RGDSS Memorandum
Phase 6 –Additional Crops
Final

TO: File
FROM: Kelley Thompson, P.E.; Division of Water Resources Modeling and DSS Team
SUBJECT: RGDSS Groundwater Model – Phase 6: Additional Crops
DATE: 5/18/2016

1. Introduction

In the phase 6 development of the Rio Grande Decision Support System (RGDSS) irrigated parcel datasets, several additional crops were identified with distinctly different water use than the primary crop types used in the RGDSS. Although the areas of these crops were small in comparison to the primary crop types, consideration of the areas of these crop types within the RGDSS StateCU model (used as a preprocessor for the RGDSS groundwater flow model) improves the accuracy of crop water requirement estimates. These additional crop types were referred to as new alfalfa, cover crops, fall winter wheat, and bluegrass.

This memorandum describes the phase 6 enhancement of the irrigated parcel datasets and the RGDSS StateCU model to include these additional crop types. These enhancements were completed as part of the Phase 6 efforts of the RGDSS Technical Advisory Committee (Peer Review Team (PRT)) to review and update the RGDSS groundwater model. The objectives of this memorandum were to:

1. *Describe the additional identified crops.*
2. *Describe the development of crop parameters and coefficients for these additional crops.*
3. *Describe the identified areas and estimated crop water requirements for these additional crops.*

2. Previous Efforts

Agro Engineering identified primary crops in the original RGDSS irrigated parcel dataset for year 1998 (Agro Engineering, K. Thompson et. al. 2000). In this original dataset and prior to RGDSS phase 6, five primary crops were identified in the irrigated parcel datasets for estimation of crop water requirements within the StateCU model. These primary crops were referred to as alfalfa, grass pasture, small grains, potatoes, and vegetables.

Leonard Rice Consulting Water Engineers (LRE) in coordination with Agro Engineering developed the methodologies to estimate crop water requirements for these primary crops as described in the June 2004 RGDSS Phase 5 report *Historic Crop Consumptive Use Analysis, Rio Grande Decision Support System* (LRE, E.M. Wilson 2004). Calibrated crop coefficients were developed for the first four of these primary crops as described in Appendix A of the 2004 RGDSS report (LRE, E.M. Wilson 1999). TR21 crop coefficients were used for vegetables due to the smaller area of vegetables grown in the San Luis Valley.

3. Approach

The following sections describe the additional crop types used in RGDSS phase 6 and the development of crop parameters and coefficients for these additional crop types.

3.1. New Alfalfa

A crop type of "new alfalfa" was used in RGDSS phase 6 for parcels that were identified as an alfalfa crop but did not have a water requirement in the spring and didn't emerge until summer. In the San Luis Valley, water users indicated that many new alfalfa crops are often planted near the first of June and establish a full cover in July. These conditions were identified in the satellite imagery as alfalfa fields with low NDVI values (below the "irrigated threshold" value) throughout the spring and early summer but with high NDVI (indicating verdant green fields) beginning in July or later.

The new alfalfa designation for the RGDSS indicates a particular water use scenario in that there is no water requirement throughout the spring. The designation would not be appropriate if new alfalfa was planted with a nurse crop in early spring that had significant crop water requirements in the spring.

The new alfalfa crop type was modeled in StateCU using the calibrated coefficients (as described earlier) developed for alfalfa but with a planting date of June 15 and reduced season length indicated in the crop parameter file. With these parameters, the new alfalfa is modeled with no water requirements in spring, about half of the water requirements of established alfalfa in the month of June, and the same water requirement as established alfalfa in July and later months.

3.2. Cover Crops

The cover crop type can indicate a number of actual crops such as sudan grass, radishes, and mustards that are currently being used in the Rio Grande Basin under intentional deficit irrigation. The crops that have been identified are typically irrigated with a sprinkler and are often beneficial as a soil amendment and used in rotation with a higher value crop such as potatoes. In coming years, these crops may be used more often in conservation reserve type programs where water application is restricted. Unlike other crop types, this crop type indicates a crop that is not provided a full water supply even if that supply could be made available and estimated water use is meant to reflect actual consumptive use rather than potential consumptive use.

The cover crop designation indicates that water use is significantly limited. The designation would not be appropriate for a crop of sudan grass that was provided a full irrigation water supply and produced a significant hay crop. Under that scenario, the crop would be better represented with a grass pasture designation.

Development of the "cover crop" crop type is described in more detail in an attached memorandum (LRE, E.M. Wilson 2011). See the attached memorandum for details on development of the crop coefficients and crop parameters for the cover crop type.

