SPDSS Phase 3 Task 50.4 Technical Memorandum
Data Centered Groundwater Modeling Enhancements
FINAL

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From:	Camp Dresser and McKee Inc. Mike Smith, Donavon Paschall, Matt Bliss, and Gordon McCurry
Subject:	SPDSS Groundwater Component Phase 3, Final Task 50.4 Data Centered Groundwater Modeling Enhancements Technical Memorandum
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Introduction

This task was undertaken for the Colorado Water Conservation Board (CWCB) and Division of Water Resources (DWR), under Task 50.4 of Phase 3 of the South Platte Decision Support System (SPDSS) by Camp Dresser & McKee (CDM). The remainder of this section reviews the Task 50 components and describes the Task 50.4 goals.

Task 50 began in Phase 2 of the SPDSS with Task 50.1, which summarized the data centered modeling process implemented by the State of Colorado for the Rio Grande Decision Support System (RGDSS) and identified candidate graphical user interface (GUI) tools for screening and selection in subsequent Task 50 phases. The evaluation focused on groundwater processes, since surface water and consumptive use-related processes are well developed and currently meet the State's needs.

The second component of Task 50 (Task 50.2) defined and prioritized potential enhancements to the data centered modeling process. This included identification of data types used in the modeling, where the data reside, a discussion of current processes to move data from the source repository to the models and an identification and prioritization of enhancements. This task also identified needed output types for model development and future model use, as well as prioritizing development activities needed to provide these outputs. Recommendations for a primary GUI were provided, along with recommended tools and processes for implementation in the SPDSS.

The third component of Task 50 (Task 50.3) provided a scope of work for implementing high priority enhancements during Phase 3. The highest priority tasks were selected for implementation. These selected development tasks focused on the elements of the data centered process required during model development activities to be conducted under Task 48 in Phase 3.

Task 50.4 implemented the Task 50.3 proposed enhancements to the existing data centered approach to groundwater modeling in Colorado's Decision Support System (CDSS). A data centered approach defines processes and tools that facilitate a linkage between data sources, such as HydroBase and State GIS files, and a numerical groundwater model. This approach facilitates rapid updating of numerical models when changes to underlying data sets occur, model simulation periods change, or additional processes need to be incorporated.

The objectives of this task are as follows:

1. *Enhance the data centered groundwater modeling process*
2. *Utilize standard packages, where applicable, to minimize development and maintenance costs*
3. *Develop a process specific for the SPDSS but flexible enough to be applied to other Colorado river basins.*

Task 50.4 incorporates the existing HydroBase data structures, supplemented by an additional database to store other types of data and engineering estimates necessary to define model characteristics. These two data sources are combined using procedures defined in this document into a modeling geodatabase used with a series of Data Management Interfaces (DMIs) to create package files for MODFLOW-2000, the groundwater flow model used in the SPDSS. The commercial model interface program Department of Defense Groundwater Modeling System (GMS) is used to create additional MODFLOW-2000 package files. Figure 1 illustrates the general concept of the data centered modeling flow process.

Approach

The following table summarizes the sections contained in this TM.

Section	Description
1.0	Groundwater Data Repositories
1.1	HydroBase
1.2	SPDSS_GW_database
1.3	SPDSS_GW_geodatabase
2.0	Streamflow-Routing Package Development
2.1	Description of SFR2 Package
2.2	Input Data Sources for SFR2 Package Development
2.3	ArcGIS Tools used to Develop the SFR2 Package
2.4	Generation of SFR2 Package
3.0	Development of New DMIs and Procedures
3.1	GMS Grid Conversion
3.2	Creating and Activating the Model Grid
3.3	Creating Model Layers with XYZ Datasets
3.4	Modification of Existing DMIs
4.0	Summary and Conclusions
5.0	Recommendations
6.0	References

To accomplish the objectives, Task 50.4 required the following:

- development of a database for measured and engineering control data,
- creation of an ArcGIS geodatabase for groundwater spatial data,
- development of custom ArcGIS tools to facilitate the development of the MODFLOW Streamflow Routing (SFR2) package,
- creation of a Data Management Interface (DMI) for the generation of a SFR2 package,
- creation of a Data Management Interface (DMI) to convert a GMS grid to ArcGIS format,
- development of procedures to create and process data through GMS, and
- modification of existing modeling related DMIs.

A detailed flow diagram of the data centered modeling flow process is shown in Figure 2. The databases, data management interface programs (DMIs), procedures, and tools enhanced or developed under Task 50.4 are described in the remainder of this Technical Memorandum (TM).

1.0 Groundwater Data Repositories

The data centered modeling process requires the model to be based on measured data and easily updated when new measured data become available. This approach requires the data to reside in a central storage location that can be easily accessed. To accomplish this, three databases are used in the groundwater data centered modeling process: HydroBase, SPDSS_GW_database, and the SPDSS_GW_geodatabase. Figure 2 illustrates the components of the data repositories and how they fit in the data centered modeling process.

1.1 HydroBase

HydroBase is the State of Colorado's hydrologic database. Among other water resources data types, it contains data pertinent to groundwater, which includes: groundwater levels, aquifer configuration data, and aquifer hydraulic properties data. The data centered modeling process can either work directly with HydroBase or with a stored procedure copy of HydroBase. In the remainder of this TM, the name HydroBase refers to either of these scenarios. Documentation of HydroBase can be found at http://cdss.state.co.us/DNN/ViewData/tabid/60/Default.aspx.

1.2 SPDSS_GW_database

This database was developed under Task 50.4 to store tables of control data (engineering estimates), exclusion data, measured data that do not reside in HydroBase, and model-specific data. Each of these is discussed below. A full listing of datasets included in the SPDSS_GW_database is found in Appendix A. In addition to local data tables, the database also contains links to tables in HydroBase. Finally the SPDSS_GW_database has queries that combine data in the local tables with linked tables to create datasets for export to the geodatabase.

When developing groundwater models, physically measured data is often not available in sufficient density. Therefore engineering control data must be used to increase the data density for interpolation onto the model grid. The control tables possess the same structure as their related measured data table in HydroBase.

Exclusion tables identify the measured data reported in HydroBase that are not suitable for modeling. Data not suitable for modeling are identified by an analyst during data analysis and model setup. Examples include anomalous aquifer configuration picks or extreme hydraulic conductivity data. If a data value marked as excluded in the exclusions table is modified in HydroBase and becomes suitable for modeling, the exclusion table can be modified to note this change and accept the previously excluded data for future use.

Some measured hydrogeologic datasets are not included in HydroBase because its current structure does not accommodate these types of data; however, they are still necessary for SPDSS groundwater modeling. Example datasets include stream channel cross sections, streambed conductance data, and municipal and industrial pumping data. New tables were designed to store these data in the SPDSS_GW_database.

Model-specific data tables in the SPDSS_GW_database contain data specific to modeling setup. These data include boundary conditions, hydrostratigraphic units, and the characteristics for the SFR2 package.

The SPDSS_GW_database has queries programmed to initiate through the database's Main Switchboard, which is further explained in Appendix A. These queries are used to create tables for exporting out of the database for model processing in the SPDSS_GW_geodatabase. Queries access the data from the linked HydroBase tables, exclude the values identified in exclusion tables and then append the data from control tables.

Appendix A outlines the structure of the SPDSS_GW_database and the steps required to load and maintain data, link the database to external data sources, and run queries to combine data for export to the SPDSS_GW_geodatabase. It also includes a data dictionary that defines the fields of each table in the database.

1.3 SPDSS_GW_geodatabase

The final database, which was developed under Task 50, is called the SPDSS_GW_geodatabase. A geodatabase is an ArcGIS database used to manage spatial and relational data and can contain feature classes (fc), feature datasets (fd), rasters, and tables. A feature class is an ArcGIS format that contains points, polylines, or polygons. A feature datasets, at its most basic level, is similar to a folder in the Windows operating system and can be used to thematically group feature classes in a geodatabase. Rasters are comprised of regularly spaced grids. GIS can facilitate the development of groundwater models because of its ability to allow viewing and processing of spatial data.

The SPDSS_GW_geodatabase stores two basic categories of spatial data: Static Data and Dynamic Data. Dynamic Data are broken into two sub-categories: Database and Analysis. Figure 2 illustrates these categories.

Static Data imported from outside sources, such as from CDSS datasets or from the USGS National Hydrography Dataset (NHD), would consist of reference and base map data, such as roads, counties, cities, and streams. It could also include model specific data such as the aquifer boundary or the model area. These types of data are imported into the geodatabase at the start of the modeling process and will likely not change during model development.

Dynamic Data are more likely to change during the modeling process and be updated as new data become available. The Dynamic Data are generated from two sources: Database and Analysis of data in the geodatabase, and are used for development of model inputs. Database data are imported from the SPDSS_GW_database and then converted to spatial datasets. The types of data include, for example, groundwater level measurements, aquifer framework elevations, aquifer hydraulic properties, and the SFR segmentation points. These datasets will be periodically updated as new data become available in HydroBase.

Analysis Data are created from the analysis of the data in the geodatabase, which were imported from the SPDSS_GW_database or other sources. These data may include, for example, the datasets created in the SFR2 package development. The analysis is performed using several tools including GMS, ArcToolbox geoprocessing tools, or the custom SFR tools coded in ArcMap VBA.

The geodatabase also includes a log table that tracks the creation and modification of the data within the geodatabase. The log table must be manually updated by the analyst.

Spatial data contained in the geodatabase will be used to create, update, and display modeling datasets. Appendix B documents the structure of the SPDSS_GW_geodatabase and the steps required to load and maintain spatial datasets in the SPDSS_GW_geodatabase.

2.0 Streamflow-Routing Package Development

One of the more complicated model input packages, the Streamflow-Routing (SFR2) package is used to simulate streams and diversions. A brief description of SFR2 and the tools developed to create this model input package are presented in this section.

2.1 Description of SFR2 Package

MODFLOW-2000 uses a new streamflow-routing package (SFR2) to simulate the stream-aquifer interaction (Niswonger and Prudic, 2006). For the RGDSS groundwater model an older stream package was utilized. Therefore, the data centered modeling process was modified for the SPDSS to incorporate the SFR2 package.

The SFR2 package defines the characteristics of the modeled stream and diversions. These stream characteristics include the stream depth calculation method, Manning's roughness for the channel and overbank areas, the power coefficients relating streamflow to stream depth and width, hydraulic conductivity, streambed thickness, streambed elevation, streambed width, streambed depth, and 8-point streambed geometry cross section data. These are the parameters used by the SFR2 package to compute the stream-aquifer interaction in the model.

The SFR2 package divides the stream system into segments, which are portions of a stream with constant or linearly varying characteristics. The segments must be numbered in ascending order from upstream to downstream Segments are then broken into reaches, which are defined by the intersection of segments and model grid cells. The reaches of each segment must also be numbered in ascending order from upstream to downstream.

Custom ArcGIS tools were created under this task to assist in defining the segments, reaches, and their respective characteristics for developing the SFR2 package. These tools and the development of the SFR2 package are highlighted in Figure 3 and discussed in the paragraphs below.

2.2 Input Data Sources for SFR2 Package Development

The development of the SFR2 package requires two input datasets:

- the framework for the stream system, and
- the points attributed with the SFR2 required parameters used to segment the framework and define the characteristics of each segment at its upstream and downstream end.

The framework of the stream system is stored as a feature class, *Streams*, in the SPDSS_GW_geodatabase database (Figure 2). The polyline features in the feature class represent the streams and diversions that will be explicitly simulated in the model. The requirements for developing this stream framework are found in Appendix C. The *Streams* (fc) is represented by the light blue box with the title *Streams* (fc) shown in Figure 3.

The second dataset used to create the SFR2 package consists of the points that break the features in the *Streams* feature class into segments. These points are located where there is a diversion, tributary, streamflow gage, or significant change, as determined by the analysts, in a stream characteristic. To create the dataset of segmentation points, an analyst must populate the table *Streams_segmentation_pts* in the SPDSS_GW_database with the location and characteristics of the segmentation points (see Appendix A). This table can then be imported into the geodatabase and converted to a feature class as outlined in Appendix B. The feature class should be called *Streams_segmentation_pts* and should be stored in the *Streams* feature class dataset. This feature class is represented by the green box with the title *SFR_segmentation_pts* (fc) shown in Figure 3.

2.3 ArcGIS Tools used to Develop the SFR2 Package

To facilitate the SFR2 package development the following customized ArcGIS tools and manual steps were developed: Snap and Split, Network Creation, Segment Numbering, Reach Creation, and Attribute Fill. The tools are coded in Visual Basic for Applications (VBA), and are preserved in an ArcMap document called "CDSS_SFR2_Development.mxd". The tools can be accessed via a custom toolbar, named CDSS SFR Tools. The purpose of each tool is described below and more detailed user documentation can be found in Appendices C to G. Figure 3 identifies the flow of data from one tool to the next for generating the SFR2 package.

2.3.1 Snap and Split Tool (Appendix C)
Input Data: Streams (fc), Stream_segmentation_pts (fc)

Description: This tool creates the segments for the SFR2 package by splitting the stream and diversion line features into segments based on the location of the segmentation point data. The tool will first move each point form its original locations to a location on the nearest stream or diversion line following the shortest distance from the point to the line. The point will only be moved if the point and the line share the same unique identifier in their respective attribute tables. The user can specify the maximum tolerance a point can be moved. If the point is within approximately 3 feet of the endpoint of a line it will be moved to the endpoint so that features with lengths of less than 3 feet will not be created.

Output Data: Streams_segments (fc), Stream_segmentation_pts_snap (fc)

2.3.2 Network Creation (Appendix D)
Input Data: Streams_segments (fc)

Description: In order to run the Segment Numbering tool it is necessary that the Streams_segments (fc) be converted to a network dataset. Appendix D identifies the procedure to create a network dataset.

Output Data: Streams_Net (network), which includes Streams_segments (fc) and Streams_Net_Junctions (fc)

2.3.3 Segment Numbering (Appendix E)
Input Data: Streams_Net (network)

Description: This tool numbers the segments in ascending order from upstream to downstream. Additionally, fields are added to capture the upstream and downstream segments a segment is connected to. Finally, the endpoints of each segment are exported out as a point feature class: Streams_segments_endpoints (fc). This feature class maintains some of the attributes of the Streams_segments (fc). A field is added to the attribute table of Streams_segments_endpoints (fc) that identifies if the point is the fnode (or starting point) or the tnode (or ending point) of a line.

Output Data: Streams_segments_endpoints (fc)

2.3.4 Create Reaches (Appendix F)

Input Data: Streams_segments (fc), Model_grid (fc)

Description: This tool creates reaches by intersecting the Streams_segments (fc) with the Model_grid (fc). After creating reaches, the reaches are then numbered in ascending order from upstream to downstream and the length of each feature is added to the attribute table in feet.

Output Data: Streams_segments_reaches (fc)

2.3.5 Attribute Fill (Appendix G)

Input Data: SFR_segmentation_pts_snap (fc), Streams_segments_endpoints (fc)

Description: The SFR_segmentation_pts_snap (fc) contains the attributes required by SFR2 at key segment locations. This tool performs a spatial and attribute join to assign attributes from SFR_segmentation_pts_snap (fc) to Streams_segments_endpoints (fc). Attributes of Streams_segments_endpoints (fc) are then linearly or constantly interpolated at points where no data exists. Only the hydraulic conductivity and elevation characteristics are linearly interpolated.

Output Data: Fields are added to Streams_segements_endpoints (fc)

2.4 Generation of SFR2 Package

A program was developed to convert the SFR2-related geodatabase files generated with the ArcGIS SFR tools into MODFLOW format. This program is represented by the grey box in Figure 3 called *SFR Generator*. The development and use of this program is documented in Appendix H. This and the other programs described in this section were tested and used in the development of the Task 48 model inputs.

3.0 Development of New DMIs and Procedures

Additional Data Management Interfaces and procedures were developed to manipulate data in the modeling process. A DMI was created to export the model grid from GMS as a feature class to be stored in the SPDSS_GW_geodatabase database. Procedures were created to document the process to create and activate a model grid with a polygon feature class and to create modeling layers in GMS with xyz datasets.

3.1 GMS Grid Conversion

Visual Basic was used to develop a program to export the model grid from GMS to a geodatabase polygon feature class. The feature class is attributed with the grid properties, row identifier, column identifier, and the cells activity code (either active or inactive). This feature class will be used for model display, and developing model data such as the SFR2 package. The development and use of this program is documented in Appendix I.

3.2 Creating and Activating the Model Grid

In GMS, a model grid can be developed and grid cells can be activated by importing a polygon feature class into GMS and intersecting the grid with the polygon. This process establishes the foundation for the model. Detailed steps for this procedure are found in Appendix J.

3.3 Creating Model Layers with XYZ Datasets

A model includes data layers for the aquifer top and bottom, the starting water level, recharge, and various hydraulic properties. These layers can be developed in GMS by importing xyz, horizontal and vertical datasets, and then interpolating the data onto the model grid. The xyz datasets can be imported as text files, shapefiles or feature classes. Once the datasets are interpolated and assigned to a data layer, GMS will then write the layer to the appropriate MODFLOW package file. Detailed steps for this procedure are found in Appendix K.

3.4 Modification of Existing DMIs

Modifications were made to two existing DMIs: StatePP and Agg to add MODFLOW's multi-node well (MNW) package capability (Halford and Hanson, 2002). The programs StatePP and Agg were modified to read in the additional required data to generate the MNW, and StatePP provides the additional processing required to generate the MNW input file. The DMI modifications are described in the following sections.

StatePP Modifications

The existing program StatePP (version 2.31) was upgraded to include the option to generate a file for the MODFLOW multi-node well (MNW) package. The multi-node well package allows users to simulate wells that extend beyond a single model node. Multi-node wells dynamically distribute flow between nodes under pumping, recharging, or non-pumping conditions (Halford and Hanson, 2002).

In comparison to previous versions of StatePP, additional data are required in the agricultural and municipal and industrial pumping input files to generate the MNW file. In addition to data provided to previous versions of StatePP, agricultural well data must include top and bottom model layers in which a given well is completed, unique well ID, and a multi-parcel flag. Municipal and industrial pumping must include model layer top and bottom in which a given well is completed. Details about the specific content and formatting of the additional data and a description of the various assumptions used in generating the MNW file can be found in the updated StatePP documentation found in Appendix L.

The MNW file is generated by StatePP if the MNW flag is set to 1 in the control file. There are also several output options for the MNW package that must be specified in the control file, and are documented in Appendix L. The modifications to StatePP and Agg were carried out in such a way that input files used and designed for previous versions of StatePP will run as before if the MNW flag is set to zero or omitted in the control file.

Agg Modifications

The program Agg is a preprocessor for StatePP that assigns agricultural wells to specific structures (canals) and individual parcels of land. This program was modified to read the new data required for StatePP to generate a multi-node well file and write this data to the irrigated wells output file. No processing of this data occurs within Agg. It is simply passed through from input to output for use in StatePP. Updated documentation of Agg to include this capability is shown in the Agg documentation in Appendix L.

4.0 Summary and Conclusions

Task 50.4 completed the enhancements to the SPDSS data-centered groundwater modeling process recommended in the Task 50.3 TM by undertaking the following:

- developing a database for measured groundwater data, engineering control data and model-specific data,
- developing an ArcGIS geodatabase for groundwater spatial data,
- developing custom ArcGIS tools and outside scripting to facilitate the development of the SFR2 modeling package,
- creating a DMI to convert a GMS grid to ArcGIS format,
- developing detailed procedures for preparing modeling datasets in GMS, and
- modifying DMIs to improve their functionality.

These enhancements will allow modelers to more quickly create, update, and interpret modeling results. Detailed procedures used to implement each of these enhancements are included in Appendices A through L.

The enhancements were made based on the current understanding of the model requirements. If the modeling requirements change, the databases and tools could be updated accordingly.

5.0 Recommendations

A guiding principle in the modifications to the data-centered groundwater modeling process was to automate steps in the process that were considered to be repetitive and where automation would streamline the modeling process. Therefore, many modeling steps were left as manual procedures because the effort to automate them did not justify the efficiency gained through automation. As the data-centered modeling process is implemented it may become apparent that some of the manual procedures should be automated. It is recommended such procedures be considered for automation as they are encountered during the Phase 4 Task 48 modeling activities.

The Task 50 data centered modeling enhancements were evaluated during the Phase 3 Task 48 modeling. The Task 48 modeling allowed the tools to be tested with actual modeling applications, and refinements were made to the tools to improve their functionality based on this phase of the modeling. It is anticipated during the Phase 4 Task 48 modeling new elements will be introduced to the modeling process that may require future enhancements to the Task 50 data centered modeling process. It is recommended such enhancements to the modeling process and related tools be considered as future modeling efforts require.

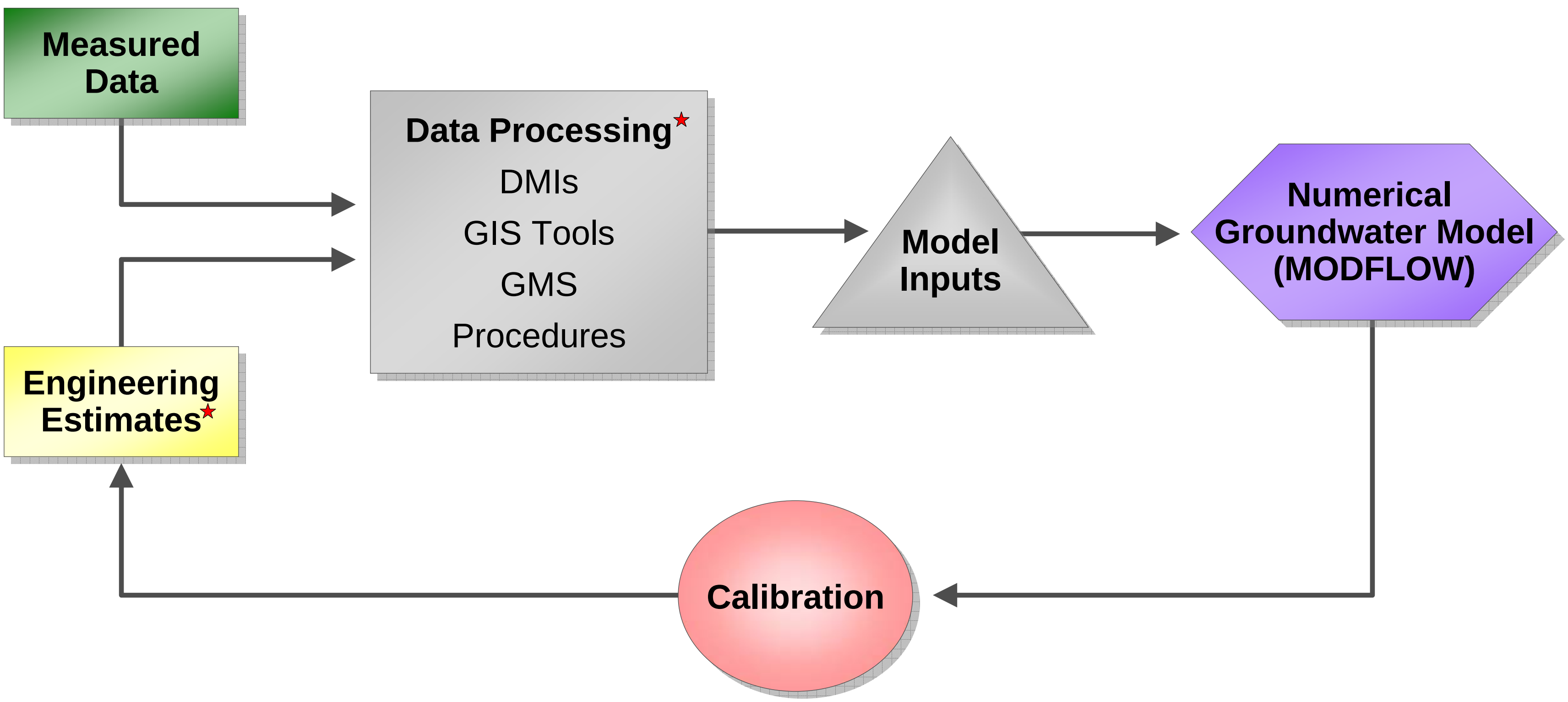
6.0 References

Halford, K.J. and Hanson R.T., 2002, User Guide for the Drawdown-Limited, Multi-Node Well (MNW) Package for the U.S. Geological Survey's Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, Versions MODFLOW-96 and MODFLOW-2000: U.S. Geological Survey Open-File Report 02-293, 33 p.

Niswonger, R.G. and Prudic, D.E., 2006, Documentation of the Streamflow-Routing (SFR2) Package to Include Unsaturated Flow Beneath Streams--A modification to SFR1 Techniques: U.S. Geological Survey Techniques and Methods, Book 6, Chap. A13. April.

SPDSS Phase 3 Task 50.4

Figure 1: Overview of SPDSS Groundwater Data Centered Modeling Process



*Enhanced in Task 50.4

COLORADO DIVISION OF WATER RESOURCES
DEPARTMENT OF NATURAL RESOURCES

State of Colorado
Department of Natural Resources
Colorado Water Conservation Board
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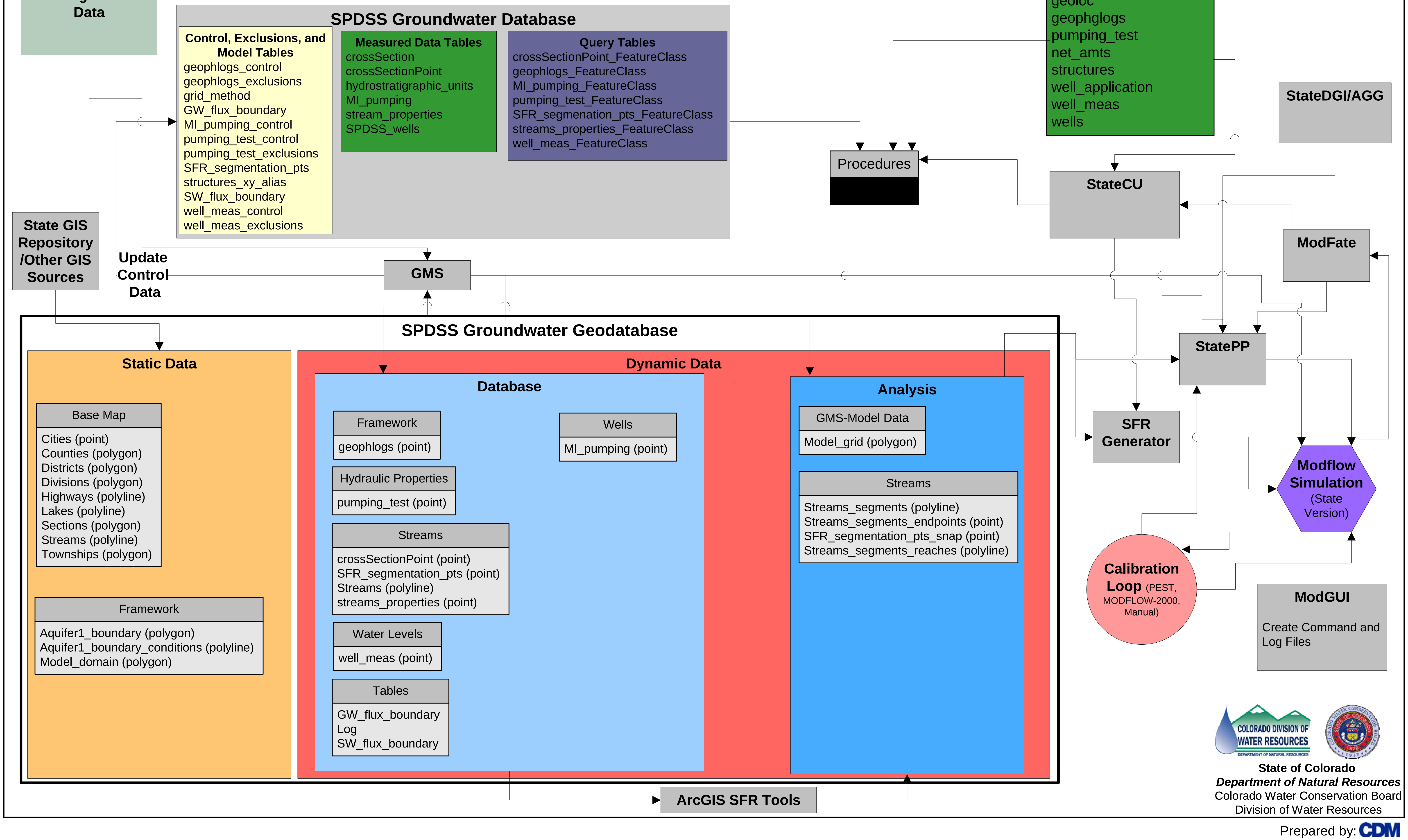
Figure 2: SPDSS Groundwater Data Centered Modeling Process



SPDSS Phase 3 Task 50.4

Figure 3: Development of the Streamflow-Routing Package (SFR2)

Update Parameters

Calibration

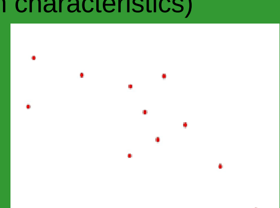
SPDSS Groundwater Database

SFR_segmentation_pts

identifier: Unique SFR segmentation point identifier
streamID: Unique identifier for the stream or diversion to be segmented
utm_x: UTM NAD83 zone 13N coordinates (meters)
utm_y: UTM NAD83 zone 13N coordinates (meters)
node_type:Type of node, either fnode or tnode.
tributary: Name of the tributary that flows in at that point
diversion: Name of the diversion diverting from the point
gage: Name of the streamflow gage at that point
icalc: Method used by the SFR package to calculate depth of water in channel
roughCH: Manning's roughness for channel
roughBK: Manning's roughness for overbank
cpth: Power coeffecient of stream depth
fdpth: Power coeffecient of stream depth
awdth: Power coeffecient of stream width
bwdth: Power coeffecient of stream width
hcond: Vertical Hydraulic conductivity of the streambed
thickm: Streambed thickness
elev: Streambed elevation
width: Streambed width
depth: Depth of water in the channell
xcpt(1-8): Distance from the left bank of the stream channel when looking downstream.
zcpt(1-8): Height relative to the lowest elevation of the streambed (thalweg)
comment: Comments
modified: Date record was last modified.
user: User who last modified the record.

SFR_segmentation_pts (fc)

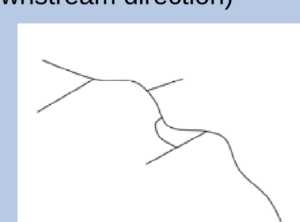
(Locations of diversions, tributaries, streamflow gages, and stream characteristics)



State GIS Repository /Other GIS Sources

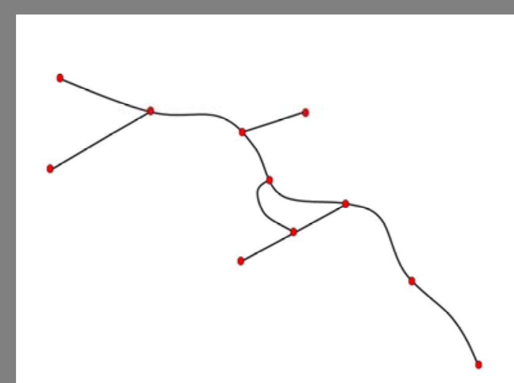
Streams (fc)

(dissolved to contain one feature per stream and features digitized in downstream direction)



Snap and Split Tool

Tool snaps points to the nearest stream with matching identifier and then splits the stream at that point.
Input: SFR_segmentation_pts (fc), Streams (fc)
Output: SFR_segmentation_pts_snap (fc), Streams_segments (fc)

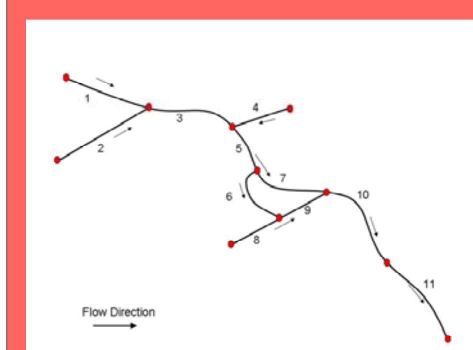


Network Creation

Creates a network from Streams_segments (fc).
Input: Streams_segments (fc)
Output: Streams_net (network)

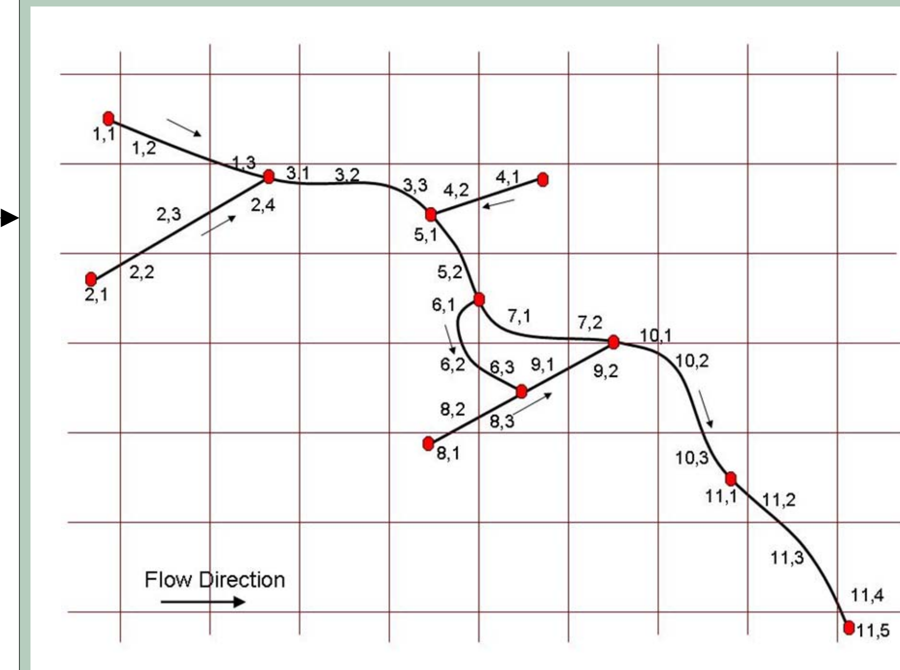
Segment Numbering Tool

Tool assigns to attribute table the SegmentID which is the order of segments from upstream to downstream.
Input: Streams_net (network)
Output: Streams_segments_endpoints (fc)



Create Reaches Tool

Tool creates reaches by intersecting the Streams_segments (fc) with the Model_grid (fc). After creating reaches, the reaches are then numbered in ascending order from upstream to downstream and the length of each feature is added to the attribute table in feet.
Input: Streams_segments (fc), Model_grid (fc)
Output: Streams_segments_reaches (fc)



Attribute Fill Tool

Tool performs a spatial and attribute join to assign attributes from SFR_segmentation_pts_snap (fc) to Streams_segments_endpoints (fc). Attributes of Streams_segments_endpoints (fc) are then linearly (stream miles) or constantly interpolated for all points.
Input: SFR_segmentation_pts_snap (fc), Streams_segments_endpoints (fc)
Ouput: Attributes populated in Streams_segments_endpoints (fc)

SFR Generator

The SFR Generator converts the attribute tables of the feature classes to MODFLOW 2000 SFR1 package format.

State of Colorado
Department of Natural Resources
Colorado Water Conservation Board
Division of Water Resources

Prepared by: CDM

Appendix A

Phase 3 Task 50.4, Documentation of the SPDSS_GW_Database

Appendix A: Documentation of the SPDSS_GW_database

Final

March 30, 2007

The purpose of this documentation is to outline the structure of the SPDSS_GW_database and the steps required to load and maintain data, link the database to external data sources, and run queries to combine data for export to the SPDSS_GW_geodatabase. This documentation assumes the user has basic familiarity with Microsoft Access software and the SPDSS data centered process. Refer to the Task 50.4 TM to understand how the SPDSS_GW_database relates to the entire data centered modeling process.

1.0 Structure of the Database

The SPDSS_GW_database contains the following types of data tables: measured data, control data, exclusion data, model-specific data. In addition to storing data in local data tables, the database also contains links to tables in a stored procedure copy of HydroBase, Colorado's hydrological database. Finally, the SPDSS_GW_database has queries that combine data in the local tables with linked tables to create datasets for export to the geodatabase.

1.1 Local Data Tables

Some measured datasets are not suitable for inclusion in HydroBase but are necessary for SPDSS groundwater modeling. Tables created in the SPDSS_GW_database for these types of data include:

- crossSection
- crossSectionPoint
- MI_pumping
- SPDSS_wells
- stream_properties

Control tables contain data needed to improve the data density in the HydroBase or SPDSS_GW_database measured data tables. The control tables possess the same structure as their related measured data tables. Control tables in the SPDSS_GW_database include:

- geophlogs_control
- MI_pumping_control
- pumping_test_control
- well_meas_control

Exclusion tables identify the measured data in HydroBase not suitable for modeling. Data not suitable for modeling are identified by an analyst during data analysis and model setup. If a data value marked as excluded in the exclusions table is modified in HydroBase and becomes suitable for modeling, the exclusion table can be manually modified to no longer exclude the value. Exclusions tables include:

- geophlogs_exclusions
- pumping_test_exclusions
- well_meas_exclusions

Model-specific data tables in the SPDSS_GW_database contain data specific to modeling setup. Such data includes fluxes into the model at the model boundary, model layering information, and characteristics for establishing the SFR package. The model-specific tables include:

- grid_method
- GW_flux_boundary
- hydrostratigraphic_Units
- structures_xy_alias
- SFR_segmentation_pts
- SW_flux_boundary

1.2 Linked Data Tables

Linked tables from HydroBase are necessary so data from HydroBase can be combined with the data in the SPDSS_GW_database to create datasets for model processing. At the inception of a project, the user must navigate to the location of the stored procedure copy of HydroBase and then create links to the following tables:

- geophlogs
- pumping_test
- well_meas
- wells

1.3 Queries

The SPDSS_GW_database has queries programmed to initiate through the database's Main Switchboard. These queries are used to create tables for exporting out of the database for model processing in the SPDSS_GW_Geodatabase. When the database is opened the Main Switchboard opens automatically. It can also be accessed under Forms.

The Switchboard has check boxes beside each category of data. When checked, macros will initiate a series of queries which create tables for export to the geodatabase. The general query process follows this pattern:

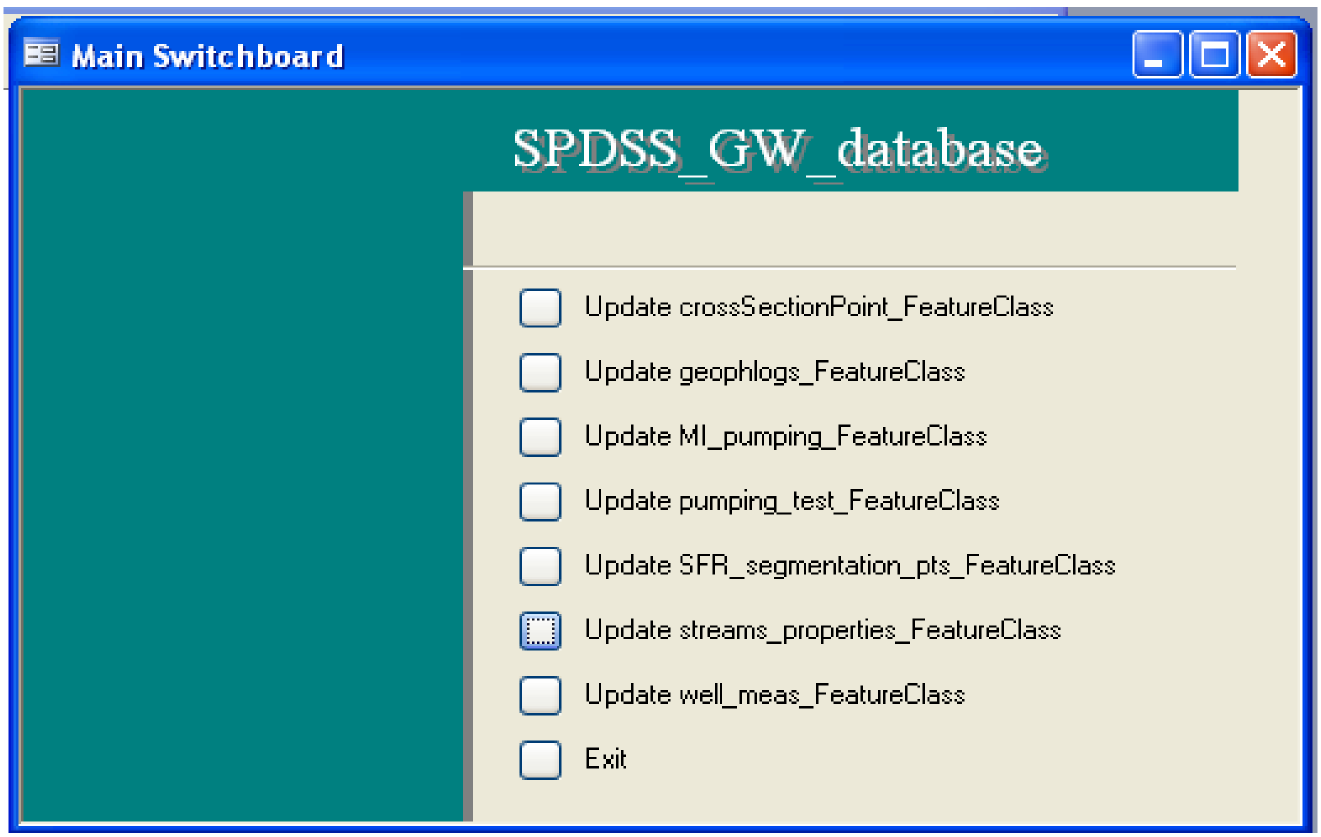
1. A new table is made from the linked HydroBase table,
2. Values in the Exclusion table are removed from the new table,
3. Values in the Control table are appended to the new table, and finally

4. Two fields are added to the new table to track the date the query was run and the name of the analyst who initiated the query.

The tables created by the queries should never be modified manually, and should only be refreshed by using the Main Switchboard. The tables created by these queries include:

- crossSectionPoint_FeatureClass
- geophlogs_FeatureClass
- MI_pumping_FeatureClass
- pumping_test_FeatureClass
- SFR_segmenation_pts_FeatureClass
- streams_properties_FeatureClass
- well_meas_FeatureClass

Additional queries can be created, as needed, by the analyst to assist in populating and modifying the measured, control, exclusion, and modeling tables in the database.



2.0 Software Requirements

The database can be viewed, managed, and modified using Microsoft Access 2003. The database has not been tested with other editions of Microsoft Access.

3.0 Sources and Loading of Data

The SPDSS_GW_database contains data from a variety of sources which are described below.

The linked HydroBase tables come from a stored procedure copy of HydroBase which can be obtained from the Colorado Division of Water Resource's (DWR) database manager.

SPDSS_GW_database measured data tables are populated from data gathered through SPDSS project tasks or other sources. The data can either be directly entered into the table or loaded from external spreadsheet sources with database queries.

Exclusions tables are populated with HydroBase data screened by an analyst based on their review of the HydroBase data. The excluded data can either be directly entered into the table or loaded from external spreadsheet sources with database queries.

Control tables are populated with data developed by the analyst after review of existing measured data. The data can either be directly entered into the table or loaded from external spreadsheet sources with database queries.

Modeling tables are populated by an analyst based on the modeling design. The data can either be directly entered into the table or loaded from external spreadsheet sources with database queries.

4.0 Maintaining Data

The SPDSS_GW_database is designed to be updated as new data become available or modeling objectives are modified.

When new HydroBase data become available, the Hydrobase table links should be re-mapped to the latest stored procedure copy of HydroBase.

When new SPDSS_GW_database measured data become available, the records should be appended to the data tables. If values to existing records need modification, the values should be modified and the user should always update the [modified] and [user] fields. These fields track the date and the user responsible for the modification.

When new measured data from either HydroBase or within the SPDSS_GW_database become available, the exclusions and control tables will likely need to be modified. New measured data might make a control value unnecessary. Modifications to measured data may require a value be unmarked as excluded, which could also make a control value unnecessary. The exclusions and control tables are designed to maintain a historical record of data used as control or marked as excluded. Records in these tables should never be deleted. Rather both exclusions and control tables have fields which can be checked to identify if the record should or should not be used for model processing. These check fields have corresponding date and user fields to track the modifications to the table.

When modifications are made to any of the aforementioned tables, queries from the Main Switchboard should be run to refresh the "*FeatureClass" tables for export to the geodatabase.

5.0 Log Procedure

The SPDSS_GW_database tables all contain user and date fields to track the modifications to the tables. In some cases these fields are populated manually while in other cases the fields are populated automatically through queries. In either case, it is imperative the fields are populated to document changes to data used for modeling.

6.0 Database Dictionary

The following tables identify the purpose of each tables, the fields the table contains, and the description of each field.

Table 1: Database Table Descriptions

Table Name	Table Description
crossSection	Streambed geometry cross section data.
crossSectionPoint	Streambed geometry cross section profile data.
crossSectionPoint_FeatureClass	Data from the crossSectionPoint table to be used for creating a feature class in the SPDSS_GW_geodatabase.
geophlogs	Linked table from HydroBase containing geophysical log picks determined by the DWR. This data is entered into the database such that for each log a separate record is used for each aquifer's picks.
geophlogs_control	Engineering estimates to complement the data in the geophlogs table.
geophlogs_exclusions	Lists the values in the geophlogs table that have been excluded by an analyst from the development of modeling inputs.
geophlogs_FeatureClass	A combination of the data from geophlogs, geophlogs_control, and geophlogs_exclusions to be used for creating a feature class in the SPDSS_GW_geodatabase.
grid_method	Stores the gridding methodology and parameters used to grid layers for the model.
GW_flux_boundary	Groundwater fluxes at the model boundary.
hydrostratigraphic_units	Model layers.
MI_pumping	Municipal and Industrial pumping records.
MI_pumping_control	Engineering estimates to complement the data in the MI_pumping table.
MI_pumping_FeatureClass	A combination of the data from MI_pumping and MI_pumping_control to be used for creating a feature class in the SPDSS_GW_geodatabase.
pumping_test	Linked table from HydroBase containing aquifer hydraulic properties test results.
pumping_test_control	Engineering estimates to complement the data in the pumping_test table.
pumping_test_exclusions	Lists the values in the pumping_test table that have been excluded by an analyst from the development of modeling inputs.
pumping_test_FeatureClass	A combination of the data from pumping_test, pumping_test_control, and pumping_test_exclusions to be used for creating a feature class in the SPDSS_GW_geodatabase.
SFR_segmentation_pts	The location of points and their characteristics for defining the stream segments for the SFR1 Modflow package.
SFR_segmentation_pts_FeatureClass	Data from the SFR_segmentation_pts table to be used for creating a feature class in the SPDSS_GW_geodatabase.

Table Name	Table Description
SPDSS_wells	Contains key information on wells including location, permit number, receipt, name, depth, aquifer tapped, and perforated interval.
streams_properties	Vertical conductivity and gradient values from streambed testing.
streams_properties_FeatureClass	Data from streams_properties to be used for creating a feature class in the SPDSS_GW_geodatabase.
structures_xy_alias	Alternative coordinates for structure locations to be used for modeling.
SW_flux_boundary	Surface water fluxes at the model boundary.
well_meas	Linked table from HydroBase containing depth to water and water level elevation time series data.
well_meas_control	Engineering estimates to complement the data in the well_meas table.
well_meas_exclusions	Lists the values in the well_meas table that have been excluded by an analyst from the development of modeling inputs.
well_meas_FeatureClass	A combination of the data from well_meas, well_meas_control, and well_meas_exclusions to be used for creating a feature class in the SPDSS_GW_geodatabase.
wells	Linked table from HydroBase containing key information on wells including location, permit number, receipt, name, depth, aquifer tapped, and perforated interval.

Table 2: Database Field Descriptions

Table Name	Field Name	Field Data Type	Field Size	Field Description
crossSection	RiverCode	dbText	30	Stream identifier
crossSection	CSCode	dbText	30	Unique identifier for a cross section line
crossSection	length	dbDouble	8	Length of the cross section line (feet)
crossSection	utm_x	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
crossSection	utm_y	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
crossSection	modified	dbDate	8	Date record was last modified.
crossSection	user	dbText	10	User who last modified the record.
crossSectionPoint	CSCode	dbText	30	Unique identifier for a cross section line
crossSectionPoint	utm_x	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
crossSectionPoint	utm_y	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
crossSectionPoint	CrossM	dbDouble	8	The linear measure location of a point along the cross section line, measured from the left side of the line when looking downstream

Table Name	Field Name	Field Data Type	Field Size	Field Description
crossSectionPoint	elevation	dbDouble	8	Elevation above mean sea level for a cross section point (NAVD 88)
crossSectionPoint	Thalweg	dbBoolean	1	Identifies the point of lowest elevation along the cross section line in the channel of main flow.
crossSectionPoint	modified	dbDate	8	Date record was last modified.
crossSectionPoint	user	dbText	10	User who last modified the record.
crossSectionPoint_FeatureClass	CSCode	dbText	30	Unique identifier for a cross section line
crossSectionPoint_FeatureClass	utm_x	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
crossSectionPoint_FeatureClass	utm_y	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
crossSectionPoint_FeatureClass	CrossM	dbDouble	8	The linear measure location of a point along the cross section line, measured from the left side of the line when looking downstream
crossSectionPoint_FeatureClass	elevation	dbDouble	8	Elevation above mean sea level for a cross section point (NAVD 88)
crossSectionPoint_FeatureClass	Thalweg	dbBoolean	1	Identifies the point of lowest elevation along the cross section line in the channel of main flow.
crossSectionPoint_FeatureClass	modified	dbDate	8	Date record was last modified.
crossSectionPoint_FeatureClass	user	dbText	10	User who last modified the record.
crossSectionPoint_FeatureClass	query_date	dbDate	8	Date information was queried from origin file.
crossSectionPoint_FeatureClass	query_user		510	User who performed the query.
geophlogs	well_id	dbLong	4	Well identifier.
geophlogs	aquifer	dbText	4	Aquifer.
geophlogs	logid	dbLong	4	[Not Used]
geophlogs	glogtop	dbInteger	2	Upper elevation of the specified aquifer. (feet above sea level)
geophlogs	glogbase	dbInteger	2	Lower elevation of the specified aquifer. (feet above sea level)
geophlogs	glogthickness	dbInteger	2	Thickness of the sand. (feet)
geophlogs	Orig_1986	dbBoolean	1	Boolean used to indicate if the well was used in the 1986 study.

Table Name	Field Name	Field Data Type	Field Size	Field Description
geophlogs	Comment	dbText	100	Comment field
geophlogs	modified	dbDate	8	Date record was last modified.
geophlogs	user	dbText	10	User who last modified the record.
geophlogs_control	control_ID	dbText	50	Unique identifier.
geophlogs_control	aquifer	dbText	4	Aquifer.
geophlogs_control	utm_x	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
geophlogs_control	utm_y	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
geophlogs_control	glogtop	dbInteger	2	Upper elevation of the specified aquifer. (feet above sea level)
geophlogs_control	glogbase	dbInteger	2	Lower elevation of the specified aquifer. (feet above sea level)
geophlogs_control	glogthickness	dbInteger	2	Thickness of the sand. (feet)
geophlogs_control	comment	dbText	100	Comment field to indicate source of control and reason for control exclusion if applicable
geophlogs_control	date_append	dbDate	8	Date record appended to table
geophlogs_control	analyst_append	dbText	50	Name of analyst that provided control
geophlogs_control	exclude	dbBoolean	1	Yes indicates control no longer needed
geophlogs_control	date_excluded	dbDate	8	Date control excluded
geophlogs_control	analyst_excluded	dbText	50	Name of analyst that excluded control
geophlogs_exclusions	well_id	dbLong	4	Well identifier. Foreign key from [wells].
geophlogs_exclusions	aquifer	dbText	4	Aquifer.
geophlogs_exclusions	Exclude_field	dbText	50	Indicates the data field to exclude from the HydroBase Geophlogs table, either glogtop, glogbase, or glogthickness
geophlogs_exclusions	Value_excluded	dbLong	4	Value exlucded, either elevation for glotop and glogbase or net sands thickness for glogthickness
geophlogs_exclusions	date_modified	dbDate	8	Date of last modification; value obtained from HydroBase when exclusion was made
geophlogs_exclusions	comment	dbText	50	Comment field to indicate reason for exclusion and reason for not excluding if applicable

Table Name	Field Name	Field Data Type	Field Size	Field Description
geophlogs_exclusions	Date_excluded	dbDate	8	Date excluded
geophlogs_exclusions	Analyst_excluded	dbText	50	Name of analyst that excluded value
geophlogs_exclusions	Not_excluded	dbBoolean	1	Yes indicates value from HydroBase no longer excluded
geophlogs_exclusions	Date_not_excluded	dbDate	8	Date value not excluded
geophlogs_exclusions	Analyst_not_excluded	dbText	50	Name of analyst that determined value should not be excluded
geophlogs_FeatureClass	well_id	dbText	255	Well identifier.
geophlogs_FeatureClass	well_name	dbText	60	Name of the well.
geophlogs_FeatureClass	permitno	dbLong	4	Well permit number.
geophlogs_FeatureClass	permitsuf	dbText	3	Well suffix code.
geophlogs_FeatureClass	utm_x		16	UTM NAD83 zone 13N coordinates (meters)
geophlogs_FeatureClass	utm_y		16	UTM NAD83 zone 13N coordinates (meters)
geophlogs_FeatureClass	logid	dbLong	4	[Not Used]
geophlogs_FeatureClass	glogtop	dbInteger	2	Upper elevation of the specified aquifer. (feet above sea level)
geophlogs_FeatureClass	glogbase	dbInteger	2	Lower elevation of the specified aquifer. (feet above sea level)
geophlogs_FeatureClass	glogthickness	dbInteger	2	Thickness of the sand. (feet)
geophlogs_FeatureClass	Orig_1986	dbBoolean	1	Boolean used to indicate if the well was used in the 1986 study.
geophlogs_FeatureClass	Comment	dbText	100	Comment field
geophlogs_FeatureClass	modified	dbDate	8	Date record was last modified.
geophlogs_FeatureClass	user	dbText	10	User who last modified the record.
geophlogs_FeatureClass	date_append	dbDate	8	Date record appended to table
geophlogs_FeatureClass	analyst_append	dbText	50	Name of analyst that provided control
geophlogs_FeatureClass	query_date	dbDate	8	Date information was queried from origin file.
geophlogs_FeatureClass	query_user		510	User who performed the query.
grid_method	grid	dbText	50	Name of the grid
grid_method	method	dbText	255	Description of the grid parameters used to develop the grid such as algorithm, grid spacing, search radius, etc.
GW_flux_boundary	gw_bound_ID	dbText	50	Unique identifier
GW_flux_boundary	date	dbDate	8	Format is Month/Year

Table Name	Field Name	Field Data Type	Field Size	Field Description
				(MM/YYYY)
GW_flux_boundary	flux	dbDouble	8	feet^3/day
GW_flux_boundary	comment	dbText	255	Comments
GW_flux_boundary	modified	dbDate	8	Date record was last modified.
GW_flux_boundary	user	dbText	20	User who last modified the record.
hydrostratigraphic_units	layer_number	dbLong	4	Model layer number
hydrostratigraphic_units	unit_name	dbText	50	Hydrostratigraphic unit name
hydrostratigraphic_units	modified	dbDate	8	Date record was last modified.
hydrostratigraphic_units	user	dbText	20	User who last modified the record.
MI_pumping	well_id	dbText	50	ID for SPDSS T30 Historical M&I pumping data
MI_pumping	cal_year	dbInteger	2	Calendar Year
MI_pumping	cal_month	dbInteger	2	Calendar Month
MI_pumping	amt	dbLong	4	Volume pumped in Acre-feet
MI_pumping	unit	dbText	50	Units for the amt, Units should be Acre-feet
MI_pumping	quality	dbText	1	Quality code which defines the uncertainty factor of th data, and is developed from the observation code and frequency of the original raw measurements
MI_pumping	source	dbText	50	Source of data
MI_pumping	comment	dbText	50	Miscellaneous comments
MI_pumping	modified	dbDate	8	Date of last modification
MI_pumping	user	dbText	50	User name of last modifcation
MI_pumping_control	control_id	dbText	50	Unique identifier
MI_pumping_control	aquifer	dbText	4	Aquifer.
MI_pumping_control	utm_x	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
MI_pumping_control	utm_y	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
MI_pumping_control	cal_year	dbInteger	2	Calendar Year
MI_pumping_control	cal_month	dbInteger	2	Calendar Month
MI_pumping_control	amt	dbLong	4	Volume pumped in Acre-feet
MI_pumping_control	unit	dbText	50	Units for the amt, Units should be Acre-feet
MI_pumping_control	quality	dbText	1	Quality code which defines the uncertainty factor of th data, and is developed from the observation code

Table Name	Field Name	Field Data Type	Field Size	Field Description
				and frequency of the original raw measurements
MI_pumping_control	modified	dbDate	8	Date of last modification
MI_pumping_control	user	dbText	50	User name of last modifcation
MI_pumping_control	comment	dbText	100	Comment field to indicate source of control and reason for control exclusion if applicable
MI_pumping_control	date_append	dbDate	8	Date record appended to table
MI_pumping_control	analyst_append	dbText	50	Name of analyst that provided control
MI_pumping_control	exclude	dbBoolean	1	Yes indicates control no longer needed
MI_pumping_control	date_excluded	dbDate	8	Date control excluded
MI_pumping_control	analyst_excluded	dbText	50	Name of analyst that excluded control
MI_pumping_FeatureClass	well_id	dbText	50	Well identifier.
MI_pumping_FeatureClass	well_name	dbText	60	Name of the well.
MI_pumping_FeatureClass	permitno	dbLong	4	Well permit number.
MI_pumping_FeatureClass	permitsuf	dbText	3	Well suffix code.
MI_pumping_FeatureClass	id	dbLong	4	Identifier
MI_pumping_FeatureClass	wdid	dbLong	4	SEO Water district.
MI_pumping_FeatureClass	utm_x		16	UTM NAD83 zone 13N coordinates (meters)
MI_pumping_FeatureClass	utm_y		16	UTM NAD83 zone 13N coordinates (meters)
MI_pumping_FeatureClass	aquifer1	dbText	4	Aquifer in which well is located.
MI_pumping_FeatureClass	aquifer2	dbText	4	If well is located in two aquifers, name of second aquifer.
MI_pumping_FeatureClass	cal_year	dbInteger	2	Calendar Year
MI_pumping_FeatureClass	cal_month	dbInteger	2	Calendar Month
MI_pumping_FeatureClass	amt	dbLong	4	Volume pumped in Acre-feet
MI_pumping_FeatureClass	unit	dbText	50	Units for the amt, Units should be Acre-feet
MI_pumping_FeatureClass	quality	dbText	1	Quality code which defines the uncertainty factor of th data, and is developed from the observation code and frequency of the original raw measurements
MI_pumping_FeatureClass	source	dbText	50	Source of data
MI_pumping_FeatureClass	comment	dbText	50	Miscellaneous comments
MI_pumping_FeatureClass	modified	dbDate	8	Date of last modification
MI_pumping_FeatureClass	user	dbText	50	User name of last

Table Name	Field Name	Field Data Type	Field Size	Field Description
				modifcation
MI_pumping_FeatureClass	date_append	dbDate	8	Date record appended to table
MI_pumping_FeatureClass	analyst_append	dbText	50	Name of analyst that provided control
MI_pumping_FeatureClass	query_date	dbDate	8	Date information was queried from origin file.
MI_pumping_FeatureClass	query_user		510	User who performed the query.
pumping_test	pump_test_num	dbLong	4	Unique pump test identifier.
pumping_test	well_id	dbLong	4	Well identifier. Foreign key from [wells].
pumping_test	testdate	dbDate	8	Date of the pump test.
pumping_test	toptestint	dbLong	4	Top of tested interval (FT).
pumping_test	basetestint	dbLong	4	Base of tested interval (FT).
pumping_test	tswl	dbSingle	4	Pre-test static water level measured in feet from ground level. Pressure head above ground level is given as a negative value.
pumping_test	tfwl	dbSingle	4	Post-test final water level measured in feet from ground level. Pressure head above ground level is given as a negative value.
pumping_test	drawdown	dbSingle	4	Change in feet between pretest water level and end of test water level. Pressure head above ground level is given as a negative number.
pumping_test	testq	dbSingle	4	Average testing discharge rate measured in gallons per minute.
pumping_test	testtime	dbSingle	4	Time in hours that the test was conducted.
pumping_test	trans	dbLong	4	Estimated transmissivity in gallons per day per foot (gpd/ft).
pumping_test	k	dbText	40	Hydraulic conductivity measured in feet per day (ft/day).
pumping_test	storativity	dbText	40	Storativity (dimensionless-can only be calculated from confined aquifer tests with one or more monitoring wells.
pumping_test	leakance	dbText	40	Composite leakance between aquifer layers in units of 1/Days.

