Appendix J Data Centered Groundwater Modeling Enhancements

1.0 Purpose

The South Platte Decision Support System (SPDSS) Alluvial Groundwater Model was developed as part of Colorado's Decision Support Systems (CDSS) using a data centered approach. To facilitate the data centered approach the CDSS has developed several tools to assist the modeling process. In the SPDSS the tools for the groundwater model were evaluated and enhanced under Task 50 (SPDSS, 2007).

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 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 Version 6.0) is used to create additional MODFLOW-2000 package files. **Figure 1** illustrates the general concept of the data centered modeling flow process.

This appendix supplements information presented in prior Task 50 technical memoranda, presenting documentation, source code and example files for the data centered process tools. Documentation for previously submitted tools in repeated in this Appendix for completeness.

Approach

Section	Description
2.0	Groundwater Data Repositories
2.1	HydroBase
2.2	SPDSS_GW_database
2.3	SPDSS_GW_geodatabase
3.0	Streamflow-Routing Package Development
3.1	Description of SFR2 Package
3.2	Input Data Sources for SFR2 Package Development
3.3	ArcGIS Tools used to Develop the SFR2 Package

The following table summarizes the sections contained in this Appendix.

3.4	Generation of SFR2 Package
4.0	Development of New DMIs and Procedures
4.1	GMS Grid Conversion
4.2	Creating and Activating the Model Grid
4.3	Creating Model Layers with XYZ Datasets
4.4	Modification of Program StatePP
4.5	Lateral Boundary Processor
4.6	Bedrock Flux Interface
4.7	Rainfall Pre-Processor
4.8	Ungaged Surface Water Runoff Processor
5.0	Summary and Conclusions
6.0	Recommendations
7.0	References

To accomplish the objectives, Task 50 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,
- *development of procedures to create and process data through GMS, and*
- *development or modification of modeling related DMIs.*

A detailed flow diagram of the data centered modeling flow process is shown in **Figure 2**, while **Figure 3** shows the process for generation of MODFLOW datasets. The databases, data management interface programs (DMIs), procedures, and tools enhanced or developed under Task 50.4 are described in the remainder of this Appendix.

2.0 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.

2.1 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 on the Colorado's Decision Support Systems website at

http://cdss.state.co.us/onlineTools/Pages/OnlineToolsHome.aspx.

2.2 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 **Attachment 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 **Attachment 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.

Attachment 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.

2.3 SPDSS_GW_geodatabase

The final database 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 may be periodically updated in the future 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. <u>The log table must be manually updated by the analyst</u>.

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

3.0 Streamflow-Routing Package Development

One of the more complicated model input packages, the Streamflow-Routing (SFR2) package is used to simulate streams and diversions. At the time of initial model development, graphical user interface programs to facilitate use of this package were not available commercially, so a specific tool was developed for the SPDSS. A brief description of SFR2 and the tools developed to create this model input package are presented in this section.

3.1 Description of SFR2 Package

MODFLOW-2000 uses a streamflow-routing package (SFR2) to simulate the streamaquifer 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. The first set of tools referred to as the SFR GIS processor are used to pre-process data in the SPDSS Groundwater geodatabase and once the inputs are configured the SFR2 file is generated using the SFR Generator. These tools and the development of the SFR2 package are highlighted in **Figure 4** and discussed in the paragraphs below.

3.2 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 **Attachment C**. The *Streams* (fc) is represented by the light blue box with the title *Streams* (fc) shown in **Figure 4**.

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 **Attachment A**). This table can then be imported into the geodatabase and converted to a feature class as outlined in **Attachment 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 4**.

3.3 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 4** identifies the flow of data from one tool to the next for generating the SFR2 package.

3.3.1 Snap and Split Tool (Attachment 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 from 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)

3.3.2 Network Creation (Attachment 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. **Attachment D** identifies the procedure to create a network dataset.

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

3.3.3 Segment Numbering (Attachment 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)

3.3.4 Create Reaches (Attachment 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)

3.3.5 Attribute Fill (Attachment 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)

3.4 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 **Attachment H**. This and the other programs described in this section were tested and used in the development of the model inputs.

4.0 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. The functionality of this tool is available in current versions of GMS (8.2), so future application of the grid is not necessary if current versions of GMS are available.

4.1 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 **Attachment I**.

4.2 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 **Attachment J**.

4.3 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 **Attachment K**.

4.4 Modification of Program StatePP

Modifications were made to the existing DMI: StatePP to add MODFLOW's multi-node well (MNW) package capability (Halford and Hanson, 2002). The program StatePP was 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 **Attachment L** which is reproduced from earlier version presented in the RGDSS, with the addition of specific sections related to the MNW package.

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 **Attachment L**. The modifications to StatePP 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.

4.5 Lateral Boundary Processor

Significant recharge to the alluvium of the South Platte and tributaries occurs from inflow of recharge from areas adjacent to the main alluvial deposits that define the model extent. Much of this originates as deep percolation of applied irrigation water and canal seepage. Minor amount will also occur from infiltration of native precipitation. A data management interface was developed to track these components of recharge and use a time lag method to route these flows to boundary cells in the model. **Attachment M** provides documentation for this program.

4.6 Bedrock Flux Interface

The SPDSS uses information generated by the Denver Basin groundwater model, developed by the USGS (USGS, 2011), in order to quantify flow between the bedrock aquifers of the Denver Basin and overlying alluvial aquifers. The primary tool for accomplishing this are programs developed by the USGS and documented in Techniques and Methods 6-A28, developed with funding from the CWCB. Since the active areas in the Denver Basin model and the SPDSS model do not exactly overlap due to different levels of discretization, an a utility was developed to process bedrock flows for use in the SPDSS alluvial model. **Attachment N** documents use of this supplemental utility.

4.7 Rainfall Pre-Processor

This utility processes precipitation time series data and land use to create files for use with StatePP and with the ungaged surface water utility described in section 4.8. Use of this program is described in **Attachment O**.

4.8 Ungaged Surface Water Runoff Processor

This utility processes ungaged surface water runoff quantities generated in the rainfall pre-processor to distribute to the nearest stream reach in the SFR package. Use of this program is documented in **Attachment P**.

5.0 Summary and Conclusions

These enhancements will allow modelers to more quickly create and update model files. Detailed procedures used to implement each of these enhancements are included in Attachments A through P.

6.0 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 in the future.

7.0 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.
- Banta, E. R., Paschke, S. S., and Litke, D. W., 2008, User Guide and Documentation for Five MODFLOW Groundwater Modeling Utility Programs, U. S. Geological Survey Techniques and Methods 6-A28.
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- SPDSS (South Platte Decision Support System). 2007. SPDSS Phase 3 Task 50.4 Technical Memorandum Data Centered Groundwater Modeling Enhancements. Prepared for the CWCB and DWR by CDM Smith. March.









Prepared by: CDM

Attachment A

Documentation of the SPDSS_GW_Database

Appendix A: Documentation of the SPDSS_GW_database

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 Geodatabase
- 2.0 Software Requirements
- 3.0 Sources and Loading of Data
- 4.0 Maintaining Data
- 5.0 Log Procedure
- 6.0 Database Dictionary

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 hydrologic 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. This information includes stream cross section data, municipal and industrial pumping estimates, data from wells installed as part of the SPDSS field investigations and stream property measurements. Change logs are also maintained in the database. Tables created in the SPDSS_GW_database for these types of data include:

- crossSection
- crossSectionPoint
- crossSection
- MI_pumping
- SPDSS_wells
- stream_properties
- Log

Control tables contain data needed to improve the data density in the HydroBase or SPDSS_GW_database measured data tables to facilitate interpolation into model data sets. 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
- structures_xy_alias
- well_meas_control

Exclusion tables identify the measured data in HydroBase that are 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 modified to note this change. 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
- SFR_segmentation_pts
- SW_flux_boundary

1.2 Linked Data Tables

Linked tables from HydroBase are necessary so that 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 that have been 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_FeatureClasswell_meas_FeatureClass

Additional queries can be created, as needed, by the analyst to assist in populating and

📧 Main Switchboard	
	SPDSS_GW_database
	Update crossSectionPoint_FeatureClass
	Update geophlogs_FeatureClass
	Update MI_pumping_FeatureClass
	Update pumping_test_FeatureClass
	Update SFR_segmentation_pts_FeatureClass
	Update streams_properties_FeatureClass
	Update well_meas_FeatureClass
	Exit

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 the HydroBase data that have been 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 that 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. Modifications to tables can also be tracked using the Log table. In either case, it is imperative that 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 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.
aeophloas	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 aguifer'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.
Log	Stores information about all other tables in database; including data append date, appending analyst and any necessary notes.
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.