3.3. Fall Winter Wheat

A crop type of "fall winter wheat" was used to identify parcels that were fallow all spring and summer, but a crop was planted very late in the season and emerged as a verdant green in September, October, or even November. These conditions were identified in the satellite imagery as fields with low NDVI values throughout the growing season but with high NDVI (indicating verdant green fields) just in the fall which also defined the field as irrigated for the entire year. Field information available for several of these fields identified them as winter wheat that was planted into previously fallow fields although some other types

of grains may have also been planted. Parcels with these conditions were designated in the irrigated parcel datasets as wheat_fall.

A designation of a fall winter wheat for the RGDSS indicates a particular condition and water use scenario in that the field should be fallow all spring and summer and green only in the fall. The designation would not be appropriate if another crop was grown during the summer season and winter wheat planted after harvest of that crop or for the spring season of a winter wheat crop. In both of these cases, there would be higher irrigation water requirements.

The crop water requirements for fall winter wheat crop was modeled using the TR21 crop coefficients developed for the Modified Blaney Criddle method (USDA-SCS 1967 (1970)) and crop parameters for wheat_fall available in StateCU. This crop type does not indicate a water demand for much of the spring and early summer but indicates a crop water requirement in the fall. To appropriately model a full winter wheat crop using the TR21 coefficients, the crop types of both wheat_fall and wheat_spring should be used and the water requirements of both "crops" summed. However, in the phase 6 RGDSS, the spring season of a winter wheat crop may be most appropriately modeled with the small grains crop type with calibrated coefficients.

3.4. Bluegrass

A bluegrass crop type was identified in the irrigated parcel datasets for years 2009 and 2010. The crop type was primarily identified in municipal parks and golf courses that are not irrigated with municipal water systems. The total identified area of bluegrass was quite small.

The bluegrass crop type was modeled in the phase 6 StateCU model using the StateCU coefficients and parameters associated with what is often referred to as the "Pochop Method" (Pochop et. al. 1984).

4. Results

Average monthly crop water requirements for phase 6 RGDSS crops including the additional new crops are presented in Table 1. The irrigated parcel datasets are discussed in more detail in the phase 6 RGDSS GIS memorandum (RGDSS 2015). Total crop acreages in the phase 6 RGDSS irrigated parcel datasets from that memorandum are presented in Table 2.

Table 1. Average Crop Water Requirements (PET in inches) for Phase 6 RGDSS Crops

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Alfalfa	0	0	0.0008	0.93	5.78	7.82	7.03	6.70	4.00	1.52	0	0	33.79
Grass Pasture	0	0	0.0029	1.35	3.53	6.66	6.73	5.61	4.42	2.35	0	0	30.65
Potatoes	0	0	0	0	1.12	3.73	7.17	5.28	0.16	0	0	0	17.47
Small Grains	0	0	0	0.22	2.45	6.60	7.27	3.92	0.13	0	0	0	20.58
Vegetables	0	0	0	0	0.16	1.69	3.58	3.60	2.13	0.42	0	0	11.56
New Alfalfa	0	0	0	0	0	3.85	7.03	6.70	4.00	1.52	0	0	23.11
Cover Crop	0	0	0	0.006	0.66	2.00	3.08	2.65	0.33	0	0	0	8.72
Wheat Fall	0	0	0	0	0	0	0	0	1.88	1.03	0	0	2.91
Bluegrass	0	0	0	0.03	3.05	5.84	6.24	5.21	3.39	0.33	0	0	24.08

Note: 1950-2010 Average PET in inches for NOAA station USC00051458 Center 4 SSW

Table 2. Crop Type Acreages in Phase 6 RGDSS Irrigated Parcel Datasets

Crop Type	1936	1998	2002	2005	2009	2010
Potatoes	46,045	77,524	73,005	64,366	59,840	63,732
Small Grains	117,554	108,432	82,821	78,326	113,550	99,416
Vegetables	11,509	8,282	5,701	5,509	1,768	1,367
Alfalfa	107,762	127,475	146,840	146,726	94,318	134,009
Grass Pasture	284,292	249,504	115,624	200,992	240,049	205,242
New Alfalfa	0	12,241	0	12,482	13,644	9,311
Cover Crop	0	1,605	0	6,077	8,509	2,411
Wheat Fall	0	394	0	2,670	247	62
Bluegrass	0	0	0	0	206	83
Total	567,161	585,457	423,991	517,148	532,130	515,633

Note: all values in acres

5. Comments and Concerns

The additional phase 6 crop types represent specific water use conditions and care should be taken to ensure that the crop types are not identified for fields where those conditions are not confirmed.

