# CDSS Toolbox

## Database and GIS Data Management Interface Documentation


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**CDSS Toolbox Version 3.0**


LEONARD RICE ENGINEERS, INC.

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**Database and GIS Data Management Interface**
**Documentation**

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## 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 Introduction

The State of Colorado's CDSS Toobox is a GIS Data Management Interface (DMI) that utilizes ArcMap capabilities to process spatial data for use in consumptive use, ground water and surface water modeling analyses. The CDSS Toolbox was developed to provide a consistent, automatic and reproducible method for developing input files required for the CDSS Consumptive Use model (StateCU), Water Resource Planning model (StateMOD), and the preprocessor to Modflow (StatePP). The main CDSS toolbox consists of five toolsets; Aggregate, Climate Weights, Soil Parameters, Well Matching and State Data-Centered Ground Water Interface (StateDGI). The Aggregate, Climate Weights, and Soil Parameters toolsets are primarily used in creating input files for StateCU and StateMOD, whereas the Well Matching and StateDGI toolset is used to create input files to StatePP and ultimately Modflow.

The CDSS toolbox was created in ArcMap's scripting language, Python, for use with ArcMap 9.1. Due to limitations of the Python Script code, it is imperative that there are no spaces in the name of any files or their associated path names. Likewise, the toolbox cannot be executed over a network; the input files and toolbox must be located on a local drive or 'mapped' network drive. It is also recommended that the CDSS tools be executed on a computer with ample virtual memory, 1 GB or more.

Each individual tool is comprised of a graphical user interface, with applicable 'Online Help' documentation, which requests the user to input control data and shapefiles used in each analysis. Tools typically output a text file, as well as offering the ability to create a new output shapefile including the analysis results.

The State Data-Centered Ground Water Interface toolset is used in conjunction with an Access Geodatabase to store and process data for use by the ground water preprocessor, StatePP. The StateDGI toolset allows users to perform numerous spatial tasks, including distributing well capacity by aquifer layers, locating wells and parcels by the model cell they fall into, and computing the fractional length and areas in each model cell of various GIS layers. StateDGI will then export the results of these spatial tasks in a format required by StatePP and ultimately Modflow.

Anyone using the CDSS Toolbox should be familiar with the use of the ArcMap GIS program. Section 1.2 provides a brief summary of how to view results using some basic ArcMap tools. For more details the user should review ArcMap documentation. Due to the GIS and Access format of the files used by the CDSS toolbox, the user is not able to create an input data set from scratch using the toolbox. Instead, new input data sets should be created by developing new GIS layers using ArcMap.

The tools within the CDSS Toolbox utilize three types of data; text, raster grids, and vector shapefiles. Text files are created in a text editor and contain lists of information, such as a key structure list. Raster grids represent continuous data over a specific area. A raster grid divides a surface into numerous cells, whereby data is continuously varying over each cell. The average annual precipitation grid and climate station weight grids are examples of raster grids. A vector shapefile represents discrete data defined as points, lines or polygons. The irrigated acreage polygon shapefile or canal polyline shapefile are examples of vector shapefiles.

Several of the files that serve as input to CDSS tools have standard formats, attributes and fields as developed in previous CDSS modeling efforts. The CDSS tools have been designed around these standard formats, and the tools that require standard files as input will not work correctly if non-standard files are used. The files required to be in the standard CDSS format are indicated as such in the description of each tool, and the CDSS format is laid out in Appendix A.

While some error checking is part of the input process, the CDSS toolbox does not check that all user-supplied data are reasonable. Each CDSS tool creates a log file that provides information on processes being completed in the Python code. The log file will have the same base name defined by the user for the output file with a ".log" extension. During execution of the tools, descriptions of the completed processes will be written to the log file to help the user troubleshoot any execution errors. The user can click on the 'Details' button in the execution window of each tool or view the log file independently to view the progress through the script.

This User's Manual contains seven sections. Sections 1.1 and 1.2 provide instructions on how to load the CDSS Toolbox and a description on how to view results in ArcMap. Users familiar with ArcMap may find these sections redundant.

Sections 2.0 – 6.0 describe the Aggregate, Climate Weights, Soil Assignments, Well Matching and StateDGI toolsets. Section 2.1 describes in great detail the Aggregate by GW Parcel tool with step by step descriptions and screen shots. Most of this information is generally applicable to the other tools; therefore the extent of detail is not repeated in the remaining sections.

Section 7.0 describes the process of creating the StateDGI Geodatabase through the StateDGI Geodatabase User Interface and how to create the StatePP files ultimately used in Modflow.

## 1.1 Loading the CDSS Toolbox

The CDSS Toolbox is a directory which includes geoprocessing tools, scripts, help files and the toolbox configuration file. It is typically installed in the C:\CDSS\bin\Toolbox directory by the installation program. Once installed, the user can begin using the toolbox by opening a project in ArcMap and activating the ArcMap Toolbox window by selecting the red toolbox icon from the Standard toolbar. If the Standard toolbar is not shown in ArcMap by default, right click on the frame of the ArcMap drawing area to activate a list of the available toolbars. Check the Standard toolbar to add the toolbar to the current view and then select the red toolbox icon in the toolbar.

In the ArcMap toolbox window, right-click on the main ArcToolbox icon and a menu will appear that includes the Add Toolbox as shown in Figure 1.

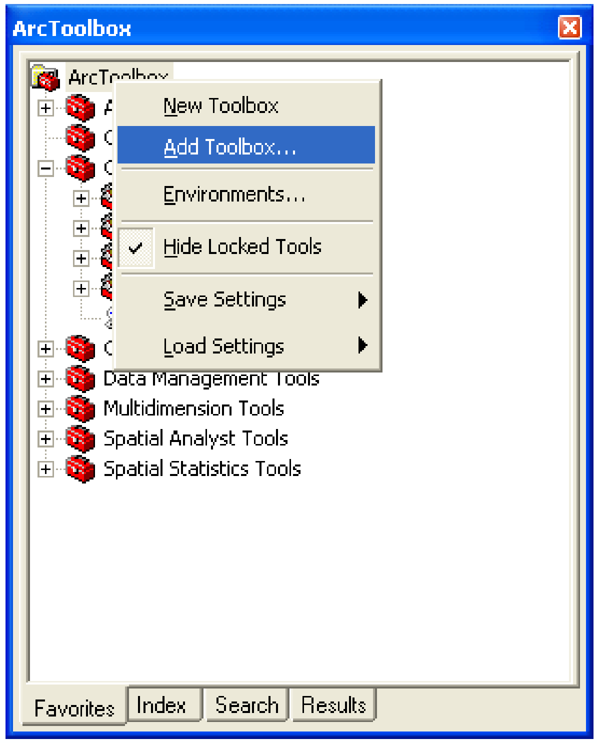



**Figure 1 – Adding a Toolbox**

Select the Add Toolbox, navigate to the directory where CDSS Toolbox is installed (C:\CDSS\bin\Toolbox) and open the CDSS Toolbox as shown in Figure 2.

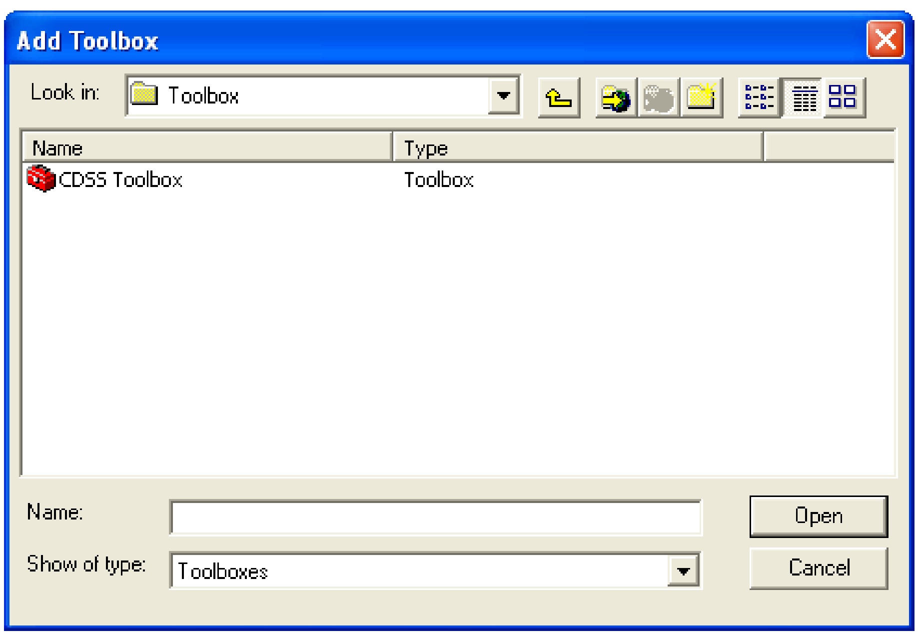



**Figure 2 – Loading CDSS Toolbox**

When the toolbox is loaded, it will appear in the toolbox window. The user can save this as the default toolbox configuration, if desired, by right-clicking on the main ArcToolbox icon, and selecting 'To Default' under the Save Settings menu as shown in Figure 3. If the toolbox is not saved as the default, the toolbox will only be loaded when a project is opened in which the user has already added the toolbox.

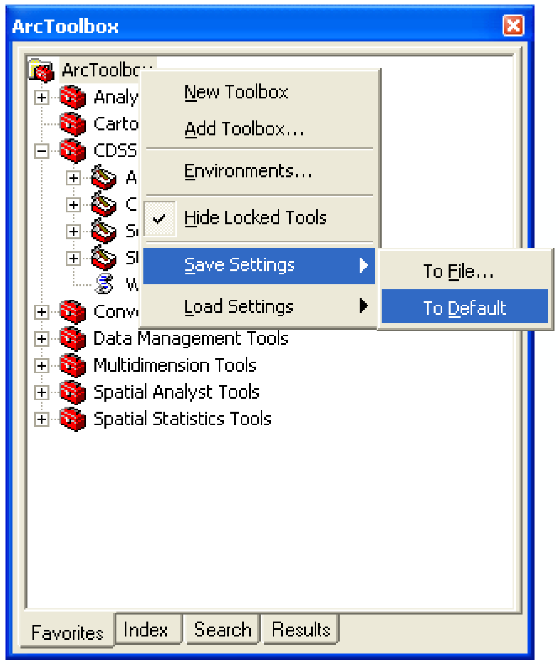



**Figure 3 – Saving CDSS Toolbox as the Default**

## 1.2 Displaying Results

This section describes how to display the results of a CDSS Toolbox analysis. It is provided for a user that has limited experience with ArcMap and because several of the CDSS tools have the option to add the results of the tool to a new shapefile. A user familiar with ArcMap may want to proceed directly to sections 2-7 for a description of the CDSS Toolbox.

For example, in the Aggregate by GW Parcels tool, a new shapefile can be created consisting of the original Irrigated Acreage Shapefile attributes and the Aggregate ID attribute. Once created the new shapefile will be added to the current ArcMap project view as the top Layer file. The new shapefile is represented by a single symbol for all the aggregate areas. Figure 4 shows an example shapefile, 2001_GW_Aggregates, with the default symbol selected by ArcMap.

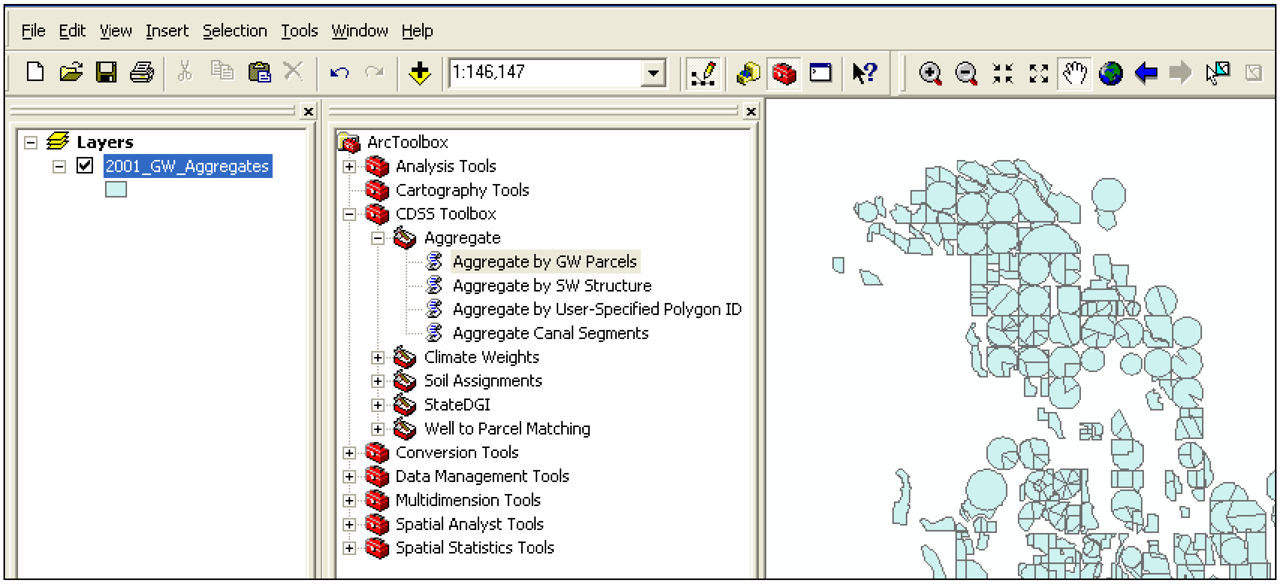



**Figure 4 – Default Symbology**

To change the symbology of the shapefile, right click on the shapefile name and select 'Properties' from the menu. This will activate the Layer Properties tabbed window with several options and information regarding the layer. Figure 5 shows the menu available for each shapefile.

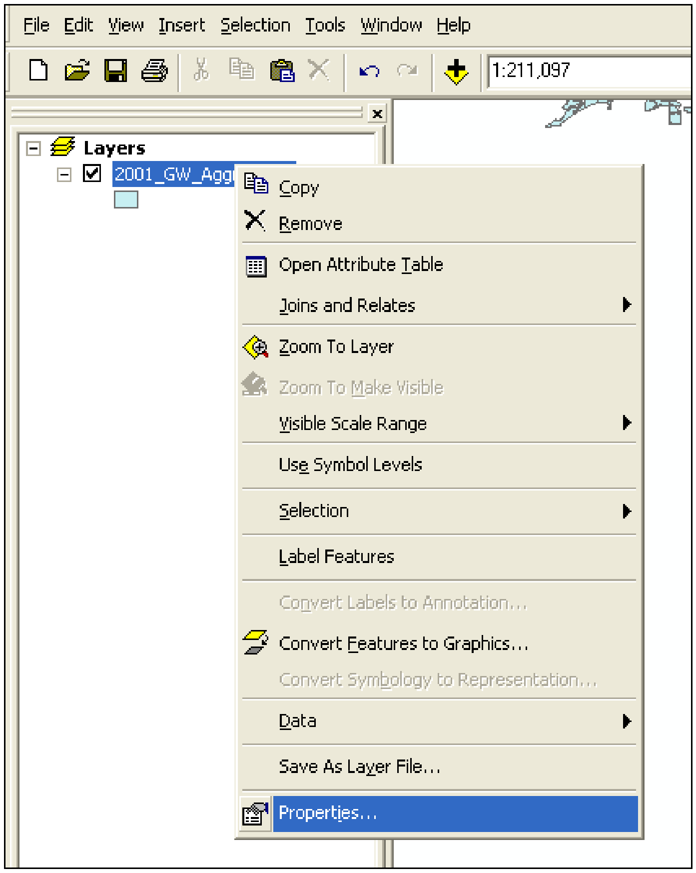



**Figure 5 – Shapefile Menu**

From the Layer Properties, click on the Symbology tab. The default symbol shows that all attributes in the layer will be represented by a single symbol, a light blue for this example. The aggregates in the shapefile would be easier to view if each aggregate is represented by a different color. Figure 6 shows the Symbology tab in the Layer Properties window.

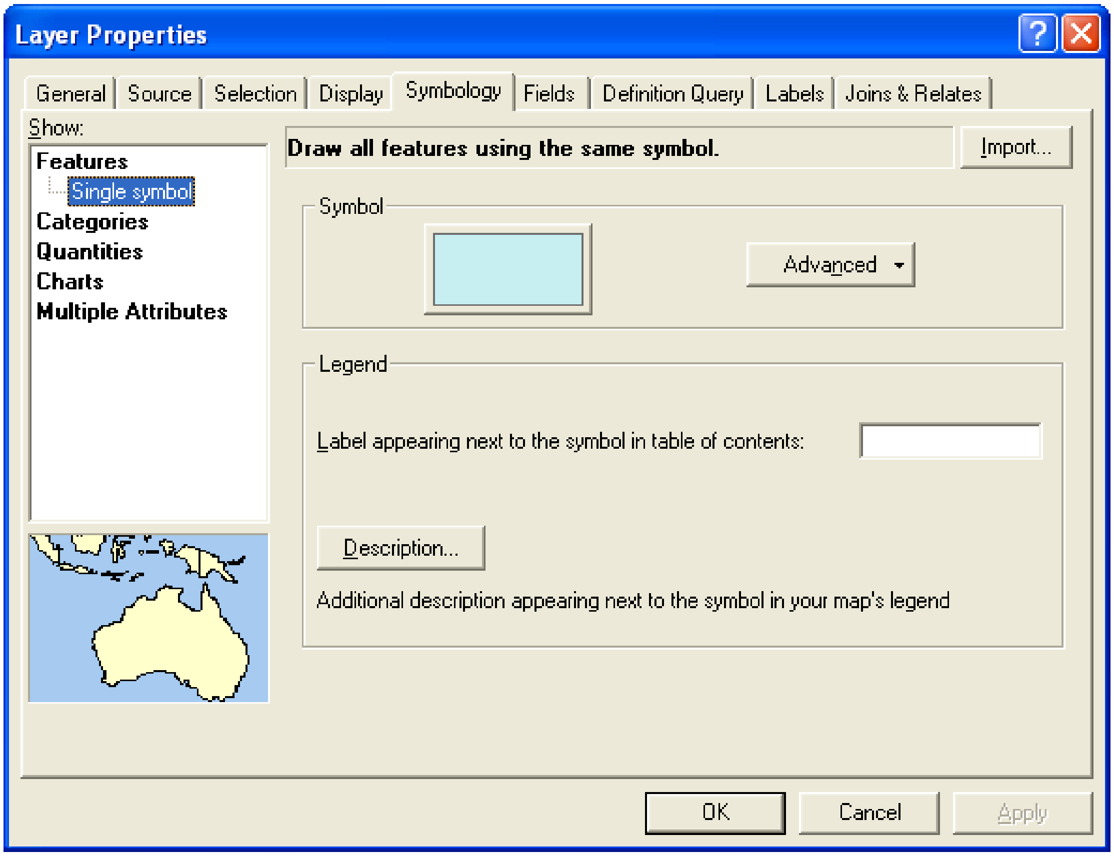



**Figure 6 – Layer Properties**

In the 'Show' field on the left of the window, select the 'Categories' option. There are three options under the 'Categories' option. Select the 'Unique Values' option, which will allow the user to specify a different symbol for each unique value in a single attribute field. The 'Unique Fields, many fields' allows the user to specify a different symbol for each unique value using a combination of up to three attributes. Scroll through the 'Value Field' pulldown menu to select the desired attribute field. For this example, the Aggregate Attribute that was selected in the Aggregate by GW Structures tool to be added to the original Irrigated Acreage shapefile is the 'GWID' field. Figure 7 shows the 'Value Field' pulldown menu of attributes available in the 2001_GW_Aggregates shapefile.

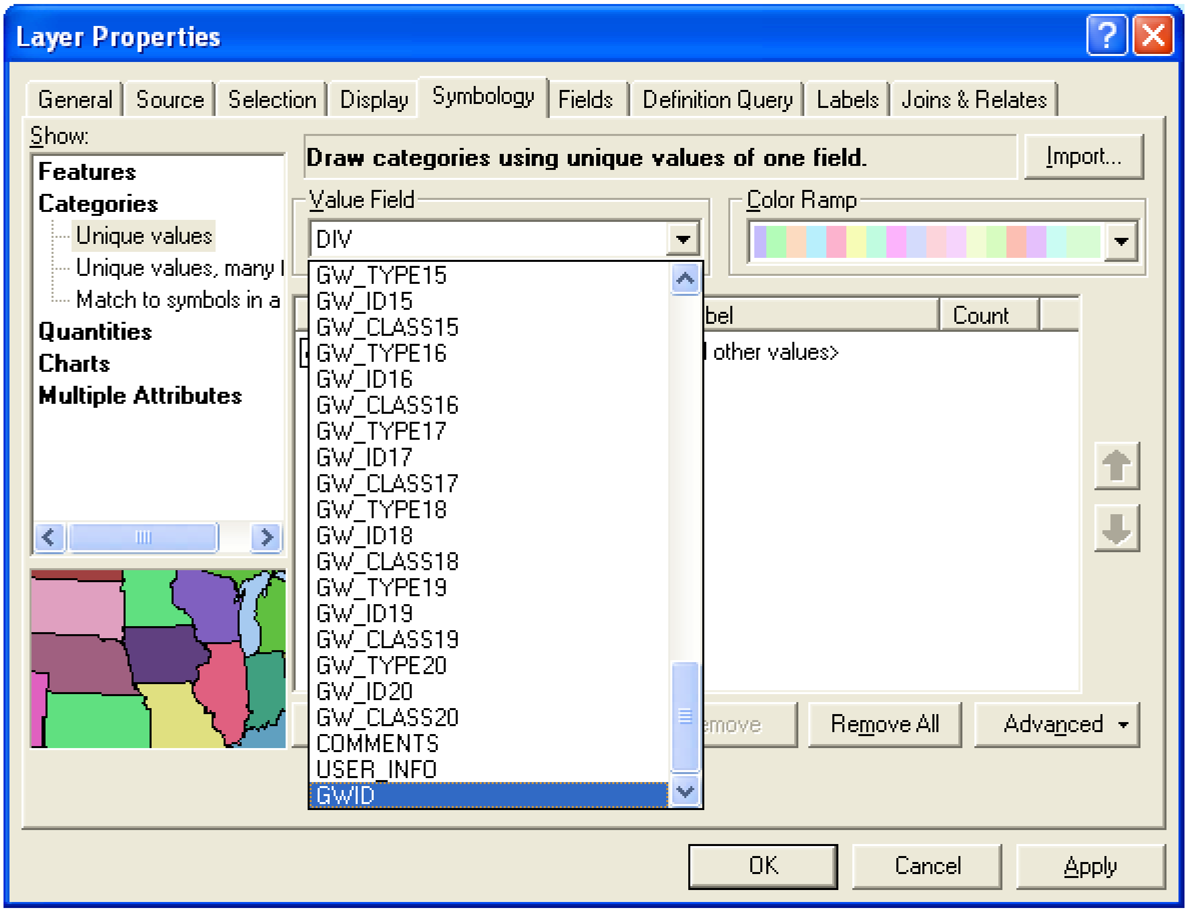



**Figure 7 – Layer Properties with 'Unique Value' Symbology**

For this example, the user would select 'GWID' from the pulldown menu, then click on the 'Add all Values' button to load all unique 'GWID' values into the Symbol view. The user can now view all the unique values in the GWID, the labeled name, and the number of values assigned that attribute. A 'Color Ramp' (default color scheme) is automatically applied to each unique GWID value. In our example, if irrigated acreage was not assigned a GWID because it is served by surface water, these structures will by represented by the '<all other values>' symbol. It is helpful in the view to remove the color scheme for these non-GWID parcels. Each value's symbol can be individually edited by double-clicking on the symbol. Figure 8 displays the GWID values and applied color scheme.

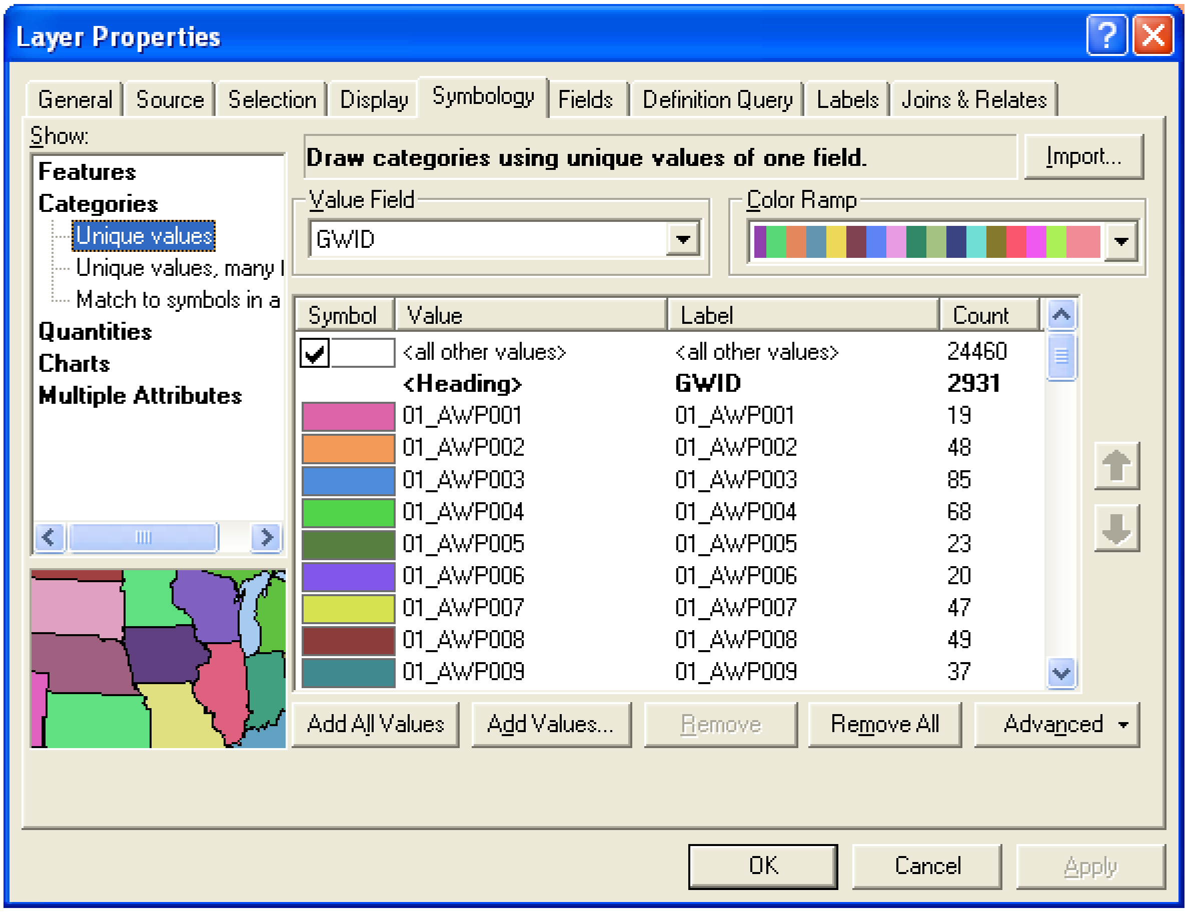



**Figure 8 – Layer Properties with 'Unique Value' Symbology**

After selecting a color scheme and applying it to the selected values, click on the 'OK' button to return to the main ArcMap view. Figure 9 shows the result of symbology changes to the 2001_GW_Aggregates shapefile.

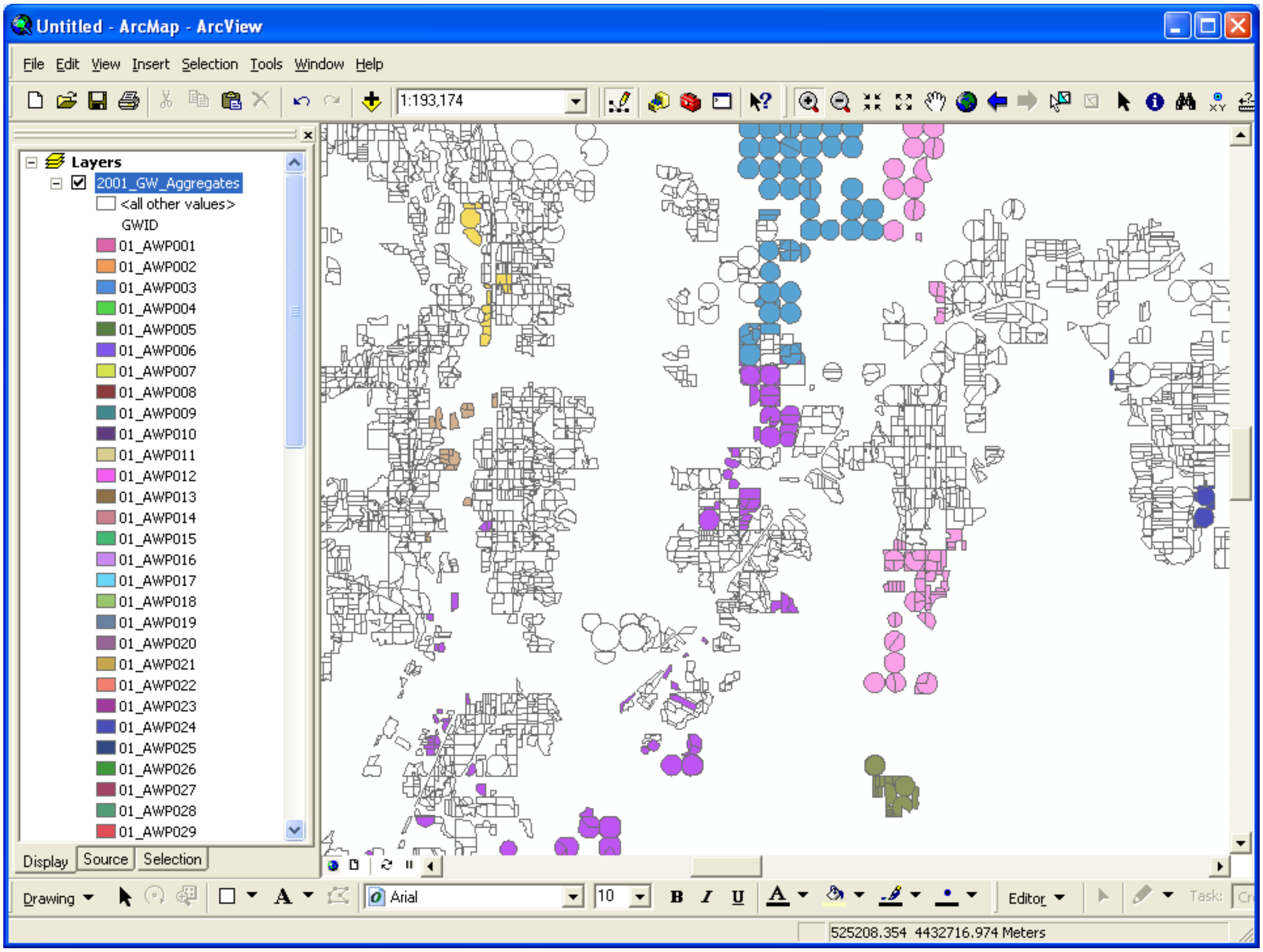



**Figure 9 – ArcMap View with Symbology Changes**

## 2.0 Aggregate Toolset

Using the tools available in the Aggregate toolset, the user can aggregate CDSS formatted irrigated parcels of land by ground water or surface water structure, sum canal lengths or aggregate any user-defined polygons from a shapefile. The output tables that result from running the Aggregate tools can be used directly in StateDMI and TSTool commands to develop specific files used for StateCU and StateMod analyses.

Select the + symbol next to the Aggregate toolset to view all of the available tools as shown in Figure 10.

