Documentation of Groundwater GIS Processing
(GIS Data Preparation for Groundwater Modeling)

Final

To: File
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Subject: RGDSS Ground Water – Documentation of **agg**, **mksub3** and **mkprf**, pre processing programs used to develop input data for **StatePP**
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The CDSS Toolbox outputs lists of cell definitions for ditches, parcels under that ditch and wells serving the parcels. In the **StateCU** calculations, some ditches are combined into multi-structures to deal with complex water use practices. The **agg** program are used to combine the individual parcel and well mappings produced by the CDSS Toolbox and output mappings for the multi structures instead, so that **StatePP** and **StateCU** can operate on the same entities.

The **mksub3** program is used to compute the potential subirrigation coverage for the "other" category that is subirrigation that occurs on lands not mapped as alfalfa or meadow.

The **mkprf** program calculates the fraction of irrigated land for calculating precipitation recharge.

This document includes the following sections:

0.0 Disclaimer

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1.0 Acknowledgment

Judith Schenk of HRS developed the initial **agg** program. Willem A. Schreüder of Principia Mathematica re-implemented and expanded **agg** using funding provided by the Colorado Division of Water Resources and the Rio Grande Water Conservation District.

2.0 agg

The **StateCU** program calculates the ditch water budget for several hundred ditches in the watershed. Some of these ditches are outside the groundwater model domain, and are therefore not processed by **StatePP**. In some instances, there are complex water management by several ditches which is best represented as a single unit called a multi structure.

The CDSS Toolbox outputs lists of cells representing the individual parcels under each ditch, where canal leakage should occur along these ditches, the location and layer of wells that serve each parcel, and meadow lands and alfalfa lands under each ditch. The **agg** program combines ditches under a multi structure and outputs the cell maps as a single structure, and omits those structures that are outside the groundwater model domain.

The following table shows the file names of the CDSS Toolbox output, and the names the **agg** program uses for the combined data. Here YYYY represents the year of the data from the GIS coverage.

Description	CDSS Toolbox output	Agg output[1]
Irrigated lands by ditch	YYYY.irr	divirln.dat
Canal leakage location by ditch	YYYY.can	divleak.dat
Wells by parcel and ditch	YYYY.wel	irrwell.dat
Meadow lands by ditch	YYYY.med	subacres1.dat
Alfalfa lands by ditch	YYYY.alf	subacres2.dat
Master list of ditch parameters		ditch.fact

The **ditch.fact** file produced by **agg** is the master lists of ditches that will be processed by **StatePP**. Any ditch in the **StateCU** data that does not occur in **ditch.fact** will be silently ignored. The **ditch.fact** file lists the ditch identifier, the fraction of the canal leakage that becomes groundwater recharge, and how the return flow from groundwater irrigation is distributed.

1 The names of the output files are a historical artifact of names chosen during Phase 3.

The **agg** program is controlled by an input file typically named **agg.par**. This file references data files used in the processing. The format of this file consists of a keyword followed by a file name.

The following table describes the keywords:

Keyword	File	Description
MS	Diversions/rg-ms.csv	Multi structure Definitions
LEAK	ManualEntry/leak.dat	Fraction of StateCU canal leakage that becomes groundwater recharge
GWRET	ManualEntry/gwret.dat	Definition of where groundwater return flows occur
OUT	ManualEntry/outside.dat	List of structures outside the groundwater model domain

The MS file contains the multi structure definitions. Each line contains comma separated values that define each multi structure. The line consists of the multi structure identifier (e.g. 20MS02), the name of the multi structure (e.g. Empire Canal Diversion System), and a sequence of WDIDs that define the individual ditches that comprise the multi structure.

The **agg** output and subsequent processing uses the multi structure identifier which is also used in the **StateCU** processing.

The LEAK file contains the fraction of the **StateCU** canal leakage that becomes groundwater recharge. For most ditches, it is assumed that 3% of the canal leakage is lost to evaporation, so that 97% of the leakage becomes recharge. Therefore, the line

DEFAULT 0.97

in this file assigns 97% of the **StateCU** computed canal leakage to the groundwater recharge. However, in the case of ditches that are explicitly modeled, part of the canal leakage may be simulated as part of the stream package. Therefore, for the six canals that are explicitly modeled during Phase 6, the LEAK files specifies the fraction of the canal leakage that occurs along the portion of the canals that are not explicitly modeled using the stream package. Any canal not explicitly named in the LEAK file is assigned the default value in the **ditch.fact** file.

The GWRET file determines where the return flow from groundwater irrigation occurs. The line

DEFAULT WELL

specifies that **StatePP** should distribute deep percolation from applied groundwater under a ditch proportional to where the wells are. In Phase 6, there are only two ditches, the Ephraim Ditch and Sanford Ditch, where groundwater is pumped into the ditch and the return flows are therefore assigned proportional to where the irrigated lands are. The lines

2200541 LAND
2200627 LAND

specified that behavior.