For identification of new alfalfa, satellite imagery or other information should confirm that there was no significant crop growth in spring months. One identification method is to confirm that NDVI values in satellite imagery are below the irrigated threshold amount prior to July. The switching of a field crop type to alfalfa does not necessarily mean that use of a new alfalfa crop type is appropriate.

The cover crop designation indicates that water use was significantly limited. The cover crop coefficients are the only crop coefficients that represent actual consumptive use rather than potential consumptive use. Satellite imagery should confirm relatively low NDVI values (ie near or below to the irrigated threshold value) for much of the season. If a crop type of sudan grass is identified but the satellite imagery suggests a well irrigated field or other information indicates that the field was hayed a grass pasture designation may be more appropriate.

The wheat fall designation in the RGDSS is meant to represent a field that was fallow for most of the growing season but with a verdant crop present only in the fall. A winter wheat crop indicated in the NASS CDL layer probably indicates a spring crop of winter wheat. This crop could be designated as wheat_spring to maintain the information in the GIS but in the current phase 6 model this designation should be reassigned to small grains.

The Pochop Methodology used for bluegrass estimates lower crop water requirements in the RGDSS than does the grass pasture crop types using the Rio Grande calibrated coefficients. Modeling park and golf course areas using the grass pasture coefficients may be more appropriate.

References

Agro Engineering; Kirk R. Thompson, Kelley Thompson, and Maya ter Kuile. July 2000. *1998 Irrigated Lands Assessment using Satellite Imagery in the Rio Grande Basin of Colorado*. Agro Engineering, Inc. RGDSS Final Report attached to RGDSS Memorandum *Irrigated Lands Assessment, Task 1* from Kirk Thompson to Ray Bennett, Ray Alvarado, and Andy Moore, Colorado Division of Water Resources and Colorado Water Conservation Board, July 24 2000.

LRE; Erin M. Wilson. June 2004. *Historic Crop Consumptive Use Analysis, Rio Grande Decision Support System*. Leonard Rice Consulting Water Engineers, Inc. Available from the CWCB CDSS website (http://cdss.state.co.us/DSSDocuments/Pages/TaskMemorandums.aspx)

LRE; Erin M. Wilson. December 19 1999. *Rio Grande Historic Consumptive Use – Calibration of Blaney-Criddle Coefficients.* Leonard Rice Consulting Water Engineers, Inc. RGDSS Memorandum to Ray Bennett, Ray Alvarado, and Andy Moore; Colorado Division of Water Resources and Colorado Water Conservation Board. Included as Appendix F to the 2004 Historic Crop Consumptive Use Analysis Report.

LRE; Erin M. Wilson. February 18 2011. *Crop Coefficients for Cover Crops*. Leonard Rice Consulting Water Engineers, Inc. Memorandum to Mary Halstead, James Heath, and Ray Alvarado; Colorado Division of Water Resources and Colorado Water Conservation Board.

Pochop, L.O., Borrelli, J. and R. Burman. 1984. *Elevation – A Bias Error in SCS Blaney Criddle ET Estimates*. Transactions of the ASAE. American Society of Agricultural Engineers.

RGDSS; Kelley Thompson. December 2015. *Phase 6 - Enhancement of Irrigated Parcel Datasets.* Colorado Division of Water Resources. RGDSS Final Memorandum to File.

USDA-SCS. April 1967 (revised September 1970). Irrigation Water Requirements, Technical Release No.21. United States Department of Agriculture Soil Conservation Service Engineering Division.

Attachments

LRE; Erin M. Wilson. February 18 2011. *Crop Coefficients for Cover Crops*. Leonard Rice Consulting Water Engineers, Inc. Memorandum to Mary Halstead, James Heath, and Ray Alvarado; Colorado Division of Water Resources and Colorado Water Conservation Board.

Attachment

LRE; Erin M. Wilson. February 18 2011. *Crop Coefficients for Cover Crops*. Leonard Rice Consulting Water Engineers, Inc. Memorandum to Mary Halstead, James Heath, and Ray Alvarado; Colorado Division of Water Resources and Colorado Water Conservation Board.

MEMORANDUM

TO: Mary Halstead, James Heath

FROM: Erin Wilson, Leonard Rice Engineers, Inc.