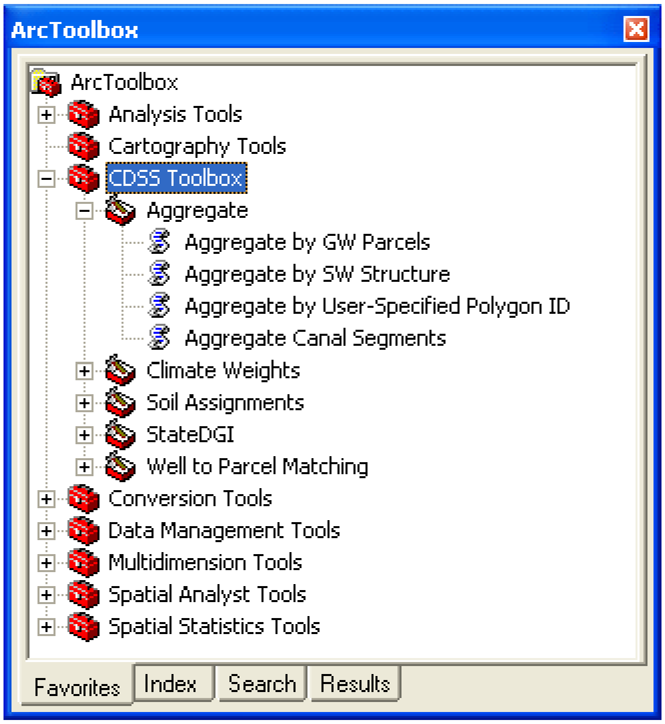



**Figure 10 – Showing Aggregate Toolset**

## 2.1 Aggregate by GW Parcels

The Aggregate by GW Parcels tool is used to combine irrigated lands with ground water as their only water source into user-defined aggregate areas. Each aggregate area is given a unique Aggregate ID. The Aggregate ID is typically made up of nine characters identifying the river basin, Water District, and use of ground water. For example, 01AWP001 indicates the first area of aggregated wells in the Platte basin (AWP) in Water District 1. Only those parcels that do not have an associated surface water WDID (i.e. ground water only parcels) will be aggregated and included in an Aggregate ID in the newly created Output Table. Note that if a ground water parcel overlaps aggregate polygon boundaries, it will be assigned to the Aggregate ID containing the greatest parcel area.

Creating aggregates can be an iterative process, whereby the user should review the results of the aggregation tool and revise the aggregate polygons as necessary to, for example, maintain a maximum irrigated area per aggregate. Upon each aggregate polygon revision, the Aggregate by GW Parcel tool should be rerun.

The SPDSS Technical Memorandum "Task 3: Aggregate Non-Key Agricultural Diversion Structures", May 15, 2007 describes this process as it was applied to the South Platte basin modeling efforts.

Double-click on Aggregate by GW Parcels to open the user interface for this tool, as shown in Figure 11. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

Additional screen captures of this tool are shown for each input as an example of the Online Help that is available for each input. This Online Help is available for each tool input, however the user manual does not show every screen capture.

The required inputs for this analysis include:

- Irrigated Acreage Shapefile: A polygon shapefile that contains irrigated parcels, crop type, irrigation method and water supply data. The shapefile must be provided in the standard CDSS format, as described in Appendix A. Irrigated acreage shapefiles have been created by river basin in support of CDSS modeling efforts and are available on the CDSS website (cdss.state.co.us). Figure 11 shows the online help screen describing the Irrigated Acreage Shapefile input.

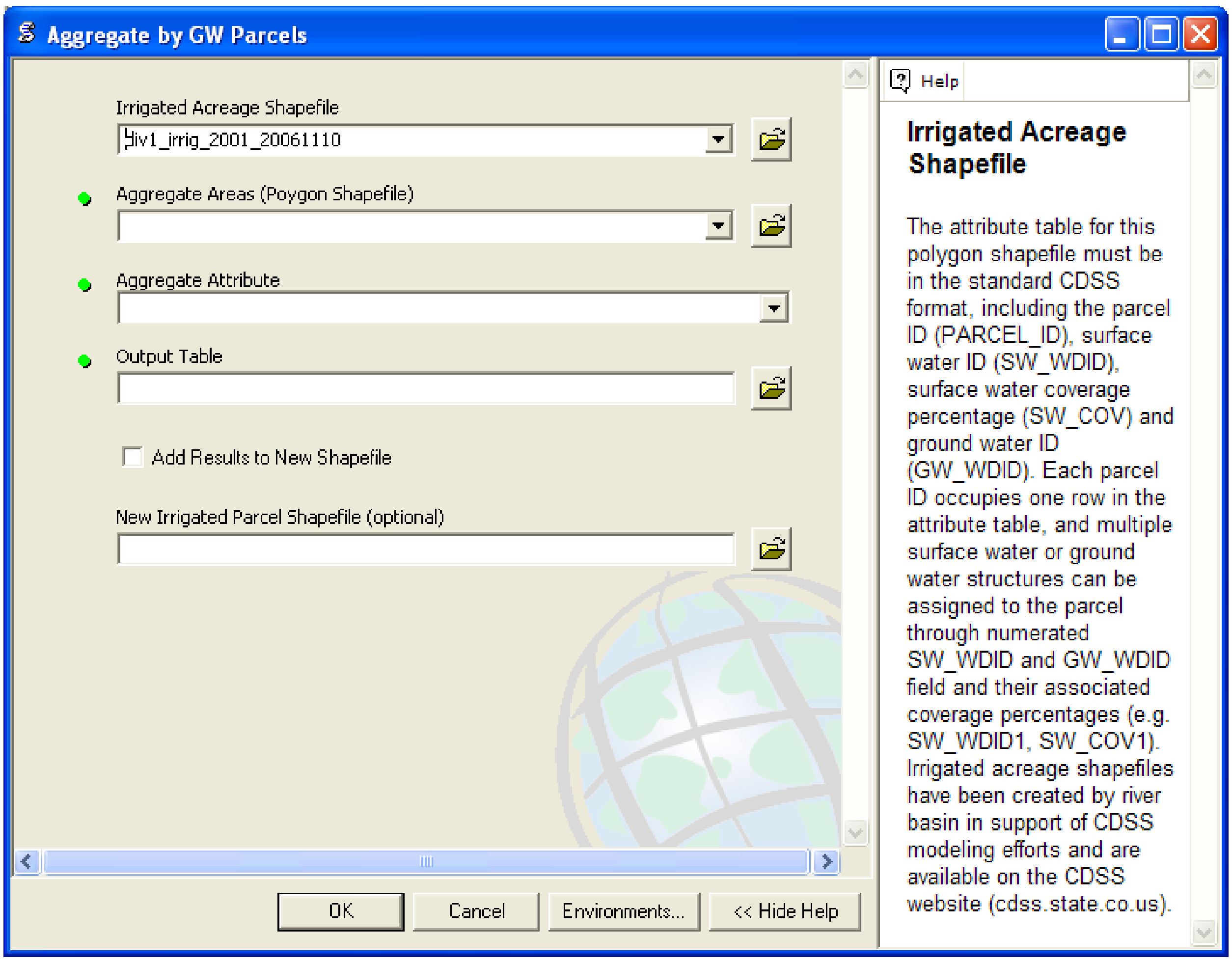



**Figure 11 – Irrigated Acreage Shapefile Online Help**

- Aggregate Areas: A polygon shapefile that defines the areas that the ground water only parcels will be grouped in. Figure 12 shows the online help screen describing the Aggregate Area input.

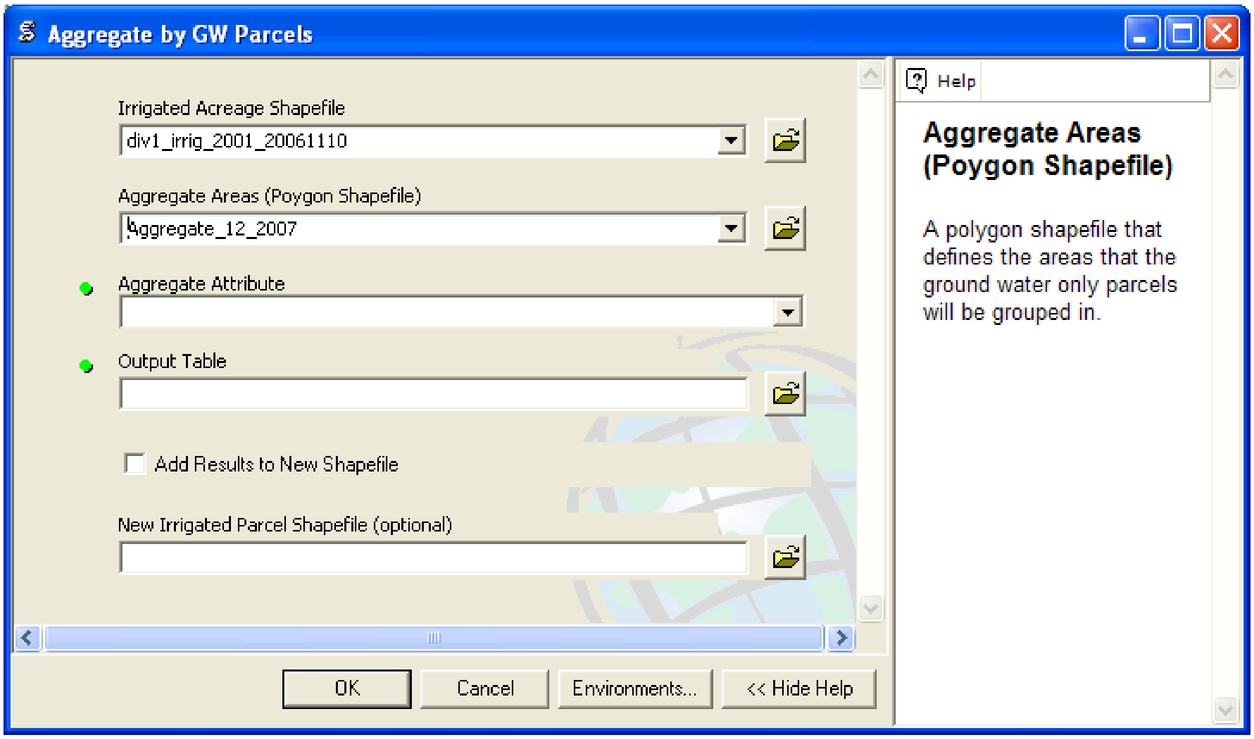



**Figure 12 – Aggregate Areas Online Help**

- Aggregate Attribute: The attribute field name in the Aggregate Areas shapefile that contains the Aggregate IDs the ground water only parcels will be assigned to in the output table. This attribute can also be added to the Irrigated Acreage shapefile to create a new Irrigated Acreage shapefile. Figure 13 shows the online help screen describing the Aggregate Attribute input.

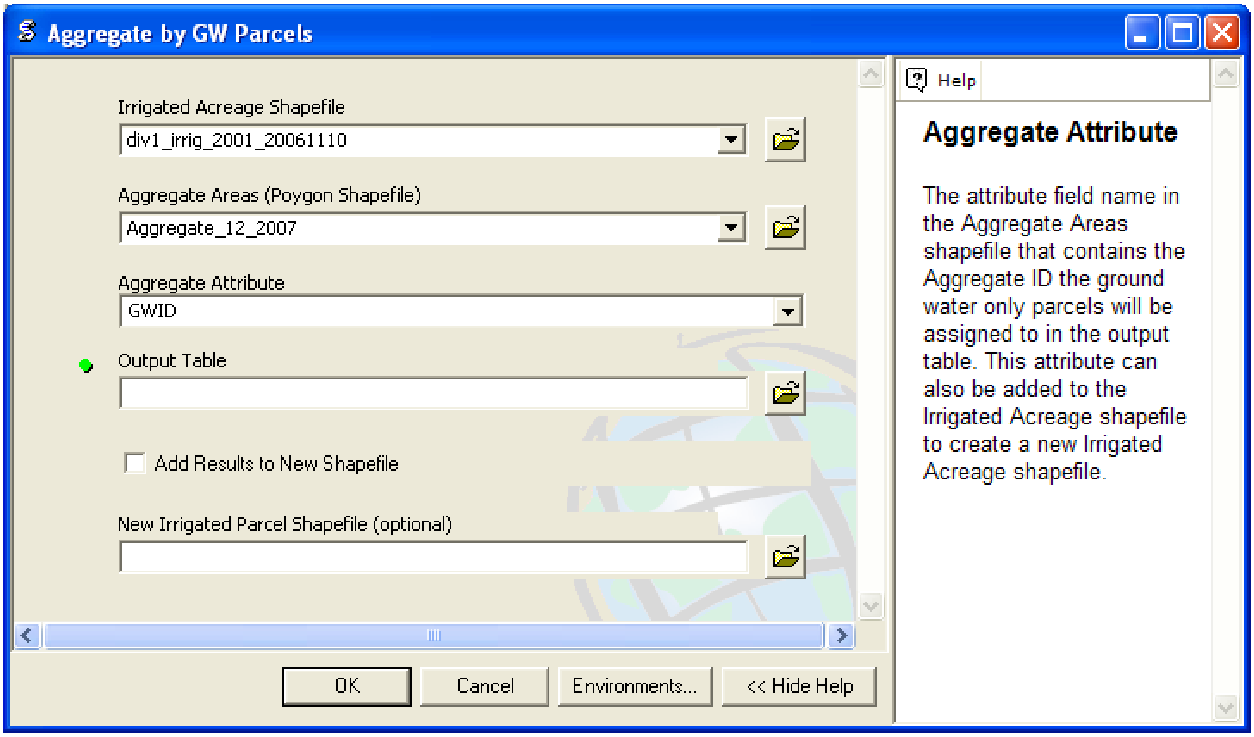



**Figure 13 – Aggregate Attribute Online Help**

- Output Table: The output file is a comma-delimited file that contains the Aggregate ID, the parcel ID and parcel acres. Note that this tool recomputes parcel areas based on map units of meters, then converts the area to acres and aggregates according to the Aggregate Area polygon coverage. Date and input parameters will be included in the header. Figure 14 shows the online help screen describing the Output Table input.

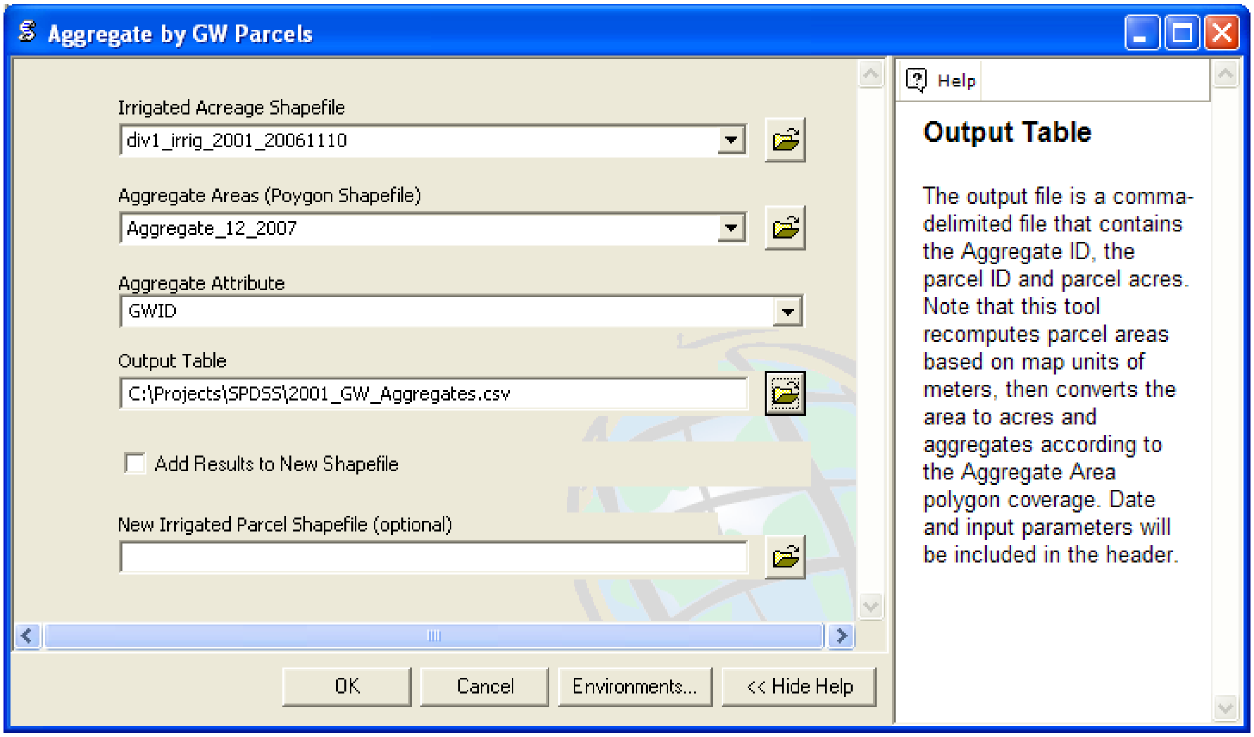



**Figure 14 – Output Table Online Help**

- New Irrigated Parcel Shapefile: If the 'Add Results to New Shapefile' checkbox is selected the Aggregate ID will be appended as a new field in a copy of the Irrigated Acreage shapefile and saved as the new shapefile. Figure 15 shows the online help screen describing the New Irrigated Parcel Shapefile input. See Section 1.2 for tips to revise the new shapefile display.

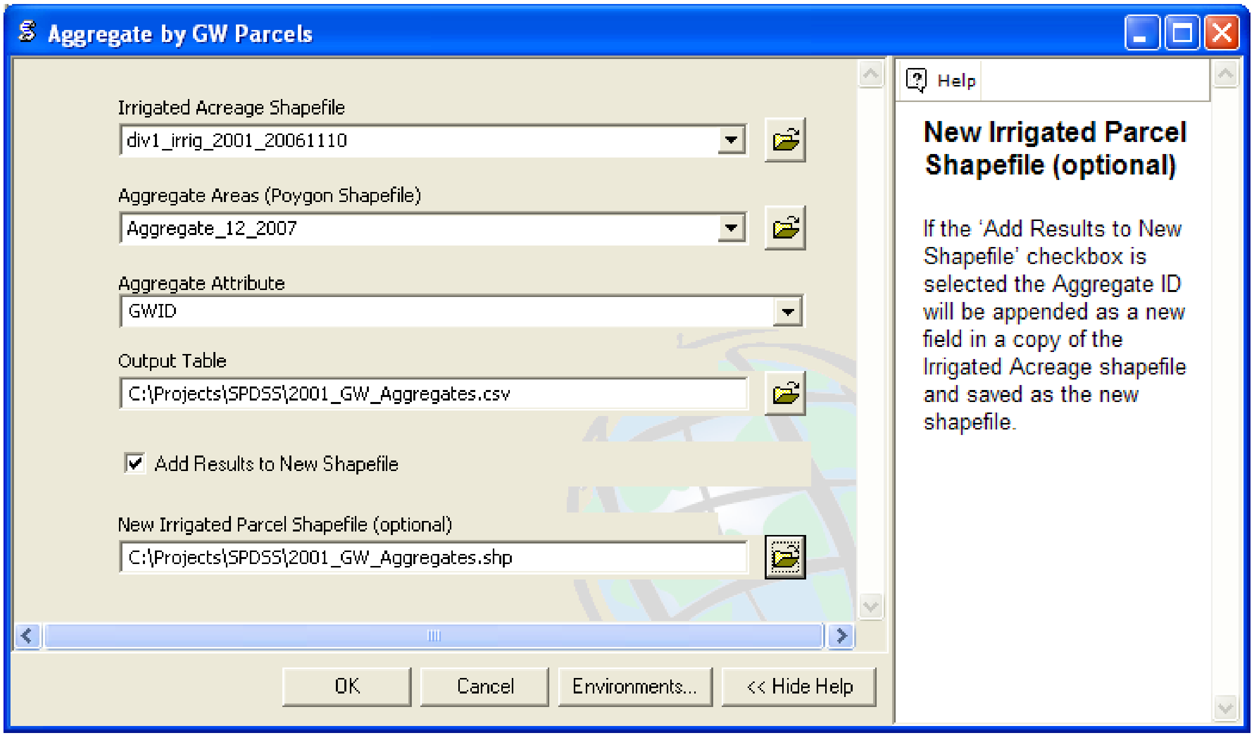



**Figure 15 – New Irrigated Parcel Shapefile Online Help**

## 2.2 Aggregate by SW Structure

The Aggregate by SW Structure tool is used to combine parcels irrigated by 'non-key' surface water structures into user-defined aggregate areas. 'Non-key' structures are generally defined in the CDSS modeling efforts as those surface water structures with sparse or no diversion records, structures diverting from a tributary not expected to be included in the water resources planning model, or structures irrigating a relatively small amount of land. These 'non-key' structures and their irrigated land are combined and given a unique Aggregate ID. The Aggregate ID is typically made up of nine characters identifying the river basin, Water District, and use of surface water. For example, 01ADP001 indicates the first group of aggregated diversion structures in the Platte basin (ADP) in Water District 1. When 'non-key' structures have irrigated lands in more than one aggregate polygon, the structure will be assigned to the aggregate containing the greatest structure area. Only those parcels that have an associated surface water WDID not included in the 'key' structure list will be aggregated and included in an Aggregate ID in the newly created Output Table.

Creating aggregates can be an iterative process, whereby the user should review the results of the aggregation tool and revise the aggregate polygons as necessary to, for example, maintain a maximum irrigated area per aggregate. Upon each aggregate polygon revision, the Aggregate by SW Structure tool should be rerun.

The SPDSS Technical Memorandum "Task 3: Aggregate Non-Key Agricultural Diversion Structures", May 15, 2007 describes this process as it was applied to the South Platte basin modeling efforts.

The required inputs for this analysis include:

- Irrigated Acreage Shapefile: A polygon shapefile that contains irrigated parcels, crop type, irrigation method and water supply data. The shapefile must be provided in the standard CDSS format, as described in Appendix A. Irrigated acreage shapefiles have been created by river basin in support of CDSS modeling efforts and are available on the CDSS website (cdss.state.co.us).

- Aggregate Areas: A polygon shapefile that defines the areas that the 'non-key' surface water parcels will be grouped in.

- Aggregate Attribute: The attribute field name in the Aggregate Areas shapefile that contains the Aggregate IDs that the 'non-key' surface water parcels will be assigned to in the output table. This attribute can also be added to the Irrigated Acreage shapefile to create a new Irrigated Acreage shapefile.

- Key Structure List: This input file is optional - if no Key Structure List is provided, the tool will aggregate all parcels with the same surface water WDID into a group. The list file is a comma-delimited file with one structure surface water WDID per line, with additional information about the structure separated by columns. These structure WDIDs will be excluded from the aggregation output tables. The surface water ID (SW_WDID) format in this file must match the 7-digit 'text' format in the Irrigated Acreage Shapefile. For example, if the structure is 503 in Water District 1, the SW_WDID must be '0100503'.

- Key Structure Column: Column number of the SW_WDID in the Key Structure List. This column number must be specified if a Key Structure List is input.

- Output Table: The output file is a comma-delimited file that contains the Aggregate ID, the surface water WDID and structure acres. Note that this tool recomputes parcel areas based on map units of meters, then converts the area to acres and aggregates according to the Aggregate Area polygon coverage. Date and input parameters are included in the header.

- New Irrigated Parcel Shapefile: If the 'Add Results to New Shapefile' checkbox is selected, the Aggregate ID (if any) assigned to the structure in SW_WDID1 will be appended as a new field in a copy of the Irrigated Acreage Shapefile and saved as the new shapefile. Note that because each irrigated parcel can be served by more than one structure (as defined by SW_WDIDx and SW_COVx) it is also possible that a single parcel could be included in more than one aggregate. Only the Aggregate ID associated with SW_WDID1 will be appended in the new shapefile. See Section 1.2 for tips to revise the new shapefile display.

Double-click on Aggregate by SW Structure to open the user interface for this tool, as shown in Figure 16. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

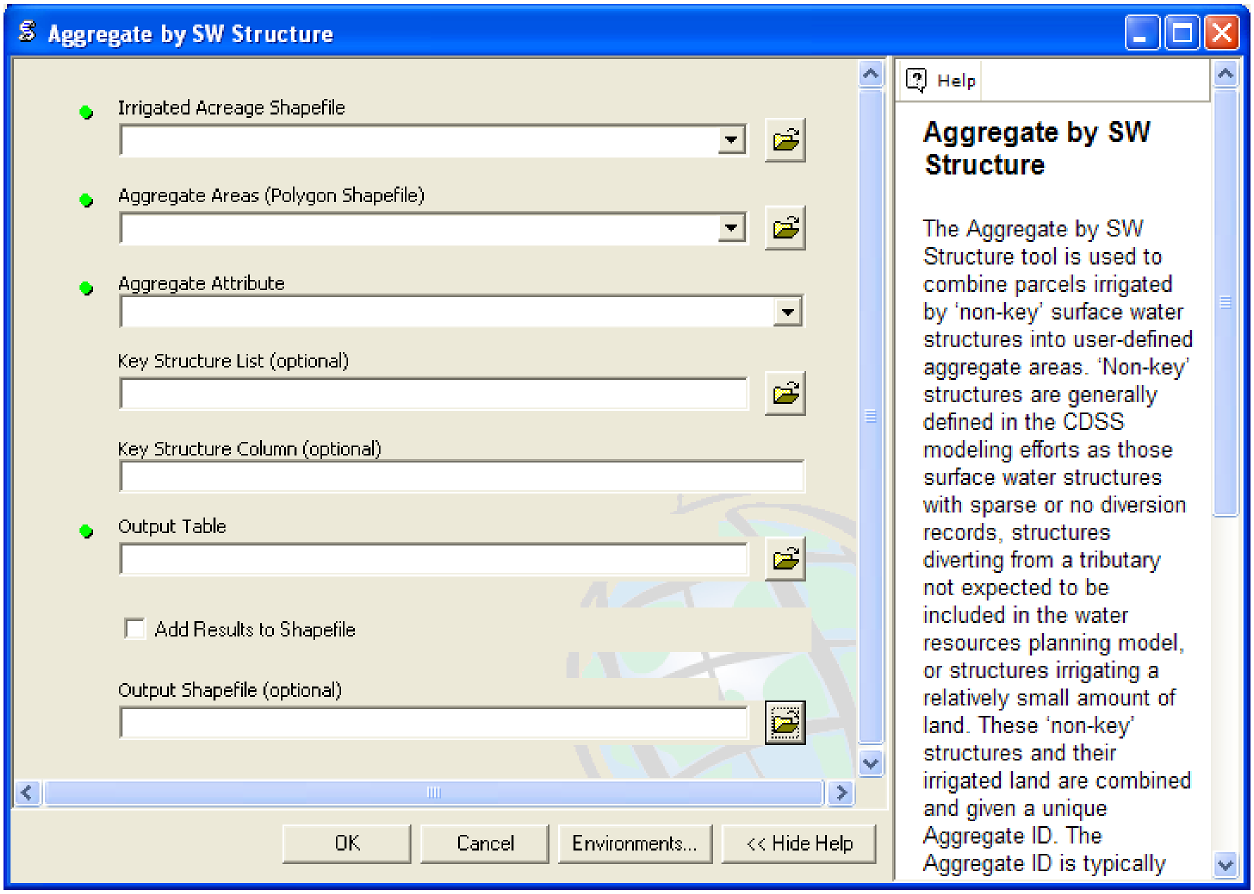



**Figure 16 – Aggregate by SW Structures Interface**

## 2.3 Aggregate by User-Specified ID

The Aggregate by User-Specified ID tool is used to combine any user-defined polygons into user-defined aggregate areas. As other tools specified that parcels served by ground water or surface water were to be aggregated, this tool allows the user to spatially assign polygons from a shapefile to a user-defined set of aggregated areas. The standard formatted CDSS Irrigated Acreage file is not required as an input for this tool. For example, if the polygon shapefile depicts alfalfa coverage and the aggregate area coverage is counties, this tool would provide the user with the area of alfalfa in each county. In this example, if an alfalfa polygon overlaps a county boundary, that alfalfa parcel will be assigned to the county that contains the greatest parcel area.

Creating aggregates can be an iterative process, whereby the user can review the results of the aggregation tool and revise the aggregate polygons as necessary. Upon each aggregate polygon revision, the Aggregate by User-Specified ID tool should be rerun.

The required inputs for this analysis include:

- Polygon Shapefile: A shapefile of polygons to spatially assign to Aggregate Areas (e.g. alfalfa parcels).

- Polygon Attribute: The attribute field name in the Polygon Shapefile attribute table that contains the Polygon IDs to be used in the aggregation assessment.

- Aggregate Areas: A polygon shapefile that defines the areas the polygons will be grouped in (e.g. counties).

- Aggregate Attribute: The attribute field name in the Aggregate Areas shapefile that contains the Aggregate IDs the polygons will be assigned to in the output table. This attribute can also be added to the original polygon shapefile to create a new shapefile.

- Output Table: The output file is a comma-delimited file that contains the Aggregate ID, the Polygon ID and total acres. Note that this tool recomputes the user-defined polygon areas based on map units of meters, then converts the area to acres and aggregates according to the Aggregate Area polygon coverage. Date and input parameters will be included in the header.

- New Output Shapefile: If the 'Add Results to New Shapefile' checkbox is selected, the Aggregate ID will be appended as a new field to a copy of the original Polygon shapefile input and saved as the new shapefile. See Section 1.2 for tips to revise the new shapefile display.

Double-click on Aggregate by User-Specified ID to open the user interface for this tool, as shown in Figure 17. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

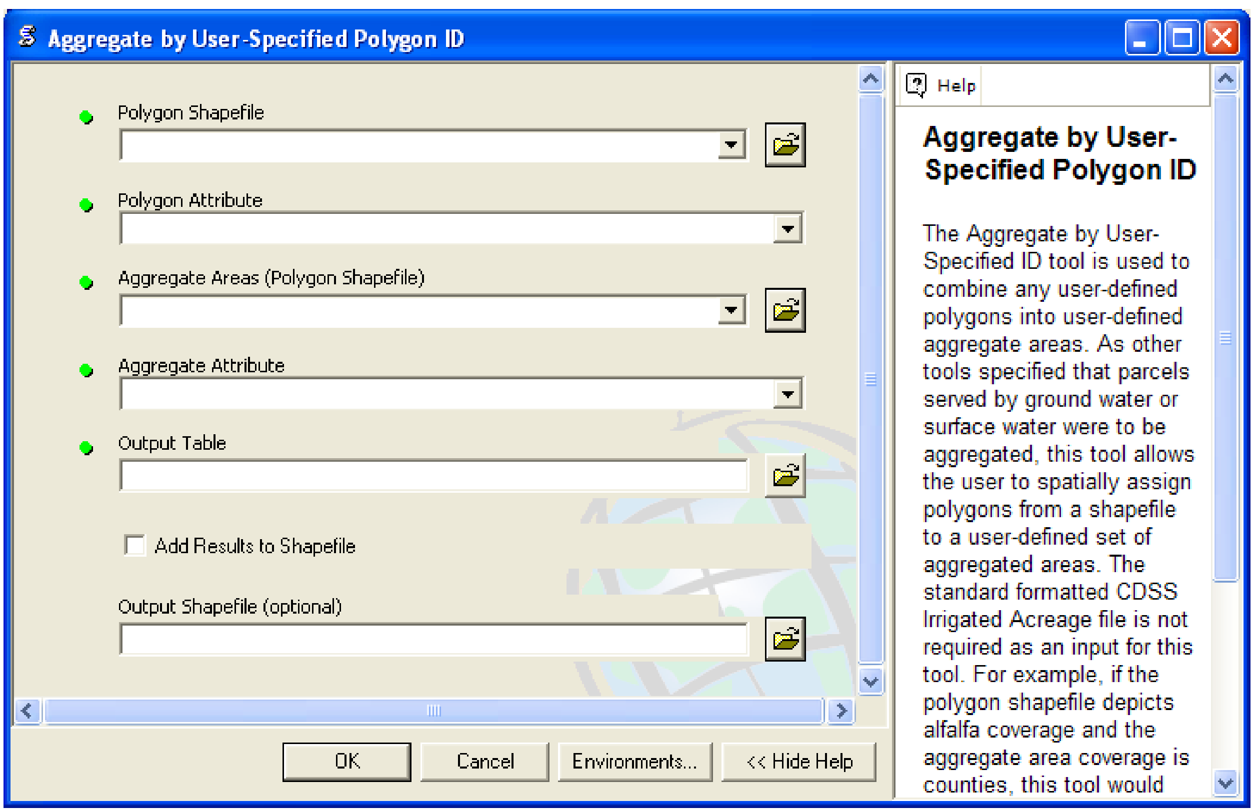



**Figure 17 – Aggregate by User-Defined ID Interface**

## 2.4 Aggregate Canal Segments

The Aggregate Canal Segments tool computes and summarizes total canal lengths. The surface water ID (SW_WDID) in the standard CDSS format for Canal Shapefiles is the attribute used in the summarization analysis.