Table 1: Database Table Descriptions

Table Name	Table Description
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.
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.
streams_segments_endpoints	Data from the SPDSS_GW_geodatabase that represent the endpoints of all stream segments.
streams segments reaches	Data from the SPDSS_GW_geodatabase that represent the reaches of all stream segments.
structures_xy_alias	Alternative coordinates for structure locations to be used for modeling.
SW_flux_boundary	Surface water fluxes at the model boundary.
SW_flux_boundary_Feature_Class	Data from SW_flux_boundary to be used for creating a feature class in the SPDSS_GW_geodatabase.
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

		Field Data	Field	
Table Name	Field Name	Туре	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

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
				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
	Oreceld	alle Davide La		coordinates (meters)
crossSectionPoint	Crossivi	abDouble	8	I ne linear measure
				the cross section line
				measured from the left
				side of the line when
				looking downstream
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
			10	modified.
crossSectionPoint	user	dblext	10	User who last modified the
crossSectionPoint FeatureClass	CSCode	dbTaxt	30	Linique identifier for a
	COCOUE	UDTEX	50	cross section line
crossSectionPoint FeatureClass	utm x	dbDouble	8	UTM NAD83 zone 13N
	•••••_		Ū.	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
arass Section Daint Feature Class	alayatian	dbDoublo	0	Tooking downstream
crossSectionPoint_FeatureClass	elevation	apponpie	0	Elevation above mean sea
				point (NAV/D 88)
crossSectionPoint FeatureClass	Thalweg	dbBoolean	1	Identifies the point of
	manog	abbooloan	•	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
			5 40	queried from origin file.
crossSectionPoint_FeatureClass	query_user		510	User who performed the

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
				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
	ale athields a so	dhintonor	~	above sea level)
geophiogs	giogtnickness	abinteger	2	(foot)
geophlags	Oria 1986	dbBoolean	1	(leet) Boolean used to indicate if
geophiogs	Ollg_1900	ubboolean	I	the well was used in the
				1986 study
geophlogs	Excl aloatop	dbBoolean	1	TEMPORARY - Flag used
300000030			-	indicate if CDM was using
				the GLOGTOP value in the
				DSS.
geophlogs	Excl_glogbase	dbBoolean	1	TEMPORARY - Flag used
				indicate if CDM was using
				the GLOGBASE value in
				the DSS.
geophlogs	Excl_glogthickness	dbBoolean	1	TEMPORARY - Flag used
				the CLOCTHICKNESS
				value in the DSS
geophlogs	Comment	dbText	100	Comment field
geophlogs	modified	dbDate	8	Date record was last
	Incomod	abbato	Ű	modified.
geophlogs	user	dbText	10	User who last modified the
				record.
geophlogs	cdm_modified	dbDate	8	Date CDM 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
	alaghasa	dblotagar	2	above sea level)
	gioguase	ubinteger	2	specified aquifer (feet
				above sea level)
geophlags control	aloathickness	dbInteger	2	Thickness of the sand
	9.090.000	Jonnogor		(feet)
geophlogs control	comment	dbText	100	Comment field to indicate
				source of control and
				reason for control

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
				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
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	query_date	dbDate	8	Date information was queried from origin file.

Table Name	Field Name	Field Data	Field Size	Field Description
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 (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.
Log	TableName	dbText	50	Database Table Name
Log	date_append	dbDate	8	Date the table last updated with new records or information
Log	analyst_append	dbText	50	Name of the analyst that provided new records or information
Log	analyst_QC	dbText	50	Name of analyst that QCed the data
Log	In_Progress	dbYes/No	1	Indicates whether data is being QCed
Log	Complete	dbYes/No	1	Indicates whether data has gone through QC process
Log	date_QC	dbDate	8	Date of last QC
Log	Notes	dbText	200	Additional comments and/or notes
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

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
MI_pumping	quality	dbText	1	Quality code which defines
				the uncertainty factor of th
				data, and is developed
				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-
ML numping control	unit	dhText	50	Linits for the amt Linits
	unit	UDTEX	50	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
				and frequency of the
ML pumping control	modified	dhData	0	Original raw measurements
ML pumping_control	Inoullieu	dbDate	0 50	
	usei	ubrext	50	modification
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
	analyst annand	albTayt	50	table
MI_pumping_control	analyst_append	abrext	50	provided control
MI pumping control	exclude	dbBoolean	1	Yes indicates control no
<u>_</u> pp <u>g_</u> ccc.				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

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
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	query_date	dbDate	8	Date information was
			E40	queried from origin file.
MI_pumping_FeatureClass	query_user		510	User who performed the
numping toot		dbl.op.g	4	query.
pumping_test	pump_test_num	uprolig	4	identifier
numping test	well id	dbl ong	1	Well identifier. Foreign key
	wen_iu	ubcong	4	from [wells]
pumping test	testdate	dbDate	8	Date of the nump test
pumping_test	toptestint	dbLong	4	Top of tested interval (ET)
	baataatint	dbLong	4	Page of tested interval (11).
pumping_test	Daseleslint	abLong	4	
numping test	tewl	dhSingle	1	(FT). Pro-tost static water level
pumping_test	ISWI	upolitigie	4	measured in feet from
				around level Pressure
				head above ground level is
				given as a negative value.
pumping test	tfwl	dbSinale	4	Post-test final water level
		5		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
	taata	dh Cin al a	4	negative number.
pumping_test	testq	abSingle	4	Average testing discharge
				nor minuto
pumping test	testtime	dhSingle	1	Time in hours that the test
pumping_test	lestime	ubolingie	-	was conducted
pumping test	trans	dbl ong	4	Estimated transmissivity in
	trano	abeoing	•	gallons per day per foot
				(apd/ft).
pumpina 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

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
				with one or more
				monitoring wells.
pumping_test	leakance	dbText	40	Composite leakance
				between aquifer layers in
numping toot	ntoouroo	dbToyt	25	Units of 1/Days.
pumping_test	pisource	ubrext	25	test data CDWR=
				Colorado Division of Water
				Resources, CBP = Closed
				Basin Project (subset of
				USBR), CWCB 11 =
				Colorado Water
				circular #11
pumping test	pttype	dbText	25	Pump test type. Either
	P)P.0			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
				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
pumping tost	ntmultiplo	dbBooloon	1	Well Elag indicating the
pumping_test	punulupie	ubboolean	1	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	В	dbLong	4	Saturated thickness (feet)
pumping_test	comments	dbText	255	Pump test comments.
pumping_test	cdm_modified	dbDate	8	Date modified by CDM.
pumping_test_control	control_ID	dbText	50	Unique identifier.
pumping_test_control	utm_x	dbDouble	8	UTM NAD83 zone 13N
pumping test control		dbDoublo	0	LITM NAD82 zopo 12N
	uun_y	abboable	0	coordinates (meters)
pumping test control	aquifer	dbText	50	Aguifer
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-
				from confined aquifer tests
				nom commed aquiter tests

T _11, N _1,,		Field Data	Field	
I able Name	Field Name	Туре	Size	Field Description
				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
· · · · ·			-	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
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
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
pumping test evolusions	data modified	dbData	0	Date of last modification:
	uale_moulleu	UDDale	0	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	dblext	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

Table Name	Field Name	Field Data	Field	Field Description
		Туре	0120	coordinates (meters)
pumping test FeatureClass	utm v		16	UTM NAD83 zone 13N
	uni_y			coordinates (meters)
pumping_test_FeatureClass	aquifer1	dbText	4	Aquifer in which well is
				located.
pumping_test_FeatureClass	aquifer2	dbText	4	If well is located in two
				aquifers, name of second
	anna taat anna		4	aquifer.
pumping_test_reatureClass	pump_test_num	abLong	4	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	hasetestint	dbLong	4	Base of tested interval
	basetestint	ubeong		(FT).
pumping test FeatureClass	tswl	dbSingle	4	Pre-test static water level
		J		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
				nead above ground level is
numping test FestureClass	drowdown	dhCinalo	1	given as a negative value.
	ulawuowii	ubolligie	4	protect 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
numping test FestureClass	tropo	dbl.opg	1	was conducted.
	lidits	ublong	4	callons per day per foot
				(apd/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
pumping toot Footure Close	laakanaa	dhTout	40	monitoring wells).
pumping_lest_reatureClass	leakance	ubrext	40	between aquifer lavers in
				units of 1/Davs.

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
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
numping test FeatureClass	nttype	dbText	25	Circular #11. Pump test type Fither
	риуре	UDTEX	20	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	В	dbLong	4	Saturated thickness (feet)
pumping_test_FeatureClass	comments	dbText	255	Pump test comments.
pumping_test_FeatureClass	cdm_modified	dbDate	8	Date modified by CDM.
pumping_test_FeatureClass	Κv	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)

Table Name	Field News	Field Data	Field	Field Description
	Field Name	Туре	Size	Field Description
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
SFR_segmentation_pts	diversion	dbText	50	Name of the diversion diverting from the point- Use HydroBase Structure
SEP cognostation atc		dbToxt	50	ID Name of the streamflow
	yaye	ubrext	50	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).

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
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 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)

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
				can be located at xcpt2 to xcpt7.
SFR segmentation pts	zcpt6	dbSinale	4	Height relative to the
		J J J J J J		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	zcpt7	dbSingle	4	Height relative to the
				lowest elevation of the
				Streambed (thatweg) at
				thelweg (set equal to 0.0)
				can be located at xcpt2 to
				xcpt7.
SFR_segmentation_pts	zcpt8	dbSingle	4	Height relative to the
		Ū		lowest elevation of the
				streambed (thalweg) at
				location xcpt8 (feet). The
				thalweg (set equal to 0.0)
				can be located at xcpt2 to
CED commentation ato		albTayt	055	xcpt/.
SFR_segmentation_pts	comment	dbText	200	Comments Data report was last
SFR_segmentation_pts	modified	doDate	8	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	UIM NAD83 zone 13N
SEP componential atc. EasturoClass	utm v	dbDoublo	0	LITM NAD82 zono 12N
	utin_y	uppouple	0	coordinates (meters)
SFR segmentation pts FeatureClass	node type	dbText	10	Type of node, either fnode
				or thode.
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
SFR segmentation nts FeatureClass	gage	dbText	50	Name of the streamflow
	guyu	GDIGAL	50	dage at that point
SFR segmentation pts FeatureClass	icalc	dbInteaer	2	Method used by the SFR
		- 3 -		package to calculate depth
				of water in channel
SFR_segmentation_pts_FeatureClass	roughch	dbSingle	4	Manning's roughness for

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
				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 =
SED accompation ato EasturaClass	fdath	dhCinala	1	Capin Qrapin)
SFR_segmentation_pts_FeatureClass	lapin	upolitigie	4	stream depth (width -
				cdoth*O^fdoth)
SER segmentation pts FeatureClass	awdth	dbSingle	4	Power coeffecient of
	awaan	abolingio		stream width (width =
				awdth*Q^bwdth)
SFR segmentation pts FeatureClass	bwdth	dbSingle	4	Power coeffecient of
		U U		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.
				(feet)
SER segmentation pts EeatureClass	vent2	dhSingle	4	Distance from the left bank
		abolingie		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
CED commentation ato EastureClass	vent5	dh Cin al a	4	(Teet).
SFR_segmentation_pts_FeatureClass	хсріэ	abSingle	4	of the stream channel
				when looking downstream
				(feet)
SFR segmentation pts FeatureClass	xcpt6	dbSinale	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
				(teet).

