ArkDSS Memorandum
Development of Soil Available Water Capacity (AWC) Data
Subtask 1.1.D

TO: File
FROM: Kelley Thompson, P.E.; Division of Water Resources Modeling and DSS Team
SUBJECT: ArkDSS – Development of Soil Available Water Capacity (AWC) data; subtask 1.1.D
DATE: 10/7/2020

INTRODUCTION

This memo describes development of the Soil Available Water Capacity (AWC) dataset for the Arkansas Basin (CDWR Division 2) as part of the Arkansas River Decision Support System (ArkDSS) project. AWC describes the amount of water that can be stored in the soil and is available to be used for crop consumptive use. The ArkDSS models require an estimate of the average AWC for the area irrigated by each diversion structure included in the model.

Two general soil mapping products are available for use in estimating AWC; STATSGO (STATSGO2) which provides generalized soil mapping based on the U.S General Soil Map and SSURGO (SSURGO 2.2) which provides detailed farm-scale soil mapping with layering by depth based on soil surveys. STATSGO has been used in all previous DSS projects and involves smaller files, but is considered by the USDA as a legacy dataset. SSURGO is now recommended by the USDA and is updated yearly, has much higher detail, and may produce better estimates on a field or ditch level.

Subtask 1.1.D as scoped to HRS was for HRS to compare use of STATSGO and SSURGO soil mapping within the DSS framework and evaluate if SSURGO may improve AWC estimates. The memorandum produced by HRS describing this evaluation is attached as Appendix A. HRS evaluated use of the datasets both within an area of small ditches (WD18) and for a large canal (Catlin Canal). The evaluations produced similar AWC values but with the SSURGO data providing slightly higher values. One explanation for the slightly higher AWC values was that irrigated parcel boundaries often extended beyond the edge of the general stream alluvium defined for the lower "resolution" STATSGO areas into tighter materials while the parcels more often remained within the alluvium materials in the higher resolution SSURGO data. Within the Catlin Canal, the higher AWC found with SSURGO data (0.1695 vs. 0.1663) was slightly closer to the H-I Model Catlin Canal AWC of 0.17. HRS found that processing steps for SSURGO data were not significantly more complex or time-consuming than for the STATSGO data. Therefore, HRS recommended that the SSURGO dataset be used for ARKDSS and other analyses.

Using these recommendations, state staff developed a simplified geodatabase to extract SSURGO AWC values and developed AWC values for structures using the ditch service areas (ArkDSS - task 1.1.B). Subsequently, Wilson Water Group has updated these AWC values to include additional ditches that have been added as part of the model development process.

METHODS

A geodatabase was developed to simplify extraction of AWC values for Colorado and for Division 2. In January 2019, a copy of the SSURGO (gSSURGO_CO.gbd) geodatabase for Colorado was downloaded from https://datagateway.nrcs.usda.gov/. As SSURGO data is refined over time, this base data may need to be updated periodically, but is not expected to change significantly during the ArkDSS project.

From the gSSURGO_CO.gbd geodatabase, the "muaggatt" table was joined to the MUPOLYGON feature class and the data fields of 'mapunit name', 'available water storage weighted average (various)', and 'hydrologic group - dominant conditions' were added to the polygon datafile. The "muaggatt" table (available water storage value) represents a depth in cm, therefore these values were divided by their respective crop rooting depths to result in AWC as a percentage. The Colorado geodatabase was cut by water division, and the Division 2 soil AWC coverage is available for download on the CDSS website (https://www.colorado.gov/pacific/cdss/division-2-arkansas).

Fields are available for 0-25cm, 0-50cm, 0-100cm, and 0-150cm depths from the surface and were included in the coverage file. The table below includes typical crop rooting depths for common crops. Field based evaluations could choose to use data for different depth ranges based on crop type. However, for ArkDSS, Wilson Water Group (WWG) and state staff jointly decided to use data for the 0-100cm (39.37 inches) range for all structures as this represents a typical average of crop rooting depths for ditches with diverse crop distributions and for ditches that irrigate primarily grass pasture.