The required inputs for this analysis include:

- Canal Shapefile: A shapefile of canals where the attribute table for this polyline shapefile must be in the standard CDSS format, as described in Appendix A. The polyline segments will be summarized by surface water ID (SW_WDID) attribute.
- Output Table: The output file is a comma-delimited file that contains the Surface Water ID (WDID) and total length in feet of the canals. Note that polyline segment lengths are not recomputed but are based on the 'Length' field and units in the Canal shapefile. Date and input parameters will be included in the header.

Double-click on Aggregate Canal Segments to open the user interface for this tool, as shown in Figure 18. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

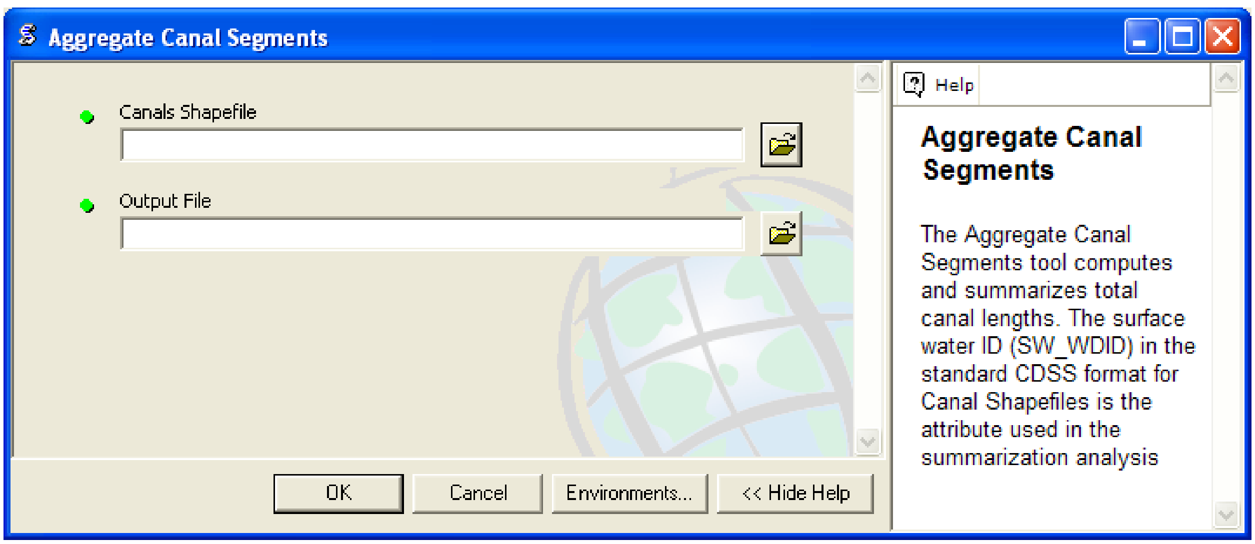



**Figure 18 – Aggregate Canal Segments Interface**

## 3.0 Climate Weights Toolset

Using the tools available in the Climate Weights Toolset, the user can compute average annual precipitation for drainage basins, assign climate station weights to irrigation structures and also assign climate station weights to user-defined polygons. The output tables that result from running the Climate Weight tools can be used directly in StateDMI commands to develop specific files used for StateCU, StateMod, and StatePP analyses.

Select the + symbol next to Climate Weights to view all of the available tools as shown in Figure 19.

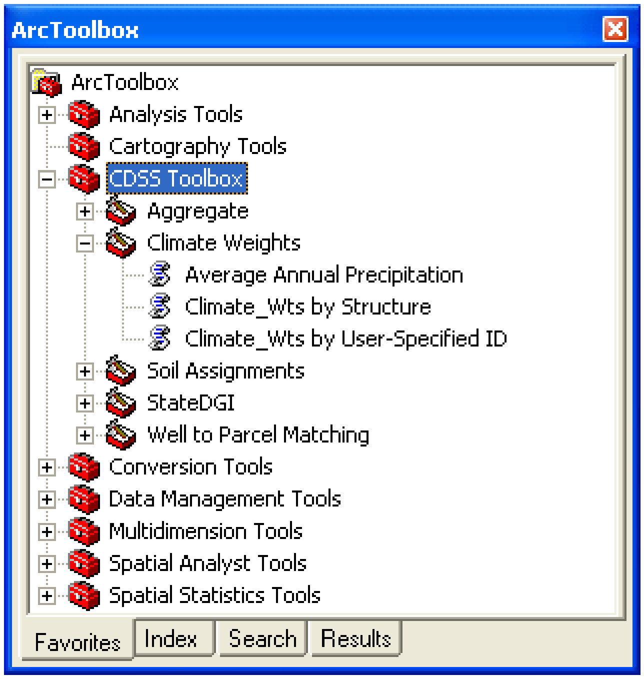



**Figure 19 – Showing Climate Weights Toolset**

## 3.1 Average Annual Precipitation

The Average Annual Precipitation tool spatially computes the average annual precipitation, as defined by the Average Annual Precipitation Grid, for a user-defined set of polygons, generally representing drainage basins. This tool is generally used to define average annual precipitation drainages above StateMod baseflow nodes. Average annual precipitation and drainage area are used to distribute natural streamflow gains to baseflow nodes on ungaged tributaries. This tool requires the **Spatial Analyst** extension to ArcMap.

The required inputs for this analysis include:

- Polygon Shapefile: A polygon shapefile, generally drainage basins.
- Polygon Attribute: The attribute field name in the Polygon Shapefile that contains the Polygon IDs to be used in the summarization assessment.
- Average Annual Precipitation Grid: The raster grid of average annual precipitation used in the summarization analysis. A statewide average annual precipitation grid has been created in support of CDSS modeling efforts and is available on the CDSS website (cdss.state.co.us). The grid was developed based on the Colorado Climate Center's average annual precipitation coverage (Date:1951-1980).
- Output Table: The output file is a comma-delimited file that contains the Polygon ID, average annual precipitation in inches and total polygon area in acres. Note that this tool recomputes areas of the polygons based on map units of meters, then converts the area to acres. Date and input parameters will be included in the header.

- New Output Shapefile: If the 'Append to New Shapefile' checkbox is selected, the average annual precipitation will be appended as a new field to a copy of the original Polygon shapefile input and saved as the new shapefile. See Section 1.2 for tips to revise the new shapefile display.

Double-click on Average Annual Precipitation to open the user interface for this tool, as shown in Figure 20. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

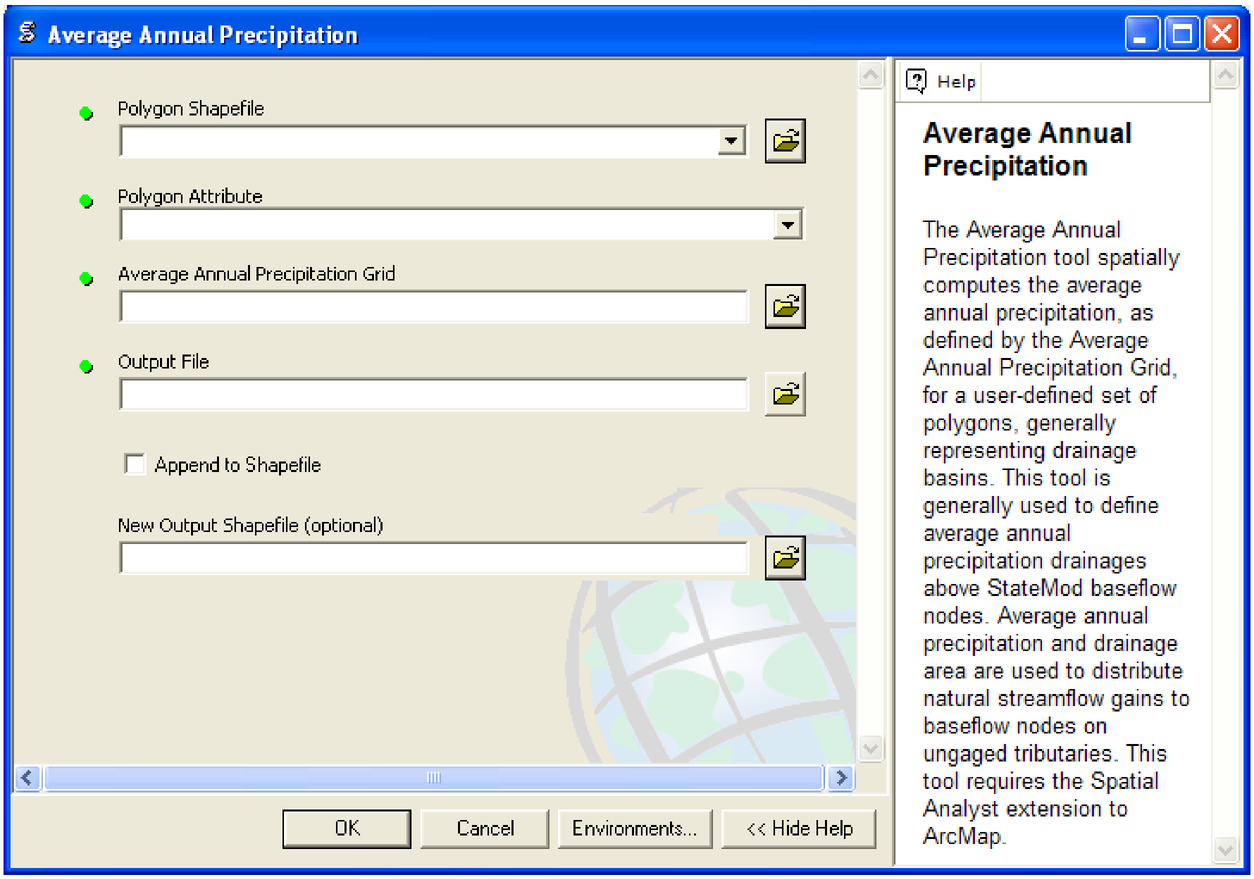



**Figure 20 – Average Annual Precipitation Interface**

## 3.2 Climate Weights by Structure

The Climate Weights by Structure tool allows the user to spatially assign climate station weights to structures in the Irrigated Acreage Shapefile. This tool prorates the climate station weights for each parcel, as defined by the selected Climate Station Grids, and then summarizes the climate station weighted parcels by structure. This tool requires the **Spatial Analyst** extension to ArcMap.

The required inputs for this analysis include:

- Irrigated Acreage Shapefile: A polygon shapefile that contains irrigated parcels, crop type, irrigation method and water supply data. The shapefile must be provided in the standard CDSS format, as described in Appendix A. Irrigated acreage shapefiles have been created by river basin in support of CDSS modeling efforts and are available on the CDSS website (cdss.state.co.us).

- Climate Station Grid Directory: The series of climate station raster grids with computed weights based on the distance to the nearest climate station to be used in the analysis. To add climate station grids click on the 'open-folder' icon to navigate to the climate station grids. Select any number of climate station grids for use in the analysis; holding down the CTRL key to select more than one climate station grid at a time. Each selected climate station grid will populate the area below the Climate Station Weight Grid navigation box. Note that the top navigation box (next to the 'open-folder' icon) will remain empty. The controls next to the populated area are basic ESRI tools and although the up and down arrows are functional, the order of the climate station grids does not matter. Use the 'X' icon to delete climate station grids. Climate Station Grids for the SPDSS study area have been created in support of SPDSS modeling efforts, as described in the SPDSS Technical Memorandum "Task 53.3: Assign Key Climate Information to Irrigated Acreage and Reservoirs", February 1, 2006. The SPDSS Climate Station grids are available on the CDSS website (cdss.state.co.us).

- Precipitation Orographic Correction Grid Directory (optional): The directory of grids that contains computed orographic weights based on the ratio of average annual precipitation at a climate station to the average annual precipitation at the structure location. Orographic adjustments are applied to precipitation data typically when irrigated parcels are at an elevation higher than nearby climate stations. To add orographic correction grids click on the 'open-folder' icon to navigate to the folder containing the grids. Orographic corrections will only be assigned to their respective climate stations if the climate station was selected as a 'weighted' station. For example, if the '2220' climate station grid was the only one selected, then the tool will only utilize the '2220' orographic correction grid when determining orographic adjustments. This is an optional input; if no orographic correction grid is provided then no orographic adjustments will be assigned to the Surface Water IDs in the Output Table. The SPDSS Orographic Adjustment grids are available on the CDSS website (cdss.state.co.us).

- Threshold Weight: Minimum weight assigned to a climate station. The default is 0.05 or 5 percent. If the minimum weight assigned to any climate station is less than the Threshold Weight, the weights assigned to the other stations will be adjusted to assure that all the weights sum to 1.0 for each structure.

- Output Table: The output file is a comma-delimited file that contains the Surface Water ID, Climate Station IDs, weights and orographic correction factors. An orographic factor is provided for each assigned climate station if the Precipitation Orographic Correction Grid Directory is provided by the user. If the minimum weight assigned to any climate station is less than the Threshold Weight, the weights assigned to the other stations will be adjusted to assure that all the weights sum to 1.0 for each structure. Date and input parameters will be included in the header.

Double-click on Climate_Wts by Structure to open the user interface for this tool, as shown in Figure 21. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

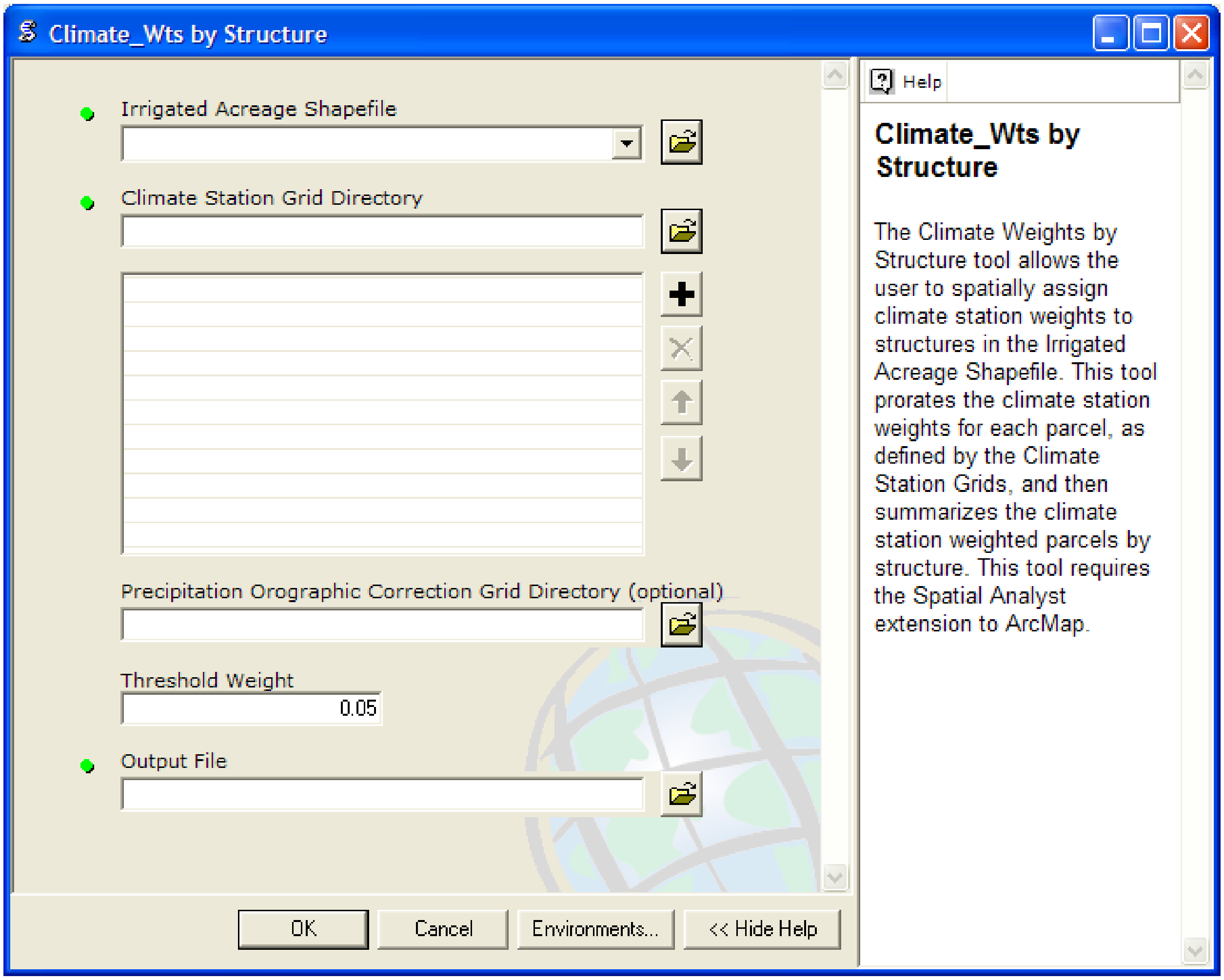



**Figure 21 – Climate Weights by Structure Interface**

## 3.3 Climate Weights by User-Specified ID

The Climate Weights by User-Specified ID tool allows the user to spatially assign climate station weights to a user-defined attribute in the Polygon Shapefile. This tool calculates either an area-weighted average or centroid-based climate weight for each of the polygons in the Polygon Shapefile. For example, in CDSS analyses the Polygon Shapefile typically represents Aggregate Areas of surface water structures (as discussed in Section 2.2) and this tool will assign either area-weighted average or centroid-based climate station weights to each Aggregate Area. The default for this tool is to use area-weighted average climate station weights, whereby the climate stations over the polygon area are averaged and a single set of climate station weights is provided for the entire area. In the centroid-based assignment, the set of climate station weights determined at the centroid of the polygon will be assigned to the entire polygon. The centroid-based analysis is typically used for very small polygons (e.g model cells) where the climate station weights would not vary greatly over the polygon area. This tool requires the **Spatial Analyst** extension for ArcMap.

The required inputs for this analysis include:

- Polygon Shapefile: A shapefile of polygons to spatially assign climate station weights to (e.g. SW Aggregate Areas).

- Polygon Attribute: The attribute field name in the Polygon Shapefile that contains the Polygon IDs used in the weight assignment analysis (e.g. Aggregate ID).

- Climate Station Weight Grids: The series of climate station raster grids with computed weights based on the distance to the nearest climate station to be used in the analysis. To add climate station grids click on the 'open-folder' icon to navigate to the climate station grids. Select any number of climate station grids for use in the analysis; holding down the CTRL key to select more than one climate station grid at a time. Each selected climate station grid will populate the area below the Climate Station Weight Grid navigation box. Note that the top navigation box (next to the 'open-folder' icon) will remain empty. The controls next to the populated area are basic ESRI tools and although the up and down arrows are functional, the order of the climate station grids does not matter. Use the 'X' icon to delete climate station grids. Climate Station Grids for the SPDSS study area have been created in support of SPDSS modeling efforts, as described in the SPDSS Technical Memorandum "Task 53.3: Assign Key Climate Information to Irrigated Acreage and Reservoirs", February 1, 2006. The SPDSS Climate Station grids are available on the CDSS website (cdss.state.co.us).

- Precipitation Orographic Correction Grid Directory (optional): The directory of grids that contains computed orographic weights based on the ratio of average annual precipitation at a climate station to the average annual precipitation at the structure location. Orographic adjustments are applied to precipitation data typically when irrigated parcels are at an elevation higher than nearby climate stations. To add orographic correction grids click on the 'open-folder' icon to navigate to the folder containing the grids. Orographic corrections will only be assigned to their respective climate stations if the climate station was selected as a 'weighted' station. For example, if the '2220' climate station grid was the only one selected, then the tool will only utilize the '2220' orographic correction grid when determining orographic adjustments. This is an optional input; if no orographic correction grid is provided then no orographic adjustments will be assigned to the Surface Water IDs in the Output Table. The SPDSS Orographic Adjustment grids are available on the CDSS website (cdss.state.co.us).

- Threshold Weight: Minimum weight assigned to a climate station. The default is 0.05 or 5 percent. If the minimum weight assigned to any climate station is less than the Threshold Weight, the weights assigned to the other stations will be adjusted to assure that all the weights sum to 1.0 for each structure.

- Check for Centroid Analysis: Check this box to perform a centroid-based climate station weight analysis. The default for this tool is perform an area-weighted climate weight station analysis. In the centroid-based assignment, the set of climate station weights determined at the centroid of the polygon will be assigned to the entire polygon. The centroid-based analysis is typically used for very small polygons (e.g model cells) where the climate station weights would not vary greatly over the polygon area. This option is recommended when assigned climate weights to the Ground Water Model Grid to enhance the tool performance.

- Output Table: The output file is a comma-delimited file that contains the Polygon ID, Climate Station IDs, weights and orographic correction factors. An orographic factor is provided for each assigned climate station if the Precipitation Orographic Correction Grid Directory is provided by the user. If the minimum weight assigned to any climate station is less than the Threshold Weight, the weights assigned to the other stations will be adjusted to assure that all the weights sum to 1.0 for each Polygon ID. Date and input parameters will be included in the header.

Double-click on Climate_Wts by User-Specified ID to open the user interface for this tool, as shown in Figure 22. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

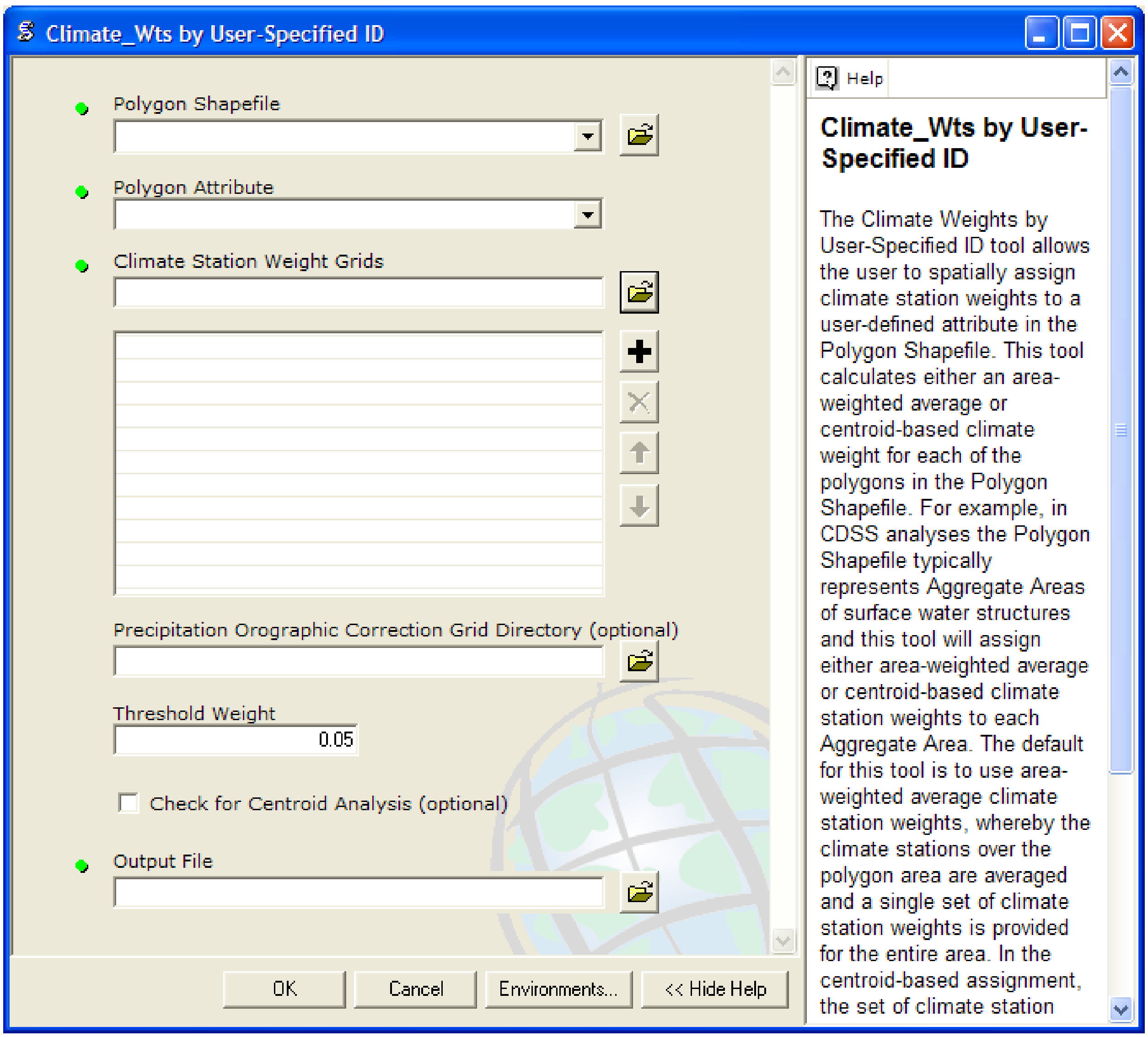



**Figure 22 – Climate Weights by User-Specified ID Interface**

## 4.0 Soil Assignments Toolset

Using the tools available in the Soil Assignments toolset, the user can assign area-weighted soil parameters to surface water structures, or user-defined polygons or polylines from a shapefile. The output tables that result from running the Soil Assignments tools can be used directly in StateDMI commands to develop specific input files for StateCU and StateMod analyses.

Select the + symbol next to Soil Assignments to view all of the available tools as shown in Figure 23.

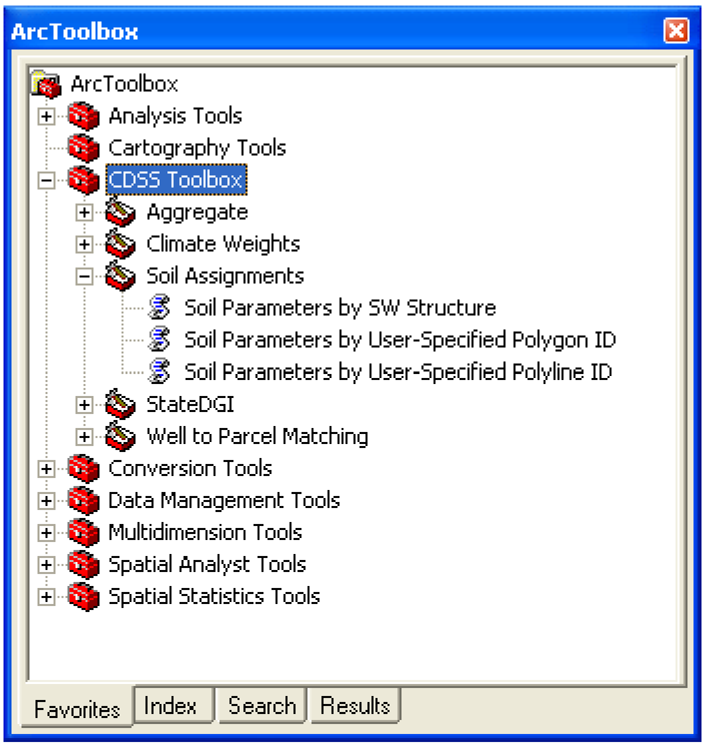



**Figure 23 – Showing Soil Assignment Toolset**

## 4.1 Soil Parameters by SW Structure

The Soil Parameters by SW Structure tool allows the user to spatially assign soil parameters to structures in the Irrigated Acreage Shapefile. The Soil Parameter Shapefile will typically reflect available water content or permeability. This tool prorates the soil parameters for each parcel, as defined by the Soil Parameter Shapefile, and then summarizes the soil parameters for the parcels by structure. Only parcels with a surface water ID (SW_WDID) in the Irrigated Acreage Shapefile will be assigned soil parameters. The SPDSS Technical Memorandum "Task 57: Assign Soil Moisture Water Holding Capacity to Structures", March, 2008 describes the process of assigning available water content values to surface water structures in the South Platte basin modeling efforts.

The required inputs for this analysis include:

- Irrigated Acreage Shapefile: A polygon shapefile that contains irrigated parcels, crop type, irrigation method and water supply data. The shapefile must be provided in the standard CDSS format, as described in Appendix A. Irrigated acreage shapefiles have been created by river basin in support of CDSS modeling efforts and are available on the CDSS website (cdss.state.co.us). Only parcels with a surface water ID will be assigned soil parameters.

- Soil Parameter Shapefile: Polygon shapefile of soil parameters. For CDSS, Statewide soil permeability and available water content coverages were derived from the NRCS STATSGO database. The coverages are available on the CDSS website (cdss.state.co.us).

- Soil Parameter Attribute: The attribute field name in the Soil Parameter shapefile that contains the soil parameter ID that will be assigned to the surface water structures (e.g. AWC for available water capacity).

- Output Table: The output file is a comma-delimited file that contains the surface water ID (SW_WDID) and the average area-weighted soil parameter. Date and input parameters will be included in the header.

- New Output Shapefile: If the 'Add Results to New Shapefile' checkbox is selected, the Soil Parameter ID will be appended as a new field to a copy of the original Irrigated Acreage shapefile input and saved as the new shapefile. See Section 1.2 for tips to revise the new shapefile display.

Double-click on Soil Parameters by SW Structure to open the user interface for this tool, as shown in Figure 24. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

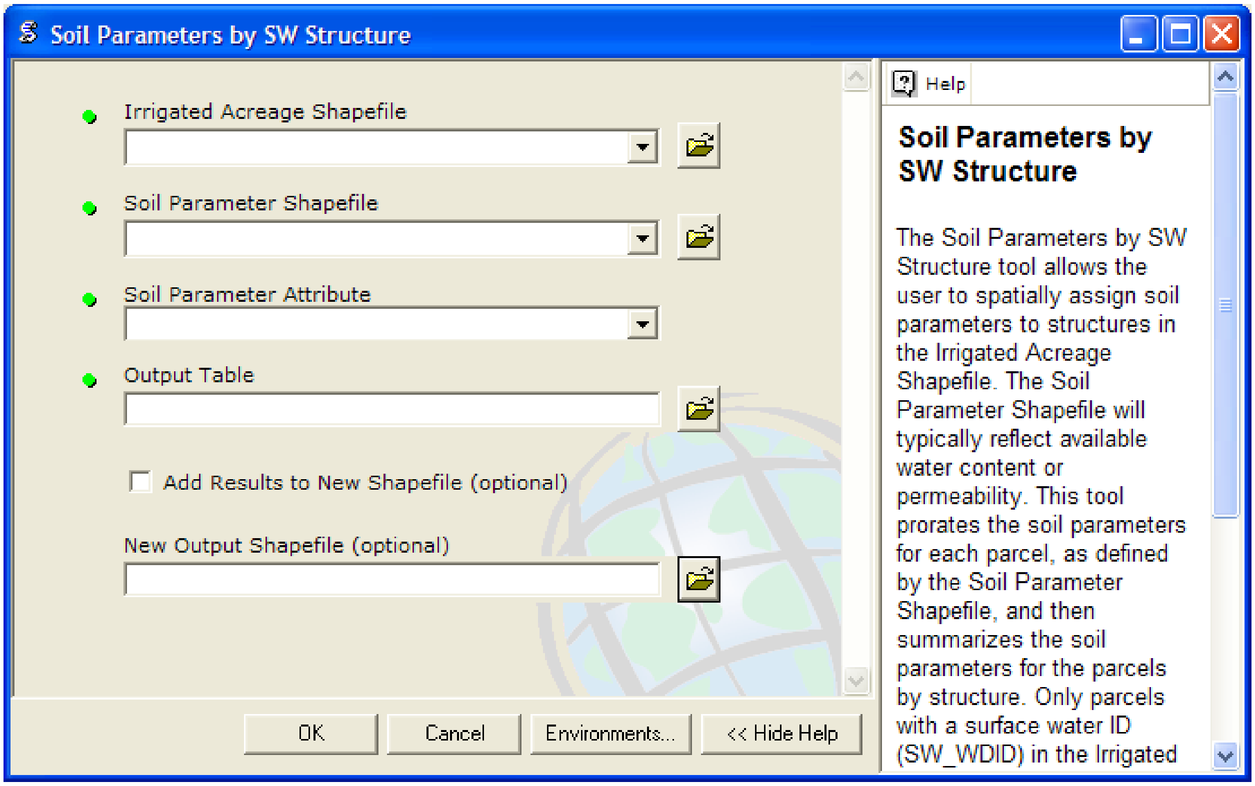



**Figure 24 – Soil Parameter by SW Structure Interface**

## 4.2 Soil Parameters by User-Specified Polygon ID

The Soil Parameters by User-Specified Polygon ID tool allows the user to spatially assign soil parameters, as defined in the Soil Parameter Shapefile, to a user-defined attribute in the Polygon Shapefile. The Soil Parameter Shapefile will typically reflect available water content or permeability. This tool calculates an area-weighted average soil parameter for each of the polygons in the Polygon Shapefile. For example, in CDSS analyses the Polygon Shapefile typically represents Aggregate Areas for surface water structures (as discussed in Section 2.2) and this tool will assign area-weighted soil parameters to each Aggregate Area. The SPDSS Technical Memorandum “Task 57: Assign Soil Moisture Water Holding Capacity to Structures”, March, 2008 describes the process of assigning available water content to aggregate surface water structures in the South Platte basin modeling efforts.