Table Name	Field Name	Field Data Type	Field Size	Field Description
pumping_test	ptsource	dbText	25	Entity reporting the pump test data. CDWR= Colorado Division of Water Resources, CBP = Closed Basin Project (subset of USBR), CWCB 11 = Colorado Water Conservation Board circular #11.
pumping_test	pttype	dbText	25	Pump test type. Either pumping, recovery, slug, flow, or other.
pumping_test	ptmon	dbBoolean	1	Indicates observation point available for test.
pumping_test	ptobs	dbBoolean	1	Check box indicating if the pump test included observation well data. Observation wells must be screened in the same aquifer as the pumping well.
pumping_test	ptobs_well	dbBoolean	1	Data from the observation well
pumping_test	ptmultiple	dbBoolean	1	Flag indicating the presence of multiple pump tests available for a well.
pumping_test	sp_cap	dbSingle	4	gpm/ft
pumping_test	sp_yield	dbSingle	4	Specific yield (decimal percent)
pumping_test	porosity	dbSingle	4	Porosity (decimal percent)
pumping_test	B	dbLong	4	Saturated thickness (feet)
pumping_test	comments	dbText	255	Pump test comments.
pumping_test_control	control_ID	dbText	50	Unique identifier.
pumping_test_control	utm_x	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
pumping_test_control	utm_y	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
pumping_test_control	aquifer	dbText	50	Aquifer
pumping_test_control	Kh	dbText	50	Horizonal hydraulic conductivity (ft/day).
pumping_test_control	Kv	dbText	50	Vertical hydraulic conductivity (ft/day).
pumping_test_control	storativity	dbText	50	Storativity (dimensionless- can only be calculated from confined aquifer tests with one or more monitoring wells).
pumping_test_control	K_ratio	dbText	50	Ratio of Kv/Kh
pumping_test_control	comment	dbText	100	Comment field to indicate source of control and reason for control

Table Name	Field Name	Field Data Type	Field Size	Field Description
				exclusion if applicable
pumping_test_control	date_append	dbDate	8	Date record appended to table
pumping_test_control	analyst_append	dbText	50	Name of analyst that provided control
pumping_test_control	exclude	dbBoolean	1	Yes indicates control no longer needed
pumping_test_control	date_excluded	dbDate	8	Date control excluded
pumping_test_control	analyst_excluded	dbText	50	Name of analyst that excluded control
pumping_test_exclusions	pump_test_num	dbLong	4	Unique pump test identifier.
pumping_test_exclusions	Exclude_field	dbText	50	Indicates the data field to exclude from the HydroBase Geophlogs table, either glogtop, glogbase, or glogthickness
pumping_test_exclusions	Value_excluded	dbLong	4	Value exlucded, either elevation for glotop and glogbase or net sands thickness for glogthickness
pumping_test_exclusions	date_modified	dbDate	8	Date of last modification; value obtained from HydroBase when exclusion was made
pumping_test_exclusions	comment	dbText	50	Comment field to indicate reason for exclusion and reason for not excluding if applicable
pumping_test_exclusions	Date_excluded	dbDate	8	Date excluded
pumping_test_exclusions	Analyst_excluded	dbText	50	Name of analyst that excluded value
pumping_test_exclusions	Not_excluded	dbBoolean	1	Yes indicates value from HydroBase no longer excluded
pumping_test_exclusions	Date_not_excluded	dbDate	8	Date value not excluded
pumping_test_exclusions	Analyst_not_excluded	dbText	50	Name of analyst that determined value should not be excluded
pumping_test_FeatureClass	well_id	dbText	255	Well identifier. Foreign key from [wells].
pumping_test_FeatureClass	well_name	dbText	60	Name of the well.
pumping_test_FeatureClass	permitno	dbLong	4	Well permit number.
pumping_test_FeatureClass	permitsuf	dbText	3	Well suffix code.
pumping_test_FeatureClass	utm_x		16	UTM NAD83 zone 13N coordinates (meters)
pumping_test_FeatureClass	utm_y		16	UTM NAD83 zone 13N coordinates (meters)
pumping_test_FeatureClass	aquifer1	dbText	4	Aquifer in which well is located.

Table Name	Field Name	Field Data Type	Field Size	Field Description
pumping_test_FeatureClass	aquifer2	dbText	4	If well is located in two aquifers, name of second aquifer.
pumping_test_FeatureClass	pump_test_num	dbLong	4	Unique pump test identifier.
pumping_test_FeatureClass	testdate	dbDate	8	Date of the pump test.
pumping_test_FeatureClass	toptestint	dbLong	4	Top of tested interval (FT).
pumping_test_FeatureClass	basetestint	dbLong	4	Base of tested interval (FT).
pumping_test_FeatureClass	tswl	dbSingle	4	Pre-test static water level measured in feet from ground level. Pressure head above ground level is given as a negative value.
pumping_test_FeatureClass	tfwl	dbSingle	4	Post-test final water level measured in feet from ground level. Pressure head above ground level is given as a negative value.
pumping_test_FeatureClass	drawdown	dbSingle	4	Change in feet between pretest water level and end of test water level. Pressure head above ground level is given as a negative number.
pumping_test_FeatureClass	testq	dbSingle	4	Average testing discharge rate measured in gallons per minute.
pumping_test_FeatureClass	testtime	dbSingle	4	Time in hours that the test was conducted.
pumping_test_FeatureClass	trans	dbLong	4	Estimated transmissivity in gallons per day per foot (gpd/ft).
pumping_test_FeatureClass	k	dbText	255	Hydraulic conductivity measured in feet per day (ft/day).
pumping_test_FeatureClass	storativity	dbText	255	Storativity (dimensionless- can only be calculated from confined aquifer tests with one or more monitoring wells).
pumping_test_FeatureClass	leakance	dbText	40	Composite leakance between aquifer layers in units of 1/Days.
pumping_test_FeatureClass	ptsource	dbText	25	Entity reporting the pump test data. CDWR= Colorado Division of Water Resources, CBP = Closed Basin Project (subset of USBR), CWCB 11 = Colorado Water Conservation Board

Table Name	Field Name	Field Data Type	Field Size	Field Description
				circular #11.
pumping_test_FeatureClass	pttype	dbText	25	Pump test type. Either pumping, recovery, slug, flow, or other.
pumping_test_FeatureClass	ptmon	dbBoolean	1	Indicates observation point available for test.
pumping_test_FeatureClass	ptobs	dbBoolean	1	Check box indicating if the pump test included observation well data. Observation wells must be screened in the same aquifer as the pumping well.
pumping_test_FeatureClass	ptobs_well	dbBoolean	1	Data from the observation well
pumping_test_FeatureClass	ptmultiple	dbBoolean	1	Flag indicating the presence of multiple pump tests available for a well.
pumping_test_FeatureClass	sp_cap	dbSingle	4	gpm/ft
pumping_test_FeatureClass	sp_yield	dbSingle	4	Specific yield (decimal percent)
pumping_test_FeatureClass	porosity	dbSingle	4	Porosity (decimal percent)
pumping_test_FeatureClass	B	dbLong	4	Saturated thickness (feet)
pumping_test_FeatureClass	comments	dbText	255	Pump test comments.
pumping_test_FeatureClass	Kv	dbText	255	Vertical hydraulic conductivity (ft/day).
pumping_test_FeatureClass	K_ratio	dbText	255	Ratio of Kv/Kh
pumping_test_FeatureClass	date_append	dbText	255	Date record appended to table
pumping_test_FeatureClass	analyst_append	dbText	255	Name of analyst that provided control
pumping_test_FeatureClass	query_date	dbDate	8	Date information was queried from origin file.
pumping_test_FeatureClass	query_user		510	User who performed the query.
SFR_segmentation_pts	identifier	dbText	20	Unique SFR segmentation point identifier
SFR_segmentation_pts	streamID	dbText	50	Unique identifier for the stream or diversion to be segmented
SFR_segmentation_pts	utm_x	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
SFR_segmentation_pts	utm_y	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
SFR_segmentation_pts	node_type	dbText	10	Type of node, either fnode or tnode.
SFR_segmentation_pts	tributary	dbText	50	Name of the tributary that flows in at that point

Table Name	Field Name	Field Data Type	Field Size	Field Description
SFR_segmentation_pts	diversion	dbText	50	Name of the diversion diverting from the point- Use HydroBase Structure ID
SFR_segmentation_pts	gage	dbText	50	Name of the streamflow gage at that point
SFR_segmentation_pts	icalc	dbInteger	2	Method used by the SFR package to calculate depth of water in channel
SFR_segmentation_pts	roughch	dbSingle	4	Manning's roughness for channel
SFR_segmentation_pts	roughbk	dbSingle	4	Manning's roughness for overbank
SFR_segmentation_pts	cdpth	dbSingle	4	Power coeffecient of stream depth (width = cdpth*Q^fdpth)
SFR_segmentation_pts	fdpth	dbSingle	4	Power coeffecient of stream depth (width = cdpth*Q^fdpth)
SFR_segmentation_pts	awdth	dbSingle	4	Power coeffecient of stream width (width = awdth*Q^bwdth)
SFR_segmentation_pts	bwdth	dbSingle	4	Power coeffecient of stream width (width = awdth*Q^bwdth)
SFR_segmentation_pts	hcond	dbSingle	4	Vertical Hydraulic conductivity of the streambed (feet/day)
SFR_segmentation_pts	thickm	dbSingle	4	Streambed thickness (feet)
SFR_segmentation_pts	elev	dbDouble	8	Streambed thickness (feet)
SFR_segmentation_pts	width	dbSingle	4	Streambed width (feet)
SFR_segmentation_pts	depth	dbSingle	4	Depth of water in streambed (feet)
SFR_segmentation_pts	xcpt1	dbSingle	4	Distance from the left bank of the stream channel when looking downstream. By default xcpt1 is 0.0. (feet)
SFR_segmentation_pts	xcpt2	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).
SFR_segmentation_pts	xcpt3	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).
SFR_segmentation_pts	xcpt4	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).
SFR_segmentation_pts	xcpt5	dbSingle	4	Distance from the left bank of the stream channel

Table Name	Field Name	Field Data Type	Field Size	Field Description
				when looking downstream (feet).
SFR_segmentation_pts	xcpt6	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).
SFR_segmentation_pts	xcpt7	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).
SFR_segmentation_pts	xcpt8	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).
SFR_segmentation_pts	zcpt1	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt1 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts	zcpt2	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt2 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts	zcpt3	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt3 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts	zcpt4	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt4 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts	zcpt5	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt5 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts	zcpt6	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at

Table Name	Field Name	Field Data Type	Field Size	Field Description
				location xcpt6 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts	zcpt7	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt7 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts	zcpt8	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt8 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts	comment	dbText	255	Comments
SFR_segmentation_pts	modified	dbDate	8	Date record was last modified.
SFR_segmentation_pts	user	dbText	20	User who last modified the record.
SFR_segmentation_pts_FeatureClass	identifier	dbText	20	Unique SFR segmentation point identifier
SFR_segmentation_pts_FeatureClass	streamID	dbText	50	Unique identifier for the stream or diversion to be segmented
SFR_segmentation_pts_FeatureClass	utm_x	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
SFR_segmentation_pts_FeatureClass	utm_y	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
SFR_segmentation_pts_FeatureClass	node_type	dbText	10	Type of node, either fnode or tnode.
SFR_segmentation_pts_FeatureClass	tributary	dbText	50	Name of the tributary that flows in at that point
SFR_segmentation_pts_FeatureClass	diversion	dbText	50	Name of the diversion diverting from the point- Use HydroBase Structure ID
SFR_segmentation_pts_FeatureClass	gage	dbText	50	Name of the streamflow gage at that point
SFR_segmentation_pts_FeatureClass	icalc	dbInteger	2	Method used by the SFR package to calculate depth of water in channel
SFR_segmentation_pts_FeatureClass	roughch	dbSingle	4	Manning's roughness for channel
SFR_segmentation_pts_FeatureClass	roughbk	dbSingle	4	Manning's roughness for overbank
SFR_segmentation_pts_FeatureClass	cdpth	dbSingle	4	Power coeffecient of stream depth (width = cdpth*Q^fdpth)

Table Name	Field Name	Field Data Type	Field Size	Field Description
SFR_segmentation_pts_FeatureClass	fdpth	dbSingle	4	Power coeffecient of stream depth (width = cdpth*Q^fdpth)
SFR_segmentation_pts_FeatureClass	awdth	dbSingle	4	Power coeffecient of stream width (width = awdth*Q^bwdth)
SFR_segmentation_pts_FeatureClass	bwdth	dbSingle	4	Power coeffecient of stream width (width = awdth*Q^bwdth)
SFR_segmentation_pts_FeatureClass	hcond	dbSingle	4	Vertical Hydraulic conductivity of the streambed (feet/day)
SFR_segmentation_pts_FeatureClass	thickm	dbSingle	4	Streambed thickness (feet)
SFR_segmentation_pts_FeatureClass	elev	dbDouble	8	Streambed thickness (feet)
SFR_segmentation_pts_FeatureClass	width	dbSingle	4	Streambed width (feet)
SFR_segmentation_pts_FeatureClass	depth	dbSingle	4	Depth of water in streambed (feet)
SFR_segmentation_pts_FeatureClass	xcpt1	dbSingle	4	Distance from the left bank of the stream channel when looking downstream. By default xcpt1 is 0.0. (feet)
SFR_segmentation_pts_FeatureClass	xcpt2	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).
SFR_segmentation_pts_FeatureClass	xcpt3	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).
SFR_segmentation_pts_FeatureClass	xcpt4	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).
SFR_segmentation_pts_FeatureClass	xcpt5	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).
SFR_segmentation_pts_FeatureClass	xcpt6	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).
SFR_segmentation_pts_FeatureClass	xcpt7	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).
SFR_segmentation_pts_FeatureClass	xcpt8	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).

Table Name	Field Name	Field Data Type	Field Size	Field Description
SFR_segmentation_pts_FeatureClass	zcpt1	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt1 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts_FeatureClass	zcpt2	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt2 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts_FeatureClass	zcpt3	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt3 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts_FeatureClass	zcpt4	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt4 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts_FeatureClass	zcpt5	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt5 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts_FeatureClass	zcpt6	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt6 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts_FeatureClass	zcpt7	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt7 (feet). The thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts_FeatureClass	zcpt8	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at location xcpt8 (feet). The

Table Name	Field Name	Field Data Type	Field Size	Field Description
				thalweg (set equal to 0.0) can be located at xcpt2 to xcpt7.
SFR_segmentation_pts_FeatureClass	comment	dbText	255	Comments
SFR_segmentation_pts_FeatureClass	modified	dbDate	8	Date record was last modified.
SFR_segmentation_pts_FeatureClass	user	dbText	20	User who last modified the record.
SFR_segmentation_pts_FeatureClass	query_date	dbDate	8	Date information was queried from origin file.
SFR_segmentation_pts_FeatureClass	query_user	dbText	255	User who performed the query.
SPDSS_wells	well_id	dbText	50	Well identifier.
SPDSS_wells	well_name	dbText	60	Name of the well.
SPDSS_wells	div	dbInteger	2	SEO Division number.
SPDSS_wells	wd	dbInteger	2	SEO Water district.
SPDSS_wells	receipt	dbText	8	Unique identifer. Generated by cash register.
SPDSS_wells	permitno	dbLong	4	Well permit number.
SPDSS_wells	permitsuf	dbText	3	Well suffix code.
SPDSS_wells	permitrpl	dbText	1	Well replacement code. Contains an ’A’ for exempt, and ’R’ for non-exempt.
SPDSS_wells	locnum	dbText	50	USBR location identifier string.
SPDSS_wells	Site_ID	dbText	50	USGS site identifier.
SPDSS_wells	basin	dbText	50	Designated basin code.
SPDSS_wells	md	dbText	2	Management district code.
SPDSS_wells	cty	dbInteger	2	County code.
SPDSS_wells	PM	dbText	1	Principle meridian.
SPDSS_wells	ts	dbInteger	2	Township number
SPDSS_wells	tsa	dbText	1	Half township indicator.
SPDSS_wells	tdir	dbText	1	Township direction.
SPDSS_wells	rng	dbInteger	2	Range number.
SPDSS_wells	rnga	dbText	1	Half range indicator.
SPDSS_wells	rdir	dbText	1	Range direction.
SPDSS_wells	sec	dbInteger	2	Section number.
SPDSS_wells	seca	dbText	1	Upper section indicator.
SPDSS_wells	q160	dbText	2	160 acre quarter section indicator.
SPDSS_wells	q40	dbText	2	40 acre quarter section indicator.
SPDSS_wells	q10	dbText	2	10 acre quarter section indicator.
SPDSS_wells	coordsns	dbInteger	2	Distance from north/south section line (feet).
SPDSS_wells	coordsns_dir	dbText	1	Direction of measurement from north/south section

Table Name	Field Name	Field Data Type	Field Size	Field Description
				line.
SPDSS_wells	coordsew	dbInteger	2	Distance from east/west section line (feet).
SPDSS_wells	coordsew_dir	dbText	1	Direction of measurement from east/west section line.
SPDSS_wells	utm_x		16	The x (Easting) component of the Universal Transverse Mercator system. NAD83 Zone 13.
SPDSS_wells	utm_y		16	The y (Northing) component of the Universal Transverse Mercator system. NAD83 Zone 13.
SPDSS_wells	latdecdeg		16	Latitude (decimal degrees).
SPDSS_wells	longdecdeg		16	Longitude (decimal degrees).
SPDSS_wells	loc_accuracy	dbInteger	2	Horizontal location accuracy indicator.
SPDSS_wells	gs_elev	dbSingle	4	Ground surface elevation.
SPDSS_wells	elev_accuracy	dbInteger	2	Vertical location accuracy indicator.
SPDSS_wells	well_depth	dbLong	4	Completed depth of well (feet).
SPDSS_wells	log_depth	dbLong	4	Geophysical log measurement depth.
SPDSS_wells	log_type	dbText	20	Geophysical log measurement method.
SPDSS_wells	log_SWL	dbLong	4	Geophysical log measurement surface water level.
SPDSS_wells	log_date	dbDate	8	Geophysical log measurement date of measurement.
SPDSS_wells	aquifer1	dbText	4	Aquifer in which well is located.
SPDSS_wells	aquifer2	dbText	4	If well is located in two aquifers, name of second aquifer.
SPDSS_wells	aquifer_comment	dbText	255	Any comments associated with the aquifer(s) that the well transverses.
SPDSS_wells	tperf	dbLong	4	Depth to top of first perforated casing. (FEET)
SPDSS_wells	bperf	dbLong	4	Depth to base of last perforated casing. (FEET)
SPDSS_wells	yield	dbSingle	4	Actual pumping rate. (GPM)
SPDSS_wells	bedrock_elev	dbSingle	4	Elevation of bedrock.
SPDSS_wells	sat_1965	dbSingle	4	

Table Name	Field Name	Field Data Type	Field Size	Field Description
SPDSS_wells	remarks1	dbText	255	Generic remarks.
SPDSS_wells	remarks2	dbText	255	Generic remarks.
SPDSS_wells	owner	dbText	50	Owner's fullname.
SPDSS_wells	address	dbText	255	Address of owner.
SPDSS_wells	city	dbText	50	City.
SPDSS_wells	st	dbText	2	State abbreviation.
SPDSS_wells	zip	dbText	10	Zip code.
SPDSS_wells	phone	dbText	20	Phone number.
SPDSS_wells	cell_phone	dbText	20	Cell phone number.
SPDSS_wells	email	dbText	50	E-mail address or internet address.
SPDSS_wells	collection_order	dbText	4	Water level collection number. Used to indicate route to gather WL measurements.
SPDSS_wells	data_source_id	dbText	50	A unique identifer of the data. Either the Site_ID or the locnum string.
SPDSS_wells	data_source	dbText	10	Source of data.
SPDSS_wells	publish?	dbBoolean	1	Boolean indicating if well is part of DWR's water level publications.
SPDSS_wells	geoplog?	dbBoolean	1	Boolean indicating if well is part of DWR's geophysical log archive.
SPDSS_wells	modified	dbDate	8	Date record was last modified.
SPDSS_wells	user	dbText	3	User who last modified the record.
SPDSS_wells	id	dbLong	4	Hydrobase structure identifier
SPDSS_wells	wdid	dbLong	4	Water district structure identifier
streams_properties	ID	dbText	50	Unique Identifier
streams_properties	utm_x	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
streams_properties	utm_y	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
streams_properties	k	dbDouble	8	Streambed hydraulic conductivity (ft/day)
streams_properties	gradient	dbLong	4	Stream-aquifer head gradient. Positive values indicate a gaining stream (ft)
streams_properties	source	dbText	50	Source of the data.
streams_properties	modified	dbDate	8	Date record was last modified.
streams_properties	user	dbText	10	User who last modified the record.
streams_properties_FeatureClass	ID	dbText	50	Unique Identifier

Table Name	Field Name	Field Data Type	Field Size	Field Description
streams_properties_FeatureClass	utm_x	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
streams_properties_FeatureClass	utm_y	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
streams_properties_FeatureClass	k	dbDouble	8	Streambed hydraulic conductivity (ft/day)
streams_properties_FeatureClass	gradient	dbLong	4	Stream-aquifer head gradient. Positive values indicate a gaining stream (ft)
streams_properties_FeatureClass	source	dbText	50	Source of the data.
streams_properties_FeatureClass	modified	dbDate	8	Date record was last modified.
streams_properties_FeatureClass	user	dbText	10	User who last modified the record.
streams_properties_FeatureClass	query_date	dbDate	8	Date information was queried from origin file.
streams_properties_FeatureClass	query_user		510	User who performed the query.
structures_xy_alias	id	dbLong	4	Hydrobase structure identifier
structures_xy_alias	utm_x_alias		16	The alias x (Easting) component of the Universal Transverse Mercator system in NAD83 Zone 13 for modeling.
structures_xy_alias	utm_y_alias		16	The alias y (Northing) component of the Universal Transverse Mercator system in NAD83 Zone 13 for modeling.
SW_flux_boundary	segment_ID	dbLong	4	Unique identifier assigned with SFR tool (must be updated every time new segmentation point is added to the SFR package)
SW_flux_boundary	stream_name	dbText	50	Name of Stream
SW_flux_boundary	date	dbDate	8	Format is Month/Year (MM/YYYY)
SW_flux_boundary	flux	dbDouble	8	feet^3/day
SW_flux_boundary	modified	dbDate	8	Date record was last modified.
SW_flux_boundary	user	dbText	25	User who last modified the record.
well_meas	well_id	dbLong	4	Well identifier. Foreign key from [wells].
well_meas	meas_date	dbDate	8	Date of water level measurement.
well_meas	wl_depth	dbDouble	8	Depth of water from measurement point. (FEET)

Table Name	Field Name	Field Data Type	Field Size	Field Description
well_meas	mp_height	dbDouble	8	Height of measurement point above ground. (FEET)
well_meas	wl_depth_calc	dbDouble	8	Depth of water below ground surface. (FEET)
well_meas	wl_elevation_calc	dbDouble	8	Elevation of water level. (Feet above sea level)
well_meas	meas_by	dbText	6	Person who made the water level measurement.
well_meas	modified	dbDate	8	Date record was last modified.
well_meas	user	dbText	3	User who last modified the record.
well_meas_control	control_ID	dbText	50	Unique identifier.
well_meas_control	utm_x	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
well_meas_control	utm_y	dbDouble	8	UTM NAD83 zone 13N coordinates (meters)
well_meas_control	aquifer	dbText	50	Aquifer
well_meas_control	meas_date	dbDate	8	Date of water level measurement.
well_meas_control	wl_elevation	dbDouble	8	Elevation of water level. (Feet above sea level)
well_meas_control	comment	dbText	100	Comment field to indicate source of control and reason for control exclusion if applicable
well_meas_control	date_append	dbDate	8	Date record appended to table
well_meas_control	analyst_append	dbText	50	Name of analyst that provided control
well_meas_control	exclude	dbBoolean	1	Yes indicates control no longer needed
well_meas_control	date_excluded	dbDate	8	Date control excluded
well_meas_control	analyst_excluded	dbText	50	Name of analyst that excluded control
well_meas_exclusions	well_id	dbText	50	Well identifier. Foreign key from [wells].
well_meas_exclusions	meas_date	dbDate	8	Date of water level measurement.
well_meas_exclusions	wl_elevation	dbDouble	8	Elevation of water level. (Feet above sea level)
well_meas_exclusions	date_modified	dbDate	8	Date of last modification
well_meas_exclusions	comment	dbText	50	Comment field to indicate reason for exclusion
well_meas_exclusions	Date_excluded	dbDate	8	Date excluded
well_meas_exclusions	Analyst_excluded	dbText	50	Name of analyst that excluded value
well_meas_exclusions	Not_excluded	dbBoolean	1	Yes indicates value from HydroBase no longer excluded

Table Name	Field Name	Field Data Type	Field Size	Field Description
well_meas_exclusions	Date_not_excluded	dbDate	8	Date value not excluded
well_meas_exclusions	Analyst_not_excluded	dbText	50	Name of analyst that determined value should not be excluded
well_meas_FeatureClass	well_id	dbText	255	Well identifier. Foreign key from [wells].
well_meas_FeatureClass	well_name	dbText	60	Name of the well.
well_meas_FeatureClass	permitno	dbLong	4	Well permit number.
well_meas_FeatureClass	permitsuf	dbText	3	Well suffix code.
well_meas_FeatureClass	utm_x		16	UTM NAD83 zone 13N coordinates (meters)
well_meas_FeatureClass	utm_y		16	UTM NAD83 zone 13N coordinates (meters)
well_meas_FeatureClass	aquifer1	dbText	4	Aquifer in which well is located.
well_meas_FeatureClass	aquifer2	dbText	4	If well is located in two aquifers, name of second aquifer.
well_meas_FeatureClass	meas_date	dbDate	8	Date of water level measurement.
well_meas_FeatureClass	wl_depth	dbDouble	8	Depth of water from measurement point. (FEET)
well_meas_FeatureClass	mp_height	dbDouble	8	Height of measurement point above ground. (FEET)
well_meas_FeatureClass	wl_depth_calc	dbDouble	8	Depth of water below ground surface. (FEET)
well_meas_FeatureClass	wl_elevation_calc	dbDouble	8	Elevation of water level. (Feet above sea level)
well_meas_FeatureClass	comment	dbText	100	Comment field to indicate source of control and reason for control exclusion if applicable
well_meas_FeatureClass	meas_by	dbText	6	Person who made the water level measurement.
well_meas_FeatureClass	modified	dbDate	8	Date record was last modified.
well_meas_FeatureClass	user	dbText	3	User who last modified the record.
well_meas_FeatureClass	date_append	dbDate	8	Date record appended to table
well_meas_FeatureClass	analyst_append	dbText	50	Name of analyst that provided control
well_meas_FeatureClass	query_date	dbDate	8	Date information was queried from origin file.
well_meas_FeatureClass	query_user		510	User who performed the query.
wells	well_id	dbLong	4	Well identifier.
wells	well_name	dbText	60	Name of the well.
wells	div	dbInteger	2	SEO Division number.

Table Name	Field Name	Field Data Type	Field Size	Field Description
wells	wd	dbInteger	2	SEO Water district.
wells	receipt	dbText	8	Unique identifer. Generated by cash register.
wells	permitno	dbLong	4	Well permit number.
wells	permitsuf	dbText	3	Well suffix code.
wells	permitrpl	dbText	1	Well replacement code. Contains an 'A' for exempt, and 'R' for non-exempt.
wells	locnum	dbText	50	USBR location identifier string.
wells	Site_ID	dbText	50	USGS site identifier.
wells	basin	dbText	50	Designated basin code.
wells	md	dbText	2	Management district code.
wells	cty	dbInteger	2	County code.
wells	PM	dbText	1	Principle meridian.
wells	ts	dbInteger	2	Township number
wells	tsa	dbText	1	Half township indicator.
wells	tdir	dbText	1	Township direction.
wells	rng	dbInteger	2	Range number.
wells	rnga	dbText	1	Half range indicator.
wells	rdir	dbText	1	Range direction.
wells	sec	dbInteger	2	Section number.
wells	seca	dbText	1	Upper section indicator.
wells	q160	dbText	2	160 acre quarter section indicator.
wells	q40	dbText	2	40 acre quarter section indicator.
wells	q10	dbText	2	10 acre quarter section indicator.
wells	coordsns	dbInteger	2	Distance from north/south section line (feet).
wells	coordsns_dir	dbText	1	Direction of measurement from north/south section line.
wells	coordsew	dbInteger	2	Distance from east/west section line (feet).
wells	coordsew_dir	dbText	1	Direction of measurement from east/west section line.
wells	utm_x		16	The x (Easting) component of the Universal Transverse Mercator system. NAD83 Zone 13.
wells	utm_y		16	The y (Northing) component of the Universal Transverse Mercator system. NAD83 Zone 13.
wells	latdecdeg		16	Latitude (decimal degrees).

Table Name	Field Name	Field Data Type	Field Size	Field Description
wells	longdecdeg		16	Longitude (decimal degrees).
wells	loc_accuracy	dbInteger	2	Horizontal location accuracy indicator.
wells	gs_elev	dbSingle	4	Ground surface elevation.
wells	elev_accuracy	dbInteger	2	Vertical location accuracy indicator.
wells	well_depth	dbLong	4	Completed depth of well (feet).
wells	log_depth	dbLong	4	Geophysical log measurement depth.
wells	log_type	dbText	20	Geophysical log measurement method.
wells	log_SWL	dbLong	4	Geophysical log measurement surface water level.
wells	log_date	dbDate	8	Geophysical log measurement date of measurement.
wells	aquifer1	dbText	4	Aquifer in which well is located.
wells	aquifer2	dbText	4	If well is located in two aquifers, name of second aquifer.
wells	aquifer_comment	dbText	255	Any comments associated with the aquifer(s) that the well transverses.
wells	tperf	dbLong	4	Depth to top of first perforated casing. (FEET)
wells	bperf	dbLong	4	Depth to base of last perforated casing. (FEET)
wells	yield	dbSingle	4	Actual pumping rate. (GPM)
wells	bedrock_elev	dbSingle	4	Elevation of bedrock.
wells	sat_1965	dbSingle	4	
wells	remarks1	dbText	255	Generic remarks.
wells	remarks2	dbText	255	Generic remarks.
wells	owner	dbText	50	Owner's fullname.
wells	address	dbText	255	Address of owner.
wells	city	dbText	50	City.
wells	st	dbText	2	State abbreviation.
wells	zip	dbText	10	Zip code.
wells	phone	dbText	20	Phone number.
wells	cell_phone	dbText	20	Cell phone number.
wells	email	dbText	50	E-mail address or internet address.
wells	collection_order	dbText	4	Water level collection number. Used to indicate route to gather WL measurements.

Table Name	Field Name	Field Data Type	Field Size	Field Description
wells	data_source_id	dbText	50	A unique identifer of the data. Either the Site_ID or the locnum string.
wells	data_source	dbText	10	Source of data.
wells	publish?	dbBoolean	1	Boolean indicating if well is part of DWR's water level publications.
wells	geoplog?	dbBoolean	1	Boolean indicating if well is part of DWR's geophysical log archive.
wells	modified	dbDate	8	Date record was last modified.
wells	user	dbText	3	User who last modified the record.
wells	cdm_id	dbText	30	TEMPORARY - Identifer originally given to well by CDM in SPDSS project.
wells	cmd_modified	dbDate	8	TEMPORARY - Date the record was last modified by CDM.

Appendix B

Phase 3 Task 50.4, Documentation of the SPDSS GW Geodatabase

Appendix B: Documentation of the SPDSS GW Geodatabase

Final

March 30, 2007

The purpose of this documentation is to outline the structure of the SPDSS_GW_geodatabase and the steps required to load and maintain spatial datasets in the geodatabase. This documentation assumes the user has basic familiarity with ArcGIS software, the geodatabase model, and Microsoft Acess.

1.0 Structure of the Geodatabase

The SPDSS_GW_geodatabase.mdb contains the following types of data: feature classes, rasters, and tables. These spatial data are stored in the root geodatabase and also in feature datasets. Feature datasets are similar to folders in a Windows operating system, because they allow the spatial datasets to be organized and stored thematically. The feature datasets present in the SPDSS_GW_geodatabase.mdb are:

- Base_Map
- Framework
- Hydraulic_Properties
- Streams
- Water_Levels
- Wells

When creating feature datasets, it is necessary to define the coordinate system and spatial extent for the dataset. The coordinate system should be set to NAD 83 UTM Zone 13N. The spatial extent should be set equal to the extent of the most expansive spatial dataset it will contain. For most feature datasets, the spatial extent will be equal to the extent of the model area. The Base_Map feature dataset is set to the extent of the state of Colorado, as some of the spatial datasets cover the entire state.

2.0 Software Requirements

The geodatabase can be viewed, managed, and modified using ArcGIS ArcCatalog and ArcMap or Microsoft Access.

3.0 Sources and Loading of Data

The geodatabase contains spatial data from three broad categories. The categories are data imported from outside sources, data imported from the SPDSS_GW_database, and data created from analysis of data in the geodatabase.

3.1 Data from Outside Sources

Spatial data from outside sources include, but are not limited to:

- Aquifer Boundary
- Aquifer Boundary Conditions
- Counties
- Cities
- Districts
- Divisions
- Highways
- Lakes
- Model Domain
- Model Grid
- Sections
- Streams
- Townships

Spatial data from outside sources are loaded into the geodatabase by using the file import options.

1. First navigate to where the files should be imported, either the root geodatabase or a feature dataset.

2. Right-Click and select Import

3. Select the data type to import, either Feature Class, Table, or Raster (the Raster-mosaic option will not be used). Each of these has the option to either import a single dataset or multiple datasets at one time.

4. Follow the directions provided by the import wizard.

3.2 Data Imported from the SPDSS_GW_database.mdb

Data imported from the SPDSS_GW_database.mdb are stored as linked tables or as feature classes generated from the tables.

Tables imported from the SPDSS_GW_database.mdb include:

- SW_flux_boundary

Tables imported and converted to feature classes from the SPDSS_GW_database.mdb are identified in Table 1.

Table 1: Correlation of Database Tables to Geodatabase Feature Classes

SPDSS_GW_Database.mdb Table	SPDSS_GW_Geodatabase.mdb Feature Class
crossSectionPoint_FeatureClass	crossSectionPoint
geophlogs_FeatureClass	geophlogs
MI_pumping_FeatureClass	MI_pumping
pumping_test_FeatureClass	pumping_test
SFR_segmentation_pt_FeatureClasss	SFR_segmentation_pts
streams_properties_FeatureClass	streams_properties
well_meas_FeatureClass	well_meas

3.2.1 Linking tables from the SPDSS_GW_database.mdb.

1. Open the SPDSS_GW_geodtabase.mdb in Microsoft Access

2. File→Get External Data→Link Tables→Navigate to the SPDSS_GW_database.mdb and click "Import"→Select the table SW_flux_boundary and click "Ok"

3.2.2 Converting a Table to a Feature Class

1. Open ArcMap

2. Tools→Add XY Data

   a) Navigate to the table in the SPDSS_GW_database.mdb

   b) Select the X and Y fields

   c) Click "Edit" and choose the correct Spatial Reference system (HydroBase data are stored in NAD 1983 UTM Zone 13N)

   d) Click "Ok"

3. Right click on the new XY Event Layer→Data→Export Data→Navigate to the SPDSS_GW_geodatabase.mdb and save the file in the appropriate Feature Dataset. The feature class name should be the same as the source table name without the "_FeatureClass".

3.3 Data created from the analysis of datasets in the SPDSS_GW_geodatabase.mdb

The custom ArcGIS tools developed to generate the Stream-Flow Routing (SFR1) package analyze feature classes in the Streams feature dataset and create new feature classes stored in the same feature dataset.. Appendices C to G document how feature classes are created with the SFR ArcGIS tools.

4.0 Maintaining Data in the Geodatabase

The SPDSS_GW_Geodatabase.mdb is designed to contain only the most current working version of the spatial data. It is not designed to contain previous versions of spatial data. Therefore, when significant changes are to be made to the geodatabase, it is recommended that a copy of the goedatabase be made and archived with a suffix of the date added to the filename.

When spatial data need to be updated, the old data should first be deleted or simply overwritten with the new data.

5.0 Log Procedure

The SPDSS_GW_Geodatabase contains a table call *Log*, which tracks the data added to or modified in the geodatabase. The table has fields for the filename, analyst, date, and comment used to document the file modified, by whom, when, and the nature of the modification. The table must be manually updated by the analyst each time a modification to the geodatabase is made. Entries to the table can be made in Microsoft Access or during an editing session in ArcMap.

Appendix C

Phase 3 Task 50.4, Documentation of Snap and Split Tool

Appendix C: Documentation of Snap and Split Tool

Final

Version 1.0 March 30, 2007

The Snap and Split tool splits streams into segments for the MODFLOW 2000 SFR2 package based on the location of user defined points. A segment is a portion of a stream with constant or linearly varying characteristics. The Snap and Split tool is one of several tools created to assist in the development of the SFR1 package. A description of the entire SFR1 development process is described in the report of the Task 50.4 TM. This documentation assumes the user has basic familiarity with ArcGIS software. It is recommended when processing data in geodatabases, ArcCatalog remain closed when using this tool. This helps prevent unwanted schema lock errors.

0.0 Disclaimer

This program is furnished by the State of Colorado (State) and is accepted and used by the recipient upon the expressed understanding that the State makes no warranties, express or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information and data contained in this program or furnished in connection therewith, and the State shall be under no liability whatsoever to any person by reason of any use made thereof.

The program herein belongs to the State of Colorado. Therefore, the recipient further agrees not to assert any proprietary rights therein or to further represent this program to anyone as other than a State program

1.0 Revision History

Version 1.0 of the Snap and Split tool was developed by Camp Dresser & McKee (CDM) for the South Platte Decision Support System (SPDSS) in January 2007.

2.0 Installation

The tool was developed in Visual Basic for Applications (VBA) and is embedded in the master document *CDSS_SFR1_Development.mxd*. A new instance of this document is copied to the working directory at project initiation. No other installation is necessary. This tool requires ArcMap version 9.1 to run. After opening the file *CDSS_SFR1_Development.mxd* in ArcMap the CDSS SFR Tools toolbar

will be present. The Snap and Split tool is initiated by clicking the button, enclosed in the red box on the figure to the left, located on the custom CDSS SFR Tools toolbar.

3.0 Program Description

The Snap and Split tool snaps point features to polyline features if the maximum search radius and attribute matching criteria are met. The search radius indicates the maximum distance a point can be displaced from its original location to its snapped location on the polyline. The attribute matching criteria is that a point can only be snapped to a polyline with the same value in their respective join fields. The point is snapped to the polyline following the shortest distance to the polyline. Once the point is snapped, if it is less than approximately 3 feet from a polyline endpoint it will be moved to the endpoint. This prevents the creation of new polyline features with a length of less than approximately 3 feet. The polyline can then be split into new features based on the location of the snapped points.

4.0 Input File Description

Input files consist of

1. The polyline feature class, *Streams* (feature class (fc)) and

2. The point feature class, *SFR_segmentation_pts* (fc),

which are located in the Streams (feature dataset (fd)) of the *SPDSS_GW_geodatabase.mdb*.

The polyline feature class, *Streams* , represents the streams and diversion canals to be modeled with the SFR1 package. This feature class can either be created directly by an analyst or imported from an existing stream coverage such as the USGS National Hydrography Dataset. The dataset must be created or modified to meet the requirements discussed below.

The feature class must only contain features to be modeled and each feature must have a unique identifier, such as the stream name. The field containing the unique identifier will be used to join with a similar field in the point feature class.

The feature class must only contain one feature per stream or diversion. If the source feature class has more than one feature per stream or diversion, the features should be generalized on the unique identifier so that only one feature remains per unique identifier. Generalization can be done in ArcGIS with a tool in ArcToolbox under Data Management Tools → Generalization → Dissolve.

The direction of digitization for each feature must be consistent with the direction of streamflow. This direction of digitization can be modified in ArcMap when in editing mode by right-clicking on the feature and using the Flip command.

The feature class must contain a field called *Str_Order* (or other name chosen by the analyst), which identifies the stream order of the system. For this application the main stem stream is given an order of one, a tributary an order of two, a tributary of a tributary an order of three, and so on. An order greater than four has not been tested, and is not expected to be needed for regional scale modeling. Diversion canals are ordered as follows: a diversion canal from the main stem is -1, a diversion canal from a tributary is -2, and a diversion canal from a tributary of a tributary is -3, and so on.

Finally, in the *Streams* layer there cannot be any intersection of features or disconnected features. For example, a tributary line cannot cross the main stem and neither can it end before the main stem. The tributary must be snapped to the main stem line. When developing the *Streams* layer, it is recommended the ArcGIS snapping environment be used to enforce these rules.

The point feature class, *SFR_segmentation_pts,* is generated from the table in the SPDSS_GW_database.mdb called *SFR_segmentation_pts_FeatureClass.* These points represent the characteristics of the streams required by the MODFLOW SFR1 package and where the streams should be segmented. The feature class contains a field, [StreamID] with values common to the field with the unique identifier values in the *Streams* (fc). The [StreamID] values identify the stream or diversion to which the point should be snapped.

The following requirements must be followed when populating the table "Streams_segmentation_pts":

1. The unique identifier of the stream to be segmented by the point must be specified.

2. Stream depth calculation method and all required characteristics will be specified for most upstream point (fnode) of every stream or diversion. Table 1 identifies the characteristics which are required for each calculation method.

3. At any location where an analyst determines there is a significant change in a stream characteristic, a point must be generated and the stream characteristic must be given a value.

4. If the analyst changes the stream depth calculation method, a point is created and all characteristics unique to that calculation method must be defined in the table.

5. Characteristics such as hydraulic conductivity and streambed elevation that can be linearly interpolated between segments must be specified at the most downstream point (tnode) of every stream or diversion. If no downstream hydraulic conductivity value is specified then the value will be populated as a constant for downstream segments.

6. All points must be identified as an fnode, starting point, or tnode, ending point, of a segment. All points should be set to fnode unless the point specifies the hydraulic conductivity or streambed elevation values for the most downstream point of the stream or diversion.

5.0 Output Files Description

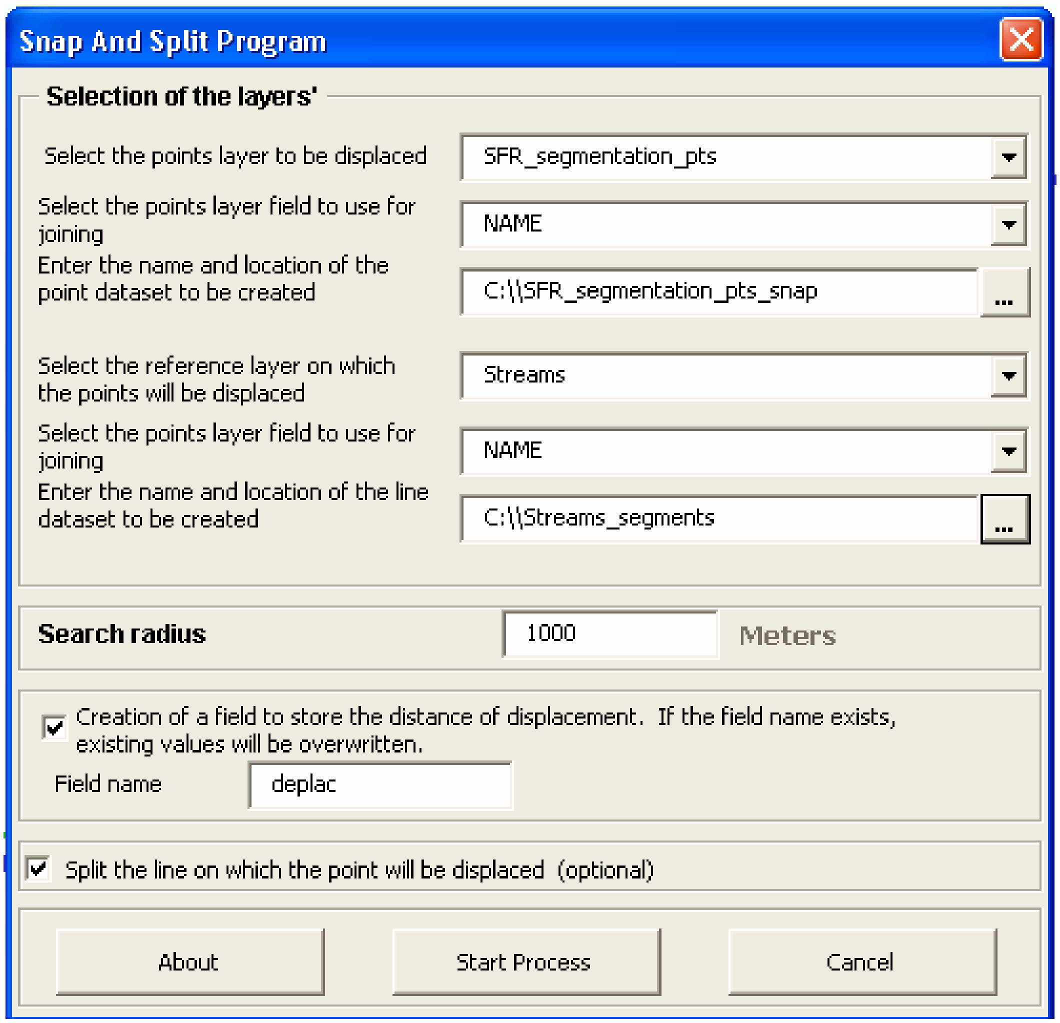
The output consists of:

1. A point feature class.

2. A polyline feature class.

The point feature class contains the new location of the points snapped to the polyline, and the default filename given by the Snap and Split tool is *SFR_segmentation_pts_snap* (fc). The polyline feature class contains the streams and diversion from *Streams* (fc) split into segments . The default filename provided by the Snap and Split tool is *Streams_segments* (fc). These datasets should be saved to the *Streams* (fd) in the SPDSS_GW_geodatabase.mdb.

6.0 User Interface



The user interface, shown in the figure below, allows the user to supply the necessary information for the tool to process. The components of the user interface are described below:

User Interface Dialog Box

Select the points layer to be displaced: A pull down box is present which allows the user to select the point layer in the ArcMap document to be snapped to the polyline and used for segmenting the polyline.

Select the points layer field to use for joining: A pull down box is present which allows the user to select the join field which will be used to link the point layer to the polyline layer.

Enter the name and location of the point dataset to be created: Opens a file location dialog box. User can navigate to the folder where the file will be saved and create a name for the new dataset. The default file name is *SFR_Segmentation_pts_snap* (fc). To change the default name, select a folder in the open file dialog box, press "Save" (closing the dialog box) and manually change the default name in the tool's user interface field. It is recommended the dataset be stored in the *Streams* (fd) of the *SPDSS_GW_geodatabase.mdb*.

Select the reference layer to which the points will be displaced: A pull down box is present which allows the user to select the polyline layer in the ArcMap document to which the points will be snapped and which will be segmented by the points.

Select the polyline layer field to use for joining: A pull down box is present which allows the user to select the join field which will be used to link the point layer to the polyline layer.

Enter the name and location of the line dataset to be created: Opens a file location dialog box. User can navigate to the folder where the file will be saved and create a name for the new dataset. The default file name is *Streams_Segments* (fc). To change the default name, select a folder in the open file dialog box, press "Save" (closing the dialog box) and manually change the default name in the tool's user interface field. It is recommended the dataset be stored in the *Streams* (fd) of the *SPDSS_GW_geodatabase.mdb*.

Search radius: This is the maximum distance a point can be snapped from its original location to a polyline.

Creation of a field to store the distance of displacement. If the field name exists, existing values will be overwritten: The user supplies the name of the field to use. The field will store the distance each point was displaced from its original location to the polyline. If the point is located beyond the search radius or the point's and polyline's join field values were not identical within the search radius, the field will store a value of -999.

Split the line on which the point will be displaced: If this box is checked, the polyline features will be split where it is covered by a point. If this is not checked then the points will be snapped to the polyline but the polyline will not be split.

About button: Clicking the button opens a window that provides general information about the tool.

Start Process button: Clicking the button runs the tool.

Cancel Process button: Clicking the button exits the tool.

7.0 Source Code

The source code is contained in the ArcMap document *CDSS_SFR1_Development.mxd* and can be viewed through ArcMap's Visual Basic Editor.

Table 1: SFR1 ICALC Methods and Required Parameters

icalc	roughch	roughbk	cdpth	fdpth	awdth	bwdth	hcond	thickm	elev	width	depth	xcpt1	xcpt2	xcpt3	xcpt4	xcpt5	xcpt6	xcpt7	xcpt8	zcpt1	zcpt2	zcpt3	zcpt4	zcpt5	zcpt6	zcpt7	zcpt8
0							X	X	X	X	X																
1	X						X	X	X	X																	
2	X	X					X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3			X	X	X	X	X	X	X	X																	

X These fields are required for the specified Icalc method

Definition of Field Names
Name: Stream or diversion to be segmented (will be the join field with the streams GIS file)
utm_x: x-coordinate
utm_y: y-coordinate
Tributary: name of the tributary joining the stream at that point
Diversion: name of the diversion diverting from that point
Type: type of node, either fnode or tnode
Icalc: method used to calculate depth of water in channel
RoughCH: Manning's roughness for channel
RoughBK: Manning's roughness for overbank
CDPTH: Power coefficient
FDPTH: Power coefficient
AWDTH: Power coefficient
BWDTH: Power coefficient
HCOND: vertical conductivity
THICKM: streambed thickness
ELEV: streambed elevation
WIDTH: streambed width
DEPTH: depth of water in channel
XCPTn: distance relative to left bank of channel
ZCPTn: height relative to lowest elevation of streambed

Appendix D

Phase 3 Task 50.4, Documentation of Procedural Steps to Create an ArcGIS Network

Appendix D: Documentation of Procedural Steps to Create an ArcGIS Network

Final

March 30, 2007

The purpose of this documentation is to outline the steps to create an ArcGIS network. A network dataset is required to run the Segment Numbering Tool used in developing the SFR1 MODFLOW 2000 package. Creating a network is part of the process used in the development of the SFR1 package. A description of the entire SFR development process is described in report of the Task 50.4 TM. This documentation assumes the user has basic familiarity with ArcGIS software.

1.0 Revision History

The procedural steps for developing a network dataset were developed by Camp Dresser & McKee (CDM) for the South Platte Decision Support System (SPDSS) in January 2007.

2.0 Software Requirements

ArcCatalog is the ArcGIS program used to create the network dataset. An ArcEditor or ArcInfo 9.1 license is required.

3.0 Procedural Steps

1. In ArcCatalog navigate to the feature dataset within the geodatabase containing the dataset to be processed.

2. Right click in the feature dataset and select New→ Geometric Network

3. Click Next on the page which states, "This wizard will help you build a geometric network."

4. Select "Build a geometric network from existing features" and click Next

5. Check the features to be included in the network (Streams_segments) and click Next

6. "Do you want complex edges in your network?" Select "No" and click Next

7. "Do your features need to be snapped?" Select "No" and click Next

8. "Do you want to assign weights to your network?" Select "No" and click Next

9. Click Finish.

4.0 Input File Description

Streams_segments (fc) from the Snap and Split Tool output is the dataset to be used for the network.