CC: Ray Alvarado

DATE: February 18, 2011

RE: Crop Coefficients for Cover Crops

Introduction

The recent irrigated acreage assessment identified cover crops, often sudan grass, planted in lieu of fallowing land. Based on the assessment of satellite signature for these crops and discussions with water users, it was determined that these crops are not provided a full water supply even when the supply is available. For other crops identified in the Rio Grande, the StateCU algorithm attempts to meet full crop demands based on available surface water supplies and assignments to wells. Unlike other crops, coefficients developed for cover crops need to reflect actual supply-limited consumptive use – not potential consumptive use.

Approach

Agro Engineering provided composite NDVI curves that reflect areas planted in cover crops. In addition, they met with water users to better understand the amount of water generally applied to these fields. Based on that information, they determined that the annual supply to these crops ranges from amount 7.5 to about 10.5 inches. This estimated supply includes both effective precipitation and applied irrigation water, with applied irrigation water generally around 6 inches.

The composite NDVI curve and growing season length for cover crops was compared to composite NDVD curves for other crops grown in the basin and it was determined that the shape of the consumptive use most closely matched potatoes. The percent difference in NDVI curves between cover crop and potatoes during the growing season was initially applied to the Rio Grande calibrated crop coefficients for potatoes. The cover crop coefficients were then adjusted down further to match user estimates of water applied.

Results

Figure 1 shows the estimated average monthly crop irrigation requirements estimated by StateCU at Monte Vista, Alamosa, Center, and Saguache using the developed crop coefficients. Effective precipitation is accounted for, and this figure represents the average monthly amount of surface or ground water that would be applied to this crop type. Figure 2 shows how the amount of water applied at Center would vary yearly based on temperature and precipitation, with an average annual amount of crop irrigation requirement of 6 inches.