The required inputs for this analysis include:

- Polygon Shapefile: A shapefile of polygons to spatially assign soil parameters to (e.g. SW Aggregate Areas developed by the Aggregate Tool).
- Polygon Attribute: The attribute field name in the Polygon Shapefile that contains the Polygon IDs used in the weight assignment analysis (e.g. Aggregate ID).
- Soil Parameter Shapefile: Polygon shapefile of soil parameters. For CDSS, Statewide soil permeability and available water content coverages were derived from the NRCS

STATSGO database. The coverages are available on the CDSS website (cdss.state.co.us).

- Soil Parameter Attribute: The attribute field name in the Soil Parameter shapefile that contains the soil parameter ID that will be assigned to the user specified polygons (e.g. AWC for available water capacity).

- Output Table: The output file is a comma-delimited file that contains the Polygon ID and the average area-weighted soil parameter. Date and input parameters will be included in the header.

- New Output Shapefile: If the 'Add Results to New Shapefile' checkbox is selected, the Soil Parameter ID will be appended as a new field to a copy of the original Polygon shapefile input and saved as the new shapefile. See Section 1.2 for tips to revise the new shapefile display.

Double-click on Soil Parameters by User-Specified Polygon ID to open the user interface for this tool, as shown in Figure 25. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

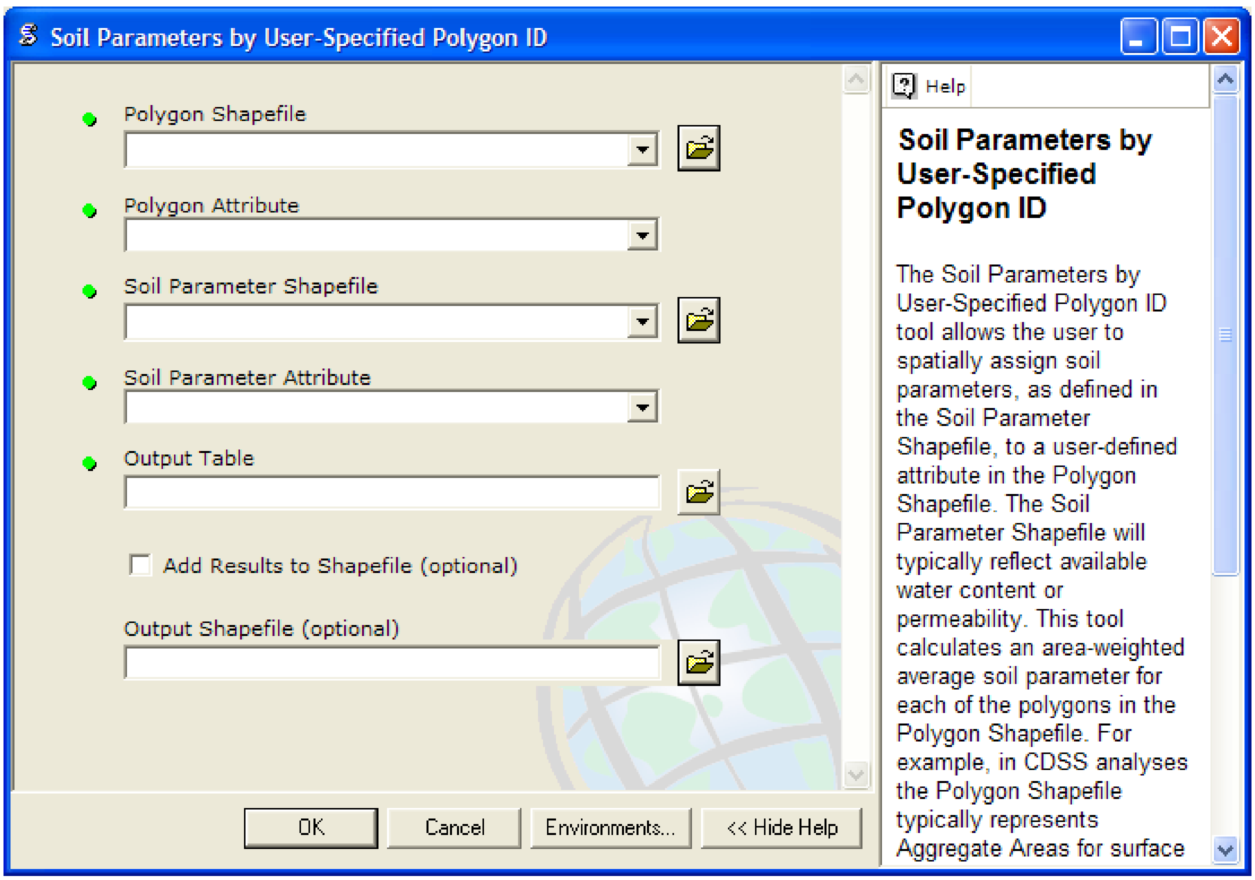



**Figure 25 – Soil Parameter by User-Specified Polygon ID**

## 4.3 Soil Parameters by User-Specified Polyline ID

The Soil Parameters by User-Specified Polyline ID tool allows the user to spatially assign soil parameters, as defined in the Soil Parameter Shapefile, to a user-defined attribute in the Polyline Shapefile. The Soil Parameter Shapefile will typically reflect available water content or permeability. This tool calculates a length-weighted average soil parameter for each of the polylines in the Polyline Shapefile. The output table will include one Soil Parameter value for each Polyline ID. For example in CDSS analyses, the Polyline Shapefile typically represents canals, whereby the tool will assign length-weighted permeability to each canal for use in estimating canal efficiencies. The SPDSS Technical Memorandum "Task 56: Conveyance and Application Efficiencies", March, 2008 describes the process of using weighted permeability to estimate canal efficiencies in the South Platte basin modeling efforts.

The required inputs for this analysis include:

- Polyline Shapefile: A shapefile of polylines to spatially assign soil parameters to (e.g. canals).

- Polyline Attribute: The attribute field name in the Polyline Shapefile used that contains the Polyline IDs in the weight assignment analysis (e.g. SW_WDID).

- Soil Parameter Shapefile: Polygon shapefile of soil parameters. For CDSS, Statewide soil permeability and available water content coverages were derived from the NRCS STATSGO database. The coverages are available on the CDSS website (cdss.state.co.us).

- Soil Parameter Attribute: The attribute field name in the Soil Parameter shapefile that contains the soil parameter ID that will be assigned to the user specified polylines (e.g. AWC for available water capacity).

- Output Table: The output file is a comma-delimited file that contains the Polyline ID and the average length-weighted soil parameter. Date and input parameters will be included in the header.

- New Output Shapefile: If the 'Add Results to New Shapefile' checkbox is selected, the Soil Parameter ID will be appended as a new field to a copy of the original Polyline shapefile input and saved as the new shapefile. See Section 1.2 for tips to revise the new shapefile display.

Double-click on Soil Parameters by User-Specified Polyline ID to open the user interface for this tool, as shown in Figure 26. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

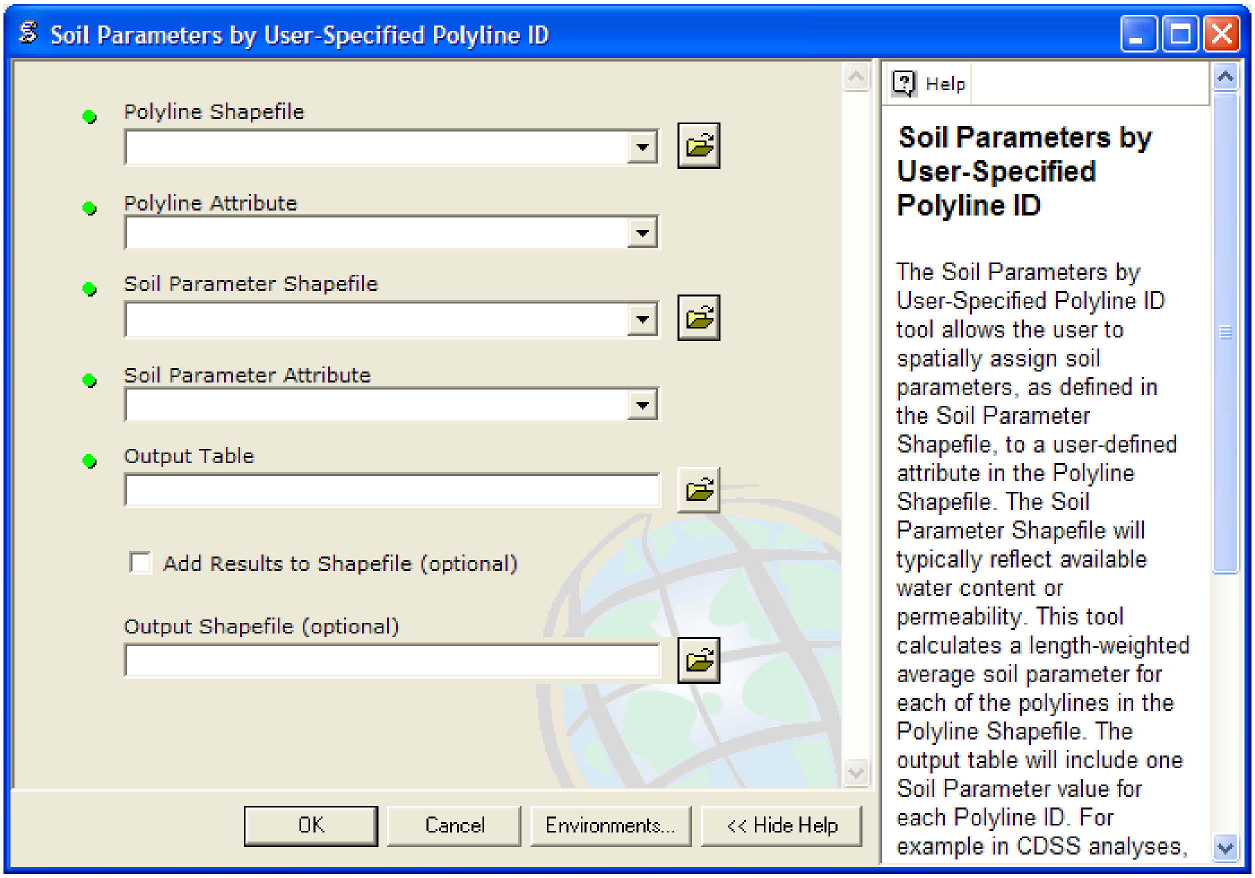



**Figure 26 – Soil Parameter by User-Specified Polyline ID**

## 5.0 Well to Parcel Matching Tool

The Well to Parcel Matching toolset contains the Well to Parcel Matching tool, as shown in Figure 27. Double-click on the Well to Parcel Matching tool to open the user interface.

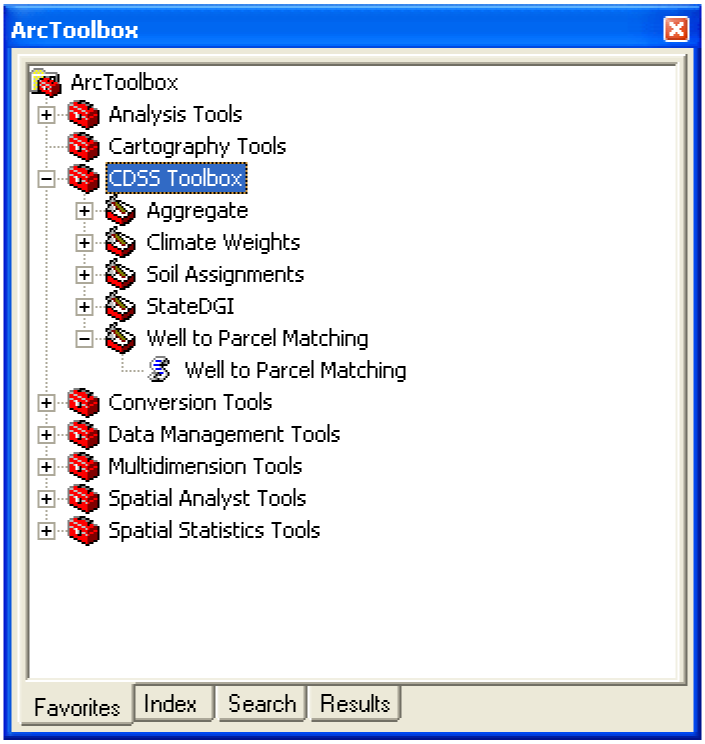



**Figure 27 – Showing Well to Parcel Matching Tool**

The Well to Parcel Matching Tool performs a preliminary automated matching of wells to irrigated parcels. Note that the well shapefile used in this tool should only include **irrigation** wells that the user would like to be matched to parcels. For example, if the irrigated acreage shapefile represents a 1976 assessment, the well shapefile should only include irrigation wells active prior to 1976. When the Well to Parcel Matching tool is run, each irrigated parcel is systematically mapped to a nearby well and assigned one of the following match types:

- Type 1: Well is located inside the parcel
- Type 2: Well is located outside the parcel but within ¼ mile
- Type 4: Well that is within 5 miles of a parcel.

If a match is found, the associated parcel, well, type of match, and distance between the parcel and the well is detailed in the output file. The resulting well to parcel matching is the preliminary assignment of wells to parcels that is included in the Irrigated Acreage Shapefile. Note that this preliminary well matching should be reviewed and updated as needed by other methods such as ditch-user interviews. See Appendix A.1 for additional well matching types. Note that once user information regarding well usage is incorporated into the Irrigated Acreage file, this tool should not be rerun as the tool will override the user supplied data. A detailed description of the process performed in the Well to Parcel Matching is described in the RGDSS Technical memorandum, "RGDSS Spatial System Integration, Task 3.1 - Data Centered Groundwater Model" attached as Appendix B.

The required inputs for this analysis include:

- Well Shapefile: The well shapefile is a point coverage of wells that will be matched to parcels in the Irrigated Acreage shapefile. The well file should include wells permitted for irrigation.

- Well ID Attribute: The attribute field name in the Well Shapefile that contains the unique Well ID that the parcels will be matched to in the output table.

- Irrigated Acreage Shapefile: A polygon shapefile that contains irrigated parcels, crop type, irrigation method and water supply data. The shapefile must be provided in the standard CDSS format, as described in Appendix A. Irrigated acreage shapefiles have been created by river basin in support of CDSS modeling efforts and are available on the CDSS website (cdss.state.co.us).

- Output Table: The output file is a comma-delimited file that contains the irrigated parcel ID, well ID, type of match, and distance between the parcel and the well. Date and input parameters will be included in the header.

- New Output Shapefile: If the ‘Add Results to New Shapefile’ checkbox is selected, the Well ID, type of match and distance between the parcel and the well will be exported as a new shapefile in the standard CDSS format.

Figure 28 shows the Well to Parcel Matching Tool. When the ‘Show Help’ button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

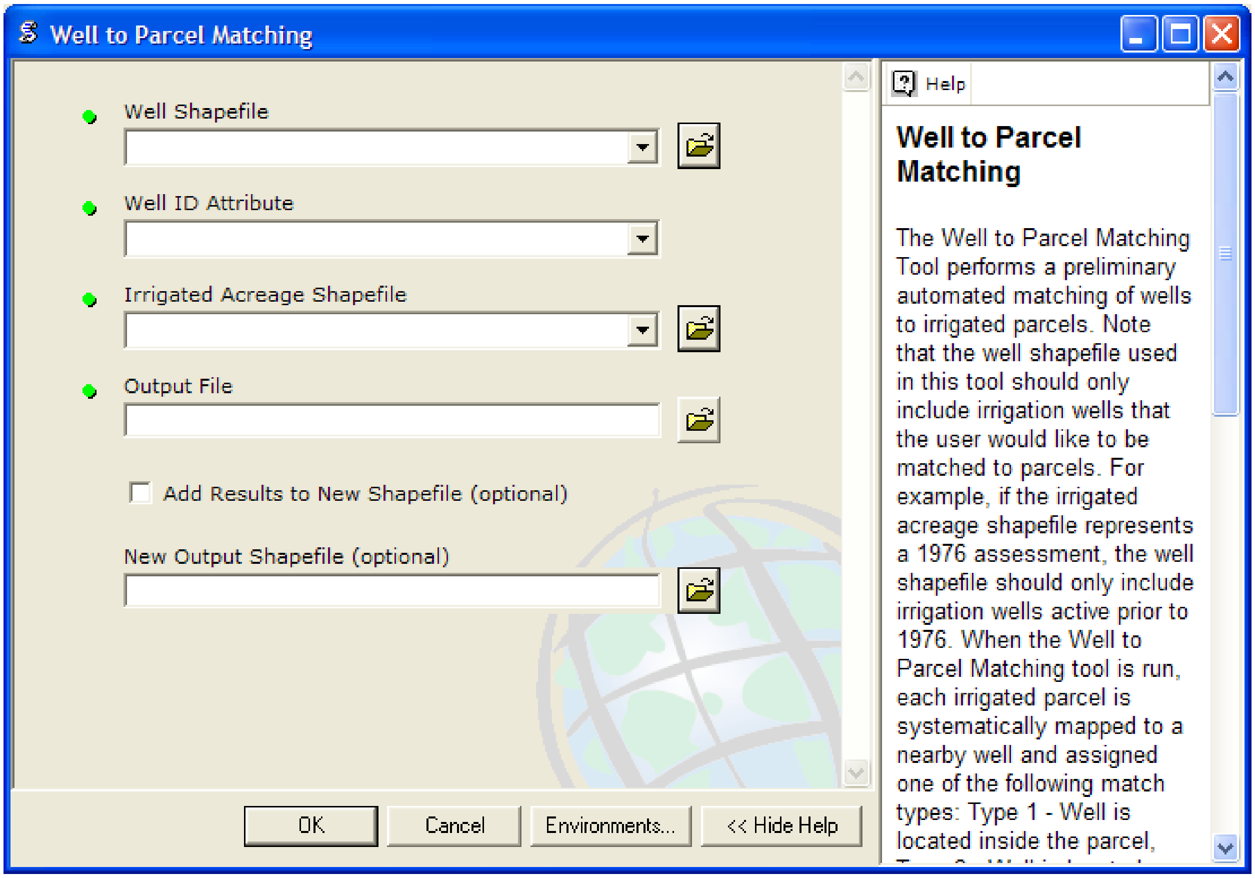



**Figure 28 – Well to Parcel Matching Tool**

## 6.0 StateDGI Toolset

The StateDGI Toolset was developed to compute the spatial components of ground water GIS layers in relation to a defined MODFLOW cell system. The StateDGI Toolset is used in conjunction with an Access relational database to store and process data for use by the ground water preprocessor, StatePP. This spatial information, used in conjunction with StateCU output files, is used as input to StatePP to develop and run a ground water simulation model. The user must run StateDGI from ArcMap and later Access to determine cell-by-cell values for input to the StatePP model.

StateDGI Toolset allows users to perform numerous spatial tasks easily, including distributing well capacity by aquifer layers, locating wells and parcels by the model cell they fall into, and computing the fractional length and areas in each model cell of various GIS layers. Due to the GIS and Access format of the files used by StateDGI, the user is not able to create an input data set from scratch using the toolset. Instead, new input data sets should be created by developing new GIS layers using ArcMap.

Click on the **+** symbol next to the StateDGI toolset to view the StateDGI tools available, as shown in Figure 29.

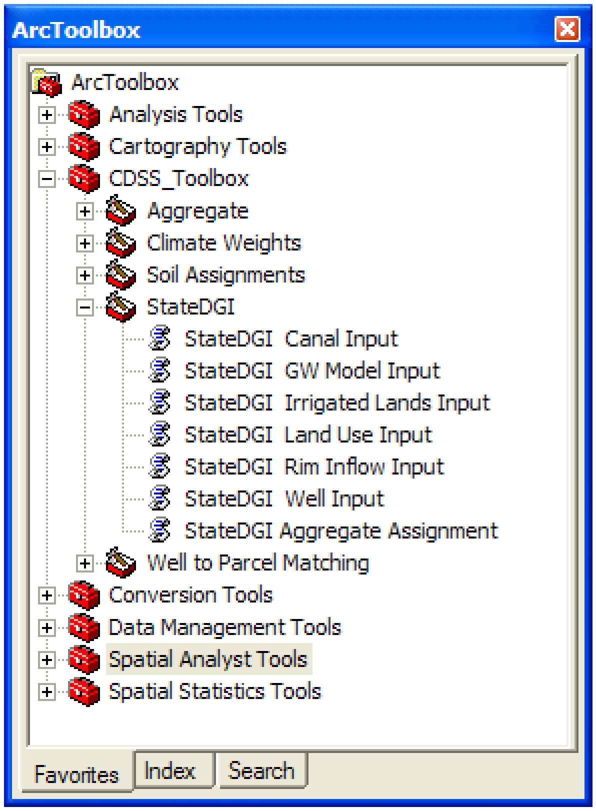



**Figure 29 – Showing StateDGI Toolset**

A typical StateDGI session consists of the following steps:

1. Make a copy of the StateDGI Access database (see Section 6.1)

2. Load the CDSS Toolbox from the ArcMap Toolbox menu project (see Section 1.1).

3. Display the StateDGI Toolset through the Icon displayed under the CDSS Toolbox menu (see Section 6.0).

4. Run the following tools in any order:

   - Input the Canals shapefile by running the StateDGI Canals Input tool (see Section 6.2).

   - Input the Ground Water Model shapefile by running the StateDGI GW Model Input tool (see Section 6.3).

   - Input the Irrigated Acreage shapefile by running the StateDGI Irrigated Acreage Input tool (see Section 6.4).

   - Input the Land Use shapefile by running the StateDGI Land Use Input tool (see Section 6.5).

- Input the Rim Inflow shapefile by running the StateDGI Rim Inflow Input tool (see Section 6.6).

- Input the Wells shapefile by running the StateDGI Model Well Input tool (see Section 6.7).

5. Input the Aggregate Assignment tables by running the StateDGI Aggregate Assignment tool (see Section 6.8). As the tables input into this tool affect the data input in other tools, **the StateDGI Aggregate Assignment tool must be run last**. **If any other StateDGI tool is rerun, the Aggregate Assignment tool must be rerun.**

6. Summarize, format and export the results from the StateDGI Geodatabase for input to StatePP (see Section 7.0)

## 6.1 Copying a StateDGI Database

Included with the StateDGI toolset is a specialized StateDGI Access database. It is formatted as a personal Geodatabase to allow ArcMap to store shapefiles within the single access file. In addition, numerous specific queries are included to allow the data processing required for output to the StatePP program. **One copy of a StateDGI Access database is required for each data set or model run.** Each copy of the database is specific to the model being analyzed and a copy should be maintained for each ground water model and each year of input if coverages representing specific years are used. For example, if multiple years of irrigated acreage coverages are modeled, a separate copy of the database should be used for each year of irrigated acreage coverage. The copied database name cannot have any spaces or periods. The copied database is not path specific, and can be stored in any directory on the users' computer. When the shapefiles are loaded into the access database all files and information for a particular model run are included in the single file.

## 6.2 Canal Input

This tool loads the Canal shapefile into the StateDGI Access database. The required inputs for this analysis are the StateDGI Geodatabase, the canal shapefile, and one of two methods to specify the relative infiltration weight. The default of the tool is for all canal segments to receive the same relative weight. An example of applying relative canal weights is a situation where a main canal and several laterals deliver irrigation water to a parcel. The main canal may be assigned more of the available recharge than the smaller laterals. These relative weights would be reflected in the Canal Weight Attribute or the Recharge Weight Shapefile. The Canal Input defines the location for canal seepage recharge.

The required inputs for this analysis include:

- StateDGI Geodatabase: This database will be used for storing and processing the information of a specific StateDGI model simulation.

- Canal Shapefile: The canal shapefile must be in the standard CDSS format for canal shapefiles (see Appendix A).

- Model Weight Input: The relative value of canal seepage recharge into the ground water model can be adjusted by specifying a weight value. This weight value can be specified in one of two methods, the Canal Weight Attribute or Recharge Weight Shapefile. The default of the tool is for all canal segments to receive the same relative weight. If another method is selected, the alternate method will override the default.

  1. Canal Weight Attribute: An attribute in the Canal Shapefile that specifies the weight by canal structures.

  2. Recharge Weight Shapefile: An input shapefile with weights defined by polygon, for instance based on soil type. This shapefile must have a 'Weight' field with values between 0 and 1 for each polygon. These weights will be spatially assigned to the canals.

Double-click on StateDGI Canal Input to open the user interface for this tool, as shown in Figure 30. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

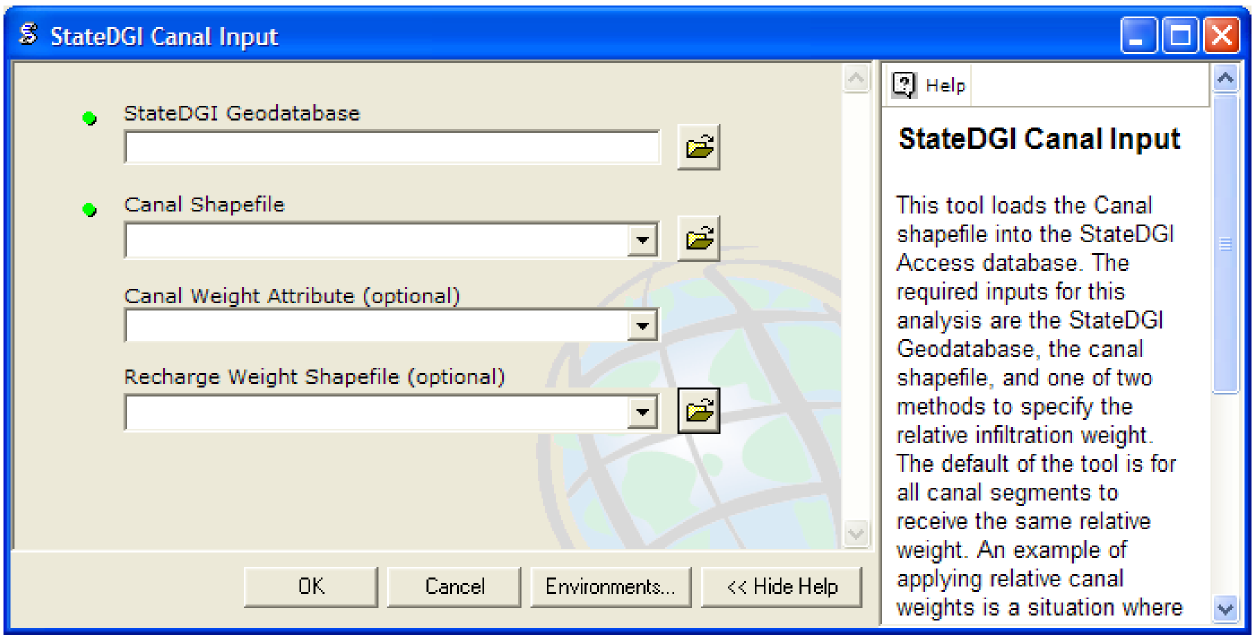



**Figure 30 – Canal Input Interface**

## 6.3 Ground Water Model Input

This tool inputs the ground water model cell configuration into the StateDGI GeoDatabase. The required inputs for this analysis are the StateDGI Geodatabase and the Ground Water Model Grid shapefile. When the GW Model Input tool is run, the model shapefile is loaded into the StateDGI Geodatabase. Due to the large size of the Ground Water Model Grid shapefile, the user may experience faster results of this tool if the shapefile has *not* been added as a layer to the ArcMap view while running the tool.

The required inputs for this analysis include:

- StateDGI Geodatabase: This database will be used for storing and processing the information of a specific StateDGI model simulation.

- Ground Water Model Grid Shapefile Input: The ground water model shapefile must be in the standard format for model shapefiles (see Appendix A). This shapefile will be intersected with other shapefiles as they are loaded into the database.

Double-click on StateDGI Ground Water Model Input to open the user interface for this tool, as shown in Figure 31. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

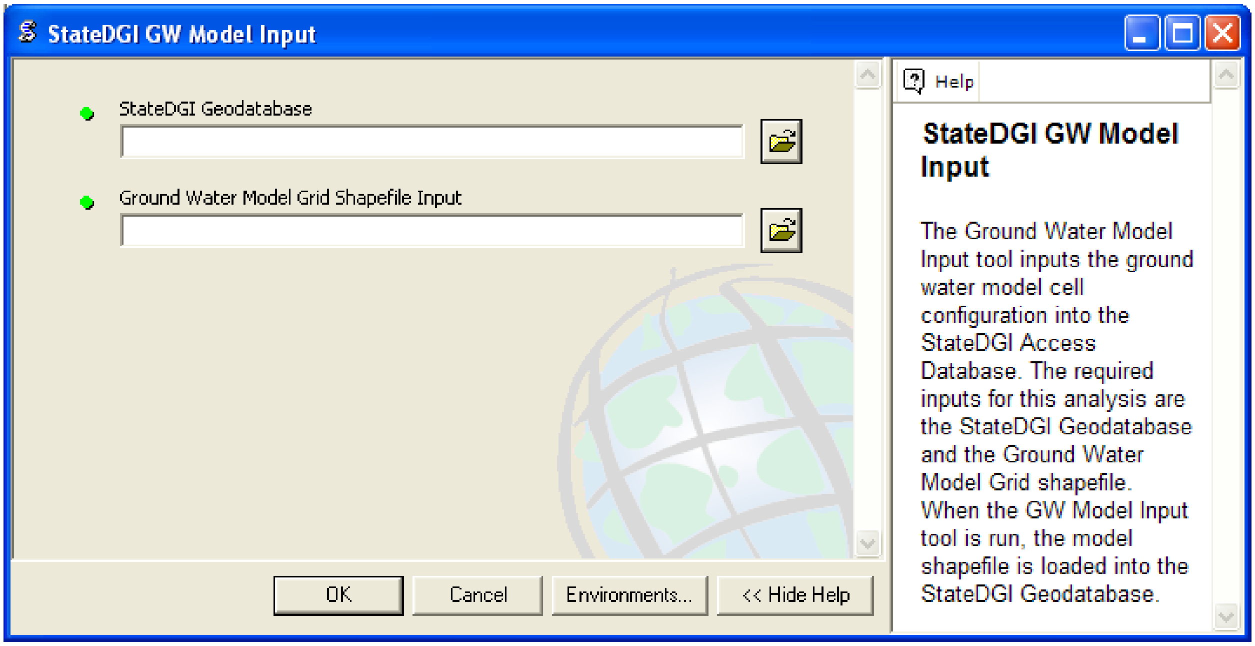



**Figure 31 – GW Model Input Interface**

## 6.4 Irrigated Acreage Input

This tool loads the Irrigated Acreage shapefile and associated attributes in to the StateDGI Access database. The required inputs for this analysis are the StateDGI Geodatabase, the Irrigated Acreage shapefile, and the method to specify the relative infiltration weight. The default of the tool is for each parcel to receive the same relative infiltration weight. The user has the option of inputting a Recharge Weight Shapefile that can vary the relative weight of recharge of each of the irrigated parcels. The surface water attributes and the well assignments are read from the shapefile attributes and translated into the form required by StateDGI. The Irrigated Acreage Input defines the location for inefficient irrigation recharge.