5.0 Output Files Description

The output is a network dataset *Streams_net,* which includes the *Streams_segments* (fc) and *Streams_Net_Junctions* (fc), generated when building the network.

Appendix E

Phase 3 Task 50.4, Documentation of Segment Numbering Tool

Appendix E: Documentation of Segment Numbering Tool

Final

Version 1.0 March 30, 2007

The purpose of the Segment Numbering tool is to number the segments for the MODFLOW 2000 SFR1 package in ascending order from upstream to downstream. A segment is a portion of a stream with constant or linearly varying characteristics. The Segment Numbering tool is one of several tools created to assist in the development of the SFR1 package. A description of the entire SFR development process is described in the report of the Task 50.4 TM. This documentation assumes the user has basic familiarity with ArcGIS software. It is recommended when processing data in geodatabases, ArcCatalog remain closed when using the tool. This helps prevent unwanted schema lock errors.

0.0 Disclaimer

This program is furnished by the State of Colorado (State) and is accepted and used by the recipient upon the expressed understanding that the State makes no warranties, express or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information and data contained in this program or furnished in connection therewith, and the State shall be under no liability whatsoever to any person by reason of any use made thereof.

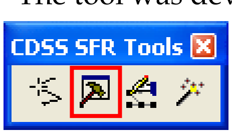
The program herein belongs to the State of Colorado. Therefore, the recipient further agrees not to assert any proprietary rights therein or to further represent this program to anyone as other than a State program

1.0 Revision History

Version 1.0 of the Segment Numbering tool was developed by Camp Dresser & McKee (CDM) for the South Platte Decision Support System (SPDSS) in January 2007.

2.0 Installation

The tool was developed in Visual Basic for Applications (VBA) and is embedded in the master



document *CDSS_SFR1_Development.mxd*. A new instance of this document is copied to the working directory at project initiation. No other installation is necessary. This tool requires ArcMap version 9.1 to run. After opening the file *CDSS_SFR1_Development.mxd* in ArcMap the CDSS SFR Tools toolbar will be present. The Segment Numbering Tool is initiated by clicking the button, enclosed in the red box on the figure to the left, located on the custom CDSS SFR Tools toolbar.

3.0 Program Description

The Segment Numbering tool numbers the segments in ascending order from upstream to downstream and creates a field [SegmentID] to store the numbering. Numbering begins at the most upstream segment of the main stem stream in the network. Numbering continues downstream until there is a junction with a tributary or a diversion. If the junction is with a tributary, the numbering stops at the main stem junction and resumes at the most upstream segment of the tributary working downstream back to the junction. When the numbering of the tributary is complete, the numbering again continues downstream with the main stem. If the junction at the main stem is with a diversion, numbering continues with the diversion leaving the main stem until it ends. Then the numbering resumes at the junction of the main stem and the diversion and continues downstream with the main stem. Similar logic is used if there is a tributary of a tributary or if there is a diversion from a tributary.

After the numbering is complete, the tool adds three new fields to the attribute table of the input file. These fields are [Outseg], [IUpseg], and [LengthFeet]. Fields [Outseg] and [IUpseg] are populated according to the requirements of the MODFLOW SFR1 package and identify the segments upstream and downstream of a particular segment. [Outseg] stores the [SegmentID] of the stream segment downstream of a segment. For a diversion segment, [IUpseg] stores the upstream stream [SegmentID] from which the diversion segment diverts. For a stream segment, [IUpseg] is always 0 unless its upstream water source is a lake or reservoir. [LengthFeet] stores the length of each segment in units of feet.

Finally, the Segment Numbering tool exports out a point feature class containing the endpoints of each segment. All segments have two endpoints. The fnode is the 'from node' or the upstream node of a segment, and the tnode is the 'to node' or the downstream node of a segment.

4.0 Input File Description

The input file is the *Stream_net* (network dataset), which includes the *Streams_segments* (feature class (fc)) output from the Snap and Split Tool and the *Streams_Net_Junctions* (fc), which is generated when creating the network. These files are located in the *Streams* (feature dataset (fd)) of the *SPDSS_GW_geodatabase.mdb*. If the user adds *Stream_net* to the ArcMap data frame *Streams_segments* and *Streams_Net_Junctions* will automatically be added to the data frame's table of contents.

5.0 Output Files Description

The Segment Numbering tool output creates four new fields in the *Streams_segments* (fc) and a new feature class, whose default filename is *Streams_segments_endpoints* (fc). *Streams_segments_endpoints* (fc) should be stored in the *Streams* (fd).

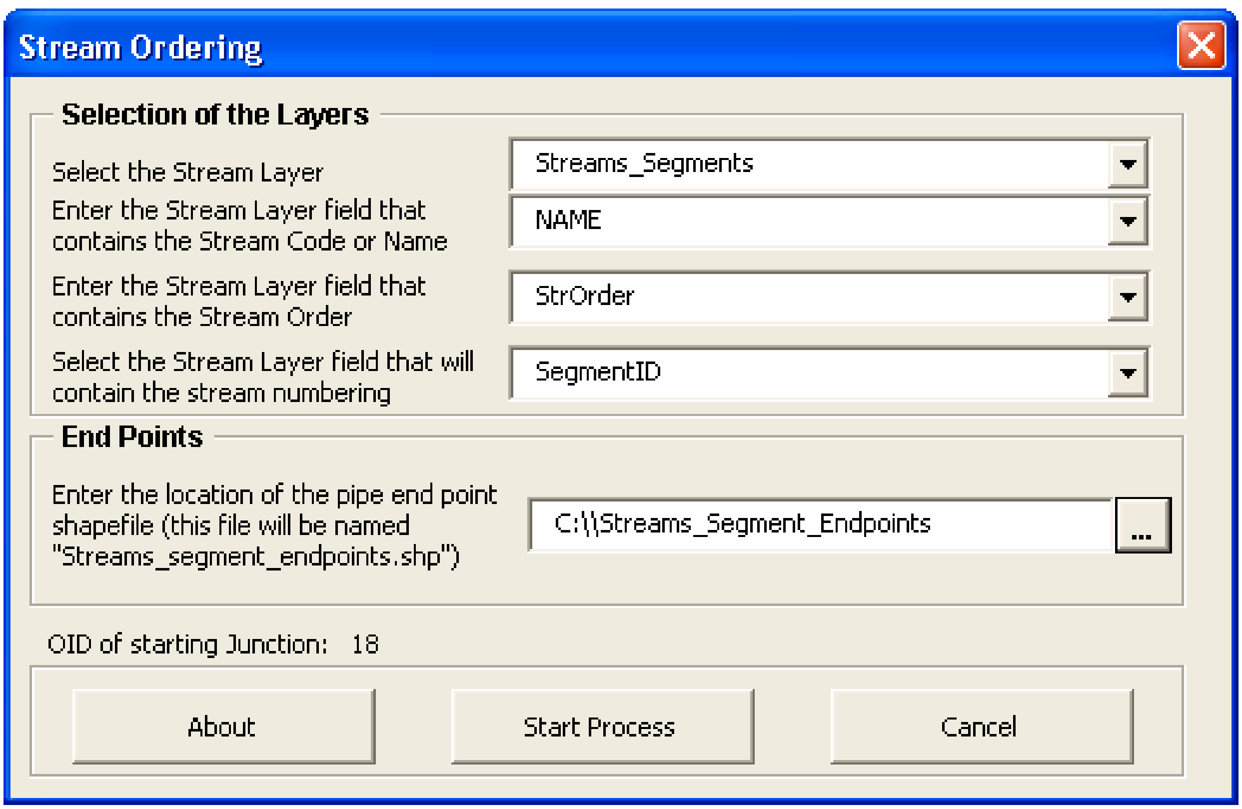
The fields added to *Streams_segments* (fc) include:

- [LengthFeet] (length of each feature in feet)
- [SegmentID]
- [Outseg]
- [IUpseg]

The new feature class contains the endpoints of all the streams segments and includes attribute fields from *Streams_segments* (fc), which include [Type] (either fnode or tnode), [LengthFeet] [StrOrder], [SegmentID], [Name] (or another field name, which contains the unique identifiers for the streams), [Outseg], and [IUpseg].

6.0 User Interface

After clicking the Segment Numbering button on the SPDSS toolbar, a message box will appear which prompts the user to click on the most downstream network junction point. After the point is clicked, the user interface, shown below, opens, and allows the user to supply the necessary information for the tool to process. The components of the user interface are described below:



Select the Stream Layer: A pull down box is present, which allows the user to select the layer in the ArcMap document which contains the streams to be numbered.

Enter the Stream Layer field that contains the Stream Order: A pull down box is present, which allows the user to select the field from the stream layer's attribute table which contains the stream order values ([StrOrder]).

Select the Stream Layer field that will contain the stream numbering: The user can type the name of the field, which will contain the stream segment numbering. The default field name is [SegmentID]

Enter the name and location of the point dataset to be created: Opens a file location dialog box. User can navigate to the folder where the file will be saved and create a name for the new dataset. The default file name is *Streams_segments_endpoints* (fc). It is recommended the dataset be stored in the *Streams* (fd) of the *SPDSS_GW_geodatabase.mdb*.

About button: Clicking the button opens a window, which provides general information about the tool.

Start Process button: Clicking the button runs the tool.

Cancel Process button: Clicking the button exits the tool.

7.0 Source Code

The source code is contained in the ArcMap document *CDSS_SFR1_Development.mxd* and can be viewed through ArcMap's Visual Basic Editor.

Appendix F

Phase 3 Task 50.4, Documentation of Create Reaches Tool

Appendix F: Documentation of Create Reaches Tool

Final

Version 1.0 March 30, 2007

The purpose of the Create Reaches tool is to create reaches by intersecting the stream segments with the model grid for the MODFLOW 2000 SFR1 package. A segment is a portion of a stream with constant or linearly varying characteristics, and a reach is the portion of a segment within a model grid cell. The Create Reaches tool is one of several tools created to assist in the development of the SFR1 package. A description of the entire SFR development process is described in the report of the Task 50.4 TM. This documentation assumes the user has basic familiarity with ArcGIS software. It is recommended when processing data in geodatabases, ArcCatalog remain closed when using the tool. This helps prevent unwanted schema lock errors.

1.0 Disclaimer

This program is furnished by the State of Colorado (State) and is accepted and used by the recipient upon the expressed understanding that the State makes no warranties, express or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information and data contained in this program or furnished in connection therewith, and the State shall be under no liability whatsoever to any person by reason of any use made thereof.

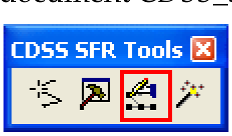
The program herein belongs to the State of Colorado. Therefore, the recipient further agrees not to assert any proprietary rights therein or to further represent this program to anyone as other than a State program.

1.0 Revision History

Version 1.0 of the Reach Creation tool was developed by Camp Dresser & McKee (CDM) for the South Platte Decision Support System (SPDSS) in January 2007.

2.0 Installation

The tool was developed in Visual Basic for Applications (VBA) and is embedded in the master document *CDSS_SFR1_Development.mxd*. A new instance of this document is copied to the working directory at project initiation. No other installation is necessary. This tool requires ArcMap version 9.1 to run. After opening the file



CDSS_SFR1_Development.mxd in ArcMap the CDSS SFR Tools toolbar will be present. The Create Reaches tool is initiated by clicking the button, enclosed in the red box on the figure to the left, located on the custom CDSS SFR Tools toolbar.

3.0 Program Description

The Create Reaches tool creates reaches by intersecting the stream segments with the model grid. This splits the segments into new features each time a segment feature intersects a model grid cell. After creating reaches, the tool numbers the reaches in consecutive ascending order from upstream to downstream, beginning with 1, for each segment. After all the reaches of a segment have been numbered, the numbering restarts at 1 for the next segment. This numbering is stored in a field called [ReachID]. Finally the tool calculates the length of each reach in feet and stores the value in the [LengthFeet] field.

4.0 Input File Description

The Create Reaches tool requires two input files:

1. *Streams_segments* (feature class (fc)) generated by the Snap and Split Tool, then processed by the Segment Numbering tool. This can be found in the Streams (feature dataset (fd)) of the *SPDSS_GW_geodatabase.mdb*.

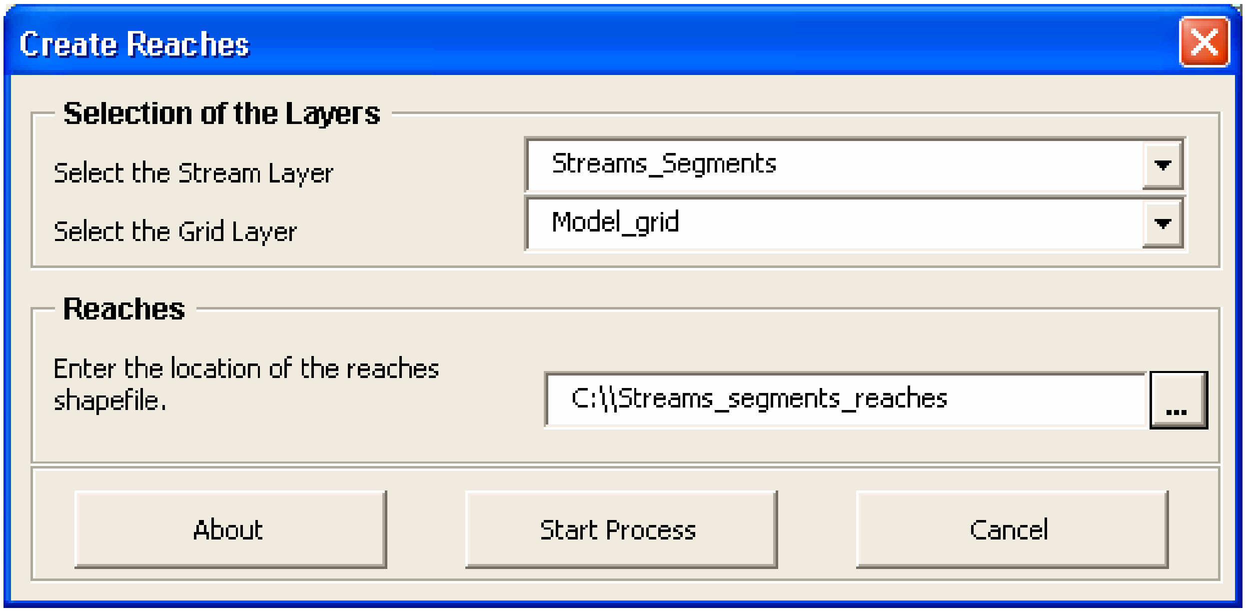
2. *Model_grid* (fc), which contains polygon features of the model grid cells, located in the *Base_Map* (fd) of the *SPDSS_GW_geodatabase.mdb*.

5.0 Output Files Description

The Segment Numbering tool output creates a new polyline feature class whose default name is *Streams_segments_reaches* (fc). This feature class contains all of the attributes of the input files *Streams_segments* (fc) and *Model_grid* (fc). Additionally a new field [ReachID] is added to store the reach numbering values. The values in the [LengthFeet] are re-calculated based on the length of the new reach feature lengths.

6.0 User Interface

The user interface, shown below, allows the user to supply the necessary information for the tool to process. The components of the user interface are described below:



Select the Stream Layer: A pull down box is present, which allows the user to select the layer in the ArcMap document which contains the streams segments to be split into reaches.

Select the Grid Layer: A pull down box is present, which allows the user to select the layer in the ArcMap document which contains the model grid cell polygons.

Enter the location of the reaches shapefile: Opens a file location dialog box. User can navigate to the folder where the file will be saved and create a name for the new dataset. The default file name is *Streams_segments_reaches* (fc). It is recommended the dataset be stored in the *Streams* (fd) of the *SPDSS_GW_geodatabase.mdb*.

About button: Clicking the button opens a window, which provides general information about the tool.

Start Process button: Clicking the button runs the tool.

Cancel Process button: Clicking the button exits the tool.

7.0 Source Code

The source code is contained in the ArcMap document *CDSS_SFR1_Development.mxd* and can be viewed through ArcMap's Visual Basic Editor.

Appendix G

Phase 3 Task 50.4, Documentation of Attribute Fill Tool

Appendix G: Documentation of Attribute Fill Tool

Final

Version 1.0 March 30, 2007

The purpose of the Attribute Fill tool is to transfer attributes from the *SFR_segmentation_pts_snap* (feature class (fc)) to the *Streams_segments_endpoints* (fc), and then fill missing attributes for all points as either a linear or constant interpolation. This satisfies the MODFLOW 2000 SFR1 package requirement to define the characteristics at the upstream and downstream end of each segment. The Attribute Fill tool is one of several tools created to assist in the development of the SFR1 package. A description of the entire SFR development process is described in the report of the Task 50.4 TM. This documentation assumes the user has basic familiarity with ArcGIS software. It is recommended when processing data in geodatabases, ArcCatalog remain closed when using the tool. This helps prevent unwanted schema lock errors.

0.0 Disclaimer

This program is furnished by the State of Colorado (State) and is accepted and used by the recipient upon the expressed understanding that the State makes no warranties, express or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information and data contained in this program or furnished in connection therewith, and the State shall be under no liability whatsoever to any person by reason of any use made thereof.

The program herein belongs to the State of Colorado. Therefore, the recipient further agrees not to assert any proprietary rights therein or to further represent this program to anyone as other than a State program.

1.0 Revision History

Version 1.0 of the Attribute Fill tool was developed by Camp Dresser & McKee (CDM) for the South Platte Decision Support System (SPDSS) in January 2007.

2.0 Installation

The tool was developed in Visual Basic for Applications (VBA) and is embedded in the master document *CDSS_SFR1_Development.mxd*. A new instance of this document is copied to the working directory at project initiation. No other installation is necessary. This tool requires ArcMap version 9.1 to run. After opening the file *CDSS_SFR1_Development.mxd* in ArcMap the CDSS SFR Tools toolbar will be present. The Attribute Fill tool is initiated by clicking the button, enclosed in the red box on the figure to the left, located on the custom CDSS SFR Tools toolbar.

3.0 Program Description

The *SFR_segmentation_pts_snap* (fc) contains the locations of points representing a diversion, tributary, streamflow gage, or significant change, as determined by an analyst, in a stream characteristic. The stream characteristics include [hcond], [thickm], [elev], [width], and [depth] [Icalc], [thickm], and [width], [depth], [roughch], [roughbk], [xcptn], and [zcptn]. The SFR1 package requires the stream characteristics be defined at every fnode and tnode in the system. However, for simplicity, when creating the *SFR_segmentation_pts_snap* (fc), it is necessary to only define these values at key locations as discussed in Appendix C. Generally these key locations include the most upstream fnode and most downstream tnode of every unique stream, and also include analyst determined stream characteristic break points.

Streams_segments_endpoints (fc) are the endpoints of the stream segments, and therefore, more than one point will usually occupy the same spatial location. This is because the endpoint of one segment (tnode) is the starting point of another second (fnode).

The first procedure of the Attribute Fill tool is the transfer of attributes from *SFR_segmentation_pts_snap* (fc) to the *Streams_segments_endpoints* (fc). The attributes are transferred based on a spatial join and an attribute join. For the spatial join, the point in the *SFR_segmentation_pts_snap* (fc) must be within 1 meter of the point in *Streams_segments_endpoints* (fc). For the attribute join, two attribute fields must have the same value between the two points. First the points must have the same stream identifier and secondly, the points must have the same node type value, either fnode or tnode. If all the criteria are met, the attributes are transferred from the *SFR_segmentation_pts_snap* (fc) point to the *Streams_segments_endpoints* (fc) point.

The Attribute Fill tool will transfer attributes from the *SFR_segmentation_pts_snap* (fc) to only the most upstream fnodes and most downstream tnodes along with the fnodes at the break point locations of the *Streams_segments_endpoints* (fc). The SFR1 package requires that the stream characteristics be defined at every fnode and tnode in the system. Therefore, the Attribute Fill tool's second procedure of interpolation is used to fill in the attributes for all intermediate fnodes and tnodes of the *Streams_segments_endpoints* (fc). The interpolation process is accomplished by beginning with an attribute value at the most upstream fnode of a unique stream. The tool searches through downstream fnodes and tnodes for that stream until it encounters a non-null value for that attribute. If the attribute is constantly interpolated, then all the intermediate nodes are given a value equal to the value at the most upstream fnode. If the value is linearly interpolated then the upstream fnode and downstream node (either tnode or fnode) along with the stream miles between the two points are used to calculate the attribute value for each intermediate node. The interpolation process continues from this downstream location searching downstream for the next non-null attribute value. The fill process is again completed, and the search continues until the most downstream tnode of the stream is reached.

This process is repeated for all the attributes for each unique stream. Fields [hcond] and [elev] are linearly interpolated, while all other fields are carried constantly interpolated.

4.0 Input File Description

The Attribute Fill tool requires two input files.

1. *SFR_segmentation_pts_snap* (fc) generated by the Snap and Split Tool.

2. *Streams_segments_endpoints* (fc) generated by the Segment Numbering Tool.

Both datasets are located in the *Streams* (feature dataset (fd)) of the *SPDSS_GW_geodatabase.mdb*.

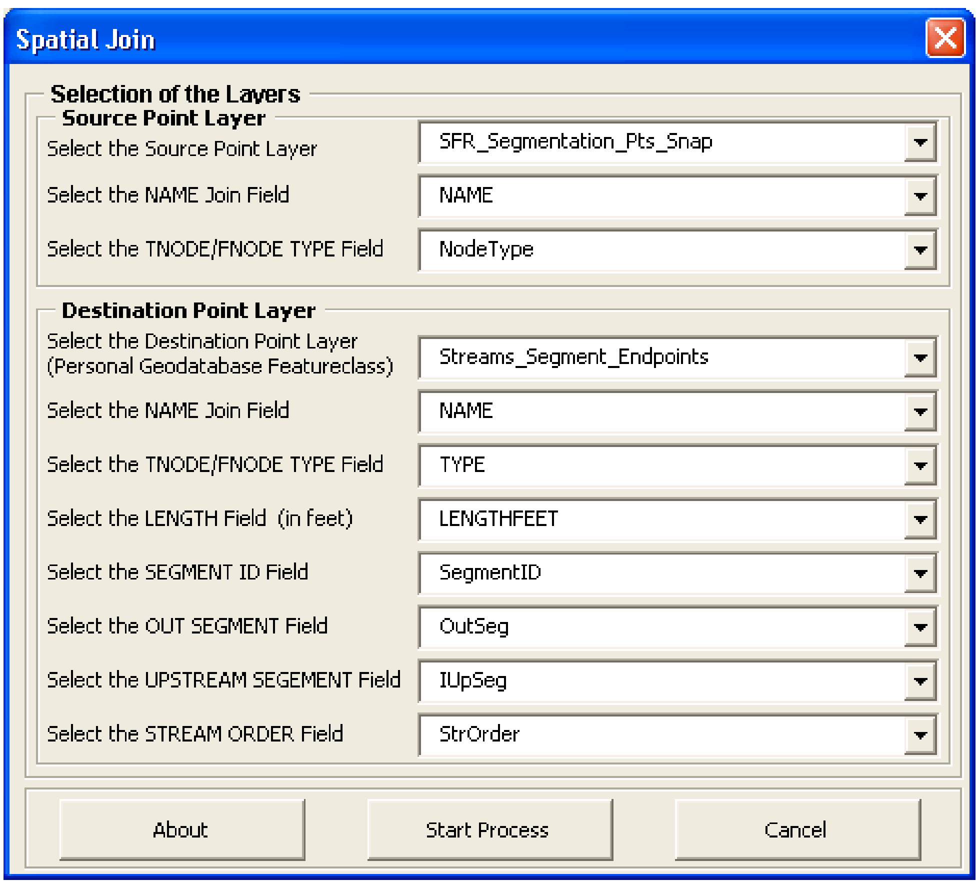
5.0 Output Files Description

The Attribute Fill tool output is the transfer of attributes to the *Streams_segments_endpoints* (fc) and the calculation of attributes by linear and constant interpolation.

6.0 User Interface

The user interface, shown below, allows the user to supply the necessary information for the tool to process. The components of the user interface are described below:

User Interface of the Attribute Fill Tool:



Select the Source Point Layer: A pull down box is present, which allows the user to select the layer in the ArcMap document which is the source of attributes to be transferred.

Select the NAME Join Field: A pull down box is present, which allows the user to select the join field which contains the unique stream identifier.

Select the TNODE/FNODE Type Field: A pull down box is present, which allows the user to select the join field which identifies the point as fnode or tnode.

Select the Destination Point Layer: A pull down box is present, which allows the user to select the layer in the ArcMap document which is the destination for attributes to be transferred to.

Select the NAME Join Field: A pull down box is present, which allows the user to select the join field which contains the unique stream identifier.

Select the TNODE/FNODE Type Field: A pull down box is present, which allows the user to select the join field which identifies the point as fnode or tnode.

Select the LENGTH Field (in feet): A pull down box is present, which allows the user to select the field that contains the length of the features in units of feet. This field is use to do the linear interpolation of attributes.

Select the SEGMENT ID Field: A pull down box is present, which allows the user to select the field that contains the segment identifier.

Select the OUT SEGMENT Field: A pull down box is present, which allows the user to select the field that contains the downstream segment identifier.

Select the UPSTREAM SEGMENT Field: A pull down box is present which allows the user to select the field that contains the upstream segment identifier.

Select the STREAM ORDER Field: A pull down box is present, which allows the user to select the field that contains the stream order values.

About button: Clicking the button opens a window, which provides general information about the tool.

Start Process button: Clicking the button runs the tool.

Cancel Process button: Clicking the button exits the tool.

7.0 Source Code

The source code is contained in the ArcMap document *CDSS_SFR1_Development.mxd* and can be viewed through ArcMap's Visual Basic Editor.

Appendix H

Phase 3 Task 50.4, SFR Generator

Appendix H: SFR Generator

Draft

Version 1.0 March 30, 2007

The SFR Generator processes feature classes in the SPDSS_GW_geodatabase created by the ArcGIS SFR tools to create the formatted SFR1 package files. A description of the entire SFR1 development process is described in the report of the Task 50.4 TM.

0.0 Disclaimer

This program is furnished by the State of Colorado (State) and is accepted and used by the recipient upon the expressed understanding that the State makes no warranties, express or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information and data contained in this program or furnished in connection therewith, and the State shall be under no liability whatsoever to any person by reason of any use made thereof.

The program herein belongs to the State of Colorado. Therefore, the recipient further agrees not to assert any proprietary rights therein or to further represent this program to anyone as other than a State program

1.0 Revision History

Version 1.0 of the SFR Generator was developed by Camp Dresser & McKee (CDM) for the South Platte Decision Support System (SPDSS) in January 2007.

2.0 Installation

The SFR generator is developed for a Windows operating environment using Visual Basic 2005 and the .NET libraries. The package is distributed as a self-contained setup program that will install the program and any required libraries that are not already on the target machine. These libraries include the .NET libraries, which consume a significant amount of disk space. The program will be installed into the local program files directory and will have an entry on the start button. Local administrative privilege is required to install this package.

3.0 Program Description

The SFR generator is the final stage in creating a SFR package file for MODFLOW-2000. This program processes feature classes in the SPDSS_GW_geodatabase that have been created by the ArcGIS SFR tools to create the formatted SFR1 package files.

4.0 Input File Description

Feature classes in the *Streams* feature dataset of the SPDSS_GW_geodatabase.mdb are the input files used by the SFR generator.

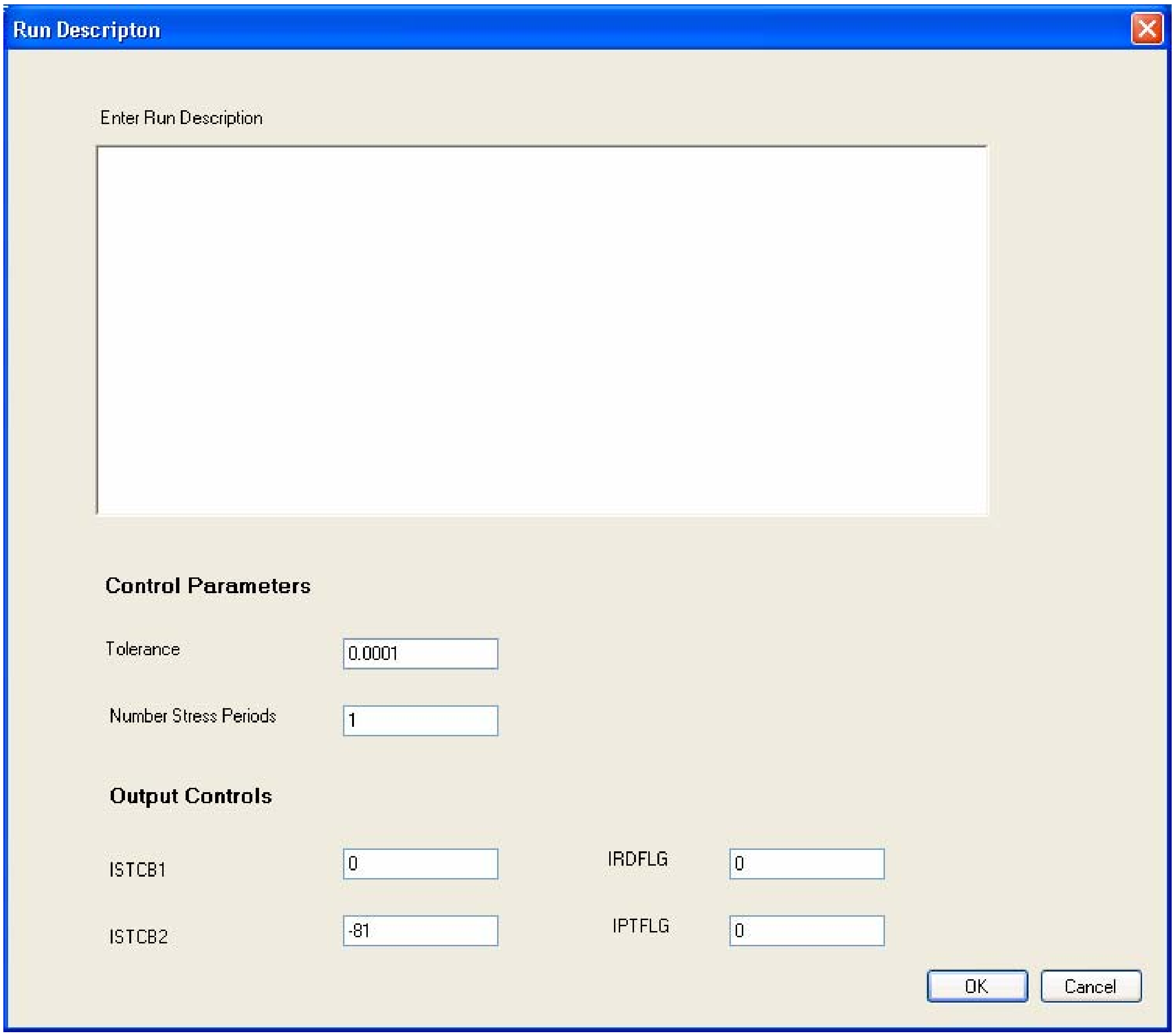
5.0 Output File Description

The SFR generator creates a log file identifying user information and source and output files. A SFR package file is generated in free format that is ready to be directly used in MODFLOW-2000. The output files will be saved in c:\spdss\out.

6.0 User Instructions

The SPDSS_GW_geodatabase.mdb must be copied to the directory c:\spdss and renamed as spdss.mdb. There is a linked table in the geodatabase, *SW_flux_boundary*, which must be copied and pasted as a local table.. A sub-directory ..\out should also be created in the c:\spdss directory prior to execution of the SFR Generator. The SFR Generator is started using the Start item. The input screen is shown below.

Input parameters are named using the standard convention for MODFLOW-2000. Tool tips defining variables have been implemented to assist the user. The SFR package file is generated when the OK button is selected. Generation of this file will take a considerable amount of time.



7.0 Source Code

The SFR generator is developed for a Windows operating environment using Visual Basic 2005 and the .NET libraries.

Appendix I

Phase 3 Task 50.4, Grid Generation Tool

Appendix I: Grid Generation Tool

Final

Version 1.0 March 30, 2007

The Grid Generation tool translates a Department of Defense Groundwater Modeling System (GMS) finite difference grid to an ArcGIS shape file.

0.0 Disclaimer

This program is furnished by the State of Colorado (State) and is accepted and used by the recipient upon the expressed understanding that the State makes no warranties, express or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information and data contained in this program or furnished in connection therewith, and the State shall be under no liability whatsoever to any person by reason of any use made thereof.

The program herein belongs to the State of Colorado. Therefore, the recipient further agrees not to assert any proprietary rights therein or to further represent this program to anyone as other than a State program

1.0 Revision History

Version 1.0 of the Grid Generation Tool was developed by Camp Dresser & McKee (CDM) for the South Platte Decision Support System (SPDSS) in January 2007.

2.0 Installation

The Grid Generation Tool is developed for a Windows operating environment using Visual Basic 2005 and the .NET libraries and is distributed as a self-contained setup program to install the program and any required libraries not already on the target machine. These libraries include the .NET libraries, which consume a significant amount of disk space. The program will be installed into the local program files directory and will have an entry on the start button. Local administrative privilege is required to install this package.

3.0 Program Description

The Grid Generation tool translates a Department of Defense Groundwater Modeling System (GMS) finite difference grid to an ArcGIS shape file. Standard methods are used within GMS to generate a finite difference grid, which can be a uniform grid, variable spacing grid, or a rotated grid. The exported grid is processed in the grid generation tool to develop the shape file. This shape file is used within the DMI StateDGI and used for various purposes within the SPDSS_GW_geodatabase.

4.0 Input File Description

A single input file describing the finite difference grid is required for input to the grid generation tool. This interface file is generated within GMS, as described in detail in Appendix J. This interface can be of the type .ASC or .3DG.

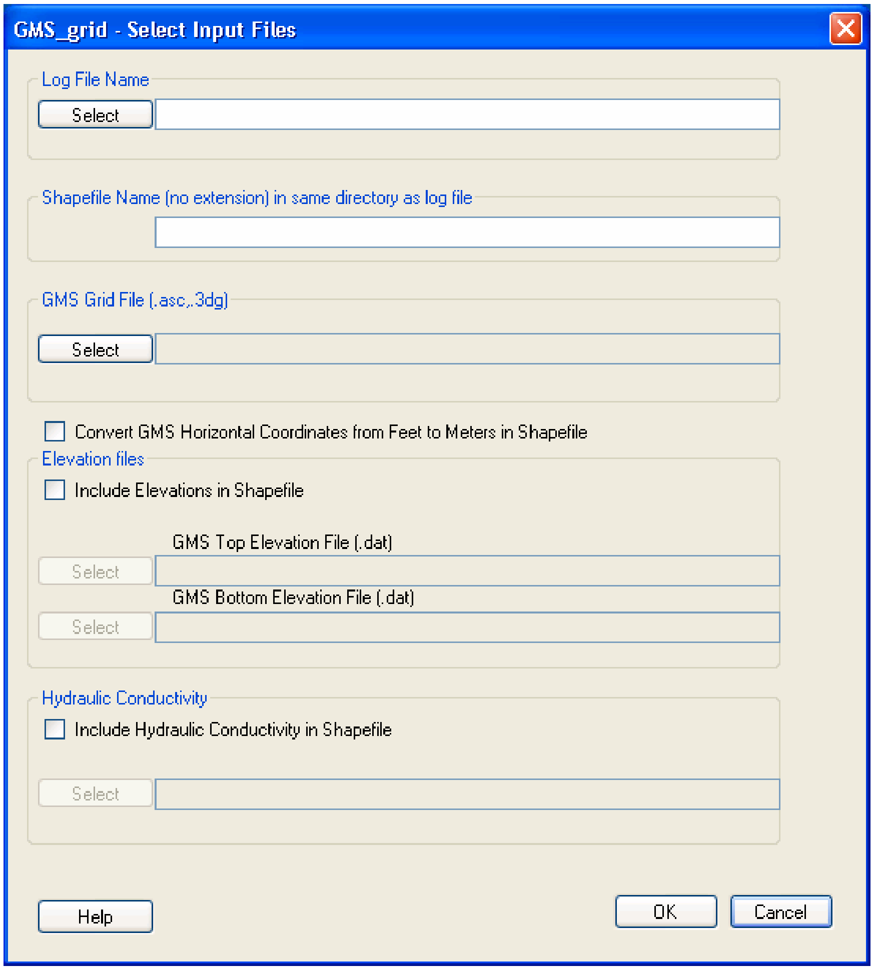
5.0 Output File Description

The grid generation tool generates a log file identifying grid data, user information, and source and output files. A shape file is generated by the DMI that includes a polygon for each cell in the grid. Each polygon is attributed with the row and column number, a concatenated row and column, and a code to indicate if the cell is active in the model grid. Future development will include addition of elevations and hydraulic characteristics to the attributes to use for model post-processing.

6.0 User Instructions

The following steps are required in order to create a shape file from a grid in GMS. The initial step is to create the grid using native GMS tools as described in Appendix J. The grid file must then be exported to an exchange format file by right clicking on the 3D Grid Data object in the left tree panel in GMS. Choose "Export" and save the export file as either a .3DG or .ASC file type. This exported file is used as input to the Grid Generation tool.

The next step is to start the Grid Generation tool by clicking on the "grid_gms.exe" file in the installation directory. The primary input screen is shown below:



In the input screen, name the log file, the root name of the shape file, and the input file defining the finite difference grid. A check box is present that allows a unit conversion to change feet to meters in the output shape file, if necessary. The other input items for writing elevations and hydraulic conductivity have not yet been activated. The shape file will be generated when the OK button is selected. Generation of the grid may take considerable time.

7.0 Source Code

The SFR generator is developed for a Windows operating environment using Visual Basic 2005 and the .NET libraries.

Appendix J

Phase 3 Task 50.4, Creating and Activating a Grid in GMS

Appendix J: Creating and Activating a Grid in GMS

Final

March 30, 2007

The purpose of this appendix is to document the procedural steps one must follow to create a grid in GMS, import a feature class (fc) of the model domain, and then activate cells in the grid with the model domain fc.

1.0 Data Input:

Model domain feature class from the SPDSS_GW_geodatabase.

2.0 Data Output:

Activated grid in GMS which can be exported as a .3dg file.

3.0 Procedural Steps:

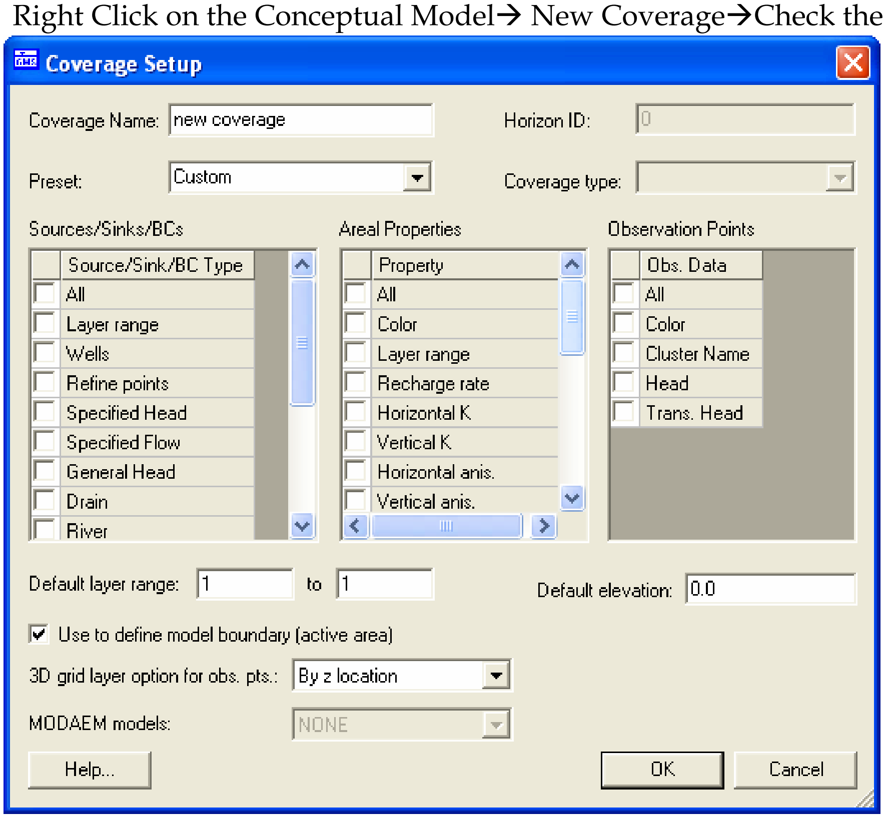
1. In GMS selct the GIS module; GIS → Enable ArcObjects

2. GIS→Add Data→Navigate to the feature class (fc) of the model domain

3. Select the Map module; Feature Objects→New Grid Frame

4. Right Click in the Project Explorer→ New Conceptual Model→OK

5. Right Click on the Conceptual Model→ New Coverage→Check the box "Use to define

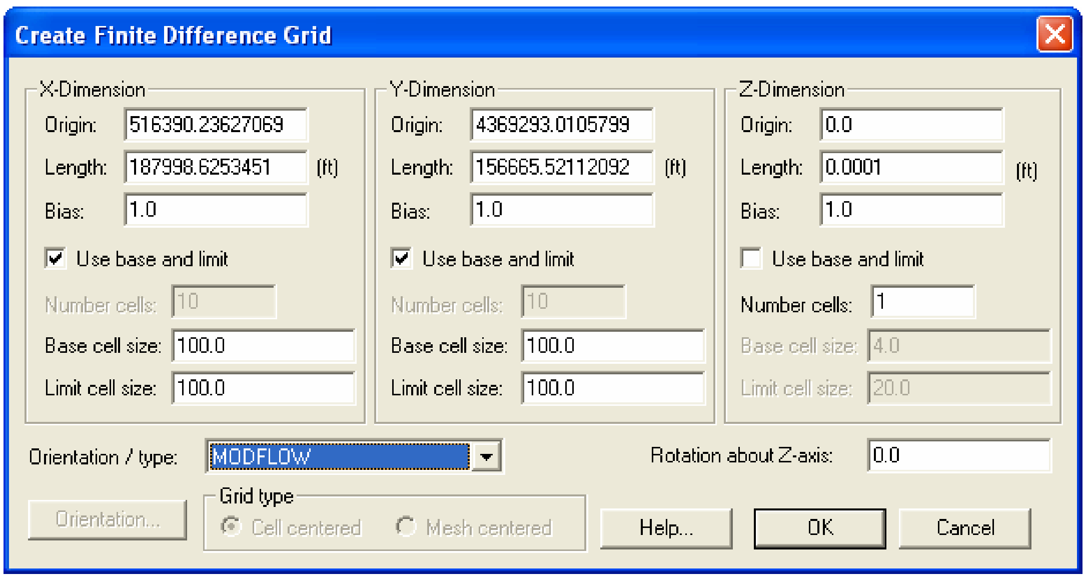


model boundary (active area)"→OK

6. In the project explorer, click the model domain fc; GIS→ArcObject->Feature Objects→At Window Prompt "No features selected. Use all features in all visible layers for mapping? Click Yes→Next→Next→Finish

7. In the project explorer, click on Grid Frame; Feature Objects→Map->3D Grid

   a. Specify the X and Y origin, Length, Base cell size, and Limit cell size (Note: the Length must be a multiple of the cell size or the cell size will be modified by GMS to fit the Length.)



   b. Click OK

9. In the project explorer, click on 3D Grid Data; MODFLOW→New Simulation→Click OK

10. In the project explorer, click on Map Data; Feature Objects→Activate Cells in Coverage(s)

11. To export the activated grid, Right click on 3D Grid Data; Export→ Save

Appendix K

Phase 3 Task 50.4, Importing a 2d Scatter Dataset to Create a Layer in GMS

Appendix K: Importing a 2d Scatter Dataset to Create a Layer in GMS

Final

March 30, 2007

The purpose of this appendix is to document the procedural steps one must follow to successfully import a 2d Scatter set to create a Layer in GMS. The layers that can be created are Top, Bottom, Starting Heads, IBOUND, Hydraulic Conductivity, Hydraulic Conductivity Anisotropy, Specific Yield, Specific Storage or Recharge. To create a layer in GMS according to these instructions, 3D grid data and MODFLOW model framework must already exist in the GMS file. See Appendix J to accomplish this task.

1.0 Data Input:

The data input can be a shapefile, feature class, or a text file. The data must contain x and y (horizontal coordinates) and z (vertical value) values. The xyz values can either represent a regularly spaced gridded data set or irregularly spaced raw data.

2.0 Data Output:

Model layer or array preserved in GMS. GMS will create a MODFLOW package file for the layer or array.

3.0 Procedural Steps:

1. For a TEXT file, In GMS, File→ Open

   a. Selected the *.txt, *.csv file type and click NEXT

   b. Under GMS Data Type: Select "2D Scatter Points"; In the table, in the Type row, select the data set (x, y, label, or data set) for each column. Select "data set" for the z value column. Click FINISH

2. For a SHAPEFILE or FEATURE CLASS

   a. In the Project Explorer, select the GIS Module, GIS → Enable ArcObjects (if not already activated), then GIS→ "Add Data", select the shapefile or feature class (fc) of interest

   b. Right click on the shapefile (or fc) and select "Convert to 2D Scatter Points"

To create a Top, Bottom, Starting Head, or IBOUND Layer continue with Step 3. To create a Hydraulic Conductivity, Hydraulic Conductivity Anisotropy, Specific Yield, Specific Storage or Recharge Layer continue with Step 4.

3. **To create a Top, Bottom, Starting Head, or IBOUND Layer** right click on the 2D Scatter dataset and select "Interpolate to → MODFLOW Layers"

a. In the dialog box, highlight the Scatter Point Data Set and MODFLOW Layer array files of interest and click "MAP". This maps the 2D Data Set to the desired surface.

b. Click INTERP. OPTS.… in the lower left corner of the window

   i. Select the interpolation method and options of choice. It is recommended to use the Linear method when importing an xyz dataset that is gridded on the same grid spacing and origin as the model grid. Click OK.

c. Click OK

4. **To create a Hydraulic Conductivity, Hydraulic Conductivity Anisotropy, Specific Yield, Specific Storage or Recharge Layer**

   a. Right click on the 2D Scatter data set and select "Interpolate to → 3D Grid"

   b. Click INTERPOLATION OPTIONS

      i. Select the interpolation method and options of choice. It is recommended to use the Linear method when importing an xyz dataset that is gridded on the same grid spacing and origin as the model grid. Click OK.

      ii. Click OK

   c. Under 3D Grid Data → MODFLOW →LPF Package → check "Use data arrays"

   d. Under 3D Grid Data → MODFLOW → right click on the Array of Choice (HK, HANI, SY, SS, RCH Rate) and click "PROPERTIES"

      i. Click "3D Data Set → Grid"

         (1) Select the 3D Grid Data and click OK

      ii. Click OK

Appendix L

Phase 3 Task 50.4, Updated Documentation of StatePP and Agg to Include the Multi-Node Well Package Capability

This appendix contains three documents from the RGDSS Technical Memorandum originally used to document StatePP and Agg with updates to include the Multi-Node Well package capability.

RGDSS Memorandum

Final

To: Ray Bennett, P.E.

From: HRS Water Consultants, Inc. Judith Schenk and Mark Palumbo

Subject: RGDSS Ground Water, Task 36 – State Pre-Processor Modifications

Date: February 19, 2003

Objectives

The State Pre-Processor (StatePP) was developed for use in the ground water model component of the Rio Grande Decision Support System (RGDSS). StatePP was written so that it can be used for any MODFLOW based project. Program listing for StatePP is included in Appendix A.

The StatePP was developed to process flow and spatial data and create MODFLOW input files. MODFLOW is a three-dimensional finite-difference ground water flow model developed by the U.S. Geological Survey (USGS).[1] StatePP produces the following MODFLOW input files:

- recharge,
- well,
- evapotranspiration,
- drain.
- multi-node well

StatePP was developed because of the volume and complexity involved in creating steady state, monthly, and average monthly MODFLOW input files and because no commercial software was available that would process input data in the manner required to create the MODFLOW input files.

[1] McDonald, M.G., and Harbaugh, A.W., 1988, A modular three-dimensional finite-difference ground-water flow model, Techniques of Water-Resources Investigations 06-A1, USGS, 576 p.

Development of StatePP is consistent with a data-centered, decision support system approach. Flow and spatial data are received from the multi-disciplined project contractors. These data are processed along with user input information to create the MODFLOW input files listed above. If any data sources are updated, the new data set is input to StatePP to produce a new set of MODFLOW input files.

Disclaimer

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The program herein belongs to the State of Colorado. Therefore, the recipient further agrees not to assert any proprietary rights therein or to further represent this program to anyone as other than a State program.

Acknowledgment

This program was developed by HRS Water Consultants, Inc. (HRS) under contract with the Colorado Water Conservation Board (CWCB). Mark Palumbo was the HRS project manager. Judith Schenk developed the program. Ray Bennett of the Colorado Division of Water Resources and Andy Moore of the CWCB directed the project development as part of the Rio Grande Decision Support System.

The multi-node well component was added in version 2.31 in April, 2006 by CDM under the South Platte Decision Support System project (SPDSS), Phase 3, Task 50. See additions to section 4.0 of this document, Appendix J as well as Agg documentation for more information regarding this addition.

Approach

The approach used to achieve the objectives of this task is described in Table 1.

Table 1. Approach used in StatePP

Section	Description
1.0	Program outline
2.0	Time step capability
3.0	Recharge components
4.0	Pumping components
5.0	Flowing wells
6.0	Native evapotranspiration
7.0	Sub-irrigation
8.0	Input and output description

1.0 Program Outline

1.1 Data Processes

StatePP data processes include:

- process canal loss, unused irrigation water, and pumping data from consumptive use model (StateCU) results, rim inflow recharge, and estimates of recharge from precipitation along with spatial data associated with the MODFLOW grid and recharge components to create a MODFLOW recharge input file,
- process municipal and industrial pumping and recharge and agricultural pumping data along with spatial data of well location to create a MODFLOW well input file,
- use the pumping data to generate a MODFLOW multi-node well (MNW) input file,
- process ground water model grid information and spatial data of distribution of wells with less than 50 gallons per minute (gpm) permitted yield to calculate data for flowing wells, and add flowing wells to the MODFLOW drain input file,
- process spatial data of the distribution of native vegetation and user input evapotranspiration functions related to vegetation types to create the MODFLOW evapotranspiration input file.

- process spatial data of the distribution of potentially sub-irrigated crops (e.g. irrigated meadowlands) and user input evapotranspiration functions for them to create a MODFLOW evapotranspiration input file that includes evapotranspiration by sub-irrigation.

The User may choose which functions are to be performed using flags located on the first line in the StatePP general input file. If the flag is zero, the function is not performed. If the flag is greater that zero, the function is performed. These flags include:

- IEVT – Native evapotranspiration
- IFLW – Flowing wells
- IRCH – Recharge
- IPMP – Pumping
- ISIR – Subirrigation
- MNW – Multi-node well flag

The general flow chart of the program is shown in Figure 1. As presented, selected input files are read to count data for allocating array program space. Space is allocated in the ALLOC subroutine. Data are read and some calculations are performed in the READ subroutine. Flow data are averaged for each stress period in the AVGDATA subroutine. Evapotranspiration functions are calculated and the MODFLOW evapotranspiration file is written in the ETPROP subroutine if sub-irrigation is not simulated. Flowing well information is processed in the FLWELL subroutine, which adds to an existing MODFLOW drain file that contains additional drain and spring data. The drain file produced by StatePP includes both drains that represent flowing wells, and other drains included in the model. Recharge rates for each stress period are calculated and the MODFLOW recharge file is written in the subroutine RECHARGE. Irrigation well pumping rates are calculated for each stress period in the subroutine PUMP, and these pumping rates, along with the municipal and industrial pumping rates, are written to the MODFLOW well file. If sub-irrigation on irrigated crop land is simulated, evapotranspiration functions for native vegetation and sub-irrigation are calculated and the MODFLOW evapotranspiration file is written in the ETSUB subroutine. The StatePP computer code is listed in Appendix A.

Input data sets designed for previous versions (version 2.30 or earlier) of StatePP will function as in previous versions, but the MNW file will not be written. Additional input data is required to produce a MNW file. See section 4.0 for a detailed discussion of the new required data.

1.2 Data Sources

Figure 2 shows the flow of data into and out of StatePP. Data input to StatePP are of three types:

- user input data,
- flow data,
- spatial data.

Table 2 lists the five (5) StatePP input files created by the user and the data contained in each file. As presented these data files include general StatePP user information, MODFLOW information, ET information, hydraulic conductivity data, and drain data.

Table 2. User created input files for StatePP

StatePP user input information	Stress period information Maximum recharge rate flag Recharge factors for each structure County abbreviations and full county name Vegetation codes for irrigated areas
MODFLOW information	Number of layers, rows, and columns in model Model grid spacing Active grid cells in each model layer
Evpotranspiration information	Number of evapotranspiration functions Number of points in evapotranspiration functions Native vegetation zones and vegetation zone types Evapotranspiration function for each zone Ground surface elevation
Hydraulic conductivity	Hydraulic conductivity data from MODFLOW files
Drain	Drains other than flowing wells

The Consumptive Use contractor, the Surface Water Modeling contractor and the Ground Water contractor provide flow data used for StatePP input. Flow data used to create MODFLOW input files are presented in Table 3.

Table 3. Flow data input for StatePP

Flow Data Description	Data Source
Canal leakage	Consumptive use modeling contractor
Unconsumed surface water from irrigation	
Unconsumed ground water from irrigation	
Ground water pumping for irrigation	
Ditch shortage for subirrigation	
Water requirement for crop for subirrigation	
Recharge from precipitation on irrigated lands	
Recharge from precipitation on non-irrigated lands	
Rim inflow recharge	Surface water modeling contractor
Municipal and Industrial pumping	Ground water contractor
Municipal and industrial recharge	

Spatial data used for input into StatePP comes from the Spatial Database contractor and the Ground Water contractor. Spatial data provided by the Spatial Database Contractor are derived using GIS information and ground water model grid information. The ground water model grid provides layer, row and column information that is matched with the GIS data to create spatial information relative the ground water model grid. The Ground Water contractor supplies layer, row, and column information for municipal and industrial wells. Spatial data used in StatePP to create MODFLOW input files are presented in Table 4.

Input files listed in Tables 2, 3 and 4 are listed in a file named "INFILES". StatePP reads the list of unit numbers and filenames in "INFILES". Each file is opened and the unit number is assigned to that file. Table 5 lists the unit numbers and the file description. The user can input any filename for these files but must use the unit number listed in Table 5 for the appropriate file. Example input files are listed in Appendix B.

In order to generate the multi-node well file (MNW), additional data is required in the input files than required in previous versions of StatePP. The irrigation groundwater pumping data must also include the top layer, bottom layer, unique well ID and multi-parcel flag. Municipal and industrial pumping data must include the top layer and bottom layer for each well. Details of the formatting of the irrigation data are provided in documentation of Agg, and of the municipal and industrial pumping in Appendix J, Tables 4.7 and 4.8.

