RGDSS Memorandum

Phase 6 - Subirrigation Maximum Monthly ETg

Final

TO: File
FROM: James R. Heath, P.E.
SUBJECT: RGDSS Phase 6 - Subirrigation Maximum Monthly ETg
DATE: July 20, 2012

1. Introduction

As part of the Phase 6 RGDSS Technical Advisory Committee (also known as the Peer Review Team (PRT)) modeling enhancements, the subirrigated crops' evapotranspiration from groundwater (ETg) were reevaluated, and updated ETg versus depth to groundwater curves (curves) were developed. The curves utilized in the Phase 6 groundwater modeling are documented in a separate memorandum (Halstead 2012).

- The alfalfa ETg versus depth to groundwater curve developed by Dr. Groeneveld (HydroBio Advanced Remote Sensing) has a maximum ETg of 2 feet per year.
- The meadows (or "grass pasture") ETg versus depth to groundwater curve developed by Dr. David Cooper and Dr. John Sanderson (Colorado State University) has a maximum ETg of 3.11 feet per year.
- The other crop ETg versus depth to groundwater curve developed by Kelly and Kirk Thompson (Agro Engineering) has a maximum ETg of 2 feet per year.

As presented above, the maximum ETg for each crop type has been provided as an annual rate. However, the groundwater model requires monthly values to assess the amount of subirrigation that can occur based on the simulated water table. For native phreatophytes Dr. Cooper and Dr. Sanderson provided a monthly distribution (Halstead, 2012) and this memorandum describes the process by which the monthly distribution was developed for subirrigated crops.

2. Approach and Results

Based on discussions with the Peer Review Team and Dr. Groeneveld, the irrigation water requirement curve based on annual climate information developed through the StateCU modeling, is the best approach to disaggregate the annual rates to monthly rates. Further, the groundwater model currently utilizes StateCU output related to crop irrigation water requirement (IWR) shortages on a monthly basis. It was further discussed that a maximum monthly limit should be imposed so as to constrain the simulated ETg to a level consistent with the maximum annual rates.

The general process for determining the maximum monthly ETg for each crop was to:

- Use StateCU to determine the basin-wide average monthly and yearly crop IWR.
- Plot the average IWR for each month on a curve.
- Create a scaled curve utilizing Step 2 where the monthly values add up to the maximum yearly ETg.

- The maximum monthly ETg limit then becomes the largest monthly value from Step 3.

Within the groundwater model, for subirrigated crops, the maximum ETg at ground surface is set as either the IWR shortage or the maximum ETg limit; whichever is less. If the IWR shortage is equal to zero for a structure during a time step, the maximum ET is set to zero and there is no ETg for that structure for that time step.

A detailed discussion of how that maximum monthly limit was determined for alfalfa, meadows, and other crops is provided in the following subsections.

Alfalfa

To translate the curve from an annual value into a maximum monthly value the following procedure was completed:

1. A consumptive use analysis was completed using StateCU with the following parameters:
    - *Model Analysis Type:* Climate Station Scenario
    - *Climate Stations:*
        - 0130 – Alamosa San Luis Valley RGNL
        - 0776 – Blanca
        - 1458 – Center 4 SSW
        - 2184 – Del Norte 2 E
        - 3541 – Great Sand Dunes N M
        - 5322 – Manassa
        - 5706 – Monte Vista 2 W
        - 7337 – Saguache
    - *Study Period:* 1950-2009
    - *Crop Types:* Alfalfa
    - *Crop Coefficients:* Phase 6 Rio Grande Calibrated Coefficients
    - *Climate Data:* Phase 6 Climate Data
    - *Effective Precipitation Method:* U.S. Bureau of Reclamation monthly method

2. For each climate station an average monthly irrigation water requirement was calculated for the study period. From the average climate station values a basin wide average monthly irrigation water requirement was calculated, see Table 1.

3. The basin wide average annual irrigation water requirement for alfalfa was calculated as 2.456 feet per year. On average for alfalfa, based on HydroBio's analysis, 2 feet per year of the irrigation water requirement can be met through subirrigation. Since the subirrigation component of the water supply for alfalfa is less than the average annual irrigation water requirement, a cap will be placed on the amount of ETg estimated by the groundwater model.