The required inputs for this analysis include:

- StateDGI Geodatabase: This database will be used for storing and processing the information of a specific StateDGI model simulation.

- Irrigated Acreage Shapefile: A polygon shapefile that contains irrigated parcels, crop type, irrigation method and water supply data. The shapefile must be provided in the standard CDSS format, as described in Appendix A.  Irrigated acreage shapefiles have been created by river basin in support of CDSS modeling efforts and are available on the CDSS website (cdss.state.co.us).  The shapefile must include the final surface water and well assignments by parcel.  This shapefile will be loaded into the specified database and is then processed for use by StateDGI.

- Recharge Weight Shapefile: An optional input shapefile with relative weights defined by polygon, for instance based on soil type.  This shapefile must have a 'Weight' field with values between 0 and 1 for each polygon.  The relative weights of inefficient irrigation recharge into the ground water model will be spatially assigned to the irrigated acreage. For example, a parcel with a relative weight of '1' will receive an assignment of twice the amount of available recharge as compared to a parcel with a relative weight of '0.5'. If the Recharge Weight Shapefile is not used, the default of the tool is for all irrigated acreage parcels to receive the same relative infiltration weight.

Double-click on StateDGI Irrigated Lands Input to open the user interface for this tool, as shown in Figure 32. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

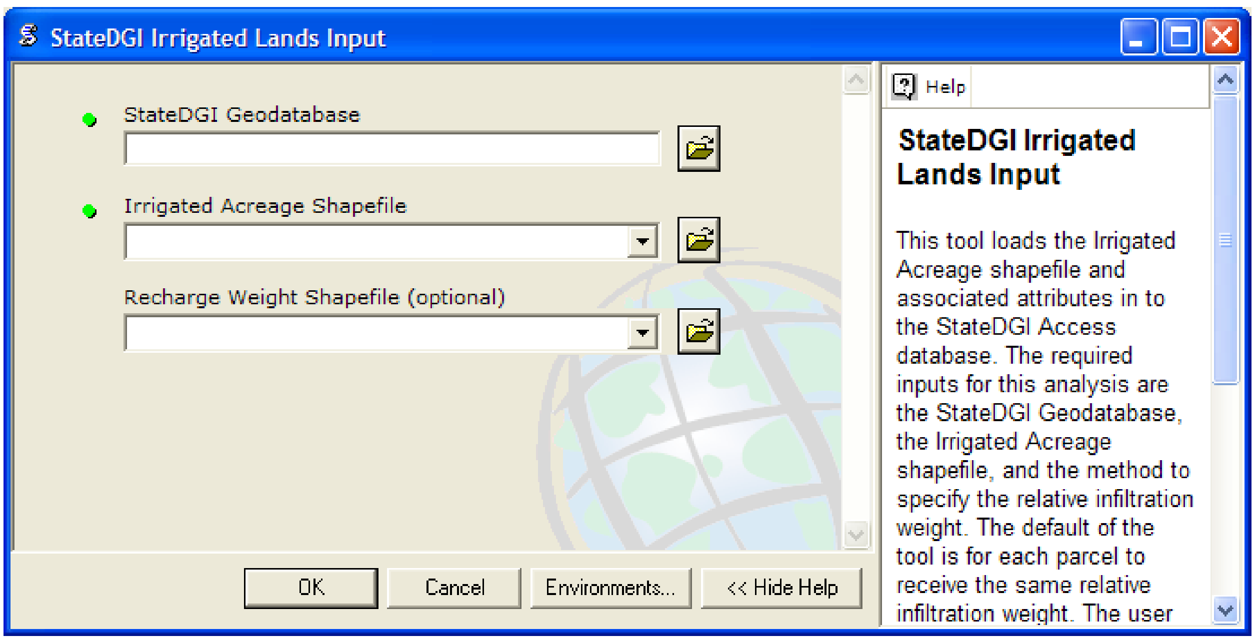



**Figure 32 – Irrigated Lands Input Interface**

## 6.5 Land Use Input

This tool loads the Land Use shapefile.  The required inputs for this analysis are the StateDGI Geodatabase, the Land Use shapefile, and the method to specify the relative infiltration weight. The default of the tool is for all land use types to receive the same relative infiltration weight. The user has the option of inputting a Recharge Weight Shapefile that can vary the relative weight of recharge for each of the land use types. The Land Use Input defines the location for precipitation recharge and native ET.

The required inputs for this analysis include:

- StateDGI Geodatabase: This database will be used for storing and processing the information of a specific StateDGI model simulation.
- Land Use Shapefile: The land use shapefile must be a polygon shapefile that includes a field with a unique ID that describes a land use. This shapefile will be loaded into the specified database and is then processed for use by StateDGI.
- Land Use Attribute: The attribute field name in the Land Use Shapefile that contains the unique land use IDs that will be used in the StateDGI analysis.
- Recharge Weight Shapefile: An optional input shapefile with relative weights defined by polygon, for instance based on soil type. This shapefile must have a 'Weight' field with values between 0 and 1 for each polygon. The relative weights of inefficient irrigation recharge into the ground water model will be spatially assigned to the land use areas. For example, a gravely land use area with a relative weight of '1' will receive an assignment of twice the amount of available recharge as compared to a clay land use type with a relative weight of '0.5'. If the Recharge Weight Shapefile is not used, the default of the tool is for all land use areas to receive the same relative infiltration weight.

Double-click on StateDGI Land Use Input to open the user interface for this tool, as shown in Figure 33. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

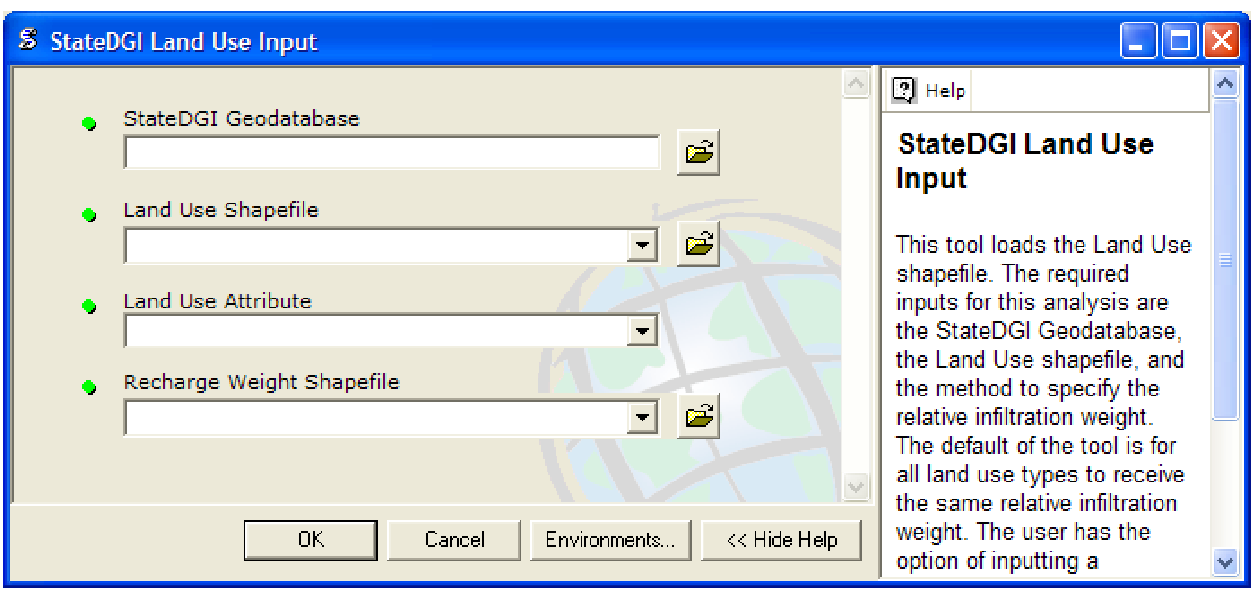



**Figure 33 – Land Use Input Interface**

## 6.6 Rim Inflow Input

This tool loads the Rim Inflow shapefile into the StateDGI Access database. The required inputs for this analysis are the StateDGI Geodatabase, the Rim Inflow shapefile, one of two methods to specify the model layer, and one of two methods to specify the relative infiltration weight. The default of the tool is for all rim inflow areas to receive the same relative weight. An example of applying relative rim inflow weights is a situation where the rim inflow area located closest to the model boundary receives more recharge than a rim inflow area located a distance away from the model boundary. These relative weights would be reflected in the Rim Inflow Weight Attribute or the Recharge Weight Shapefile. The Rim Inflow Input defines the location for rim inflow recharge.

The required inputs for this analysis include:

- StateDGI Geodatabase: This database will be used for storing and processing the information of a specific StateDGI model simulation.

- Rim Inflow Shapefile: The rim inflow shapefile defines the spatial extent of rim inflow. The shapefile must be in the standard CDSS format (see Appendix A) for rim inflow shapefiles and include the rim inflow IDs appropriate for the model.

- Model Weight Input: The relative value of rim inflow recharge into the ground water model can be adjusted by specifying a weight value. This weight value can be specified in one of two methods, the Rim Inflow Weight Attribute or Recharge Weight Shapefile. The default of the tool is for all rim inflow areas to receive the same relative weight. If another method is selected, the alternate method will override the default.

    1. Rim Inflow Weight Attribute: An attribute in the Rim Inflow Shapefile that specifies the weight for each rim inflow area.

    2. Recharge Weight Shapefile: An input shapefile with weights defined by polygon, for instance based on soil type. This shapefile must have a 'Weight' field with values between 0 and 1 for each polygon. These weights will be spatially assigned to the rim inflow areas.

- Model Layer Input: The model layer receiving recharge from the rim inflows is specified in one of two methods, however the default of the tool is to use the Rim Inflow Layer Value. If another method is selected, the alternate method will override the default of Rim Inflow Layer Value.

    1. Rim Inflow Layer Value: Specify a single layer number for all rim inflow recharge. The default value for this input is 1.

    2. Recharge Layer Shapefile: An input shapefile with infiltration layer defined by polygon. This shapefile must have a 'Layer' attribute field corresponding to the model layer number for infiltration. These model layers will be spatially assigned to the rim inflow areas.

Double-click on StateDGI Rim Inflows Input to open the user interface for this tool, as shown in Figure 34. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

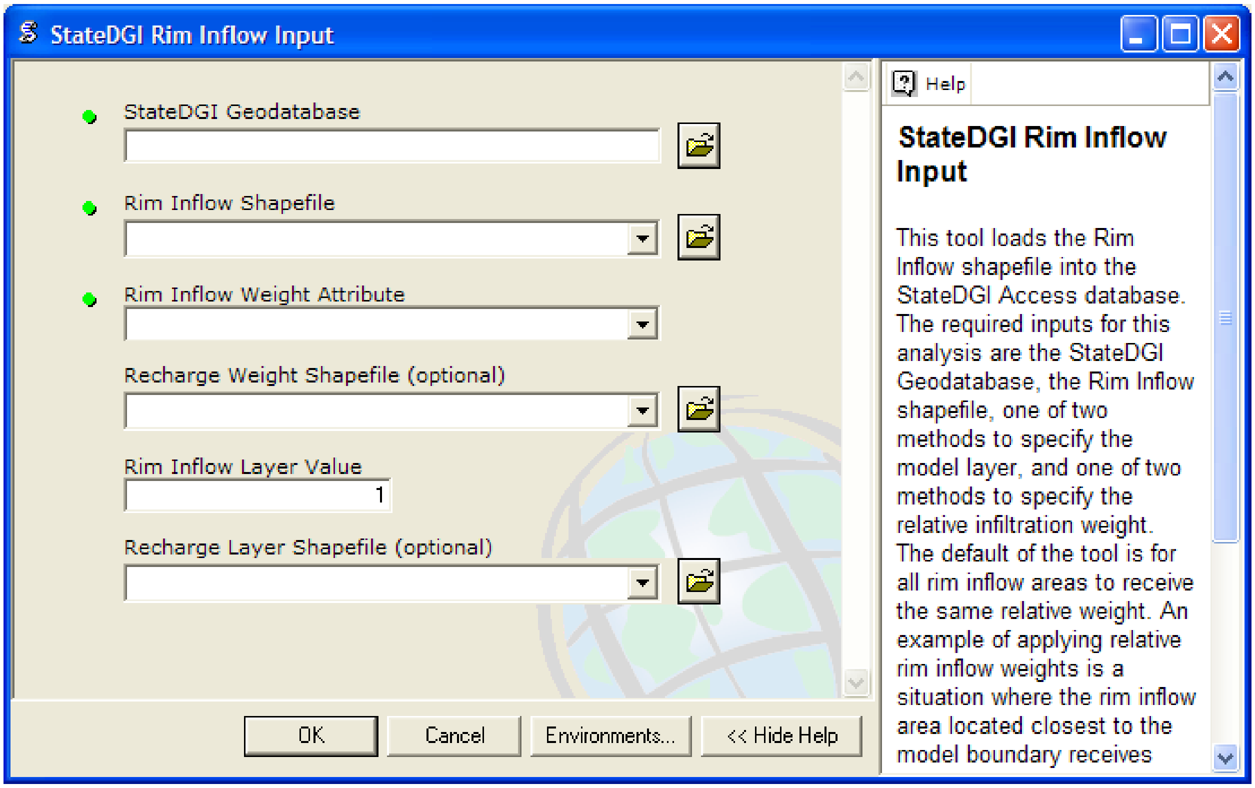



**Figure 34 – Rim Inflow Input Interface**

## 6.7 Well Input

This tool loads the Wells Shapefile into the StateDGI Access database. The required inputs for this analysis are the StateDGI Geodatabase and the Wells shapefile. The well input defines the location, depth and screened interval for each well. Using the ground water model input, StateDGI determines the well location (row, column) and the layer of pumping. The Well shapefile should include all wells matched to irrigated land, and is generally created by 'linking' HydroBase decreed wells with the States' Well Permit database. If wells in the Irrigated Acreage shapefile are not found in the Well Shapefile, a warning will be provided to the user through the QA/QC Review option in StateDGI.

The required inputs for this analysis include:

- StateDGI Geodatabase: This database will be used for storing and processing the information of a specific StateDGI model simulation.
- Well Shapefile: The well point shapefile must be in the standard CDSS format (see Appendix A).

Double-click on StateDGI Well Input to open the user interface for this tool, as shown in Figure 35. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

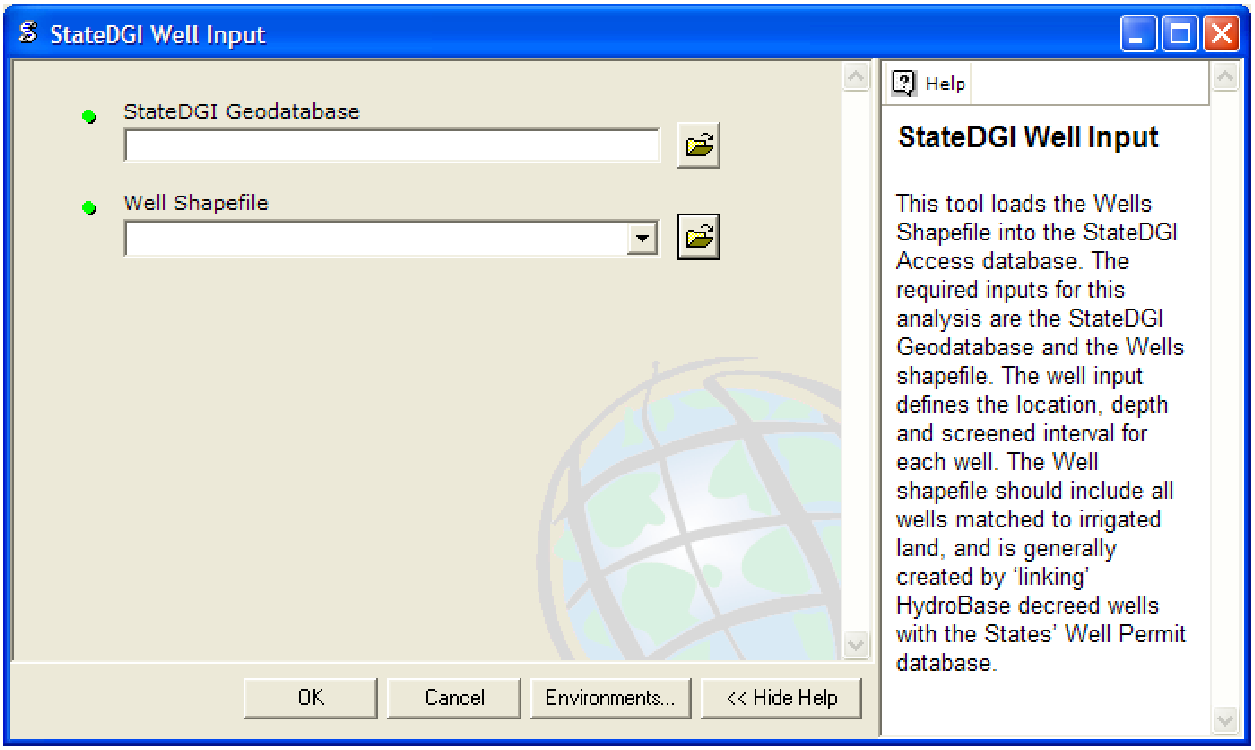



**Figure 35 – Well Input Interface**

## 6.8 Aggregate Assignment

A useful modeling option is the ability to not model every diversion structure or well explicitly, rather some diversion structures and wells can be aggregated and modeled as a single combined structure. The aggregation of structures and their associated acreage was historically determined using an external FORTRAN program (agg.for). This functionality has now been added to StateDGI through this tool. Likewise, there are diversion structures that are operated in conjunction to serve the same lands and these structures are better modeled as diversion structures as opposed to being explicitly modeled. This tool loads these Aggregate, Diversion System, and Canal Alias Lists into the StateDGI Access database. The required inputs for this analysis are the StateDGI Geodatabase, the Aggregate, Diversion System, and Canal Alias Lists, and the Phreatophyte Classification Table. **The StateDGI Aggregate Assignment tool must be run last, after all other StateDGI tools have been run and inputs have been loaded into the database. If any other StateDGI tool is rerun, the Aggregate Assignment tool must be rerun.**

The Aggregate, Diversion System, and Canal Alias Lists tell StateDGI how to assign GIS structures (e.g. parcels, diversion points, wells or canals) to Aggregate, Diversion System, or Canal IDs. For example, if the surface water structure 0100503 is assigned to surface water aggregate area 01_ADP001, StateDGI will assign the parcels associated to surface water structure ID to the Aggregate ID. The alias lists must have the Aggregate, Diversion System or Canal ID in the first column but the comma-delimited parts to be reassigned can begin in any column (user will specify which column number) and extend indefinitely along the same row. The Aggregate, Diversion System, and Canal IDs can also be repeated in the first column.

In most modeling scenarios, canals that serve aggregated (or diversion system) lands would also be aggregated in the same fashion. Therefore the SW Aggregate List reassigns not only the irrigated parcels but also the canals to the same aggregate list. The South Platte basin introduced the need however for a new modeling approach whereby the canals need to be reassigned to a Canal ID that differs from either the Aggregate or Diversion System ID. The situation, for example, exists where a canal serves as a carrier to an off-channel reservoir and also provides direct flow irrigation water to lands that reside below the reservoir. Therefore, the irrigation demand sitting below the reservoir receives water that experiences two different conveyance losses, one conveyance loss for direct flow water from the headgate and typically a lesser conveyance loss for the reservoir releases. The single canal is then effectively modeled as two canals, one canal with total diversions at the headgate and one 'canal' with diversions and reservoir releases that meet the irrigation demand. The canal with total diversions will keep the original structure ID, but the Canal Alias ID would reassign the canal that meets the irrigation demand with a *SWID*_IRR ID.

The classification of 'native phreatophytes' may differ from one analysis to another based on the classification provided by the Land Use GIS Coverage in the Land Use Input. Due to this fact, it is necessary to tell StateDGI which land use types to include as native phreatophyte vegetation. The comma-delimited Phreatophyte Classification Table lists the land use types from the Land Use GIS Shapefile that will be included in the StatePP phreatophyte (*.etz) file in the first column and the name that will ultimately be shown in the phreatophyte (*.etz) file in the second column. The first and second columns can reflect the same name.

The required inputs for this analysis include:

- StateDGI Geodatabase: This database will be used for storing and processing the information of a specific StateDGI model simulation.

- GW Aggregate List (optional): A comma-delimited list of parcels served by ground water only that will be modeled as aggregates and the Aggregate ID each parcel is assigned to. The format of this file must be in column with the Aggregate ID in the first column and the Parcel ID in the second column. The output file from the Aggregate by GW Parcel tool is in the correct format (see Section 2.1) and can be used for this input. This input is optional only if all irrigated acreage is assigned to surface water sources.

- GW Aggregate Lists Parts Column (optional): Column number of the GW-WDIDs assigned to an Aggregate ID in the Ground Water Aggregate List. This column number must be specified if a Ground Water List is input. The Aggregate by GW Parcel Tool default is column 2.

- SW Aggregate List (optional): A comma-delimited list of surface water structures that will be modeled as aggregates and the Aggregate ID each surface water structure ID is assigned to. The output file from the Aggregate by SW Parcel (see Section 2.2) can be used for this input. The Aggregate ID must be in the first column of this list.

- SW Aggregate List Parts Column (optional): Column number of the SW_WDIDs assigned to an Aggregate ID in the Surface Water Aggregate List. This column number must be specified if a Surface Water Aggregate List is input.

- Diversion System List (optional): A comma-delimited list of surface water structures that will be modeled as diversion systems and the primary SW_WDID each surface water structure ID is assigned to. The Diversion System ID must be in the first column of this list.

- Diversion System List Parts Column (optional): Column number of the SW_WDIDs assigned to a diversion system in the Diversion System List. This column number must be specified if a Diversion System List is input.

- Canal Alias List (optional): A comma-delimited list of canal structures that will be reassigned a canal alias ID to represent a modeling difference between two portions of a canal. The Canal Alias ID must be in the first column of this list.

- Canal Alias List Parts Column (optional): Column number of the SW_WDIDs reassigned by the Canal Alias List. This column number must be specified if a Canal Alias List is input.

- Phreatophyte Classification Table (optional): A comma-delimited file containing the list of Land Use Types, as provided in the Land Use GIS Coverage, to be included in the StatePP Phreatophyte (*etz) file and the name of the land use types that will ultimately be shown in the StatePP Phreatophyte (*etz) file. The two columns can show the same name if no renaming is necessary. If a Phreatophyte Classification Table is not provided, the StatePP Phreatophyte (*etz) file will be blank.

Double-click on StateDGI Aggregate Assignment to open the user interface for this tool, as shown in Figure 36. When the 'Show Help' button is activated, the online help screen describes what is expected by the tool as each individual input box is selected.

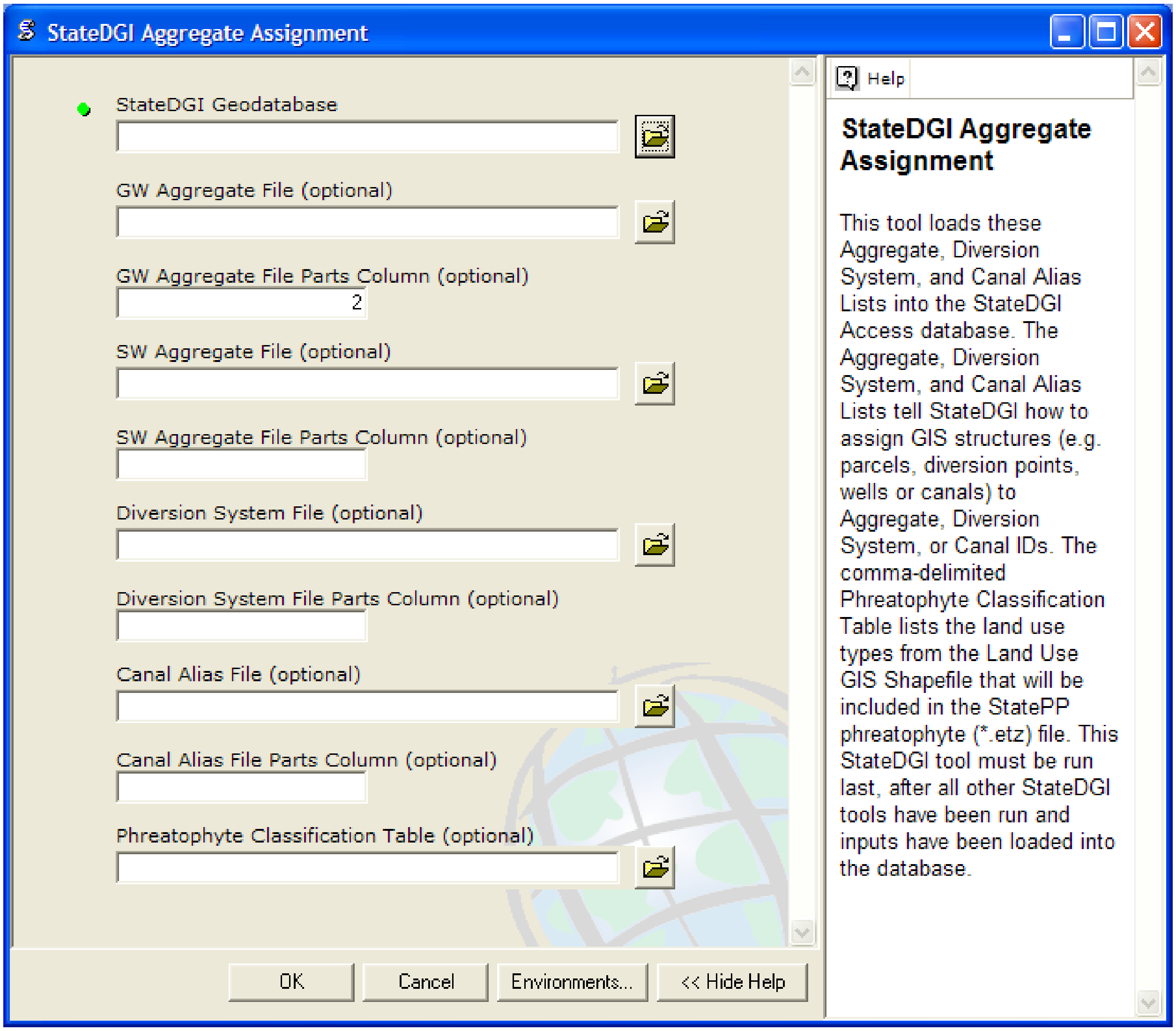



**Figure 36 – Aggregate Assignment Interface**

## 7.0 StateDGI Geodatabase User Interface

After the StateDGI Toolset is used to update the StateDGI Access database (Section 6), the final results are stored in several tables in the specified database. This database is a copy of the standardized StateDGI Geodatabase and includes all the queries and reports necessary to create the input files for StatePP. Each copy of the database is specific to the model being analyzed and a copy should be maintained for each ground water model and each year of input if coverages representing specific years are used. Begin a Microsoft Access session, then open the StateDGI database developed for the specific application. See Figure 37 for the initial StateDGI database Access interface.


**Figure 37 – StateDGI Database Access Interface**

From the initial StateDGI Database Access Interface, select the Structure Summary button to view results for individual structures. Figure 38 shows the StateDGI Structure Summary interface, with example structure 2000753 already selected.

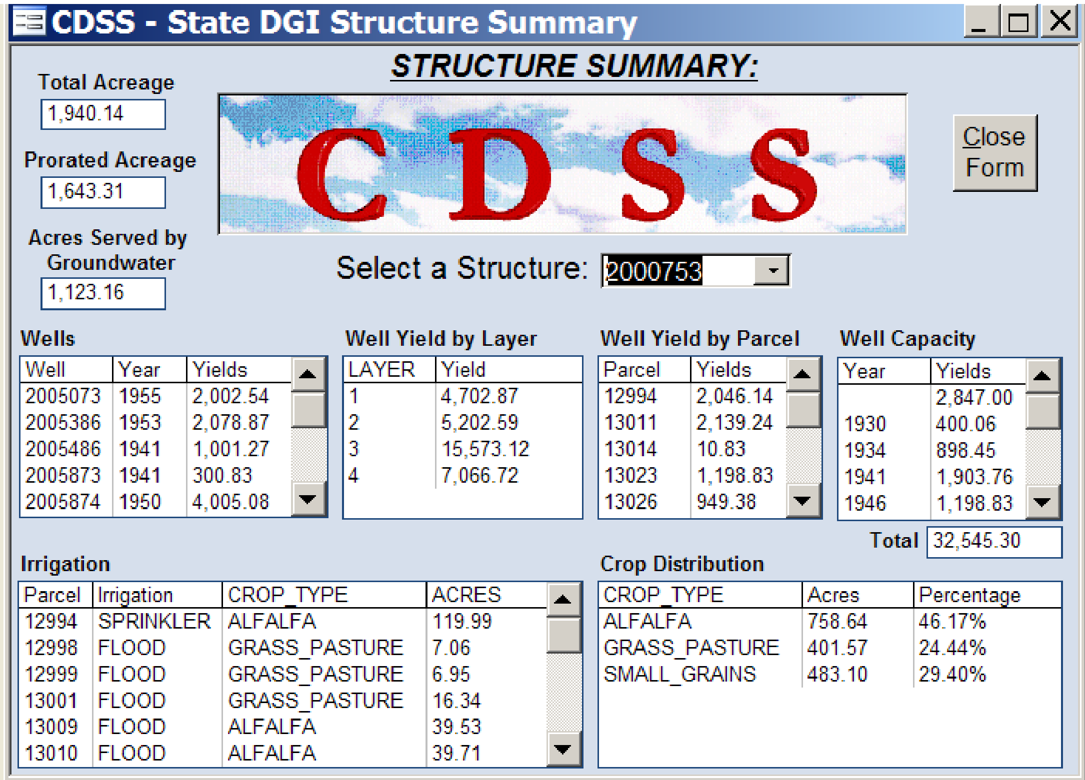



**Figure 38 – StateDGI Structure Summary Interface**

A pull down menu of all available structures in the specific StateDGI database is provided in the interface. Figure 38 shows the detailed information for Structure 2000753. When a structure is selected, the summary information boxes in the interface are automatically populated from the StateDGI database. The information boxes are not interactive and structure data cannot be edited from this interface.

After reviewing the structure summary data, select the 'Close Form' button and return to the StateDGI Database Access Interface. Select the 'Create StatePP Input' button to view the StateDGI tables used as input into the StatePP program. Figure 39 shows the interface used to Create Input Files for StatePP.