Table 1. Typical Crop Rooting Depths

Crop	Feet	Inches	Centimeters
Alfalfa	4.9	59	149
Corn Grain	3.3	40	101
Grass Pasture	3.3	40	101
Sorghum Grain	4.9	59	149
Spring Grain	3.5	42	107
Vegetables	1.6	19	49
Wheat Fall	5.4	65	165

To determine AWC values by structure, the Division 2 AWC coverage was intersected in GIS with the Division 2 ditch service area coverage. The AWC coverage lists areas that are primarily water covered or have no data with an AWC of zero, and from that file intersected areas with an AWC of zero were deleted. In the resulting file, intersected areas were multiplied by AWC/100, those areas were dissolved by the WDID while summing the multiplied (area*AWC) field, and then the dissolved areas were divided by area. For ditches without AWC data, the most appropriate nearest structure was used to assign an AWC value. For the ditch service area layer used by the state, 24 ditches did not have AWC data (WD-19(2), WD-15(2), WD-12(1), WD-11(19)).

Wilson Water Group has subsequently recalculated AWC and updated AWC values to include additional ditches that have been added as part of the model development process.

APPENDIX A – HRS COMPARISON OF STATSGO and SSURGO DATABASES

ArkDSS SPATIAL SYSTEMS INTEGRATION COMPONENT
TASK 1.1.D MEMORANDUM

To: Kelley Thompson, Brian Macpherson, Bill Tyner
From: Fern Beetle-Moorcroft, Matthew Seitz, HRS Water Consultants, Inc.
Subject: Task 1.1.D Comparison of STATSGO and SSURGO Soil Water Availability
Date: June 11, 2018

1.0 INTRODUCTION

This memorandum describes the process used to compare STATSGO and SSURGO, two soil databases, both compiled by the United States Department of Agriculture (USDA). STATSGO and SSURGO both include Available Water Capacity (AWC) data, which will be used in the ArkDSS consumptive use model. AWC is the amount of water that the soil is able to store for use by plants[1].

AWC, along with crop rooting depth and crop acreage, provide the inputs needed to calculate the volume of water diverted from a given diversion structure that can be stored in the soil types served by that structure and that are available for crop consumptive use. The goal of ArkDSS Task 1.1.D is to compare the two soil data sets and to provide a recommendation on which dataset to use for calculating AWC for the entire ArkDSS study area once the irrigated parcel datasets ("historic snapshots") are completed under Task 1.3. This memorandum also documents the approach used to assign AWC to two pilot study areas.

STATSGO has been used in all previous DSS projects, but is an older and more generalized legacy dataset. SSURGO is updated yearly and posted to the USDA Web Soil Survey, and is the product recommended by the USDA. As the majority of the data processing steps were completed in ArcMap™ 10.4.1 GIS software, ArcMap program commands are written in italics within this memorandum to facilitate future data processing. Table names within STATSGO or SSURGO appear in all caps and attribute field names appear in bold font.

2.0 SOIL DATA STRUCTURE AND GIS PROCESSING STEPS

Per USDA documentation, STATSGO and SSURGO are both "SSURGO type" databases and thus contain a shapefile with an attribute field named "**MUKEY**". The **MUKEY** field contains a unique identifier for each polygon. Numerous tables can be joined or related to the soil polygon coverage using the **MUKEY** common to each attribute table.

The GIS processing steps to determine the AWC are:

[1] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at the following link: https://websoilsurvey.sc.egov.usda.gov/. Accessed [05/30/2018].

1. The *Join Field* tool was used to *Join* depth-weighted averages for Available Water Storage (AWS), as well as, the **Muname**, and **MuSym** fields in the MUAGGAT table to the soil polygon shapefile.
2. The AWS of a soil is equal to the AWC multiplied by the soil thickness. As depth-weighted averages for soil thickness were used, in this case the words depth and thickness are interchangeable. Thus, using the *Field Calculator*, each AWS was divided by its corresponding depth zone to determine the AWC for each depth range.

2.1 STATSGO and SSURGO Division 2 Coverages

A version of the USDA STATSGO coverage[2] modified by the Colorado Division of Water Resources (CDWR) was provided by Mr. Kelley Thompson. This coverage was already clipped to the Division 2 boundary and had an associated AWC in the coverage's attribute table. HRS downloaded the SSURGO[3] coverage from the USDA web soil survey website as well as the gSSURGO[4] data set. HRS clipped the gSSURGO file to the Division 2 boundary and then joined the shapefile's attribute table to the MUAGGAT table using the steps described above to create a new file (filename: "SSURGO_div 2"). The difference in detail between the two coverages is shown below for Water District 18 (Figure 1).