4. Based on discussions with the Peer Review Team and Dr. Groeneveld, the best method to cap the amount of irrigation water requirement met through subirrigation within the groundwater model is to impose a uniform maximum monthly limit. The basis of this decision is that the limiting factor in groundwater uptake by the plant is the root structure, which for an established alfalfa crop does not significantly vary as a monthly function. Therefore, one maximum monthly limit can be used for the entire year.

5. The annual alfalfa ETg was distributed monthly based on the average monthly irrigation water requirement curve to develop the subirrigation water supply curve. For peak summer months a maximum monthly limit was imposed so that the sum of the monthly values of the subirrigation

water supply curve did not exceed the annual ETg developed by HydroBio. For the months of March, September, and October the subirrigation water supply curve is equal to the irrigation water requirement curve. For the months of May, June, July, and August the subirrigation water supply curve is limited by the maximum monthly limit. The maximum monthly limit was determined to be 0.391 feet, see Table 2 and Figure 1.

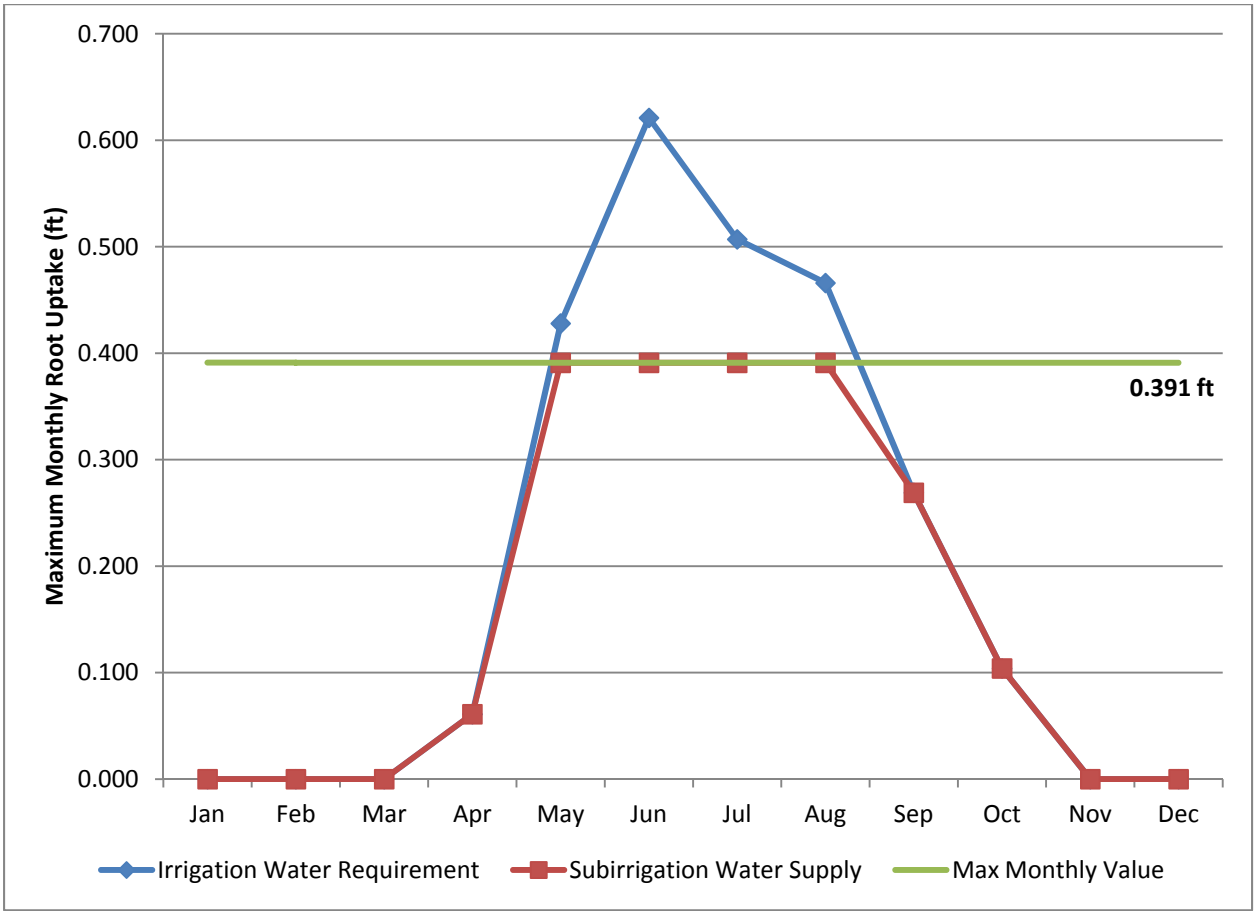
Table 1
Alfalfa Average Monthly Irrigation Water Requirement 1950-2009 (ft)