Table 4. StatePP input files that include spatial information

Files with Spatial Data Information	Data Source
Canals*	Spatial database contractor
Irrigated acreage*	
Irrigation wells*	
Rim inflow recharge areas	
County/HUC/vegetation distribution	
Native vegetation	
Wells with less than 50 GPM permitted yield	
Irrigated crop for subirrigation*	
Municipal and Industrial wells	Ground water contractor

* These files may require processing by AGG program before being used by StatePP if there are any aggregated structures in the surface water model

Table 5. Unit number and description of files listed in the file "INFILES"

Unit no.	File Description	Example file name
15	StatePP user input information	STATEPP.DAT
10	MODFLOW information	MFGRID.DAT
98	Hydraulic conductivity data	HYCN.DAT
60	Evapotranspiration functions and information	ETZONE.DAT
88	MODFLOW drain file with drains other than flowing wells	DRAIN.DAT
30	Consumptive Use model results	CUDATA.DAT
20	Canals from GIS data	DIVLEAK.DAT
25	Irrigated acreage from GIS data	DIVIRLN.DAT
40	Irrigation wells from GIS data	IRRWELLS.DAT
55	Native vegetation from GIS data	RGDSS.ETZ
45	Rim inflow areas from GIS data	RGDSS.RIM
95	Wells with less than 50 GPM permitted yield from GIS data	RGDSS.SFW
16	County/HUC/vegetation distribution from GIS data	RGDSS.PCP
50	Rim inflow recharge estimates	RIMFLOW.DAT
80	Municipal and industrial pumping	MUINP.DAT
85	Municipal and industrial recharge	MUINI.DAT
17	Recharge from precipitation on irrigated lands	PPTREIRR.STM
18	Recharge from precipitation on non-irrigated lands	PPTRENON.STM
14	Surface elevation for each grid cell	SURF.DAT
52	Irrigated crop from GIS data for subirrigation	IRRMEAD.DAT

1.3 Preprocessing of Structure Data

The consumptive use data file contains both explicitly modeled structures and aggregated structures (a grouping of smaller structures). These data were provided for the entire San Luis Valley in RGDSS. The spatial data contain information related to the ground water model area and no aggregated structure information. Therefore, the Consumptive Use contractor supplies a list of structures that are within the ground water model boundaries as well as a list of original structure IDs that are to be combined under an aggregated ID. This structure list is derived from the structure identifications included in the consumptive use model results. Four spatial data files, the canal file, irrigated lands file, irrigation well file, and sub-irrigated crop file, are processed by a utility program, AGG, to combine individual structures under a single structure name and to include only those structures that fall within, or partially within, the ground water model boundary. The files created by AGG are the input files read by StatePP. Table 6 lists the files created by AGG. Figure 3 is a general flow chart for the AGG program that insures consistent structure IDs exist in the spatial and flow data files input into StatePP. The user can change the name of the output files created by AGG because StatePP allows the user to input any filename. Program documentation and the computer code for the AGG program are listed in a separate document.

Table 6. Files created by the utility program AGG

Input file name	AGG file name	Description
filename .can	DIVLEAK.DAT	Canals
filename .irr	DIVIRLN.DAT	Irrigated lands
filename .wel	IRRWELLS.DAT	Irrigation wells
filename .irm	CROP.DAT	Irrigated crop

1.4 StatePP Output Files

StatePP creates four (4) MODFLOW files plus an optional MNW file. In addition to the four MODFLOW files, five (5) reports and two (2) files for post-processing ET data are created. Table 7 lists the MODFLOW files and the reports created by StatePP and a description of these files. Examples of output files are included in Appendix C.

SPP.OUT is a general output file that echoes some input data and lists the total amount of recharge and pum ping for each stress period. CUAVG.OUT lists average flow data for each stress period for each structure listed in the consumptive use model results.   SPP.LOG tracks the progress through the program. The RARRAY.OUT file lists recharge arrays for each recharge component for each stress period. The RCHCHK.OUT file is a list of grid cell in which the recharge rate exceeds the maximum recharge rate input by the user. The recharge rate is not changed in these grid cells, but the information is printed to warn the user of high recharge rates

StatePP has the capability to process a wide variety of model grid sizes and time steps. For the RGDSS project the preprocessor was successfully used to generate a monthly input data set from 1950 to 1997 for a 5 layer model with 196 rows by 116 columns.

Table 7. MODFLOW files and other files created by StatePP

FILE TYPE	OUTPUT FILE	DESCRIPTION
MODFLOW	MODEL.RCH	MODFLOW recharge file
	MODEL.WEL	MODFLOW well file
	MODEL.EVT	MODFLOW evapotranspiration file
	MODEL.DRN	MODFLOW drain file
	MODEL.MNW	MODFLOW multi-node well file (optional)
StatePP information	SPP.OUT	StatePP output file
	SPP.LOG	StatePP log file
	CUAVG.OUT	CU averages for each stress period
	RARRAY.OUT	Recharge arrays
	RCHCHK.OUT	Grid cells that exceed max recharge rate
ET post-processing files	IRRMEDPP.OUT	Distribution of irrigated crop
	SUBIRR.OUT	List of ET functions for natural subirrigation

The subroutine that simulates evapotranspiration to represent sub-irrigation on irrigated crop produces output files that are used by a post-processing program. The post-processing program reads the results of the MODFLOW output in the binary head file produced by MODFLOW, and calculates the amount of sub-irrigation on irrigated crop lands. The first file, IRMEDPP.OUT, is a file that contains spatial data to be read by the post-processing program. These data include the structure ID and information on the spatial data of sub-irrigated crop for structures within the ground-water model boundary. The second file, SUBIRR.OUT, includes the ET function for each stress period for each grid cell listed in the irrigated crop file

In addition to the four (4) MODFLOW files, and the five (5) reports, and two (2) post-processing files, thirteen (13) output files are created by StatePP that echo input information. These files are produced so that the user can check that the input files are read correctly. The optional MNW file is generated from the same input files as the MODFLOW well file, and therefore generates no additional output files that echo input data. Table 8 lists these files.

Table 8. Output files created by StatePP that echo input file information

TYPE	OUTPUT FILE	INPUT FILE DESCRIPTION
User input	MFGRID.OUT	MOFLOW data
	HYCN.OUT	Hydraulic conductivity data
Flow data	CUDATA.OUT	Consumptive use data
	PRCPRCH.OUT	Precipitation recharge
	RIMFLOW.OUT	Rim inflow recharge
	MUIN.OUT	Municipal and industrial wells
Spatial Data	CANAL.OUT	Canals
	IRRLAND.OUT	Irrigated lands
	IRRWELLS.OUT	Irrigation wells
	RIMAREA.OUT	Rim inflow areas
	GISPRCH.OUT	Precipitation areas
	ETVEG.OUT	Native vegetation areas
	FLWELL.OUT	Small capacity wells (flowing wells)
	CROP.OUT	Irrigated crop for subirrigation

2.0 Time Step Capability

StatePP is designed to provide average flow data for a defined stress period. A stress period may be, for example, a steady state analysis, monthly average data for a transient analysis, or monthly data for a monthly transient analysis. All flow data are entered in acre-feet per month except precipitation recharge data, which is entered in inches per month. Results are output in cubic feet per day (ft^3/d) to conform with MODFLOW length and time units used in the ground water model.

2.1 Averaging Data

Figure 4 shows a general flowchart for the AVGDATA subroutine. The following data are averaged for each stress period:

- Consumptive use requirement (each structure),
- Surface water diversion (each structure),

- Canal leakage, unconsumed irrigation water and irrigation pumping (each structure),
- Groundwater pumped for sprinkler parcels,
- Groundwater pumped for non-sprinkler parcels,
- Ditch shortage for structure,
- Irrigation water requirement for crop (each structure),
- Potential ET for sub-irrigated crop (each structure),
- Municipal and industrial pumping and recharge data (each well),
- Recharge from rim inflow (each rim inflow zone),
- Precipitation data (each county/HUC combination for irrigated and non-irrigated land).

Flow data for each month are stored in acre-feet per month and are converted to cubic feet per day by dividing by the number of days in the month and multiplying by 43560 square feet per acre. Flow data for each stress period are averaged as:

$$AVGFLOW_{sp} = \frac{\sum_{m=1}^{n}\left(Flow_m \times ndm_m\right)}{\sum_{m-1}^{n} ndm_m}$$

Where:

sp = index for stress period,

m = index for month,

n = total number of months in the stress period,

$AVGFLOW_{sp}$ = average flow for stress period *sp* (ft^3/d),

$Flow_m$ = flow for month *m* (ft^3/d),

ndm_m = number of days in month m.

Calculation of average potential ET for a stress period is performed by adding the smaller of the ditch water shortage or the irrigation water requirement for the sub-irrigated crop. The value for $Flow_m$ is the smaller of these two values for month m in the calculation of average potential ET.

Precipitation recharge rate data are averaged for transient simulations using the following calculation:

$$AVGRATE_{sp} = \frac{\sum_{m=1}^{n}\left(Rate_m \times ndm_m\right)}{\sum_{m=1}^{n} ndm_m} \div 12\,in/\,ft$$

Where:

$AVGRATE_{sp}$ = average precipitation recharge rate for stress period *sp* (ft^3/d),

$Rate_m$ = rate of precipitation recharge for month *m* (inches).

3.0 Aquifer Recharge

Recharge is calculated from the following sources:

- canal leakage for canals with GIS information,
- unconsumed surface water from irrigation,
- unconsumed ground water from irrigation,
- canal leakage for canals with no GIS information,
- rim inflows,
- precipitation.

Flow data of recharge estimates, and spatial data of where recharge is to be distributed in the model area, are used to calculate recharge by cell for the ground water model (Table 9). The Consumptive Use model results are the source of flow data for canal leakage and unconsumed surface water and ground water from irrigation. The Surface Water Modeling contractor provides rim inflow recharge data. The Consumptive Use contractor provides precipitation recharge. Figure 5 is a general flow chart for the calculations in the RECHARGE subroutine. A match is found between the identification of the GIS spatial data and the identification of the flow data source. Recharge is calculated for each grid cell associated with the structure. These calculations are described below.

Table 9. Flow and spatial data sources associated with recharge calculations

Recharge data sources	
Flow data source	**Corresponding Spatial data**
Canal leakage	Distribution of canals
Unconsumed surface water from irrigation	Distribution of irrigated lands
Unconsumed ground water from irrigation	Distribution of irrigated lands
Rim inflow recharge	Distribution of rim inflow areas
Precipitation recharge - irrigated lands	Distribution of County/HUC/vegetation type
Precipitation recharge - non-irrigated lands	Distribution of County/HUC/vegetation type

3.1 Leakage Through Canals

Results of the consumptive use model provide monthly canal leakage estimates for each structure. An average leakage amount is calculated for the structure for the specified stress period. The spatial data provides information on where the canal is located in the model grid. A total canal length is specified for each structure. A list of cells that contains portions of the canal is also provided. The recharge is distributed to each grid cell containing a canal segment according to the length of each segment in a grid cell associated with a canal, and a weight for each segment (provided with the spatial data). For structure by structure adjustments sometimes required during calibration, a user-entered factor can be employed in StatePP to adjust the calculated recharge. The calculation for recharge in a grid cell from canal leakage in a stress period is:

$$RCLK_{i,str,sp} = \frac{L_i w_i}{\sum_{i=1}^{n} \left(L_i w_i\right)} \times AVGDLOS_{str,sp} \times faclk_{str}$$

Where:

i = index for grid cell,

n = total number of grid cells associated with the structure,

str = index for structure,

$RCLK_{i,str,sp}$ = recharge from canal leakage in grid cell *i* from structure *str* in stress period *sp* (ft^3/d),

L_i = length of a canal reach in a grid cell *i* (ft),

w_i = weight associated with canal reach in grid cell *i*,

$AVGDLOS_{str,sp}$ = average canal loss for this structure for stress period *sp* (ft^3/d),

$faclk_{str}$ = user entered recharge adjustment factor for canal leakage for structure *str*.

The calculated volumetric recharge is added to the total volumetric recharge in the grid cell from canal leakage. This is done because a grid cell may contain more than one canal segment. The total volumetric recharge is calculated as a recharge rate per grid cell by dividing the volumetric recharge by the dimensions of the grid cell:

$$RCLKR_{i,str,sp} = \frac{RCLK_{i,str,sp}}{ROWH_i \times COLW_i}$$

Where:

$RCLKR_{i,str,sp}$ = recharge rate in grid cell *i* from structure *str* for stress period *sp* from canal leakage (ft/d),

$ROWH_i$ = row height for grid cell *i* (equivalent to DELC in MODFLOW) (ft),

$COLW_i$ = column width for grid cell *i* (equivalent to DELR in MODFLOW) (ft).

3.2 <u>Recharge from Unconsumed Surface Water, Unconsumed Ground Water, and Canal Leakage with no GIS Data</u>

Results of the consumptive use model provide estimates of unconsumed surface water and unconsumed ground water from irrigation. An estimate is provided for each structure listed in the consumptive use model. The average unconsumed surface water and average unconsumed ground water amounts are calculated for each structure for each stress period. This unconsumed water is treated as recharge.

Canal leakage with no GIS data is determined in the AVGDATA subroutine. If a structure has a canal leakage amount associated with it but there is no corresponding structure in the GIS spatial data for canals, the canal leakage amount is stored in an array for canal leakage with no GIS data. This water is then distributed over the irrigated area for the structure in the same way unconsumed surface water and unconsumed ground water are distributed as recharge.

For structure by structure adjustments sometimes required during calibration, the user can enter a recharge factor for each one of these recharge components for each structure in the general StatePP input file. The amount of recharge calculated for each component in each grid cell will be adjusted by that factor as shown in the calculations listed below.

Spatial data provide information on the total area, and total area times a weight associated with the irrigated land for the structure. The area of the irrigated land and a weight is provided for each grid cell associated with the structure. The calculation for recharge in a grid cell from unconsumed surface water is:

$$RCDP_{i,str,sp} = \frac{A_i w_i}{\sum_{i=1}^{n}\left(A_i w_i\right)} \times AVGSW_{str,sp} \times facsw_{str}$$

Where:

A_i = area of irrigated land in grid cell *i* for structure *str* (acres),

w_i = weight associated with irrigated area in grid cell *i*,

$RCDP_{i,str,sp}$ = recharge from unconsumed surface water in grid cell *i* from structure *str* for stress period *sp* (ft^3/d),

$AVGSW_{str,sp}$ = average unconsumed surface water for structure *str* for stress period *sp* (ft^3/d),

$facsw_{str}$ = user entered recharge adjustment factor for unconsumed surface water for structure *str*.

The total volumetric recharge is calculated as a recharge rate:

$$RCDPR_{i,str,sp} = \frac{RCDP_{i,str,sp}}{ROWH_i \times COLW_i}$$

Where:

$RCDPR_{i,str,sp}$ = recharge rate for grid cell *i* from structure *str* for stress period *sp* from unconsumed surface water (ft/d).

The calculation for recharge on a grid cell from unconsumed ground water is:

$$RCGR_{i,str,sp} = \frac{A_i w_i}{\sum_{i=1}^{n}(A_i w_i)} \times AVGGW_{str,sp} \times facgr_{str}$$

Where:

$RCGR_{i,str,sp}$ = recharge from unconsumed ground water in grid cell *i* from structure *str* for stress period *sp* (ft^3/d),

$AVGW_{str,sp}$ = average unconsumed ground water for structure *str* for stress period *sp* (ft^3/d),

$facgr_{str}$ = user entered recharge adjustment factor for unconsumed ground water for structure *str*.

This total volumetric recharge is calculated as a recharge rate per grid cell:

$$RCGRR_{i,str,sp} = \frac{RCGR_{i,str,sp}}{ROWH_i \times COLW_i}$$

Where:

$RCGRR_{i,str,sp}$ = recharge rate in grid cell *i* from structure *str* for stress period *sp* from unconsumed ground water (ft/d).

The calculation for recharge on a grid cell from canal leakage with no GIS data is:

$$RCNA_{i,str,sp} = \frac{A_i w_i}{\sum_{i=1}^{n}(A_i w_i)} \times AVGNA_{str,sp} \times facna_{str}$$

Where:

$RCNA_{i,str,sp}$ = recharge from canals with no GIS information for grid cell *i* from structure *str* for stress period *sp* (ft^3/d),

$AVGNA_{str,sp}$ = average canal leakage for canals with no GIS data for structure *str* for stress period *sp* (ft^3/d),

$facna_{str}$ = user entered recharge adjustment factor for structure *str* with no GIS data.

The total volumetric recharge is calculated as a recharge rate:

$$RCNAR_{i,str,sp} = \frac{RCNA_{i,str,sp}}{ROWH_i \times COLW_i}$$

Where:

$RCNAR_{i,str,sp}$ = recharge rate in grid cell *i* from structure *str* for stress period *sp* from canal leakage with no GIS data (ft/d).

3.3 Recharge from Rim Inflows

Rim inflows are stream flows in intermittent or ephemeral streams that rim a valley. These streams typically have high flow in the spring when snowmelt is occurring in mountainous areas surrounding the valley. As the streams flow over these areas, water from the streams recharges the ground-water system.

Rim inflow zones are defined based on stream basin areas. GIS spatial data provide information on each rim inflow zone, including the cell locations where rim inflow recharge is assigned, and a weight that indicates grid cells may receive a larger or smaller proportion of the total rim inflow recharge. The calculation for recharge on a grid cell from rim inflow is:

$$RCRM_{i,rm,sp} = \frac{A_i w_i}{\sum_{i=1}^{n}(A_i w_i)} \times AVGRMF_{rm,sp} \times fac_{rm}$$

Where:

rm = index for rim inflow zone,

$RCRM_{i,rm,sp}$ = recharge from rim inflows in grid cell *i* from rim area *rm* for stress period *sp* (ft^3/d),

$A_{rm,i}$ = rim area for rim inflow zone *rm* in grid cell *i*,

$AVGRMF_{rm,sp}$ = average rim inflow recharge for rim inflow zone *rm* for stress period *sp* (ft^3/d),

fac_{rm} = user entered recharge adjustment factor for rim inflow recharge for rim inflow zone *rm*.

The calculated volumetric recharge from rim inflow is added to the total volumetric recharge in the grid cell. The total volumetric recharge from rim inflow is calculated as a recharge rate per grid cell:

$$RCRMR_{i,rm,sp} = \frac{RCRM_{i,rm,sp}}{ROWH_i \times COLW_i}$$

Where:

$RCRMR_{i,rm,sp}$ = recharge rate in grid cell *i* from rim area *rm* for stress period *sp* from rim inflow recharge (ft/d).

3.4 Recharge from Precipitation

Aquifer recharge from precipitation occurs when some water from precipitation reaches the saturated zone. The Consumptive Use contractor provides estimates of recharge from precipitation in units of inches per month. Estimates are provided by county and hydrologic unit code (HUC). One data set is provided for precipitation recharge on irrigated lands, and a second data set is provided for precipitation recharge on non-irrigated lands. Recharge from precipitation is averaged for the stress period time period and converted to feet per day. The GIS contractor provides spatial information on county/HUC/vegetation type. The vegetation type is flagged as irrigated or non-irrigated as the data are read in the READ subroutine. Each set of county/HUC/vegetation type combination from the GIS data are matched with the county/HUC/irrigated or county/HUC/non-irrigated precipitation recharge data. The calculation for precipitation recharge for a grid cell on irrigated land is:

$$RCPI_{i,sp} = AI_i \times AVGPRI_{sp} \times 43560\ ft^2 / acre$$

Where:

$RCPI_{i,sp}$ = recharge from precipitation on irrigated land for grid *i* cell for stress period *sp* (ft^3/d),

AI_i = area of irrigated land in grid cell *i* (acres),

$AVGPRI_{sp}$ = average precipitation recharge for this county/HUC combination on irrigated land for stress period *sp* (ft/d).

The calculation for precipitation recharge for a grid cell on non-irrigated land for a particular county/HUC combination is:

$$RCPN_{i,sp} = AN_i \times AVGPRN_{sp} \times 43560\ ft^2 / acre$$

Where:

$RCPN_{i,sp}$ = recharge from precipitation on non-irrigated land in grid cell *i* for stress period *sp* (ft^3/d),

AN_i = area of non-irrigated land in grid cell *i* (acres),

$AVGPRN_{sp}$ = average precipitation recharge in ft/d for this county/HUC combination on non-irrigated land for stress period *sp*.

The calculated recharge is added to the total recharge in the grid cell from precipitation on irrigated and non-irrigated land. This total volumetric recharge is calculated as a recharge rate per grid cell:

$$RCPRR_{i,sp} = \frac{\left(RCPI_{i,sp} + RCPN_{i,sp}\right)}{ROWH_i \times COLW_i}$$

Where:

$RCPRR_{i,sp}$ = recharge rate for grid cell from precipitation on irrigated and non-irrigated land in grid cell *i* for stress period *sp* (ft/d).

3.5 Total Recharge Rate

After each component of recharge is calculated for the stress period, the total recharge rate for each grid cell is calculated and provided to MODFLOW as:

$$RCSM_{i,sp} = RCLKR_{i,sp} + RCDPR_{i,sp} + RCGRR_{i,sp} + RCNAR_{i,sp} + RCRMR_{i,sp} + RCPRR_{i,sp}$$

Where:

$RCSM_{i,sp}$ = total recharge rate in grid cell *i* for stress period *sp* (ft/d).

3.6 Maximum Recharge Rate Check

Each recharge array is written to a file, RARRAY.OUT. The user has the option of designating a maximum recharge rate in inches per year in the general input file for StatePP. This maximum recharge rate is a flag so that if this recharge rate is exceeded in any grid cell, the stress period, grid cell location, recharge rate for the grid cell, and the amount of recharge from each recharge component is written to a file, RCHCHK.OUT. The recharge rate from the grid cell is not changed, but the information allows the user to evaluate high recharge rates. A recharge array for each stress period is written to the MODFLOW recharge file, MODEL.RCH.

4.0 Well pumping

Well pumping data are calculated from the following sources:

- Municipal and Industrial (M&I) wells,
- Agricultural wells with sprinkler data,
- Agricultural wells without sprinkler data.

In general, pumping from M&I wells is developed from user supplied data while pumping from agricultural wells is provided by the Consumptive Use model. Because the Consumptive Use model calculates pumping based on the method of irrigation (flood or sprinkler) StatePP may be used to distribute pumping using this same approach. However, because the data that describes the method of irrigation may not exist or be representative of the modeling study period, StatePP may also be used to distribute pumping without sprinkler data (e.g. as a lumped term that represents total pumping). An option added to StatePP in version 2.31 generates a MODFLOW multi-node well (MNW) file.

4.1 Municipal and Industrial Wells

The Ground Water Contractor provides pumping and recharge estimates for municipal and industrial wells. Data for municipal and industrial pumping and recharge is provided by the ground water contractor and is included in the municipal and industrial pumping file and recharge file input into StatePP. A grid cell location (layer, row, and column) is provided for each well listed. Data are entered in acre-feet for each month for each year of information. The average pumping and recharge from each well is averaged in the AVGDATA subroutine as described previously. The well location and average pumping or recharge rate in cubic feet per day is printed in the MODFLOW well file, MODEL.WEL for each stress period. To generate a MNW file, the top layer and bottom layer in which a particular well is screened are required in the municipal and industrial well data input files.

4.2 Agricultural Wells without Sprinkler Data

This section describes the approach used to estimate pumping by agricultural wells as a total (e.g. without consideration of the method of irrigation). It is appropriate to use this method when the spatial data describing the irrigation method is not considered representative of the entire modeling study period. It operates when the IPMP flag of StatePP general input file is set to one (1).

Agricultural pumping data are provided for each structure listed in the Consumptive Use model results by irrigation method (sprinkler and flood). Spatial data for agricultural wells, including model grid location (layer, row, and column) are provided from GIS data in the irrigation well file. A match is found between the structure ID from the Consumptive Use model results, and the ID from the GIS data. Each structure may have one or more irrigated parcels, and each parcel that uses ground water may be associated with one or more wells. Each parcel is designated as a sprinkler parcel or a non-sprinkler parcel (irrigation method is not considered when IPMP is set to one). The pumping estimates for each structure are averaged for each stress period in the AVGDATA subroutine. Figure 6 is a general flow chart for the PUMP subroutine. Pumping estimates for each well associated with a structure include the following steps:

- calculate the ratio of weighted parcel area to total weighted area served by ground water for the structure,
- calculate the proportion of ground water diversion for the parcel,
- distribute pumping per well associated with the parcel based on permitted well yield and proportion of time well is on line during the stress period,
- aggregate total agricultural pumping by grid cell.

Because agricultural pumping data are provided for each structure listed in the Consumptive Use model results by irrigation method (sprinkler and flood), the total pumping for a structure is calculated and averaged for each stress period simulated in the AVGDATA subroutine. The model then distributes pumping to agricultural wells using the following equation:

$$WLPMP_{wl,p.sp} = AVGGW_{str,sp} \times PROPPA_{p,str} \times WLPROP_{wl,p,sp} \times -1.0$$

Where:

wl = index for well,

p = index for parcel for this structure,

$WLPMP_{wl,p,sp}$ = amount of ground water to be pumped for well *wl*, in parcel *p*, during stress period *sp* (ft^3/d),

$AVGGW_{str,sp}$ = Average ground water diversion for all parcels for structure *str* for stress period *sp* (ft^3/d),

$PROPPA_{p,str}$ = proportion of area of parcel p served by ground water to total area of all parcels served by ground water associated with structure *str* (dimensionless),

$WLPROP_{wl,p,sp}$ = proportion of ground water to be pumped by well *wl*, in parcel *p* during stress period *sp* to total amount of water that can be pumped by all wells in parcel *p* (dimensionless).

$PROPPA_p$ is calculated as:

$$PROPPA_{p,str} = \frac{A_{p,str}}{\sum_{p=1}^{n} A_{p,str}}$$

where:

$A_{p,str}$ = Area of parcel *p* associated with structure *str* in irrigated lands served by ground water.

$WLPROP_{wl,p,sp}$ is calculated as:

$$WLPROP_{wl,p,sp} = \frac{\frac{YRSWEL_{wl,p,sp}}{YRS_{sp}} \times WLCAP_{wl,p}}{\sum_{wl=1}^{n}\left[\frac{YRSWEL_{wl,p,sp}}{YRS_{sp}} \times WLCAP_{wl,p}\right]}$$

Where:

$YRSWEL_{wl,p,sp}$ = number of years well *wl* in parcel *p* is online during stress period *sp*,

YRS_{sp} = number of years for stress period *sp*,

$WLCAP_{wl,p}$ = permitted yield of well *wl* in parcel *p*(ft^3/d).

A message is written to the SPP.LOG file if a parcel associated with a structure does not have any pumping capacity. A ground water parcel with no pumping capacity can result from:

- wells associated with a parcel are not online during the stress period,
- wells fall on an inactive or constant head grid cell,
- wells have no pumping capacity,
- there is no ID from the GIS data to match the ID from the CU model results,
- a combination of the above that results in no pumping capacity for the parcel.

The number of wells (irrigation, industrial, and municipal) for each stress period is calculated and the maximum number of wells for any one stress period is calculated. The cell-by-cell flag required in the MODFLOW well file and the well data are written to the MODEL.WEL file along with the well data.

The amount to be pumped for the well is added to the total amount pumped in grid cell *i* for stress period *sp*. The amount to be pumped for each model layer is summed and printed to the SPP.OUT output file.

4.3 Agricultural Wells with Sprinkler Data

This section describes the approach used to estimate pumping by agricultural wells based on the method of irrigation (flood or sprinkler). It is appropriate to use this method only when the spatial data describing the irrigation method is considered representative of the modeling study period. It operates when the IPMP flag of the StatePP general input file is set to two (2).

The amount of ground water to be pumped by each well on a per-parcel basis for sprinkler parcels associated with a structure is:

$$WLPMPS_{wl,p.sp} = AVGGWS_{str,sp} \times PROPPAS_{p,str} \times WLPROP_{wl,p,sp} \times -1.0$$

Where:

$WLPMPS_{wl,p,sp}$ = amount of ground water to be pumped for well *wl*, in sprinkler parcel *p*, during stress period *sp* (ft^3/d),

$AVGGWS_{str,sp}$ = Average ground water diversion for all sprinkler parcels for structure *str* for stress period *sp* (ft^3/d),

$PROPPAS_{p,str}$ = proportion of area of sprinkler parcel p served by ground water to total area of all sprinkler parcels served by ground water associated with structure *str* (dimensionless),

$PROPPAS_p$ is calculated as:

$$PROPPAS_{p,str} = \frac{AS_{p,str}}{\sum_{p=1}^{n} AS_{p,str}}$$

Where:

$AS_{p,str}$ = Area of sprinkler parcel *p* associated with structure *str* in irrigated lands served by ground water.

The amount of ground water to be pumped by each well on a per-parcel basis for non-sprinkler parcels associated with a structure is:

$$WLPMPN_{wl,p.sp} = AVGGWN_{str,sp} \times PROPPAN_{p,str} \times WLPROP_{wl,p,sp} \times -1.0$$

Where:

$WLPMPN_{wl,p,sp}$ = amount of ground water to be pumped for well *wl*, in non-sprinkler parcel *p*, during stress period *sp* (ft^3/d),

$AVGGWN_{str,sp}$= Average ground water diversion for all non-sprinkler parcels for structure *str* for stress period *sp* (ft^3/d),

$PROPPAN_{p,str}$ = proportion of area of non-sprinkler parcel p served by ground water to total area of all sprinkler parcels served by ground water associated with structure *str* (dimensionless),

$PROPPAN_p$ is calculated as:

$$PROPPAN_{p,str} = \frac{AN_{p,str}}{\sum_{p=1}^{n} AN_{p,str}}$$

Where:

$AN_{p,str}$ = Area of non-sprinkler parcel p associated with structure str in irrigated lands served by ground water.

4.4 Multi-Node Well File

StatePP version 2.31 was upgraded to include the option to generate a MODFLOW multi-node well file (MNW). The multi-node well file allows users to simulate wells that extend beyond a single model node. Multi-node wells dynamically distribute flow between nodes under pumping, recharging, or unpumped conditions (Halford and Hanson, 2002, USGS Open-File Report 02-293).

The MNW package is implemented with linear aquifer-loss and well-loss coefficients. In addition, the MNW package's ability to account for differences in transmissivity near the bore hole (due to formation damaged during well drilling, the gravel pack , and the well screen) through use of the 'SKIN' parameter is disabled in StatePP (Skin = 0). The radius of all wells is assumed to be 0.75 feet. Although this may not represent an accurate measurement for all wells in the model, when the model cell size is greater than approximately 1000 feet, drawdown in the well is not sensitive to small (< 1foot) changes in the well radius. This version of StatePP assumes a well is completed in its specified top and bottom model layers and all intervening layers.

The MNW option is selected by setting the MNW flag in the control file. When this flag is set, the MNW file will be generated in addition to the MODFLOW well input file. Only one of these files should be used in the MODFLOW simulation. In comparison to previous versions of StatePP, additional data are required in the agricultural and municipal and industrial pumping input files to generate the MNW file. In addition to data provided to previous versions of StatePP, agricultural well data must include top and bottom model layers in which a given well is completed, unique well ID, and a multi-parcel flag. The multi-parcel flag indicates that an agricultural well supplies more than one parcel of land and is therefore listed in the well input file more than once. Municipal and industrial pumping must include top model layer and bottom model layer in which a given well is completed. These additional data and the required formatting for agricultural wells are discussed in detail in the documentation for program Agg. The corresponding detailed data and formatting requirements for the municipal and industrial pumping are contained in Appendix J, Tables 4.7 and 4.8. Specified boundary fluxes that are simulated as pumping or injection wells in MODFLOW are also incorporated into the MNW. These wells, however, are not treated as multi-node wells since there is no borehole through which flow can occur between model layers, and are all simulated as single node wells.

The MNW option was implemented in StatePP through the addition of a new subroutine 'write_mnw' and modifications to other sections of the program to read-in and pass the new required data to 'write_mnw'. The FORTRAN computer code is given in the Appendix A Addendum. This implementation was carried out in such a way that input files used and designed for previous versions of StatePP will run as before if the MNW flag is set to zero or omitted in the control file. In addition, the program Agg was modified to read in the new MNW data and pass these data through to StatePP via the IRWWELLS.dat file (as described in section 1.3). Modifications made to Agg do not affect its performance if the additional MNW data is not provided. However, in such instances where the additional MNW data is not given as input to Agg, StatePP cannot generate a MNW file. An error file named 'mnwerror.err' is generated which contains a listing of errors encountered during MNW generation. Table 4.1 summarizes the possible states of input and the resulting output in StatePP.

Table 4.1. Input options and results

MNW flag	Required MNW Data Provided in Input Well Files	Result
1	Yes	MNW file generated
	No	Error during read-in, program stops
0 or omitted (blank)	Yes	MNW not generated, additional MNW data ignored
	No	MNW not generated

5.0 Drains

StatePP processes two types of drain data; flowing wells and other features represented as drains. Flowing wells are artesian wells that flow at the ground surface. These flowing wells are represented as drains. The elevation of the "drain" (flowing well) is ground elevation. If head in the grid cell is above the average ground elevation, the drain is activated and discharge will occur to simulate a flowing well. If there is a decline in head in the grid cell that contains the flowing well, flowing well discharge will be reduced to reflect the decline in head. There is zero discharge if the head elevation is below ground elevation. A portion of the discharge from flowing wells may recharge the top layer of the model. The U.S.G.S. has also written a new drain package, DRT1[2], which allows for recharge to the top layer of a model in proportion to drain flow. The user designates a proportion of the drain discharge that recharges the top model layer.

The location and number of flowing wells are commonly not known. For the RGDSS project, flowing well locations were estimated by using the location of wells

[2] Banta, E.R., 2000, MODFLOW-2000, The U.S. Geological Survey modular ground-water model – documentation of packages for simulating evapotranspiration with a segmented function (ETS1) and drains with return flow (DRT1), Open-file report 00-466, U.S.G.S., 127 p.

with a less than 50 gpm permitted yield.   The Spatial Data Base contractor provides spatial data on the location of the wells with less then 50 gpm permitted yield.

The following steps are used to create a list of flowing wells for the MODEL.DRN MODFLOW input file for each well listed in the flowing well data file:

- obtain grid location in which well is located,
- if the well is in layer 2 or 3, obtain grid cell ground surface elevation,
- obtain grid cell hydraulic conductivity, and
- calculate drain conductance.

Drain conductance is calculated as:

$$DRNCND_j = \frac{K_i A}{L}$$

Where:

j	= index for drain,
$DRNCND_j$	= drain conductance for drain *j*,
K_i	= hydraulic conductivity in grid cell *i* (ft/d),
A	= flow area (circumference of well x length of perforation) (ft^2),
L	= length of flow path (ft).

Drain conductance for flowing wells is estimated based on the hydraulic conductivity of the grid cell, an estimated well circumference, an estimated length of perforation, and a one-foot flow path. A well circumference and a perforation length are entered in the general input file to StatePP (See Appendix B for input file examples). This calculation is used as an initial estimate of drain conductance. The user can enter a factor to increase or decrease flowing well drain conductance during calibration. One factor is used to adjust all drain conductances for drains representing flowing wells.

The user enters a factor for flowing well recharge to the top layer from flowing well discharge. This is the proportion of flowing well discharge that recharges the uppermost model layer. The grid cell location (layer, row, column), drain elevation, conductance, and recharge factor for each flowing well is written the MODFLOW drain file. Figure 7 shows a general flow chart for the FLWELL subroutine.

Other features represented as drains include agricultural drains and springs. Some streams may be represented as drains if the observed behavior of the stream is more like a drain. These data are provided in a standard MODFLOW drain file that is read by StatePP. The elevation of each of these drains is compared against the average ground elevation for the grid cell. The user enters a minimum depth below ground surface in the StatePP general input file (Appendix B). If the elevation of the drain is above the average ground elevation in the grid cell, the elevation is changed to the ground surface elevation minus the minimum depth specified in the StatePP input file because by definition a drain elevation cannot be higher than ground elevation. The calculation for the adjusted drain elevation is:

$$DRELEV_j = SURF_i - DRMIN$$

Where:

$DRELEV_j$ = drain elevation for drain *j* (ft),

$SURF_i$ = average ground elevation in grid cell *i* (ft),

DRMIN = minimum depth below ground surface (ft).

The user also enters a maximum depth for a drain in the StatePP general input file (Appendix B). An adjustment is made if the drain elevation falls below this maximum depth. This ensures that the drain is at a reasonable depth below ground surface. If the drain elevation is more than maximum depth below the land surface, the drain elevation is changed to:

$$DRELEV_j = SURF_i - DRMAX$$

Where:

DRMAX = maximum depth below ground surface (ft).

The number of drains (other than flowing wells) listed in the MODFLOW drain file is added to the number of flowing well drains to calculate the total number of drains.

Data for each drain listed in the drain input file are written to the MODEL.DRN file followed by the flowing well drain data and drain data from the drain input file. If more than one stress period is simulated, a flag is printed in the MODEL.DRN file for each stress period that indicates the drain information from the previous stress period will be used.

6.0 Evapotranspiration

StatePP processes evapotranspiration functions and land use data to prepare an evapotranspiration (ET) data file from MODFLOW. A new evapotranspiration (ET) package for MODFLOW, ETS1, has also been developed by the U.S.G.S. that allows the user to enter a piecewise linear ET function for each grid cell.[3] The ETPROP subroutine and the ETSUB subroutine (used if sub-irrigation is simulated using evapotranspiration) in StatePP was developed to process spatial data of the distribution of vegetation types and piecewise linear functions for each vegetation zone to create an ET input file for the ETS1 package. The ETPROP and ETSUB subroutines performs the following functions:

- combines vegetation types in ET zones,
- calculates proportion of grid cell area occupied by ET zone type,
- calculates an equivalent ET function for a grid cell,
- calculates ET rate proportion array and ET extinction depth proportion array for each function point between the first and last function points,
- creates MODFLOW evapotranspiration file for the ETS1 package.

Figure 8 shows a general flow chart for the ETPROP subroutine.

6.1 Spatial Data

The Spatial Database contractor provides GIS spatial data on vegetation types. For each vegetation type the file contains a list of grid cell locations and the grid cell area

[3] Ibid.

covered by the vegetation type. In some cases, the spatial data may not cover the entire model area, and a “blank vegetation” type may have been entered in the input file. The user can default a vegetation type to fill in the blank areas.

The user specifies ET zones in the ET zone data file. One or more vegetation types may be included in a zone. For example, two vegetation types, such as “medium vegetation” and “non-irrigated crop” may be combined under one zone labeled as “medium vegetation”.

Calculation of the equivalent ET function for a grid cell has the following steps:

- combine vegetation types into zones,
- calculate the proportion of a grid cell occupied by a vegetation zone,
- calculate the equivalent ET function point value for a grid cell.

6.2 Calculation of Equivalent Evapotranspiration Function

The user enters ET functions for each vegetation zone. The ET function is a piece-wise linear function. The X variable is a series of points that specifies depth of water below ground surface. The first X data point is zero (depth to water equals zero). The last X data point is the extinction depth. The Y variable is a series of points that specifies an ET rate at the depth specified by the X variable. The same series of X data points (depth to ground water) must be used for each ET function. The value of the series of Y data points can vary by vegetation zone. If the ET function consists of only two data points, the resulting function is a linear ET function. If the ET function consists of three or more data points, the resulting function is piecewise linear. An example of how a piecewise linear function is used to approximate a nonlinear function is shown in Figure 10. The piecewise linear curve in Figure 10 is an example of an ET function used in the San Luis Valley ground water model for wetland areas.

Combining the vegetation types into vegetation zones creates an array for each vegetation zone. The proportion of the area of a grid cell occupied by an ET zone is calculated as:

$$ETPR_{z,i} = \frac{ETAREA_{z,i}}{ROWH_i \times COLW_i} \times 43560\, ft^2 / acre$$

Where:

z	= index for ET zone,
$ETPR_{z,i}$	= proportion of ET zone z in grid cell *i*,
$ETAREA_{z,i}$	= area of ET zone z in grid cell *i* (acres).

The value of the Y variable, (ET rate) for each point on the ET function for a grid cell is adjusted by the amount of area occupied by the ET zone in the grid cell:

$$PTY_{pt,z,i} = ETPY_{pt,z} \times ETPR_{z,i}$$

Where:

pt	= index for data point in ET function,
$PTY_{pt,z,i}$	= ET rate for ET data point *pt*, for vegetation zone *z* in grid cell *i* (ft/d),
$ETPY_{pt,z}$	= ET rate for data point *pt*, for vegetation zone *z* (ft/d).

The total ET rate for a y variable data point for a grid cell is calculated as:

$$TOTPTY_{i,pt} = \sum_{z=1}^{n} PTY_{i,pt,z}$$

Where:

$TOTPTY_{i,pt}$	= ET rate for ET point *pt* in grid cell *i* (ft/d).

The U.S.G.S. ETS1 package includes the following arrays:

- ground surface elevation,
- maximum ET rate,
- extinction depth,

- proportion of extinction depths for data points between the first X data point (depth to water equal to zero) and the last X data point (extinction depth),
- proportion of maximum ET rate for data points between the first and last Y data points.

The proportion of extinction depth for each data point is calculated as:

$$PXDP_{pt} = \frac{ETPX_{pt}}{EXDP}$$

Where:

$PXDP_{pt}$ = proportion of extinction depth for data point *pt*,

$ETPX_{pt}$ = depth entered by user for data point *pt* (ft),

EXDP = extinction depth (ft).

The proportion of maximum ET rate for each grid cell for each data point between the first and last data points is calculated as:

$$PETM_{i,pt} = \frac{EVTR_{i,pt}}{EVTR_{i,1}}$$

Where:

$PETM_{i,pt}$ = proportion of maximum ET rate in grid cell *i* for data point *pt*,

$EVTR_{i,pt}$ = ET rate in grid cell *i* for data point *pt* (ft),

$EVTR_{i,1}$ = maximum ET rate in grid cell *i* for first data point (ft/d).

Seasonal fluctuation of ET is represented by entering a multiplier for the maximum ET rate for each stress period in the ET zone data input file for SPP. The MODFLOW ETS1 input file is written with the assigned multiplier in the control record for the maximum ET rate for each stress period. The multiplier used is dependent on the ET rates entered for the data points. For example, if the ET rate entered for the equations is an average annual ET rate, the multiplier may be greater than one during stress periods with higher ET and less than one during stress periods with lower ET. If the ET rate entered for the data points represents a maximum rate for the year, the largest multiplier would be one, and multipliers for other stress periods that are not peak ET periods would be less than one.

7.0 Sub-irrigation by Irrigated Crops

StatePP can be used to simulate sub-irrigation from groundwater by an irrigated crop. Like native ET, sub-irrigation ET is simulated as a function of the land cover, depth to water, and time of year. However, unlike native ET, some or all of the sub-irrigated lands water requirement may be served by surface or ground water supplies. Therefore potential sub-irrigation ET varies by month and structure based on location and other water supplies.

When the ISIR flag is set equal to one, the ET data generated by StatePP will include a sub-irrigation ET component added to the ET from native vegetation. The additional ET associated with a sub-irrigated crop (e.g. irrigated meadowlands) is calculated and added to the ET from native vegetation to result in one equivalent ET function for each grid cell for each stress period.

7.1 Spatial Data

The Spatial Database contractor provides GIS spatial data for the irrigated crop that may, potentially, be sub-irrigated (e.g. irrigated meadowlands). The spatial data includes the structure ID along with the number of grid cells in the model that contain the irrigated crop (e.g. irrigated meadowlands) associated with that structure. For each structure and associated grid cell that includes a sub-irrigated crop its location in the model grid (layer, row, column), the area occupied by the sub-irrigated crop within the grid, and a weighted area are provided. The weighted area term allows a user to adjust the ET calculations based on some spatial property. Typically a weight of 1.0 is used which results in the weighted area equaling the area occupied by the sub-irrigated crop.

7.2 Consumptive Use Data

The consumptive use contractor provides the irrigation water requirement for the sub-irrigated crop as well as the total (all crops) ditch shortage for each structure in the consumptive use model output. The potential amount of ET for a sub-irrigated crop for a structure is calculated using the smaller value of the sub-irrigated crops irrigation water requirement or the total ditch water shortage. By including the total ditch shortage in the calculations, StatePP recognizes total CU by a structure is limited by the crops being grown and that the CU model does not have explicit knowledge of exactly how surface and ground water supplies were applied.

7.3 Calculation of Equivalent Subirrigation Function

The data associated with ET from sub-irrigated lands is incorporated into Modflow as a composite ET function that includes ET from native lands and ET from sub-irrigated lands. The user specifies ET zones in the ET zone data file. An ET zone can include one or more vegetation or crop types that share a common ET function. If sub-irrigation is simulated, the last ET zone listed in this file is the sub-irrigation zone. In addition, a preliminarily sub-irrigation ET function is provided that dictates the shape of the ET vs. depth to water relationship.

Calculation of the equivalent ET function for both native and sub-irrigated lands for each stress period by grid cell has the following steps:

- Calculate the equivalent ET function for native vegetation for this time period (see Section 6.0),
- Find the lesser amount of the irrigation water requirement the sub-irrigated crop (e.g. irrigated meadow) or the total ditch water shortage for every structure,
- Calculate the maximum possible ET rate for the sub-irrigated crop to be the smaller value of the sub-irrigated crops irrigation water requirement or the total ditch water shortage,

- Calculate the ET rate for sub-irrigated lands for each ET vs. depth to water data point for each grid cell associated with the structure,
- Write ET function for sub-irrigated crop for this structure for each depth to water data point to file to be used in post-processing irrigated crop ET,
- Add the sub-irrigated ET rate to the native ET rate for each ET vs. depth data point for the grid cell,
- Calculate the ET proportion array required by MODFLOW,
- Write the MODFLOW ET input file.

As described above, the maximum possible ET rate for sub-irrigation by a structure is the irrigation water requirement, or the total ditch shortage whichever is smaller. If the total ditch shortage for a structure is less than the irrigation water requirement for the sub-irrigated crop (e.g. irrigated meadow) the maximum possible ET rate is:

$$ETRATEM_{str,sp} = \frac{DEFSTR_{str,sp}}{TOTIRMA_{str} \times 43560\, ft^2 / acre}$$

Where:

str = index for structure,

sp = index for stress period,

$ETRATEM_{str,sp}$ = maximum possible ET rate (ft/d),

$DEFSTR_{str,sp}$ = ditch shortage for the structure for stress period sp (ft^3/d),

$TOTIRMA_{str}$ = total area of irrigated crop for the structure (acres).

If the irrigation water requirement for irrigated meadow for a structure is less than the total ditch shortage, the maximum possible ET rate is:

$$ETRATEM_{str,sp} = \frac{WRMEAD_{str,sp}}{TOTIRMA_{str} \times 43560\, ft^2 / acre}$$

Where:

$WRMEAD_{str,sp}$ = irrigation water requirement for the irrigated crop for the structure (ft^3/d).

To complete the sub-irrigation ET versus depth relationship each subsequent point entered for the ET function, the points are adjusted to be proportional to the maximum ET calculated. This adjustment factor is calculated for each stress period because the maximum ET rate for irrigated crop changes each stress period. The adjustment factor is calculated as:

$$ETADJ_{str,sp} = \frac{ETRATEM_{str,sp}}{ETMAXM_{str,sp}}$$

Where:

$ETADJ_{str,sp}$ = Adjustment factor for ET data points for structure str for stress period sp.

$ETMAXM_{str}$ = Maximum ET rate input as the first data point as part of the ET function for irrigated crop input by the user in the ET input file (ft/d).

The first data point for the ET function is the calculated maximum ET rate. The ET rate for the last data point is zero because the last data point is the extinction depth. The ET rate for each data point between the first and last data point for structure in a stress period is calculated as:

$$ETIC_{str,pt,sp} = ETPY_{pt,z} \times ETADJ_{str,sp}$$

Where

$ETIC_{str,pt,sp}$ = ET rate for irrigated crop for structure str, point pt, in stress period sp,

$ETPY_{pt,z}$ = Initial ET data point pt for irrigated crop (ft/d).

The ET rate for each depth to water data point (except the last data point where the ET rate is always zero) for structure str in stress period sp is written to an output file to be used in post-processing ET data.

In addition to calculating the ET rate from irrigated crop for post-processing ET, the contribution of ET from irrigated crop for the grid cell is added to the total ET rate from the grid cell. The contribution of ET from irrigated crop for the grid cell considers the area of the cell occupied by the irrigated crop. An area proportion is required because the sub-irrigated crop (e.g. irrigated meadowland) may occupy only a portion of the grid cell. The area proportion for the grid cell is:

$$AREAPRP_i = \frac{AREACL_i \times 43560\ ft^2 / acre}{ROWM_i \times COLM_i}$$

Where:

$AREAPRP_i$ = proportion of area of grid cell i occupied by irrigated crop (dimensionless),

$AREACL_i$ = area in grid cell occupied by irrigated crop (acres),

$ROWM_i$ = length of row for cell i (ft),

$COLM_i$ = length of column for cell i (ft).

The maximum possible ET rate calculated, ETRATEM, is dependent on the irrigation water requirement and total ditch water shortage for each stress period. The first data point (maximum ET rate) for the ET function for irrigated crop for a grid cell is calculated as:

$$PTYIM_{i,str,1,sp} = ETRATEM_{str} \times AREAPRP_i$$

Where:

1 = index for the first ET data point in ET function,

$PTYIM_{i,str,1,sp}$ = ET rate for irrigated crop in cell i for structure sp, for the first ET data point (maximum ET rate) in stress period sp (L/T),

The additional ET data points for the ET function (except the last data point where the ET rate is zero at the extinction depth) for a structure are calculated as:

$$PTYIM_{i,str,pt,sp} = ETPY_{pt,z} \times AREAPRP_i \times ETADJ_{str,sp}$$

The ET rate from irrigated crop is added to the total ET rate for the grid cell. The equivalent ET rate for an ET data point for a grid cell is calculated as:

$$EVTR_{i,pt,sp} = \sum_{z=1}^{n} PTY_{i,pt,z} + \sum_{im=1}^{nn} PTYIM_{i,str,sp}$$

Where:

im = Index for irrigated crop that fall within the grid cell,

nn = Total number of structures with irrigated crop that fall within the grid cell,

$EVTR_{i,pt,sp}$ = Equivalent ET rate in grid cell i for ET point pt for stress period sp (ft/d),

$PTY_{i,pt,z}$ = ET rate for grid cell i for ET data point *pt*, for native vegetation zone *z*

$PTYIM_{pt,z}$ = ET rate for data point *pt*, for vegetation zone *z* (ft/d).

Modflow input requires ET data to be provided as the proportion of maximum ET rate for each grid cell for each ET data point. Therefore this proportion is calculated between the first and lasts data points as follows:

$$PETM_{i,pt,sp} = \frac{EVTR_{i,pt,sp}}{EVTR_{i,1,sp}}$$

Where:

$PETM_{i,pt,sp}$ = Proportion of maximum ET rate in grid cell i for data point pt for stress period sp (dimensionless),

$EVTR_{i,pt,sp}$ = ET rate in grid cell i for data point pt for stress period sp (ft/d).

$EVTR_{i,1,sp}$ = Maximum ET rate in grid cell i for data point 1 for stress period sp (ft/d).

8.0 Input and Output Description

An example problem is included on a CD-rom disc accompanying this memo. The file sizes are too large to be included in the text of this report, but are included in their entirety on the CD-rom disc. The file names for the input files are listed in Table 5.

These filenames are found in the file "INFILES". Table 7 lists output files produced by StatePP. The data are from the RGDSS project. The example problem is for one stress period, which is from 1978 to 1987, January through December time period. Data are averaged data values for this stress period as described in section 2.0.

General information entered by the user for the StatePP run is included in the StatePP general input file (STATEPP.DAT) including:

- Flags for program options and printing options,
- Number of stress periods,
- Number of diversions in consumptive use information,
- Number of rim inflow zones and number of years of rim inflow recharge data,
- Number of county abbreviations (to be used in the calculation of recharge from precipitation),
- For each stress period, beginning and ending year, beginning and ending month,
- List of structures and recharge factors for each structure for canal leakage, excess surface water, excess ground water, and canal leakage for structures with a canal leakage amount in the Consumptive Use data, but no canal information in the GIS data,
- List of names for rim inflow recharge areas and recharge factor for each area,
- Recharge factor for drains (factor to multiply discharge from flowing wells and apply as recharge to layer 1),
- Conductance multiplication factor,
- Flowing well circumference,
- Flow well perforation length,
- Minimum depth of drain below ground elevation,
- Maximum depth of drain below ground elevation,
- County abbreviation and corresponding county identification,
- Vegetation code and corresponding vegetation type.

MODFLOW grid information and other MODFLOW information are included in the MODFLOW information file (MFGRID.DAT) including:

- Number of layers, rows, and columns in the model,
- Column and row dimensions,
- IBOUND arrays for each layer,
- Data for MODFLOW recharge file,
- Data for MODFLOW well file.

Hydraulic conductivity data is included in the HYCN.DAT file including:

- Number of layers with data,
- List of the layer numbers,
- Flag to specify if an array is read or if there is a single value for hydraulic conductivity for the layer (in the example provided arrays are read),
- Array of hydraulic conductivity data for each layer listed (layers 2 and 3).

Evapotranspiration functions and other ET information are read in the ETZONE.DAT file including:

- Number of vegetation zones,
- Total number of vegetation types,
- Number of points for each function,
- Name for areas with no vegetation type listed,
- Vegetation type to fill in for areas with no vegetation type listed,
- For each vegetation zone, the name of the zone and the number of vegetation types listed under that zone,
- For each vegetation zone, the name of each vegetation type associated with the zone,
- X coordinates for depth to ground water,
- For each vegetation zone, Y coordinates that correspond to X coordinates,
- Ground elevation,
- List of multipliers for each stress period to be entered in the control record in the MODFLOW ETS1 input file,
- Data to be read and printed to the MODFLOW ET file.

A MODFLOW drain file containing information on drains other than flowing wells is included in the DRAIN.DAT file. Drain elevations are checked as described in Section 5.0 on drains. Flowing well data are added to this file after flowing well data are processed in StatePP. Consumptive Use model results are included in the CUDATA.DAT file. This is an output file created from StateCU, a consumptive use model.

GIS data for canals, irrigated lands, and irrigation wells may require processing using the AGG program if some structures need to be aggregated. GIS produced data files include the following:

- DIVLEAK.DAT - canals (from *filename*.CAN processed in AGG),
- DIVIRLN.DAT – irrigated lands (from *filename*.IRR processed in AGG),
- IRRWELLS.DAT – irrigation wells (from *filename*.WEL processed in AGG),
- CROP.DAT - irrigated crop (from *filename*.IRM processed in AGG)
- RGDSS.ETZ – native vegetation distribution,
- RGDSS.RIM – rim inflow areas,
- RGDSS.SFW – wells with less than 50 gpm permitted yield,
- RGDSS.PCP – county/HUC/vegetation distribution for use in calculation of precipitation recharge.
- RGDSS.IRM – irrigated crop

Flow data for rim inflow recharge, municipal and industrial pumping and recharge from precipitation come from different sources. These include the following files:

- RIMFLOW.DAT – rim inflow recharge estimates for designated rim inflow areas (from Surface Water contractor),
- MUINP.DAT – municipal and industrial pumping (from Ground Water contractor),
- MUINI.DAT – municipal and industrial recharge (from Ground Water contractor),
- PPTREIRR.STM – recharge from precipitation on irrigated lands (from Consumptive Use contractor),

- PPTRENON.STM – recharge from precipitation on non-irrigated lands (from Consumptive Use contractor).

These files are in the same directory as the SPP.EXE program. To run the program, enter SPP. The program automatically looks for the file INFILES to get the name of the input files to be read. Calculations are done for each stress period and the following MODFLOW files are written:

- MODEL.RCH – MODFLOW recharge file,
- MODEL.WEL – MODFLOW well file,
- MODEL.EVT – MODFLOW ETS1 evapotranspiration file,
- MODEL.DRN – MODFLOW drain file.

Other files created include:

- SPP.OUT – StatePP output file,
- SPP.LOG - StatePP log file,
- CUAVG.OUT – Average consumptive use components for each stress period,
- RARRAY.OUT – recharge arrays for each recharge component for each stress period,
- RCHCHK.OUT – list of grid cells that exceed maximum recharge rate for each stress period and the components of recharge that sum to the recharge rate for the grid cell.