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
SFR_segmentation_pts_FeatureClass	xcpt8	dbSingle	4	Distance from the left bank of the stream channel when looking downstream (feet).
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.
		Field Data	Field	
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Table Name	Field Name	Туре	Size	Field Description
SFR_segmentation_pts_FeatureClass	zcpt8	dbSingle	4	Height relative to the
				lowest elevation of the
				location vont8 (feet) The
				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
		alle T e suit	00	modified.
SFR_segmentation_pts_FeatureClass	user	dblext	20	User who last modified the
SFR segmentation pts FeatureClass	querv date	dbDate	8	Date information was
	1		-	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
SPDSS wells	normitno	dbl.ong	1	register.
SPDSS_wells	permittuf	dbLong	4	Well suffix code
	permitsul	dbText	3	Well suffix code.
SFD35_wells	permittpi	ubrext	1	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
SPDSS wells	a40	dbToyt	2	Indicator.
	 	UDTEXL	2	indicator
SPDSS wells	q10	dbText	2	10 acre guarter section
				indicator.

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
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
				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
00000				degrees).
SPDSS_wells	loc_accuracy	dbInteger	2	Horizontal location
00000 "				accuracy indicator.
SPDSS_wells	gs_elev	abSingle	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
			4	measurement method.
SPDSS_wells	IOG_SVVL	abLong	4	Geophysical log
				measurement surface
SDDSS wolls	log data	dhData	0	Goophysical log
	log_date	ubbale	0	measurement date of
				measurement
SPDSS wells	aquifer1	dbText	4	Aquifer in which well is
	aquitori	abrext	т	located.
SPDSS wells	aguifer2	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.

Table Name	Field Name	Field Data	Field	Field Description
		туре	JIZE	(GPM)
SPDSS wells	bedrock elev	dbSingle	4	Elevation of bedrock
SPDSS wells	sat 1965	dbSingle	- т Д	
	romarke1	dbText	255	Generic remarks
	remarka2	dbText	200	Generic remarks
	Terriarksz		200	
	owner	dbText	00	Owner's luiname.
	address	dbText	255	Address of owner.
	City	dblext	50	City.
SPDSS_wells	st	dblext	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.

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
streams_properties	user	dbText	10	User who last modified the record.
streams_properties_FeatureClass	ID	dbText	50	Unique Identifier
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.
streams_segments_endpoints	TYPE	dbText	10	Type of node, either fnode or tnode.
streams_segments_endpoints	LENGTHFEET	dbDouble		
streams_segments_endpoints	StrOrder	dbLong	4	Identifies stream order
streams_segments_endpoints	SegmentID			Segment identifier
streams_segments_endpoints	NAME	dbText		Name of stream or diversion
streams_segments_endpoints	OutSeg			Stores the [SegmentID] of the stream segment downstream of a segment
streams_segments_endpoints	IUpSeg			Stores the upstream stream [SegmentID] from which the diversion segment diverts
streams_segments_endpoints	tributary	dbText	50	Name of the tributary that flows in at that point
streams_segments_endpoints	diversion	dbText	50	Name of the diversion diverting from the point- Use HydroBase Structure ID
streams_segments_endpoints	gage	dbText	50	Name of the streamflow gage at that point
streams_segments_endpoints	icalc	dbInteger	2	Method used by the SFR package to calculate depth of water in channel
streams_segments_endpoints	roughch	dbSingle	4	Manning's roughness for channel
streams_segments_endpoints	roughbk	dbSingle	4	Manning's roughness for overbank

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
streams_segments_endpoints	cdpth	dbSingle	4	Power coeffecient of
				stream depth (width =
streams segments endpoints	fdoth	dhSinglo	1	Rewer coeffections of
streams_segments_enupoints	iupin	ubolingle	4	stream depth (width -
				cdpth*Q^fdpth)
streams segments endpoints	awdth	dbSinale	4	Power coeffecient of
		J		stream width (width =
				awdth*Q^bwdth)
streams_segments_endpoints	bwdth	dbSingle	4	Power coeffecient of
				stream width (width =
				awdth*Q^bwdth)
streams_segments_endpoints	hcond	dbSingle	4	Vertical Hydraulic
				conductivity of the
streams segments endpoints	thickm	dhSinala	1	Streambed thickness (feet)
streams_segments_endpoints		dbDouble	- + 8	Streambed thickness (feet)
streams_segments_endpoints	width	dbDouble	0	Streambed width (foot)
streams_segments_endpoints	depth	dbSingle	4	Dopth of water in
streams_segments_endpoints	depth	upsingle	4	streambed (feet)
streams_segments_endpoints	xcpt1	dbSingle	4	Distance from the left bank
				of the stream channel
				when looking downstream.
				By default xcpt1 is 0.0.
atroone componte ondrointe		dh Cin al a	4	(Teet)
streams_segments_endpoints	xcptz	abSingle	4	of the stream channel
				when looking downstream
				(feet).
streams_segments_endpoints	xcpt3	dbSingle	4	Distance from the left bank
				of the stream channel
				when looking downstream
				(feet).
streams_segments_endpoints	xcpt4	dbSingle	4	Distance from the left bank
				of the stream channel
				(feet)
streams segments endpoints	xcpt5	dbSinale	4	Distance from the left bank
	хорю	asenigie	•	of the stream channel
				when looking downstream
				(feet).
streams_segments_endpoints	xcpt6	dbSingle	4	Distance from the left bank
				of the stream channel
				when looking downstream
streams segments endpoints	vont7	dhSinglo	1	(leet). Distance from the left bank
streams_segments_enupoints	хори	ubolingle	4	of the stream channel
				when looking downstream
				(feet).
streams_segments_endpoints	xcpt8	dbSingle	4	Distance from the left bank
				of the stream channel
				when looking downstream

Table Name	Field Name	Field Data	Field Size	Field Description
		Type	0120	(feet).
streams_segments_endpoints	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.
streams_segments_endpoints	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.
streams_segments_endpoints	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.
streams_segments_endpoints	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.
streams_segments_endpoints	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.
streams_segments_endpoints	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.
streams_segments_endpoints	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.
streams_segments_endpoints	zcpt8	dbSingle	4	Height relative to the lowest elevation of the streambed (thalweg) at

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
				location xcpt8 (feet). The
				thalweg (set equal to 0.0)
				can be localed at xcpiz to
atrooma acamonta racebaa		dbToyt		Nome of stream or
streams_segments_reaches		ubrext		diversion
streams segments reaches	StrOrder	dbl ong		Identifies the stream order
streams segments reaches		abeong		
streams_segments_reaches	Enabled	dbl.ong		Created as part of the
streams_segments_reaches	LIIdbieu	ubeong		deometric network process
streams segments reaches	L enathFeet	dbDouble		Stream length of reach
	Longin oot	abboable		(feet)
streams segments reaches	SegmentID			Segment identifier
streams segments reaches	OutSeg	dbLona		Stores the [SegmentID] of
_ 0 _	5	5		the stream segment
				downstream of a segment
streams_segments_reaches	IUpSeg	dbLong		Stores the upstream
				stream [SegmentID] from
				which the diversion
				segment diverts
streams_segments_reaches	ROW	dbLong		Model grid row of stream
				segment reach
streams_segments_reaches	COLUMN_	dbLong		Model grid column of
atroomo cogmonto rocoboo		dhlana		stream segment reach
streams_segments_reaches	ACTIVE_COD	abLong		arid cell is part of the
				active grid
streams segments reaches	Cell ID	dbText		Combination of model grid
	0011_12	abrox		row and model grid column
streams segments reaches	REACHID	dbLong		Number created for each
		0		reach of all stream
				segments
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
				Zone 13 for modeling
structures vy alias	utm v alias		16	The alias v (Northing)
Structures_xy_anas	utin_y_anas		10	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
CW/ flux hounders		allaTarret	F 0	package)
	stream_name		50	
SW_flux_boundary	date	dbDate	8	Format is Month/Year

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
				(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.
SW_flux_boundary_Feature_Class	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_Feature_Class	stream_name	dbText	50	Name of Stream
SW_flux_boundary_Feature_Class	date	dbDate	8	Format is Month/Year (MM/YYYY)
SW_flux_boundary_Feature_Class	flux	dbDouble	8	feet^3/day
SW_flux_boundary_Feature_Class	modified	dbDate	8	Date record was last modified.
SW_flux_boundary_Feature_Class	user	dbText	25	User who last modified the record.
SW_flux_boundary_Feature_Class	query_date	dbDate	8	Date information was queried from origin file.
SW_flux_boundary_Feature_Class	query_user	dbText	255	User who performed the query.
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)
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	cdm_modified	dbDate	8	TEMPORARY - Date CDM 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)

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
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.
			400	(Feet above sea level)
well_meas_control	comment	dblext	100	Comment field to indicate
				reason for control
well meas control	date append	dbDate	8	Date record appended to
	date_append	abbato	Ű	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
	maga data	dhData		from [wells].
well_meas_exclusions	meas_date	doDate	8	Date of water level
well mass exclusions	w. elevation	dbDoublo	0	Elevation of water level
well_meas_exclusions	wi_elevation	apponpie	0	(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
	commone	UDICAL	50	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
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
			055	not be excluded
well_meas_FeatureClass	well_id	dblext	255	Well identifier. Foreign key
well mass FeatureClass	woll name	dbToxt	60	Nome of the well
	weil_liame	dbl.ong	00	
	permitrio	dbLong	4	
weil_meas_FeatureClass	permitsuf	dblext	3	VVell suffix code.
well_meas_FeatureClass	utm_x		16	UTM NAD83 zone 13N
well many Fasture Class	utro v		16	
well_lileds_realureClass	uun_y		10	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.