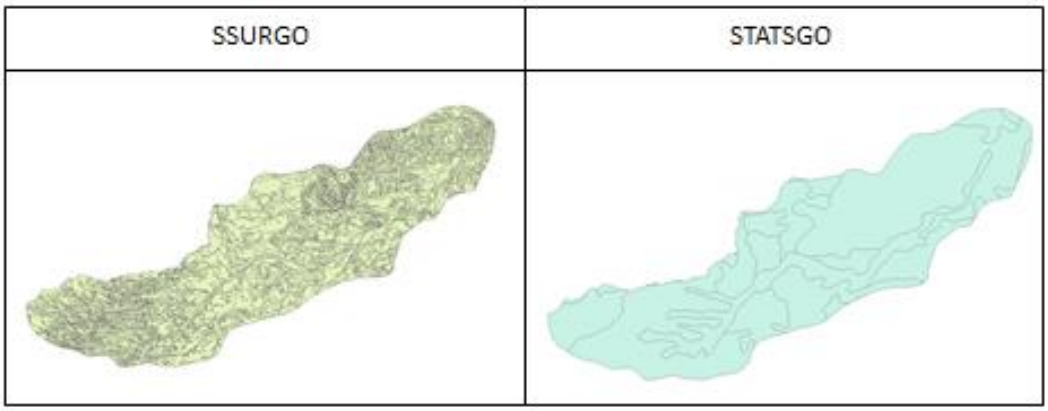

Figure 1: STATSGO and SSURGO coverages in Water District 18.

As shown in Figure 1, SSURGO contains significantly more spatial detail than STATSGO.

2.2 Comparison Case Studies in Division 2: STATSGO vs. SSURGO

In the consumptive use model for ArkDSS, each ditch service area will be assigned a composite AWC value based on the crops grown, soil properties, and irrigated acreage. To examine the extent to which the composite AWC values derived from STATSGO and SSURGO differ, HRS completed two case studies. The first focused on Water District 18 (WD18), an area with minimal irrigation and only two crop types:

[2] filename: STATSGO_div2
[3] Web Soil Survey. (2017). gSSURGO. Retrieved from https://datagateway.nrcs.usda.gov/.
[4] gSSURGO contains both a raster and a vector version, whereas, SSURGO contains only the vector version. gSSURGO was used as the vector version covers all of division 2 and is referred to as SSURGO from here on. SSURGO.

grass pasture and alfalfa. The second looked at the Catlin Canal, a single diversion structure (WDID: 1700552) irrigating approximately 16,140 acres.

2.2.1 Water District 18

Water District 18 was isolated from the Water Districts shapefile using a *definition query*. A shapefile of 2015 Irrigated Acreage was *clipped* to the boundary of WD 18. Both the STATSGO and SSURGO datasets were *clipped* to the boundary of WD18. *Unions* were run to combine STATSGO and 2015 Irrigated Acreage (IA), as well as, SSURGO and 2015 Irrigated Acreage (see Figure 2).

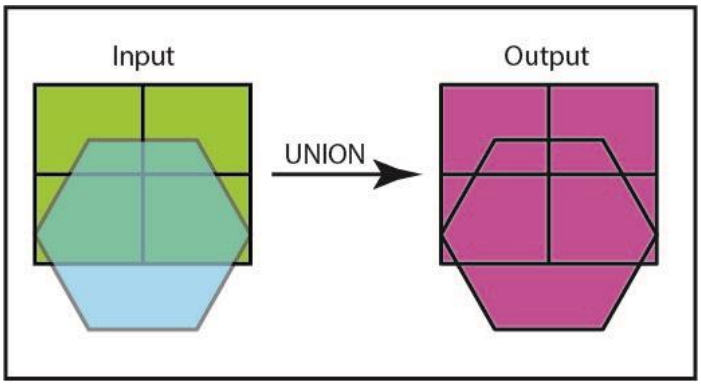

Figure 2: graphically depicts the union tool from the Arc toolbox. This tool takes two inputs and combines the boundaries of both input datasets into an output dataset. This figure was adapted from ArcMap 10.4.1 help[5].