Figure 1 – Average Monthly Crop Irrigation Requirements at Select Locations

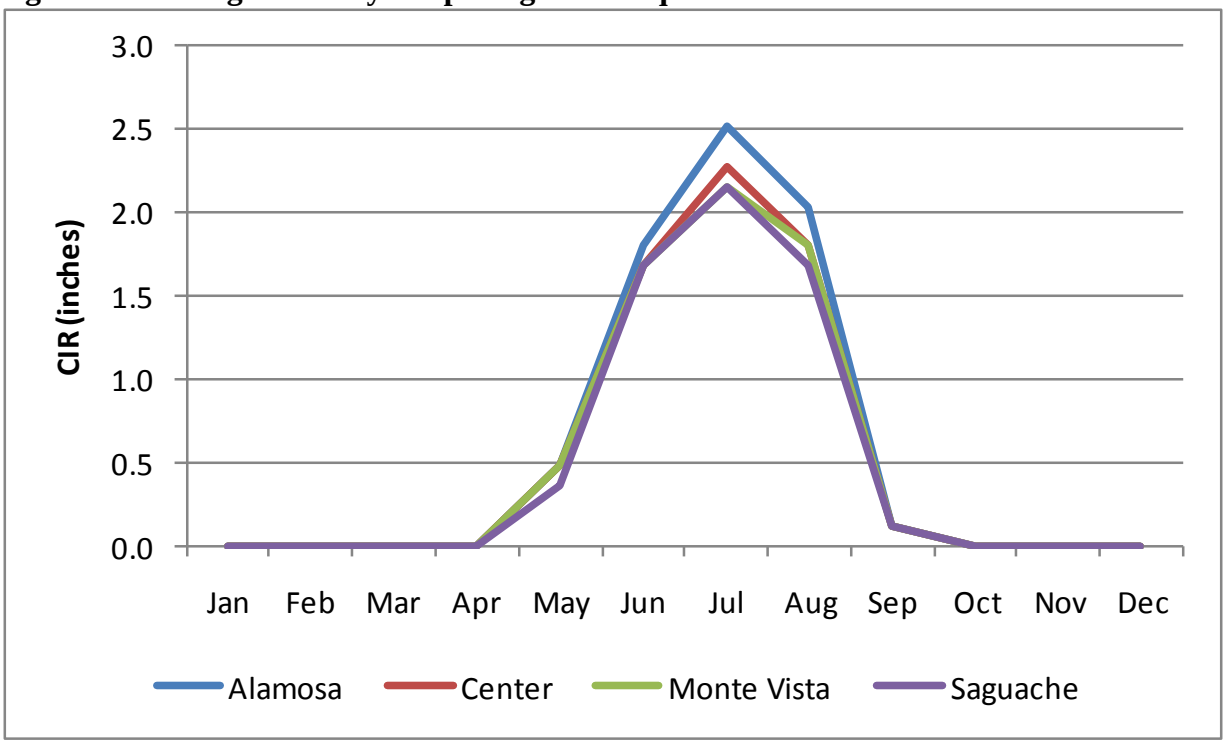
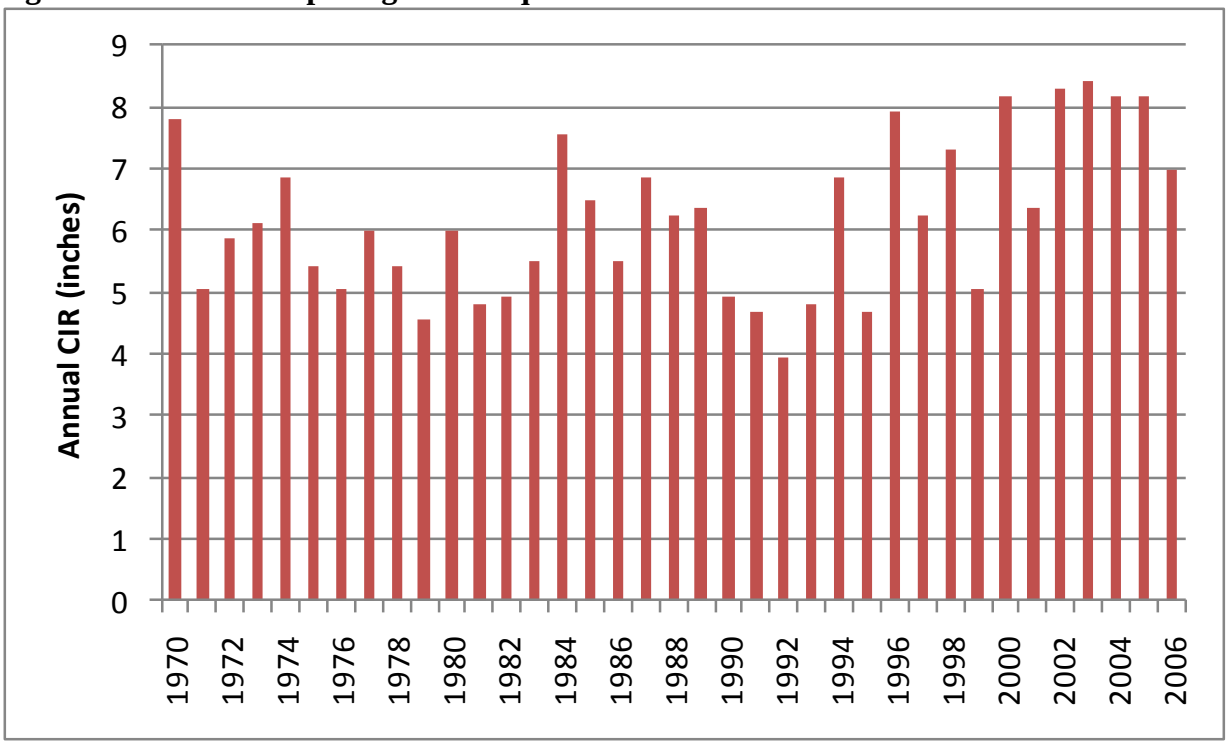


Figure 2 – Annual Crop Irrigation Requirements at Center



Based on these results, Agro Engineering and LRE recommend that crop characteristics used to define the growing season for potatoes be used for cover crops in the Rio Grande. Crop growth should begin when the mean monthly temperature reaches 50 degrees F and end when the minimum temperature reaches 28 degrees F, plus be limited to a maximum growing season of 120 days. Table 1 shows the SCS modified Blaney-Criddle crop coefficients recommended to define actual crop use for cover crops.

Table 1 – Recommended Cover Crop Coefficients

Percent of Growing Season	Blaney-Criddle Crop Coefficient
0	0.280
5	0.308
10	0.336
15	0.385
20	0.427
25	0.490
30	0.504
35	0.511
40	0.515
45	0.540
50	0.544
55	0.680
60	0.700
65	0.683
70	0.665
75	0.648
80	0.630
85	0.613
90	0.422
95	0.280
100	0.168

Comments and Concerns

Unlike all other crop coefficients used in the Rio Grande analysis, these cover crop coefficients cannot be used to represent *potential* consumptive use. They have been developed to estimate actual consumptive use based on intentional deficit irrigation practices. For this reason, we are not recommending these coefficients be included in HydroBase.