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
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.
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.

		Field Data	Field	
Table Name	Field Name	Туре	Size	Field Description
wells	utm_y		16	The y (Northing)
				component of the
				Universal Transverse
				Mercator system. NAD83
welle	latdaadaa		16	Zone 13.
wens	laidecdeg		10	degrees)
wells	lonadecdea		16	Longitude (decimal
Wens	longueddeg		10	degrees)
wells	loc accuracy	dblnteger	2	Horizontal location
				accuracy indicator.
wells	gs_elev	dbSingle	4	Ground surface elevation.
wells	elev accuracy	dbInteger	2	Vertical location accuracy
		Ū		indicator.
wells	well_depth	dbLong	4	Completed depth of well
				(feet).
wells	log_depth	dbLong	4	Geophysical log
				measurement depth.
wells	log_type	dblext	20	Geophysical log
welle	log SW/	dbl.ong	1	Coophysical log
wens		abcong	4	measurement surface
				water level
wells	log date	dbDate	8	Geophysical log
	109_0010	abbato	Ũ	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
- 11-			055	aquiter.
weils	aquiter_comment	ablext	255	Any comments associated
				with the aquiler(s) that the
wells	toorf	dbl ong	1	Depth to top of first
weils	ipen	ubeong	4	perforated casing (FEET)
wells	bperf	dbLona	4	Depth to base of last
				perforated casing. (FEET)
wells	yield	dbSingle	4	Actual pumping rate.
	-	Ū		(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		dbText	20	Cell phone number
WOID	oon_priorio		20	

Table Name	Field Name	Field Data	Field Size	Field Description
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.
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.

Attachment B

Documentation of the SPDSS GW Geodatabase

Attachment B: Documentation of the SPDSS GW Geodatabase

Purpose

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 Access.

- 1.0 Structure of the Geodatabase
- 2.0 Software Requirements
- 3.0 Sources and Loading of Data
- 4.0 Maintaining Data
- 5.0 Log Procedure

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 (Version 9.2) or Microsoft Access 2003. Use of versions other than those noted has not been tested.

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
- SW_flux_boundary_Feature_Class

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

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

Table 1: Correlation of Database Tables to Geodatabase Feature Classes

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"
- 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 versions of a 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 needs 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 that are added to and modified in the geodatabase. The table has fields for the filename, analyst, date, and comment, which are 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.

Attachment C

Documentation of Snap and Split Tool

Attachment C: Documentation of Snap and Split Tool

The Snap and Split tool splits streams into segments for the MODFLOW 2000 SFR 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 SFR2 package. 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
1.0 Revision History
2.0 Installation
3.0 Program Description
4.0 Input File Description
5.0 Output Files Description
6.0 User Interface
7.0 Source Code

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 CDM Smith for the South Platte Decision Support System (SPDSS).

2.0 Installation

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



document *CDSS_SFR2_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 9.2 to run. After opening the file *CDSS_SFR2_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 that has 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 1 meter from a polyline endpoint it will be moved to the endpoint. This is so that new polyline features will not be created with a length of less than 1 meter. 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 which will be modeled with the SFR2 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 \rightarrow Generalization \rightarrow 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 SFR2 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 which will 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 that 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 that were 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. The output files will need to be merged with the SRF diversion points and diversion segments. A detailed description of this process can be found in the SFR Geotools Processing Guide.

6.0 User Interface

Snap And Split Program	X							
– Selection of the layers' –								
Select the points layer to be displaced	SFR_segmentation_pts							
Select the points layer field to use for joining	NAME							
Enter the name and location of the point dataset to be created	C:\\SFR_segmentation_pts_snap							
Select the reference layer on which the points will be displaced	Streams 💌							
Select the points layer field to use for joining	NAME							
Enter the name and location of the line dataset to be created	C:\\Streams_segments							
Search radius	1000 Meters							
Creation of a field to store the distance of displacement. If the field name exists, existing values will be overwritten. Field name deplac								
Split the line on which the point will be displaced (optional)								
About	Start Process Cancel							

The user interface, shown in the figure above, 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. We recommend using a search radius of 4000 feet.

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 the user wishes 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_SFR2_Development.mxd* and can be viewed through ArcMap's Visual Basic Editor.

Table 1: SFR 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							Х	Х	Х	Х	Х																
1	Х						Х	Х	Х	Х																	
2	Х	Х					Х	Х	Х			Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х
3			Х	Х	Х	Х	Х	Х	Х	Х																	
		Thes requ spec	se fields ired for :ified Ica	are the IIC																							

X 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

Attachment D

Documentation of Procedural Steps to Create an ArcGIS Network

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

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 SFR MODFLOW 2000 package. Creating a network is part of the process used in the development of the SFR1 package. This documentation assumes the user has basic familiarity with ArcGIS software.

- 1.0 Revision History
- 2.0 Software Requirements
- 3.0 Procedural Steps
- 4.0 Input File Description
- 5.0 Output Files Description

1.0 Revision History

The procedural steps for developing a network dataset were developed by CDM Smith for the South Platte Decision Support System (SPDSS).

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

The following procedural steps describe the development of a network dataset. An additional detailed description of this process can be found in the SFR Geotools Processing Guide.

- 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 \rightarrow 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.

Attachment E

Documentation of Segment Numbering Tool

Attachment E: Documentation of Segment Numbering Tool

The purpose of the Segment Numbering tool is to number the segments for the MODFLOW 2000 SFR 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 SFR2 package. 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 Disclaimer1.0 Revision History2.0 Installation3.0 Program Description4.0 Input File Description5.0 Output Files Description6.0 User Interface7.0 Source Code

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.

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1.0 Revision History

Version 1.0 of the Segment Numbering tool was developed by CDM Smith.

2.0 Installation

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



document *CDSS_SFR2_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_SFR2_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 SFR2 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. A detailed description of this process can be found in the SFR Geotools Processing Guide. The components of the user interface are described below:

Stream Ordering		×							
- Selection of the Layers		1							
Select the Stream Layer	Streams_Segments								
Enter the Stream Layer field that contains the Stream Code or Name	NAME								
Enter the Stream Layer field that contains the Stream Order	StrOrder 🗸								
Select the Stream Layer field that will contain the stream numbering	SegmentID								
End Points		1							
Enter the location of the pipe end point shapefile (this file will be named "Streams_segment_endpoints.shp")									
OID of starting Junction: 18									
About	Start Process Cancel								

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_SFR2_Development.mxd* and can be viewed through ArcMap's Visual Basic Editor.

Attachment F

Documentation of Create Reaches Tool

Attachment F: Documentation of Create Reaches Tool

Version 1.0 June 21, 2010

The purpose of the Create Reaches tool is to create reaches by intersecting the stream segments with the model grid for the MODFLOW 2000 SFR 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 SFR2 package. 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
1.0 Revision History
2.0 Installation
3.0 Program Description
4.0 Input File Description
5.0 Output Files Description
6.0 User Interface
7.0 Source Code

1.0 Disclaimer

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1.0 Revision History

Version 1.0 of the Reach Creation tool was developed by CDM Smith.

2.0 Installation

The tool was developed in Visual Basic for Applications (VBA) and is embedded in the master document *CDSS_SFR2_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_SFR2_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. A detailed description of this process can be found in the SFR Geotools Processing Guide. The components of the user interface are described below:
Create Reaches		×
- Selection of the Layers		
Select the Stream Layer	Streams_Segments	•
Select the Grid Layer	Model_grid	•
Reaches Enter the location of the reaches shapefile.	C:\\Streams_segments_reaches	
About	Start Process Cancel	

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_SFR2_Development.mxd* and can be viewed through ArcMap's Visual Basic Editor.

Attachment G

Documentation of Attribute Fill Tool

Attachment G: Documentation of Attribute Fill Tool

Version 1.0 June 21, 2010

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 SFR 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 SFR package. 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
1.0 Revision History
2.0 Installation
3.0 Program Description
4.0 Input File Description
5.0 Output Files Description
6.0 User Interface
7.0 Source Code

0.0 Disclaimer

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1.0 Revision History

Version 1.0 of the Attribute Fill tool was developed by CDM Smith.

2.0 Installation



The tool was developed in Visual Basic for Applications (VBA) and is embedded in the master document *CDSS_SFR2_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_SFR2_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 (thode) 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 SFR2 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 thode 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. A detailed description of this process can be found in the SFR Geotools Processing Guide. The components of the user interface are described below:

User Interface of the Attribute Fill Tool:

Spatial Join			
Selection of the Lavers			
Select the Source Point Layer	SFR_Segmentation_Pts_Snap		
Select the NAME Join Field	NAME		
Select the TNODE/FNODE TYPE Field	NodeType		
Destination Point Layer			
Select the Destination Point Layer (Personal Geodatabase Featureclass)	Streams_Segment_Endpoints		
Select the NAME Join Field	NAME		
Select the TNODE/FNODE TYPE Field	TYPE		
Select the LENGTH Field (in feet)	LENGTHFEET		
Select the SEGMENT ID Field	SegmentID		
Select the OUT SEGMENT Field	OutSeg 🗸		
Select the UPSTREAM SEGEMENT Field	IUpSeg 🗨		
Select the STREAM ORDER Field	StrOrder		
About	Start Process Cancel		

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.

Attachment H

SFR Generator

Attachment H to Appendix J

Attachment H: SFR Generator

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

0.0 Disclaimer
1.0 Revision History
2.0 Installation
3.0 Program Description
4.0 Input File Description
5.0 Output Files Description
6.0 User Instructions
7.0 Source Code

0.0 Disclaimer

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1.0 Revision History

Version 1.0 of the SFR Generator was developed by CDM Smith.