SPP.OUT echoes some input data and directs the user to files that echo other input where the size of the data are too large to include in SPP.OUT. Additional files that echo input data include:

- MFGRID.OUT – MODFLOW grid information,
- HYCN.OUT – hydraulic conductivity information,
- GISPRCH.OUT – GIS precipitation recharge area data,
- PRCPRCH.OUT – precipitation recharge,
- CANALS.OUT – GIS canal data,

- IRRLAND.OUT – GIS irrigated land data,
- CUDATA.OUT – Consumptive use data,
- IRRWELLS.OUT – GIS irrigation well data,
- MUIN.OUT – municipal and industrial well discharge and recharge,
- RIMFLOW.OUT – rim inflow recharge,
- RIMAREA.OUT – GIS rim inflow area data,
- ETSURF.OUT – Ground elevation data,
- ETVEG.OUT – GIS native vegetation data,
- FLWELLS.OUT – GIS low capacity well data,
- CUAVG.OUT – average CU data for each stress period,
- CROP.OUT – GIS irrigated crop data.

SPP.OUT also includes a summary of information such as the total number of structures in each GIS file that includes structures, the total number of municipal and industrial wells, etc. The data from the consumptive use model are averaged for each stress period, and the information written to SPP.OUT. These data include:

- Consumptive use requirement,
- Diversion flow,
- Ground water diversion,
- Canal and ditch leakage,
- Surface water return flow (excess surface water),
- Ground water return flow (excess ground water),
- Canal and ditch leakage for canals with no GIS data.

Consumptive use requirement and diversion flows are not used in any calculations in StatePP, but they are presented for the user's information. The rim inflow recharge, precipitation recharge, and municipal and industrial pumping and recharge are calculated for each stress period and reported in SPP.OUT. Differences may result between averaged consumptive use model results, averaged rim inflow recharge and the final recharge amount used as input in MODEL.RCH. This is because the user has the option of using a factor to reduce recharge. For example, in the RGDSS project, the option to adjust recharge was used to reduce recharge for all structures by 3%. In addition, some canals were modeled as streams. Therefore, the recharge from canal leakage was reduced for these structures because leakage would be calculated in the stream module. Detail information on canal leakage for canals modeled as streams in included in Appendix D. The differences between the averaged consumptive use model results, rim inflow results, and the final recharge and pumping for a steady-state simulation for RGDSS are listed in Table 10.

Table 10. Comparison between flow components and actual MODFLOW input for the RGDSS project for steady-state simulation

Flow Componenent	Calculated* (ac-ft/yr))	Actual Model (ac-ft/yr)	Difference (ac-ft/yr)	Percent Difference
Canal Leakage	354,323	309,073	45,250.25	12.77%
Excess surface water	319,878	310,282	9,596.38	3.00%
Excess ground water	123,392	119,691	3,701.71	3.00%
Canal leakage - no GIS data	4977.5	4,828	149.33	3.00%
Rim Inflow	215,073	215,073	0.00	0.00%
Precipitation	55,408	55,408	0.00	0.00%
TOTAL RECHARGE	**1,073,053**	**1,014,355**	**58,697.67**	**5.47%**
Muni. and Industrial Net Pumping	-8,082	-8,082	0.00	0.00%
Irrigation pumping	-515,816	-515,816	0.00	0.00%
TOTAL PUMPING	**-523,898**	**-523,898**	**0.00**	**0.00%**

* Recharge components calculated from Consumptive Use model results, rim inflow recharge estimates, and precipitation recharge. Municipal and industrial net pumping calculated from ground water contractor data. Irrigation pumping calculated from Consumptive Use model results.

A log file, SPP.LOG is written that records progress as the program is executed. Additional information in the SPP.LOG file includes information on:

- irrigation wells and parcels with no pumping capacity,
- municipal and industrial wells that fall on inactive or constant head grid cells,
- differences between calculated and reported areas in rim inflow areas,
- drain elevation corrections,
- rim inflow areas in GIS data with no matching rim inflow information in rim inflow recharge data,

- Consumptive Use structure IDs with no matching ID in the GIS irrigation well data,
- irrigation parcels where amount to be pumped exceeds pumping capacity of parcel (pumping, however, is not limited by this amount),
- irrigation wells located on inactive or constant head grid cells.

The average consumptive use model results for each stress period are written to a file, CUAVG.OUT. This file includes for each structure the stress period and structure ID and average values for the stress period for**:**

- consumptive use requirement,
- diversion,
- canal and ditch leakage,
- canal and ditch leakage for canals with no GIS data,
- surface water return flow (excess surface water),
- ground water diversion,
- ground water return flow (excess ground water).

A recharge array for each recharge component for each stress period is written to RARRAY.OUT. These arrays include recharge from:

- canal and ditch leakage,
- deep percolation from surface water,
- deep percolation from ground water,
- canal and ditch leakage for canals with no corresponding GIS data,
- rim inflow,
- precipitation,
- final recharge array.

The file RCHCHK.OUT is a check for cells with high recharge rates. The user enters a maximum recharge rate to be compared against the recharge rate calculated for each grid cell. If the recharge rate in the grid cell exceeds the maximum recharge rate, the information is written to RCHCHK.OUT. This information includes recharge rate in inches per year, and the components of recharge that make up that rate. The user can examine the various recharge components in the grid cell and see which component(s) is causing the high recharge rate. The actual recharge rate is not changed. However, this gives the user the opportunity to examine cells with high recharge rates and make appropriate decisions regarding these rates.

Summary

HRS has completed Task 8, "Enhance the San Luis Valley Preprocessor" and Task 36, "State Preprocessor modifications". The scope of Task 8 was expanded to develop StatePP, a program designed to process flow data and spatial data to create MODFLOW input files for recharge, wells, evapotranspiration and drains. In addition, StatePP creates other output files containing model reports and input data information.

Development of StatePP is consistent with a data-centered approach because ground water model input files can be easily updated when new data are available, and MODFLOW files for a wide variety of model sizes and number of stress periods. StatePP was successfully applied to a 5 layer model containing a maximum of 22736 cells per layer to generate monthly data from 1950 to 1997 for RGDSS.

StatePP processes flow and spatial data along with user input information. Flow data sources include:

- municipal and industrial well pumping and recharge,
- canal leakage, unconsumed irrigation water (surface water and ground water sources), irrigation well pumping, ditch shortage, and crop water requirement (e.g. irrigated meadow),
- rim inflow recharge,
- precipitation recharge
- potential ET.

Comments and Concerns

- The Consumptive Use model produces agricultural pumping data for sprinkler and non-sprinkler lands based on historical records of the distribution of sprinkler and non-sprinkler lands over time. StatePP was designed to use an agricultural well file that provides the distribution of sprinkler and non-sprinkler parcels for a structure at one point in time. StatePP was used in the RGDSS project where the use of sprinklers has increased over time. Therefore, the spatial distribution of agricultural pumping based on sprinkler and non-sprinkler parcels as calculated by StatePP is not representative of the actual spatial distribution of pumping in earlier times when there were fewer sprinkler parcels. Therefore, the development of spatial data for lands served by sprinkler and enhancing StatePP to use such data should be considered. The recommended and adopted approach, which distributes total pumping without regard to irrigation method (sprinkler vs. non-sprinkler), is considered appropriate for the RGDSS ground water model at this time.
- Similar to above, recharge from unused surface and ground water might be expected to vary over time as sprinkler and well development occurred. Therefore, the development of spatial data for lands served by different water sources and enhancing StatePP to use such data should be considered. The recommended approach, which distributes unused surface and ground water without regard to water supply, is considered appropriate for the RGDSS ground water model at this time.

Read files to count for space allocation of data
DIVCNT
IRLCNT
RMACNT
CUCNT
WLCNT
ETVCNT
FLWCNT
PCPCNT
PPTCNT

Allocate space
ALLOC

Read and store data
READ

Average data for each stress period
AVGDATA

Calculate Evapotranspiration functions and write MODFLOW file
ETPROP

Calculate flowing well data and write MODFLOW file
FLWELL

<u>For each stress period</u>

Calculate recharge and write MODFLOW file
RECHARGE

Calculate pumping rates and write MODFLOW file
Subroutine write_mnw
PUMP

Generate MODFLOW Multi-Node Well File (Optional)
write_mnw

Calculate ET and sub-irrigation on irrigated crop land
ETSUB

<u>**Finish stress period calculations**</u>

Figure 1. General flow chart of StatePP.

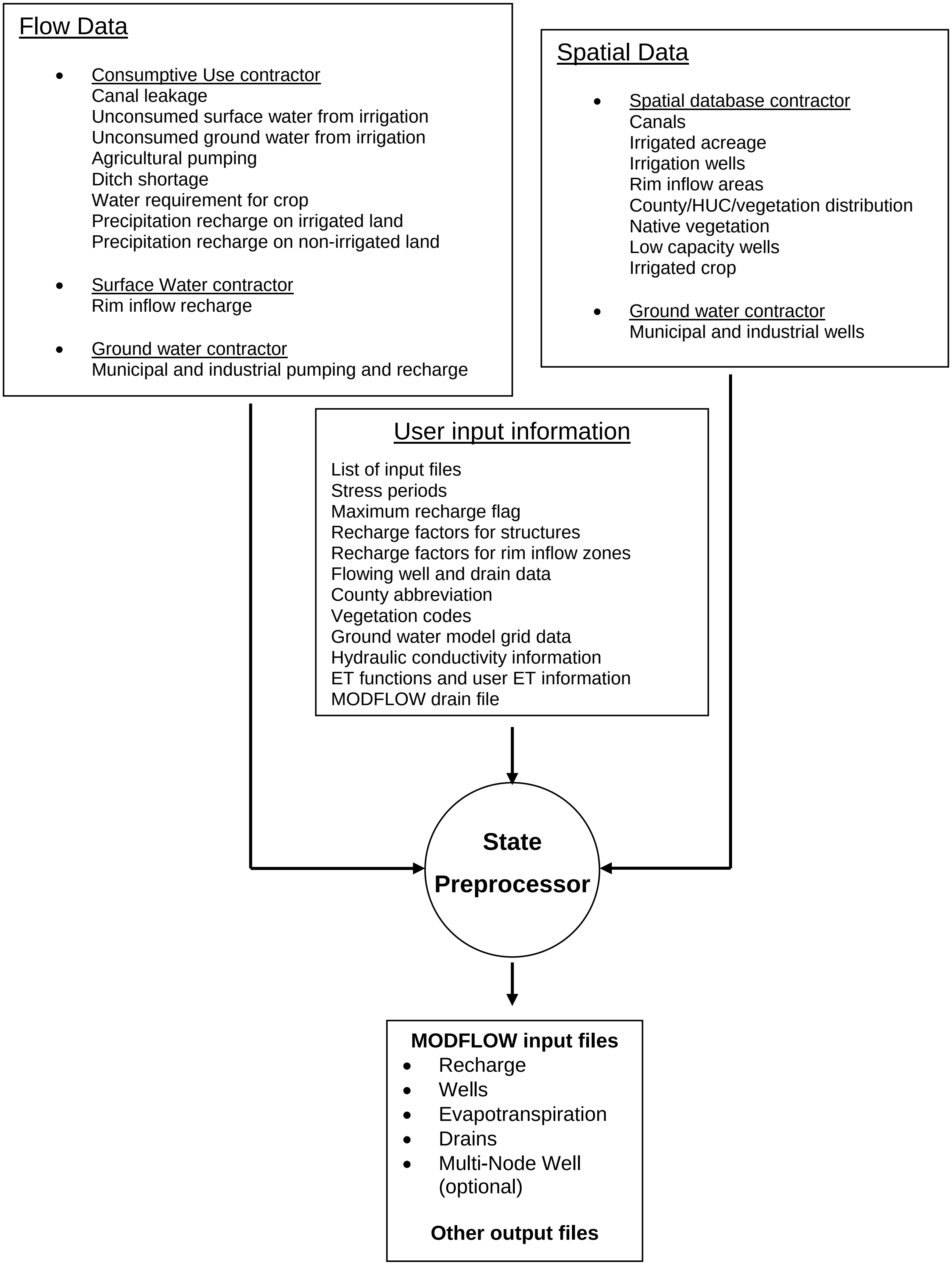

Figure 2. General flow of data into and out of StatePP.

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AGG Utility Program

Read files to count for space allocation of data
DIVCNT
IRLCNT
WELCNT
IRMCNT

Subroutine ALLOC
Allocate Space
Subroutine READ
Read and store data

Subroutine CMPRAG
Check the following GIS data files against the consumptive use ID lists to check if there are no matches for consumptive use IDs
filename.can
filename.irr
filename.wel
filename.irm
List missing ID information to output files for canals, irrigated lands and irrigation wells

Subroutine COMBINE
Aggregate data and assign new IDs for aggregates
Aggregate data for:
canals
irrigated lands
irrigation wells
irrigated crop

Subroutine WRITE
Write new data files to be used as input files in StatePP
DIVLEAK.DAT
DIVIRLN.DAT
IRRWELLS.DAT
CROP.DAT

Figure 3. Flow chart of AGG utility program for aggregating GIS data to match Consumptive Use model structure IDs.

AVGDATA Subroutine

FOR EACH STRESS PERIOD
Calculate total number of months to be averaged for this stress period

Average consumptive use data
Average flow data for each structure for:
Consumptive use requirement
Surface water diversion amount
Ground water diversion amount
Canal leakage
Unconsumed surface water
Unconsumed ground water

If structure has canal leakage and no GIS coverage for canal remove amount from canal leakage
Store flow for canal leakage with no GIS data
Calculate total from each component
Count number of missing canal structures in GIS data and write information to SPP.OUT

Average rim inflow recharge data
Average rim inflow recharge data for each rim inflow zone
Calculate total recharge from rim inflow

Average municipal and industrial well data
Average total municipal and industrial pumping
Average total municipal and industrial recharge
Count number of municipal and industrial wells with pumping rates not equal to zero
Calculate total municipal and industrial pumping and recharge

Average precipitation recharge
Average precipitation recharge for each county/HUC combination on irrigated lands
Average precipitation recharge for each county/HUC combination on non-irrigated lands
Calculate total recharge from precipitation

Figure 4. General flow chart for data averaging subroutine AVGDATA.

RECHARGE Subroutine
FOR EACH STRESS PERIOD
Calculate recharge from leakage through canals
For each structure listed in GIS canal file
Find matching structure ID between GIS data and CU data
Get average canal leakage for this structure from CU data and recharge factor
Calculate total length of reaches in active grid cells multiplied by weight
For each grid cell associated with this structure
Get grid cell location, length of canal in grid cell and weight
Calculate recharge in ft^3/d for grid cell – Add amount to total recharge sum
Calculate recharge rate in ft/d and store in canal leakage recharge array

Calculate recharge on irrigated lands from:
unconsumed surface water,
unconsumed ground water, and
leakage from canals with no GIS data
For each structure listed in GIS irrigated lands file
Find matching structure ID between GIS data and CU data
Get average and recharge factor for each component
Calculate total irrigated area in active grid cells multiplied by weight
Get recharge factors for this structure
For each grid cell associated with this structure
Get grid cell location, area of irrigated land in grid cell and weight
Calculate recharge in ft^3/d for each component – Add amount to total recharge sum
Calculate recharge rate in ft/d and store in arrays for each recharge component

Calculate recharge from rim inflow
For each rim inflow area
Get rim inflow area ID and rim inflow recharge
Find matching structure ID between rim inflow recharge data and GIS spatial data
Calculate total rim inflow area in active cells multiplied by weight
Get recharge factor for this rim inflow area
For each grid cell associated with this rim inflow area
Get grid cell location, area of rim inflow zone in grid cell, and weight
Calculate recharge in ft^3/d for grid cell – Add amount to total recharge sum
Calculate recharge rate in ft/d and store in rim inflow recharge array

Calculate recharge from precipitation
For each GIS county/HUC/vegetation code combination
Check flag to see if vegetation type is irrigated
If irrigated, find county/HUC match from precipitation recharge data on irrigated lands
If not irrigated, find county/HUC match from precipitation recharge data on non-irrigated lands
Get precipitation recharge flow data for county/HUC/irrigated or non-irrigated combination
For each grid cell associated with this county/HUC/vegetation code combination
Get grid cell location, area of county/HUC combination in grid cell, and weight
Calculate recharge in ft^3/d for grid cell – Add amount to total recharge sum
Calculate recharge rate in ft/d and store in precipitation recharge array

Sum total recharge rate for each grid cell for stress period
Check if recharge rate exceeds maximum recharge rate entered by user

Write recharge data for stress period to MODFLOW recharge file

Figure 5. General flow chart for RECHARGE subroutine.

PUMP Subroutine
FOR EACH STRESS PERIOD

<u>For each structure in the GIS irrigation well file</u>
Find the matching structure ID from the CU data
Get number of parcels for this structure (If using sprinkler designation option divide parcels between sprinkler and non-sprinkler)
Get total amount of ground water diversion for this structure (If using sprinkler designation option, divide ground water diversions for structure between sprinkler and non-sprinkler)

Calculate total weighted area for parcels with wells active during this stress period

For each parcel served by ground water associated with this structure
Calculate ratio of weighted area of parcel to total weighted of all parcels for structure
Calculate proportion of ground water diversion for this parcel
Get total number of wells for this parcel

For each well associated with this parcel calculate pumping proportion
Get grid cell location
If grid cell is constant head or inactive, well proportion is zero
Check year well came on line.
Calculate proportion of time well is online during stress period
Multiply time proportion by well capacity
Sum time-well capacity proportion

If the sum of time-well capacity proportions exceeds ground water diversion for parcel served by ground water, write a message to log file (do not alter gw diversion)

For each well associated with this parcel calculate pumping amount
Get well capacity
Get grid cell location (layer, row, column)
Get well time-capacity proportion
Calculate proportion of total ground water this well can pump
Multiply well proportion times total amount to be pumped for parcel to get amount pumped by this well
If well does not have a zero pumping rate, count this well
Sum pumping rate for layer in which well is located

Write MODFLOW file
Accumulate irrigation pumping for each grid cell
Write irrigation well data and municipal and industrial well data to MODFLOW well file

Call subroutine write_mnw if MNW flag is set
See figure 9 for write_mnw subroutine flow chart

Figure 6. General flow chart for PUMP subroutine.

FLWELL Subroutine

For each flowing well listed in the GIS low capacity well file

Get grid cell location of well

If this well is not located in layers 2 or 3, go to next well

Get ground surface elevation in grid cell

Get hydraulic conductivity of grid cell

Calculated drain conductance using the following information:

Hydraulic conductivity of grid cell,

Area perpendicular to the direction of flow estimated to be:

well circumference times length of perforation, 1 foot travel distance, and user input factor

For each drain listed in the MODFLOW drain file (drains other than flowing wells)

Check drain elevation

If drain elevation is above ground elevation, drain elevation changed to ground elevation –DRMIN

If drain elevation is greater than DRMAX below ground elevation, drain elevation changed to ground elevation –DRMAX

Write information on flowing wells and other drains to MODFLOW drain file

Figure 7. General flow chart for FLWELL subroutine.

ETPROP Subroutine

Calculate area in each grid cell occupied by each vegetation zone
For each vegetation zone specifed in ET zone data file
Get number of vegetation types that fall under this zone

For each vegetation type specified in this zone
Find match for vegetation type from GIS data in GIS vegetation data file
Get grid cell location, area occupied by vegetation type in grid cell, and weight
Add area times weight to total weighted area for vegetation zone in this grid cell

For each vegetation zone
Calculate proportion of each grid cell occupied by vegetation zone

Calculate equivalent ET function for each grid cell
For each grid cell for each ET function point
Calculate arrays for each ET function point of the proportion of total depth
Assign values to extinction depth array
Multiply ET rate for point for this veg. zone by the proportion of the grid cell occupied by this veg. zone
Add amount to total ET rate for this grid cell – Total is ET rate for this ET function point for this grid cell
Calculate proportion of ET rate for this point to maximum ET rate

Write evapotranspiration data to MODFLOW ETS1 file
For each stress period, read multiplier for control record
Write data for stress period to ETS1 file

Figure 8. General flow chart for ETPROP subroutine.

write_mnw subroutine

Process agricultural wells
Write single node well data (layer, row, column, pumping) to scratch file
Consolidate pumping by well ID to top node of each multi-node well
Consolidation of pumping from all layers and all parcels connected to a unique well
Write layer, row and column data for subsequent layers, 'MN' flag, set pumping to zero

Process municipal and industrial pumping wells
Write single node well data (layer, row, column, pumping) to scratch file
Consolidate pumping by well ID to top node of each multi-node well
Write layer, row and column data for subsequent layers

Process municipal and industrial injection wells
Write single node well data (layer, row, column, pumping) to scratch file
Consolidate pumping by well ID to top node of each multi-node well
Write layer, row and column data for subsequent layers

Process boundary fluxes simulated with wells
Write well data (layer, row, column, pumping) to scratch file

During final model stress period
Write header files for MNW file
Read data from scratch file and write to MNW file

Return program control to subroutine PUMP

Figure 9. General flow chart for write_mnw subroutine.

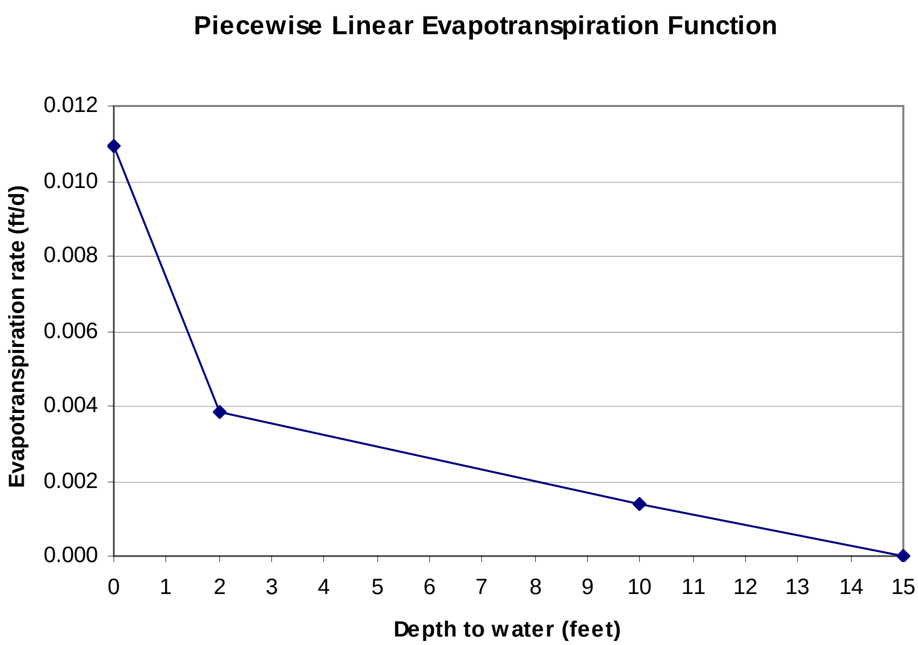

Figure 10. Example of a piecewise linear evapotranspiration function with four points and three segments.

Appendix J StatePP Documentation
RGDSS Memorandum
Final (Version 2)

To: File
From: HRS Water Consultants, Inc. - Judy A. Schenk and Mark R. Palumbo and Colorado Division of Water Resources – Ray R. Bennett, PE
Subject: StatePP a Pre-Processor for Modflow
Date: July 19, 2004

StatePP was developed to pre process flow and spatial data for the ground water model MODFLOW (USGS).[4] StatePP produces the following input files for MODFLOW:1. Recharge, 2. Well, 3. Evapotranspiration, and 4. Drain.

0.0 Disclaimer

This program is furnished by The State of Colorado (State) and is accepted and used by the recipient upon the expressed understanding that the State makes no warranties, express or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information and data contained in this program or furnished in connection therewith, and the State shall be under no liability whatsoever to any person by reason of any use made thereof.

The program herein belongs to the State of Colorado. Therefore, the recipient further agrees not to assert any proprietary rights therein or to further represent this program to anyone as other than a State program.

1.0 Acknowledgment

This program was developed as part of the Rio Grande Decision Support System in three major steps. Development steps 1 and 2 were performed under Tasks 8 and 36 by Judith

[4] McDonald, M.G., and Harbaugh, A.W., 1988, A modular three-dimensional finite-difference ground-water flow model, Techniques of Water-Resources Investigations 06-A1, USGS, 576 p.

Schenk and Mark Palumbo of HRS Water Consultants. Development step 3 was performed by Ray Bennett of the Colorado Division of Water Resources as part of the Phase 4 enhancements.

The multi-node well component was added in April, 2006 by CDM under the South Platte Decision Support System project (SPDSS), Phase 3, Task 50. See tables 4.2, 4.7 and 4.8 in this document, along with StatePP documentation and Agg documentation for more information.

2.0.Introduction

The State Pre-Processor (StatePP) was developed for use in the ground water model component of the Rio Grande Decision Support System (RGDSS). StatePP was written so that it can be used for any MODFLOW based project. StatePP was developed to process flow and spatial data in order to create files compatible with the USGS ground water model MODFLOW. StatePP produces the following input files for MODFLOW:1. Recharge, 2. Well, 3. Evapotranspiration, and 4. Drain.

3.0.Program Description

StatePP data processes include:

- **Recharge**. Process canal loss, unused irrigation from surface water, unused irrigation from ground water, pumping and subirrigation data from consumptive use model (StateCU). Also process rim inflow and precipitation recharge along with spatial data associated with the MODFLOW grid and recharge components to create a MODFLOW recharge input file,
- **Pumping.** Process municipal and industrial pumping and recharge and agricultural pumping data along with spatial data of well location to create a MODFLOW well input file,
- **Flowing Wells**. Process ground water model grid information and spatial data of distribution of wells with less than 50 gallons per minute (gpm) permitted yield to calculate data for flowing wells, and add flowing wells to the MODFLOW drain input file,
- **Native ET from Ground Water**. Process spatial data of the distribution of native vegetation and user input evapotranspiration functions related to vegetation types to create the MODFLOW evapotranspiration input file.
- **Subirrigation from Ground Water**. Process spatial data of the distribution of potentially subirrigated crops (e.g. irrigated meadowlands, alfalfa, etc.) and user input evapotranspiration functions to create a MODFLOW evapotranspiration input file that includes evapotranspiration by subirrigation.
- **Constant Boundary Flux**. Process flux and location data to generate a constant boundary flux estimates as part of the Well package.

3.1 Time Step Capability. StatePP is designed to provide average flow data for a defined stress period. A stress period may range from a single steady state time steps, to 12 average monthly time steps to 100 years of monthly time steps. All flow data are entered in acre-feet per month except precipitation recharge data, which is entered in inches per month. Results are output in cubic feet per day (ft^3/d) to conform with the length and time units used in the ground water model.

3.2 Preprocessing of Structure Data. The consumptive use data file contains both explicit and aggregated structures (a grouping of smaller structures). These data may be provided for the entire San Luis Valley or a subset that represents the ground water model area only. The spatial data contain information related to the ground water model area by structure ID only (e.g. they do not contain aggregated structure information). Therefore, spatial input to StatePP must be processed by a program named AGG to contain explicit and aggregated structures that are contained within the ground water model area. As presented in **Table 6**, Agg processes four spatial data files; the canal file, irrigated lands file, irrigation well file, and irrigated crop file. Program documentation and the computer code for the AGG program are provided separately (Documentation of AGG).

Table 6.
Files created by the utility program AGG

AGG Input file name	AGG Output File Name	Description
Finlename.can	Divleak.dat	Canal leakage
Filename.irr	DivIrln.dat	Irrigated lands
Filename.wel	IrrWells	Irrigation wells
Filename.med	SubAcres1.dat	Subirrigated Crop 1 land
Filename.alf	SubAcres2.dat	Subirrigated Crop 2 land

3.3 Program Flow. The general flow chart of the program is shown in **Figure 1.** As presented, selected input files are read to count data for allocating array program space. Space is allocated in the ALLOC subroutine. Data are read and some calculations are performed in the READ subroutine. Flow data are averaged for each stress period in the AVGDATA subroutine. Evapotranspiration functions are calculated and the MODFLOW evapotranspiration file is written in the ETPROP subroutine if subirrigation is not simulated. Flowing well and spring information is processed in the FLWELL subroutine that may build a new drain file or add data to an existing MODFLOW drain file. Recharge rates for each stress period are calculated and the MODFLOW recharge file is written in the subroutine RECHARGE. Irrigation well pumping rates are calculated for each stress period in the subroutine PUMP, and these pumping rates, along with the municipal and industrial pumping rates, are written to the MODFLOW well file. If subirrigation on irrigated cropland is simulated, evapotranspiration functions for native vegetation and subirrigation are calculated and the MODFLOW evapotranspiration file is written in the ETSUB subroutine. The StatePP computer code is listed in **Appendix A**.

4.0 Input File Description

The number and type of input files that may be provided to StatePP are listed in a response (*.rsp) file as presented in **Table 4.1**. Note that some files may not be required based on the information specified in the control file (Section 4.2). For example if orographic precipitation option is selected (control variable ipp=3) then the County-Huc data, Krigged ppt data, and Sand Dune data are not required or if provided will not be used.

Most files allow comments to be included by entering a '#' in column 1 or text to the right of input data. Following is a detailed description of each file while an example is provided in **Appendix A-2**.

Response File The response file (*.rsp) contains the name of all input files to be read by StatePP. An example is provided in **Appendix A2**. File types are case (upper and lower) sensitive. Note that based on the control data specified (Section 4.2) some data files may not be used. It may contain the following information:

Table 4.1

Response File

Row	Section	File Type	Typical File Name	Type
1	4.2	StatePP_Control =	STATEPPSs.ctl	Control file name
2		Modflow_Grid =	mfgrid5.dat	Modflow grid
3		Hydraulic_Conductivity =	M3A02F7B.HYC	Hydraulic conductivity data
4		Et_Data =	Etzone16.dat	ET data
5		Rim_Inflow_Data =	Recharge_UpdateApr04.prn	Rim inflow data
6		M&I_Pumping_Data =	ModMiPump.out	M&I pumping data
7		M&I_Recharge_Data =	ModMiRech.out #	M&I recharge data
8		CountyHucPpt_Irr =	ModPptIrr.out	Counth-Huc Ppt data on irrigated land
9		CountyHucPpt_Non =	ModPptNon.out	Counth-Huc Ppt data on non-irrigated land
11		SubIrrigated_Crop_01	..\Agg\SubAcres1.dat	GIS subirrigated crop #1 data
12		SubIrrigated_Crop_02	..\Agg\SubAcres2.dat	GIS subirrigated crop #2 data
13		Spring_Location_Data =	Spring.dat	GIS spring data
14		Constant_Boundary_Data =	ss051704.ghb	Constant flux data
15		Well_Adjustment_Data	Adjustwells_02.prn	
16		SurfaceWater_GroundWater =	..\modfate\modfate.xgw	
17		Recharge_Zones	X4p000.flg	
18		CU_Data =	..\StateCu\X4R005.dwb	CU data

Table 4.1

Response File (cont.)

Row		File Type	Typical File Name	Type
19		Well_Adjustment_Data =	adjustwells_02.prn	Well adjustment data
20		SurfaceWater_GroundWater =	..\Modfate\modfate.xgw	Surafce water return data
21		Recharge_Zones =	X4P000.flg	Recharge zone data
22		CountyHUcPpt_Irr =	ModPptIrr.out	Ppt data for irrigated lands via County Huc
23		CountyHucPpt_Non =	ModpptNon.out	Ppt data for non-irrigated lands via County Huc
24		Ground_01	Surf.dat	
25		Ground_02	x4p000_040223.surf	GIS ground data
26		GIS_Canal_Data =	..\Agg\Divleak.dat	GIS canal data
27		GIS_IrrigLand_Data =	..\Agg\Divirln.dat	GIS irrigated Land data
28		GIS_Well_Data =	..\Agg\Irrwells.dat	GIS well data
29		GIS_NativeLand_Data =	RGDSS2.ETZ	GIS native land data
30		GIS_RimInflow_Data =	RGDSS2.RIM	GIS rim inflow data
31		GIS_FlowingWell_Data =	RGDSS3.SFW	GIS flowing well data
32		GIS _PrecipZone Data	Rgdss2.pcp	GIS of precipitation zones (County_Huc) area
33		GIS_Sand_Dunes =	SandDune3.prn	GIS of sand dune location
35		Krigged_Precipitation =	Ppt.out	Krigged Ppt data
36		Orographic_Ground_Data =	x4p000.pptz	Orographic ground data
37		Orographic_Ppt_Data =	X4P000.ppt	Orographic ppt data.
38		Orographic_Ppt_Weights	X4P000.pptw	Orographic ppt weights
39		Orographic_Irrig_Land	X4P000.prfi	Orographic irrigated lands
40		Orographic_NonIrr_Land	X4P000.prfn	Orographic non irrigated lands

4.2 Control File The control file (*.ctl) contains options and parameters used by StatePP. An example is provided in **Appendix A2**. All data is provided in free format with the file name expected after the file descriptor.

Table 4.2
Control Data

Row	Variable	Description
1-1	Ievt	ET switch 0 = 0ff, 1 = on
1-2	Iflw	Flowing Well switch 0 = 0ff, 1 = flowing wells, springs and ag drains on (Phase 3), 2 = flowing wells and springs only (No ag drains Phase 4)
1-3	Irch	Recharge switch 0 = off, 1 = on
1-4	Ipmp	Pumping switch 0 = off, 1 = on
1-5	Isir	Subirrigation switch 0 = off, >0 = # of subirrigated crops
1-6	Iprn	Print detail control 0 = none, 1=detailed
1-7	Iweg	Canal weight switch 0 = Phase 3 data, 1 = Phase 4 update
1-8	ibflux	Boundary Flux switch 0 = off, >0 = number of boundary flux values
1-9	Igr	Ground switch 0 = use Ground_01, 1=use Ground_02
1-10	Iswgw	Surface water runoff switch 0 = off, 1 = on
1-11	Isand	Sand dune switch 0 = off, 1 = on
1-12	Ippt	Ppt switch 1=county Huc, 2 = Krigged ppt data, 3 = Orographic ppt data
1-13	Im2k	Modflow 2k switch; 0 = Modflow 1998, 1 = Modflow 2000
1-14	Iwadj	Well adjustment switch; 0 = off, 1 = on
1-15	Isw2Gw	Surface water to ground water switch; 0 = off, 1 = on
1-16	IrchFac	Global recharge factor; 0 = off, >0 = recharge factor
1-17	mnwflag	Switch for generating a Multi-Node Well (MNW) package; 0 = off, 1 = on If set to 1, input well files must contain ID, top layer and bottom layer
1-18	mnw_iunw1	Unit number and flag. If set to greater than 0, value is unit number for the MNW file output of the WEL1 file (See USGS MNW documentation item 3a). If set to 0 or less, WEL1 not written. If set greater than 0, must be a two-digit number.
1-19	mnw_iunby	Unit number and flag. If set to greater than 0, value is unit number for the MNW file output of the BYNODE file (See USGS MNW documentation item 3b). If set to 0 or less, BYNODE not written. If set greater than 0, must be a two-digit number.
1-20	mnw_iunqs	Unit number and flag. If set to greater than 0, value is unit number for the MNW file output of the QSUM file (See USGS MNW documentation item 3c). If set to 0 or less, QSUM not written. If set greater than 0, must be a two-digit number.
2-1…12	Pfaci(im)	Irrigated acreage monthly recharge factors (%)
3-1…12	Pfacn(im)	Non Irrigated acreage monthly recharge factors (%)
4-1…12	Pfacsp(im)	Special (Sand Dune) monthly recharge factors (%)
5-1	Ibapp	Boundary flux flag 0 = proportion flux by the number of cells; 1 = proportion by the conductance data provided in the boundary flux file
6-1	Nd	Constant flux counter (not used)
6-2	Bdir(nd)	Constant flux direction (must correspond to name in file

		Constant_Flux_Data)
6-3	Bflow(l,nd)	Flux (af/yr) in layer il direction nd
6-4	Bflux(2,n)	Flux (af/yr) in layer 2
	…	*Repeat for each layer*
		Repeat 5-1 through 5-n for each direction (ibflux field 1-8)

Table 4.2
Control Data (cont.)

7-1	Nstpr	Number of stress periods
7-2	Nrcfc	Number of diversions
8-1	Nrims	Number of rim inflow zones
8-2	Nrmyrs	Number of years of rim inflow data
9-1	Ncc	Number of County Huc abbreviations
10-1	Niv	Number of native vegetation types
11-1	Nchp	Number of county Huc zones
12-1	Ispd(1,isp)	Beginning year for stress period 1
12-2	Ispd(2,isp)	Ending year for stress period 1
12-3	Ispd(3,isp)	Beginning month for stress period 1
12-4	Ispd(4,isp)	Ending month for stress period 1
12-1…4		*Repeat 11-1 through 11-4 for each stress period (nspr field 6-1)*
13-1	rchmax	Maximum recharge warning value (in/yr)
14-1	Idfc(i)	Structure ID
14-2	Rcfc(1,I)	Recharge factor for canal leakage
14-3	Rcfc(2,I)	Recharge factor for surface water recharge
14-4	Rcfc(3,I)	Recharge factor for ground water recharge
14-5	Rcfc(4,I)	Recharge factor for canals without GIS data
		Repeat 13-1 through 13-4 for each structure (nrcfc field 6-2)
15-1	Idrm	Rim inflow name (must match data in fileRim_Inflow_Data
15-2	Rmfc(i)	Rim inflow factor
		Repeat 14-1 through 14-24 for each rim inflow (nrims field 7-1)
16-1	Fwfac	Flowing well return factor
16-2	Fwcfac	Flowing well conductance factor
16-3	Fwdiam	Flowing well diameter (ft)
16-4	Fwperf	Flowing well perforared length (ft)
16-5	Drmin	Minimum drain depth
16-6	Drmax	Maximum drain depth
17-1	Ctab(1)	County Code abbreviation
17-2	Ctab(2)	County Code description
18-1	Vgir	Vegetation code
18-2	Idveg	Vegetation code description
19-1	Crchfac	Recharge area (must match data in file ____)
19-2	Rchfacz	Recharge factor

4.3 Modflow Grid The Modflow Grid file is used to determine which cells are active in a layer. Input is similar to a Modflow *.bas file. An example is provided in **Appendix A2**.

Table 4.3
Modflow Grid Data

Row	Variable	Description
1-1	Layer	Number of layers
1-2	Rows	Number of rows
1-3		Number of columns
2-1	Iflgcw	Column flag 0 = constant, 1 = variable
2-2	Colwdth	Constant column width
3-1	colw(j)	If(iflgcw.ne.0) column width for row j
		Repeat for number of columns
4-1	Iflgrw	Row width0 = constant, 1 = variable
4-2	Rowwdth	Constant row width
5-1	roww(k)	If(iflgrw.ne.0) row width row j
		Repeat for number of rows
6-1	Iflgib	Ibound flag 0 = constant, 1 = variable
6-2	Ibval	Constant ibound value
7-1	Ibnd(i,j,k)	If(ibound.ne.0) Ibound for layer i, row , column k

4.4 Hydraulic Conductivity The hydraulic conductivity file is used to estimate conductance for flowing wells. Input is similar to a Modflow *.bcf file. An example is provided in **Appendix A2**.
All data is provided in fixed format with the file name expected after the file descriptor.

Table 4.4
Hydraulic Conductivity Data

Row	Variable	Description
1-1	Inhdl	Number of layers of hydraulic conductivity data
2-1	Ihdl(1)	Layer of hydraulic conductivity matrix 1
2-2	Ihdl(2)	Layer of hydraulic conductivity matrix 2
		Repeat for inhdl layers
3-1	Ihdflg	Hydraulic conductivity flag 0 = constant, 1 = variable
3-2	phdval	Constant hydraulic conducitivyt
4-1	Phed	If(ihdflg>) Hydraulic conductivity for layer, row, column per layer specified by ihdl
		Repeat for each layer specified (inhdl)

4.5 ET Data The ET data file is used to build eth Modflow ET file for native lands. An example is provided in **Appendix A2**.
All data is provided in fixed format with the file name expected after the file descriptor.

Table 4.5
ET Data

Row	Variable	Description
1-1	Nez	Number of ET zones
1-2	Nevg	Number of vegetation types
1-3	Npts	Number of points in the ET curve
2-1	blanveg	Name for areas with no known vegetation
3-1	fillveg	Default vegetation type when not known
4-1	Idez(i)	Vegetation zone
4-2	Netv(i)	Number of Vegetation types in this zone
		Repeat 3-1 and 3-2 for each vegetation type (nez)
5-1		Vegetation type is this zone
		Repeat 5-1 for each vegetation type in this zone idez(i)
		Repeat cards 4 and 5 for each vegetation zone (nez)
6-1	Etpz(1)	X coordinate1 (Ft) for ET function
6-2	Etpz(2)	X coordinate 2 (ft) for ET function
		Repeat for number of points in ET function (npts)
7-1	Etpz(1,i)	Y coordinate1 (Ft) for ET function
7-2	Etpz(2,I)	Y coordinate 2 (ft) for ET function
…	…	*Repeat for number of points in ET function (npts)*
		Repeat for each ET zone (nevg)
8-1	Etpc(ird)	ET multiplier for stress period (1)
8-2	Etpc(2)	ET mutliplier for stress period (2)
…	…	*Repeat for the minimum (each stress period, or 12). For stress periods gteater than 12 monthy values are repeated.*

4.6 Rim Inflow Data The rim inflow data contains rim recharge estimates for each rim recharge zone. An example is provided in **Appendix A2**.
All data is provided in fixed format with the file name expected after the file descriptor.

Table 4.6
Rim Recharge Data

Row	**Variable**	**Description**
1-1	Idrf	Rim inflow ID (Must match
2-1	Iyrff	Year
2-1..2-13	Rmfl(Id,iy,im)	Rim inflow for rim id Id, year iy, month im
		Repeat for each year (control file variable nrmyrs)
		Repeat for each rim id (control file variable nrims)

4.7 M&I Pumping Data The M&I pumping file contains data for each M&I pumping location An example is provided in **Appendix A2**.

Table 4.7
M&I Pumping Data

Row	**Variable**	**Description**
1-1	Nmip	Number of M&I pumping wells
1-2	Mipy	Number of years of M&I pumping data
2-1	Idml(1)	ID
2-2	Mipl(1,id)	Years of data
2-3	Mipl(2,id)	Layer
2-4	Mipl(3,id)	Row
2-5	Mipl(4,id)	Column
2-6	Mipl(5,id)	Year pumping begins
2-7	Mipl_append%toplay	Top layer in which well is completed (format I10)
2-8	Mipl_append%botlay	Bottom layer in which well is completed (format I10)
3-1	Iyrff	Year
3-1..3-13	Rmfl(Id,iy,im)	M&I pumping for id Id, year iy, month im
		Repeat for each year (control file variable nrmyrs)
		Repeat for each rim id (control file variable nrims)

4.8 M&I Recharge Data The M&I recharge file contains data for each M&I recharge location. An example is provided in **Appendix A2**.

Table 4.8
M&I Recharge Data

Row	Variable	Description
1-1	Nmii	Number of M&I recharge wells
1-2	miiy	Number of years of M&I recharge data
2-1	Idmi(1)	ID
2-2	Miil(1,id)	Years of data
2-3	Miil(2,id)	Layer
2-4	Miil(3,id)	Row
2-5	Miil(4,id)	Column
2-6	Miil(5,id)	Year recharge begins
2-7	Miil_append%toplay	Top layer in which well is completed (format I10)
2-8	Miil_append%botlay	Bottom layer in which well is completed (format I10)
3-1	Iyrff	Year
3-1..3-13	wmii(Id,iy,im)	M&I recharge for id Id, year iy, month im
		Repeat for each year (control file variable nrmyrs)
		Repeat for each recharge well (control file variable nrims)

4.9 County-Huc Irrigated Precipitation Data The County-Huc Irrigated Precipitation file contains precipitation recharge data for irrigated lands by County-Huc zone. **It is only used if the control variable ippt = 1.** An example is provided in **Appendix A2**.

Table 4.9
County-Huc Irrigated Precipitation Data

Row	Variable	Description
1-1	iyrp	Year
1-2 - 13	Pymi	Ppt recharge (in/month) for months 1-12
		Repeat for each County-Huc Irrigated ppt station (npi). Note npi is calculated by StatePP based on the number of entries in the first year

4.10 County-Huc Non-Irrigated Precipitation Data The County-Huc Non-Irrigated Precipitation file contains precipitation recharge data for non-irrigated lands by County-Huc zone. **It is only used if the control variable ippt = 1.** An example is provided in **Appendix A2**.

Table 4.10
County-Huc Non-Irrigated Precipitation Data

Row	Variable	Description
1-1	iyrp	Year
1-2 - 13	Pymn	Ppt recharge (in/month) for months 1-12
		Repeat for each County-Huc Non-Irrigated station (npi). Note npi is calculated by StatePP based on the number of entries in the first year

4.11 Subirrigated Crop_01 Data The Subirrigated Crop_01 data is used to distribute subirrigated acreage to model cells. Note this file is preprocessed by the program AGG in order to combine GIS data for structures that are not explicitly modeled (e.g. aggregated structures, multi structures, .etc.). Its format is described in Appendix A of **Appendix Q Data Centered Ground Water Model.**

4.12 Subirrigated Crop_02 Data The Subirrigated Crop_02 data is used to distribute subirrigated acreage to model cells. Note this file is preprocessed by the program AGG in order to combine GIS data for structures that are not explicitly modeled (e.g. aggregated structures, multi structures, .etc.). Its format is described in Appendix A of **Appendix Q Data Centered Ground Water Model.**

4.13 Spring Location Data The Spring data contains location and flow information for springs. An example is provided in **Appendix A2**.

Table 4.14
Spring Data

Row	Variable	Description
1-1	Isprl(1)	Spring 1 layer
1-2	Isprr(1)	Spring 1 row
1-3	Isprc(1)	Spring 1 column
1-4	Espr(1)	Spring 1 elevation
1-5	Cspr(1)	Spring 1 conductance
		Repeat for each spring. Note StatePP counts the number of springs based on an end of file record

4.14 Constant Boundary Data The Constant boundary data contains cells where constant flux is calculated as part of the well package. It is formatted to be similar to a Modflow general head file with flow direction data added to the right side of the file. **It is only**

used if the control variable ibflux is greater than zero and the direction data specified matches boundary flux information provided in the control file. Therefore it may contain information which is never used (e.g. if the direction does not match one specified in the control file). An example is provided in **Appendix A2**.

Note that the control variable ibapp allows the user the ability to distribute constant flux based on flux or the number of cells specified.

Table 4.16
Constant Boundary Flux Data

Row	Variable	Description
1-1	Mxbnd	Maximum number of constant boundary flux values
1-2	ighbcb	Flux flag (not used)
2-1	Itmp	Flag if > 0 number of flux values this stress period. Note StatePP assumes this data is used every stress period.
1-3	Ibl(1)	Constant boundary layer
1-4	Ibr(1)	Constant boundary row
1-5	Ibc(1)	Constant boundary column
	Bh(1)	Constant boundary head
	Bcon(1)	Constant boundary conductance
	Rec10	Constant boundary direction
		Repeat for each constant boundary flux values (mxbnd)

<u>4.15 Well Adjustment Data</u> The well adjustment data is used to adjust the location of pumping data to insure it occurs inside the active ground water model area. **It is only used if the control variable iwadj is set to 1.** An example is provided in **Appendix A2**.

Table 4.17
Constant Boundary Flux Data

Row	Variable	Description
1-1	Adjid(1)	Row
1-2	Adjipl(1)	Column
1-3	Ilay1(1)	Original layer
1-4	Irow1(1)	Original row
1-5	Icol1(1)	Original column
1-6	Ilay2(1)	Adjusted layer
1-7	Irow2(1)	Adjusted row
1-8	Icol2(1)	Adjusted column
		Repeat for each well to be adjusted. Note StatePP counts the number of wells to adjust based on an end of file indicator.

<u>4.16 Surface Water Ground Water Data</u> The surface water to ground water data is used to provide surface water to ground water data estimated by the program ModFate. It is formatted to exactly match a standard StateMod data format. **It is only used if the control variable isw2gw is set to 1.** An example is provided in **Appendix A2**. Note data

is provided by structure for every year. If information is not provided for a structure it is estimated to be zero.

Table 4.18
Surface Water to Ground Water Data

Row	Variable	Description
1-1	Rec1	Period of record descriptor (not currently used)
2-1	Iryr	Year
2-2	cid1	Structure Id
2-3 – 14	Qin(1)	Surface water to ground water for month 1
		Repeat for each structure with surface water to ground data.
		Repeat for each year of the study period

4.17 Recharge Zones The recharge zone data is used to globally adjust recharge to a specific recharge zone. **It is only used if the control variable irchfac is set greater than zero.** An example is provided in **Appendix A2**. Zero is used to indicate a cell is not located within a recharge zone.

Table 4.19
Recharge Zone Data

Row	Variable	Description
1-1	Crchfac	Recharge zone ID
		Repeat for each recharge zone. Note StatePP counts the number of recharge zones base on the number of entries in the file
2-1	Iparm(ir,ic)	Recharge zone for row ir column 1 to ncol
		Repeat for each column

4.18 CU Data The CU data file is used to build part of the Modflow recharge and well file. It contains canal loss, unused surface water, unused ground water, pumping, and subirrigation data. It is formatted exactly the same as the StateCU ditch water budget (*.dwb) output file. An example is provided in **Appendix A2**.

4.19 Ground 01 Data The Ground_01 data contains ground elevation data used by the ET and drain components of StatePP. **It is only used if the control variable igr = 1.** An example is provided in **Appendix A2**.

Table 4.11
Ground_01 Data

Row	Variable	Description
1-1	Iflgsf	Ground flag 0=constant 1=variable
1-2	Sfval	Constant ground elevation (ft)
2-1	Surf(j,1)	Ground elevation for row j column 1
2-1	Surf(j,2)	Ground elevation for row j column 2
		Repeat for every row

4.20 Ground 02 Data The Ground_02 data contains ground elevation data used by the ET and drain components of StatePP. **It is only used if the control variable igr = 2.** An example is provided in **Appendix A2**.

Table 4.12
Ground_02 Data

Row	Variable	Description
1-1	Surf(j,1)	Ground elevation for row j column 1
1-1	Surf(j,2)	Ground elevation for row j column 2
		Repeat for every row

4.21 GIS Canal Data The GIS canal data file is used to disctribute canal loss to model cells. Its format is described in Appendix A of **Appendix Q Data Centered Ground Water Model.**

4.22 GIS Irrigated Land Data The GIS irrigated land data file is used to distribute unused surface water and ground water to model cells. Its format is described in Appendix A of **Appendix Q Data Centered Ground Water Model.**

4.23 GIS Well Data The GIS well land data file is used to distribute pumping to model cells and layers. Its format is described in Appendix A of **Appendix Q Data Centered Ground Water Model.**

4.24 GIS Native Land Data The GIS native land data file is used to distribute unused to estimate ET. Its format is described in Appendix A of **Appendix Q Data Centered Ground Water Model.**

4.25 GIS Rim Inflow Data The GIS rim inflow data file is used to distribute unused rim inflow to model cells. Its format is described in Appendix A of **Appendix Q Data Centered Ground Water Model.**

4.26 GIS Flowing Well Data The GIS flowing well data file is used to estimate the model cell and layer of flowing wells Its format is described in Appendix A of **Appendix Q Data Centered Ground Water Model.**

4.27 GIS Precipitation Zone Data The GIS precipitation zone data file is used to distribute precipitation recharge estimates provided by County-Huc to model cells. **It is only used if the control variable ippt = 1.** Its format is described in Appendix A of **Appendix Q Data Centered Ground Water Model.**

4.28 GIS Sand Dune Data The GIS sand Dune data file is used to estimate the model cells where special (sand dune) recharge data is used. **It is only used if the control variables ippt and isand are set to 1.** An example is provided in **Appendix A2**.

Table 4.17
Constant Boundary Flux Data

Row	Variable	Description
1-1	Iprow	Row
1-2	Ipcol	Column
1-3	iparea	Acres
		Repeat for each cell located within the Sand dunes. Note StatePP counts the number of sand dune cells based on an end of file indicator of if the row data is blank or equal to 0.

4.29 Krigged Precipitation Data The Krigged precipitation data is used to provide precipitation recharge estimates. **It is only used if the control variable ippt is set to 2.** An example is provided in **Appendix A2**. Note data entered for inactive cells are not used.

4.30 Orographic Ground Data The orographic ground data is used to apply an oragrophic adjustment to precipitation recharge estimates. **It is only used if the control variable ippt is set to 3.** An example is provided in **Appendix A2**. Note data entered for inactive cells are not used

Table 4.20
Orographic Ground Data

Row	Variable	Description
1-1	Surfp(j,k)	Orographic ground data for row j, column 1-ncol
		Repeat for each row.

4.31 Orographic Ppt Data The orographic ppt data is used to estimate an oragrophic precipitation recharge estimate. **It is only used if the control variable ippt is set to 3.** An example is provided in **Appendix A2**.

Table 4.21
Orographic Ground Data

Row	Variable	Description
		Format free
1-1	Pptid(1-n)	Precipitation id for stations 1-n (not used)
		Repeat for each station.
		Format(4x,i4, 12f6.2)
2-1-2-12	Zppt(1-12)	Precipitation for station pptid for months 1-12
		Repeat for every station
		Repeat for every year

4.32 Orographic Ppt Weight Data The orographic ppt weight data is used to estimate an oragrophic precipitation recharge estimate. **It is only used if the control variable ippt is set to 3.** An example is provided in **Appendix A2**.

Table 4.22
Orographic Ppt Weight Data

Row	Variable	Description
		Format free
1-1	Orogcoef(1)	Orographic function parameter 1
1-2	Orogcoef(2)	Orographic function parameter 2
1-3	Orogcoef(3)	Orographic function parameter 3
2-1	Pptid(1-n)	Station ID for stations 1-n
3-1	Zppt(1-n)	Elevation for stations 1-n
2-1-2-12	I	Row
	J	Column
	Weight(j,I,l-n)	Precipitation weight for row 1, column j, station l-n. Note StatePP counts the number of stations based on the number of non zero entreis in the pptid field.
		Repeat for every column
		Repeat for every row

4.33 Orographic Irrigated Land Data The orographic irrigated land data is used to estimate an oragrophic precipitation recharge estimate. **It is only used if the control variable ippt is set to 3.** An example is provided in **Appendix A2**. Note values located outside the active ground water model area must be zero.

Table 4.23
Orographic Irrigated Land Data

Row	Variable	Description
		Format free
1-1	Frac(1,j,k)	Fraction of land * recharge percent for row j column 1-n
		Repeat for every column

4.34 Orographic Non-Irrigated Land Data The orographic non-irrigated land data is used to estimate an oragrophic precipitation recharge estimate. **It is only used if the control variable ippt is set to 3.** An example is provided in **Appendix A2**. Note values located outside the active ground water model area must be zero.

Table 4.23
Orographic Non-Irrigated Land Data

Row	Variable	Description
		Format free
1-1	Frac(1,j,k)	Fraction of land * recharge percent for row j column 1-n
		Repeat for every column

5.0 Output File Description

StatePP creates two major types of output files; key and detailed. The key output files (**Table 5.1**) include four (4) MODFLOW files, two (2) files per subirrigated crop for post-processing ET and six (6) information reports.

In addition to the key output files StatePP creates a number of detailed output files (**Table 5.2**) that include two (2) user input reports, five (5) flow data reports, and eight GIS reports. These files are produced so that the user can check that the input files are read correctly.