Climate Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
0130	0.000	0.000	0.000	0.059	0.436	0.635	0.544	0.502	0.273	0.088	0.000	0.000	2.537
0776	0.000	0.000	0.000	0.061	0.418	0.626	0.516	0.482	0.272	0.100	0.000	0.000	2.475
1458	0.000	0.000	0.000	0.063	0.438	0.605	0.505	0.466	0.272	0.101	0.000	0.000	2.450
2184	0.000	0.000	0.000	0.059	0.424	0.596	0.474	0.435	0.259	0.114	0.000	0.000	2.361
3541	0.000	0.000	0.000	0.056	0.418	0.648	0.509	0.456	0.270	0.117	0.000	0.000	2.474
5322	0.000	0.000	0.000	0.067	0.437	0.630	0.511	0.471	0.275	0.106	0.000	0.000	2.497
5706	0.000	0.000	0.000	0.060	0.425	0.601	0.497	0.456	0.260	0.093	0.000	0.000	2.392
7337	0.000	0.000	0.000	0.063	0.431	0.623	0.503	0.457	0.267	0.111	0.000	0.000	2.455
Basin Average	**0.000**	**0.000**	**0.000**	**0.061**	**0.428**	**0.621**	**0.507**	**0.466**	**0.269**	**0.104**	**0.000**	**0.000**	**2.456**

Table 2
Alfalfa Average Monthly Irrigation Water Requirement Limited to Annual Average ETg (ft)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Basin Average	0.000	0.000	0.000	0.061	0.428	0.621	0.507	0.466	0.269	0.104	0.000	0.000	2.456
Average ETg	**0.000**	**0.000**	**0.000**	**0.061**	**0.391**	**0.391**	**0.391**	**0.391**	**0.269**	**0.104**	**0.000**	**0.000**	**1.998**

Figure 1
Average Alfalfa Monthly Curves



Meadow (Grass Pasture)
To translate the curve from an annual value into a maximum monthly value the following procedure was completed:

1. A consumptive use analysis was completed using StateCU with the following parameters:
    - *Model Analysis Type:* Climate Station Scenario
    - *Climate Stations:*
        - 0130 – Alamosa San Luis Valley RGNL
        - 0776 – Blanca
        - 1458 – Center 4 SSW
        - 2184 – Del Norte 2 E
        - 3541 – Great Sand Dunes N M
        - 5322 – Manassa
        - 5706 – Monte Vista 2 W
        - 7337 – Saguache
    - *Study Period:* 1950-2009
    - *Crop Types:* Grass Pasture
    - *Crop Coefficients:* Phase 6 Rio Grande Calibrated Coefficients
    - *Climate Data:* Phase 6 Climate Data
    - *Effective Precipitation Method:* U.S. Bureau of Reclamation monthly method

2. For each climate station an average monthly irrigation water requirement was calculated for the study period. From the average climate station values a basin wide average monthly irrigation water requirement was calculated, see Table 3.

3. The basin wide average annual irrigation water requirement for grass pasture was calculated as 2.194 feet per year. For grass pasture, based on Cooper's and Sanderson's analysis, 3.11 feet per year of the irrigation water requirement can be met through subirrigation. Since the potential subirrigation component of the water supply for grass pasture is greater than the average annual irrigation water requirement, the average annual irrigation water requirement curve was scaled up for each month by a ratio of 1.417 (3.11 ft / 2.195 ft = 1.417) to create the subirrigation water supply curve.

4. The maximum monthly value of the subirrigation water supply curve was determined to be 0.740 feet, see Table 4 and Figure 2.