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.

cripton				
Enter Run Description				
Control Parameters				
Tolerance	0.0001			
Number Stress Periods	1			
Output Controls				
	0	IRDFLG	0	
ISTCB1				
ISTCB1	-81	IPTFLG	0	

7.0 Source Code

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

Attachment I

Grid Generation Tool

Attachment I to Appendix J

Attachment I: Grid Generation Tool

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

0.0 Disclaimer
1.0 Revision History
2.0 Installation
3.0 Program Description
4.0 Input File Description
5.0 Output Files Description
6.0 User Instructions
7.0 Source Code

0.0 Disclaimer

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1.0 Revision History

Version 1.0 of the Grid Generation Tool was developed by CDM Smith.

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 **Attachment 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:

GMS_grid - Select h	nput Files	×
CLog File Name		
Select		
⊂ Shapefile Name (no e	xtension) in same directory as log file	
GMS Grid File (.asc,.3	dg)	
Select		
🔲 Convert GMS Ho	rizontal Coordinates from Feet to Meters in Shapefile	
Elevation files		
Include Elevation	s in Shaperlie	
GMS	S Top Elevation File (.dat)	
GM	S Bottom Elevation File (.dat)	
Select		
Hydraulic Conductivity	· · · · · · · · · · · · · · · · · · ·	
Include Hydraulic	Conductivity in Shapefile	
Select		
Help	OK Cance	
Tieb		

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.

Attachment J

Creating and Activating a Grid in GMS

Attachment J: Creating and Activating a Grid in GMS

June 21, 2010

The purpose of this appendix is to document the procedural steps one must follow to create a grid in GMS (Version 6.0), 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 select the GIS module; GIS \rightarrow Enable ArcObjects
- 2. GIS \rightarrow Add Data \rightarrow 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 \rightarrow New Conceptual Model \rightarrow OK
- 5. Right Click on the Conceptual Model \rightarrow New Coverage \rightarrow Check the box "Use to define

🔤 Coverage Setup	
Coverage Name: new coverage	e Horizon ID:
Preset: Custom	Coverage type:
Sources/Sinks/BCs	Areal Properties Observation Points
Source/Sink/BC Type All Layer range Wells Refine points Specified Head Specified Flow General Head Drain River	 Property All Color Layer range Recharge rate Horizontal K Vertical K Vertical anis. Vertical anis.
Default layer range: 1	to 1 Default elevation: 0.0
🔽 Use to define model bounda	ary (active area)
3D grid layer option for obs. pts.	: By z location
MODAEM models:	NONE
Help	OK Cancel

model boundary (active area)" \rightarrow 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.)

Create Finite Difference Grid					
X-Dimension Origin: 516390.23627069 Length: 187998.6253451 (ft) Bias: 1.0 ✓ Use base and limit Number cells: 10 Base cell size: 100.0 Limit cell size: 100.0	Y-Dimension Origin: 4369293.0105799 Length: 156665.52112092 (ft) Bias: 1.0 (ft) I Image: the set of the s	Z-Dimension Origin: 0.0 Length: 0.0001 (ft) Bias: 1.0 Use base and limit Number cells: 1 Base cell size: 4.0 Limit cell size: 20.0			
Orientation / type: MODFLOW Rotation about Z-axis: 0.0 Orientation Grid type Grid type Mesh centered Help OK Cancel					

- b. Click OK
- 9. In the project explorer, click on 3D Grid Data; MODFLOW \rightarrow New Simulation \rightarrow 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

Attachment K

Importing a 2d Scatter Dataset to Create a Layer in GMS

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

June 21, 2010

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(Version 6.0). 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 \rightarrow 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 \rightarrow 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 \rightarrow MODFLOW \rightarrow LPF Package \rightarrow 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

Attachment L

Updated Documentation of StatePP to Include the Multi-Node Well Package Capability

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

- 1.) Documentation of StatePP (pages L-1 L-60)
- 2.) Appendix J of StatePP documentation (pages L-61 L 89)

RGDSS Memorandum

Final

To: Ray Bennett, P.E.

From: HRS Water Consultants, Inc. Judith Schenk and Mark PalumboSubject: 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, <u>A modular three-dimensional finite-difference ground-water flow model</u>, Techniques of Water-Resources Investigations 06-A1, USGS, 576 p.

Attachment L to Appendix J

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

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.

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.

14010 11 11	ppi ouch used in Statel I		
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		

 Table 1. Approach used in StatePP

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.

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

 Table 2. User created input files for StatePP

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	
Unconsumed surface water from irrigation	
Unconsumed ground water from irrigation	
Ground water pumping for irrigation	Consumptive use modeling
Ditch shortage for subirrigation	contractor
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	inforn	nation
----------	---------	-------	-------	------	---------	---------	--------	--------

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

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

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

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.

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

Table 6. Files created by the utility program AGG

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.

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

Table 7. MODFLOW files and other files created by StatePP

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.

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
	CANAL.OUT	Canals
	IRRLAND.OUT	Irrigated lands
	IRRWELLS.OUT	Irrigation wells
Spatial Data	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

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

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:

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

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 subirrigated 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:

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

Where:

AVGRATE_{sp} = average precipitation recharge rate for stress period *sp* (ft³/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.

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

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

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:

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

Where:

= 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 <i>str</i> in
	stress period sp (ft ³ /d),
L _i	= length of a canal reach in a grid cell i (ft),
Wi	= 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 <i>str</i> .

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 <i>str</i> for stress period <i>sp</i> 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</u> <u>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:

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

Where:

A _i	= area of irrigated land in grid cell <i>i</i> for structure <i>str</i> (acres),
Wi	= weight associated with irrigated area in grid cell <i>i</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 <i>str</i> for
	stress period sp (ft ³ /d),
facsw _{str}	= user entered recharge adjustment factor for unconsumed surface
	water for structure <i>str</i> .

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:

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 <i>str</i>
	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 <i>rm</i> in grid cell <i>i</i> ,
AVGRMF _{rm,sp}	= average rim inflow recharge for rim inflow zone <i>rm</i> for stress
	period sp (ft ³ /d),
fac _{rm}	= user entered recharge adjustment factor for rim inflow recharge
	for rim inflow zone <i>rm</i> .

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:

 $\text{RCRMR}_{i,rm,sp}$ = 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:

$$\begin{array}{ll} \text{RCPI}_{i,\text{sp}} &= \text{recharge from precipitation on irrigated land for grid } i \text{ cell for stress} \\ & \text{period } sp \ (\text{ft}^3/\text{d}), \end{array}$$

$$\begin{array}{ll} \text{AI}_i &= \text{area of irrigated land in grid cell } i \ (\text{acres}), \end{array}$$

$$\begin{array}{ll} \text{AVGPRI}_{\text{sp}} &= \text{average precipitation recharge for this county/HUC} \\ & \text{combination on irrigated land for stress period } sp \ (\text{ft/d}). \end{array}$$

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

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

Where:

RCPN _{i,sp}	= recharge from precipitation on non-irrigated land in grid cell <i>i</i> for
	stress period sp (ft ³ /d),
AN _i	= area of non-irrigated land in grid cell <i>i</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 (ft³/d),AVGGW_str,sp= Average ground water diversion for all parcels for structure str
for stress period sp (ft³/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 pumpedby 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 <i>sp</i> ,
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 <i>wl</i> , 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 (ft³/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 waterassociated 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 (< 1 foot) 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.

MNW flag	Required MNW Data Provided in Input Well Files	Result
1	Yes	MNW file generated
1	No	Error during read-in, program stops
0 or	Vac	MNW not generated, additional MNW
omitted	1 65	data ignored
(blank)	No	MNW not generated

 Table 4.1. Input options and results

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, DRT1², 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, <u>MODFLOW-2000, The U.S. Geological Survey modular ground-water model –</u> <u>documentation of packages for simulating evapotranspiration with a segmented function (ETS1) and drains</u> <u>with return flow (DRT1)</u>, 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:

$$DRELEV_i = SURF_i - DRMIN$$

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:

$$DRELEV_i = SURF_i - DRMAX$$

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 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 p				
	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 forthe 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**

For each stress period

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

Finish stress period calculations

Figure 1. General flow chart of StatePP.
Flow Data

- <u>Consumptive Use contractor</u> Canal leakage Unconsumed surface water from irrigation Unconsumed ground water from irrigation Agricultural pumping Ditch shortage Water requirement for crop Precipitation recharge on irrigated land Precipitation recharge on non-irrigated land
- Surface Water contractor Rim inflow recharge
- <u>Ground water contractor</u>
 Municipal and industrial pumping and recharge

Spatial Data

- Spatial database contractor Canals Irrigated acreage Irrigation wells Rim inflow areas County/HUC/vegetation distribution Native vegetation Low capacity wells Irrigated crop
- <u>Ground water contractor</u> Municipal and industrial wells



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

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 <u>For each grid cell associated with this structure</u> Get grid cell location, length of canal in grid cell and weight Calculate recharge in ft³/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 <u>For each grid cell associated with this structure</u> Get grid cell location, area of irrigated land in grid cell and weight Calculate recharge in ft³/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 ft³/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 ft³/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

For each structure in the GIS irrigation well file

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 specified 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.



Piecewise Linear Evapotranspiration Function

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
- 1.0 Acknowledgment
- 2.0 Introduction
- 3.0 Program Description
- 4.0 Input File Description
- 5.0 Output File Description
- 6.0 Comments and Concerns
- 1. A-1 Program Listing
- 2. A-2 Input File Listing
- 3. A-3 Output File Listing
- 4. A-4 StatePP Processing Details

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, <u>A modular three-dimensional finite-difference ground-water flow model</u>, 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.

<u>3.1 Time Step Capability</u>. 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.

<u>3.2 Preprocessing of Structure Data</u>. 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).

These reacted 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	

Table 6.Files created by the utility program AGG

<u>3.3 Program Flow</u>. 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 well file. If subirrigation are calculated and the MODFLOW well 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**.

<u>Response File</u> 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:

Kesponse File				
Row	Section	File Type	Typical File Name	Туре
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

<u>Table 4.1</u> Response Filo

Row	File Type	Typical File Name	Туре
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
2.1			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
		L.	lands
40	Orographic_NonIrr_Land	X4P000.prfn	Orographic non
		*	irrigated lands

<u>Table 4.1</u> Response File (cont.)

