteria for an Aquasol. If the modal pedon of the series met the criteria, but the RIC suggested that soils may vary such that they didn't fit the criteria, we examined descriptions of actual pedons that had been, described sampled and correlated within this same series from the NASIS/Kellogg database. We selected as many as 10 correlated pedons to assess and focused on those correlated after 1981 if possible. This effort was made to determine whether issues identified in the series RIC were commonly, rarely or never actually described. Data for the series evaluated are included in Table 2 and Fig. 2.

In total, the series evaluated represented 28.6 million acres, which is 54% of the total area covered by series in aquic suborders that are SWPD. For a given order, this percentage ranged from 43% for Aqualfs to 94% for Aquerts.

Table 2. Extent of SWPD series in aquic suborders and of those evaluated.

SWPD Soils						
Suborder		**total acres**	**acres in top 10**	**M acres**	**M acres**	**%**
Aqualfs		22,806,879	9,655,635	22.8	9.65	42%
Aquands		188,361	175,746	0.19	0.18	93%
Aquents		3,801,553	3,180,412	3.80	3.18	84%
Aquepts		12,450,633	6,826,191	12.45	6.83	55%
Aquerts		749,011	706,855	0.75	0.71	94%
Aquods		3,333,238	2,013,765	3.33	2.01	60%
Aquolls		9,739,510	6,081,383	9.74	6.08	62%
Aquults		2,924,171	2,568,046	2.92	2.57	88%
Total		53,069,185	28,639,987	53.1	28.6	54%

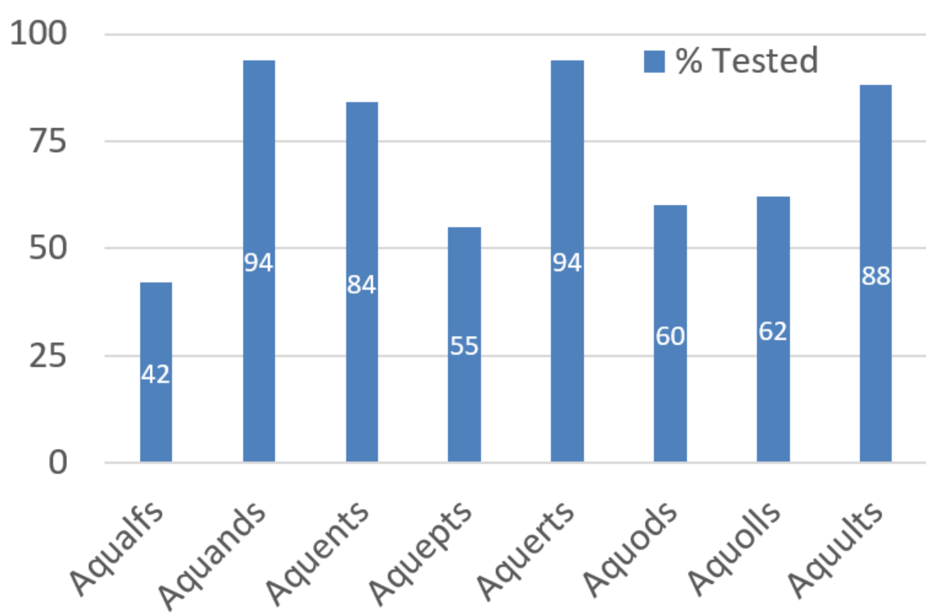

Figure 2: Percent by area the top ten somewhat poorly drained series based on the area of each relative to the total area of those SWPD soils in the associated Aqu suborder.

Discussion:

Below we have discussed the observations obtained during the testing. These are done on an order by order basis.

Aquox: All three of the Aquox PD-VPD series met the Aquasol criteria. One each making criteria 2b, 2f, and criteria 1. There were no SWPD series to test.

Aqualfs: Eight of the 10 PD and VPD Aqualf series met the Aquasol criteria. All met criteria 2b. The two series that did not meet the criteria were Pineda and Riviera. Both OSDs indicated a water table within 25 cm of the soil surface for 1 to 6 months of the year (suggesting aquic conditions within 30 cm of the soil surface) but the morphologies were not indicative of a wet soil, especially for Pineda where gleyed colors (chroma 2 or less with RMFs) do not start until 60 cm below the soil surface. Our assessment: We are content that these soils did not meet the Aquasol criteria because they do not have the morphology of Aquasols.

Three of the 10 SWPD Aqualf series met the Aquasol criteria. One soil, Dundee, met the morphology criteria but did not meet the aquic conditions criteria as the water table was listed as >45 cm from the soil surface. The three SWPD soils that did meet the criteria were all described as having aquic conditions within 23 cm of the soil surface. Our assessment: Considering the depth noted of aquic conditions and the soil morphology, these soils are likely wetter than SWPD and should be classified as Aquasols.