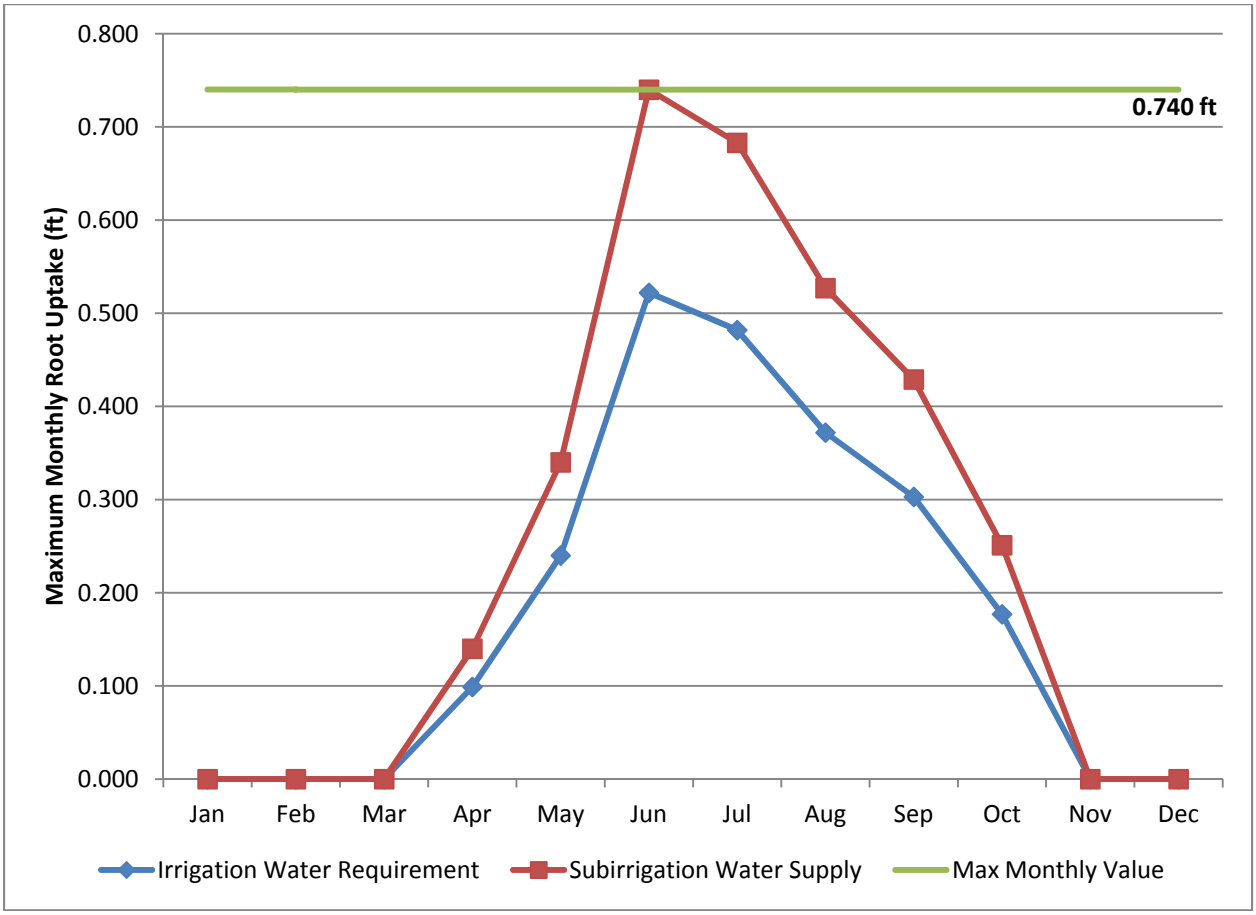
Table 3
Grass Pasture Average Monthly Irrigation Water Requirement 1950-2009 (ft)

Climate Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
0130	0.000	0.000	0.000	0.082	0.249	0.536	0.517	0.406	0.308	0.150	0.000	0.000	2.248
0776	0.000	0.000	0.000	0.095	0.229	0.525	0.490	0.387	0.308	0.170	0.000	0.000	2.204
1458	0.000	0.000	0.000	0.095	0.250	0.508	0.481	0.376	0.306	0.168	0.000	0.000	2.184
2184	0.000	0.000	0.001	0.108	0.235	0.501	0.450	0.345	0.294	0.195	0.000	0.000	2.129
3541	0.000	0.000	0.001	0.101	0.225	0.543	0.483	0.359	0.306	0.202	0.000	0.000	2.220
5322	0.000	0.000	0.001	0.120	0.247	0.530	0.485	0.378	0.311	0.182	0.000	0.000	2.254
5706	0.000	0.000	0.000	0.086	0.243	0.507	0.471	0.365	0.293	0.158	0.000	0.000	2.123
7337	0.000	0.000	0.000	0.102	0.242	0.525	0.476	0.362	0.301	0.188	0.000	0.000	2.196
Basin Average	**0.000**	**0.000**	**0.000**	**0.099**	**0.240**	**0.522**	**0.482**	**0.372**	**0.303**	**0.177**	**0.000**	**0.000**	**2.195**