Finally, the OUT file lists those structures that are outside the groundwater model domain. Any structure or multi structure specified in this list will be omitted from **ditch.fact** and will therefore be silently ignored by **StatePP**. The purpose of this list is to allow the **StateCU** processing to be done for the entire watershed, but recognize that some of the ditches fall outside the groundwater model domain. The OUT file list is used to remove those ditches outside the groundwater model domain that would otherwise generate warnings or errors in the **StatePP** processing.

The **agg** program is run in the GIS directory corresponding to the coverage for a particular year. During Phase 6, this was done using the commands

```
for yr in 1936 1998 2002 2005 2009 2010; do
    (cd $yr;ln ../agg.par $yr.par;agg $yr >$yr.err);
done
```

The **.err** file contains warnings from **agg** processing. These warnings are typically that for multi structures that are outside the groundwater model domain and contains no data in the CDSS Toolkit output and are harmless.

3.0 mksub3

The **agg** program generates files **subacres1.dat** and **subacres2.dat** that defines the irrigated lands of type meadow and alfalfa, respectively. The **mksub3** program creates a third coverage **subacres3.dat** which defines the acreage associated with all other irrigated lands.

The **mksub3** program loads the cell-by-cell irrigated lands from the **divirln.dat** file, subtracts the meadow and alfalfa lands specified in the **subacres1.dat** and **sunacres2.dat** files, and then saves the remainder to the **subacres3.dat** file.

The **mksub3** program takes as arguments the directories in which to do the calculations. It is typically run from the GIS root directory as

```
../src/mksub3 1936 1998 2002 2005 2009 2010
```

which will then perform the calculations for all the years that there are coverages for.

4.0 mkprf

The **mkprf** program is used to calculate the precipitation recharge fractions for the irrigated and non-irrigated seasons. During Phase 3 it was established that recharge from precipitation is 3% on non-irrigated lands and 10% on irrigated lands. During Phase 4 it was established that recharge over the Sand Dunes equals 30% of precipitation.

The **mkprf** program produces two files, **pptfrac.irr** and **pptfrac.non** which represent the cell-by-cell fraction of precipitation that becomes recharge for the irrigation and non-irrigation seasons, respectively.

The **mkprf** program is controlled by a parameter file named **prf.par**. This is a key and value file controlling the behavior of the **mkprf** program. The following table lists the keys required by the **mkprf** program

Key	Value	Description
GRID	../StatePP/X6P008.grd	Grid definition files shared with StatePP
DUNES	General/Intersect_Data/ SD_Grid_Soils_Inter.dbf	Database of cells covered by sand dunes
Fnon	0.03	Fraction of precipitation that becomes recharge on non-irrigated lands
Firr	0.10	Fraction of precipitation that becomes recharge on irrigated lands
Fdun	0.30	Fraction of precipitation that becomes recharge on sand dunes
IRR	divirln.dat	Irrigated lands coverage
PRFI	pptfrac.irr	Irrigation season recharge fraction output file
PRFN	pptfrac.non	Non-irrigation season recharge fraction output file
YEARS	1936,1998,2002,2005,2009,2010	Comma separated list of years to processes

The **mkprf** program reads the grid definition from the **StatePP** grid definition file. The fractions of each cell covered by irrigated lands are determined by the IRR file, while the fractions of each cell covered by dunes are read from the DUNES file. The remainder of the cell is considered non-irrigated. The recharge fraction for the irrigation season is calculated as the precipitation fractions weighted proportional to the fraction of each cell covered by the dunes, irrigated lands and non-irrigated lands. The recharge fraction for the non-irrigation season is similarly calculated, but using the non-irrigated fraction on irrigated lands because it is outside the irrigation season.

The **mkprf** program is typically run from the GIS directory as

```
../src/mkprf prf.par
```

Note that the input and output files are processed in each of the subdirectories specified by the YEARS key.

5.0 Comments and Concerns

During Phase 6, the additional GIS processing was performed by Principia. This was mostly due to the fact that the processing was more closely related to **StatePP** than the CDSS Toolkit. However, since these tools have sufficiently matured, future Phases should incorporate this processing as part of the GIS processing.

6.0 References

Appendix G: RGDSS Ground Water, Task 19 – Recharge Data, Judith Schenk and Eric Harmon, April 30, 2001.

RGDSS Phase 6 Memorandum: Ground Water – Documentation of StatePP (RGDSS_P6_MOD_StatePP.pdf)

Appendix J StatePP Documentation, RGDSS Memorandum Phase 4, July 2004

Appendix J A-4: RGDSS Groundwater StatePP Processing Details, Phase 4, July 2004