HRS then used a *definition query* to extract only irrigated areas in the STATSGO and SSURGO union datasets. Using *definition queries*, separate SSURGO shapefiles were created for grass pasture and alfalfa. A crop rooting depth of 3.3 ft (~ 100 cm) was used for grass pasture and a rooting depth of 4.9 ft (~150 cm) was used for alfalfa[6]:

Crop Type	Rooting Depth (ft)	SSURGO Depth Zone (cm)
Alfalfa	4.9	0-150
Corn Grain	3.3	0-100
Grass Pasture	3.3	0-100
Sorghum Grain	4.9	0-150
Spring Grain	3.5	0-100
Vegetables	1.6	0-50
Wheat Fall (Winter)	5.4	0-150

In the SSURGO grass pasture file, the value **AWS0100wta** was divided by 100 using the *field calculator* to calculate the AWC for the depth range of 0-100 cm. The same process was used for the SSURGO alfalfa file, except the interval **AWS0150wta** was divided by 150 to determine the AWC for the depth range 0-

[5] ESRI. (2016). ArcGIS Desktop: 10.4.1. Redlands, CA: Environmental Systems Research Institute.
[6] Unites States Department of Agriculture. (1970). Irrigation Water Requirements Technical Release No 17.

150 cm. The SSURGO grass pasture and alfalfa files were combined using the *merge tool*. Then, the merged file was *dissolved* on the **SWDID1** field to determine the total irrigated acreage associated with each ditch service area. The irrigated acreage associated with each SWDID was then *joined* to the SSURGO merged file. The AWC for each parcel was multiplied by the area of the parcel. This result was next divided by the corresponding **SWDID1** area. This file was again *dissolved* on the **SWDID1** field and set to sum the previous result to determine the area-weighted AWC value for each ditch service area. The following table shows the AWC values for each dataset:

Dataset	**Min AWC**	**Max AWC**	**Mean AWC**	**Irrigated Acreage (IA)**
STATSGO	.1493	.1851	.1572	3530
SSURGO	.1564	.1796	.1583	3530

Dataset	STATSGO		SSURGO	
Crop Type	Alfalfa	Grass Pasture	Alfalfa	Grass Pasture
Irrigated Area (‘IA’; acres)	624	2906	624	2906
Crop Rooting Depth (ft)	4.9	3.3	4.9	3.3
IA x Crop Rooting Depth = C (acre-feet)	3057	9590	3057	9590
C Alfalfa+ C Grass Pasture = D	12,647		12,647	
D x Mean AWC = AWS in acre-feet	1988		2002	

These AWC values for STATSGO and SSURGO were multiplied by the irrigated acreage and rooting depth for each crop type to determine the area-weighted AWS for each dataset for WD 18. SSURGO yielded 14 additional acre-feet of water in WD 18. The WD18 results between STATSGO and SSURGO are within 0.7 percent of each other. This indicates that the difference between the two soil datasets in the area of WD 18 is minimal.

2.2.2 The Catlin Canal

The Catlin Canal was isolated from the other ditch service areas in the 2015 Irrigated Acreage shapefile using a *definition query*. Areas with null values or “no crop” for crop type were removed from the dataset also using a *definition query*. The dataset was then color coded to show the corresponding crop type for each area (Figure 3).

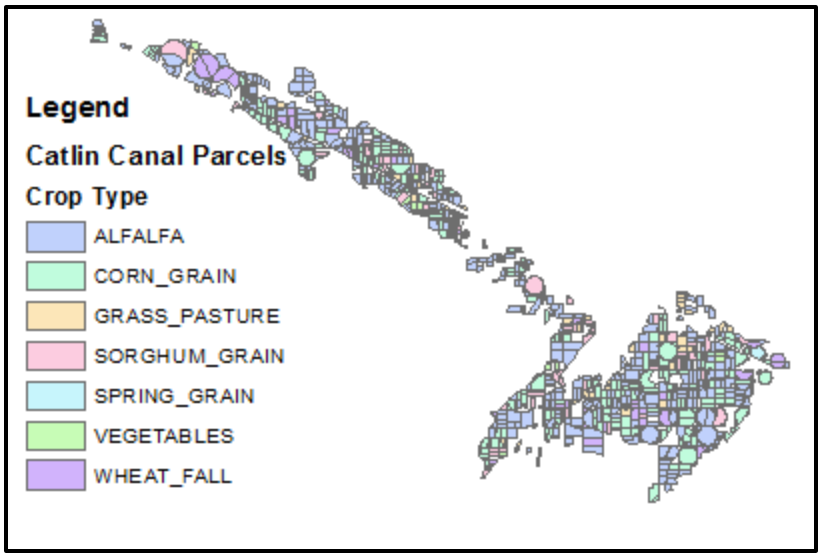

Figure 3: Catlin Canal ditch service area and the crop type associated with each parcel