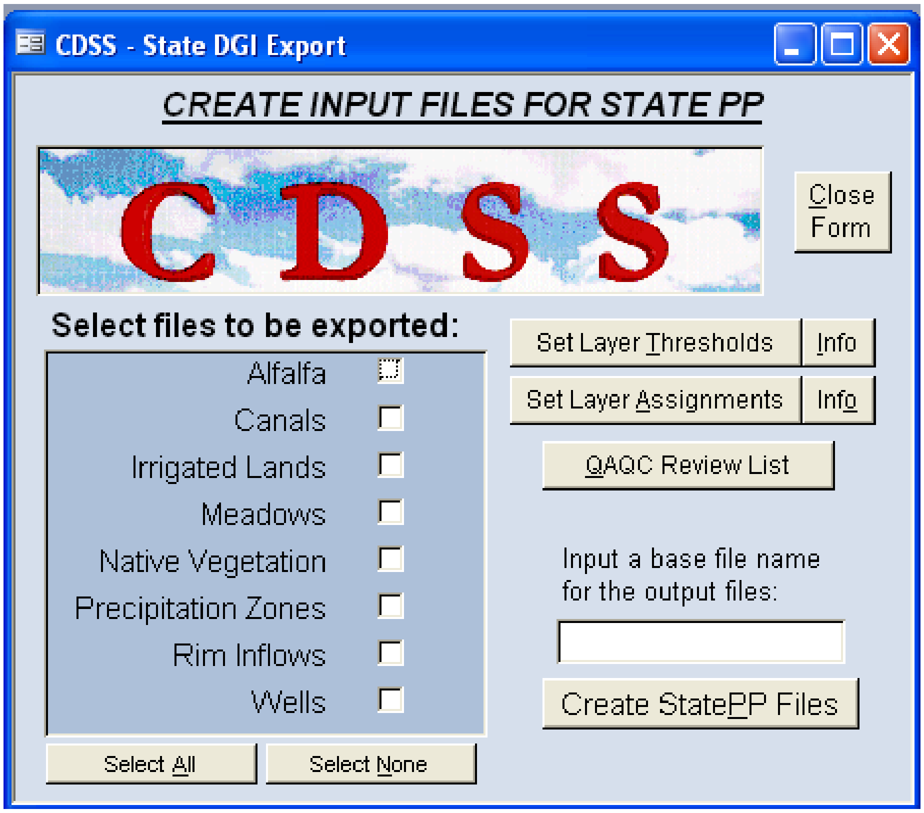



**Figure 39 – Create Files for StatePP Interface and Help Screen**

This interface contains the following options: Set Layer Thresholds, Set Layer Assignments, QA/QC Review List, selection of files to be exported and output file name designation. The 'Set Layer Thresholds' button opens a new window in which the user can view the default for the Well Layer Threshold values or set a new threshold value. Help and information regarding the layer threshold value can be accessed through either the 'Info' button on the main StatePP screen or the 'Layer Threshold Help/Info' button in the new window. The threshold value indicates the minimum percentage of well pumping StateDGI can assign to each layer of the aquifer. Layer 1 generally refers to the unconfined or alluvial aquifer, and Layer 2 refers to the top layer of the confined or non-tributary aquifers. For example, if a user selects a 10 percent threshold in Layer 1, the program will reassign all wells with 10 percent or less of their total depth assigned to Layer 1 to Layer 2. Enter the threshold percentages as a decimal. Figure 40 shows the Well Layer Threshold interface.

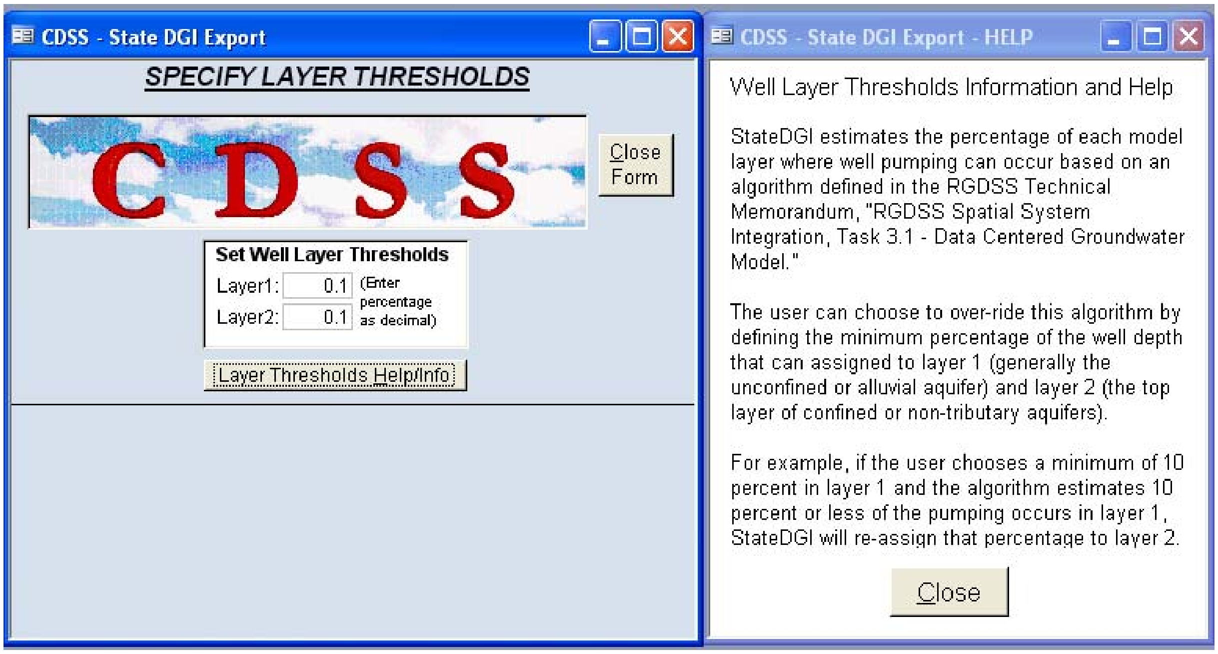



**Figure 40 – Specify Layer Threshold Interface**

The 'Set Layer Assignments' button opens a new window in which the user can specify new layer assignments for wells in the database that have depth information but are missing top and bottom perforation (perf) depths. When wells are missing perforation information, the StateDGI default is to assign the top perforation depth equal to the top of the model layer into which the well depth extends to. The bottom perforation is assigned to the well depth. The user however may want to override this default assignment by specifying a different model layer to use for the top perforation depth. For example, if a series of wells missing perforation information have depths that extend into Layer 5 of the model, the default would set the perforation elevation to correspond with the top of Layer 5. If the user has knowledge that these wells are screened from Layer 2 through Layer 5, then the user would set the top perforation layer to '2' for these wells. The bottom perforation depth is then set to the well depth.

The Specify Layer Assignment window allows the user to set the new top perforation layer assignment for all wells that fall into a specific layer. The first column indicates which layer the well depth extends to and the second column indicates the new top perforation assignment layer. There can only be one top perforation assignment layer for each model layer and the top perforation assignment layer must be equal to or less than the well depth model layer. The user can specify many different layer assignments, add a layer assignment using the pull-down boxes at the bottom of the window, and delete layer assignments with the 'Remove Override' button. Help and information regarding the layer assignments can be accessed through either the 'Info' button on the main StatePP screen or the 'Layer Assignments Help/Info' button in the new window. Figure 41 shows the Well Layer Assignment interface.

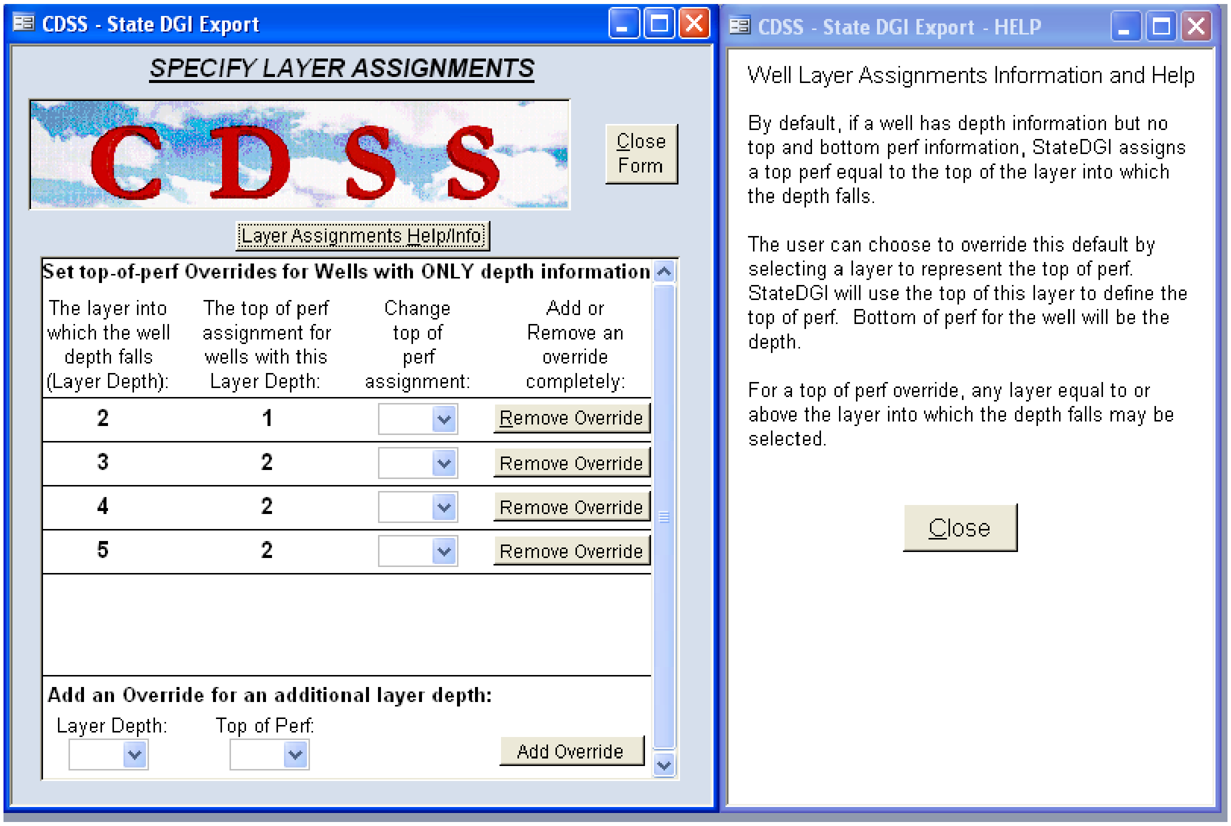
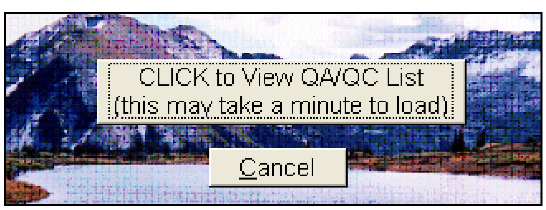



**Figure 41 – Specify Layer Assignment Interface**

The ‘QA/QC Review’ performs a five-point review of the data entered into the StateDGI database. The window simply presents the questionable data and advises the user to revisit the inputs to the database and check the questionable data. Data cannot be edited or removed through this window. As the database typically contains numerous tables and vast amounts of data, this review can take a few minutes to run. After the user selects the ‘QA/QC Review’ button, the following window will appear asking the user to confirm the request. The user needs to select the top button in this window to continue with the review process, or can Cancel through this screen.




Once the review process is complete, the QA/QC Review window will appear summarizing the results of the review. The following four reviews are performed:

- Wells to Parcel Match to Irrigation Wells: The wells matched to irrigated parcels are compared against the wells input in the database. Wells that are assigned to parcels but are not included in the Well Shapefile input in the Well Input Tool (Section 6.7) will appear in the upper left corner of the review window.

- Irrigated Acreage per Model Cell: If the irrigated acreage assigned to each model cell totals more than the model cell area (+/- 5%), this may indicate that the Irrigated Acreage Shapefile (Section 6.4) contains overlapping polygons. Any model cells with irrigated acreage greater than the model cell area will appear in the upper right corner of the review window.

- Well Assignment: If the '% Assigned' to a specific well is greater than 100 percent, this may indicate that there are two wells with the same Well ID in the Well Input file (Section 6.7). The duplicate Well IDs may actually represent a replacement well, therefore the user needs to review and potentially remove one of the duplicate wells from the Well Input file. If the '% Assigned' to a specific well is less than 100 percent, this may indicate that the well extends to a depth greater than the bottom model layer. Any Well IDs with greater than or less than 100 percent will appear in the middle left side of the review window.

- Land Use Acreage per Model Cell: If the land use acreage assigned to each model cell totals more than the model cell area (+/- 5%), this may indicate that the Land Use Shapefile (Section 6.5) contains overlapping polygons. Any model cells with land use acreage greater than the model cell area will appear in the middle right side of the review window.

- Parcel Assignment: If the '% Assigned' to a Parcel ID is greater or less than 100 percent, this indicates that a parcel in the Irrigated Acreage coverage (Section 6.4) has not been correctly assigned to structure WDIDs. For example, an irrigated parcel may be served by two structures, resulting in a possible assignment of 50% to one structure and 50% to another structure. If the sum of these assignments is greater or less than 100%, the parcel IDs will appear in the lower left corner of the review window.

Scroll through the records using the arrow functions at the bottom of each review section. Figure 42 shows an example QA/QC Review Interface, indicating the user has four possible duplicate wells.

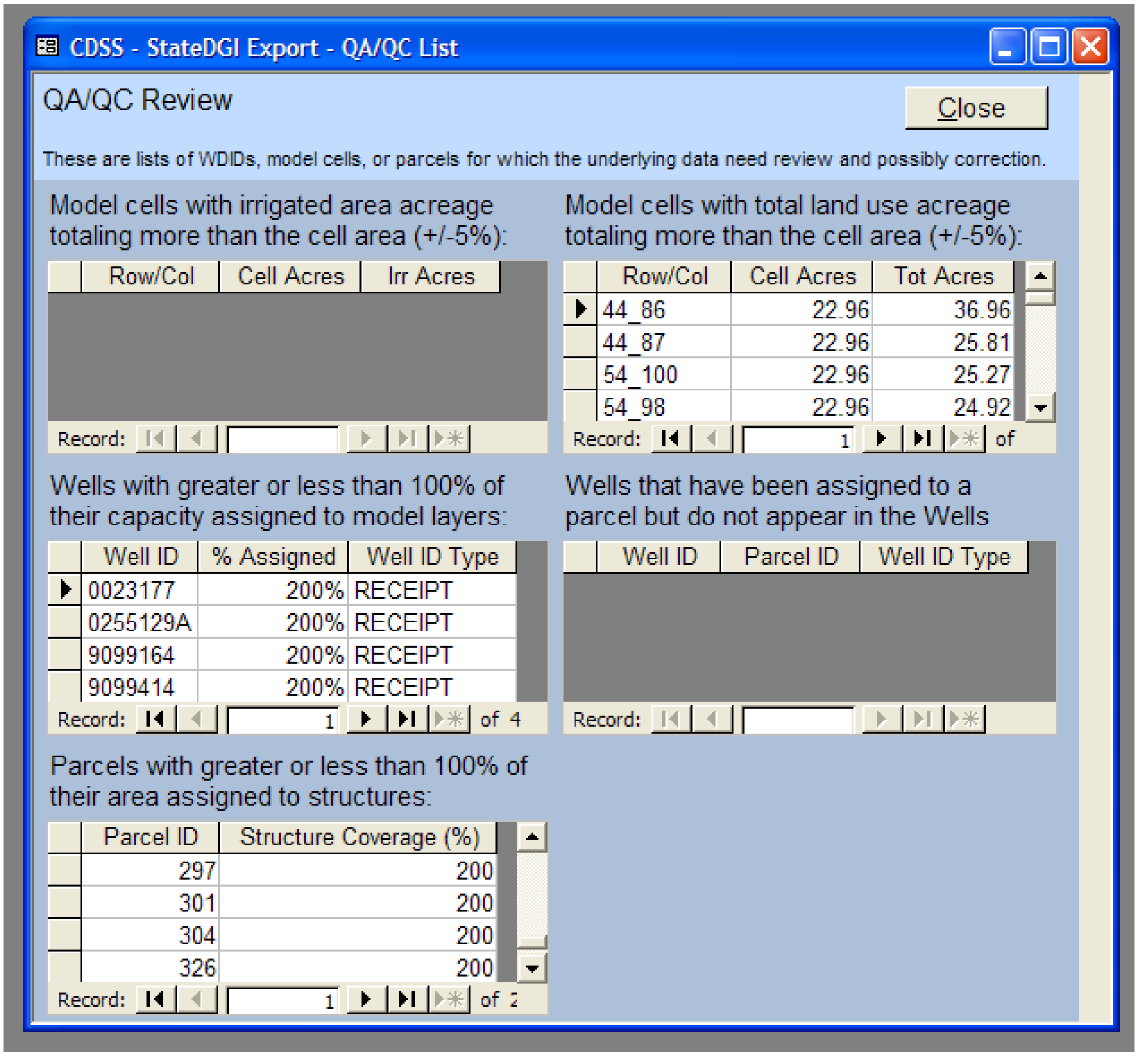



**Figure 42 – QA/QC Review Interface**

If there is any questionable data, the user should correct the issues and re-enter any revised coverages through the StateDGI tools. After completing the QA/QC Review and correcting any questionable data, return to the main 'Create StatePP Input Files' interface and use the 'Select' buttons or individual checkboxes to select the files to be exported to StatePP files. The user cannot export any files that have not been input into the StateDGI database. If the user tries to check files for export that are not present in the StateDGI database, a message will appear indicating which export file cannot be exported and the corresponding StateDGI Tool used to input that file. The user would then need to run the corresponding StateDGI tool to input the missing file prior to exporting the file to the database. Figure 43 shows an example Missing Files Overview message, indicating the user must input the Land Use and Rim Inflow files prior to exporting the Native Vegetation and Rim Inflows files.

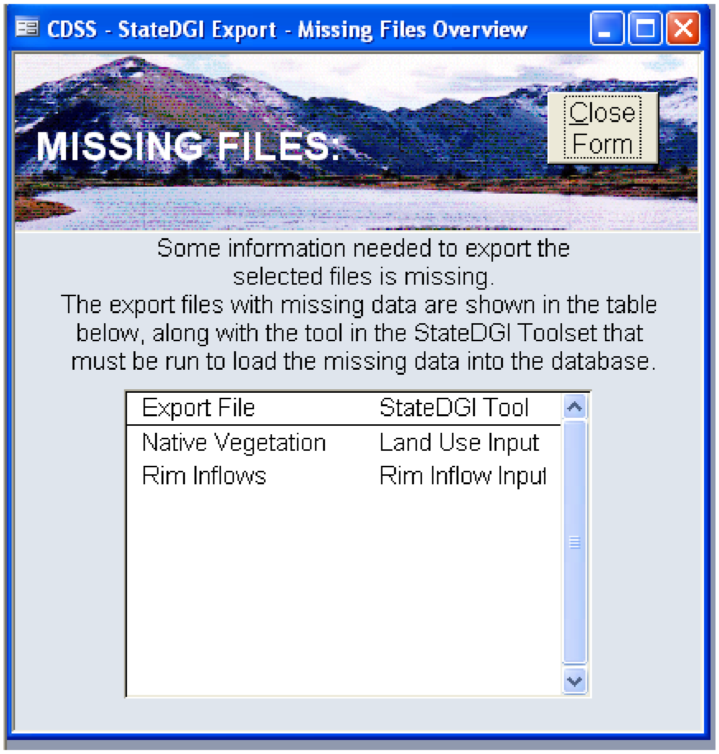



**Figure 43 – Missing Files Overview**

After selecting the files to be exported through the checkboxes, enter a base file name for the eight output files. These output files are described in detail in "RGDSS Spatial System Integration, Task 3.1 - Data Centered Groundwater Model" attached as Appendix B. Then select the 'Create StatePP Files' button to export the files to StatePP.

The StateDGI Access database includes several tables and queries. The tables are updated by running the tools in the StateDGI toolset described above. The queries perform the detailed analysis required for input to StatePP. The tables and queries are described below.

## 7.1 Database Tables

Figure 44 shows the Tables that are included in the StateDGI Geodatabase. Several of the tables are controlled and updated by the StateDGI Toolset. Tables beginning with *canal_*, *ground_cover_*, *parcel_*, *model_*, *riminflow_*, and *wells_* are created as the result of the input tools described in Section 6. Note that it is not necessary for the user to view the tables. This information is for users with more Access experience and information only. Data should not be edited through these tables or it will corrupt the application.

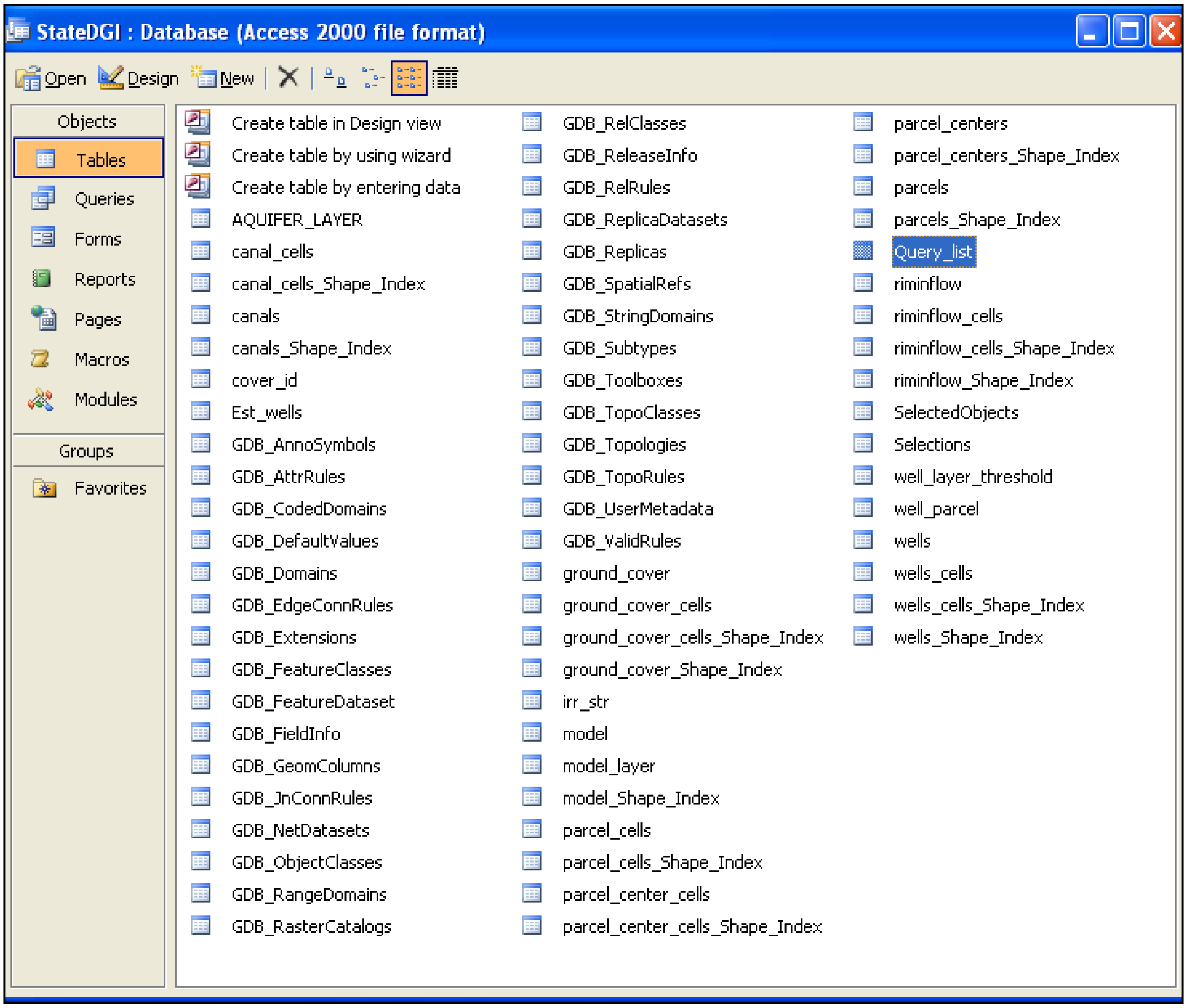



**Figure 44 – Tables in StateDGI Geodatabase**

## 7.2 Queries

After the tables are input and updated into the database via the ArcMap extension described in Section 6, a series of database queries automatically analyze, group, and format the data into a form for use by the StatePP. Figure 45 shows the queries included as part of the database. Again, the queries are automatically performed when StateDGI is loaded into Access. These queries are for users with more Access experience only. Queries should not be edited or it will corrupt the application.

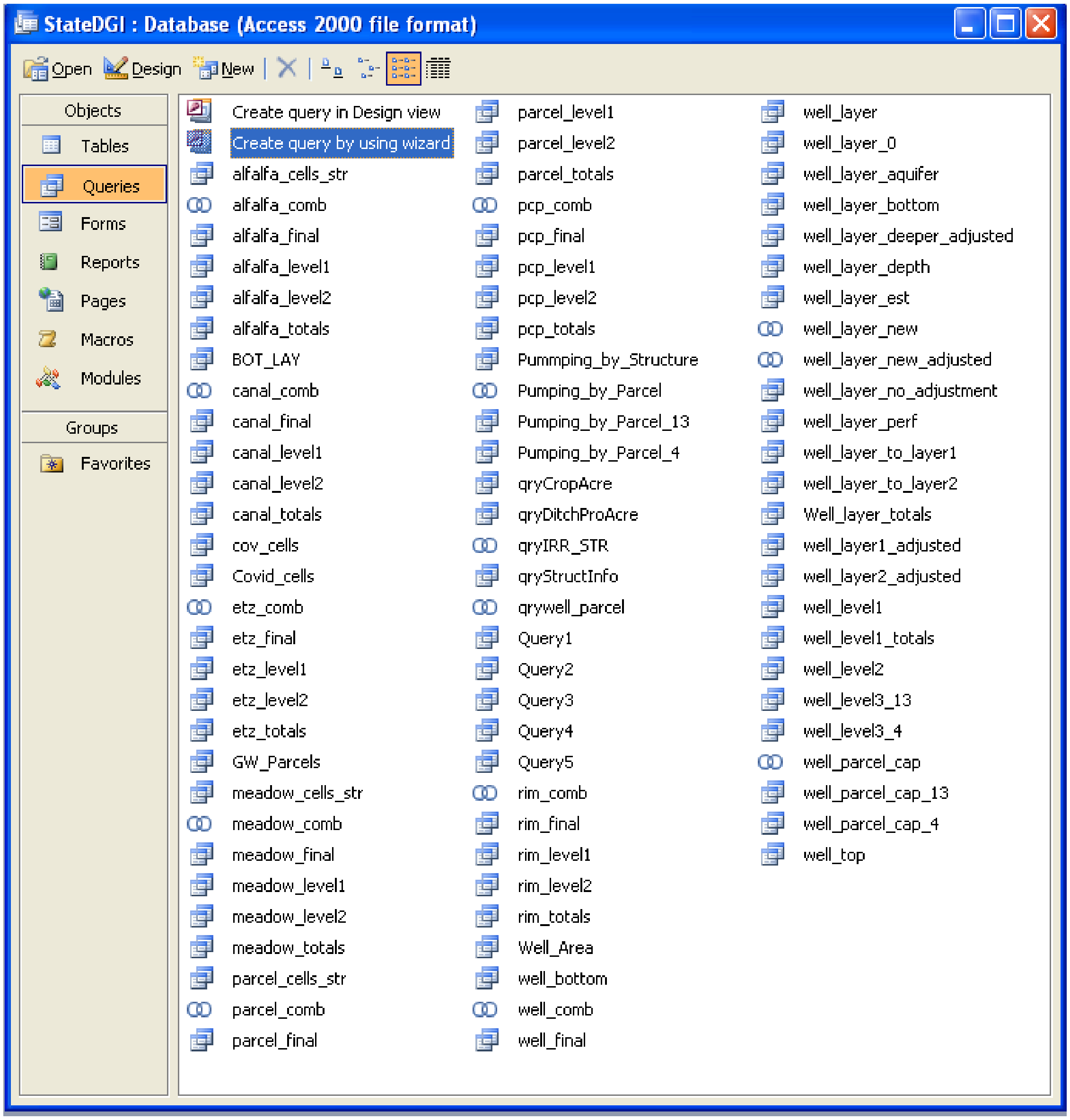



**Figure 45 – Queries in StateDGI Geodatabase**

It is not necessary to provide a detailed description of each query but a simplified example for processing canal data will clarify the process.

- The *canal_totals* query computes the total weighted canal lengths by structure, layer, row, and column from the *canal_cells* table updated by the StateDGI ArcMap Extension.
- The *canal_level1* query sums the canal lengths and weighted length by layer, row, column, and structure. This creates the individual value rows input to StatePP.
- The *canal_level2* query sums the total cells affected and the total and weighted lengths by structure. This creates the header rows input to StatePP.

The above queries are combined in the *canal_comb* query. The required fields are sorted and output in the *canal_final* query, which is in the final format for StatePP. All of this is transparent to the user and requires no interaction on their part other than running the Canal Input tool (Section 6.2). The above example is similar for creating input files for Rim Inflows, Land Use, Alfalfa and Sub-irrigation (Irrigated Meadows).

## 7.3 Output

The final StateDGI output resulting in input files for StatePP is done via a Visual Basic module in the database. This output is in the final format required by StatePP and is performed by the Create StatePP Files button (see Figure 39). The following table lists the eight files generated by StateDGI as part of the data centered ground water modeling process.

| Item | File Name | Description |
|---|---|---|
| Alfalfa | *.alf | Irrigated Alfalfa acreage by cell for each ditch system (SPDSS) |
| Canals | *.can | Canal length by cell for each ditch system |
| ET Zones | *.etz | Non agricultural acreage by cell for each vegetation zone (RGDSS) |
| Irrigated Lands | *.irr | Total Irrigated acreage by cell for each ditch system |
| Meadow | *.med | Irrigated Meadow acreage by cell for each ditch system |
| Precipitation Zones | *.pcp | Vegetation acreage by cell for each county, HUC, and vegetation zone |
| Rim Inflow | *.rim | Rim Inflow acreage by cell for each inflow area (RGDSS) |
| Wells | *.wel | Well location, capacity and year for each ditch or well system |

Note: The * in the file name represents the base file name for a particular model and is the same for the files listed.

The Alfalfa, Canals, ET Zones, Irrigated Lands, Meadow, and Rim Inflow have the same format. This file format is a tabular form of the model cells affected by each ditch system. A series of header lines will be allowed for comments and information with a "#" symbol as the first character in the line. This follows the standard StateMod format. Following the header, blocks of data will be output, one block of data per structure.

The format of each block will consist of one line for the structure ID and the number of cell records in each block. Following the first line in each block will be one record for each cell affected by the specific structure ID. The number of these cell records for each block will be equal to the second field in the first line of each block.