Table 4
Grass Pasture Average Monthly Irrigation Water Requirement Limited to Annual Average ETg (ft)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Basin Average	0.000	0.000	0.000	0.099	0.240	0.522	0.482	0.372	0.303	0.177	0.000	0.000	2.195
Average ETg	**0.000**	**0.000**	**0.000**	**0.140**	**0.340**	**0.740**	**0.683**	**0.527**	**0.429**	**0.251**	**0.000**	**0.000**	**3.110**

Figure 2
Average Grass Pasture Monthly Curves



Other Crops
To translate the curve from an annual value into a maximum monthly value the following procedure was completed:

1. A consumptive use analysis was completed using StateCU with the following parameters:
    - *Model Analysis Type:* Climate Station Scenario
    - *Climate Stations:*
        - 0130 – Alamosa San Luis Valley RGNL
        - 0776 – Blanca
        - 1458 – Center 4 SSW
        - 2184 – Del Norte 2 E
        - 3541 – Great Sand Dunes N M
        - 5322 – Manassa
        - 5706 – Monte Vista 2 W
        - 7337 – Saguache
    - *Study Period:* 1950-2009
    - *Crop Types:* Other Crops (Potatoes, Small Grains, Vegetables, Fall Wheat, New Alfalfa, and Cover Crops)
    - *Crop Coefficients:* Phase 6 Rio Grande Calibrated Coefficients for all crops except where TR-21 was used for Vegetables and Fall Wheat

- *Climate Data:* Phase 6 Climate Data
- *Effective Precipitation Method:* U.S. Bureau of Reclamation monthly method

2. For each climate station an average monthly irrigation water requirement was calculated for the study period by averaging the monthly values for each crop. From the average climate station values a basin wide average monthly irrigation water requirement was calculated, see Table 5.

3. Since the potential subirrigation component of the water supply for other crops is greater than the average annual irrigation water requirement, the average annual irrigation water requirement curve was scaled up for each month by a ratio of 2.158 (2 ft / 0.927 ft = 2.158) to create the subirrigation water supply curve.

4. The maximum monthly value of the subirrigation water supply curve was determined to be 0.695 feet, see Table 6 and Figure 3.