<u>4.2 Control File</u> 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.

1-1 levt 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 = off, >0 = number of boundary flux values 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, 2 = number of boundary flux values 1-12 Ippt Ppt switch 1=county Huc, 2 = Krigged ppt data, 3 = Orographic ppt data 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 = charge factor 1-17 mnwflag Switch for generating a Multi	Row	Variable	Description
1-2 Iflw Flowing Well switch 0 = off, 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 = off, >0 = mumber of boundary flux values 1-8 ibflux Boundary Flux switch 0 = off, >0 = number of boundary flux values 1-9 Igr Ground switch 0 = off, >0 = number of boundary flux values 1-9 Igr Ground 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 = off, 1 = on 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) packa	1-1	Ievt	ET switch $0 = 0$ ff, $1 = 0$ n
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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 = off, >0 = number of boundary flux values 1-8 ibflux Boundary Flux switch 0 = off, >0 = number of boundary flux values 1-9 Igr Ground switch 0 = off, 1 = on 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 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_iunps U	1-4	Ipmp	Pumping switch $0 = off$, $1 = on$
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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_iungs 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 3c). If set to 0 o	1-6	Iprn	Print detail control 0 = none, 1=detailed
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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, 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. 1-20 mnw_iunqs Unit number and flag. If set to greater than 0, value is unit number for the MNW file output of th	1-13	Im2k	Modflow 2k switch; 0 = Modflow 1998, 1 = Modflow 2000
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 reless, 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_iungs 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. 2-112 Pfaci(im) Irrigated acreage monthly recharge factors (%) 3-112 Pfacn(im) Non Irrigated acreage monthly recharge factors (%)	1-14	Iwadj	Well adjustment switch; $0 = off$, $1 = on$
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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. 2-112 Pfaci(im) Irrigated acreage monthly recharge factors (%) 3-112 Pfacn(im) Non Irrigated acreage monthly recharge factors (%)	1-16	IrchFac	Global recharge factor; $0 = off$, $>0 = recharge factor$
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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 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. 2-112 Pfaci(im) Irrigated acreage monthly recharge factors (%) 3-112 Pfacn(im) Non Irrigated acreage monthly recharge factors (%)			= on If set to 1, input well files must contain ID, top layer and bottom
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. 1-20 mnw_iunqs Unit number and flag. If set to 0 or less, QSUM not written. If set greater than 0, must be a two-digit number. 2-112 Pfaci(im) Irrigated acreage monthly recharge factors (%) 3-112 Pfacn(im) Non Irrigated acreage monthly recharge factors (%)			layer
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. 2-112 Pfaci(im) Irrigated acreage monthly recharge factors (%) 3-112 Pfacn(im)	1-18	mnw_iunw1	Unit number and flag. If set to greater than 0, value is unit number for
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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. 2-112 Pfaci(im) Irrigated acreage monthly recharge factors (%) 3-112 Pfacn(im) Non Irrigated acreage monthly recharge factors (%)			documentation item 3a). If set to 0 or less, WEL1 not written. If set
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1-20 mnw_iunqs Unit number and flag. 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. 2-112 Pfaci(im) Irrigated acreage monthly recharge factors (%) 3-112 Pfacn(im) Non Irrigated acreage monthly recharge factors (%)			the MNW file output of the BYNODE file (See USGS MNW
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. 2-112 Pfaci(im) Irrigated acreage monthly recharge factors (%) 3-112 Pfacn(im) Non Irrigated acreage monthly recharge factors (%)			documentation item 3b). If set to 0 or less, BYNODE not written. If
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112 Pfacn(im) Irrigated acreage monthly recharge factors (%) 3-112 Pfacn(im) Non Irrigated acreage monthly recharge factors (%)	1-20	mnw_iunqs	Unit number and flag. If set to greater than 0, value is unit number for
2-112 Pfaci(im) Irrigated acreage monthly recharge factors (%) 3-112 Pfacn(im) Non Irrigated acreage monthly recharge factors (%)			decumentation item 2a). If set to 0 or less OSUM not written. If set
2-112 Pfaci(im) Irrigated acreage monthly recharge factors (%) 3-112 Pfacn(im) Non Irrigated acreage monthly recharge factors (%)			greater than 0, must be a two digit number
2-112 Pfaci(im) Irrigated acreage monthly recharge factors (%) 3-112 Pfacn(im) Non Irrigated acreage monthly recharge factors (%)			
3-112 Pfacn(im) Non Irrigated acreage monthly recharge factors (%)	2_1 12	Pfaci(im)	Irrigated acreage monthly recharge factors (%)
3-112 Pfacn(im) Non Irrigated acreage monthly recharge factors (%)	2-112		
The initial actual initial control in the initial of the initial o	3-1 12	Pfacn(im)	Non Irrigated acreage monthly recharge factors (%)
	5 112	T fuen(iiii)	
4-1 12 Pfacsp(im) Special (Sand Dune) monthly recharge factors (%)	4-1 12	Pfacsp(im)	Special (Sand Dune) monthly recharge factors (%)
i i i i i i i i i i i i i i i i i i i	1 112	T luesp(iiii)	Special (Sund Dune) monthly rectailing interiors (70)
5-1 Ibapp Boundary flux flag $0 =$ proportion flux by the number of cells: $1 =$	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		-Supp	proportion by the conductance data provided in the boundary flux file
proportion of the conditionnee data provided in the boundary nux me			
6-1 Nd Constant flux counter (not used)	6-1	Nd	Constant flux counter (not used)
6-2 Bdir(nd) Constant flux direction (must correspond to name in file	6-2	Bdir(nd)	Constant flux direction (must correspond to name in file

Table 4.2 Control Data

		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 4.2Control 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
-	1	
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
12-14		Repeat 11-1 through 11-4 for each stress period (nspr field 6-1)
13-1	rchmax	Maximum recharge warning value (in/vr)
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
		Source Free
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

<u>4.3 Modflow Grid</u> 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**.

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 $0 = \text{constant}, 1 = \text{variable}$
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 width $0 = \text{constant}, 1 = \text{variable}$
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 $0 = \text{constant}, 1 = \text{variable}$
6-2	Ibval	Constant ibound value
7-1	Ibnd(i,j,k)	If(ibound.ne.0) Ibound for layer i, row , column k

Table 4.3 **Modflow Grid Data**

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.

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 $0 = \text{constant}, 1 = \text{variable}$
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)

Table 4.4 Hydraulic Conductivity Dat

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
		<i>Repeat 5-1 for each vegetation type in this zone idez(i)</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.

<u>4.6 Rim Inflow Data</u> 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.

Row	Variable	Description		
1-1	Idrf	Rim inflow ID (Must match		
2-1	Iyrff	Year		
2-12-13	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)		

Table 4.6Rim Recharge Data

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

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
3-13-13	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)

Table 4.7 M&I Pumping Data

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

		Mer Keenarge 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
3-13-13	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)

Table 4.8 M&I Recharge Data

<u>4.9 County-Huc Irrigated Precipitation Data</u> 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.

County-fluc infigated recipitation 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

Table 4.9County-Huc Irrigated Precipitation Data

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.

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

Table 4.10 County-Huc Non-Irrigated Precinitation Data

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 O **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.

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

Table 4	4.14
Spring 1	Data

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.

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)

Table 4.16 Constant Boundary Flux Data

<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 4.17Constant 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.

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

Table 4.18Surface Water to Ground Water Data

<u>4.17 Recharge Zones</u> 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 4.19Recharge Zone Data

Variable	Description	
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	
Iparm(ir,ic)	Recharge zone for row ir column 1 to ncol	
	Repeat for each column	
	Variable Crchfac Iparm(ir,ic)	

<u>4.18 CU Data</u> 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**.

<u>4.19 Ground 01 Data</u> 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.

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

Table 4.11 Ground 01 Data

<u>4.20 Ground 02 Data</u> 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 4.12Ground_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

<u>4.21 GIS Canal Data</u> 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.

<u>4.22 GIS Irrigated Land Data</u> 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.**

<u>4.23 GIS Well Data</u> 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.**

<u>4.24 GIS Native Land Data</u> 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.**

<u>4.25 GIS Rim Inflow Data</u> 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.

<u>4.26 GIS Flowing Well Data</u> 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.**

<u>4.27 GIS Precipitation Zone Data</u> 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.

<u>4.28 GIS Sand Dune Data</u> 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.

_	Constant Doundary Flux Data				
	Row	Variable	Description		
	1-1	Iprow	Row		
1-2 Ipcol Column		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.		

Table 4.17Constant Boundary Flux Data

<u>4.29 Krigged Precipitation Data</u> 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.

<u>4.30 Orographic Ground Data</u> 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	a

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

<u>4.31 Orographic Ppt Data</u> 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.

Orographic Oround Data				
Row Variable Description		Description	ion	
		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		

Table 4.21Orographic Ground Data

<u>4.32 Orographic Ppt Weight Data</u> 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.

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	2-1-2-12 I Row			
	J	Column		
	Weight(j,I,l-n)	Precipitation weight for row 1, column j, station 1-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		

Table 4.22Orographic Ppt Weight Data

<u>4.33 Orographic Irrigated Land Data</u> 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.

Orographic Irrigated Land Data				
Row	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			

Table 4.23Orographic Irrigated Land Data

<u>4.34 Orographic Non-Irrigated Land Data</u> 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.

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		

 Table 4.23

 Orographic Non-Irrigated Land Data

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.

		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 5.1 StatePP Key Output File

	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.