The following is the output format and descriptions of each output parameter:

| Row-Data | Program Variable | Description |
|---|---|---|
| Row 1 | Format (A12,I12,F12.3,F12.3) | |
| 1-1 | ID(1) | Value for the individual system in character format. All of these files will have a field width of 12 and be left justified (A12)<br><br>▪ In the ET Zones file the ID will be the ET zone land use type. |

- In the Rim Inflow file the ID is the name of the Rim Inflow zone.
- In the Alfalfa, Irrigated Lands and Canals the ID is the structure WDID from Hydrobase.

| | | |
|---|---|---|
| 1-2 | Numrec(1) | Total number of cells affected by the ID (I12) |
| 1-3 | Total_Value(1) | The total length or area of the Id system (F12.3) |
| 1-4 | Sumproduct(1) | The sum of the product of individual value and weight terms (F12.3) |

Row 2 Format (I12, I12, I12, F12.3, F12.3)

| | | |
|---|---|---|
| 2-1 | Layer(1) | The layer number of the model cell in integer format (I12) |
| 2-2 | Row(1) | The row number of the model cell in integer format (I12) |
| 2-3 | Column(1) | The column number of the model cell in integer format (I12) |
| 2-4 | Value(1) | See description in table below (F12.3) |
| 2-5 | Weight(1) | See description in table below (F12.3) |

*One record for each cell affected – Numrec. Repeat Rows 1 & 2 for each ID.*

The **Value** and **Weight** parameters vary for each of the output files, therefore the following table summarizes these parameters for each output file

| File | Value | Weight |
|---|---|---|
| Canal | Length (Ft.) of the Canal in the Cell | Relative infiltration factor for the cell |
| Rim Inflows | Area (Ac.) of the affected lands in the Cell | Relative infiltration factor for the cell |
| Alfalfa | Area (Ac.) of the alfalfa land irrigated by the Structure in the Cell | Relative recharge factor for the cell |
| Irrigated Lands | Area (Ac.) of the lands irrigated by the Structure in the Cell | Relative recharge factor for the cell |
| Meadow | Area (Ac.) of the meadow land irrigated by the Structure in the Cell | Relative recharge factor for the cell |
| ET Zones | Area (Ac.) of the ET zone in the Cell | Relative recharge factor for the cell |

The following is the output format and descriptions of each output parameter in the Precipitation file (*.pcp):

| **Row-Data** | **Program Variable** | **Description** |
|---|---|---|

Row 1 Format (A24,I12,F12.3,F12.3)

| | | |
|---|---|---|
| 1-1 | ID | Unique identifier for each system in character format. The file will have a field width of 24 and be left justified (A24) |

- In the Precipitation file the ID is a code that may be made up of the HUC identifier, county code, land use type, and soil classification.

| | | |
|---|---|---|
| 1-2 | Numrec(1) | Total number of cells affected by the ID (I12) |
| 1-3 | Total_Value(1) | The total area of the Id system (F12.3) |
| 1-4 | Sumproduct(1) | The sum of the product of individual value and weight terms (F12.3) |

Row 2 Format (I24, I12, I12, F12.3, F12.3)

| | | |
|---|---|---|
| 2-1 | Layer(1) | The layer number of the model cell in integer format (I24) |
| 2-2 | Row(1) | The row number of the model cell in integer format (I12) |
| 2-3 | Column(1) | The column number of the model cell in integer format (I12) |
| 2-4 | Value(1) | Area (Ac.) of the PCP zone in the Cell (F12.3) |
| 2-5 | Weight(1) | Relative recharge factor for the cell (F12.3) |

*One record for each cell affected – Numrec. Repeat Rows 1 & 2 for each ID.*

The following is the output format and descriptions of each output parameter in the Wells file (*.wel):

| **Row-Data** | **Program Variable** | **Description** |
|---|---|---|
| Row 1 | Format (A12, I12, F12.3, F12.3) | |
| 1-1 | ID(1) | The unique ID for individual irrigation structures (A12) |
| 1-2 | NumPar(1) | The total number of Parcels with wells served by DitchID (I12) |
| 1-3 | Total_Acreage(1) | The total area of parcels served by groundwater of the Ditch system (F12.3) |
| | Weighted_Acreage(1) | The sum of the product of individual parcel area and the percentage served by this Ditch_Id (F12.3) |

| | | |
|---|---|---|
| Row 2 | Format (I12, I12, F12.3, F12.3, I12) | |
| 2-1 | Parcel_ID (1) | The layer number of the model cell in integer format (I12) |
| 2-2 | NumWells (1) | The row number of the model cell in integer format (I12) |
| 2-3 | Area (1) | The total area of parcels served by groundwater of the Ditch (F12.3) |
| 2-4 | Weighted_Area | The product of individual parcel area and the percentage served by this Ditch_Id (F12.3) |
| 2-5 | Irrig_type | If the parcel is flood irrigated the value is 0, otherwise the value is 1 for sprinklered parcels (I12) |

*One parcel block for each parcel with wells = NumPar*

*For each Well serving Parcel_Id*

| | | |
|---|---|---|
| Row 3 | Format (I12, I12, I12, F12.3, I12, A12) | |
| 3-1 | Layer(1) | The layer number of the model cell in integer format (I12) |
| 3-2 | Row(1) | The row number of the model cell in integer format (I12) |
| 3-3 | Column(1) | The column number of the model cell in integer format (I12) |
| 3-4 | Yield(1) | The prorated yield of the well for this Ditch_Id, Parcel_Id, and Layer for the well (F12.3) |
| 3-5 | Year(1) | The Year the well was first used (Appr or Permit Date) (I12) |
| 3-6 | WDID(1) | WDID or permit associated with model cell (A12) |

*(One record for each cell affected - Numrec.)*

*Repeat Rows 1, 2, & 3 for each ID*

# Appendix A: StateDGI Input File Guidelines

## A.1 Irrigated Lands Shapefile Attribute Descriptions (Polygon)

The CDSS standard format for Irrigated Acreage Shapefiles must include the following fields and data.

| Attribute | Type | Definition |
|---|---|---|
| Div | Integer | Water Division |
| Cal_year | Integer | 4-digit year that Crop_type represents |
| Parcel_id | Integer | Parcel identifier, unique for each parcel and year |
| Crop_type | String | Crop type name. Valid crop types:<br>ALFALFA<br>BARLEY<br>CORN<br>CORN_GRAIN<br>CORN_SILAGE<br>COTTON<br>DRY_BEANS<br>GRAPES<br>GRASS_PASTURE<br>ORCHARD_WITH_COVER<br>ORCHARD_WO_COVER<br>POTATOES<br>SMALL_GRAINS<br>SNAP_BEANS<br>SOD_FARM<br>SPRING_GRAIN<br>SUGAR_BEETS<br>SUNFLOWER<br>SWEET_CORN<br>VEGETABLES<br>WHEAT<br>WHEAT_FALL<br>WHEAT_SPRING<br>NO_CROP |
| Irrig_type | String | Irrigation method. Valid irrigation methods:<br>DRIP<br>DRY<br>FLOOD<br>FURROW<br>GRATED_PIPE<br>SPRINKLER<br>UNKNOWN |
| Acres | Double | Area of the parcel in acres |
| SW_WDID1 | String | WDID of surface water structure 1.<br>Fixed format: xxyyyyy where x = the WD and y = the ID (e.g. 0100501) |
| SW_COV1 | Single | Percent of parcel area irrigated by structure 1 (0-100) |
| SW_WDID2 | String | WDID of surface water structure 2 |
| SW_COV2 | Single | Percent of parcel area irrigated by structure 2 |
| *Up to 9 Surface Water structures can be identified.* | | |
| GW_TYPE1 | String | Identifier type for the groundwater structure identified. |

| | | |
|---|---|---|
| | | Valid types are:<br>WDID<br>RECEIPT |
| GW_ID1 | String | WD or RECEIPT number of groundwater structure |
| GW_CLASS1 | String | Determination method for supply well #1. Valid types are:<br>1 – Well is located inside parcel<br>2 – Well is outside parcel but within ¼ mile<br>3 – Well is within ¼ mile of parcel but has no yield (not used in SPDSS)<br>4 – Well that is within 5 miles of the parcel. This estimated well receives attributes from a well that may or may not already be associated with a parcel through a different type.<br>5 – Well is within ½ mile of the parcel. The well is shared with this parcel because it has already been assigned as a Type 1 or 2 with another parcel.<br>6 – User supplied information that parcel receives groundwater (not used in SPDSS)<br>7 – Well is located inside parcel. Well matched to a parcel with user supplied information on a groundwater use. Parcel was described as supplemental or groundwater only. Specific irrigation well was not supplied.<br>8 – Well is outside parcel but within ¼ mile. Well matched to a parcel with user supplied information on a groundwater use. Parcel was described as supplemental or groundwater only. Specific irrigation well was not supplied.<br>9 – Well that is within 5 miles of a parcel. Well matched to a parcel with user supplied information on a groundwater use. Parcel was described as supplemental or groundwater only. Specific irrigation well use was not supplied. This estimated well receives attributes from a well that may or may not already be associated with a parcel through a different type.<br>10 – Well is within ½ mile of the parcel. Well matched to a parcel with user supplied information on a groundwater use. Parcel was described as supplemental or groundwater only. Specific irrigation well use was not supplied. The well is shared with this parcel because it has already been assigned as a Type 7 or 8 with another parcel. |
| GW_TYPE2 | String | Identifier type for the groundwater structure identified |
| GW_ID2 | String | WD or RECEIPT number of groundwater structure |
| GW_CLASS2 | String | Determination method for the groundwater structure identified |
| *Up to 20 Ground Water structures can be identified.* | | |
| COMMENTS | | |

## A.2 Canal Shapefile Attribute Descriptions (Polyline)

| Attribute | Type | Definition |
|---|---|---|
| Length | Double | Length of canal segment (feet) |
| ID | Long | Unique identifier for each polyline |
| Source | String | Source of digitized polyline |
| Name | String | Common name of the ditch |
| Weight | Float | Weight |
| DIV | Number | Water Division |
| SW_WDID | String | The 7 Digit HydroBase ID related to the Water District and assigned structure ID |
| HB_Name | String | HydroBase Name of the Structure |

## A.3 Well Shapefile Attribute Descriptions (Point)

| Attribute | Type | Definition |
|---|---|---|
| Div | Number | Water Division |
| WD | Number | Water District |
| ID | Number | Structure ID |
| RECEIPT | String | Well Receipt Number |
| PERMITNO | Number | Well Permit Number |
| PERMITSUF | String | Well Permit Suffix from Well Permit Database |
| PERMITTRPL | String | Well Permit Replacement Code from Well Permit Database |
| WELL_NAME | String | Well Name |
| YIELD | Number | Summary of all net absolute rights for the specified WDID. Converted by the following: CFS*449= GPM |
| YIELDAPEX | Number | Summary of all net alternate point/exchange rights for the specified WDID. Converted by the following: CFS*449= GPM |
| PERMDATE | Date | Determined in the following order based on availability.<br>1. [npdate] – Date the permit, denial (AD) or monitoring hole was issued.<br>2. [sadate] – Date of first beneficial use.<br>3. [wcdate] – Date well construction completed. |
| APPRDATE | Date | Oldest appropriation data available for the specified WDID. |
| TPERF | Number | Top of Perforation from Well Permit Database |
| BPERF | Number | Bottom of Perforation from Well Permit Database |
| DEPTH | Number | Depth of Well from Well Permit Database |
| AQUIFER1 | String | Use Aquifer1 from Well Permit Database, if it is NULL, default value set to 'GW'. |
| USE1 | String | Well Use1 from Use Codes from Hydrobase |
| USE2 | String | Well Use2 from Use Codes from Hydrobase |
| USE3 | String | Well Use3 from Use Codes from Hydrobase |
| WELL_ID | String | HydroBase WDID of Receipt number. WDID values take precedence over RECEIPT numbers. |
| ID_TYPE | String | WDID or Receipt |
| UTM_X | Number | UTM X Coordinates |
| UTM_Y | Number | UTM Y Coordinates |

## A.4 Ground Water Model Boundary Shapefile Attribute Descriptions (Polygon)

| Attribute | Type | Definition |
|---|---|---|
| Row | Number | Grid Row Location (i.e. 1) |
| Col | Number | Grid Column Location (i.e. 10) |
| Row_Col | String | Combination of Row and Column to come up with unique cell reference. (i.e. 1_10) |
| Gnd_Elev | Number | Ground Elevation (feet) (i.e. 9000) |
| BOT_LYR1 | Number | Elevation of the bottom of layer 1 (feet) (i.e 8791) |
| BOT_LYR2 | Number | Elevation of the bottom of layer 2 (feet) (i.e. 8787) |
| BOT_LYR3 | Number | Elevation of the bottom of layer 3 (feet) (i.e. 8783) |
| *Up to as many layers identified in the model. Note, Bot_Lyr1 is required at a minimum.* | | |

## A.5 Rim Inflow Shapefile Attribute Descriptions (Polygon)

| Attribute | Type | Definition |
|---|---|---|
| ID | Number | Rim inflow ID |
| Name | String | Name of the contributing Rim inflow |
| Weight | Number | Weight of contributing Rim inflow |
| DIV | Number | Water Division |
| WD | Number | Water District |
| SW_WDID | String | The WDID related to the HydroBase Structure ID |

## A.6 Climate Station Grid Description (Raster Grid)

A series of climate station raster grids, with computed weights based on the distance to the nearest climate station, which are assigned to irrigated acreage parcels or a user-specified ID. Each climate station to be used in the analysis needs to be loaded into the Climate Weights tool and each grid is processed individually to determine the climate station weight for each parcel. Each grid within the directory must be named with the 4-digit Station ID (e.g. 0945, 1179) and the weights are represented by values between 0-1.

Climate Station Grids for the SPDSS study area have been created in support of SPDSS modeling efforts, as described in the SPDSS Technical Memorandum "Task 53.3: Assign Key Climate Information to Irrigated Acreage and Reservoirs", February 1, 2006. The SPDSS Climate Station grids are available on the CDSS website (cdss.state.co.us).

## A.7 Precipitation Orographic Correction Grid Directory Description (Raster Grid)

A directory that contains a series of precipitation orographic correction factor raster grids. The orographic correction factors are based on the ratio of average annual precipitation at a climate station to the average annual precipitation at the structure location. Orographic adjustments are applied to precipitation data typically when irrigated parcels are at an elevation higher than nearby climate stations. Each grid within the directory must be named with the 4-digit Station ID (e.g. 0945, 1179). The Climate Weight tools will only use the orographic grids for which a matching climate station grid has been selected. For example, if the '2220' climate station grid was the only grid selected, the tool will only use the ‘2220’ orographic grid to apply orographic adjustments. This is an optional input to the Climate Weight tools.

## A.8 Annual Average Precipitation Template Descriptions (Raster Grid)

A single Annual Average Precipitation raster grid is a required input to the Average Annual Precipitation tool. The raster grid has no specific naming convention. The grid was developed based on the Colorado Climate Center’s average annual precipitation coverages.

# Appendix B: RGDSS Spatial System Integration

Task 3.1 - Data Centered Groundwater Mode

**RGDSS Memorandum**
**Draft**

**To**: Ray Bennett, Andy Moore

**From:** Bruce Rindahl, Brown and Caldwell

**Subject:** RGDSS Spatial System Integration,
Task 3.1 - Data Centered Groundwater Model

**Date:** April 22, 2002

## INTRODUCTION

This memorandum summarizes the results in Task 3.1 of the Spatial System Integration portion of the Rio Grande Decision Support System (RGDSS). The objective of this task is as follows:

> *Design and develop selected portions of a data centered ground water modeling system for the Rio Grande Basin.*

### Approach

The procedures used to design and develop the data centered ground water modeling system for the Rio Grande basin was as follows:

1. Several meetings were held with the RGDSS ground water consultant to review the existing San Luis Valley preprocessor developed by the State of Colorado for the AWDI trial in 1991. The capabilities of the commercially available groundwater modeling interface, GMS, were reviewed.
2. Several meetings were held with the groundwater consultant and state personnel to discuss the needs and requirements for a data centered groundwater system. These requirements included the interaction between GIS data, the selected groundwater modeling interface, GMS, the existing tools from HydroBase, the results of StateMod simulations, and the CU/Water Budget task as part of the RGDSS.
3. A procedure was developed to implement a data centered ground water modeling approach for those components not available from GMS. This procedure has been named StateGWP for State of Colorado Data Centered Ground Water Modeling Process.

The major components associated with a ground water model and the data centered modeling process used in their development are presented in Table 1. The process is a combination of using GMS, a commercially available modeling software, with StateGWP, an application developed as part of RGDSS. StateGWP combines commercially available GIS software (ArcView), existing components available under the State of Colorado's Decision Support System (HydroBase, StateCU, and StateMOD), and new processes (StateDGI and StatePP) developed to accommodate components not currently available on the market place. Since GMS is described elsewhere, the balance of this memorandum describes the StateGWP process (Table 1 items 10 - 17). The procedures available in StateGWP are separated into 3 main components:

1. Historic Simulation Procedure that describes the StateGWP associated with developing historic data for calibration,
2. What-If Simulation Procedure that describes the StateGWP associated with developing data for a Future or What-If analysis, and
3. Data Display and Analysis that describes how both historic and What-If data may be presented.

The process described herein is not basin specific and may be applied to any ground water basin. In order to apply this process to a different area, the user simply has to identify the hydrogeologic process to be modeled, develop the appropriate geographic coverages and develop model input. The data centered ground water modeling process (analysis methods, data transfer protocols, database structure and ground water modeling formatting) is considered completely transferable.

**Table 1. Data Centered Ground Water Modeling Processes - Historic Mode**

| Number | Item | Key Data Sources | Process |
|---|---|---|---|
| 1 | Model Grid | HRS Task | GMS |
| 2 | Model Layer – Land Surface | HRS Task | GMS |
| 3 | Model Layer – Stratigraphy | HydroBase & HRS Task 7 | GMS |
| 4 | Aquifer Parameters | HydroBase & HRS Task 7 | GMS |
| 5 | Springs | HRS Task 17 | GMS |
| 6 | Streams | HydroBase & Hydrosphere Task 8.9& HRS Task 18 | GMS |
| 7 | Diversions | HydroBase & Hydrosphere Task & HS Task 18 | GMS |
| 8 | Boundary Inflow – Subsurface | HRS Task 4 | GMS |
| 9 | Drains | HDR Task 17 | GMS |
| 10 | Recharge - Canal Leakage | HDR Task 1 & StateCU Leonard Rice Task 3 | StateGWP |
| 11 | Recharge - Deep Percolation | HDR Task 1 & StateCU Leonard Rice Task 3 | StateGWP |
| 12 | Recharge – Precipitation | HDR Task 1 & StateCU Leonard Rice Task 3 | StateGWP |
| 13 | Pumping – Agricultural | HDR Task 1 & StateCU Leonard Rice Task 3 | StateGWP |
| 14 | Rim Inflow - Surface | HDR Task 1 & HydroBase & Hydrosphere Task 8.9 | StateGWP |
| 15 | Potential Evapotranspiration from Ground Water | HRS Task 15 | StateGWP |
| 16 | Flowing Wells | HRS Task 17 | StateGWP |
| 17 | Pumping - M&I | HRS Task 16 | StateGWP |

## HISTORIC SIMULATION PROCEDURE

The procedures for preparing an historic data set using Colorado's Data Centered Groundwater Modeling Process (StateGWP) is presented in Attachment 1Figure 1 and consist of the following 5 steps:

- Step 1. Develop Basic GIS Coverages,

- Step 2. GMS Modeling Interface,
- Step 3. ArcView Data Analysis,
- Step 4. StateCU Analysis , and
- Step 5. State Preprocessor.

**Step 1. Develop Basic GIS Coverages**

GIS coverages were developed by HDR Engineering (RGDSS Task 1, Develop Spatial Coverages) from various sources of information. The coverages that are used by StateGWP include: Canals, Irrigated Lands (Surface, Ground Water and both), Wells, Non-Irrigated Lands, Soils, Rim Inflow Areas, Drains, Digital Elevation Model (DEM) for ground elevation, and Small Flowing Wells. All GIS coverages were developed on a common datum (UTM Zone 13) and consistent units (meters).

**Step 2. Develop Model Coverages**

The groundwater modeling interface tool, GMS, was used with selected GIS coverages to develop the following input files required by the StateGWP:

- Model Grid,
- Model Layers.

GMS was used to export the MODFLOW model cells as a DXF export file, which gets translated into a shapefile by a script developed in the ArcView Data Analysis (Step 3). The bottom elevations for each model layer are exported in an Excel spreadsheet format. These elevations for each layer are converted into a shapefile in ArcView as an event theme and then converted into an ArcView grid format using the Spatial Analyst extension. Detailed examples of the output files and formats for GMS can be found in their documentation. Additional information concerning the features and implementation of GMS can be found in the design memorandum by HRS Water Consultants Inc. (RGDSS Ground Water, Task 1. - Ground Water Visualization Tool).

**Step 3. ArcView Data Analysis**

The GIS coverages developed in Step 1 and the model coverages developed in Step 2 are used by StateDGI to develop seven (7) output files (Table 2) for use by the State PreProcessor (StatePP) to compute information on a cell-by-cell basis. StateDGI uses ArcView's Avenue scripting language and Microsoft Access to provide all spatial data (irrigated and non irrigated) required for the data centered ground water model processing.

StateDGI provides the area within each ground water model cell that is associated with a particular land use and groundwater flux term. Agricultural data is provided by structure or ditch system (e.g. the X Ditch) while non-agricultural data is provided by land use (e.g. dense Chico lands, open water bodies, etc.). Note that a single ground water cell may have one to many ground water flux terms associated with it. For example, a cell may be recharged by ditch X and receive deep percolation from ditch Y. Similarly, another cell may contain 80% dense Chico lands and 10% open water bodies which each have a different ground water evapotranspiration function.

Table 2 lists the 8 files generated by StateDGI as part of the data centered ground water modeling process.

**Table 2. ArcView Generated Files for the Data Centered Approach**

| Item | File Name | Description |
|---|---|---|
| 1 | *.can | Canal length by cell for each ditch system |
| 2 | *.irr | Total Irrigated acreage by cell for each ditch system |
| 3 | *.wel | Well location, capacity and year for each ditch or well system |
| 4 | *.etz | Non agricultural acreage by cell for each vegetation zone |
| 5 | *.rim | Rim Inflow acreage by cell for each inflow area |
| 6 | *.sfw | Well capacity by cell for each flowing well |
| 7 | *.pcp | Vegetation acreage by cell for each county, HUC, and vegetation zone |
| 8 | *.med | Irrigated Meadow acreage by cell for each ditch systems |

Note: The * in the file name represents the base file name for a particular model and is the same for all files.

These output files are used by the StatePP in Step 5 to develop input data for the MODFLOW program. Detailed examples of the output files and formats produced by StateDGI can be found in Appendix A. In general, the ArcView data analysis is required only once for a particular basin and model grid configuration. This is because the output files are independent of the flux quantity, the time period being modeled and the number of time steps being simulated. However, if the basic spatial data does change (e.g. the model grid is revised, additional canals are modeled, etc.), the above process can be repeated easily.

The files developed by StateDGI give the areas and lengths for the entire defined model grid. There is no attempt to define the active or inactive cells in StateDGI. This assures the maximum flexibility to the groundwater modeler for adjustments to active cells, boundaries, and other estimates without the need for a revised analysis by StateDGI. The lone exception to this is the well output file. Each well must pump from a defined layer in the model as created by GMS. Thus a well located outside of any computed layer boundary will be assigned to layer 0 as a flag to StatePP.

**Step 4. StateCU Analysis**

For agricultural lands, the State's Consumptive Use Model (StateCU) performs a water supply limited analysis consumptive use (CU) by structure for the 1950 - 1997 study period. This CU analysis provides monthly estimates of canal loss, deep percolation and pumping for agricultural lands by structure. It uses parametric CU data (crop coefficients, root zone depth, etc.), climate data (temperature, precipitation and frost data), diversion records and well data obtained from State’s central database, HydroBase. It also uses the irrigated lands, crop types, soil types, and water source data (surface water only, ground water only or both) from the spatial data developed in Step 1.

A water budget analysis that provides precipitation recharge from both irrigated and non irrigated lands by land use (e.g. agricultural lands, dense Chico lands, etc.) was performed as part of the RGDSS. The details of this analysis is described in "RGDSS Memorandum – Recharge from Precipitation, August 21, 2000" by LRCWE. The water budget performed on irrigated lands uses the same data as the CU analysis described above. The non-irrigated water budget analysis uses parametric and climate data from HydroBase and land use data developed in Step 1.

The ground water flux data provided by the State CU model are contained in the detailed water budget file (*.dwb) and the recharge from precipitation file (pptrech.stm), as shown in Table 3 and on Figure 1. The detailed water budget file has values by month and structure for canal loss, surface water applied in excess of CU requirements, groundwater applied in excess of CU requirements, and surface water applied as direct recharge. The recharge from precipitation file contains the monthly recommended recharge from precipitation for both irrigated and non-irrigated lands by county and HUC. These output files are used in Step 5 by the StatePP to develop input data for the MODFLOW groundwater model.

**Table 3. StateCU Generated Files for the Data Centered Approach**

| Item | Description |
|---|---|
| 1 | Canal loss for each ditch system by month |
| 2 | Excess surface water applied for each ditch system by month |
| 3 | Direct recharge applied for each ditch system by month |
| 4 | Well pumping for each ditch or well system by month |
| 5 | Precipitation recharge for each land use by month |

### Step 5. State Preprocessor (StatePP)

The StatePP uses the input files developed from the Arc View Analysis (Step 3) and the StateCU Analysis (Step 4) to generate the following three (3) input files for MODFLOW (Table 4).

**Table 4. MODFLOW files generated by StatePP**

| Item | Description |
|---|---|
| 1 | Recharge package input |
| 2 | ET package input |
| 3 | Well package input |

**Recharge Package.** The Data Centered Ground Water Modeling Process generates the recharge package input for MODFLOW. The Recharge package input contains the sum of canal leakage, deep percolation, rim inflows, and precipitation recharge by cell for a user specified study period (1950 - 1997 for the Rio Grande Basin).

Recharge from Canal Leakage. The Data Centered Ground Water Modeling Process generates recharge from canal leakage for each cell containing a canal or lateral using the following formula:

$$TotLeakage_{ijk} = \frac{\left(Length_{ijk} * Weight_{ijk} * Leakage_k\right)}{\sum_{i,j}\left(Length_{ijk} * Weight_{ijk}\right)}$$

Where: i = Model cell row
j = Model cell column
k = Structure number
$Length_{ijk}$ = Length of structure k in cell i,j
$Weight_{ijk}$= Weight to be applied from structure k in cell i,j
Leakage = Canal loss from structure k
TotLeakage = Total recharge from canal loss to cell i,j

Canal Length ($Length_{ijk}$) and weight ($Weight_{ijk}$) are obtained from the ArcView data analysis output in the Canal Length file (Step 3). The weight typically assigned to each cell is 1.0, although a user may adjust the weight to represent canal segments that carry a greater volume of water, different soil types, etc. The monthly canal loss by structure ($Leakage_k$) is obtained from the StateCU analysis (Step 4). StatePP executes the above formula to estimate total canal leakage by cell (TotLeakage) at any desired time step (monthly, annual, average annual, etc.) within the study period.

Numerous canals were identified and digitized as part of the basic canals GIS coverage development of the RGDSS. Not all of the canals are located in the groundwater model grid as defined by HRS Water Consultants, Inc. Table 5 shows the total number and length of canals in the GIS coverage and their relationship to the groundwater model grid.

**Table 5. Canals located within the Groundwater Model Area**

| Description | Number | Length | % | Sum % |
|---|---|---|---|---|
| Canals completely within model grid | 442 | 3,092,222 | 96 | 96 |
| Canals completely outside the model grid | 27 | 124,447 | 4 | 100 |
| Canals crossing the model grid boundary | 2 | 12648 | 0.3 | 100 |
| Total | 471 | 3,229,317 | 100 | |

Deep Percolation. The Data Centered Ground Water Modeling Process generates recharge from deep percolation for each cell associated with irrigated lands using the following formula:

$$TotDeepPerc_{ij} = \frac{\left(Area_{ijk} * Weight_{ijk} * DeepPerc_k\right)}{\sum_{i,j}\left(Area_{ijk} * Weight_{ijk}\right)}$$

Where: i = Model cell row
j = Model cell column
k = Structure number

Irrigated area ($Area_{ijk}$)and weight ($Weight_{ijk}$) are obtained from the ArcView data analysis output in the Irrigated Acreage file (Step 3). The weight typically assigned to each cell is 1.0, although a user may adjust the weight to represent different soil types, crops, etc. Deep percolation from agriculture ($DeepPerc_k$) is obtained from the StateCU analysis for each structure (Step 4) by month for the study period. StatePP executes the above formula to estimate total deep percolation by cell (TotDeepPer) at any desired time step (monthly, annual, average annual, etc.) within the study period.

Irrigated parcels and the associated ditch systems were identified and digitized as part of the basic irrigated lands GIS coverage development of the RGDSS. Not all of the ditch systems are located in the groundwater model grid as defined by HRS Water Consultants, Inc. Table 6 shows the total number and area of ditch systems in the GIS coverage and their relationship to the groundwater model grid.

**Table 6. Ditch Structures within the Groundwater Model Area**

| Description | Number | Area | % | Sum % |
|---|---|---|---|---|
| Ditch systems completely within model grid | 578 | 598,276 | 98 | 98 |
| Ditch systems completely outside the model grid | 71 | 12,612 | 2 | 100 |
| Ditch systems crossing the model grid boundary | 11 | 1,852 | 0.3 | 100 |
| Total | 660 | 612,740 | 100 | . |

Recharge from Rim Inflows. The Data Centered Ground Water Modeling Process generates recharge from rim inflows for each cell associated with rim inflows using the following formula:

$$TotRimInflow_{ij} = \frac{\left(Area_{ijk} * Weight_{ijk} * RimInflow_k\right)}{\sum_{i,j}\left(Area_{ijk} * Weight_{ijk}\right)}$$

Where: i = Model cell row
j = Model cell column
k = Rim inflow estimate

Area ($Area_{ijk}$) and weight ($Weight_{ijk}$) are obtained from the ArcView data analysis output in the Rim Inflow Area file (Step 3). The weight typically assigned to each cell is 1.0, although a user may adjust the weight to represent different stream segments, soil types, etc. The rim inflow estimate ($RimFlow_k$) was obtained from a surface water analysis by Hydrosphere Resource Consultants (RGDSS Memorandum for Task 8.9, Estimate Rim Inflows) and represents the portion of surface inflows that recharge each rim inflow area by month for the study period. StatePP executes the above formula to estimate total rim inflow by cell (TotRimInflow) at any desired time step (monthly, annual, average annual, etc.) within the study period.

Recharge from Precipitation. The Data Centered Ground Water Modeling Process generates recharge from precipitation for each cell using the following formula:

$$TotPreRech_{ij} = \frac{\left(Area_{ijk} * Weight_{ijk} * PreRech_k\right)}{\sum_{i,j}\left(Area_{ijk} * Weight_{ijk}\right)}$$

Where: i = Model cell row
j = Model cell column
k = Unique zone based on County, HUC and Vegetation Type

Area ($Area_{ijk}$ ) and weight ($Weight_{ijk}$ ) are obtained from the StateDGI output from the precipitation file (*.pcp) in (Step 3). The weight typically assigned to each cell is 1.0, although a user may adjust the weight to represent different soil types, etc. the recommended precipitation recharge ($PreRech_k$ ) is obtained from the StateCU analysis (Step 4) and represents estimated monthly precipitation recharge for each land use, county, and Hydrologic Unit Code (HUC) for the study period. StatePP executes the above formula to estimate total precipitation recharge by cell (TotPreRech) for any desired time step (monthly, annual, average annual, etc.) within the study period.

Total Recharge. The total recharge for each $cell_{ij}$ is the sum of the canal leakage, deep percolation, rim inflows and precipitation computed from the above steps. StatePP creates a file of total recharge in a standard MODFLOW format for the recharge package. Any cell in the groundwater model can have one or more components from any or all of the above sources. For example, a cell may contain 75% irrigated lands and 25% native vegetation. That same cell may have 15% of its lands that receive rim inflows. Since the output from the StateCU is a recharge rate, the total recharge is the sum of the various components.

**ET Package.** The Data Centered Ground Water Modeling Process generates a composite ET relationship (ET versus depth to ground water) for each cell using the following formula:

$$TotETRate_{ij} = \frac{\left(Area_{ijk} * Weight_{ijk} * ETRate_k\right)}{\sum_{i,j}\left(Area_{ijk} * Weight_{ijk}\right)}$$

Where: i = Model cell row
j = Model cell column
k = Rim inflow estimate

Area ($Area_{ijk}$ ) and weight ($Weight_{ijk}$ ) are obtained from the StateDGI output from the native vegetation file (*.etz) for each non agricultural land use. In general, the weight assigned to each cell is 1.0 although it may be adjusted by a user to represent different soil types, depth to water, etc. The evaporation rate equations ($ETRate_k$ ) were developed by HRS Water Consultants, Inc. (RGDSS Memorandum for Task 15, Native ET Data) and represents an average relationship between depth to water and ET from ground water for each non agricultural land use. StatePP executes the above formula to estimate a composite ET relationship for each cell. Since the estimated ET from ground water is dependent on the depth to groundwater it is calculated for each time step in Modflow. Therefore, there is no need for the StatePP to perform any aggregation over time.

**Well Package.** Each individual well in the study area is included in the Data Centered Ground Water Modeling Process and is represented in several ways. In general, a well can serve only one parcel and pump from several layers. The assignment of wells to an irrigated parcel is based on the distance between the well and any irrigated land in a process described below. The capacity of each well is distributed between layers in the groundwater model in a manner also described below. The estimated pumping for each well is calculated using the following formula:

$$WellPumpingj_{ijkl} = \frac{\left(Pumping_k * AreaParcel_{jk} * WellCap_{ijkl}\right)}{\left(GWArea_k * \sum WellCap_j\right)}$$

Where: i = Well number
j = Parcel number
k = Structure number
l = Layer number

Monthly pumping for each structure ($Pumping_k$) is obtained from the StateCU analysis (Step 4) for each study period. $GWArea_k$ is the total irrigated area for structure k supplemented by groundwater and is obtained from the StateDGI output from the *.wel file. $AreaParcel_{jk}$ is the weighted area of any parcel j associated with structure k and is obtained from the StateDGI output from the *.wel file. Where one parcel is associated with several structures, the weighted area is the area of the parcel prorated between the various surface structures serving it. $\sum WellCap_j$ is the total well capacity of every well associated with parcel j for an individual stress period and is computed by StatePP from the StateDGI output from the *.wel file. $WellCap_{ijkl}$ is the well capacity of well i pumping from layer l associated with parcel j served by structure k and is obtained from the StateDGI output from the *.wel file. StatePP executes the above formula to estimate individual well pumping by layer, parcel and structure (WellPumping) for any desired time step (monthly, annual, average annual, etc.) in the study period.