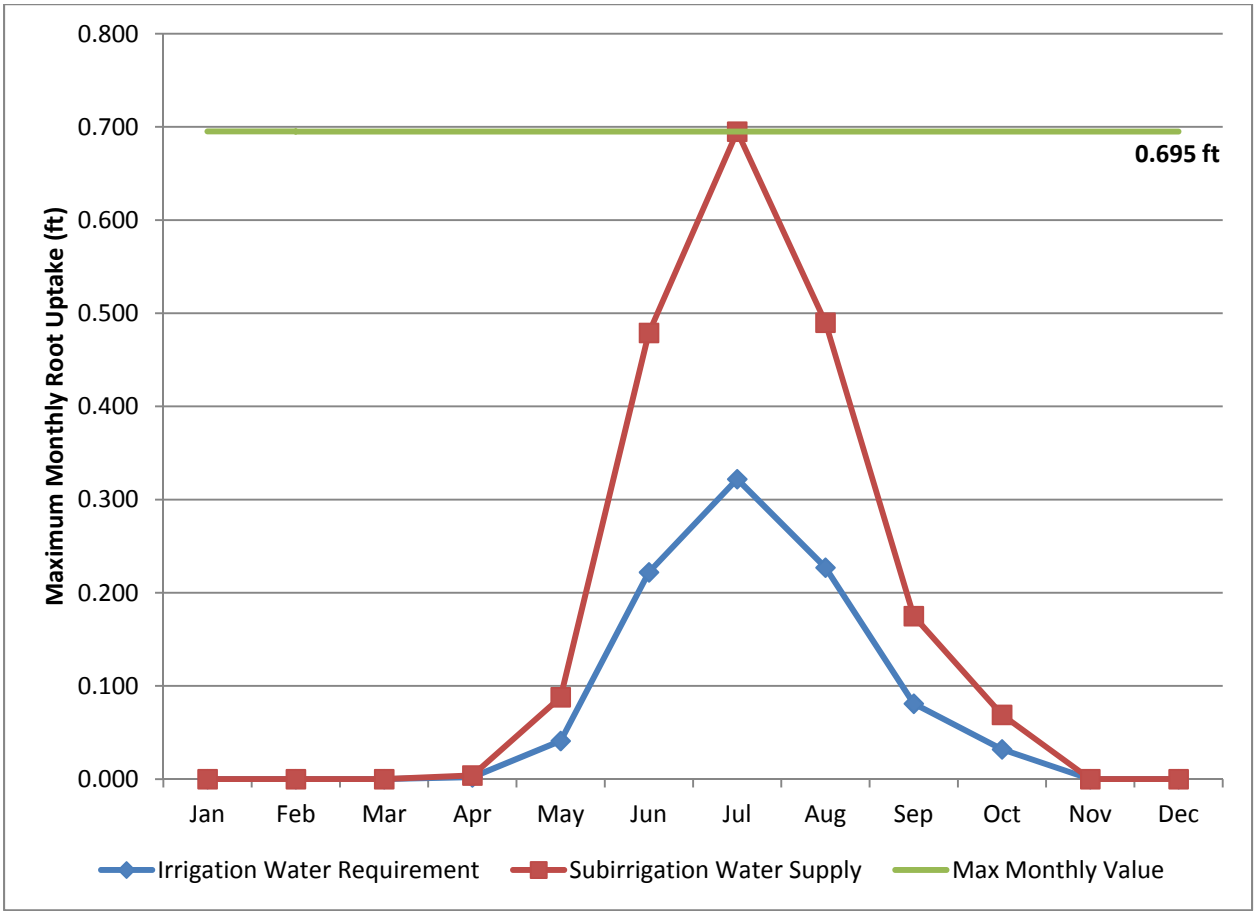
Table 5
Other Crops Average Monthly Irrigation Water Requirement 1950-2009 (ft)

Climate Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
0130	0.000	0.000	0.000	0.001	0.042	0.229	0.352	0.259	0.085	0.027	0.000	0.000	0.995
0776	0.000	0.000	0.000	0.002	0.038	0.222	0.327	0.238	0.083	0.031	0.000	0.000	0.941
1458	0.000	0.000	0.000	0.002	0.044	0.215	0.324	0.232	0.084	0.031	0.000	0.000	0.932
2184	0.000	0.000	0.000	0.002	0.041	0.211	0.297	0.206	0.076	0.036	0.000	0.000	0.869
3541	0.000	0.000	0.000	0.002	0.039	0.232	0.320	0.210	0.079	0.036	0.000	0.000	0.918
5322	0.000	0.000	0.000	0.003	0.044	0.230	0.324	0.228	0.083	0.032	0.000	0.000	0.944
5706	0.000	0.000	0.000	0.002	0.040	0.213	0.317	0.227	0.080	0.029	0.000	0.000	0.908
7337	0.000	0.000	0.000	0.002	0.041	0.225	0.317	0.218	0.080	0.034	0.000	0.000	0.917
Basin Average	**0.000**	**0.000**	**0.000**	**0.002**	**0.041**	**0.222**	**0.322**	**0.227**	**0.081**	**0.032**	**0.000**	**0.000**	**0.927**

Table 6
Other Crops Average Monthly Irrigation Water Requirement Limited to Annual Average ETg (ft)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Basin Average	0.000	0.000	0.000	0.002	0.041	0.222	0.322	0.227	0.081	0.032	0.000	0.000	0.927
Average ETg	**0.000**	**0.000**	**0.000**	**0.004**	**0.088**	**0.479**	**0.695**	**0.490**	**0.175**	**0.069**	**0.000**	**0.000**	**2.000**

Figure 3
Average Other Crops Monthly Curves



3. References

Halstead, Mary R., July 20, 2012, RGDSS Memorandum, RGDSS Phase 6 - Evapotranspiration from Groundwater.