Flow Data

- <u>Consumptive Use</u> Canal leakage Unconsumed surface water from irrigation Unconsumed ground water from irrigation Agricultural pumping Ditch shortage Water requirement for crop Precipitation recharge on irrigated land Precipitation recharge on non-irrigated land
- <u>Surface Water</u> Rim inflow recharge
- <u>Ground water</u> Municipal and industrial pumping and recharge

Spatial Data

- <u>Spatial database</u> Canals Irrigated acreage Irrigation wells Rim inflow areas County/HUC/vegetation distribution Native vegetation Low capacity wells Irrigated crop Subirrigated crop
- <u>Ground water</u>
 Municipal and industrial wells



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

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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 10 3 3 3 10 10 10 10 3 3 3 3
NonIrrigated Recharge factors (%) # Format Free Oct #Jan Feb May Jun Jul Aug Sep Nov Dec Total Mar Apr 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 May Sep Dec Total Mar Jul Aug Oct Nov Apr Jun 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 #_ 400. 200. 1 East 5000. 6200. 11800. Ο. 1600. 21000 23200 2 West-SAG 0. 600. 0. 3 West-CON 5500. 1500. 3300. 37500. 47800. Ο. 3500. 4 West-RGD 7700. 1300. 15000. Ο. 27500. 5 South-west 1600. Ο. -4300. Ο. Ο. -2700. Ο. -1900. 6 South-east -29200. 0. 0. -31100. 7 South-Cin 800. Ο. Ο. Ο. Ο. 800. 8 South-Cout -400. Ο. Ο. Ο. Ο. -400. 10700. # Total 4300. -7800. 79700. 0. 76900. # # # 399 no stress periods, no. of diversion with info 1 19 53 no of rimflow zones number of years of data no of county abbreviations 6 5 no of vegetation types that are irrigated 15 no of county/huc combos from precip rch data 1998 1 12 1990 stress period info 100. max recharge rate in in/yr # .97 200505 .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 Saquache 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 Costilla COS RGR Rio Grande SAG Saguache NMX New Mexico # # Vegetation Codes 001 Alfalfa VEG CODE FOR IRRIGATED AREAS 005 Grain 800 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 1.0

San Pedro Mesa

Attachment M

Lateral Boundary Flow Estimation

Attachment M to Appendix J

Attachment M: Lateral Boundary Flow Estimation

The lateral boundary flow represent recharge from outside of the active model domain that discharge in the subsurface to the alluvial aquifer. These flow originate from percolation of native precipitation, irrigation seepage and canal leakage. These quantities are calculated within StatePP and are processed to determine a lag time for discharge to the alluvial aquifer boundary cells. The lag time is calculated using the same methods routinely applied in Colorado for estimating stream depletions from pumping. This program was developed in FORTRAN. The purpose of this appendix is to document the inputs, program logic, and outputs associated with this FORTRAN program.

1.0 Inputs

The inputs consist of two categories:

- **Pre-processed input files:** these files are pre-processed prior the program execution.
 - Control.txt: this file lets user specify starting and ending simulation period, numbers of total rows and columns of the study area grid matrix, width of each grid, and number of images.
 - Model_Cells_Contributing_Send.txt: this file shows the numbers of row and columns of irrigation grids (which contribute return flow to the model boundary), aquifer transmissivity, and aquifer specific yield.
 - Model_Boundary_Cells_Send.txt: this file shows the numbers of row and columns of the groundwater model boundary grids.
 - RCH_Full_POR_20080417.rch: this file shows the recharge rate from each irrigation grid during the entire stress periods.
- **User-defined parameters:** these parameters need to be determined by users in the beginning of program execution.
 - Number of year for an initial equilibration period.
 - Units of the lateral flow output (acre-feet per day or cubic-feet per day).

2.0 Logic of Estimating Lateral Boundary Flow

The following summarizes the logic incorporated in the FORTRAN program to estimate the lateral boundary flow from the irrigation recharge.

Step 1. Read above-mentioned inputs.

Step 2. Match each model boundary grid to its associated irrigation grid by calculating the shortest distance. For one boundary grid, if multiple irrigation grids were found with

identical shortest distance, it is assumed to use the irrigation grid that is further downstream (i.e. with the maximum column number) as the matched grid.

Step 3. Calculate the lateral boundary flow returned from irrigation grids.

- Step 3.1. Calculate cumulative return flow factors for each irrigation grid under each stress period by using Glover equation.
- Step 3.2. Calculate return flow factors for each irrigation grid under each stress period.
- Step 3.3. Calculate return flow from each irrigation grid for each stress period by using the irrigation recharge flow input and return flow factors (see Step 3.2). The cumulative condition is also incorporated (i.e. the flow at current period includes the flow from previous periods).
- Step 3.4. Calculate the total lateral return flow for each boundary grid considering the matched boundary-irrigation relationship (see Step 2) and return flow from each irrigation grid (see Step 3.3).

3.0 Program Execution

The program is executed by entering the program name in a command window. File names are specified in the program source code.

4.0 Outputs

The outputs consist of two categories:

- Interim outputs
 - Paired_cells.txt: this file shows the matched boundary-irrigation grids with shortest distances.
 - Crff_array.txt: this file shows the cumulative return flow factors array.
 - Rff_array.txt: this file shows the return flow factors array.
 - Qrf_array.txt: this file shows the return flow from each irrigation grid.
- **Final output:** lateral boundary flow output as a MODFLOW well file.

The output files are located at the same directory as the input files.

Attachment N

Distribute Bedrock Flux (distribute_bedrock_flux.exe)

Attachment N - Distribute Bedrock Flux (distribute_bedrock_flux.exe)

The distribute bedrock flux tool (distribute_bedrock_flux) assigns bedrock to alluvial aquifer flux quantities assigned to inactive model cells to the nearest active model cell based on location. The output of the tool is a MODFLOW WEL file that can be combined with other WEL input files.

0.0 Disclaimer
2.0 Installation
3.0 Program Description
4.0 Input File Description
5.0 Output Files Description
6.0 User Instructions
7.0 Source Code

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. This open source program is released under the GNU General Public License.

2.0 Installation

Distribute_bedrock_flux is developed for use with 32-bit windows operating systems. The program is developed in Intel Fortran and runs within a command window. The Intel redistributable libraries should be installed prior to use of the program. No special installation of the program is required, just copy the file proc_runoff.exe to a location along the current search path.

3.0 Program Description

This program processes an output file from the USGS's GRID2GRIDFLOW (GRID2GRID) utility assigning any "excluded" bedrock-alluvial aquifer fluxes computed by the USGS's Denver Basin Model to nearest active model cells of the target model.

The GRID2GRID utility is used to extract the bedrock-alluvial aquifer fluxes computed by the Denver Basin Model to an overlapping target model. In this case the SPDSS Alluvial Groundwater Model. The utility provides two output files. The first file is a listing of the calculated bedrock-alluvial flux in cells where the majority of the cell area of the target model overlaps the Denver Basin Model. This file can be used to simulate bedrock-alluvial flux in the target model. The second file created by the GRID2GRID utility is a listing of cells with

bedrock-alluvial flux from the Denver Basin Model that is assigned to inactive cells of the target model. This file is termed 'excluded' by the GRID2GRID utility. The distribute_bedrock_flux tool was developed to distribute the flux assigned to these inactive cells to the nearest active model cell in the target model. The magnitude and direction (positive or negative) is preserved in the tool. The output is a MODFLOW WEL file.

4.0 Input File Description

All input files must be standard ASCII files with standard Windows record delineators. These may be created with any standard text editor. Each input file is documented below.

4.1 Command File

The command file identifies input parameters and file names and locations. This file may be documented by placing comments anywhere through the file that do not affect processing. Comments are delineated by placing **#** in the first position in a record. All records may use FORTRAN free format conventions. The contents of the file are as follow.

Record 1: LAYER, IWELCB

LAYER - model layer for which bedrock-alluvial fluxes are to be applied

IWELCB - is a flag and a unit number for which cell by cells flows are written

Record 2: Output WEL file name

Record 3: Boundary cells file name

Record 4: Excluded cells data file name (from GRID2GRIDFLOW utility)

Table 1 – Example command file

```
# Command File for the Distribute_Bedrock_Flux Tool
# record 1: Layer, IWELCB
# record 2: path and filename of output WEL file
# record 3: path and filename of boundary cells
# record 4: path and filename of excluded cells data file
# (this is output from Grid2Grid)
1 0
Output.wel
Model_Boundary_Cells.txt
Spdss_Excluded_Data.txt
```

4.2 Boundary Cells File

This file contains a listing of the Row and Columns of all the active cells on the edge of the target model. These are a list of the cells for which 'excluded' bedrock-alluvial flux can be assigned. A header of listing the contents of the file such as "Row Column" should be used in the file.

4.3 Excluded Cells Data File

This file is generated by the USGS GRID2GRIDFLOW utility and should be used without modification.

5.0 Output Files

All output files are standard ASCII text files for windows. Specified output files will overwrite files with the same name. The individual output files are described below.

5.1 WEL Output File

This is a standard format MODFLOW WEL package file that includes the portion of the bedrock-alluvial flux reassigned to active model cells in the target model.

6.0 User Instructions

This program runs in a command window. Open a command window and navigate to the desired location. Enter the command "distribute_bedrock_flux <command file name>" on the command line. When processing is completed, the command prompt will display.

Attachment O

Rainfall Pre-Processor (Proc_rainfall.exe)

Attachment O to Appendix J

Attachment 0 - Rainfall Pre-Processor (Proc_rainfall.exe)

The rainfall pre-processor uses time series precipitation data, kriging factors, land use data and factors for runoff or recharge associated with each of the land use types. An output file that is used as input to StatePP in the case of recharge estimates, or proc_runoff for estimation of ungaged surface water runoff is created. This document is organized into the following sections.

0.0 Disclaimer
2.0 Installation
3.0 Program Description
4.0 Input File Description
5.0 Output Files Description
6.0 User Instructions
7.0 Source Code

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. This open source program is released under the GNU General Public License.

2.0 Installation

Proc_runoff is developed for use with 32-bit windows operating systems. The program is developed in Intel Fortran and runs within a command window. The Intel redistributable libraries should be installed prior to use of the program. No special installation of the program is required; just copy the file proc_runoff.exe to a location along the current search path.