Table 5.1
StatePP Key Output Files

#	**File Type**	**Name**	**Description**
1	Modflow	Filename.rch	Modflow recharge file
2	Modflow	Filename.wel	Modflow well file
3	Modflow	Filename.evt	Modflow ET file
4	Modflow	Filenamd.drn	Modflow drain file
5	ET Post Processing	Filename.su1	Subirrigated crop 01
6	ET Post Processing	Filename.su2	Subirrigated crop 02
7	Information	Filename.out	StatePP output file
8	Information	Filename.log	StatePP log file
9	Information	Filename.chk	StatePP check file
10	Information	Cuavg.out	CU averages
11	Information	Rarray.out	Recharge arrays
12	Information	Rchchk.out	Recharge check

Table 5.2
StatePP Detailed Output Files

#	**File Type**	**Name**	**Description**
1	User Input	Mfgrid.out	Modflow data
2	User Input	Hycn.out	Hydraulic Conductivity
3	Flow Data	Cudata.out	CU data
4	Flow data	Prcprch.out	Precipitation recharge
5	Flow data	Rimflow.out	Rim inlfow recharge
6	Flow data	Muin.out	M&I wells
7	Spatial data	Canal.out	Canal locations
8	Spatial data	Irrland.out	Irrigatged lands
9	Spatial data	Irrwells.out	Irrigation wells
10	Spatial data	Rimarea.out	Rim inflow areas
11	Spatial data	Gisprch	Precipitation areas
12	Spatial data	Etveg.out	Native vegetation areas
13	Spatial data	Flwell	Flowing wells
14	Spatial data	Crop.out	Sibirrigated crop areas

6.0 Comments and Concerns

The StatePP was developed to pre process flow and spatial data in order to produces the following MODFLOW input files:1. recharge, 2.well, 3.evapotranspiration, and 4.drain. Comments and concerns identified during the development of StatePP include the following:

- Development of StatePP is consistent with a data-centered approach because ground water model input files can be easily updated when new data are available, and MODFLOW files for a wide variety of model sizes and number of stress periods. StatePP was successfully applied to a 5-layer model containing a maximum of 22736 cells per layer to generate monthly data from 1950 to 1997 for RGDSS.
- StatePP has the capability to process a wide variety of model grid sizes and time steps. For the RGDSS project the preprocessor was successfully used to generate a monthly input data set from 1950 to 1997 for a 5-layer model with 196 rows by 116 columns.
- The Consumptive Use model produces agricultural pumping data for sprinkler and non-sprinkler lands based on historical records of the distribution of sprinkler and non-sprinkler lands over time. StatePP was designed to use an agricultural well file that provides the distribution of sprinkler and non-sprinkler parcels for a structure at one point in time. StatePP was used in the RGDSS project where the use of sprinklers has increased over time. Therefore, the spatial distribution of agricultural pumping based on sprinkler and non-sprinkler parcels as calculated by StatePP is not representative of the actual spatial distribution of pumping in earlier times when there were fewer sprinkler parcels. Therefore, the development of spatial data for lands served by sprinkler and enhancing StatePP to use such data should be considered. The recommended and adopted approach, which distributes total pumping without regard to irrigation method (sprinkler vs. non-sprinkler), is considered appropriate for the RGDSS ground water model at this time.
- Similar to above, recharge from unused surface and ground water might be expected to vary over time as sprinkler and well development occurred. Therefore, the development of spatial data for lands served by different water sources and enhancing StatePP to use such data should be considered. The recommended approach, which distributes unused surface and ground water without regard to water supply, is considered appropriate for the RGDSS ground water model at this time.

Read files to count for space allocation of data
DIVCNT
IRLCNT
RMACNT
CUCNT
WLCNT
ETVCNT
FLWCNT
PCPCNT
PPTCNT
Allocate space
ALLOC
Read and store data
READ
Average data for each stress period
AVGDATA
Calculate Evapotranspiration functions and write MODFLOW file
ETPROP
Calculate flowing well data and write MODFLOW file
FLWELL

For each stress period
Calculate recharge and write MODFLOW file
RECHARGE
Calculate pumping rates and write MODFLOW file
PUMP
Calculate ET and subirrigation on irrigated crop land
ETSUB

Finish stress period calculations

Figure 1. General flow chart of StatePP.

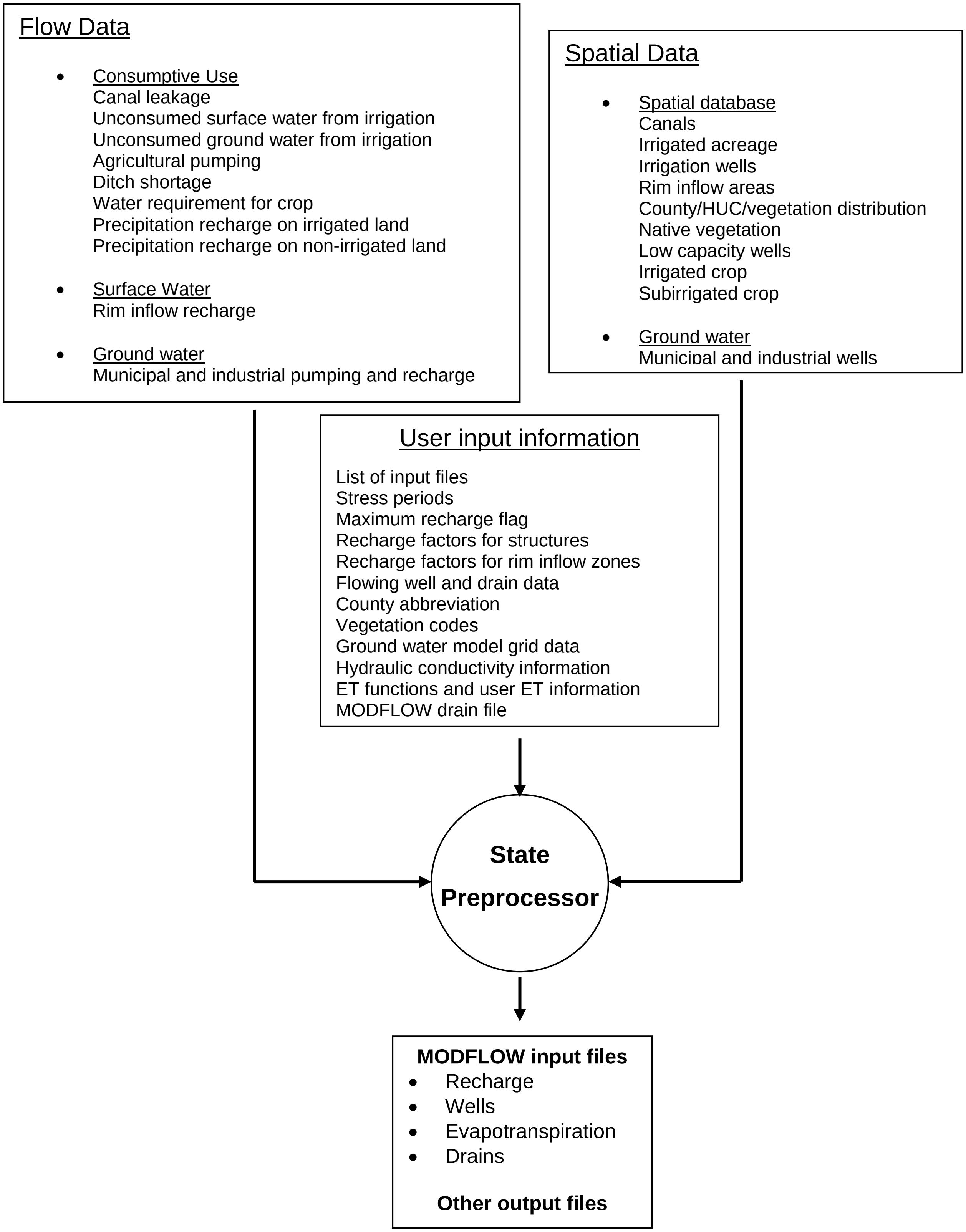

Figure 2. General flow of data into and out of StatePP.

```
#
#
# StatePP.ctl; Control file For running StatePP Steady State
#
#                         If ievt , 0 no ET calculations
#                         If ievt , 1 yes ET calculations
#
#                         If iflw , 0 no flowing wells
#                         If iflw , 1 yes flowing wells & Ag drains
#                         If iflw , 2 yes flowing wells & No Ag drains
#                                    they are part of stream package
#
#                         If irch , 0 no recharge calculations
#                         If irch , 1 yes recharge calculations
#
#                         If ipmp , 0 no pumping calculations
#                         If ipmp , 1 yes pumping calculations
#
#                         If isir , 0 no subirrigated crop calculations
#                          If isir , n # of subirrigated crops
#
#                         If iweg , 0 use HRS canal weights
#                         If iweg , 1 use SEO correction
#
#                         If ibflux,0 Do not use constant boundary flux
#                         If ibflux,n # of constant boundary flux values
#
#                         If igr  , 1 use HRS ground data
#                         If igr  , 2 use Principia ground data
#
#                         If iswgw, 0 No SWGW Return Function
#                         If iswgw, 1 Yes SWGW Return Function
#
#                         If isand, 0 No Sand Dune adjustment
#                         If isand, 1 Yes Sand Dune Adjustment
#
#                         If ippt , 1 County Huc ppt approach
#                         If ippt , 2 Krigged Ppt data approach
#                         If ippt , 3 Orographic Ppt data approach
#
#                         If im2K , 0 Modflow 1998
#                         If im2K , 1 Modflow 2000
#
#                         If iwadj , 0 Do not adjust well locatin data
#                         If iwadj , 1 Adjust well location data
#
#                         If isw2gw , 0 No Sw returns to GW
#                         If isw2gw , 1 Yes Sw returns to GW
#
#                         If iFacRch , 0 No Global recharge factor
#                         If iFacRch , 1 Yes Global recharge factor
#
# Phase 4
#
#
# Control Data Format (free)
# ievt iflw irch ipmp isir iprn iweg ibflux  igr  iswgw  isand  ippt im2K  iwadj isw2gw iFacRch iswgw2
 1  2  1  1  2  0  1  8  2  1   1   3  0  1  1   0   0
#
# Irrigated Recharge factors (%)
# Format free
#Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep Oct   Nov   Dec   Total
 3      3     3     3    10    10    10    10    10     3     3     3
```

```
#
# NonIrrigated Recharge factors (%)
# Format Free
#Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec    Total
3       3      3      3      3      3      3      3      3      3      3      3
#
# Krigged PPt data (irch, 2 or 4)
# Special (e.g. Great Sand Dunes) Recharge factors (%)
# Format Free
#Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec    Total
 21     21     21     21     21     21     21     21     21     21     21     21
#
# Boundary approach ibApp (0,porportion by cells, 1 porportion by conductance)
# Note use conductance approach If boundary data contains a series of 0's and 1's
# Format free
1
#   Boundary Flux Estimates (af/yr)
# Format (i4, 1x, a10, 20f10.0)
# # Direction   Layer 1  Layer 2  Layer 3   Layer 4  Layer 5    Total
#___ __________ __________ __________ __________ __________ __________ __________
   1 East            400.       200.      5000.      6200.         0.     11800.
   2 West-SAG          0.       600.      1600.     21000.         0.     23200.
   3 West-CON       5500.      1500.      3300.     37500.         0.     47800.
   4 West-RGD       3500.      7700.      1300.     15000.         0.     27500.
   5 South-west     1600.         0.     -4300.         0.         0.     -2700.
   6 South-east        0.     -1900.    -29200.         0.         0.    -31100.
   7 South-Cin       800.         0.         0.         0.         0.       800.
   8 South-Cout     -400.         0.         0.         0.         0.      -400.
#    Total         10700.      4300.     -7800.     79700.         0.     76900.
#
#
#
         1       399          no stress periods, no. of diversion with info
        19        53          no of rimflow zones  number of years of data
         6     no of county abbreviations
         5     no of vegetation types that are irrigated
        15                    no of county/huc combos from precip rch data
      1990      1998         1         12       stress period info
      100.                                      max recharge rate in in/yr
#
200505            .97       .97       .97       .97
200512            .97       .97       .97       .97
200513            .97       .97       .97       .97
…
…
…
#
# Rim Inflow factors
Zapata                     1.0
Upper San Luis             1.0
Trujillo                   1.0
Culebra&Rito               1.0
San Juan                   1.0
San Isabel                 1.0
San Francisco              1.0
Saguache                   1.0
Rock Creek                 1.0
Rito Hondo                 1.0
Raton                      1.0
Pole Creek                 1.0
Middle San Luis            1.0
Lower San Luis             1.0
La Garita                  1.0
Gato                       1.0
Cove Lake                  1.0
Cottonwood                 1.0
Carnero                    1.0
#
# Flowing Well data
```

```
0.6     3.0     0.25     62.5       4       10 FL WELL RCH FAC, COND.FAC, WELL DIAMETER, WELL PERF., DR MIN DEPTH BELOW LAND, DR MAX DEPTH BELOW LAND
#
# County Codes
ALA         Alamosa                       ABBREVIATION AND COUNTY ID
CON         Conejos
COS         Costilla
RGR         Rio Grande
SAG         Saguache
NMX         New Mexico
#
# Vegetation Codes
001         Alfalfa                    VEG CODE FOR IRRIGATED AREAS
005         Grain
008         Irrigated Meadow
011         Potatoes
013         Vegetables
#
# Global (canal, SW, GW, rim ppt) Zone Recharge factors (If iFacRch , 1).
# Note default is 1.0 unless da*ta is provided For a zone
# Note the names must match those in the parameter zone (*.flg) file
# Format(a24,1x,f8.0)
#_______________________eb______e
Mountain Fans                1.0
Conejos Valley               1.0
San Luis Hills               1.0
Manassa Fault                1.0
Costilla Plain               1.0
Rio Grande Fan               1.0
Closed Basin Fan             1.0
Closed Basin Clay            1.0
Closed Basin Graben          1.0
San Pedro Mesa               1.0
```

Documentation of AGG

(Program for aggregating structures)

FINAL

To: Ray Bennett, P.E.
From: HRS Water Consultants, Inc. Judith Schenk and Mark Palumbo
Subject: RGDSS Ground Water, Task 36 – State Pre-Processor Modifications
Date: January 24, 2003

The purpose of the program AGG (aggregate structures) is insure consistent ID's are contained in the GIS and CU data provided to StatePP. The program aggregates appropriate information in the GIS data files so that the structure identifications (IDs) in these files correspond to the structure IDs listed in the Consumptive Use data files.

This document includes the following sections:

<u>0.0 Disclaimer</u>

This program is furnished by The State of Colorado (State) and is accepted and used by the recipient upon the expressed understanding that the State makes no warranties, express or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information and data contained in this program or furnished in connection therewith, and the State shall be under no liability whatsoever to any person by reason of any use made thereof.

The program herein belongs to the State of Colorado. Therefore, the recipient further agrees not to assert any proprietary rights therein or to further represent this program to anyone as other than a State program.

<u>1.0 Acknowledgment</u>

This program was developed by HRS Water Consultants, Inc. (HRS) under contract with the Colorado Water Conservation Board (CWCB). Mark Palumbo was the HRS project

manager. Judith Schenk developed the program. Ray Bennett of the Colorado Division of Water Resources and Andy Moore of the CWCB directed the project development as part of the Rio Grande Decision Support System.

The multi-node well component was added in April, 2006 by CDM under the South Platte Decision Support System project (SPDSS), Phase 3, Task 50. This addition is compatible with previous versions of Agg input data. See section 4.5 for more information.

2.0 Introduction

The GIS contractor provides ground water data by Structure ID and Well Only ID for the ground water model area. The Consumptive Use contractor provides ground water data by Structure ID, Well Only ID, and Multiple Structure ID for the ground water model area. Therefore, some GIS data needs to be aggregated before it can be used by StatePP to prepare ground water model input files. AGG was developed to aggregate the GIS data associated with Multiple Structure IDs and perform various data checks on the GIS data as follows:

- Aggregate GIS data for multiple structures.
- Write data files with Structure IDs, Well Only IDs, and Multiple Structure IDs for StatePP.
- Compares IDs from the GIS data to the Consumptive Use data in order to identify any discrepancies.
- Check the GIS canal data by comparing the total canal length to the sum of the lengths assigned to individual grid cells for that structure.
- Check the GIS irrigated acreage data by comparing the total area of irrigated land for a structure to the sum of the area assigned to individual grid cells for that structure.

3.0 Program Description

The AGG program performs the following functions:

- Check GIS canal length and area data.
- Check GIS data for missing IDs in the canal, irrigated land, irrigation wells, and sub-irrigated crop files.
- Aggregate the GIS data associated with Multiple Structure IDs for canals, sub-irrigated crop, irrigated land, and irrigation well data.
- Write new files with Structure IDs, Well Only IDs, and Multiple Structure IDs.

3.1 Check GIS Canal Lengths and Areas

The following data are checked in the AGG program:

- Compare total length listed for a canal structure to the sum of the lengths assigned to individual cells associated with that structure,

- Compare total area listed for an irrigated land structure to the sum of the areas of the individual cells associated with that structure,
- Compare total area listed for an sub-irrigated crop structure to the sum of the areas of the individual cells associated with that structure.

If there is a difference between the totals, the information is printed to output files. Minor differences are the result of round-off error. Large differences typically indicate a problem with file formatting or data file errors.

3.2 Checking Input GIS Data Files for Missing IDs

As described in Section 2.0, the GIS contractor provides ground water data by Structure ID and Well Only ID while the Consumptive Use contractor provides ground water data by Structure ID, Well Only ID, and Multiple Structure ID. Each ID type is defined as follows by the RGDSS Consumptive Use and Surface Water Contractors:

- Structure ID (AKA WDID) A Structure ID is provided to describe a relatively large structure that is modeled explicitly. A one to one correspondence between the GIS and the Consumptive use data is expected for all structures located within the ground water model area.
- Well Only ID (AKA URF ID) A Well Only ID is provided to describe a group of irrigated lands that do not have a surface water supply. A one to one correspondence between the GIS data and the Consumptive Use data is expected for all structures located within the ground water model area.
- Multiple Structure ID (AKA MS ID) A Multiple Structure ID is provided when two or more structures operate as one or when several relatively small structures have been combined. One or more structures listed in the GIS data correspond to one Multiple Structure ID in the Consumptive Use data.

The WDID, URF, and MS IDs are listed in separate input files to the AGG program. The WDID and URF files contain a list of structures expected to be contained in both the GIS and CU data files. The file containing the MS IDs includes a list of structures that were aggregated in the CU model. The files produced from GIS data are checked against these three ID files to see if any IDs are missing in the input GIS files. The user must examine the missing ID data and determine if they are appropriate or if an error exists.

Missing IDs for some structures may be appropriate in some cases for the following reasons:

- Not all WDID structures have a canal associated with the structure.
- No URF structures are expected in the canal file because they have no surface water supply.
- Some structures are surface water only structures. Therefore, the well file, which includes only structures associated with ground water, may not have all WDID structures listed.

- The sub-irrigated crop file includes only structures with sub-irrigated crop. A structure may not be listed in this file if the structure does not include a sub-irrigated crop.
- Some of the structures listed under a multiple structure may fall outside the boundary of the ground-water model.

The user should investigate all missing IDs and determine if they are appropriately absent from the GIS data. At least one WDID listed under a multiple structure should be identified in the irrigated land file and the well file. If a multiple structure does not have at least one match for a WDID listed as part of a multiple structure, the user must investigate to determine why there is no match. This process may involve reviewing the basic GIS data and/or contacting the Spatial Data Base contractor and/or the Consumptive Use contractor to determine if a structure should or should not be included in the ground-water model.

3.3 Aggregate GIS Data

The program AGG processes each WDID listed under a multiple structure. If a match to the WDID is made, GIS data are totaled and assigned to the MS ID.

3.4 Creation of New Files Containing Aggregated Data

The following sequence is used for creating new data files for WDID and URF structures:
- Find match for each WDID in the canal file, irrigated land file, sub-irrigated crop file, and well file, and write data for these structures to new files.
- Find match for each URF in irrigated land file, sub-rrigated crop file, and irrigated well file and write data for these structures to new files.

The following sequence is used for creating new data files for MS structures:
- Check to see if there was a match for at least one of the structures listed under the MS ID structure.
- If no match is found print a warning to an output file.
- If there is at least one match, write MS structure data to new data files.
- Go through each structure listed under the MS ID structures list and find a match.
- If a match is found, sum the appropriate data for the type of file.
- If a match is not found, proceed to the next WDID structure in the MS structure list.
- Once all the structures associated with a MS ID have been processed write the aggregated data to the new input files.

4.0 Input File Description

As presented in **Table 1**, the program AGG requires eight (8) input files to operate. This includes one response file, 4 GIS files and three structure list files. **Appendix A-2** provides an example of each.

Table 1
AGG Input Files

No.	Typical File Name	Description
1	AGGFILES	Response file containing input file names
2	RGDSS2.CAN	Canal file created from GIS data
3	RGDSS2.IRR	Irrigated Land file created from GIS data
4	RGDSS2.IRM	Sub-irrigated Crop file created from GIS data
5	RGDSS6.WEL	Irrigation Well file created from GIS data
6	WDID2.DAT	Water District Structure IDs
7	URF.DAT	Ground Water Only (URF) Structure IDs
8	AGG2.DAT	Multiple Structure IDs

4.1 Response File

The response file named AGGFILES lists the input files to be read by the program AGG. The following input files are required:
- Canal file created from GIS data,
- Irrigated land file created from GIS data,
- Irrigation well file created from GIS data,
- Irrigated crop file created from GIS data,
- List of WDID (water district) structure IDs,
- List of URF (ground-water only lands) structure IDs,
- List of MS (multiple structure) IDs.

4.2 Canal File Created from GIS Data

The GIS canal file includes the following information for each structure:
- Structure ID,
- Total number of grid cells,
- Total length of canal for structure,
- Total weighted length of canal for structure. Note most canal data are typically weighted by a factor of 1.0. However some canal data may be weighted differently to

represent the percent of time water is in a particular portion of a canal and/or the nonlinear relationship of canal loss versus canal length.

The following information is listed for each grid cell listed under a structure ID:

- Layer,
- Row,
- Column,
- Length of canal reach in grid cell,
- Weight.

4.3 Irrigated Land File Created from GIS Data

The GIS irrigated land file includes the following information for each structure:

- Structure ID,
- Number of grid cells,
- Total area for structure,
- Total weighted area for structure. Note all irrigated land data are typically weighted by a factor of 1.0.

The following information is included for each grid cell associated with the structure:

- Layer,
- Row,
- Column,
- Area of irrigated land in grid cell,
- Weight.

4.4 Sub-irrigated Crop File Created from GIS Data

The GIS sub-irrigated crop file includes the following information for each structure with a sub-irrigated crop:

- Structure ID,
- Number of grid cells,
- Total area for structure,
- Total weighted area for structure. Note all sub-irrigated land data are typically weighted by a factor of 1.0.

The following information is included for each grid cell associated with a sub-irrigated crop structure:

- Layer,
- Row,
- Column,
- Area of sub-irrigated crop in grid cell,
- Weight.

4.5 Irrigation Well File Created from GIS Data

The irrigation well file includes the following information for each structure:

- Structure ID,
- Number of parcels,
- Total area of parcels,
- Total weighted area for parcels. Note well data are often weighted to represent the portion of an irrigated parcel served by a well in a given aquifer.

The following information is included for each parcel associated with the structure:

- Parcel ID,
- Number of wells,
- Area of parcel,
- Weighted area. Note well data are often weighted to represent the portion of an irrigated parcel served by a well in a given aquifer layer.
- Indicator for sprinkler or non-sprinkler parcel. A value of 0 indicates no sprinkler, while a value of 1 indicates a sprinkler exists.

The data written for each well listed under a parcel includes:

- Layer,
- Row,
- Column,
- Permitted yield in gallons per minute,
- Year of well.

If a multi-node well file (MNW) is desired output from StatePP, the following items must be included with each well record:
The data written for each well listed under a parcel includes:

- Top layer in which a well is completed
- Column,
- Permitted yield in gallons per minute,
- Year of well.

The FORTRAN formatting for the well data, including the data for the MNW input data is the following: (3I12, F12.0, I12, A20, 3I10)

The additional data fields are not required if the MNW is not desired output in StatePP.

4.6 Water District Structure Identifications

The data contained in the Structure ID (WDID) file include the following:

- Total number of WDID structures,
- List of each WDID structure.

4.7 Ground Water Only (URF) Structure Identifications

Data contained in the ground water only (URF) structure ID file include the following:
- Total number of URF structures,
- List of each URF structure.

4.8 Multiple Structure Identifications

Data contained in the file of multiple structures (MS) IDs include the following:
- Total number of multiple structures,
- Total number of individual structures that make up multiple structures,
- Multiple structure ID,
- Number of WDID structures that make up the MS structure,
- List of WDID structure identifications that make up the MS structure.

5.0 Output File Description

As presented in **Table 2, t**he program AGG creates sixteen output files. These files include a general output file, four files with aggregated data to be used with StatePP, four files that echo input file data, three files that compare lengths or areas, and four files that list missing structures. **Appendix A-3** provides an example of each.

Table 2
AGG Output Files

No.	Typical File Name	Description
1	AGG.OUT	General output file
2	DIVLEAK.DAT	Canal leakage file for StatePP
3	DIVIRLN.DAT	Irrigated land file for StatePP
4	IRRMEAD.DAT	Sub-irrigated crop file for StatePP
5	IRRWELLS.DAT	Irrigation well file for StatePP
6	CANAGG.OUT	Canal file echoing input data
7	IRRAGG.OUT	Irrigated land file echoing input data
8	IRMAGG.OUT	Sub-irrigated crop file echoing input data
9	WELAGG.OUT	Irrigation well file echoing input data
10	CANAGG.ERR	Canal file comparing lengths
11	IRRAGG.ERR	Irrigated land file comparing areas
12	IRMAGG.ERR	Sub-irrigated crop file comparing areas
13	NMCAN.DAT	Canal file with missing IDs
14	NMIRR.DAT	Missing IDs in the Irrigated Land file
15	NMIRM.DAT	Missing IDs in the Sub-irrigated Crop file
16	NMWEL.DAT	Missing IDs in the Irrigation Well file

5.1 General output file

The general output file, AGG.OUT, contains the following information:

- Summary of number of structures listed in input files,
- List of WDID structures,
- List of URF structures,
- List of MS structures and WDID structures included in the aggregate,
- Data files as they are read,
- List of files that have missing structure IDs.

5.2 Files Created for StatePP Input

As presented in **Table 2**, four files are created for input to StatePP. These files include all ground water data associated with a Structure ID (WDID), Ground Water Only ID (URF ID), and Multiple Structure ID (MS ID).

Note that the irrigation well file may require additional hand editing. To provide additional flexibility to the ground water modeler, StatePP identifies wells that do not fall on active grid cells. In some cases, the wells may be assigned to layer 0, or assigned to a layer that is inactive at a grid cell location. The user needs to examine the well data printed to the StatePP log file (SPP.LOG) and make changes to the well file if necessary. A list of hand edits to the well file for the RGDSS project is included in Appendix A-4.

5.3 Files that Echo Input Data

As presented in **Table 2**, files echoing input data are created so that the user can examine the files to be sure input data are read correctly. These files are particularly useful for checking input file formats.

5.4 Files Comparing Lengths and Areas

Lengths in the canal file and areas in the irrigated land and sub-irrigated crop files are compared as described in section 3.1. As presented in **Table 2**, if there is a difference the data are written to one of three files that represent canal, irrigated land, and sub-irrigated crop data.

The following information is included in the CANAGG.ERR file:

- Sequence number of structure,
- Structure ID,
- Length calculated from summing length in each grid cell,

- Total length listed for structure,
- Difference between the length calculated and total length listed.

The following information is included in the IRRAGG.ERR and IRMAGG.ERR files:
- Sequence number of structure,
- Structure ID,
- Area calculated from summing area in grid cell,
- Total area listed for structure,
- Difference between the area calculated and the total area listed.

5.5 Files Listing Missing IDs

As presented in **Table 2**, four files are created to identify missing IDs in the GIS files. Data listed in these files include the missing ID and total number of missing IDs.

Data listed in these files include the following information for missing Multiple Structure (MS) IDs:
- Sequence number of MS structure,
- MS structure ID,
- Total number of individual structures listed under MS structure ID,
- List of missing structure IDs for MS structure.

6.0 Comments and Concerns

- The Structure (WDID), Well Only (URF), and Multiple Structure (MS) files must contain all structures located within the ground water model and contained in the Consumptive Use Model file that is input to StatePP. If any IDs are missing AGG prints a warning that the IDs should be investigated by the user. A future enhancement to AGG might allow the user to supply information regarding structure ID that are expected to be missing in order to preserve such an analysis each time the program is rerun for a basin.
- Similarly, the irrigation well file produced by AGG may require additional hand editing for wells assigned to a layer or grid cell that is inactive. A future enhancement to AGG might allow the user to supply information regarding these wells in order to preserve such an analysis each time that the program is rerun for a basin.
- The Consumptive Use data used by AGG and ultimately StatePP is a subset of the consumptive use data developed for Division 3 that represents the ground water model area only. If the CU data were not subdivided into only those lands that overly the RGDSS ground water model area both AGG and StatePP should operate. However significantly more missing IDs should be expected to be identified.

- If there is a question about missing structures, the user may need to evaluate the basic GIS data and/or coordinate with the Spatial Data Base contractor and the Consumptive Use modeling contractor to clarify any discrepancies.
- The AGG program is structured to accommodate only one sub-irrigated crop. If additional crops were identified as potentially sub-irrigated, the input data and program would need to be revised.
- Coordination between the RGDSS Consumptive Use, GIS, and Ground Water Contractors allowed structures to be identified as predominantly inside or outside the ground water model area. Therefore the programs AGG and StatePP are not required to accommodate structures located partially inside and partially outside the ground water model area.

Appendices

A-1 Program listing
A-2 Input file listing
A-3 Output file listing
A-4 Adjustments to well file