A *union* was run between the Catlin Canal Parcels and STATSGO and SSURGO respectively. Areas not containing irrigated acreage were removed from the dataset using a *definition query*. All of the parcels in the STATSGO dataset contained the same AWC value. The SSURGO dataset was formatted using *definition queries* such that the AWC for each crop type corresponded to the correct crop rooting depth. A mean area-weighted AWC was also calculated for SSURGO. These AWC values are shown in the table below:

Dataset	**Mean AWC**	**Irrigated Acreage (IA)**
STATSGO	.1663	16,139
SSURGO	.1695	16,139

The STATSGO file was then *dissolved* on the crop type field and set to sum the acreage associated with each crop type. These areas, in acres, were then multiplied by the respective crop rooting depth to determine the soil area relevant for the consumptive use analysis for each crop type. These soil areas were then summed to determine the relevant soil area for understanding consumptive use in the Catlin Canal. These values are shown in the tables below:

Crop Type	Alfalfa	Corn Grain	Grass Pasture	Sorghum Grain	Spring Grain	Vegetables	Winter Wheat
IA	7655	4634	846	1451	69	201	1282
Crop Rooting Depth (ft)	4.9	3.3	3.3	4.9	3.5	1.6	5.4
IA x Crop Rooting Depth = C (acre-feet)	37509	15293	2792	7111	242	322	6922
Total Area (acre-feet)	70,191						

Dataset	Mean AWC	Total Area (Acre-Feet)	Available Water Storage (Acre-feet)
STATSGO	.1663	70,191	11,673
SSURGO	.1695	70,191	11,897

SSURGO yields 224 more acre-feet of water stored in the soils associated with the Catlin Canal service area. The Caitlin Canal results between STATSGO and SSURGO are within 1.9 percent of each other.

3.0 CONCLUSIONS

In both case studies the SSURGO dataset yielded a slightly larger available water storage than the STATSGO dataset. WD 18, an area with minimal irrigation, showed an AWS difference of 14 acre-feet of water (1988 acre-feet using STATSGO versus 2002 acre-feet using SSURGO). The Catlin Canal, a heavily irrigated area, had a difference of 224 acre-feet of water (11,673 acre-feet using STATSGO versus 11,897 acre-feet using SSURGO). These two case studies suggest that SSURGO will yield slightly higher amounts of available water storage. While the difference in AWS using these two soil data sets was minor for the two pilot study areas, it is possible that other areas in Division 2 will have larger differences. Once the Task 1.3 irrigated acreage snapshots are completed, the GIS-based approach described herein could be readily used to determine the AWS for all irrigation structures within Water Division 2. Prior to completing the Division-wide AWS calculation, the ArkDSS project team will need to define the key diversion structures and aggregated groups of diversion structures that AWS will be calculated for. This will include the determination of a protocol for parcels that contain multiple SWDID's, multiple GWDID's, and a combination of SWDI's and GWDID's.

As the STATSGO data set is a legacy USDA product and the GIS processing steps to derive AWC using the more detailed SSURGO data set are not significantly more complex or time-consuming than processing the STATSGO data, HRS recommends that the SSURGO dataset be used for ARKDSS and all future analyses.

4.0 REFERENCES

ESRI. (2016). ArcGIS Desktop: 10.4.1. Redlands, CA: Environmental Systems Research Institute.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at the following link: https://websoilsurvey.sc.egov.usda.gov/. Accessed [05/30/2018].

Unites States Department of Agriculture. (1970). Irrigation Water Requirements Technical Release No 17.

Web Soil Survey. (2017). gSSURGO. Retrieved from https://datagateway.nrcs.usda.gov/.