3.0 Program Description

The program has two functions; namely to interpolate precipitation time series onto a model grid and to then apply a multiplier that is a function of land use to this precipitation quantity to develop either recharge rates or ungaged runoff. The interpolation factors are provided by the consumptive use contractor and are weighting factors that related each precipitation station to each model cell. The result of this processing step is a matrix of precipitation depths (in/month) for each cell in the model. The second step in the process uses a land use file provided by the consumptive use contractor that assigns a land use code and area of this land use within each cell. The land use is constant over the entire period associated with a run. A land use factor is then applied to the precipitation file to create a matrix of depths for each stress period. The output file may be used as an input file to StatePP in the case where a recharge factor is used, or input to proc_runoff in cases where ungaged surface water runoff is to be calculated.

4.0 Input File Description

All input files must be standard ASCII files with standard Windows record delineators. These may be created with any standard text editor or other SPDSS DMIs. Each input file is documented below.

4.1 Command File

The command file identifies input parameters and file names and locations. This file may be documented by placing comments anywhere through the file that do not affect processing. Comments are delineated by placing **#** in the first position in a record. All records may use FORTRAN free format conventions. The contents of the file are as follow.

Record 1: NROW, NCOL, NSTRESS, ROW_HT, COL_WIDTH, BUFFER, SFR_EFF, RECH_EFF

NROW - Number of rows

NCOL - Number of columns

NSTRESS – Number of stress periods in files

ROW_HT - Constant dimension of model cells in the y direction (ft)

COL_WIDTH - Constant dimension of model cells in the x direction (ft)

BUFFER - Distance outside of active model grid to route to nearest SFR cell (ft)

SFR_EFF – Delivery efficiency factor to apply to calculated runoff (range 0 – 1)

RECH_EFF – Delivery efficiency factor to apply to calculated recharge (range 0 – 1)

Record 2 : Active Grid file name

Record 3: Runoff Mask file name

Record 4: Runoff depth file name

Record 5: Stream flow routing input file name

Record 6: Stream flow routing output file name

Record 7: Recharge output file name

Record 8: Log file name

Record 9: CALCULATION_TYPE, START_STRESS, END_STRESS

CALCULATION_TYPE – Specify either **transient** or **average**, using lower case. The average option indicates that only a single stress period will be included in the output file, which is an average of the specified starting and ending periods.

START_STRESS – For a transient case, the starting stress period will be the first stress period in the output files, for the average case, this indicates the start of the averaging period.

END_STRESS – For a transient case, the ending stress period will be the last stress period included in the output files, for the average case, this indicates the end of the averaging period.

```
Table 1 – Example command file
#example input file
#record 1
655
     848 12
                                     15000.
                                              1.0 1.0
                    1000.
                         1000.
#record 2
spdss p5 grid active.dat
#record 3
runoff_matrix_mask_20090425.dat
#record 4
Z:\utilities\Proc rainfall 2\runoff out full2009 04 14.out
# record 5
stream out.sfr
# record 6
sfr output avg.sfr
# record 7
runoff recharge avg.rch
# record 8
runoff_avg.log
# record 9
average 1 12
```

4.2 Active Grid File

This file contains the IBOUND array indicating active and inactive cells in the model. The file is in free format, as in the MODFLOW Basic package and should be extracted from the Basic package by deleting header information, leaving only the IBOUND array. No header or format information should be present in the file.

4.3 Runoff Mask File

The runoff mask file is similar in format to the active grid file. It contains a code identifying areas that will be processed to calculate ungaged surface water runoff. A value of 1 indicates runoff is to be calculated, while a value of 0 indicates this cell should be bypassed. The bypassed cells are located in areas that have ungaged surface water already accounted for, such as in areas where surface water is gaged, and alluvial underflow is directly specified.

4.4 Runoff Depth File

This file is generated by Proc_Rainfall_2 and contains a matrix of runoff depths for all model cells, in units of in/month.

4.5 SFR Input File

This is a standard format MODFLOW SFR file that includes baseline flows.

5.0 Output Files

All output files are standard ASCII text files for windows. Specified output files will overwrite files with the same name. The individual output files are described below.

5.1 SFR Output File

This is a standard format MODFLOW SFR package file that includes the input flow, plus the calculated ungaged runoff.

5.2 Recharge Output File

This is a standard format MODFLOW recharge package file that contains additional recharge depth associated with ungaged surface water in ft/day units. This file is used in developing lateral boundary inflows.

5.3 Log File

The log file contains summary information on inputs to the program, and summarizes the flows added to the SFR and recharge files in af/month.

6.0 User Instructions

This program runs in a command window. Open a command window and navigate to the desired location. Enter the command "proc_runoff" on the command line. When prompted, enter the name of the command file. When processing is completed, the command prompt will display.

Attachment P

Ungaged Surface Water Runoff Generator (Proc_runoff.exe)

Attachment P - Ungaged Surface Water Runoff Generator (Proc_runoff.exe)

The ungaged surface water runoff generator tool (Proc_runoff) generates runoff quantities based on native precipitation and land use, and appends these data to an existing stream flow routing file (.SFR).

0.0 Disclaimer2.0 Installation3.0 Program Description4.0 Input File Description5.0 Output Files Description6.0 User Instructions7.0 Source Code

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. This open source program is released under the GNU General Public License.

2.0 Installation

Proc_runoff is developed for use with 32-bit windows operating systems. The program is developed in Intel Fortran and runs within a command window. The Intel redistributable libraries should be installed prior to use of the program. No special installation of the program is required; just copy the file proc_runoff.exe to a location along the current search path.

3.0 Program Description

This program processes runoff depth information generated in Proc_rainfall into two components, direct runoff that is added to an existing SFR file, and additional recharge associated with native precipitation occurring outside of the active model grid and adjacent buffer area. The additional recharge information is used as input to the lateral boundary flow processor. The program includes masking capability to bypass processing in selected portions of the inactive grid, where flows are already accounted for by other processes, such as alluvial underflow. Processing is controlled by a command file.

Surface runoff due to native precipitation is calculated for each model cell in the active and buffer areas of the model. The program locates the nearest stream segment for each cell, and adds contributing cell flows to the upstream end of the closest SFR segment. For areas outside

of the active area and buffer zone, the recharge depth associated with ungaged surface water runoff is accumulated in a recharge package for merging with other recharge sources for further processing in the lateral boundary processor. Delivery efficiency factors may be separately applied to the SFR and recharge components.

4.0 Input File Description

All input files must be standard ASCII files with standard Windows record delineators. These may be created with any standard text editor. Each input file is documented below.

4.1 Command File

The command file identifies input parameters and file names and locations. This file may be documented by placing comments anywhere through the file that do not affect processing. Comments are delineated by placing **#** in the first position in a record. All records may use FORTRAN free format conventions. The contents of the file are as follow.

Record 1: NROW, NCOL, NSTRESS, ROW_HT, COL_WIDTH, BUFFER, SFR_EFF, RECH_EFF

NROW - Number of rows

NCOL - Number of columns

NSTRESS - Number of stress periods in files

ROW_HT - Constant dimension of model cells in the y direction (ft)

COL_WIDTH - Constant dimension of model cells in the x direction (ft)

BUFFER - Distance outside of active model grid to route to nearest SFR cell (ft)

SFR_EFF – Delivery efficiency factor to apply to calculated runoff (range 0 – 1)

RECH_EFF – Delivery efficiency factor to apply to calculated recharge (range 0 – 1)

Record 2 : Active Grid file name

Record 3: Runoff Mask file name

Record 4: Runoff depth file name

Record 5: Stream flow routing input file name

Record 6: Stream flow routing output file name

Record 7: Recharge output file name

Record 8: Log file name

Record 9: CALCULATION_TYPE, START_STRESS, END_STRESS

CALCULATION_TYPE – Specify either **transient** or **average**, using lower case. The average option indicates that only a single stress period will be included in the output file, which is an average of the specified starting and ending periods.

START_STRESS – For a transient case, the starting stress period will be the first stress period in the output files, for the average case, this indicates the start of the averaging period.

END_STRESS – For a transient case, the ending stress period will be the last stress period included in the output files, for the average case, this indicates the end of the averaging period.

```
Table 1 – Example command file
#example input file
#record 1
655 848 12 1000. 1000. 15000. 1.0 1.0
#record 2
spdss p5 grid active.dat
#record 3
runoff matrix mask 20090425.dat
#record 4
Z:\utilities\Proc rainfall 2\runoff out full2009 04 14.out
# record 5
stream out.sfr
# record 6
sfr output avg.sfr
# record 7
runoff recharge avg.rch
# record 8
runoff avg.log
# record 9
average 1 12
```

4.2 Active Grid File

This file contains the IBOUND array indicating active and inactive cells in the model. The file is in free format, as in the MODFLOW Basic package and should be extracted from the Basic package by deleting header information, leaving only the IBOUND array. No header or format information should be present in the file.

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4.4 Runoff Depth File

This file is generated by Proc_Rainfall_2 and contains a matrix of runoff depths for all model cells, in units of in/month.

4.5 SFR Input File

This is a standard format MODFLOW SFR file that includes baseline flows.

5.0 Output Files

All output files are standard ASCII text files for windows. Specified output files will overwrite files with the same name. The individual output files are described below.

5.1 SFR Output File

This is a standard format MODFLOW SFR package file that includes the input flow, plus the calculated ungaged runoff.

5.2 Recharge Output File

This is a standard format MODFLOW recharge package file that contains additional recharge depth associated with ungaged surface water in ft/day units. This file is used in developing lateral boundary inflows.

5.3 Log File

The log file contains summary information on inputs to the program, and summarizes the flows added to the SFR and recharge files in af/month.

6.0 User Instructions

This program runs in a command window. Open a command window and navigate to the desired location. Enter the command "proc_runoff" on the command line. When prompted, enter the name of the command file. When processing is completed, the command prompt will display.