A-1 Program listing

```
C
C  UTILITY PROGRAM TO AGGREGATE DATA FROM THE FOLLOWING FILES:
C     FILENAME.CAN   GIS CANAL FILE
C     FILENAME.IRR   GIS IRRIGATED LANDS FILE
C     FILENAME.WEL   GIS WELL FILE
C     FILENAME.IRM   GIS IRRIGATED CROP FILE
C
C  PROGRAM WRITTEN BY JUDITH SCHENK
C
C  VERSION 1.0  JANUARY, 2002
C  AGGREGATE CANAL, IRRIGATED LANDS, AND IRRIGATION WELL FILE
C
C  VERSION 1.1
C  APRIL, 2002
C  ADDED IRRIGATED CROP FILE
C
C  THIS PROGRAM ALSO ASSIGNS AN MULTIPLE STRUCTURE ID
C
C  THIS PROGRAM ALSO CHECKS THE FILES AND COMPARES THEM AGAINST STRUCTURE
C  IDS FROM LIST FROM ERIN WILSON.
C
C  AGG53
C
C        SPECIFICATIONS:
C    ----------------------------------------------------------------------
      CHARACTER CH*20
      CHARACTER FLNAME*15
      COMMON X(10000000),IX(200000),CH(100000)
      LENX=10000000
      LENIX=200000
      LENC=100000
C
C       OPEN FILES:
C    ----------------------------------------------------------------------
C
C-----OPEN FILE CONTAINING NAMES OF GIS INPUT FILES
      OPEN(UNIT=3, FILE='AGGFILES')
C
C-----GENERAL OUTPUT FILE
      OPEN(UNIT=5, FILE='AGG.OUT')
C
C-----READ INPUT FILENAMES FROM GIS PRODUCED DATA AND OPEN FILES
C-----FILES SHOULD BE IN THE FOLLOWING ORDER:
C     UNIT 20 - CANAL FILE
C     UNIT 25 - IRRIGATED LANDS FILE
C     UNIT 40 - IRRIGATION WELL FILE
C     UNIT 50 - IRRIGATED CROP FILE
C     UNIT 45 - STRUCTURE (WDID) IDS
C     UNIT 55 - URF IDS
C     UNIT 60 - AGGREGATED STRUCTURE IDS
C
      DO 2 I=1,7
      READ(3,4)FLNAME
    4 FORMAT(A15)
      IF(I.EQ.1) OPEN(UNIT=20,FILE=FLNAME)
      IF(I.EQ.2) OPEN(UNIT=25,FILE=FLNAME)
      IF(I.EQ.3) OPEN(UNIT=40,FILE=FLNAME)
      IF(I.EQ.4) OPEN(UNIT=50,FILE=FLNAME)
      IF(I.EQ.5) OPEN(UNIT=45,FILE=FLNAME)
      IF(I.EQ.6) OPEN(UNIT=55,FILE=FLNAME)
      IF(I.EQ.7) OPEN(UNIT=60,FILE=FLNAME)
```

```
    2 CONTINUE
C
C-----OUTPUT FILES CREATED TO BE READ BY PRE-PROCESSOR
      OPEN(UNIT=96, FILE='DIVLEAK.DAT')
      OPEN(UNIT=97, FILE='DIVIRLN.DAT')
      OPEN(UNIT=98, FILE='IRRWELLS.DAT')
      OPEN(UNIT=99, FILE='IRRMEAD.DAT')
C
C-----OUTPUT FILES SHOWING WHAT IDS ARE MISSING
      OPEN(UNIT=70, FILE='NMCAN.DAT')
      OPEN(UNIT=80, FILE='NMIRR.DAT')
      OPEN(UNIT=90, FILE='NMWEL.DAT')
      OPEN(UNIT=92, FILE='NMIRM.DAT')
C
C-----OUTPUT FILES COMPARING LENGTHS TO TOTAL LENGTHS AND AREAS TO TOTAL AREAS
      OPEN(UNIT=28, FILE='IRRAGG.ERR')
      OPEN(UNIT=23, FILE='CANAGG.ERR')
      OPEN(UNIT=24, FILE='IRMAGG.ERR')
C
C-----OUTPUT FILES ECHOING INPUT DATA FROM GIS PRODUCED FILES
      OPEN(UNIT=22, FILE='CANAGG.OUT')
      OPEN(UNIT=27, FILE='IRRAGG.OUT')
      OPEN(UNIT=42, FILE='WELAGG.OUT')
      OPEN(UNIT=43, FILE='IRMAGG.OUT')
C
      WRITE(5,927)
  927 FORMAT(/' AGG PROGRAM '/)
C
C-----READ NUMBER OF STRUCTURES LISTED IN VARIOUS FILES TO ALLOCATE SPACE
      READ(45,5)NPLN
    5 FORMAT(I10)
      READ(55,5)NURF
      READ(60,6)NAGG,NAGS
    6 FORMAT(2I10)
C
C-----READ DATA TO GET NO. OF STRUCTURES AND TOTAL NO. OF CANALS
C     IN THE CANAL FILE TO ALLOCATE SPACE IN X ARRAY
      CALL DIVCNT(NDL,NDVR,NHDNG1)
C
C-----READ DATA TO GET NO. OF STRUCTURES AND TOTAL NO. OF GRID CELLS
C     IN THE IRRIGATED LAND FILE TO ALLOCATE SPACE IN X ARRAY
      CALL IRLCNT(NDA,NDVA,NHDNG2)
C
C-----READ DATA TO GET NO. OF STRUCTURES AND TOTAL NUMBER OF WELLS
C     IN THE IRRIGATION WELL FILE TO ALLOCATE SPACE IN THE X ARRAY
      CALL WELCNT(NDW,NDPA,NDWL,NHDNG3)
C
C-----READ DATA TO GET NO. OF STRUCTURES AND TOTAL NO. OF GRID CELLS
C     IN THE IRRIGATED CROP FILE TO ALLOCATE SPACE IN X ARRAY
      CALL IRMCNT(NDM,NDVM,NHDNG4)
C
C-----ALLOCATE SPACE IN "X" ARRAY
      CALL ALLOC(NDL,NDVR,NDA,NDVA,NDW,NDPA,NDWL,LCIDLK,LCDLKS,LCDLKR,
     #           LCIDIL,LCDVAC,LCCLAC,LCIDPW,LCDVPW,LCIDPA,LCDVPA,
     #           LCDVWL,LENX,LENC,LENIX,NPLN,NURF,NAGG,NAGS,
     #           LCPLAN,LCURFS,LCAGGR,LCAGST,LCNAST,LCAGCN,
     #           LCAGIR,LCAGWL,NDM,NDVM,LCDVIM,LCCLIM,LCIDIM,LCAGIM)
C
C-----READ DATA
      CALL READ(NDL,NDVR,NDA,NDVA,NDW,NDPA,NDWL,CH(LCIDLK),X(LCDLKS),
     #          X(LCDLKR),CH(LCIDIL),X(LCDVAC),X(LCCLAC),
     #          CH(LCIDPW),X(LCDVPW),CH(LCIDPA),X(LCDVPA),
     #          X(LCDVWL),NHDNG1,NHDNG2,NHDNG3,NPLN,NURF,NAGG,NAGS,
```

```
     #          CH(LCPLAN),CH(LCURFS),CH(LCAGGR),CH(LCAGST),
     #          IX(LCNAST),NDM,NDVM,X(LCDVIM),X(LCCLIM),CH(LCIDIM),
     #          NHDNG4)
C
C-----CHECK FILES FOR MISSING IDS
      CALL CMPRAG(NDL,NDVR,NDA,NDVA,NDW,NDPA,NDWL,CH(LCIDLK),X(LCDLKS),
     #          X(LCDLKR),CH(LCIDIL),X(LCDVAC),X(LCCLAC),
     #          CH(LCIDPW),X(LCDVPW),CH(LCIDPA),X(LCDVPA),
     #          X(LCDVWL),NHDNG1,NHDNG2,NHDNG3,NPLN,NURF,NAGG,NAGS,
     #          CH(LCPLAN),CH(LCURFS),CH(LCAGGR),CH(LCAGST),
     #          IX(LCNAST),NDM,NDVM,X(LCDVIM),X(LCCLIM),CH(LCIDIM))
C
C-----AGGREGATE DATA AND ASSIGN MS ID
      CALL COMBINE(NDL,NDVR,NDA,NDVA,NDW,NDPA,NDWL,CH(LCIDLK),
     #          X(LCDLKS),X(LCDLKR),CH(LCIDIL),X(LCDVAC),X(LCCLAC),
     #          CH(LCIDPW),X(LCDVPW),CH(LCIDPA),X(LCDVPA),
     #          X(LCDVWL),NHDNG1,NHDNG2,NHDNG3,NPLN,NURF,NAGG,NAGS,
     #          CH(LCPLAN),CH(LCURFS),CH(LCAGGR),CH(LCAGST),
     #          IX(LCNAST),X(LCAGCN),X(LCAGIR),X(LCAGWL),NDM,NDVM,
     #          X(LCDVIM),X(LCCLIM),CH(LCIDIM),X(LCAGIM))
C
C-----WRITE FILES WITH MS AND AGGREGATE IDS
      CALL WRITEFL(NDL,NDVR,NDA,NDVA,NDW,NDPA,NDWL,CH(LCIDLK),
     #          X(LCDLKS),X(LCDLKR),CH(LCIDIL),X(LCDVAC),X(LCCLAC),
     #          CH(LCIDPW),X(LCDVPW),CH(LCIDPA),X(LCDVPA),
     #          X(LCDVWL),NHDNG1,NHDNG2,NHDNG3,NPLN,NURF,NAGG,NAGS,
     #          CH(LCPLAN),CH(LCURFS),CH(LCAGGR),CH(LCAGST),
     #          IX(LCNAST),X(LCAGCN),X(LCAGIR),X(LCAGWL),
     #          NDM,NDVM,CH(LCIDIM),X(LCDVIM),X(LCCLIM),
     #          X(LCAGIM),NHDNG4)
      END
C
C*******************************************************************************
      SUBROUTINE DIVCNT (NDL,NDVR,NHDNG1)
C
C-----THIS SUBROUTINE GOES THROUGH CANAL FILE TO COUNT NUMBER OF
C     STRUCTURES, AND NUMBER OF RECORDS FOR EACH STRUCTURE SO THAT
C     SPACE CAN BE PROPERLY ALLOCATED IN X ARRAY
C
C-----PROGRAMED TO READ TO END OF FILE
C-----READ HEADINGS AND COUNT HOW MANY LINES OF HEADING ARE IN FILE
      CHARACTER HD1
      NHDNG1=0
   32 READ(20,612)HD1
  612 FORMAT(A1)
      IF(HD1.EQ.'#')THEN
        NHDNG1=NHDNG1+1
        GO TO 32
      ENDIF
      REWIND20
C
C-------READ DUMMY LINES
      DO 36 IDUM=1,NHDNG1
      READ(20,34)HD1
   34 FORMAT(A1)
   36 CONTINUE
C
C-------INITIALIZE NDL AND NDVR
      NDL=0
      NDVR=0
C
C------READ NUMBER OF REACHES, TOTAL LENGTH, TOTAL LENGTH*DIVFAC
C------IF EOF IS REACHED, WILL GO TO STATEMENT 60
```

```
   40 READ(20,620,END=60)IDCAN,NUMR
  620 FORMAT(A12,I12)
C
C-----GET MAXIMUM NUMBER OF REACHES FOR ANY ONE
      IF(NUMR.GT.NDVR)NDVR=NUMR
C
C-----GO THROUGH NUMBER OF REACHES
      DO 50 IRD=1,NUMR
        READ(20,630)
  630   FORMAT()
   50 CONTINUE
C
C-------COUNT NEXT IF THERE ARE MORE RECORDS TO BE READ
      NDL=NDL+1
      GO TO 40
C
C-------IF YOU ARE HERE, THEN YOU HAVE REACHED THE END OF THE FILE
   60 CONTINUE
C
C-----RETURN TO MAIN PROGRAM
      RETURN
      END
C
C*******************************************************************************
      SUBROUTINE IRLCNT (NDA,NDVA,NHDNG2)
C
C-----THIS SUBROUTINE GOES THROUGH THE IRRIGATED LAND FILE TO COUNT NUMBER OF
C     STRUCTURES, AND NUMBER OF RECORDS FOR EACH STRUCTURE SO THAT
C     SPACE CAN BE PROPERLY ALLOCATED IN X ARRAY
C
C-----PROGRAMED TO READ TO END OF FILE
C-----READ HEADINGS AND COUNT HOW MANY LINES OF HEADING ARE IN FILE
      CHARACTER HD2
      NHDNG2=0
   32 READ(25,612)HD2
  612 FORMAT(A1)
      IF(HD2.EQ.'#')THEN
        NHDNG2=NHDNG2+1
        GO TO 32
      ENDIF
      REWIND25
C
C-------READ DUMMY LINES
      DO 36 IDUM=1,NHDNG2
      READ(25,34)HD2
   34 FORMAT(A1)
   36 CONTINUE
C
C-------INITIALIZE NDA AND NDVA
      NDA=0
      NDVA=0
C
C------READ NUMBER OF REACHES, TOTAL LENGTH, TOTAL LENGTH*DIVFAC
C------IF EOF IS REACHED, WILL GO TO STATEMENT 60
   40 READ(25,620,END=60)IDCAN,NUMA
  620 FORMAT(A12,I12)
C
C-----SUM NDVA
      IF(NUMA.GT.NDVA)NDVA=NUMA
C
C-----GO THROUGH NUMBER OF REACHES
      DO 50 IRD=1,NUMA
        READ(25,630)
```

```
  630   FORMAT()
   50 CONTINUE
C
C-------COUNT
      NDA=NDA+1
      GO TO 40
C
C-------IF YOU ARE HERE, THEN YOU HAVE REACHED THE END OF THE FILE
   60 CONTINUE
C
C-----RETURN TO MAIN PROGRAM
      RETURN
      END
C
C******************************************************************************
      SUBROUTINE WELCNT(NDW,NDPA,NDWL,NHDNG3)
C
C-----THIS SUBROUTINE GOES THROUGH IRRIGATION WELL FILE TO COUNT NUMBER OF
C     STRUCTURES, THE NUMBER OF PARCELS FOR EACH STRUCTURE, AND THE
C     NUMBER OF WELLS FOR EACH PARCEL SO THAT SPACE CAN BE PROPERLY
C     ALLOCATED IN THE X ARRAY
C
C-----PROGRAMED TO READ TO END OF FILE
C-----READ HEADINGS AND COUNT HOW MANY LINES OF HEADING ARE IN FILE
      CHARACTER HD3
      CHARACTER*12  IDDVP,PID
      NHDNG3=0
   32 READ(40,612)HD3
  612 FORMAT(A1)
      IF(HD3.EQ.'#')THEN
        NHDNG3=NHDNG3+1
        GO TO 32
      ENDIF
      REWIND40
C
C-------READ DUMMY LINES
      DO 36 IDUM=1,NHDNG3
      READ(40,34)HD3
   34 FORMAT(A1)
   36 CONTINUE
C
C-------INITIALIZE NDW, NDPA, AND NDWL
      NDW=0
      NDPA=0
      NDWL=0
C
C------READ ID AND NUMBER OF PARCELS
C------IF EOF IS REACHED, WILL GO TO STATEMENT 60
   40 READ(40,620,END=60)IDDVP,NUMP
  620 FORMAT(A12,I12)
C
C-----SUM THE NUMBER OF PARCELS
      NDPA=NDPA+NUMP
C
C-----GO THROUGH PARCELS TO READ NO. OF WELLS FOR EACH PARCEL
      DO 50 IRD=1,NUMP
        READ(40,630)PID,NWLS
  630   FORMAT(A12,I12)
C
C-----COUNT THE TOTAL NUMBER OF WELLS
        NDWL=NDWL+NWLS
C
C-----GO THROUGH LINES OF WELL DATA BUT DO NOT READ DATA
```

```
        DO 45 N=1,NWLS
          READ(40,640)
  640     FORMAT()
   45   CONTINUE
   50 CONTINUE
C
C-------COUNT
      NDW=NDW+1
      GO TO 40
C
C-------IF YOU ARE HERE, THEN YOU HAVE REACHED THE END OF THE FILE
   60 CONTINUE
C
C-----RETURN TO MAIN PROGRAM
      RETURN
      END
C
C*******************************************************************************
      SUBROUTINE IRMCNT (NDM,NDVM,NHDNG4)
C
C-----THIS SUBROUTINE GOES THROUGH IRRIGATED CROP FILE TO COUNT NUMBER OF
C     STRUCTURES, AND NUMBER OF RECORDS FOR EACH STRUCTURE SO THAT
C     SPACE CAN BE PROPERLY ALLOCATED
C
C-----PROGRAMED TO READ TO END OF FILE
C-----READ HEADINGS AND COUNT HOW MANY LINES OF HEADING ARE IN FILE
      CHARACTER HD4
      CHARACTER*12  IDMED
      NHDNG4=0
   32 READ(50,612)HD4
  612 FORMAT(A1)
      IF(HD4.EQ.'#')THEN
        NHDNG4=NHDNG4+1
        GO TO 32
      ENDIF
      REWIND50
C
C-------READ DUMMY LINES
      DO 36 IDUM=1,NHDNG4
      READ(50,34)HD4
   34 FORMAT(A1)
   36 CONTINUE
C
C-------INITIALIZE NDM AND NDVM
      NDM=0
      NDVM=0
C
C------READ NUMBER OF REACHES, TOTAL LENGTH, TOTAL LENGTH*DIVFAC
C------IF EOF IS REACHED, WILL GO TO STATEMENT 60
   40 READ(50,620,END=60)IDMED,NUMM
  620 FORMAT(A12,I12)
C
C-----SUM NDVM
      IF(NUMM.GT.NDVM)NDVM=NUMM
C
C-----GO THROUGH NUMBER OF REACHES
      DO 50 IRD=1,NUMM
        READ(50,630)
  630   FORMAT()
   50 CONTINUE
C
C-------COUNT STRUCTURE
      NDM=NDM+1
```

```
      GO TO 40
C
C-------IF YOU ARE HERE, THEN YOU HAVE REACHED THE END OF THE FILE
   60 CONTINUE
C
C-----RETURN TO MAIN PROGRAM
      RETURN
      END
C
C*******************************************************************************
C-----ALLOCATE SPACE IN ARRAYS
      SUBROUTINE ALLOC(NDL,NDVR,NDA,NDVA,NDW,NDPA,NDWL,LCIDLK,LCDLKS,
     #                 LCDLKR,LCIDIL,LCDVAC,LCCLAC,LCIDPW,LCDVPW,
     #                 LCIDPA,LCDVPA,LCDVWL,LENX,LENC,LENIX,
     #                 NPLN,NURF,NAGG,NAGS,LCPLAN,LCURFS,
     #                 LCAGGR,LCAGST,LCNAST,LCAGCN,LCAGIR,LCAGWL,
     #                 NDM,NDVM,LCDVIM,LCCLIM,LCIDIM,LCAGIM)
C
      WRITE(5,198)NDL,NDA,NDW,NDM,NPLN,NURF,NAGG,NAGS
  198 FORMAT
     #(/5X, 'NUMBER OF STRUCTURES FOR LEAKAGE CALCULATIONS (NDL)   =',
     #I4/5X,'NUMBER OF STRUCTURES FOR IRRIGATED LAND FILE (NDA)    =',
     #I4/5X,'NUMBER OF STRUCTURES FROM WELL FILE (NDW)             =',
     #I4/5X,'NUMBER OF STRUCTURES FROM IRRIGATED CROP FILE (NDM) =',
     #I4/5X,'NUMBER OF STRUCTURES FROM WDID FILE (NPLN)            =',
     #I4/5X,'NUMBER OF STRUCTURES FROM URF FILE  (NURF)            =',
     #I4/5X,'NUMBER OF AGGREGATES FROM AGG. FILE (NAGG)            =',
     #I4/5X,'NUMBER OF AGG. STRUCTURES FROM AGG. FILE (NAST)       =',
     #I4/)
C
C-----INITIALIZE ISUM AND ISUMC
      ISUMI=1
      ISUM=1
      ISUMC=1
C
C-----ALLOCATE SPACE FOR INTEGER ARRAYS
      LCNAST=ISUMI
      ISUMI=ISUMI+NAGG
C
C-----ALLOCATE SPACE FOR NUMERIC ARRAYS
      LCDLKS=ISUM
      ISUM=ISUM+NDL*4
      LCDLKR=ISUM
      ISUM=ISUM+NDL*NDVR*5
      LCDVAC=ISUM
      ISUM=ISUM+NDA*4
      LCCLAC=ISUM
      ISUM=ISUM+NDA*NDVA*5
      LCDVPW=ISUM
      ISUM=ISUM+NDW*4
      LCDVPA=ISUM
      ISUM=ISUM+(7*NDPA)
      LCDVWL=ISUM
      ISUM=ISUM+(5*NDWL)
      LCDVIM=ISUM
      ISUM=ISUM+NDM*4
      LCCLIM=ISUM
      ISUM=ISUM+NDM*NDVM*5
      LCAGCN=ISUM
      ISUM=ISUM+3*NAGG
      LCAGIR=ISUM
      ISUM=ISUM+3*NAGG
      LCAGWL=ISUM
```

```
      ISUM=ISUM+3*NAGG
      LCAGIM=ISUM
      ISUM=ISUM+3*NAGG
C
C-----ALLOCATE SPACE FOR CHARACTER ARRAYS
      LCIDLK=ISUMC
      ISUMC=ISUMC+NDL*12
      LCIDIL=ISUMC
      ISUMC=ISUMC+NDA*12
      LCIDIM=ISUMC
      ISUMC=ISUMC+NDM*12
      LCIDPW=ISUMC
      ISUMC=ISUMC+NDW*12
      LCIDPA=ISUMC
      ISUMC=ISUMC+NDPA*12
      LCPLAN=ISUMC
      ISUMC=ISUMC+NPLN*12
      LCURFS=ISUMC
      ISUMC=ISUMC+NURF*12
      LCAGGR=ISUMC
      ISUMC=ISUMC+NAGG*12
      LCAGST=ISUMC
      ISUMC=ISUMC+NAGS*12
C
      WRITE(5,15)ISUM,LENX
   15 FORMAT(/1X,I15,' ELEMENTS IN  X ARRAY ARE USED OUT OF ',I15)
      WRITE(5,16)ISUMI,LENIX
   16 FORMAT(1X,I15,' ELEMENTS IN IX ARRAY ARE USED OUT OF ',I15)
      WRITE(5,17)ISUMC,LENC
   17 FORMAT(1X,I15,' ELEMENTS IN CH ARRAY ARE USED OUT OF ',I15/)
      RETURN
      END
C
C*******************************************************************************
      SUBROUTINE READ(NDL,NDVR,NDA,NDVA,NDW,NDPA,NDWL,IDLK,DLKS,
     #                DLKR,IDIL,DVAC,CLAC,IDPW,DVPW,IDPA,DVPA,
     #                DVWL,NHDNG1,NHDNG2,NHDNG3,NPLN,NURF,NAGG,
     #                NAGS,PLAN,URFS,AGGR,AGST,NAST,
     #                NDM,NDVM,DVIM,CLIM,IDIM,NHDNG4)
C
C-----THIS SUBROUTINE READS IN DATA FOR PREPROCESSOR
C
      INTEGER NAST(NAGG)
C
      DIMENSION DLKS(4,NDL),DLKR(5,NDVR,NDL),DVAC(4,NDA),
     #          CLAC(5,NDVA,NDA),DVPW(4,NDW),DVPA(7,NDPA),
     #          DVWL(5,NDWL),DVIM(4,NDM),CLIM(5,NDVM,NDM)
C
      CHARACTER*12 IDLK(NDL),IDIL(NDA),IDPW(NDW),IDPA(NDPA),
     #             PLAN(NPLN),URFS(NURF),AGGR(NAGG),
     #             AGST(NAGS),IDIM(NDM)
C
C-------------------------------------------------------------------------------
C-----READ DATA FROM WDID.DAT
C                    45
      WRITE(5,390)
  390 FORMAT(//40('-')/' STRUCTURES IN CU MODEL'/40('-'))
      DO 400 IRD=1,NPLN
      READ(45,410)PLAN(IRD)
  410 FORMAT(A12)
      WRITE(5,410)PLAN(IRD)
  400 CONTINUE
C-------------------------------------------------------------------------------
```

```
C-----READ DATA FROM URF.DAT
C                     55
      WRITE(5,491)
  491 FORMAT(//40('-')/' GROUND WATER ONLY STRUCTURES IN CU ',
     #       'MODEL'/40('-'))
      WRITE(5,493)
  493 FORMAT(/5X,'GROUND WATER STRUCTURE ID')
      DO 600 IRD=1,NURF
      READ(55,610)URFS(IRD)
      WRITE(5,610)URFS(IRD)
  610 FORMAT(A12)
  600 CONTINUE
C------------------------------------------------------------------------------
C-----READ DATA FROM AGG.DAT
C                     60
      WRITE(5,591)
  591 FORMAT(//40('-')/' AGGREGATE STRUCTURES IN ',
     #       'MODEL'/40('-'))
      WRITE(5,593)
  593 FORMAT(/5X,'AGGREGATE STRUCTURE ID   NO. STRUCTURES')
C
C-----INITIALIZE ICOUNT
      ICOUNT=0
      DO 700 IRD=1,NAGG
      READ(60,710)AGGR(IRD),NUMAG
      WRITE(5,711)AGGR(IRD),NUMAG
  710 FORMAT(A12,I12)
  711 FORMAT(5X,A12,5X,I12)
      NAST(IRD)=NUMAG
      DO 650 IRD2=1,NUMAG
      ICOUNT=ICOUNT+1
      READ(60,712)AGST(ICOUNT)
      WRITE(5,712)AGST(ICOUNT)
  712 FORMAT(12X,A12)
  650 CONTINUE
  700 CONTINUE
C
C
C------------------------------------------------------------------------------
C
C-----READ DATA FROM CANAL FILE
      REWIND20
C
      WRITE(5,33)
      WRITE(22,33)
   33 FORMAT(//40('-')/' CANAL LENGTH DATA'/
     #       ' LENGTH IS IN FEET'/40('-'))
C
      WRITE(5,37)
   37 FORMAT(/5X,'SEE CANAGG.OUT')
C-------READ DUMMY LINES
      DO 36 IDUM=1,NHDNG1
      READ(20,34)HD1
   34 FORMAT(A1)
      WRITE(96,34)HD1
   36 CONTINUE
C
C-----READ NUMBER OF REACHES, TOTAL LENGTH, TOTAL LENGTH*DIVFAC
C
      WRITE(23,44)
   44 FORMAT('     SEQ. NO.     ID           LENGTH CALC.',
     #       '   TOTAL LENGTH   DIFFERENCE')
C
```

```
      DO 50 IRD=1,NDL
C
      WRITE(22,39)
   39 FORMAT(/'   CANAL ID     SEQ NO.   NO. CELLS   ',
     #       'TOT LENGTH  TOT LNTH*FC')
C
      DLKS(1,IRD)=IRD
      READ (20,40)IDLK(IRD),NUMR,DLKS(3,IRD),DLKS(4,IRD)
   40 FORMAT(A12,I12,2F12.0)
      DLKS(2,IRD)=NUMR
      WRITE(22,496)IDLK(IRD),IRD,NUMR,DLKS(3,IRD),
     #            DLKS(4,IRD)
  496 FORMAT(A12,I8,I12,3X,2F12.2)
C
      WRITE(22,41)
   41 FORMAT('  LAYER   ROW   COLUMN      LENGTH       FACTOR')
      SUML=0
      SUMLF=0
C-----FOR THIS CANAL REACH, READ LAYER, ROW, COLUMN, LENGTH, FACTOR
         DO 45 IRD2=1,NUMR
         READ(20,42)ILL,IRL,ICL,DLKR(4,IRD2,IRD),DLKR(5,IRD2,IRD)
   42    FORMAT(3I12,2F12.0)
         DLKR(1,IRD2,IRD)=ILL
         DLKR(2,IRD2,IRD)=IRL
         DLKR(3,IRD2,IRD)=ICL
C-----SUM LENGTH AND LENGTH * FACTOR
         SUML=SUML+DLKR(4,IRD2,IRD)
         SUMLF=SUMLF+(DLKR(4,IRD2,IRD)*DLKR(5,IRD2,IRD))
       WRITE(22,402)ILL,IRL,ICL,DLKR(4,IRD2,IRD),DLKR(5,IRD2,IRD)
  402  FORMAT(I5,2I8,4F13.3)
   45    CONTINUE
C
C-------CHECK THAT TOTAL LENGTH SUMMED EQUALS TOTAL LENGTH ENTERED
C       AND WRITE ERROR MESSAGE IF THEY DO NOT MATCH - BUT CONTINUE PROGRAM
      DIFCAN=SUML-DLKS(3,IRD)
      IF(SUML.NE.DLKS(3,IRD))WRITE(23,305)IRD,IDLK(IRD),SUML,
     #                             DLKS(3,IRD),DIFCAN
  305 FORMAT(5X,I5,6X,A12,2X,3G15.8)
C
   50 CONTINUE
C
C
C-------------------------------------------------------------------------------
C-----READ DATA FROM IRRIGATED LAND FILE
      REWIND25
C
      WRITE(5,63)
      WRITE(27,63)
   63 FORMAT(//40('-')/' IRRIGATED LAND DATA'/40('-'))
      WRITE(5,67)
   67 FORMAT(/'     SEE IRRAGG.OUT')
C-------READ DUMMY LINES
      DO 66 IDUM=1,NHDNG2
      READ(25,64)HD2
      WRITE(97,64)HD2
   64 FORMAT(A1)
   66 CONTINUE
C
      WRITE(28,68)
   68 FORMAT('     SEQ. NO.     ID            AREA CALC.',
     #       '     TOTAL AREA    DIFFERENCE')
C
C-----READ NUMBER OF GRID CELLS, TOTAL ACRES, TOTAL ACRES*AFAC
```

```
      DO 70 IRD=1,NDA
      DVAC(1,IRD)=IRD
      READ (25,60)IDIL(IRD),NUMA,DVAC(3,IRD),DVAC(4,IRD)
   60 FORMAT(A12,I12,2F12.0)
      DVAC(2,IRD)=NUMA
C
      WRITE(27,412)
  412 FORMAT(/' IRR. LAND ID   SEQ NO.   NO. CELLS   ',
     #       'TOT ACRES  TOT AC*FAC')
C
      WRITE(27,392)IDIL(IRD),IRD,NUMA,DVAC(3,IRD),
     #            DVAC(4,IRD)
  392 FORMAT(A12,I8,I12,3X,2F11.2)
C
      WRITE(27,413)
  413 FORMAT('  LAYER   ROW   COLUMN   ACRES    FACTOR')
      SUMA=0
      SUMAF=0
C-----FOR THIS CANAL, READ LAYER, ROW, COLUMN, ACRES, FACTOR
         DO 65 IRD2=1,NUMA
         READ(25,62)ILA,IRA,ICA,CLAC(4,IRD2,IRD),CLAC(5,IRD2,IRD)
   62    FORMAT(3I12,2F12.0)
         CLAC(1,IRD2,IRD)=ILA
         CLAC(2,IRD2,IRD)=IRA
         CLAC(3,IRD2,IRD)=ICA
C
C-----IF AFAC=0, THEN MAKE AFAC=1
         IF(CLAC(5,IRD2,IRD).EQ.0.0)CLAC(5,IRD2,IRD)=1.0
C
C-----SUM LENGTH AND LENGTH * FACTOR
         SUMA=SUMA+CLAC(4,IRD2,IRD)
         SUMAF=SUMAF+(CLAC(4,IRD2,IRD)*CLAC(5,IRD2,IRD))
C
       WRITE(27,302)ILA,IRA,ICA,CLAC(4,IRD2,IRD),CLAC(5,IRD2,IRD),
     #       SUMA,SUMAF
  302  FORMAT(I5,2I8,4F9.2)
   65    CONTINUE
C
C-------CHECK THAT TOTAL ACRES SUMMED EQUALS TOTAL ACRES ENTERED
C       AND WRITE ERROR MESSAGE IF THEY DO NOT MATCH - BUT CONTINUE PROGRAM
C       CALCULATION OF DEEP PERCOLATIONS WILL USE SUMDAF
      DIFIRR=SUMA-DVAC(3,IRD)
      IF(SUMA.NE.DVAC(3,IRD))WRITE(28,315)IRD,IDIL(IRD),SUMA,
     #                           DVAC(3,IRD),DIFIRR
  315 FORMAT(5X,I5,6X,A12,2X,3G15.8)
   70    CONTINUE
C
C-----------------------------------------------------------------------
C-----READ DATA FROM WELL FILE
      REWIND40
C
      WRITE(5,163)
      WRITE(42,163)
  163 FORMAT(//40('-')/' WELL DATA'/' WELL CAPACITY IS IN GPM'/40('-'))
      WRITE(5,167)
  167 FORMAT(/'     SEE WELAGG.OUT')
C-------READ DUMMY LINES
      DO 166 IDUM=1,NHDNG3
      READ(40,164)HD3
  164 FORMAT(A1)
      WRITE(98,164)HD3
  166 CONTINUE
C
```

```
C-----INITIALIZE PARCEL COUNTER
      ICNTPA=0
C
C-----INITIALIZE WELL NUMBER
      ICNTWL=0
C
C-----BEGIN LOOP FOR EACH WELL
C-----READ WELL ID, NO. OF PARCELS, TOTAL ACRES, WEIGHTED TOTAL ACRES
      DO 170 IRD=1,NDW
      DVPW(1,IRD)=IRD
      READ (40,160)IDPW(IRD),NUMP,DVPW(3,IRD),WTACDV
  160 FORMAT(A12,I12,2F12.0)
      DVPW(2,IRD)=NUMP
      DVPW(4,IRD)=WTACDV
C
      WRITE(42,1198)
 1198 FORMAT(/'   DIV ID     NO. PAR.       TOT ACRES       ',
     #       'WTED TOT ACS')
      WRITE(42,1197)IDPW(IRD),NUMP,DVPW(3,IRD),WTACDV
 1197 FORMAT(A12,I5,6X,2F15.3)
C
      WRITE(42,1196)
 1196 FORMAT(/'  PARCEL ID   NO. WELLS      TOT ACRES       ',
     #       'WTED ACRES     PROPORTION OF AREA  SPRINKLER (1)')
C
C-----FOR EACH PARCEL ASSOCIATED WITH THIS WELL, READ PARCEL ID
C     NUMBER OF WELLS, TOTAL ACRES, WEIGHTED ACRES
         DO 165 IRD2=1,NUMP
         ICNTPA=ICNTPA+1
         DVPA(1,ICNTPA)=IRD2
         READ(40,162)IDPA(ICNTPA),NUMW,DVPA(3,ICNTPA),WTACPA,ISPRNK
  162    FORMAT(A12,I12,2F12.0,I12)
C
         DVPA(2,ICNTPA)=NUMW
         DVPA(4,ICNTPA)=WTACPA
         DVPA(7,ICNTPA)=ISPRNK
C
C-----CALCULATE PROPORTION OF AREA FOR THIS PARCEL TO TOTAL ACRES
         PROPPA=WTACPA/WTACDV
C
C-----STORE PROPORTION IN ARRAY
         DVPA(5,ICNTPA)=PROPPA
C
      WRITE(42,1195)IDPA(ICNTPA),NUMW,DVPA(3,ICNTPA),WTACPA,PROPPA,
     #ISPRNK
 1195 FORMAT(A12,I5,7X,2F15.3,5X,F15.3,I12)
C
C------FOR EACH WELL ASSOCIATED WITH THIS PARCEL, READ LAYER, ROW, COLUMN
C      CAPACITY, YEAR
C      ALSO CALCULATE PROPORTION EACH WELL CAN PUMP FOR THIS PARCEL
C
      WRITE(42,1194)
 1194 FORMAT('   LAY  ROW  COL  CAPACITY    YEAR')
C
         SUMCAP=0
         DO 180 IRD3=1,NUMW
C
C-----INCREMENT ICNTWL
         ICNTWL=ICNTWL+1
         READ(40,168)ILW,IRW,ICW,WLCAP,IWLYR
  168    FORMAT(3I12,F12.0,I12)
C
C-----CONVERT WELL CAPACITY TO FT/D
```

```
         CAPFTD=WLCAP*.1337*60*24
C
C-----SUM WELL CAPACITY
         SUMCAP=SUMCAP+CAPFTD
         DVWL(1,ICNTWL)=ILW
         DVWL(2,ICNTWL)=IRW
         DVWL(3,ICNTWL)=ICW
         DVWL(4,ICNTWL)=WLCAP
         DVWL(5,ICNTWL)=IWLYR
C
      WRITE(42,1193)ILW,IRW,ICW,WLCAP,IWLYR
 1193 FORMAT(3I5,F11.1,I8)
C        IF THE WELL YEAR IS MISSING, MAKE WELL YEAR=1960
         IF(IWLYR.EQ.0)DVWL(5,ICNTWL)=1960.
  180    CONTINUE
C
C-----STORE TOTAL WELL CAPACITY FOR THIS PARCEL IN DVPA ARRAY
         DVPA(6,ICNTPA)=SUMCAP
C
  165    CONTINUE
  170    CONTINUE

C-------------------------------------------------------------------------------
C-----READ DATA FROM IRRIGATED CROP FILE
      REWIND50
C
      WRITE(5,363)
      WRITE(24,363)
  363 FORMAT(//40('-')/' IRRIGATED CROP DATA'/40('-'))
      WRITE(5,367)
  367 FORMAT(/'     SEE IRMAGG.OUT')
C-------READ DUMMY LINES
      DO 366 IDUM=1,NHDNG4
      READ(50,364)HD4
      WRITE(99,364)HD4
  364 FORMAT(A1)
  366 CONTINUE
C
      WRITE(24,368)
  368 FORMAT('     SEQ. NO.     ID            AREA CALC.',
     #       '     TOTAL AREA    DIFFERENCE')
C
C-----READ NUMBER OF GRID CELLS, TOTAL ACRES, TOTAL ACRES*AFAC
      DO 370 IRD=1,NDM
      DVIM(1,IRD)=IRD
      READ (50,360)IDIM(IRD),NUMM,DVIM(3,IRD),DVIM(4,IRD)
  360 FORMAT(A12,I12,2F12.0)
      DVIM(2,IRD)=NUMM
C
      WRITE(43,1412)
 1412 FORMAT(/' IRR. MEADOW ID   SEQ NO.   NO. CELLS   ',
     #       'TOT ACRES  TOT AC*FAC')
C
      WRITE(43,1392)IDIM(IRD),IRD,NUMM,DVIM(3,IRD),
     #            DVIM(4,IRD)
 1392 FORMAT(A12,I8,I12,3X,2F11.2)
C
      WRITE(43,1413)
 1413 FORMAT('  LAYER   ROW   COLUMN   ACRES    FACTOR')
      SUMA=0
      SUMAF=0
C-----FOR THIS STRUCTURE, READ LAYER, ROW, COLUMN, ACRES, FACTOR
         DO 365 IRD2=1,NUMM
```

```
         READ(50,362)ILA,IRA,ICA,CLIM(4,IRD2,IRD),CLIM(5,IRD2,IRD)
  362    FORMAT(3I12,2F12.0)
         CLIM(1,IRD2,IRD)=ILA
         CLIM(2,IRD2,IRD)=IRA
         CLIM(3,IRD2,IRD)=ICA
C
C-----IF AFAC=0, THEN MAKE AFAC=1
         IF(CLIM(5,IRD2,IRD).EQ.0.0)CLIM(5,IRD2,IRD)=1.0
C
C-----SUM LENGTH AND LENGTH * FACTOR
         SUMA=SUMA+CLIM(4,IRD2,IRD)
         SUMAF=SUMAF+(CLIM(4,IRD2,IRD)*CLIM(5,IRD2,IRD))
C
       WRITE(43,1302)ILA,IRA,ICA,CLIM(4,IRD2,IRD),CLIM(5,IRD2,IRD),
     #       SUMA,SUMAF
 1302  FORMAT(I5,2I8,4F9.2)
  365    CONTINUE
C
C-------CHECK THAT TOTAL ACRES SUMMED EQUALS TOTAL ACRES ENTERED
C       AND WRITE ERROR MESSAGE IF THEY DO NOT MATCH - BUT CONTINUE PROGRAM
C       CALCULATION OF DEEP PERCOLATIONS WILL USE SUMDAF
      DIFIRR=SUMA-DVIM(3,IRD)
      IF(SUMA.NE.DVIM(3,IRD))WRITE(24,1315)IRD,IDIM(IRD),SUMA,
     #                             DVIM(3,IRD),DIFIRR
 1315 FORMAT(5X,I5,6X,A12,2X,3G15.8)
  370    CONTINUE
C
      RETURN
      END
C
C*******************************************************************************
      SUBROUTINE CMPRAG(NDL,NDVR,NDA,NDVA,NDW,NDPA,NDWL,IDLK,DLKS,
     #                DLKR,IDIL,DVAC,CLAC,IDPW,DVPW,IDPA,DVPA,
     #                DVWL,NHDNG1,NHDNG2,NHDNG3,NPLN,NURF,NAGG,
     #                NAGS,PLAN,URFS,AGGR,AGST,NAST,NDM,NDVM,DVIM,
     #                CLIM,IDIM)
C
C-----THIS SUBROUTINE CHECKS TO SEE IF CU DATA HAS
C     DATA NOT INCLUDED IN FILES PRODUCED FROM GIS
C
      INTEGER NAST(NAGG)
C
      DIMENSION DLKS(4,NDL),DLKR(5,NDVR,NDL),DVAC(4,NDA),
     #          CLAC(5,NDVA,NDA),DVPW(4,NDW),DVPA(7,NDPA),
     #          DVWL(5,NDWL),DVIM(4,NDM),CLIM(4,NDVM,NDM)
C
      CHARACTER*12 IDLK(NDL),IDIL(NDA),IDPW(NDW),IDPA(NDPA),
     #             PLAN(NPLN),URFS(NURF),AGGR(NAGG),
     #             AGST(NAGS),IDIM(NDM)
C
      WRITE(5,50)
   50 FORMAT(//40('-')/' CHECK FOR MATCHING IDS'/40('-'))
      WRITE(5,52)
   52 FORMAT(/' SEE RESULTS IN THE FOLLOWING FILES:'/' NMCAN.DAT FOR',
     #        ' COMPARING TO CANAL FILE'/' NMIRR.DAT FOR',
     #        ' COMPARING TO IRRIGATED LAND FILE'/' NMWEL.DAT FOR',
     #        ' COMPARING TO IRRIGATION WELL FILE'/' NMIRM.DAT FOR',
     #        ' COMPARING TO THE IRRIGATED CROPW FILE')
C
C-------------------------------------------------------------------------------
C-----COMPARE DATA TO WDID.DAT FILE
C
      WRITE(70,60)
```

```
      WRITE(80,60)
      WRITE(90,60)
      WRITE(92,60)
   60 FORMAT(/' CHECKING WDID.DAT FILE')
C
C-----INITIALIZE COUNTERS
      NPLCAN=0
      NPLIRR=0
      NPLWEL=0
      NPLIRM=0
C
C-----BEGIN OUTER LOOP FOR EACH STRUCTURE LISTED IN WDID.DAT FILE
      DO 100 IPLN=1,NPLN
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE CANAL FILE
      DO 70 IDL=1,NDL
C
C-----COMPARE IDS
      IF(IDLK(IDL).EQ.PLAN(IPLN))GO TO 75
   70 CONTINUE
C
C-----IF YOU ARE HERE, THERE WAS NO MATCH
      WRITE(70,55)PLAN(IPLN)
   55 FORMAT('IN THE CANAL FILE THERE WAS NO MATCH FOR ', A12)
      NPLCAN=NPLCAN+1
   75 CONTINUE
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATED LANDS FILE
      DO 80 IDA=1,NDA
C-----COMPARE IDS
      IF(IDIL(IDA).EQ.PLAN(IPLN))GO TO 85
   80 CONTINUE
C
C-----IF YOU ARE HERE, THERE WAS NO MATCH
      WRITE(80,45)PLAN(IPLN)
   45 FORMAT('IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR ', A12)
      NPLIRR=NPLIRR+1
   85 CONTINUE
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATION WELL FILE
      DO 90 IDW=1,NDW
C-----COMPARE IDS
      IF(IDPW(IDW).EQ.PLAN(IPLN))GO TO 95
   90 CONTINUE
C
C-----IF YOU ARE HERE, THERE WAS NO MATCH
      WRITE(90,35)PLAN(IPLN)
   35 FORMAT('IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR ', A12)
      NPLWEL=NPLWEL+1
   95 CONTINUE
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATED CROP FILE
      DO 180 IDM=1,NDM
C-----COMPARE IDS
      IF(IDIM(IDM).EQ.PLAN(IPLN))GO TO 185
  180 CONTINUE
C
C-----IF YOU ARE HERE, THERE WAS NO MATCH
      WRITE(92,145)PLAN(IPLN)
  145 FORMAT('IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR ',
     #        A12)
      NPLIRM=NPLIRM+1
  185 CONTINUE
```

```
C
  100 CONTINUE
C
      WRITE(70,105)NPLCAN,NPLN
      WRITE(80,105)NPLIRR,NPLN
      WRITE(90,105)NPLWEL,NPLN
      WRITE(92,105)NPLIRM,NPLN
  105 FORMAT(/'NUMBER OF STRUCTURE IDS NOT MATCHED =',I5,' OUT OF',I5)
C
C-----------------------------------------------------------------------
C-----COMPARE DATA TO URF.DAT FILE
C
      WRITE(80,260)
      WRITE(90,260)
  260 FORMAT(/' CHECKING URF.DAT FILE')
C
C-----INITIALIZE COUNTERS
      NGWIRR=0
      NGWWEL=0
C
C-----BEGIN OUTER LOOP FOR EACH STRUCTURE LISTED IN URF.DAT FILE
      DO 300 IURF=1,NURF
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATED LANDS FILE
      DO 380 IDA=1,NDA
C-----COMPARE IDS
      IF(IDIL(IDA).EQ.URFS(IURF))GO TO 385
  380 CONTINUE
C
C-----IF YOU ARE HERE, THERE WAS NO MATCH
      WRITE(80,345)URFS(IURF)
  345 FORMAT('IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR ', A12)
      NGWIRR=NGWIRR+1
  385 CONTINUE
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN IRRIGATION WELL FILE
      DO 290 IDW=1,NDW
C-----COMPARE IDS
      IF(IDPW(IDW).EQ.URFS(IURF))GO TO 295
  290 CONTINUE
C
C-----IF YOU ARE HERE, THERE WAS NO MATCH
      WRITE(90,235)URFS(IURF)
  235 FORMAT('IN IRRIGATION WELL FILE THERE WAS NO MATCH FOR ', A12)
      NGWWEL=NGWWEL+1
  295 CONTINUE
C
  300 CONTINUE
C
      WRITE(80,305)NGWIRR,NURF
      WRITE(90,305)NGWWEL,NURF
  305 FORMAT(/'NUMBER OF STRUCTURES NOT MATCHED =',I5,' OUT OF',I5)
C
C-----------------------------------------------------------------------
C-----COMPARE DATA TO AGG.DAT FILE
C
      WRITE(70,360)
      WRITE(80,360)
      WRITE(90,360)
      WRITE(92,360)
  360 FORMAT(/' CHECKING AGG.DAT FILE'/)
C
C-----INITIALIZE COUNTERS
```

```
      NAGCAN=0
      NAGIRR=0
      NAGWEL=0
      NAGIRM=0
C
C-----INITIALIZE COUNTER
      ICNT=0
C
C-----BEGIN OUTER LOOP FOR EACH STRUCTURE LISTED IN AGG.DAT FILE
      DO 400 IAGG=1,NAGG
      NUMAG=NAST(IAGG)
      WRITE(70,362)IAGG,AGGR(IAGG),NUMAG
      WRITE(80,362)IAGG,AGGR(IAGG),NUMAG
      WRITE(90,362)IAGG,AGGR(IAGG),NUMAG
      WRITE(92,362)IAGG,AGGR(IAGG),NUMAG
  362 FORMAT('SEQ. NO.=',I5,' AGG. ID=',A12,' NO. AGGS=',I3)
C
C-----BEGIN LOOP FOR EACH WDID LISTED UNDER THIS AGG ID
C
      DO 399 IAS=1,NUMAG
C-----INCREMENT COUNTER
      ICNT=ICNT+1
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE CANAL FILE
      DO 370 IDL=1,NDL
C
C-----COMPARE IDS
      IF(IDLK(IDL).EQ.AGST(ICNT))GO TO 376
  370 CONTINUE
C
C-----IF YOU ARE HERE, THERE WAS NO MATCH
      WRITE(70,355)AGST(ICNT)
  355 FORMAT('IN RGDSS.CAN THERE WAS NO MATCH FOR ', A12)
C    #       '  AGG. STRUCTURE WDID ',A12)
      NAGCAN=NAGCAN+1
      GO TO 376
  376 CONTINUE
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATED LANDS FILE
      DO 480 IDA=1,NDA
C-----COMPARE IDS
      IF(IDIL(IDA).EQ.AGST(ICNT))GO TO 485
  480 CONTINUE
C
C-----IF YOU ARE HERE, THERE WAS NO MATCH
      WRITE(80,445)AGST(ICNT)
  445 FORMAT('IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR ', A12)
      NAGIRR=NAGIRR+1
  485 CONTINUE
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATED CROP FILE
      DO 580 IDM=1,NDM
C-----COMPARE IDS
      IF(IDIM(IDM).EQ.AGST(ICNT))GO TO 585
  580 CONTINUE
C
C-----IF YOU ARE HERE, THERE WAS NO MATCH
      WRITE(92,545)AGST(ICNT)
  545 FORMAT('IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR ',
     #       A12)
      NAGIRM=NAGIRM+1
  585 CONTINUE
C
```

```
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATION WELL FILE
      DO 390 IDW=1,NDW
C-----COMPARE IDS
      IF(IDPW(IDW).EQ.AGST(ICNT))GO TO 395
  390 CONTINUE
C
C-----IF YOU ARE HERE, THERE WAS NO MATCH
      WRITE(90,335)AGST(ICNT)
  335 FORMAT('IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR ', A12)
      NAGWEL=NAGWEL+1
  395 CONTINUE
C
  399 CONTINUE
  400 CONTINUE
      WRITE(70,405)NAGCAN,NAGS
      WRITE(80,405)NAGIRR,NAGS
      WRITE(90,405)NAGWEL,NAGS
      WRITE(92,405)NAGIRM,NAGS
  405 FORMAT(/'NUMBER OF STRUCTURES NOT MATCHED =',I5,' OUT OF',I5)
C
      RETURN
      END
C*******************************************************************************
      SUBROUTINE COMBINE(NDL,NDVR,NDA,NDVA,NDW,NDPA,NDWL,IDLK,DLKS,
     #                DLKR,IDIL,DVAC,CLAC,IDPW,DVPW,IDPA,DVPA,
     #                DVWL,NHDNG1,NHDNG2,NHDNG3,NPLN,NURF,NAGG,
     #                NAGS,PLAN,URFS,AGGR,AGST,NAST,AGCN,AGIR,
     #                AGWL,NDM,NDVM,DVIM,CLIM,IDIM,AGIM)
C
C-----THIS SUBROUTINE AGGREGATES DATA AND ASSIGNS A MS STRUCTURE ID
C
      INTEGER NAST(NAGG)
C
      DIMENSION DLKS(4,NDL),DLKR(5,NDVR,NDL),DVAC(4,NDA),
     #          CLAC(5,NDVA,NDA),DVPW(4,NDW),DVPA(7,NDPA),
     #          DVWL(5,NDWL),AGCN(3,NAGG),AGIR(3,NAGG),AGWL(3,NAGG),
     #          DVIM(4,NDM),CLIM(5,NDVM,NDM),AGIM(3,NAGG)
C
      CHARACTER*12 IDLK(NDL),IDIL(NDA),IDPW(NDW),IDPA(NDPA),
     #             PLAN(NPLN),URFS(NURF),AGGR(NAGG),
     #             AGST(NAGS),IDIM(NDM)
C
C-----AGGREGATE DATA FOR CANAL, IRRIGATED LANDS, IRRIGATED CROP AND
C     IRRIGATION WELL FILES
C
C-----INITIALIZE ICOUNT
      ICOUNT=0
C
C-----BEGIN LOOP FOR EACH MULTIPLE STRUCTURE
      DO 100 IAGG=1,NAGG
C
C-----GET NUMBER OF WDIDS FOR THIS MULTIPLE STRUCTURE
      NUMAG=NAST(IAGG)
C
C-----BEGIN LOOP FOR EACH WDID LISTED UNDER THE MULTIPLE STRUCTURE
      DO 90 IAST=1,NUMAG
      ICOUNT=ICOUNT+1
C
C-----GO THROUGH CANAL FILE DATA TO FIND A MATCH
      DO 60 IDL=1,NDL
C
C-----CHECK TO SEE IF THERE IS A MATCH - IF YES, SUM THE CELLS AND LENGTHS
      IF(IDLK(IDL).EQ.AGST(ICOUNT))THEN
```

```
  227 CONTINUE
        AGCN(1,IAGG)=AGCN(1,IAGG)+DLKS(2,IDL)
        AGCN(2,IAGG)=AGCN(2,IAGG)+DLKS(3,IDL)
        AGCN(3,IAGG)=AGCN(3,IAGG)+DLKS(4,IDL)
      ENDIF
   60 CONTINUE

C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATED LANDS FILE
C-----GO THROUGH IRRIGATED LANDS DATA TO FIND A MATCH
      DO 70 IDA=1,NDA
C
C-----CHECK TO SEE IF THERE IS A MATCH - IF YES, SUM THE CELLS AND LENGTHS
      IF(IDIL(IDA).EQ.AGST(ICOUNT))THEN
      AGIR(1,IAGG)=AGIR(1,IAGG)+DVAC(2,IDA)
      AGIR(2,IAGG)=AGIR(2,IAGG)+DVAC(3,IDA)
      AGIR(3,IAGG)=AGIR(3,IAGG)+DVAC(4,IDA)
      ENDIF
   70 CONTINUE

C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATED CROP FILE
C-----GO THROUGH IRRIGATED CROP DATA TO FIND A MATCH
      DO 170 IDM=1,NDM
C
C-----CHECK TO SEE IF THERE IS A MATCH - IF YES, SUM THE CELLS AND LENGTHS
      IF(IDIM(IDM).EQ.AGST(ICOUNT))THEN
      AGIM(1,IAGG)=AGIM(1,IAGG)+DVIM(2,IDM)
      AGIM(2,IAGG)=AGIM(2,IAGG)+DVIM(3,IDM)
      AGIM(3,IAGG)=AGIM(3,IAGG)+DVIM(4,IDM)
      ENDIF
  170 CONTINUE
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN IRRIGATION WELL FILE
C-----GO THROUGH IRRIGATION WELL DATA TO FIND A MATCH
      DO 80 IDW=1,NDW
C
C-----CHECK TO SEE IF THERE IS A MATCH - IF YES, SUM THE CELLS AND LENGTHS
      IF(IDPW(IDW).EQ.AGST(ICOUNT))THEN
      AGWL(1,IAGG)=AGWL(1,IAGG)+DVPW(2,IDW)
      AGWL(2,IAGG)=AGWL(2,IAGG)+DVPW(3,IDW)
      AGWL(3,IAGG)=AGWL(3,IAGG)+DVPW(4,IDW)
      ENDIF
   80 CONTINUE
C
   90 CONTINUE
  100 CONTINUE
      RETURN
      END
C***************************************************************************
      SUBROUTINE WRITEFL(NDL,NDVR,NDA,NDVA,NDW,NDPA,NDWL,IDLK,DLKS,
     #                DLKR,IDIL,DVAC,CLAC,IDPW,DVPW,IDPA,DVPA,
     #                DVWL,NHDNG1,NHDNG2,NHDNG3,NPLN,NURF,NAGG,
     #                NAGS,PLAN,URFS,AGGR,AGST,NAST,AGCN,AGIR,
     #                AGWL,NDM,NDVM,IDIM,DVIM,CLIM,AGIM,NDHNG4)
C
C-----THIS SUBROUTINE WRITES DATA TO NEW FILE NAME
C
      INTEGER NAST(NAGG)
C
      DIMENSION DLKS(4,NDL),DLKR(5,NDVR,NDL),DVAC(4,NDA),
     #          CLAC(5,NDVA,NDA),DVPW(4,NDW),DVPA(7,NDPA),
     #          DVWL(5,NDWL),AGCN(3,NAGG),AGIR(3,NAGG),
```

```
     #          AGWL(3,NAGG),DVIM(4,NDM),CLIM(5,NDVM,NDM),
     #          AGIM(3,NAGG)
C
      CHARACTER*12 IDLK(NDL),IDIL(NDA),IDPW(NDW),IDPA(NDPA),
     #             PLAN(NPLN),URFS(NURF),AGGR(NAGG),
     #             AGST(NAGS),IDIM(NDM)
C
C-------------------------------------------------------------------------------
C-----WRITE DATA THAT MATCH WDIDS
C
C-----BEGIN OUTER LOOP FOR EACH STRUCTURE LISTED IN WDID.DAT FILE
      DO 200 IPLN=1,NPLN
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN CANAL FILE
      DO 70 IDL=1,NDL
C
C-----COMPARE IDS - IF IDS MATCH, WRITE DATA TO OUTPUT FILE
      IF(IDLK(IDL).EQ.PLAN(IPLN))THEN
         NUMR=DLKS(2,IDL)
         WRITE(96,40)IDLK(IDL),NUMR,DLKS(3,IDL),DLKS(4,IDL)
   40    FORMAT(A12,I12,2G12.5)
C
C-----FOR THIS CANAL, WRITE LAYER, ROW, COLUMN, LENGTH, FACTOR
         DO 45 IDL2=1,NUMR
           ILL=DLKR(1,IDL2,IDL)
           IRL=DLKR(2,IDL2,IDL)
           ICL=DLKR(3,IDL2,IDL)
           WRITE(96,42)ILL,IRL,ICL,DLKR(4,IDL2,IDL),DLKR(5,IDL2,IDL)
   42      FORMAT(3I12,2G12.6)
   45    CONTINUE
      ENDIF
   70 CONTINUE
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATED LANDS FILE
      DO 80 IDR=1,NDA
C
C-----COMPARE IDS - IF IDS MATCH, WRITE DATA TO OUTPUT FILE
      IF(IDIL(IDR).EQ.PLAN(IPLN))THEN
         NUMA=DVAC(2,IDR)
         WRITE(97,60)IDIL(IDR),NUMA,DVAC(3,IDR),DVAC(4,IDR)
   60    FORMAT(A12,I12,2G12.6)
C
C-----FOR THIS STRUCTURE, WRITE LAYER, ROW, COLUMN, ACRES, FACTOR
         DO 65 IDR2=1,NUMA
           ILA=CLAC(1,IDR2,IDR)
           IRA=CLAC(2,IDR2,IDR)
           ICA=CLAC(3,IDR2,IDR)
           WRITE(97,62)ILA,IRA,ICA,CLAC(4,IDR2,IDR),CLAC(5,IDR2,IDR)
   62      FORMAT(3I12,2G12.6)
   65    CONTINUE
      ENDIF
   80 CONTINUE

C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATED CROP FILE
      DO 810 IDM=1,NDM
C
C-----COMPARE IDS - IF IDS MATCH, WRITE DATA TO OUTPUT FILE
      IF(IDIM(IDM).EQ.PLAN(IPLN))THEN
         NUMM=DVIM(2,IDM)
         WRITE(99,801)IDIM(IDM),NUMM,DVIM(3,IDM),DVIM(4,IDM)
  801    FORMAT(A12,I12,2G12.6)
C
C-----FOR THIS STRUCTURE, WRITE LAYER, ROW, COLUMN, ACRES, FACTOR
```

```
         DO 805 IDM2=1,NUMM
           ILM=CLIM(1,IDM2,IDM)
           IRM=CLIM(2,IDM2,IDM)
           ICM=CLIM(3,IDM2,IDM)
           WRITE(99,806)ILM,IRM,ICM,CLIM(4,IDM2,IDM),CLIM(5,IDM2,IDM)
  806      FORMAT(3I12,2G12.6)
  805    CONTINUE
      ENDIF
  810 CONTINUE
C
C-----INITIALIZE PARCEL COUNTER
      ICNTPA=0
C
C-----INITIALIZE WELL NUMBER
      ICNTWL=0
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATION WELL FILE
      DO 160 IWL=1,NDW
      IF(IDPW(IWL).EQ.PLAN(IPLN))THEN
         NUMP=DVPW(2,IWL)
         WRITE(98,90)IDPW(IWL),NUMP,DVPW(3,IWL),DVPW(4,IWL)
   90    FORMAT(A12,I12,2G12.6)
           DO 110 IWL2=1,NUMP
           ICNTPA=ICNTPA+1
           NUMW=DVPA(2,ICNTPA)
           ISPRNK=DVPA(7,ICNTPA)
           WRITE(98,95)IDPA(ICNTPA),NUMW,DVPA(3,ICNTPA),DVPA(4,ICNTPA),
     #                 ISPRNK
   95      FORMAT(A12,I12,2G12.6,I12)
             DO 100 IWL3=1,NUMW
             ICNTWL=ICNTWL+1
              ILW=DVWL(1,ICNTWL)
              IRW=DVWL(2,ICNTWL)
              ICW=DVWL(3,ICNTWL)
              IWLYR=DVWL(5,ICNTWL)
             WRITE(98,96)ILW,IRW,ICW,DVWL(4,ICNTWL),IWLYR
   96        FORMAT(3I12,G12.6,I12)
  100        CONTINUE
  110      CONTINUE
         GO TO 200
      ELSE
C
C-----IF THERE IS NO MATCH, NEED TO INCREMENT ICNTPA AND ICNTWL
         NUMP=DVPW(2,IWL)
         DO 130 IWL4=1,NUMP
         ICNTPA=ICNTPA+1
         NUMW=DVPA(2,ICNTPA)
           DO 120 IWL5=1,NUMW
           ICNTWL=ICNTWL+1
  120      CONTINUE
  130    CONTINUE
      ENDIF
C
C-----END OF WELL LOOP
  160 CONTINUE
C
C-----END OF IPLAN LOOP
  200 CONTINUE
C
C----------------------------------------------------------------------------
C-----WRITE DATA THAT MATCH URF STRUCTURE IDS
C
C-----BEGIN OUTER LOOP FOR EACH URF STRUCTURE IN THE URF.DAT FILE
```

```
      DO 400 IURF=1,NURF
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATED LANDS FILE
      DO 280 IDR=1,NDA
C
C-----COMPARE IDS - IF IDS MATCH, WRITE DATA TO OUTPUT FILE
      IF(IDIL(IDR).EQ.URFS(IURF))THEN
         NUMA=DVAC(2,IDR)
         WRITE(97,60)IDIL(IDR),NUMA,DVAC(3,IDR),DVAC(4,IDR)
C
C-----FOR THIS STRUCTURE, WRITE LAYER, ROW, COLUMN, ACRES, FACTOR
         DO 265 IDR2=1,NUMA
           ILA=CLAC(1,IDR2,IDR)
           IRA=CLAC(2,IDR2,IDR)
           ICA=CLAC(3,IDR2,IDR)
           WRITE(97,62)ILA,IRA,ICA,CLAC(4,IDR2,IDR),CLAC(5,IDR2,IDR)
  265    CONTINUE
      ENDIF
  280 CONTINUE
C
C-----INITIALIZE PARCEL COUNTER
      ICNTPA=0
C
C-----INITIALIZE WELL NUMBER
      ICNTWL=0
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATION WELL FILE
      DO 360 IWL=1,NDW
      IF(IDPW(IWL).EQ.URFS(IURF))THEN
         NUMP=DVPW(2,IWL)
         WRITE(98,90)IDPW(IWL),NUMP,DVPW(3,IWL),DVPW(4,IWL)
           DO 235 IWL2=1,NUMP
           ICNTPA=ICNTPA+1
           NUMW=DVPA(2,ICNTPA)
           ISPRNK=DVPA(7,ICNTPA)
           WRITE(98,95)IDPA(ICNTPA),NUMW,DVPA(3,ICNTPA),DVPA(4,ICNTPA),
     #     ISPRNK
             DO 225 IWL3=1,NUMW
             ICNTWL=ICNTWL+1
              ILW=DVWL(1,ICNTWL)
              IRW=DVWL(2,ICNTWL)
              ICW=DVWL(3,ICNTWL)
              IWLYR=DVWL(5,ICNTWL)
             WRITE(98,96)ILW,IRW,ICW,DVWL(4,ICNTWL),IWLYR
  225        CONTINUE
  235      CONTINUE
         GO TO 400
      ELSE
C
C-----IF THERE IS NO MATCH, NEED TO INCREMENT ICNTPA AND ICNTWL
         NUMP=DVPW(2,IWL)
         DO 330 IWL4=1,NUMP
         ICNTPA=ICNTPA+1
         NUMW=DVPA(2,ICNTPA)
           DO 320 IWL5=1,NUMW
           ICNTWL=ICNTWL+1
  320      CONTINUE
  330    CONTINUE
      ENDIF
C
C-----END OF WELL LOOP
  360 CONTINUE
C
```

```
C-----END OF URF LOOP
  400 CONTINUE
C
C-------------------------------------------------------------------------------
C-----WRITE AGGREGATE STRUCTURES FOR CANALS
C
C
C-----INITIALIZE ICOUNT
      ICOUNT=0
C
C-----BEGIN OUTER LOOP FOR EACH AGGREGATE ID FOR THE CANAL DATA
      DO 500 IAGG=1,NAGG
C
C-----CHECK IF THERE WERE ANY MATCHES FOR THE WDID ASSOCIATED WITH THIS
C     STRUCTURE - IF NUMCAN=0, THEN THERE WERE NO MATCHES
      NUMCAN=AGCN(1,IAGG)
C
C-----IF THERE ARE NO CELLS ASSOCIATED WITH THIS STRUCTURE, SKIP IT
      IF(NUMCAN.EQ.0)GO TO 460
C
C-----WRITE INFORMATION ABOUT FIRST AGGREGATE STRUCTURE
      WRITE(96,410)AGGR(IAGG),NUMCAN,AGCN(2,IAGG),AGCN(3,IAGG)
  410 FORMAT(A12,I12,2G12.6)
C
C-----GET NUMBER OF WDIDS ASSOCIATED WITH THIS AGGREGATE
      NUMAG=NAST(IAGG)
C
C-----GO THROUGH EACH WDID LISTED FOR THIS STRUCTURE
      DO 450 I=1,NUMAG
C
C-----INCREMENT ICOUNT
      ICOUNT=ICOUNT+1
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE CANAL FILE
      DO 440 IDL=1,NDL
C
C-----COMPARE IDS - IF IDS MATCH, GET CELL DATA
      IF(IDLK(IDL).EQ.AGST(ICOUNT))THEN
         NUMR=DLKS(2,IDL)
C
C-----WRITE LAYER, ROW, COLUMN, LENGTH, FACTOR
         DO 430 IDL2=1,NUMR
           ILL=DLKR(1,IDL2,IDL)
           IRL=DLKR(2,IDL2,IDL)
           ICL=DLKR(3,IDL2,IDL)
           WRITE(96,42)ILL,IRL,ICL,DLKR(4,IDL2,IDL),DLKR(5,IDL2,IDL)
  430    CONTINUE
      ENDIF
  440 CONTINUE
  450 CONTINUE
C
C-----GO PAST THE NEXT DO LOOP
      GO TO 500
C
C-----IF YOU ARE HERE, THERE WERE NO MATCHING WDIDS FOR THIS AGGREGATE
C     INCREMENT ICOUNT
  460 NUMAG=NAST(IAGG)
      DO 470 I=1,NUMAG
      ICOUNT=ICOUNT+1
  470 CONTINUE
  500 CONTINUE
C-------------------------------------------------------------------------------
C-----WRITE AGGREGATE STRUCTURES FOR IRRIGATED LANDS
```

```
C
C-----INITIALIZE ICOUNT
      ICOUNT=0
C
C-----BEGIN OUTER LOOP FOR EACH AGGREGATE ID FOR RGDSS.IRR DATA
      DO 600 IAGG=1,NAGG
C
C-----CHECK IF THERE WERE ANY MATCHES FOR THE WDID ASSOCIATED WITH THIS
C     STRUCTURE - IF NUMIRR=0, THEN THERE WERE NO MATCHES
      NUMIRR=AGIR(1,IAGG)
C
C-----IF THERE ARE NO CELLS ASSOCIATED WITH THIS STRUCTURE, SKIP IT
      IF(NUMIRR.EQ.0)GO TO 560
C
C-----WRITE INFORMATION ABOUT FIRST AGGREGATE STRUCTURE
      WRITE(97,510)AGGR(IAGG),NUMIRR,AGIR(2,IAGG),AGIR(3,IAGG)
  510 FORMAT(A12,I12,2G12.6)
C
C-----GET NUMBER OF WDIDS ASSOCIATED WITH THIS AGGREGATE
      NUMAG=NAST(IAGG)
C
C-----GO THROUGH EACH WDID LISTED FOR THIS STRUCTURE
      DO 550 I=1,NUMAG
C
C-----INCREMENT ICOUNT
      ICOUNT=ICOUNT+1
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE CANAL FILE
      DO 540 IDA=1,NDA
C
C-----COMPARE IDS - IF IDS MATCH, GET CELL DATA
      IF(IDIL(IDA).EQ.AGST(ICOUNT))THEN
         NUMA=DVAC(2,IDA)
C
C-----WRITE LAYER, ROW, COLUMN, LENGTH, FACTOR
         DO 530 IDA2=1,NUMA
           ILL=CLAC(1,IDA2,IDA)
           IRL=CLAC(2,IDA2,IDA)
           ICL=CLAC(3,IDA2,IDA)
           WRITE(97,42)ILL,IRL,ICL,CLAC(4,IDA2,IDA),CLAC(5,IDA2,IDA)
  530    CONTINUE
      ENDIF
  540 CONTINUE
  550 CONTINUE
C
C-----GO PAST THE NEXT DO LOOP
      GO TO 600
C
C-----IF YOU ARE HERE, THERE WERE NO MATCHING WDIDS FOR THIS AGGREGATE
C     INCREMENT ICOUNT
  560 NUMAG=NAST(IAGG)
      DO 570 I=1,NUMAG
      ICOUNT=ICOUNT+1
  570 CONTINUE
  600 CONTINUE
C
C-----------------------------------------------------------------------
C-----WRITE AGGREGATE STRUCTURES FOR IRRIGATED CROPS
C
C-----INITIALIZE ICOUNT
      ICOUNT=0
C
C-----BEGIN OUTER LOOP FOR EACH AGGREGATE ID FOR RGDSS.IRR DATA
```

```
      DO 850 IAGG=1,NAGG
C
C-----CHECK IF THERE WERE ANY MATCHES FOR THE WDID ASSOCIATED WITH THIS
C     STRUCTURE - IF NUMIRM=0, THEN THERE WERE NO MATCHES
      NUMIRM=AGIM(1,IAGG)
C
C-----IF THERE ARE NO CELLS ASSOCIATED WITH THIS STRUCTURE, SKIP IT
      IF(NUMIRM.EQ.0)GO TO 845
C
C-----WRITE INFORMATION ABOUT FIRST AGGREGATE STRUCTURE
      WRITE(99,825)AGGR(IAGG),NUMIRM,AGIM(2,IAGG),AGIM(3,IAGG)
  825 FORMAT(A12,I12,2G12.6)
C
C-----GET NUMBER OF WDIDS ASSOCIATED WITH THIS AGGREGATE
      NUMAG=NAST(IAGG)
C
C-----GO THROUGH EACH WDID LISTED FOR THIS STRUCTURE
      DO 840 I=1,NUMAG
C
C-----INCREMENT ICOUNT
      ICOUNT=ICOUNT+1
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE CANAL FILE
      DO 835 IDM=1,NDM
C
C-----COMPARE IDS - IF IDS MATCH, GET CELL DATA
      IF(IDIM(IDM).EQ.AGST(ICOUNT))THEN
         NUMM=DVIM(2,IDM)
C
C-----WRITE LAYER, ROW, COLUMN, LENGTH, FACTOR
         DO 830 IDM2=1,NUMM
           ILM=CLIM(1,IDM2,IDM)
           IRM=CLIM(2,IDM2,IDM)
           ICM=CLIM(3,IDM2,IDM)
           WRITE(99,42)ILM,IRM,ICM,CLIM(4,IDM2,IDM),CLIM(5,IDM2,IDM)
  830    CONTINUE
      ENDIF
  835 CONTINUE
  840 CONTINUE
C
C-----GO PAST THE NEXT DO LOOP
      GO TO 850
C
C-----IF YOU ARE HERE, THERE WERE NO MATCHING WDIDS FOR THIS AGGREGATE
C     INCREMENT ICOUNT
  845 NUMAG=NAST(IAGG)
      DO 846 I=1,NUMAG
      ICOUNT=ICOUNT+1
  846 CONTINUE
  850 CONTINUE
C
C-----------------------------------------------------------------------
C-----WRITE AGGREGATE STRUCTURES FOR IRRIGATION WELLS
C
C
C-----INITIALIZE ICOUNT
      ICOUNT=0
C
C-----BEGIN OUTER LOOP FOR EACH AGGREGATE ID FOR THE IRRIGATION WELL DATA
      DO 800 IAGG=1,NAGG
C
C-----CHECK IF THERE WERE ANY MATCHES FOR THE WDID ASSOCIATED WITH THIS
C     STRUCTURE - IF NUMPAR=0, THEN THERE WERE NO MATCHES
```

```
      NUMPAR=AGWL(1,IAGG)
C
C-----IF THERE ARE NO PARCELS ASSOCIATED WITH THIS STRUCTURE, SKIP IT
      IF(NUMPAR.EQ.0)GO TO 660
C
C-----WRITE INFORMATION ABOUT FIRST AGGREGATE STRUCTURE
      WRITE(98,610)AGGR(IAGG),NUMPAR,AGWL(2,IAGG),AGWL(3,IAGG)
  610 FORMAT(A12,I12,2G12.6)
C
C-----GET NUMBER OF WDIDS ASSOCIATED WITH THIS AGGREGATE
      NUMAG=NAST(IAGG)
C
C-----GO THROUGH EACH WDID LISTED FOR THIS STRUCTURE
      DO 650 I=1,NUMAG
C
C-----INCREMENT ICOUNT
      ICOUNT=ICOUNT+1
C
C-----INITIALIZE PARCEL COUNTER
      ICNTPA=0
C
C-----INITIALIZE WELL NUMBER
      ICNTWL=0
C
C-----BEGIN INNER LOOP FOR EACH STRUCTURE LISTED IN THE IRRIGATION WELL FILE
      DO 760 IWL=1,NDW
      IF(IDPW(IWL).EQ.AGST(ICOUNT))THEN
         NUMP=DVPW(2,IWL)
C
C-----NOTE:THE ABOVE LINE IS WRITTEN IN PLACE OF LINE BELOW
C
           DO 710 IWL2=1,NUMP
           ICNTPA=ICNTPA+1
           NUMW=DVPA(2,ICNTPA)
           ISPRNK=DVPA(7,ICNTPA)
           WRITE(98,795)IDPA(ICNTPA),NUMW,DVPA(3,ICNTPA),DVPA(4,ICNTPA),
     #                 ISPRNK
  795      FORMAT(A12,I12,2G12.6,I12)
             DO 700 IWL3=1,NUMW
             ICNTWL=ICNTWL+1
              ILW=DVWL(1,ICNTWL)
              IRW=DVWL(2,ICNTWL)
              ICW=DVWL(3,ICNTWL)
              IWLYR=DVWL(5,ICNTWL)
             WRITE(98,796)ILW,IRW,ICW,DVWL(4,ICNTWL),IWLYR
  796        FORMAT(3I12,G12.6,I12)
  700        CONTINUE
  710      CONTINUE
         GO TO 760
      ELSE
C
C-----IF THERE IS NO MATCH, NEED TO INCREMENT ICNTPA AND ICNTWL
         NUMP=DVPW(2,IWL)
         DO 730 IWL4=1,NUMP
         ICNTPA=ICNTPA+1
         NUMW=DVPA(2,ICNTPA)
           DO 720 IWL5=1,NUMW
           ICNTWL=ICNTWL+1
  720      CONTINUE
  730    CONTINUE
      ENDIF
C
C-----END OF WELL LOOP
```

```
  760 CONTINUE
C
C-----END OF WDID LOOP
  650 CONTINUE
C
C-----GO TO NEXT AGGREGATE
      GO TO 800
C
C-----IF YOU ARE HERE, THERE WERE NO MATCHING WDIDS FOR THIS AGGREGATE
C     INCREMENT ICOUNT
  660 NUMAG=NAST(IAGG)
      DO 670 I=1,NUMAG
      ICOUNT=ICOUNT+1
  670 CONTINUE
  800 CONTINUE
C
      RETURN
      END
```

A-2 Input file listing

Response file AGGFILES

```
RGDSS2.CAN
RGDSS2.IRR
RGDSS6.WEL
RGDSS1.IRM
WDID2.DAT
URF.DAT
AGG2.DAT
```

Canal file from GIS data

```
# StateDGI 4/17/2002 10:57:42 AM
# StateDGI Canals Output
200505                18   41569.435    4252.549
1                    136          62     3367.31          0.1
1                    136          63     729.361          0.1
1                    133          57    1871.407          0.1
1                    133          56     3051.78          0.1
1                    133          55     3075.46          0.1
1                    133          54     2656.03          0.1
1                    133          53     2640.08          0.1
1                    133          52     2639.95          0.1
1                    133          51     2648.19          0.1
1                    134          57     3218.71          0.1
1                    137          63     389.505          0.1
1                    136          61     2928.23          0.1
1                    136          60     2753.81          0.1
1                    135          57     1233.87          0.1
1                    135          58     3100.43          0.1
1                    135          59     1796.35          0.1
1                    136          59     1594.34          0.1
1                    133          50    1874.622        0.151
200512                 6   10388.524   10388.524
1                    112          19     1721.67            1
1                    114          22      31.474            1
1                    113          20     3388.75            1
1                    114          21     2789.98            1
1                    113          19     1286.67            1
1                    113          21     1169.98            1
200513                 3     6132.17     6132.17
1                    101           5     1482.88            1
1                    102           6     2529.72            1
1                    102           5     2119.57            1
.
.
.
Continue for each structure
```

Irrigated Land file from GIS data

```
# StateDGI 4/17/2002 11:00:27 AM
# StateDGI Irrigated Lands Output
200505               17     1208.16     1208.16
1                   134          58      92.633           1
1                   137          58      12.582           1
1                   136          57      12.885           1
1                   136          58      86.663           1
1                   137          59      86.809           1
1                   137          60      89.532           1
1                   136          59     155.739           1
1                   136          60      41.594           1
1                   138          59        68.9           1
1                   135          58     159.895           1
1                   138          60      99.717           1
1                   135          59     122.476           1
1                   135          57      91.319           1
1                   135          60       2.318           1
1                   139          59      11.324           1
1                   134          57      56.289           1
1                   139          60      17.485           1
200512               16     665.759     665.759
1                   114          24      74.911           1
1                   113          24       5.476           1
1                   113          25       0.761           1
1                   116          25       0.739           1
1                   114          21      10.505           1
1                   115          21       20.72           1
1                   114          23     115.308           1
1                   114          25      15.254           1
1                   116          22       1.526           1
1                   113          23       7.205           1
1                   115          22     100.367           1
1                   115          23      20.764           1
1                   115          24       1.679           1
1                   115          25     117.472           1
1                   115          26      48.995           1
1                   114          22     124.077           1
200513                8      315.89      315.89
1                   103           6      17.496           1
1                   104           8      29.257           1
1                   102           6      26.493           1
1                   102           7      56.455           1
1                   103           8      76.661           1
1                   103           7      94.879           1
1                   102           8       6.857           1
1                   104           7       7.792           1
.
.
.
Continue for each structure
```

Sub-irrigated Crop file from GIS data

```
# StateDGI 4/17/2002 11:00:48 AM
# StateDGI Meadows Output
200505              17     1208.16     1208.16
1                  139          60      17.485          1
1                  138          59        68.9          1
1                  138          60      99.717          1
1                  137          60      89.532          1
1                  137          59      86.809          1
1                  139          59      11.324          1
1                  134          57      56.289          1
1                  135          57      91.319          1
1                  135          58     159.895          1
1                  135          59     122.476          1
1                  136          59     155.739          1
1                  134          58      92.633          1
1                  136          58      86.663          1
1                  135          60       2.318          1
1                  136          57      12.885          1
1                  136          60      41.594          1
1                  137          58      12.582          1
200512              16     560.618     560.618
1                  115          21       20.72          1
1                  114          21      10.505          1
1                  113          23       7.205          1
1                  115          25      49.489          1
1                  115          24       1.679          1
1                  115          26      11.837          1
1                  115          22     100.367          1
1                  113          24       5.476          1
1                  113          25       0.761          1
1                  114          25      15.254          1
1                  114          24      74.911          1
1                  114          23     115.308          1
1                  114          22     124.077          1
1                  115          23      20.764          1
1                  116          22       1.526          1
1                  116          25       0.739          1
200513               8      315.89      315.89
1                  103           7      94.879          1
1                  102           6      26.493          1
1                  103           8      76.661          1
1                  104           7       7.792          1
1                  102           7      56.455          1
1                  104           8      29.257          1
1                  103           6      17.496          1
1                  102           8       6.857          1
.
.
.
Continue for each structure
```

Irrigation Well file from GIS data

```
# StateDGI 5/29/2002 2:32:16 PM
# StateDGI Well Output
200512                   4     102.007      101.51
11866                    1      10.424      10.424           0
1                      115          22      149.97        1950
11885                    1       20.26       20.26           0
1                      115          22      350.22        1962
12078                    1      26.133      26.133           0
1                      115          25         600        1958
12080                    1       45.19      44.693           0
2                      115          24         989
200513                   1      67.436      33.448
16770                    1      67.436      33.448           0
1                      104           8      396.41        1946
200516                   2     143.663       58.29
16605                    1      44.392      44.392           0
0                      126          19      227.64        1952
16621                    1      99.271      13.898           0
0                      126          17       24.52        1952
200552                   1      64.007      62.727
16780                    1      64.007      62.727           0
1                      102           4     1962.49        1947
200556                   2     169.121      61.842
11783                    2     122.913      61.334           1
1                      110          21      379.24        1942
1                      110          21      378.65        1942
11786                    2      46.208       0.508           1
1                      111          22        1.48        1958
1                      111          22        9.93        1943

.
.
.
Continue for each structure
```

Water District (WDID) structure ID list

```
       266
200505                          THE FOLLOWING WDID HAVE BEEN REMOVED BECAUSE
200512                          THEY ARE OUTSIDE OF THE MODEL AREA
200513                           10/1/00
200517                           200583
200518                           210552
200546                           210553
200552                           200599
200556                           260539
200566                           270505
200582                           270509
200587                           270549
200606                           270554
200627                           270566
200631                           200583
200636
200671                         THE FOLLOWING STRUCTURE HAS BEEN REMOVED BECAUSE
200677                          IT IS OUTSIDE THE MODEL AREA
200680                          5/20/02
200682                          220579
200694
200699
200731
200736
200737
200753
200777
200781
200798
200801
200810
200811
200812
200816
200817
200820
200826
200829
200833
200846
200853
200863
200865
200901
200903
200915
200966
210501
210503
210505
210506
210510
210511

.
.
.
Continue for each Water District ID
```