Aquands: Nine of the 10 PD and VPD Aquands met the Aquasol criteria. The soil that did not, Capjac, met the morphology criteria but did not meet the aquic conditions criteria as the water table was listed as >45 cm from the soil surface.

Assessment of the SWPD Aquands was difficult. Of the 10 OSDs that were reviewed, 3 met the Aquasol criteria but the range in characteristics (RIC) for the series did not. For example, for the Pegati soil the depth of the water table was listed as 0 to 25 cm, but under the RIC 25 to 50 cm. Similar discrepancies occurred in the other two soils. All three of these soils met criteria 2d1 which only requires 2 percent concentrations. Our assessment: As noted by Parfitt and Clayden (1991), morphological assessment of wet Andisols is fundamentally problematic. Parfitt and Clayden (1991) suggested that one reason Aquands are not that extensive (Leamy et al., 1990) is because in saturated conditions halloysite is more likely to form instead of allophane. Thus, there appears to be issues regardless of whether we are discussing aquic suborders or Aquasols with andic soil properties.

Aquents: Nine of the 10 PD and VPD Aquent series met the Aquasol criteria. These soils met criteria 2b and 2c. The soil that did not meet the criteria (Roscommon) met the aquic conditions requirement (“This soil is ponded or has saturation within 1 foot of the surface, at some time during the months of September through June”) but did not have gray colors below 35 cm.

Of the SWPD Aquent soil series, only one met the Aquasol criteria. This was the Mattex series which showed strong gleying from 22 cm and was described as having aquic conditions from 22 cm. Our assessment: We are content that the Roscommon soil does not meet Aquasol criteria, and we think that the Mattex soil actually PD and is likely an Aquasol.

Aquepts: All 10 of the PD and VPD Aquept series met the Aquasol criteria. Of the SWPD series, none of these met the Aquasol criteria. Our assessment: No issues.

Aquerts: All 10 of the PD and VPD Aquert OSDs met the Aquasol criteria. None of the SWPD Aquerts meet the Aquasol criteria. Our assessment: We expected issues with the Aquerts because of the heavy clay textures and related documented issues with understanding morphological evidence of saturation and strongly reducing conditions in these soils.

Aquods: Of the 10 PD and VPD Aquod OSDs, 7 met the Aquasol criteria. Most of the difficulty related to meeting the requirements stemmed from the range in hydrology of the soils. For the same series, some soils were ponded for 6 months while others had a SHWT that reached 45 cm from the soil surface. Thus, some of the OSD soil descriptions did not meet the morphology criteria and some of the correlated soils did. For example, the Leon OSD did not meet the morphology criteria (just missed by 1 cm) but 4 of the 5 correlated pedons that we reviewed did.

Of the SWPD Aquod series, two of the soils series may meet the Aquasol criteria, both soils have albic horizons with concentrations but are described as E and not Eg horizons suggesting the soil is not considered strongly reducing in the upper 30 cm. Our assessment: The difficulty in identifying aquic conditions through soil morphology in Aquods is well documented (see Pilgrim and Harter, 1977; Nichols et al., 1990; Zampella, 1994; Kuehl et al.,1997; Stolt et al., 2016). This is why the criteria currently used to identify Aquods is so simple: either 1) a histic epipedon or 2) aquic conditions within and albic or spodic horizon with 50 cm of the soil surface.

Aquolls: All 10 of the Aquoll OSDs met the Aquasol criteria. Of the SWPD Aquolls, 2 of the series may be considered Aquasols. For example, in the Woodson series notes indicate aquic conditions within 20 cm of the soil surface, but horizons are designated as Bt and not Btg suggesting these soils may not have strongly reducing conditions in the upper 30 cm. Our assessment: We expect soils that classify as Aquolls to have morphological evidence of strongly reducing conditions (i.e. Eg, Bg, or Btg horizons) and aquic conditions within 30 cm of the mineral soil surface.

Aquults: All 10 of the PD and SWPD Aquult series met the Aquasol criteria. In addition, none of the SWPD Aquults met the criteria. Our assessment: No issues.

In summary, of the 83 PD and VPD OSDs we examined (representing 37% of the area of likely Aquasols), over 90% (76/83) were appropriately captured by the Aquasol criteria. Those that did not meet the criteria showed morphologies that were not indicative of a soils with sustained saturation and reducing conditions within the upper 30 cm, or were problematic soils relative to identifying saturation and reducing conditions (Aquods or Aquands). When we examined the 80 OSDs that we thought would be marginally wet (SWPD soils in aquic suborders and not Aquasols), we found that only 5% were captured by the Aquasol criteria (Type 2 error). Several of these soils, based on their morphologies and noted very shallow persistent water tables within 30 cm of the soil surface were likely wet enough to be considered Aquasols and should be classified as such. Our overall conclusion is that these criteria are effective at identifying soils that are wet at shallow depths (<30 cm from the mineral soil surface) for sufficient duration to become strongly biochemically reducing and to express this morphologically and excluding those that are not.

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