Ground Water Only (URF) structure ID list

```
        59
20URF24
20URF25
20URF29
20URF30
20URF33
20URF34
20URF35
20URF36
20URF39
20URF40
20URF41
20URF42
20URF43
20URF45
20URF47
20URF51
20URF52
20URF54
20URF58
20URF59
20URF76
20URF77
20URF78
21URF59
21URF60
22URF70
24URF0a
24URF0b
24URF0c
24URF0d
24URF48
24URF71
24URF72
24URF84
24URF85
25URF17a
25URF17b
25URF18
25URF22
25URF23
25URF7
25URF8
25URF83
25URF9
26URF13
26URF15
26URF16
26URF19
26URF20
27URF19
27URF21
27URF22
27URF24
27URF25
35URF0
35URF31
35URF37
```

35URF47
35URF48

Multiple Structure (MS) ID list

	70	339
20MS02		4
	200623	
	201060	
	210521	
	210522	
20MS03		2
	200706	
	200784	
20MS04		2
	200814	
	200815	
20MS05		2
	200683	
	200775	
20MS06		3
	200575	
	200773	
	201676	
21MS01		3
	210558	
	210576	
	210575	
21MS02		2
	210539	
	210716	
22MS01		2
	220509	
	220510	
22MS02		2
	220543	
	220617	
22MS03		2
	220553	
	220519	
22MS04		2
	220556	
	220557	
22MS05		3
	220571	
	220572	
	220573	
22MS06		2
	220591	
	220609	
22MS07		5
	220593	
	220596	
	220533	
	220595	
	220653	
22MS08		3
	220621	
	220511	
	220534	

.

```
.
.
Continue for each multiple structure ID
```

A-3 Output file listing

General output file AGG.OUT

```
 AGG PROGRAM


     NUMBER OF STRUCTURES FOR LEAKAGE CALCULATIONS (NDL)   = 444
     NUMBER OF STRUCTURES FOR IRRIGATED LAND FILE (NDA)    = 586
     NUMBER OF STRUCTURES FROM WELL FILE (NDW)             = 297
     NUMBER OF STRUCTURES FROM IRRIGATED CROP FILE (NDM) = 540
     NUMBER OF STRUCTURES FROM WDID FILE (NPLN)            = 266
     NUMBER OF STRUCTURES FROM URF FILE  (NURF)            =  59
     NUMBER OF AGGREGATES FROM AGG. FILE (NAGG)            =  70
     NUMBER OF AGG. STRUCTURES FROM AGG. FILE (NAST)       = 339


         4582679 ELEMENTS IN  X ARRAY ARE USED OUT OF        10000000
              71 ELEMENTS IN IX ARRAY ARE USED OUT OF          200000
           74773 ELEMENTS IN CH ARRAY ARE USED OUT OF          100000



----------------------------------------
 STRUCTURES IN CU MODEL
----------------------------------------
200505
200512
200513
200517
200518
200546
200552
200556
200566
200582
200587
200606
200627
200631
200636
200671
200677
200680
200682
200694
200699
200731
200736
200737
200753
200777
200781
200798
200801
200810
200811
200812
200816
200817
200820
```

```
200826
200829
200833
200846
200853
200863
200865
200901
200903
200915
200966
210501
210503
210505
210506
210510
210511
210512
210513
210514
210515
210520
210523
.
.
.
Continue for each structure

----------------------------------------
 GROUND WATER ONLY STRUCTURES IN CU MODEL
----------------------------------------

     GROUND WATER STRUCTURE ID
20URF24
20URF25
20URF29
20URF30
20URF33
20URF34
20URF35
20URF36
20URF39
20URF40
20URF41
20URF42
20URF43
20URF45
20URF47
20URF51
20URF52
20URF54
20URF58
20URF59
20URF76
20URF77
20URF78
21URF59
21URF60
22URF70
.
.
.
Continue for each structure
```

```
---------------------------------------
 AGGREGATE STRUCTURES IN MODEL
---------------------------------------

     AGGREGATE STRUCTURE ID   NO. STRUCTURES
     20MS02                       4
            200623
            201060
            210521
            210522
     20MS03                       2
            200706
            200784
     20MS04                       2
            200814
            200815
     20MS05                       2
            200683
            200775
     20MS06                       3
            200575
            200773
            201676
     21MS01                       3
            210558
            210576
            210575
     21MS02                       2
            210539
            210716
     22MS01                       2
            220509
            220510
     22MS02                       2
            220543
            220617
     22MS03                       2
            220553
            220519
     22MS04                       2
            220556
            220557
     22MS05                       3
            220571
            220572
            220573
     22MS06                       2
            220591
            220609
     22MS07                       5
            220593
            220596
            220533
            220595
            220653
     22MS08                       3
            220621
.
.
.
Continue for each structure
```

```
----------------------------------------
 CANAL LENGTH DATA
 LENGTH IS IN FEET
----------------------------------------

     SEE CANAGG.OUT


----------------------------------------
 IRRIGATED LAND DATA
----------------------------------------

     SEE IRRAGG.OUT


----------------------------------------
 WELL DATA
 WELL CAPACITY IS IN GPM
----------------------------------------

     SEE WELAGG.OUT


----------------------------------------
 IRRIGATED CROP DATA
----------------------------------------

     SEE IRMAGG.OUT


----------------------------------------
 CHECK FOR MATCHING IDS
----------------------------------------

 SEE RESULTS IN THE FOLLOWING FILES:
 NMCAN.DAT FOR COMPARING TO CANAL FILE
 NMIRR.DAT FOR COMPARING TO IRRIGATED LAND FILE
 NMWEL.DAT FOR COMPARING TO IRRIGATION WELL FILE
 NMIRM.DAT FOR COMPARING TO THE IRRIGATED CROPW FILE
```

Canal leakage file for StatePP DIVLEAK.DAT

```
#
#
200505             18  41569.      4252.5
          1       136         62 3367.31    0.100000
          1       136         63 729.361    0.100000
          1       133         57 1871.41    0.100000
          1       133         56 3051.78    0.100000
          1       133         55 3075.46    0.100000
          1       133         54 2656.03    0.100000
          1       133         53 2640.08    0.100000
          1       133         52 2639.95    0.100000
          1       133         51 2648.19    0.100000
          1       134         57 3218.71    0.100000
          1       137         63 389.505    0.100000
          1       136         61 2928.23    0.100000
          1       136         60 2753.81    0.100000
          1       135         57 1233.87    0.100000
          1       135         58 3100.43    0.100000
          1       135         59 1796.35    0.100000
          1       136         59 1594.34    0.100000
          1       133         50 1874.62    0.151000
200512              6  10389.      10389.
          1       112         19 1721.67     1.00000
          1       114         22 31.4740     1.00000
          1       113         20 3388.75     1.00000
          1       114         21 2789.98     1.00000
          1       113         19 1286.67     1.00000
          1       113         21 1169.98     1.00000
200513              3  6132.2      6132.2
          1       101          5 1482.88     1.00000
          1       102          6 2529.72     1.00000
          1       102          5 2119.57     1.00000
200517              5  11671.      1167.1
          1       113         19 1289.90    0.100000
          1       113         21 1176.36    0.100000
          1       112         19 5367.98    0.100000
          1       113         20 3375.03    0.100000
          1       114         21 461.672    0.100000
.
.
.
20MS03              6 10430.7     10430.7
          1       122         19 56.8370     1.00000
          1       123         19 2642.52     1.00000
          1       124         19 2683.33     1.00000
          1       126         18 1296.81     1.00000
          1       125         18 403.994     1.00000
          1       125         19 3347.17     1.00000
20MS04              9 18273.7     2657.44
          1       101          7 2894.63    0.100000
          1       101          5 3393.88    0.200000
          1       102          8 1741.23    0.100000
          1       102          7 293.471    0.100000
          1       101          6 2863.71    0.163000
          1       101          4 2300.10    0.200000
          1       101          2 752.573    0.200000
          1       102          2 1667.27    0.103000
          1       102          3 2366.85    0.100000
20MS05              6 13059.2     1612.76
          1       114         27 1442.90    0.200000
```

```
           1         114            26 3250.92    0.150000
           1         114            25 2578.35    0.100000
           1         113            22 771.941    0.100000
           1         113            24 1614.04    0.100000
           1         113            23 3401.03    0.100000
20MS06                41 116080.       77430.1
           1         136            63 3908.28    0.100000
           1         133            60 1770.20    0.100000
           1         136            64 403.845    0.100000
           1         134            60 3095.22    0.100000
           1         133            59 3279.53    0.145000
           1         139            65 2697.62    0.100000
           1         137            64 3273.10    0.100000
           1         142            65 1765.39    0.100000
           1         136            61 1191.56    0.100000
           1         141            65 2709.73    0.100000
           1         141            64 387.310    0.100000
           1         135            62 1057.26    0.100000
           1         135            61 2995.06    0.100000
           1         132            58 1659.30    0.200000
           1         138            65 2759.59    0.100000
           1         142            64 1989.47    0.100000
           1         134            61 874.824    0.100000
           1         143            65 568.439    0.100000
           1         140            65 3821.41    0.100000
           1         132            59 886.406    0.200000
           1         136            62 1906.67    0.100000
           1         137            65 390.706    0.100000
           1         140            65 2788.34     1.00000
           1         145            66 218.331     1.00000
           1         141            66 4821.63     1.00000
           1         146            67 1224.79     1.00000
           1         140            66 4460.78     1.00000
           1         140            67 2944.55     1.00000
           1         141            67 4721.71     1.00000
           1         142            66 6907.46     1.00000
           1         142            67 7617.19     1.00000
           1         143            68 258.786     1.00000
           1         145            67 5256.92     1.00000
           1         143            67 8654.51     1.00000
           1         141            65 3695.07     1.00000
           1         143            66 3707.69     1.00000
           1         138            65 2182.46     1.00000
           1         139            65 3811.17     1.00000
           1         139            66 1570.74     1.00000
           1         144            68 471.396     1.00000
           1         144            67 7375.35     1.00000

.
.
.
Continue for each structure
```

Irrigated land file for StatePP DIVIRLN.DAT

```
#
#
200505            17 1208.16     1208.16
          1         134           58 92.6330     1.00000
          1         137           58 12.5820     1.00000
          1         136           57 12.8850     1.00000
          1         136           58 86.6630     1.00000
          1         137           59 86.8090     1.00000
          1         137           60 89.5320     1.00000
          1         136           59 155.739     1.00000
          1         136           60 41.5940     1.00000
          1         138           59 68.9000     1.00000
          1         135           58 159.895     1.00000
          1         138           60 99.7170     1.00000
          1         135           59 122.476     1.00000
          1         135           57 91.3190     1.00000
          1         135           60 2.31800     1.00000
          1         139           59 11.3240     1.00000
          1         134           57 56.2890     1.00000
          1         139           60 17.4850     1.00000
200512            16 665.759     665.759
          1         114           24 74.9110     1.00000
          1         113           24 5.47600     1.00000
          1         113           250.761000     1.00000
          1         116           250.739000     1.00000
          1         114           21 10.5050     1.00000
          1         115           21 20.7200     1.00000
          1         114           23 115.308     1.00000
          1         114           25 15.2540     1.00000
          1         116           22 1.52600     1.00000
          1         113           23 7.20500     1.00000
          1         115           22 100.367     1.00000
          1         115           23 20.7640     1.00000
          1         115           24 1.67900     1.00000
          1         115           25 117.472     1.00000
          1         115           26 48.9950     1.00000
          1         114           22 124.077     1.00000
.
.
.
20URF29           29 2087.88     2087.88
          1         103           390.571000     1.00000
          1          97           40 107.984     1.00000
          1          97           39 3.69700     1.00000
          1          99           44 112.475     1.00000
          1         102           41 145.583     1.00000
          1         103           40 20.3420     1.00000
          1          98           41 113.965     1.00000
          1         103           42 15.6790     1.00000
          1         102           40 127.554     1.00000
          1         102           43 111.181     1.00000
          1         101           40 12.0730     1.00000
          1          98           40 14.6980     1.00000
          1         100           41 13.7510     1.00000
          1         100           42 124.710     1.00000
          1         101           41 115.899     1.00000
          1         103           41 21.3860     1.00000
          1          99           43 115.621     1.00000
          1         101           44 9.11000     1.00000
```

```
           1         102           42 132.482     1.00000
           1         103           43 14.5570     1.00000
           1          98           42 113.207     1.00000
           1         101           42 125.985     1.00000
           1          99           42 123.954     1.00000
           1          99           41 114.822     1.00000
           1          99           40 6.90600     1.00000
           1         102           39 8.27600     1.00000
           1         100           44 123.281     1.00000
           1         101           43 10.3440     1.00000
           1         100           43 127.787     1.00000
20URF30                7 300.919      300.919
           1          99           58 4.35000     1.00000
           1          98           590.174000     1.00000
           1          98           600.788000     1.00000
           1          99           60 122.282     1.00000
           1          99           59 127.131     1.00000
           1         112           56 43.5650     1.00000
           1         112           55 2.62900     1.00000
20URF33                3 71.4940      71.4940
           1          95           10 62.2160     1.00000
           1          96           10 3.91700     1.00000
           1          95            9 5.36100     1.00000
20URF34               12 725.728      725.728
           1         111           39 98.8490     1.00000
           1         111           38 128.471     1.00000
           1         111           37 32.0570     1.00000
           1         112           36 27.6370     1.00000
           1         112           37 128.857     1.00000
           1         113           37 50.2550     1.00000
           1         112           39 18.3670     1.00000
           1         113           36 1.26100     1.00000
           1         112           38 119.382     1.00000
           1         114           37 1.51100     1.00000
           1         114           38 12.3820     1.00000
           1         113           38 106.699     1.00000
.
.
.
22MS08                17 617.246      617.246
           1         178           50 10.0020     1.00000
           1         177           51 6.95700     1.00000
           1         176           50 78.6330     1.00000
           1         177           50 81.7210     1.00000
           1         173           520.701000     1.00000
           1         176           51 127.592     1.00000
           1         177           49 17.9490     1.00000
           1         176           52 54.4530     1.00000
           1         175           52 82.1680     1.00000
           1         175           51 74.1280     1.00000
           1         174           530.349000     1.00000
           1         175           50 1.18300     1.00000
           1         178           49 38.5390     1.00000
           1         174           52 32.8530     1.00000
           1         178           48 9.22700     1.00000
           1         174           510.622000     1.00000
           1         173           530.169000     1.00000
22MS09                47 4120.52      4120.52
           1         182           45 133.871     1.00000
           1         178           47 1.39800     1.00000
           1         181           48 155.919     1.00000
           1         181           49 155.376     1.00000
           1         181           50 154.117     1.00000
```

```
           1         181          51 144.840     1.00000
           1         182          42 16.4400     1.00000
           1         181          46 159.357     1.00000
           1         182          44 131.326     1.00000
           1         181          45 132.862     1.00000
           1         180          44 17.1000     1.00000
           1         182          47 141.465     1.00000
           1         178          500.737000     1.00000
           1         180          51 90.0170     1.00000
           1         178          490.295000     1.00000
           1         178          48 12.1800     1.00000
           1         182          43 75.1980     1.00000
           1         180          47 135.896     1.00000
           1         179          51 8.31100     1.00000
           1         179          50 100.692     1.00000
           1         179          49 81.8770     1.00000
           1         179          48 74.9850     1.00000
           1         179          47 70.1800     1.00000
           1         179          46 27.8250     1.00000
           1         181          47 160.281     1.00000
           1         180          46 150.629     1.00000
           1         182          48 126.763     1.00000
           1         180          48 160.001     1.00000
           1         180          49 160.763     1.00000
           1         180          50 158.082     1.00000
           1         181          42 4.99400     1.00000
           1         181          43 55.6870     1.00000
           1         181          44 115.660     1.00000
           1         180          45 68.8370     1.00000
           1         183          44 2.65500     1.00000
           1         183          51 46.8550     1.00000
           1         183          50 74.5800     1.00000
           1         183          49 55.1880     1.00000
           1         183          48 46.7500     1.00000
           1         183          47 40.2260     1.00000
           1         182          46 139.868     1.00000
           1         183          45 42.8730     1.00000
           1         183          43 2.16800     1.00000
           1         182          51 149.793     1.00000
           1         182          50 159.180     1.00000
           1         182          49 137.376     1.00000
           1         183          46 39.0510     1.00000
22MS10                11 371.997     371.997
           1         185          470.410000E-01 1.00000
           1         186          49 61.1140     1.00000
           1         186          50 22.7820     1.00000
           1         186          48 90.7650     1.00000
           1         186          47 43.4650     1.00000
           1         185          48 54.2980     1.00000
           1         185          49 69.7270     1.00000
           1         185          50 24.2270     1.00000
           1         184          49 1.94100     1.00000
           1         187          48 3.51900     1.00000
           1         187          470.118000     1.00000
.
.
.
Continue for each structure
```

Sub-irrigated crop file for StatePP IRRMEAD.DAT

```
#
#
200505                    17 1208.16     1208.16
           1         139           60 17.4850     1.00000
           1         138           59 68.9000     1.00000
           1         138           60 99.7170     1.00000
           1         137           60 89.5320     1.00000
           1         137           59 86.8090     1.00000
           1         139           59 11.3240     1.00000
           1         134           57 56.2890     1.00000
           1         135           57 91.3190     1.00000
           1         135           58 159.895     1.00000
           1         135           59 122.476     1.00000
           1         136           59 155.739     1.00000
           1         134           58 92.6330     1.00000
           1         136           58 86.6630     1.00000
           1         135           60 2.31800     1.00000
           1         136           57 12.8850     1.00000
           1         136           60 41.5940     1.00000
           1         137           58 12.5820     1.00000
200512                    16 560.618     560.618
           1         115           21 20.7200     1.00000
           1         114           21 10.5050     1.00000
           1         113           23 7.20500     1.00000
           1         115           25 49.4890     1.00000
           1         115           24 1.67900     1.00000
           1         115           26 11.8370     1.00000
           1         115           22 100.367     1.00000
           1         113           24 5.47600     1.00000
           1         113           250.761000     1.00000
           1         114           25 15.2540     1.00000
           1         114           24 74.9110     1.00000
           1         114           23 115.308     1.00000
           1         114           22 124.077     1.00000
           1         115           23 20.7640     1.00000
           1         116           22 1.52600     1.00000
           1         116           250.739000     1.00000
200513                     8 315.890     315.890
           1         103            7 94.8790     1.00000
           1         102            6 26.4930     1.00000
           1         103            8 76.6610     1.00000
           1         104            7 7.79200     1.00000
           1         102            7 56.4550     1.00000
           1         104            8 29.2570     1.00000
           1         103            6 17.4960     1.00000
           1         102            8 6.85700     1.00000
200517                    10 346.078     346.078
           1         113           19 8.53100     1.00000
           1         113           20 105.313     1.00000
           1         112           21 14.0920     1.00000
           1         112           20 63.1130     1.00000
           1         111           20 4.72400     1.00000
           1         111           19 3.18300     1.00000
           1         112           19 70.3170     1.00000
           1         114           200.550000E-01 1.00000
           1         114           21 11.8920     1.00000
           1         113           21 64.8580     1.00000
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20MS03              18 589.007     589.007
           1         124          19 92.8930     1.00000
           1         124          21 6.99600     1.00000
           1         127          160.140000E-01 1.00000
           1         124          20 102.191     1.00000
           1         125          21 1.25400     1.00000
           1         126          210.290000E-01 1.00000
           1         126          200.246000     1.00000
           1         126          19 19.1560     1.00000
           1         126          18 49.4480     1.00000
           1         122          19 8.59800     1.00000
           1         126          170.942000     1.00000
           1         122          20 6.63200     1.00000
           1         126          160.154000     1.00000
           1         125          18 101.535     1.00000
           1         125          20 52.7720     1.00000
           1         125          19 120.070     1.00000
           1         123          19 19.0230     1.00000
           1         123          20 7.05400     1.00000
20MS04               8 266.417     266.417
           1         101           80.109000     1.00000
           1         102           8 19.0090     1.00000
           1         101           7 86.7050     1.00000
           1         102           6 17.3090     1.00000
           1         102           7 38.5370     1.00000
           1         101           6 82.2370     1.00000
           1         100           5 1.05300     1.00000
           1         101           5 21.4580     1.00000
20MS05              17 475.549     475.549
           1         114          26 18.4730     1.00000
           1         115          26 2.37200     1.00000
           1         115          27 4.76900     1.00000
           1         114          27 9.03700     1.00000
           1         115          25 4.67100     1.00000
           1         113          24 42.6940     1.00000
           1         115          260.382000     1.00000
           1         114          270.150000E-01 1.00000
           1         114          26 98.2580     1.00000
           1         115          270.530000E-01 1.00000
           1         114          24 10.5980     1.00000
           1         112          250.127000     1.00000
           1         112          240.317000     1.00000
           1         113          25 118.418     1.00000
           1         116          250.800000E-02 1.00000
           1         113          26 26.5620     1.00000
           1         114          25 138.795     1.00000
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Continue for each structure
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Irrigation well file for StatePP IRRWELLS.DAT

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#
#
200512                  4 102.007     101.510
11866                   1 10.4240     10.4240                0
           1          115          22 149.970             1950
11885                   1 20.2600     20.2600                0
           1          115          22 350.220             1962
12078                   1 26.1330     26.1330                0
           1          115          25 600.000             1958
12080                   1 45.1900     44.6930                0
           2          115          24 989.000             1960
200513                  1 67.4360     33.4480
16770                   1 67.4360     33.4480                0
           1          104           8 396.410             1946
200552                  1 64.0070     62.7270
16780                   1 64.0070     62.7270                0
           1          102           4 1962.49             1947
200556                  2 169.121     61.8420
11783                   2 122.913     61.3340                1
           1          110          21 379.240             1942
           1          110          21 378.650             1942
11786                   2 46.2080    0.508000                1
           1          111          22 1.48000             1958
           1          111          22 9.93000             1943
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20URF36                 1 37.1530     37.1530
13587                   1 37.1530     37.1530                0
           1          131          67 74.9800             1952
20URF39                15 741.766     741.766
10900                   5 117.097     117.097                1
           2          103          10 593.900             1957
           1          103          10 1107.81             1957
           1          103          10 351.100             1961
           2          103          10 1449.39             1961
           2          103          11 1000.00             1975
10902                   1 81.7370     81.7370                1
           2          103           9 900.000             1981
11726                   3 81.0170     81.0170                1
           1          105          14 278.910             1947
           3          105          14 344.630             1947
           2          105          14 979.390             1947
11753                   1 88.1400     88.1400                1
           2          107          16 1001.27             1905
11780                   1 69.4140     69.4140                1
           2          110          20 683.340             1979
11781                   2 32.1670     32.1670                1
           2          111          19 700.440             1954
           2          110          20 316.660             1979
11782                   2 55.6350     55.6350                1
           2          110          20 297.010             1963
           1          110          20 803.040             1963
11787                   5 52.2600     52.2600                1
           1          111          23 1499.66             1946
           1          112          24 449.000             1951
           1          111          24 440.020             1955
           2          112          23 412.000             1997
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           1         112            23 588.000            1997
11788                  1 5.17200     5.17200               0
           1         111            23 2002.54            1955
16764                  2 16.1690     16.1690               0
           2         104            10 593.900            1957
           1         104            10 1107.81            1957
16783                  1 77.4940     77.4940               0
           1         101             3 848.610            1955
16784                  2 40.1170     40.1170               0
           1         100             4 1001.27            1953
           1         100             3 848.610            1955
16794                  1 9.16500     9.16500               0
           1         101             2 400.060            1955
16795                  1 6.82200     6.82200               0
           1         100             3 400.060            1955
16798                  1 9.36000     9.36000               0
           1         100             3 400.060            1955
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25MS10                 1 49.0680     49.0680
17133                  2 49.0680     49.0680               0
           2          58            66 104.130            1970
           1          58            66 1898.41            1970
26MS01                 5 2831.97     2831.97
17177                  3 420.763     420.763               0
           4          59            42 1400.88            1956
           3          59            44 683.630            1957
           4          59            44 717.250            1957
19101                  2 143.355     143.355               0
           4          57            42 2238.15            1964
           3          57            42 199.920            1964
19103                  1 351.493     351.493               0
           3          58            47 100.130            1951
19104                  1 727.283     727.283               0
           4          62            43 600.000            1960
19105                  1 1189.07     1189.07               0
           4          59            45 1616.40            1956
26MS02                 1 41.1550    0.823000
17293                  1 41.1550    0.823000               0
           1          46            22 7.81000            1955
26MS03                 1 317.111     149.359
17306                  3 317.111     149.359               0
           2          44            18 234.740            1952
           2          44            18 234.740            1952
           3          44            18 234.740            1952
26MS04                 2 442.470     341.790
17236                  3 84.4680     24.2420               0
           2          49            28 156.330            1940
           1          49            28 114.660            1940
           3          49            28 16.3800            1940
17250                  2 358.002     317.548               0
           1          48            25 364.120            1936
           2          48            25 1232.91            1936
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Continue for each structure
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Canal file echoing input data CANAGG.out

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----------------------------------------
 CANAL LENGTH DATA
 LENGTH IS IN FEET
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   CANAL ID      SEQ NO.   NO. CELLS   TOT LENGTH  TOT LNTH*FC
200505             1          18        41569.43     4252.55
  LAYER   ROW   COLUMN       LENGTH        FACTOR
    1     136      62     3367.310         0.100
    1     136      63      729.361         0.100
    1     133      57     1871.407         0.100
    1     133      56     3051.780         0.100
    1     133      55     3075.460         0.100
    1     133      54     2656.030         0.100
    1     133      53     2640.080         0.100
    1     133      52     2639.950         0.100
    1     133      51     2648.190         0.100
    1     134      57     3218.710         0.100
    1     137      63      389.505         0.100
    1     136      61     2928.230         0.100
    1     136      60     2753.810         0.100
    1     135      57     1233.870         0.100
    1     135      58     3100.430         0.100
    1     135      59     1796.350         0.100
    1     136      59     1594.340         0.100
    1     133      50     1874.622         0.151

   CANAL ID      SEQ NO.   NO. CELLS   TOT LENGTH  TOT LNTH*FC
200512             2           6        10388.52    10388.52
  LAYER   ROW   COLUMN       LENGTH        FACTOR
    1     112      19     1721.670         1.000
    1     114      22       31.474         1.000
    1     113      20     3388.750         1.000
    1     114      21     2789.980         1.000
    1     113      19     1286.670         1.000
    1     113      21     1169.980         1.000

   CANAL ID      SEQ NO.   NO. CELLS   TOT LENGTH  TOT LNTH*FC
200513             3           3         6132.17     6132.17
  LAYER   ROW   COLUMN       LENGTH        FACTOR
    1     101       5     1482.880         1.000
    1     102       6     2529.720         1.000
    1     102       5     2119.570         1.000

   CANAL ID      SEQ NO.   NO. CELLS   TOT LENGTH  TOT LNTH*FC
200517             4           5        11670.94     1167.09
  LAYER   ROW   COLUMN       LENGTH        FACTOR
    1     113      19     1289.900         0.100
    1     113      21     1176.360         0.100
    1     112      19     5367.980         0.100
    1     113      20     3375.030         0.100
    1     114      21      461.672         0.100
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Continue for each structure

Irrigated land file echoing input data IRRAGG.OUT

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 IRRIGATED LAND DATA
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 IRR. LAND ID   SEQ NO.   NO. CELLS   TOT ACRES  TOT AC*FAC
200505            1          17       1208.16    1208.16
  LAYER   ROW   COLUMN   ACRES    FACTOR
    1     134      58    92.63     1.00    92.63     92.63
    1     137      58    12.58     1.00   105.22    105.22
    1     136      57    12.89     1.00   118.10    118.10
    1     136      58    86.66     1.00   204.76    204.76
    1     137      59    86.81     1.00   291.57    291.57
    1     137      60    89.53     1.00   381.10    381.10
    1     136      59   155.74     1.00   536.84    536.84
    1     136      60    41.59     1.00   578.44    578.44
    1     138      59    68.90     1.00   647.34    647.34
    1     135      58   159.90     1.00   807.23    807.23
    1     138      60    99.72     1.00   906.95    906.95
    1     135      59   122.48     1.00  1029.43   1029.43
    1     135      57    91.32     1.00  1120.74   1120.74
    1     135      60     2.32     1.00  1123.06   1123.06
    1     139      59    11.32     1.00  1134.39   1134.39
    1     134      57    56.29     1.00  1190.68   1190.68
    1     139      60    17.49     1.00  1208.16   1208.16

 IRR. LAND ID   SEQ NO.   NO. CELLS   TOT ACRES  TOT AC*FAC
200512            2          16        665.76     665.76
  LAYER   ROW   COLUMN   ACRES    FACTOR
    1     114      24    74.91     1.00    74.91     74.91
    1     113      24     5.48     1.00    80.39     80.39
    1     113      25     0.76     1.00    81.15     81.15
    1     116      25     0.74     1.00    81.89     81.89
    1     114      21    10.51     1.00    92.39     92.39
    1     115      21    20.72     1.00   113.11    113.11
    1     114      23   115.31     1.00   228.42    228.42
    1     114      25    15.25     1.00   243.67    243.67
    1     116      22     1.53     1.00   245.20    245.20
    1     113      23     7.20     1.00   252.40    252.40
    1     115      22   100.37     1.00   352.77    352.77
    1     115      23    20.76     1.00   373.54    373.54
    1     115      24     1.68     1.00   375.21    375.21
    1     115      25   117.47     1.00   492.69    492.69
    1     115      26    48.99     1.00   541.68    541.68
    1     114      22   124.08     1.00   665.76    665.76
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Continue for each structure
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Sub-irrigated crop file echoing input data IRMAGG.OUT

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 IRR. MEADOW ID   SEQ NO.   NO. CELLS   TOT ACRES  TOT AC*FAC
200505             1          17       1208.16    1208.16
  LAYER   ROW   COLUMN   ACRES    FACTOR
    1     139      60    17.49     1.00    17.49    17.49
    1     138      59    68.90     1.00    86.39    86.39
    1     138      60    99.72     1.00   186.10   186.10
    1     137      60    89.53     1.00   275.63   275.63
    1     137      59    86.81     1.00   362.44   362.44
    1     139      59    11.32     1.00   373.77   373.77
    1     134      57    56.29     1.00   430.06   430.06
    1     135      57    91.32     1.00   521.38   521.38
    1     135      58   159.90     1.00   681.27   681.27
    1     135      59   122.48     1.00   803.75   803.75
    1     136      59   155.74     1.00   959.49   959.49
    1     134      58    92.63     1.00  1052.12  1052.12
    1     136      58    86.66     1.00  1138.78  1138.78
    1     135      60     2.32     1.00  1141.10  1141.10
    1     136      57    12.89     1.00  1153.98  1153.98
    1     136      60    41.59     1.00  1195.58  1195.58
    1     137      58    12.58     1.00  1208.16  1208.16

 IRR. MEADOW ID   SEQ NO.   NO. CELLS   TOT ACRES  TOT AC*FAC
200512             2          16        560.62     560.62
  LAYER   ROW   COLUMN   ACRES    FACTOR
    1     115      21    20.72     1.00    20.72    20.72
    1     114      21    10.51     1.00    31.22    31.22
    1     113      23     7.20     1.00    38.43    38.43
    1     115      25    49.49     1.00    87.92    87.92
    1     115      24     1.68     1.00    89.60    89.60
    1     115      26    11.84     1.00   101.43   101.43
    1     115      22   100.37     1.00   201.80   201.80
    1     113      24     5.48     1.00   207.28   207.28
    1     113      25     0.76     1.00   208.04   208.04
    1     114      25    15.25     1.00   223.29   223.29
    1     114      24    74.91     1.00   298.20   298.20
    1     114      23   115.31     1.00   413.51   413.51
    1     114      22   124.08     1.00   537.59   537.59
    1     115      23    20.76     1.00   558.35   558.35
    1     116      22     1.53     1.00   559.88   559.88
    1     116      25     0.74     1.00   560.62   560.62

 IRR. MEADOW ID   SEQ NO.   NO. CELLS   TOT ACRES  TOT AC*FAC
200513             3           8        315.89     315.89
  LAYER   ROW   COLUMN   ACRES    FACTOR
    1     103       7    94.88     1.00    94.88    94.88
    1     102       6    26.49     1.00   121.37   121.37
    1     103       8    76.66     1.00   198.03   198.03
    1     104       7     7.79     1.00   205.82   205.82
    1     102       7    56.46     1.00   262.28   262.28
    1     104       8    29.26     1.00   291.54   291.54
    1     103       6    17.50     1.00   309.03   309.03
    1     102       8     6.86     1.00   315.89   315.89
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Continue for each structure
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Irrigation well file echoing input data WELAGG.OUT

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 WELL DATA
 WELL CAPACITY IS IN GPM
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   DIV ID     NO. PAR.       TOT ACRES       WTED TOT ACS
200512          4              102.007        101.510

  PARCEL ID   NO. WELLS      TOT ACRES       WTED ACRES     PROPORTION OF AREA
SPRINKLER (1)
11866           1               10.424          10.424               0.103
0
   LAY  ROW  COL  CAPACITY    YEAR
    1  115   22      150.0    1950
11885           1               20.260          20.260               0.200
0
   LAY  ROW  COL  CAPACITY    YEAR
    1  115   22      350.2    1962
12078           1               26.133          26.133               0.257
0
   LAY  ROW  COL  CAPACITY    YEAR
    1  115   25      600.0    1958
12080           1               45.190          44.693               0.440
0
   LAY  ROW  COL  CAPACITY    YEAR
    2  115   24      989.0       0

   DIV ID     NO. PAR.       TOT ACRES       WTED TOT ACS
200513          1               67.436         33.448

  PARCEL ID   NO. WELLS      TOT ACRES       WTED ACRES     PROPORTION OF AREA
SPRINKLER (1)
16770           1               67.436          33.448               1.000
0
   LAY  ROW  COL  CAPACITY    YEAR
    1  104    8      396.4    1946

   DIV ID     NO. PAR.       TOT ACRES       WTED TOT ACS
200516          2              143.663         58.290

  PARCEL ID   NO. WELLS      TOT ACRES       WTED ACRES     PROPORTION OF AREA
SPRINKLER (1)
16605           1               44.392          44.392               0.762
0
   LAY  ROW  COL  CAPACITY    YEAR
    0  126   19      227.6    1952
16621           1               99.271          13.898               0.238
0
   LAY  ROW  COL  CAPACITY    YEAR
    0  126   17       24.5    1952
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Continue for each structure
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Canal file comparing lengths CANAL.ERR

SEQ. NO.	ID	LENGTH CALC.	TOTAL LENGTH	DIFFERENCE
1	200505	41569.438	41569.434	0.39062500E-02
2	200512	10388.523	10388.524	-0.97656250E-03
6	200546	40566.160	40566.156	0.39062500E-02
8	200556	13761.821	13761.822	-0.97656250E-03
9	200566	62030.051	62030.047	0.39062500E-02
10	200575	43390.926	43390.922	0.39062500E-02
13	200587	102683.00	102682.98	0.15625000E-01
17	200623	397712.00	397712.06	-0.62500000E-01
18	200627	55066.434	55066.430	0.39062500E-02
19	200631	578874.88	578875.00	-0.12500000
21	200671	6553.3647	6553.3652	-0.48828125E-03
28	200737	6599.1963	6599.1958	0.48828125E-03
29	200753	119866.59	119866.61	-0.15625000E-01
33	200781	6293.8926	6293.8931	-0.48828125E-03
36	200810	27470.096	27470.098	-0.19531250E-02
37	200811	58238.316	58238.320	-0.39062500E-02
38	200812	1156568.1	1156568.0	0.12500000
39	200814	13487.018	13487.017	0.97656250E-03
40	200815	4786.6934	4786.6929	0.48828125E-03
41	200816	46843.668	46843.664	0.39062500E-02
42	200817	52278.164	52278.160	0.39062500E-02
46	200829	383631.09	383631.13	-0.31250000E-01
49	200863	17910.133	17910.135	-0.19531250E-02
50	200865	28908.213	28908.211	0.19531250E-02
52	200903	39451.852	39451.855	-0.39062500E-02
53	200966	2759.3262	2759.3259	0.24414063E-03
56	210501	7719.0464	7719.0459	0.48828125E-03
58	210503	100470.21	100470.22	-0.78125000E-02
64	210512	13583.496	13583.497	-0.97656250E-03
68	210516	14600.569	14600.570	-0.97656250E-03
70	210521	108399.23	108399.22	0.78125000E-02
76	210529	6738.9385	6738.9380	0.48828125E-03
83	210538	10157.987	10157.988	-0.97656250E-03
84	210539	23232.068	23232.066	0.19531250E-02
85	210543	5157.8203	5157.8198	0.48828125E-03
93	210554	3906.6958	3906.6960	-0.24414063E-03
94	210557	22250.281	22250.283	-0.19531250E-02
95	210558	38799.535	38799.531	0.39062500E-02
99	210564	46958.395	46958.398	-0.39062500E-02
102	210569	7860.9624	7860.9619	0.48828125E-03
107	210579	3854.5698	3854.5701	-0.24414063E-03
108	210580	5756.0273	5756.0269	0.48828125E-03
111	210583	5155.8027	5155.8032	-0.48828125E-03
113	210585	7094.8267	7094.8271	-0.48828125E-03
115	210587	9841.3838	9841.3828	0.97656250E-03
119	210596	18479.543	18479.545	-0.19531250E-02
120	210599	2913.8499	2913.8501	-0.24414063E-03
121	210600	5901.2827	5901.2832	-0.48828125E-03
122	210601	129652.26	129652.25	0.78125000E-02

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Continue for each structure

Irrigated land file comparing areas IRRAGG.ERR

SEQ. NO.	ID	AREA CALC.	TOTAL AREA	DIFFERENCE
2	200512	665.75903	665.75897	0.61035156E-04
3	200513	315.88998	315.89001	-0.30517578E-04
8	200552	103.73100	103.73100	-0.76293945E-05
9	200555	71.395004	71.394997	0.76293945E-05
10	200556	149.05702	149.05701	0.15258789E-04
13	200566	7498.4272	7498.4292	-0.19531250E-02
14	200575	2813.6521	2813.6531	-0.97656250E-03
17	200585	43.579002	43.578999	0.38146973E-05
18	200587	9583.9893	9583.9902	-0.97656250E-03
20	200606	386.94702	386.94699	0.30517578E-04
21	200623	34985.320	34985.336	-0.15625000E-01
22	200627	7455.9741	7455.9731	0.97656250E-03
23	200631	50250.160	50250.152	0.78125000E-02
24	200634	18.876999	18.877001	-0.19073486E-05
34	200694	130.38301	130.38300	0.15258789E-04
35	200699	143.53099	143.53101	-0.15258789E-04
37	200706	846.95190	846.95203	-0.12207031E-03
41	200731	176.05002	176.05000	0.15258789E-04
45	200753	23335.693	23335.695	-0.19531250E-02
52	200798	22596.896	22596.906	-0.97656250E-02
54	200810	911.77594	911.77600	-0.61035156E-04
56	200812	84967.875	84967.852	0.23437500E-01
58	200815	20.973001	20.973000	0.19073486E-05
59	200816	2905.3347	2905.3350	-0.24414063E-03
60	200817	3415.2556	3415.2561	-0.48828125E-03
63	200824	189.17001	189.17000	0.15258789E-04
64	200826	393.19202	393.19199	0.30517578E-04
65	200829	22567.459	22567.447	0.11718750E-01
66	200833	252.05501	252.05499	0.15258789E-04
67	200846	712.26611	712.26599	0.12207031E-03
69	200863	730.91907	730.91901	0.61035156E-04
70	200865	405.90897	405.90900	-0.30517578E-04
74	200903	1869.4623	1869.4620	0.24414063E-03
77	200967	13.237999	13.238000	-0.95367432E-06
79	200969	33.095997	33.096001	-0.38146973E-05
81	200971	37.468002	37.467999	0.38146973E-05
87	20URF24	571.02094	571.02100	-0.61035156E-04
88	20URF25	1172.0802	1172.0800	0.24414063E-03
89	20URF29	2087.8801	2087.8799	0.24414063E-03
90	20URF30	300.91898	300.91901	-0.30517578E-04
92	20URF34	725.72797	725.72803	-0.61035156E-04
93	20URF35	2408.5012	2408.5010	0.24414063E-03
95	20URF39	741.76508	741.76501	0.61035156E-04
96	20URF40	119.16399	119.16400	-0.76293945E-05
99	20URF43	1017.9850	1017.9850	0.61035156E-04
103	20URF52	141.51599	141.51601	-0.15258789E-04
107	20URF76	53.482998	53.483002	-0.38146973E-05
109	20URF78	224.92198	224.92200	-0.15258789E-04
110	210501	126.35500	126.35500	-0.76293945E-05
111	210502	37.702003	37.702000	0.38146973E-05

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Continue for each structure

Sub-irrigated crop file comparing areas IRMAGG.ERR

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 IRRIGATED CROP DATA
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     SEQ. NO.     ID            AREA CALC.     TOTAL AREA    DIFFERENCE
         2      200512          560.61804      560.61798     0.61035156E-04
         3      200513          315.88995      315.89001    -0.61035156E-04
         6      200518          82.491005      82.490997     0.76293945E-05
         9      200555          71.395004      71.394997     0.76293945E-05
        10      200556          87.725006      87.724998     0.76293945E-05
        13      200566          4757.1563      4757.1558     0.48828125E-03
        14      200575          2813.6528      2813.6531    -0.24414063E-03
        17      200585          43.579002      43.578999     0.38146973E-05
        18      200587          8516.7324      8516.7334    -0.97656250E-03
        20      200606          386.94702      386.94699     0.30517578E-04
        21      200623          16053.741      16053.740     0.97656250E-03
        22      200627          7008.4673      7008.4668     0.48828125E-03
        23      200631          1617.9231      1617.9230     0.12207031E-03
        24      200634          18.876999      18.877001    -0.19073486E-05
        31      200680          493.43903      493.43900     0.30517578E-04
        33      200683          34.650997      34.651001    -0.38146973E-05
        41      200731          176.05002      176.05000     0.15258789E-04
        43      200736          536.83997      536.84003    -0.61035156E-04
        45      200753          9466.2393      9466.2412    -0.19531250E-02
        46      200773          467.19608      467.19601     0.61035156E-04
        52      200798          1585.4391      1585.4390     0.12207031E-03
        55      200811          5592.9937      5592.9932     0.48828125E-03
        56      200812          12619.379      12619.376     0.29296875E-02
        58      200816          799.72913      799.72900     0.12207031E-03
        59      200817          1609.7292      1609.7290     0.24414063E-03
        64      200829          7452.5303      7452.5308    -0.48828125E-03
        66      200846          580.83203      580.83197     0.61035156E-04
        69      200865          393.76303      393.76300     0.30517578E-04
        72      200901          204.05899      204.05901    -0.15258789E-04
        73      200903          1869.4619      1869.4620    -0.12207031E-03
        76      200967          13.237999      13.238000    -0.95367432E-06
        85      201676          895.51404      895.51398     0.61035156E-04
        89      20URF39         159.12698      159.12700    -0.15258789E-04
        91      20URF41         301.82098      301.82101    -0.30517578E-04
        94      20URF54         117.31001      117.31000     0.76293945E-05
        97      20URF76         53.482998      53.483002    -0.38146973E-05
        99      210501          126.35500      126.35500    -0.76293945E-05
       101      210503          206.29301      206.29300     0.15258789E-04
       103      210506          412.78397      412.78400    -0.30517578E-04
       104      210510          162.49701      162.49699     0.15258789E-04
       105      210511          4.4189997      4.4190001    -0.47683716E-06
       106      210512          1147.8369      1147.8370    -0.12207031E-03
       107      210513          174.29901      174.29900     0.15258789E-04
       111      210521          5162.7568      5162.7559     0.97656250E-03
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Continue for each structure
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Missing IDs in the Canal file NMCAN.DAT

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 CHECKING WDID.DAT FILE
IN THE CANAL FILE THERE WAS NO MATCH FOR 200677
IN THE CANAL FILE THERE WAS NO MATCH FOR 200682
IN THE CANAL FILE THERE WAS NO MATCH FOR 200853
IN THE CANAL FILE THERE WAS NO MATCH FOR 200915
IN THE CANAL FILE THERE WAS NO MATCH FOR 220502
IN THE CANAL FILE THERE WAS NO MATCH FOR 220505
IN THE CANAL FILE THERE WAS NO MATCH FOR 220513
IN THE CANAL FILE THERE WAS NO MATCH FOR 240521
IN THE CANAL FILE THERE WAS NO MATCH FOR 240544
IN THE CANAL FILE THERE WAS NO MATCH FOR 240549
IN THE CANAL FILE THERE WAS NO MATCH FOR 240599
IN THE CANAL FILE THERE WAS NO MATCH FOR 250508
IN THE CANAL FILE THERE WAS NO MATCH FOR 250591
IN THE CANAL FILE THERE WAS NO MATCH FOR 250592
IN THE CANAL FILE THERE WAS NO MATCH FOR 250661
IN THE CANAL FILE THERE WAS NO MATCH FOR 270533
IN THE CANAL FILE THERE WAS NO MATCH FOR 270535

NUMBER OF STRUCTURE IDS NOT MATCHED =   17 OUT OF  266

 CHECKING AGG.DAT FILE

SEQ. NO.=    1 AGG. ID=20MS02       NO. AGGS=  4
IN RGDSS.CAN THERE WAS NO MATCH FOR 201060
IN RGDSS.CAN THERE WAS NO MATCH FOR 210522
SEQ. NO.=    2 AGG. ID=20MS03       NO. AGGS=  2
IN RGDSS.CAN THERE WAS NO MATCH FOR 200784
SEQ. NO.=    3 AGG. ID=20MS04       NO. AGGS=  2
SEQ. NO.=    4 AGG. ID=20MS05       NO. AGGS=  2
IN RGDSS.CAN THERE WAS NO MATCH FOR 200683
SEQ. NO.=    5 AGG. ID=20MS06       NO. AGGS=  3
IN RGDSS.CAN THERE WAS NO MATCH FOR 201676
SEQ. NO.=    6 AGG. ID=21MS01       NO. AGGS=  3
IN RGDSS.CAN THERE WAS NO MATCH FOR 210576
IN RGDSS.CAN THERE WAS NO MATCH FOR 210575
SEQ. NO.=    7 AGG. ID=21MS02       NO. AGGS=  2
IN RGDSS.CAN THERE WAS NO MATCH FOR 210716
SEQ. NO.=    8 AGG. ID=22MS01       NO. AGGS=  2
IN RGDSS.CAN THERE WAS NO MATCH FOR 220510
SEQ. NO.=    9 AGG. ID=22MS02       NO. AGGS=  2
IN RGDSS.CAN THERE WAS NO MATCH FOR 220617
SEQ. NO.=   10 AGG. ID=22MS03       NO. AGGS=  2
IN RGDSS.CAN THERE WAS NO MATCH FOR 220519
SEQ. NO.=   11 AGG. ID=22MS04       NO. AGGS=  2
IN RGDSS.CAN THERE WAS NO MATCH FOR 220557
SEQ. NO.=   12 AGG. ID=22MS05       NO. AGGS=  3
IN RGDSS.CAN THERE WAS NO MATCH FOR 220572
IN RGDSS.CAN THERE WAS NO MATCH FOR 220573
SEQ. NO.=   13 AGG. ID=22MS06       NO. AGGS=  2
SEQ. NO.=   14 AGG. ID=22MS07       NO. AGGS=  5
IN RGDSS.CAN THERE WAS NO MATCH FOR 220596
IN RGDSS.CAN THERE WAS NO MATCH FOR 220533
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NUMBER OF STRUCTURES NOT MATCHED =  195 OUT OF  339
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Missing IDs in the irrigated land file NMIRR.DAT

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 CHECKING WDID.DAT FILE

NUMBER OF STRUCTURE IDS NOT MATCHED =    0 OUT OF  266

 CHECKING URF.DAT FILE

NUMBER OF STRUCTURES NOT MATCHED =    0 OUT OF   59

 CHECKING AGG.DAT FILE

SEQ. NO.=    1 AGG. ID=20MS02       NO. AGGS=  4
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 201060
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 210522
SEQ. NO.=    2 AGG. ID=20MS03       NO. AGGS=  2
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 200784
SEQ. NO.=    3 AGG. ID=20MS04       NO. AGGS=  2
SEQ. NO.=    4 AGG. ID=20MS05       NO. AGGS=  2
SEQ. NO.=    5 AGG. ID=20MS06       NO. AGGS=  3
SEQ. NO.=    6 AGG. ID=21MS01       NO. AGGS=  3
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 210576
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 210575
SEQ. NO.=    7 AGG. ID=21MS02       NO. AGGS=  2
SEQ. NO.=    8 AGG. ID=22MS01       NO. AGGS=  2
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220510
SEQ. NO.=    9 AGG. ID=22MS02       NO. AGGS=  2
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220617
SEQ. NO.=   10 AGG. ID=22MS03       NO. AGGS=  2
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220519
SEQ. NO.=   11 AGG. ID=22MS04       NO. AGGS=  2
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220557
SEQ. NO.=   12 AGG. ID=22MS05       NO. AGGS=  3
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220572
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220573
SEQ. NO.=   13 AGG. ID=22MS06       NO. AGGS=  2
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220609
SEQ. NO.=   14 AGG. ID=22MS07       NO. AGGS=  5
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220596
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220533
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220595
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220653
SEQ. NO.=   15 AGG. ID=22MS08       NO. AGGS=  3
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220511
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220534
SEQ. NO.=   16 AGG. ID=22MS09       NO. AGGS=  2
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220623
SEQ. NO.=   17 AGG. ID=22MS10       NO. AGGS=  3
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220569
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220570
SEQ. NO.=   18 AGG. ID=22MS11       NO. AGGS=  3
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220647
IN THE IRRIGATED LANDS FILE THERE WAS NO MATCH FOR 220648
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NUMBER OF STRUCTURES NOT MATCHED =  143 OUT OF  339
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Missing IDs in the sub-irrigated lands file NMIRM.DAT

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 CHECKING WDID.DAT FILE
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 210527
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 210537
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 210569
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 210591
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 240521
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 240524
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 240549
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 270533
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 270535
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 270545

NUMBER OF STRUCTURE IDS NOT MATCHED =   10 OUT OF  266

 CHECKING AGG.DAT FILE

SEQ. NO.=    1 AGG. ID=20MS02       NO. AGGS=  4
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 201060
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 210522
SEQ. NO.=    2 AGG. ID=20MS03       NO. AGGS=  2
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 200784
SEQ. NO.=    3 AGG. ID=20MS04       NO. AGGS=  2
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 200815
SEQ. NO.=    4 AGG. ID=20MS05       NO. AGGS=  2
SEQ. NO.=    5 AGG. ID=20MS06       NO. AGGS=  3
SEQ. NO.=    6 AGG. ID=21MS01       NO. AGGS=  3
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 210576
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 210575
SEQ. NO.=    7 AGG. ID=21MS02       NO. AGGS=  2
SEQ. NO.=    8 AGG. ID=22MS01       NO. AGGS=  2
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 220510
SEQ. NO.=    9 AGG. ID=22MS02       NO. AGGS=  2
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 220617
SEQ. NO.=   10 AGG. ID=22MS03       NO. AGGS=  2
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 220519
SEQ. NO.=   11 AGG. ID=22MS04       NO. AGGS=  2
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 220557
SEQ. NO.=   12 AGG. ID=22MS05       NO. AGGS=  3
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 220572
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 220573
SEQ. NO.=   13 AGG. ID=22MS06       NO. AGGS=  2
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 220609
SEQ. NO.=   14 AGG. ID=22MS07       NO. AGGS=  5
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 220596
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 220533
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 220595
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 220653
SEQ. NO.=   15 AGG. ID=22MS08       NO. AGGS=  3
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 220511
IN THE IRRIGATED CROP FILE THERE WAS NO MATCH FOR 220534
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NUMBER OF STRUCTURES NOT MATCHED =  152 OUT OF  339
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Missing IDs in the irrigation well file NMWEL.DAT

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 CHECKING WDID.DAT FILE
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200505
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200517
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200518
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200546
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200582
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200682
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200731
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200781
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200820
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200863
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200966
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 210501
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 210511
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 210515
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 210527
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 210528
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 210529
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 210530
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NUMBER OF STRUCTURE IDS NOT MATCHED =  110 OUT OF  266

 CHECKING URF.DAT FILE

NUMBER OF STRUCTURES NOT MATCHED =    0 OUT OF   59

 CHECKING AGG.DAT FILE

SEQ. NO.=    1 AGG. ID=20MS02       NO. AGGS=  4
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 201060
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 210522
SEQ. NO.=    2 AGG. ID=20MS03       NO. AGGS=  2
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200784
SEQ. NO.=    3 AGG. ID=20MS04       NO. AGGS=  2
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200815
SEQ. NO.=    4 AGG. ID=20MS05       NO. AGGS=  2
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200683
SEQ. NO.=    5 AGG. ID=20MS06       NO. AGGS=  3
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 200773
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 201676
SEQ. NO.=    6 AGG. ID=21MS01       NO. AGGS=  3
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 210576
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 210575
SEQ. NO.=    7 AGG. ID=21MS02       NO. AGGS=  2
SEQ. NO.=    8 AGG. ID=22MS01       NO. AGGS=  2
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 220509
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 220510
SEQ. NO.=    9 AGG. ID=22MS02       NO. AGGS=  2
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 220617
SEQ. NO.=   10 AGG. ID=22MS03       NO. AGGS=  2
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 220519
SEQ. NO.=   11 AGG. ID=22MS04       NO. AGGS=  2
IN THE IRRIGATION WELL FILE THERE WAS NO MATCH FOR 220557
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NUMBER OF STRUCTURES NOT MATCHED =  261 OUT OF  339
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A-4 Adjustments to well file

The following wells were changed from the well file produced by AGG (IRRWELLS.DAT) and the well file used in StatePP (IRRWELLS8.DAT)

		Starting			Change to		
Structure ID	Parcel	Layer	Row	Column	Layer	Row	Column
200753	12375	3	119	19	2	119	19
200811	12375	3	119	19	2	119	19
200812	10627	3	91	14	2	91	14
220576	15833	3	182	33	2	182	33
220604	15839	3	183	32	2	183	32
220619	15287	0	173	35	1	173	35
220619	15309	3	171	36	2	171	36
220619	15311	3	173	36	2	173	36
220619	15311	0	173	36	2	173	36
240521	18197	0	196	81	1	196	81
260535	17263	3	48	23	2	48	23
260542	17306	3	44	18	2	44	18
270502	10499	3	85	13	2	85	13
270502	10501	0	85	14	2	85	14
270522	10476	3	83	14	2	83	14
20URF51	12368	0	117	18	2	117	18
20URF51	12370	3	118	19	2	118	19
20URF51	16669	0	113	16	2	113	16
20URF51	16670	0	113	16	2	113	16
20URF78	19004	5	117	39	4	117	39
20URF78	19910	5	117	39	4	117	39
20MS03	12378	3	122	19	2	122	19
20MS03	12379	3	123	20	2	123	20
20MS03	16621	0	126	17	1	126	17
22MS06	15287	0	173	35	1	173	35
22MS06	15309	3	171	36	2	171	36
22MS06	15311	0	173	36	2	173	36
22MS06	15822	4	179	34	2	179	34
22MS06	15822	3	179	34	2	179	34
22MS06	15833	3	182	33	2	182	33
26MS03	18306	3	44	18	2	44	18
35MS01	11096	0	128	107	1	128	107
35MS03	17633	5	148	103	4	148	103
20ADW12	11621	0	126	17	1	126	20
20ADW12	11621	0	126	17	1	126	20
ADW04	17292	3	46	17	2	46	17