Well Assignment to Irrigated Lands. In order to associate irrigated lands with ground water use and consequent aquifer pumping, a spatial comparison between the irrigated lands and a well coverage was performed. In general, a parcel is estimated to be served by groundwater if in a given year an irrigated parcel is within a specified distance of a decreed or permitted irrigation well (greater than 50 gpm), if it was irrigated by a sprinkler, or the parcel had no surface water supply. The irrigation well coverage was developed by HDR Engineering (RGDSS Report for Well File Analysis, February 9, 2000). Sprinklers were determined by maps provided by the Rio Grande Water Conservation District and an inspection of the irrigated acreage coverage (circles are estimated to be served by sprinklers). The surface water source to each parcel was developed by LRCWE Engineering (RGDSS Irrigated Lands Assessment – Task 1). The procedure to match irrigation wells with groundwater irrigated parcels is outlined below and presented in the following figure.

1. Where an irrigation well is located within a specified distance of an parcel not served by a surface supply or irrigated by sprinkler, assign the well to the closest parcel found. For clarity, those wells within an irrigated parcel are called Type 1 wells while those close to the parcel are called Type 2 wells. The specified distance is mutually agreed upon with the State and is currently set at 0.25 mile or 1320 feet.

2. When an irrigation well is not assigned in Step 1 above, but is located within a specified distance of any irrigated parcel, assign the well to the closest parcel found. For clarity, those wells within an irrigated parcel are called Type 1 wells while those close to the parcel are called Type 2 wells. This specified distance is mutually agreed upon with the State and is currently set at 0.25 mile or 1320 feet.

3. For lands without a surface water supply or irrigated by a sprinkler but not assigned a Type 1 or 2 Well in steps 1 and 2 above, determine if a well permit exists within or near the parcel with no specified yield. A well permit with no value for yield was not included in the well coverage because it had no decreed capacity or pumping rate data. This search is limited to distance mutually agreed upon between State and is currently set at 0.25 mile or 1320 feet. For clarity, these wells are called Type 3 wells. NOTE: Based on further analysis by the State (RGDSS Memorandum, Jana Reidesel to Ray Bennett, December 6, 2001) it was decided that this step would be omitted as part of the RGDSS

4. For lands without a surface water supply or irrigated by a sprinkler but not assigned a Type 1, 2 or 3 Well in steps 1 through 3 above, estimate that a well is located in the centroid of the parcel with attributes from the closest nearby well. A program in StateDGI performs a systematic search for the closest well to the parcel and assigns well attributes (capacity and aquifer pumped) to the centroid of the parcel. This search is limited to distance mutually agreed upon between the State and is currently set at 5 miles. The wells included in this search are limited to all of the wells identified in the well coverage and those well permits identified in step 3 above. For clarity, these wells are called Type 4 wells.

5. In certain cases a well can be assigned to more than one parcel. This can happen when one center-pivot field is planted with two or more crops resulting in a separate parcel for each crop. In this case, the well within the center pivot is assigned to one parcel growing one crop and one or more of the other parcels growing other crops are incorrectly assigned a Type 4 well. When such a condition occurrred the type 4 wells were changed to a Type 5 well. Two hundred sixty-three (263) of these matches were adjusted as part of the RGDSS. The capacity of the single well is then shared among both parcels.

As presented in the **Table 7**, 323,936 acres were estimated to be served by groundwater. Of that amount 285,339 acres or 46% of all in 1998 have a physical well (type 1, 2, or 5) while 38,597 acres or 6% have an estimated well. The results of this well to parcel matching program are provided in an Access table that gives the unique well id, the associated parcel id, the type of match made (1 through 5) and the distance from the well to the parcel where applicable.

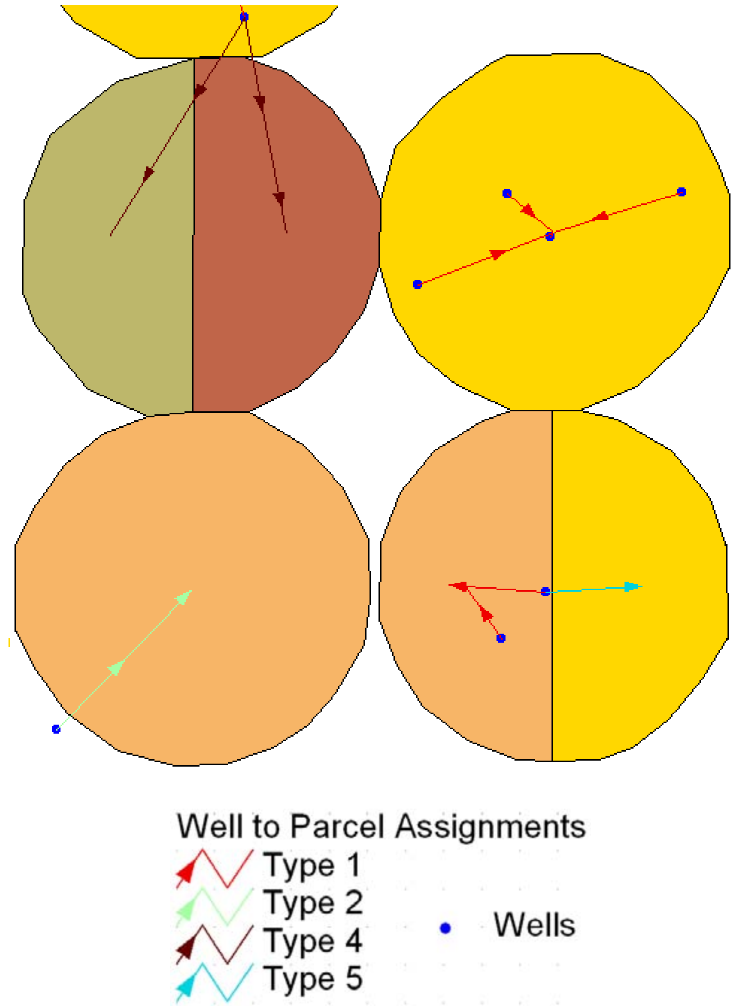
### Table 7. Wells Assignment to Irrigated Parcels Served by Ground Water

| Description | Type | Number | Acres [1] | % of Area |
|---|---|---|---|---|
| Well located in or near a parcel | 1 | 3161 | 285,339[3] | 46 |
| | 2 | 1801 | | |
| | 5 | 263[2] | | |
| Well without capacity data | 3 | 0 | 0 | 0 |
| Estimated Well | 4 | 301[2] | 38,597 | 6 |
| **SubTotal** | | **4972[2]** | **323,936** | **52** |
| Well not assigned to a parcel | | 2716 | 293,346 | 48 |
| **Total** | | **7,668** | **617,282** | **100** |

[1] Acres within rectangular ground water model boundary (includes active and inactive cells)

[2] Note there were 263 type 5 matches but every one of these matches utilized a well already matched as a type 1 or 2. In addition there were 467 type 4 matches or 467 parcels that required a well were assigned a well via method 4. This was accomplished using 301 unique wells (some wells were the closest well to several parcels). Of these 301 wells only 10 were additional wells not already matched to another parcel using method 1,2 or 5. Thus the total number of wells assigned was 3161 + 1801 + 0 + 10 or 4972.

[3] While in general a well was assigned to only one parcel, several wells could be assigned to one parcel (a parcel could have two wells within its boundary and another close by). Thus it is impossible to clearly delineate the acres served by a type 1 well versus a type 2 or 5. The total acreage served by all three types is 285,339 acres.




**Methods and Types of Well Assignments**

**Note: The arrows shown above are for illustrative purposes to show which parcels are served by a particular well. The actual well location is used for type 1,2, and 5 matches while the centroid of the parcel is used as the location for type 4 matches.**

Aquifer Assignment to Model Layers. In addition to assigning irrigation wells to groundwater irrigated parcels, StateDGI estimates the distribution of pumping for each well by model layer. The layers defining the bottom elevation of each aquifer are input to the StateDGI. The layers are created as part of the GMS modeling process and exported as an Excel spreadsheet with every bottom elevation by layer for each cell . This tabular data is imported as a table into ArcView and an event theme is created in ArcView. The event theme has points at each model cell center with the bottom elevations for each layer as an attribute. Using the Spatial Analyst extension to ArcView, a surface is created as an ArcView grid that passes through each elevation point. These grids are then used for analysis by StateDGI. The first layer is the ground elevation in an ArcView grid format for the model area, and each subsequent layer is the bottom elevation for each aquifer in ArcView grid format. Attributes for each well obtained from HydroBase are used to define the percentage of well capacity and pumping from each well layer as described below.

1. For wells with values for the top of perforation (tperf) and the bottom of perforation (bperf), pumping by layer is computed based on the linear distribution of screened interval between layers. For clarity, wells assigned using this approach are called Method 1.
2. For the remaining wells with values in the depth field defined, the well is estimated to be pumping entirely from the layer where the bottom depth of the well is located. If the bottom depth is below any defined layer, the well is estimated to be pumping entirely from the lowest aquifer at that location. For clarity, wells assigned using this approach are called Method 2.
3. For the remaining wells with values in the Aquifer1 field, the well is estimated to pump from layer 1 if the values of Aquifer1 is "UNC" or "GW". If the value for Aquifer1 is "CON" then the well is estimated to come from layer 2. For clarity, wells assigned using this approach are called Method 3.
4. Finally, all remaining wells use an estimated depth from the closest well with depth information found in steps 1 or 2 above. For clarity, wells assigned using this approach are called Method 4.

As presented in **Table 8**, 91% of all irrigation wells serving irrigated lands in 1998 have an aquifer assigned by steps 1 through 3 above, while only 9% had an estimated aquifer assigned by step 4. The results of this well layer program are contained in an Access table that gives the unique well id, the layer number, the percentage of pumping from that layer, and the well id of the closest well found in step 4 above if applicable.

**Table 8. Irrigation Wells Assigned to Ground Water Layers [1]**

| Description | Method | Number | % | Sum % |
|---|---|---|---|---|
| Layers assigned using top and bottom data | 1 | 2273 | 46 | 46 |
| Layers assigned using well depth data | 2 | 2255 | 45 | 91 |
| Layers assigned using aquifer type data | 3 | 0 | 0 | 91 |
| Layers assigned using a nearby well | 4 | 444 | 9 | 100 |
| Total | | 4972 | | 100 |

[1] Note every well was assigned to a model layer. Those wells outside the GW model boundary were assigned to layer 0. Table 8 shows only those wells also assigned to an irrigated parcel.

Time Varying Pumping Estimates. The amount and location of pumping that occurs over the study period (1950 to 1997) varies based on when a well was constructed and the acres served by that well. Wells with a water right only or a water right and a permit were estimated to exist after the adjudication date listed in the water rights tabulation. Wells with a permit only were estimated to exist after their permit date. This data is used in Step 4 by StateCU to limit pumping over time. Similarly this data is used by StatePP to determine the location of pumping over time.

Pumping Calculation Example. The following is an example of how the well data is processed in StatePP using the data shown in Appendix A. This example recognizes the pumping estimate provided by StateCU is already constrained to not exceed the acreage served by ground water and capacity available in the year of interest.

*Structure 200512 pumps 100AF for a given time step from the results of StateCU.*
*Structure 200512 has a total weighted area served by ground water of 81.25 acres.*
*Therefore, pumping by structure 200512 is 100AF/81.25 = 1.23 AF/acre.*

*Parcel 11866, one of several parcels served by structure 200512, has a weighted area served by ground water of 10.424 acres.*
*Therefore, the pumping associated with the cell containing this parcel is 1.23*10.424 or 12.83 AF.*

*The total capacity of all the wells serving parcel 11866 is (78.28 + 71.68) = 149.96 GPM.*
*Therefore the prorated capacity by well is 6.70 AF ((78.28/149.96)*12.83) in layer 1 and 6.13AF ((71.68/149.96)*12.83) in layer 2.*

**Small Flowing Wells**

The Data Centered Ground Water Modeling Process generates a file for use by StatePP to estimate the artesian flow of groundwater in the San Luis Valley. A GIS coverage was developed of small wells (capacity less than 50 gpm) located in layers 2 or 3 as defined by the groundwater contractor. State DGI generates a file (*.sfw) of all the small flowing wells and their location within the model grid. Each well is identified by layer, row, column, capacity and permit date. This data is summed by cell by StatePP to simulate flowing well discharges from a confined aquifer and recharges a portion of that discharge to the unconfined aquifer.

Since the estimated discharge from flowing wells is dependent on the depth to groundwater it is calculated for each time step in Modflow. Therefore, there is no need for the StatePP to perform any aggregation over time.

## WHAT-IF SIMULATION PROCEDURE

The procedures for preparing a What-If data set using Colorado's Data Centered Groundwater Modeling Process (StateGWP) is presented in **Figure 2** and consist of the following 5 steps.

- Step 1. Develop Basic GIS Coverages*
- Step 2. GMS Modeling Interface*
- Step 3. ArcView Data Analysis*
- Step 4. StateMod Analysis
- Step 5. State Preprocessor*

*Identical to Historic Data Preparation

The What-If procedure is very similar to the historic data procedure. The only difference is that the surface model StateMod, is used in Step 4 instead of the StateCU consumptive use analysis. The surface water model (StateMod) is designed to simulate a river basin's operation under a "What If" scenario using the prior appropriation doctrine. Results include canal loss, deep percolation and pumping estimates required for ground water modeling. As presented in Table 9 and on Figure 2, the three (3) ground water flux terms provided by StateMod under a What-IF simulation include canal loss, deep percolation and well pumping.

**Table 9. StateMod Generated Data for the by Data Centered Approach under a What IF Simulation**

| Item | Description |
|---|---|
| 1 | Canal loss for each ditch system by month |
| 2 | Deep percolation for each ditch system by month |
| 3 | Well pumping for each ditch or well system by month |

These output files are used in Step 5 by the StatePP to develop input data for the MODFLOW groundwater model under a "What If" scenario.

## SUMMARY

A data centered approach for groundwater modeling has been developed as part of RGDSS. The process is a combination of using GMS, a commercially available modeling software, with StateGWP, a application developed as part of RGDSS. StateGWP combines commercially available GIS software (ArcView), existing components available under the State of Colorado's Decision Support System (StateCU) and new processes (StateDGI and StatePP) developed to accommodate components not currently available on the market place. By using the existing models and a data centered approach, the process is a robust system that can quickly respond to revised data and refinements of modeling techniques.

### Comments and Concerns

Comments and concerns identified during the development of the data centered ground water modeling processing include the following.

1. Municipal wells in the study area will be handled individually for the specific non-irrigation wells in the valley. The row, column, and layer for those wells can be computed separately and the pumping rates can be obtained from well records.
2. Development of the streamflow package via GMS and its ability to automatically locate approximately 400 structures on the streams may present a challenge. It is unknown at this time how well the GMS program will be able to deal with the quality of existing structure location data and how much data processing, if any, will be required to incorporate numerous streamflow and diversion data sets.
3. This memorandum should be considered a guide to the development of the data centered groundwater modeling process. It is anticipated that during the implementation of the process, additional revisions and enhancements will be required.

# RGDSS Data Centered Groundwater Model Historic Mode

FIGURE 1

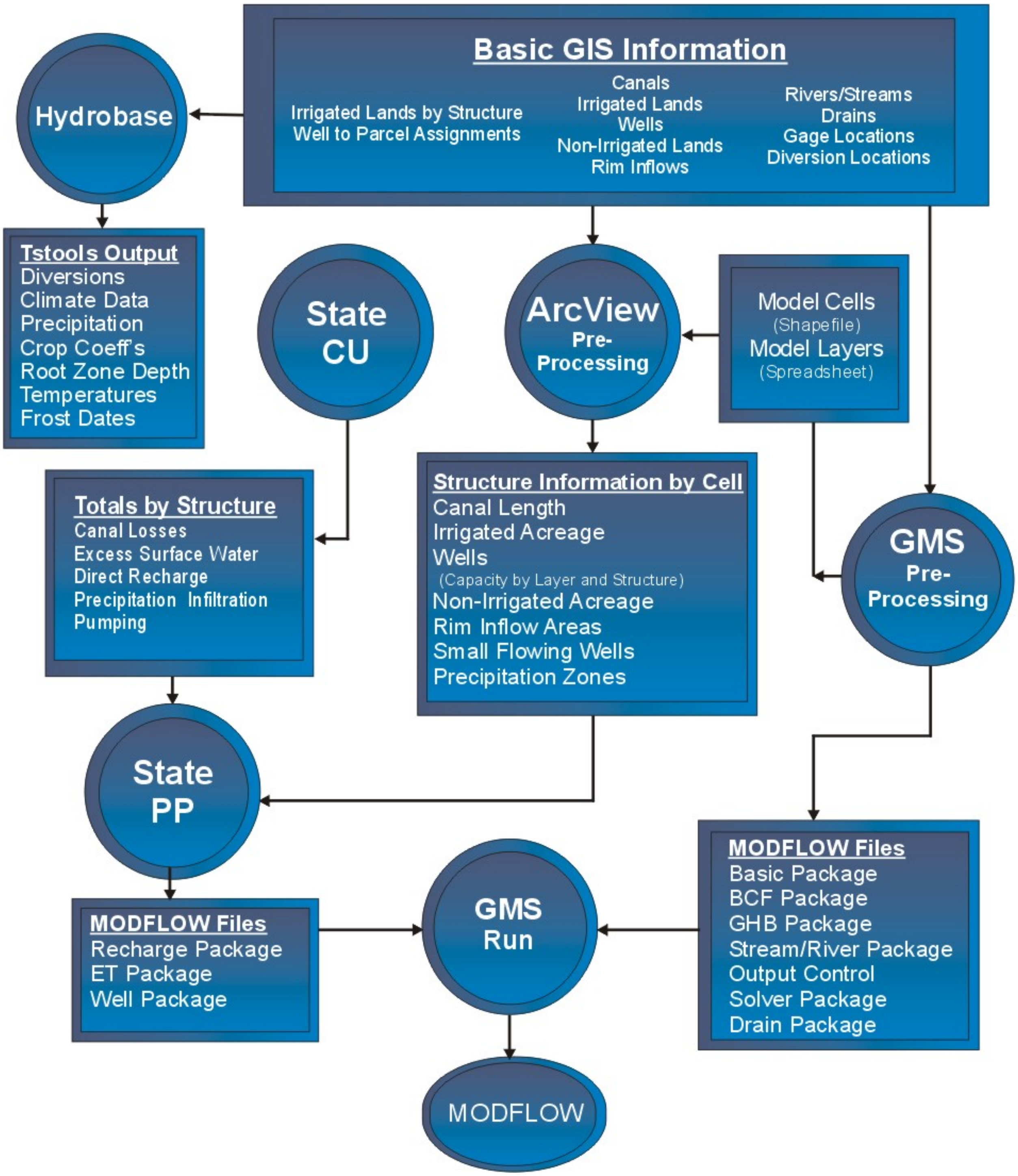


**FIGURE 2**

# RGDSS Data Centered Groundwater Model "What-If" Mode

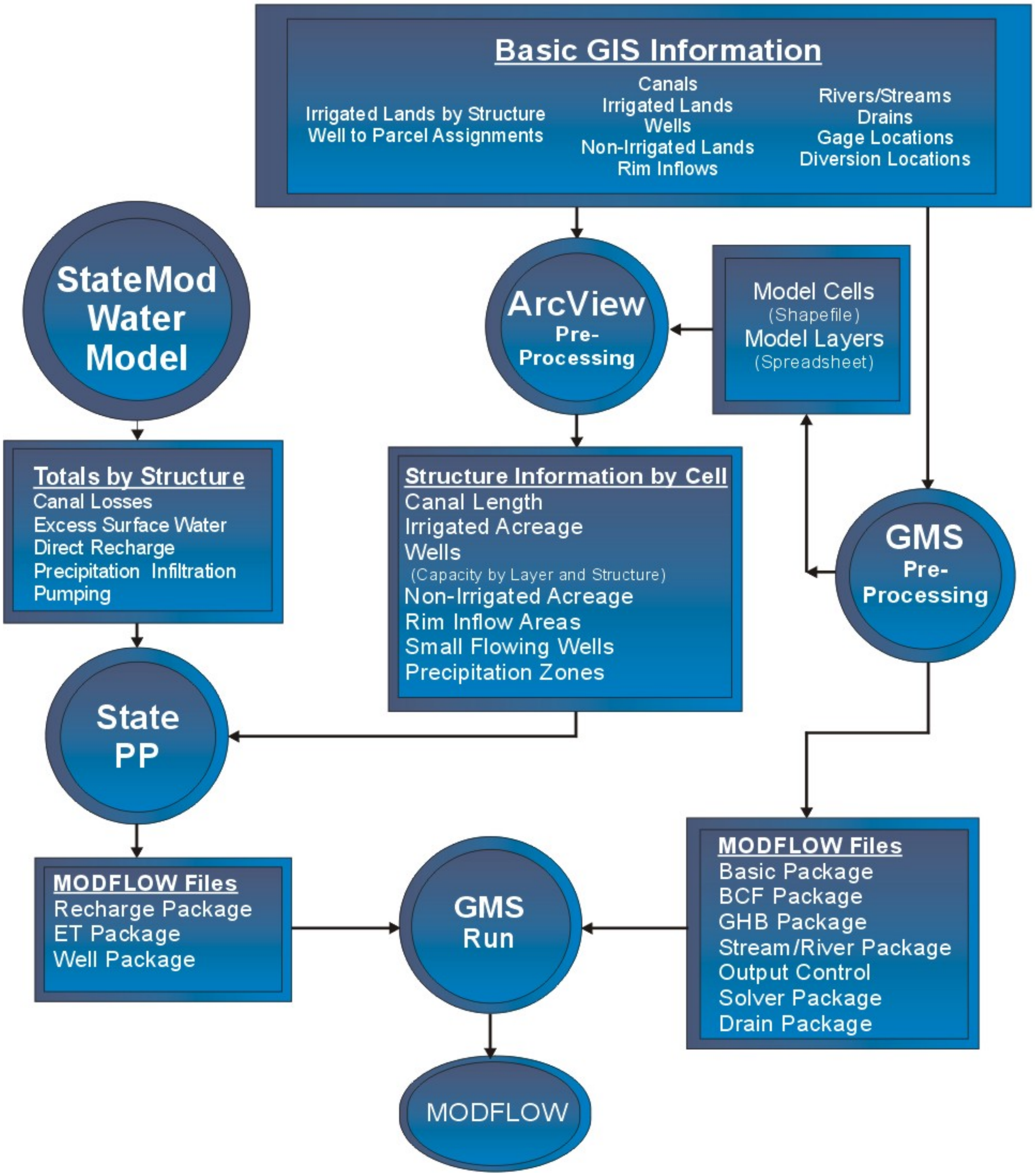
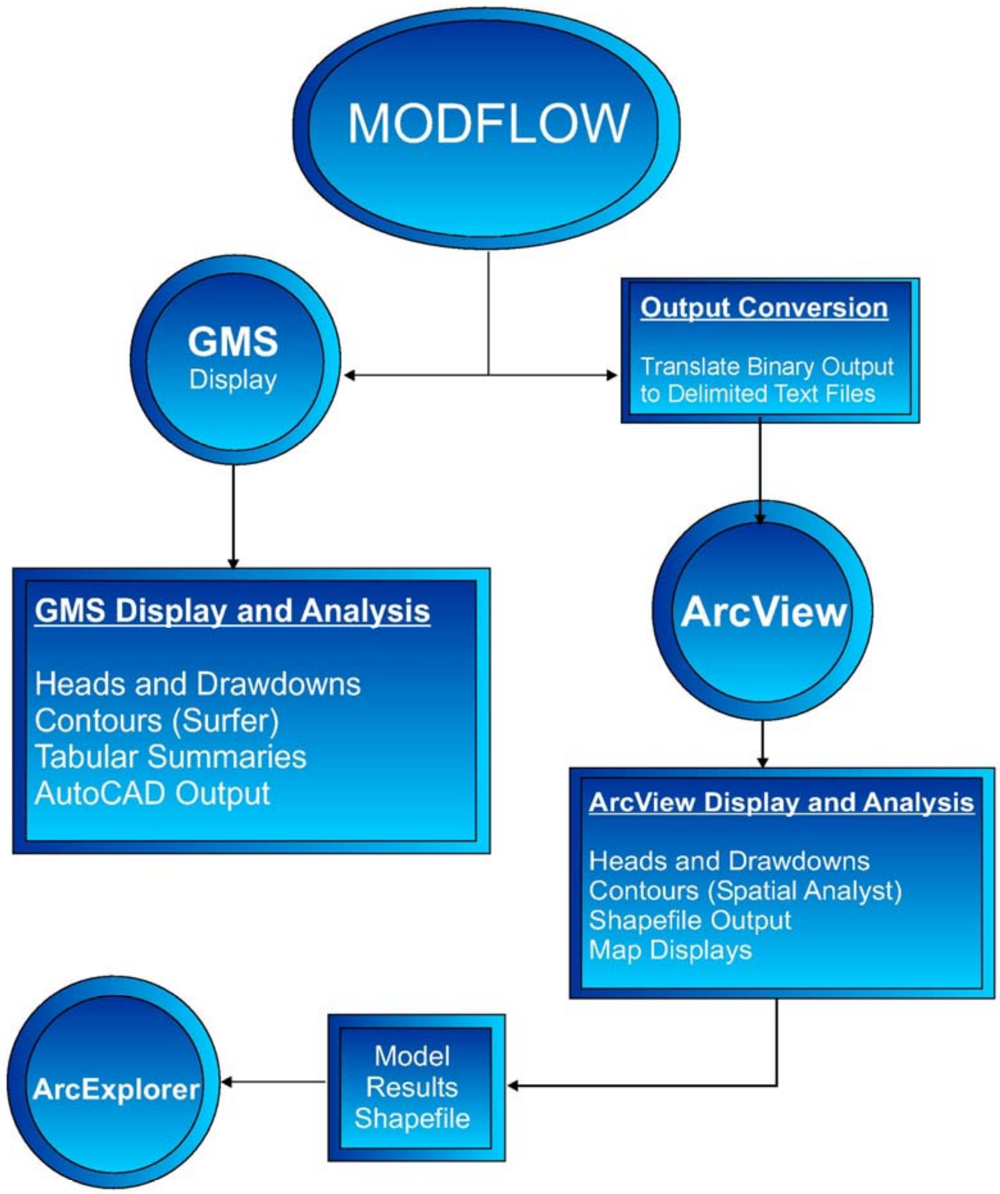


**FIGURE 3**

# RGDSS Data Centered Groundwater Model Data Display and Analysis



## APPENDIX A

## StateDGI Detailed Description

An ArcView GIS application called StateDGI uses various GIS coverages to develop seven (7) output files, **Table A1**, for use by the StatePP. StateDGI provides the spatial data required to process selected input files for Modflow.

**Table A1. ArcView Generated Files for Data Centered Ground Water Modeling Approach**

| Item | File Name | Description |
|---|---|---|
| 1 | *.can | Canal length by cell for each ditch system |
| 2 | *.irr | Total Irrigated acreage by cell for each ditch system |
| 3 | *.wel | Well location, capacity and year for each ditch or well system |
| 4 | *.etz | Non agricultural acreage by cell for each vegetation zone |
| 5 | *.rim | Rim Inflow acreage by cell for each inflow area |
| 6 | *.sfw | Well capacity by cell for each flowing well zone |
| 7 | *.pcp | Land cover acreage by cell for each county, HUC, and vegetation zone |
| 8 | *.med | Irrigated Meadow acreage by cell for each ditch systems |

Note: The * in the file name represents the base file name for a particular model and is the same for all files.

StateDGI reads a user specified response file (*.res) for a list of the coverages required for the data analysis (**Table A2**). The format for this file is free format with separate lines for each type of coverage, the name of the shapefile, and the names of the fields required for each particular coverage. There are up to nine lines in the file, which can be in any order. Seven of these lines consist of the coverage type, the full path to the shapefile, and the required field names. The model layers are specified by one line with the keyword layers followed by the path to each layer grid starting with the ground elevation and then each layer in succession. This database will include the queries and report necessary for creating the output files. Comments can be included in the control file if the first character is "#". The coverage types are as follows:

**Table A2. StateDGI Input Coverages**

| Item | Type | Description |
|---|---|---|
| 1 | model | Model Cells |
| 2 | canals | Canals and Ditches |
| 3 | irr_lands | Irrigated lands |
| 4 | wells | Well locations |
| 5 | permits | Null Yield permits |
| 6 | native | Land cover zones |
| 7 | inflows | Rim Inflow Zones |
| 8 | layers | Layer Elevation Grids |

An example of a response file:

```
# Test Response File
#
#
model c:/cdss/gis/riogrande/rmodel.shp row column
Irr_Lands c:/cdss/gis/riogrande/div3_irrparcels.shp parcel weight 1
```

```
Canals c:\cdss\gis\riogrande\slvcanals.shp wd_id weight 1
Inflows c:/cdss/gis/riogrande/riminflows.shp wd_id weight layer
Native c:/cdss/gis/riogrande/div3_landcover.shp id weight 1
Wells c:/cdss/gis/riogrande/div3_wells_2000-07-18.shp well_id
Permits c:/cdss/gis/riogrande/no_yield.shp well_id
Layers c:/cdss/dem c:/cdss/layer1 c:/cdss/layer2 c:/cdss/layer3
```

Note that the response file is not sensitive to upper or lower case and the "/" and "\" characters are interchangeable. Table A3 specifies the required fields for each type:

**Table A3. StateDGI GIS Input Coverages**

| **Type** | **Required fields** |
|---|---|
| Model | Shapefile, Row Field, Column Field |
| Canals | Shapefile, Structure_ID Field, Weight Field, Layer* |
| Irr_lands | Shapefile, Parcel_ID Field, Weight Field, Layer* |
| Native | Shapefile, HUC-County-Type Field, Weight Field, Layer* |
| Inflows | Shapefile, Structure_ID Field, Weight Field, Layer* |
| Wells | Shapefile, Well_ID Field |
| Permits | Shapefile, Well_ID Field |
| Layers | DEM, Layer1, Layer2, Layer3, … (ArcView Grid files) |

* Layer can be a constant value or a field name.

Eight input files for the StatePP will be developed by this process. These files will be as follows:

| File | Name |
|---|---|
| • Canal Leakage | *.can |
| • Rim Inflows | *.rim |
| • Irrigated Lands | *.irr |
| • ET Zones | *.etz |
| • Precipitation Zones | *.pcp |
| • Irrigated Meadow | *.med |
| • Wells | *.wel |
| • Flowing Wells | *.sfw |

Where * is the base name specified for the output files.

The first five output files will be in one format. This file format is a tabular form of the model cells affected by each ditch system. A series of header lines will be allowed for comments and information with a "#" symbol as the first character in the line. This follows the format used in the output files for use by the StateMod model. Following the header, blocks of data will be output, one block for each ditch system.

The format of each block will consist of one line for the Ditch Id and the number of cell records in each block. Following the first line in each block will be one record for each cell affected by the ditch. The number of these cell records for each block will be equal to the second field in the first line of each block.

**Output Format (Canals, Rim Inflows, Irrigated Lands, ET Zones, Precipitation Zones)**

For each ditch system.

**Id Numrec Total_Value Sumproduct**

For each cell affected by DitchID

**Layer Row Column Value Weight**

*(One record for each cell affected - Numrec.)*

*Next Id …*

**Explanation of Output Values**

ID--is the ID value for the individual system in character format.

For the ET file, the ID will be the ET zone land use type. For the Precipitation file, the ID is a code including the HUC identifier, a county code, and a code identifying the vegetation type. For the Rim Inflow file, the Id is the name of the rim Inflow zone. All of these files will have a field width of 24 and be left justified. For the Irrigated Lands and Canals the ID is the WDID value for the individual Ditch system from Hydrobase.

Numrec--is the total number of cells affected by the ID in integer format (I12).

Total_Value – The total length or area of the Id system in floating format (F12.2).

Sumproduct – The sum of the product of individual value and weight terms in floating format (F12.2)

Layer--is the layer number of the model cell in integer format (I12).

Row--is the row number of the model cell in integer format (I12).

Column--is the column number of the model cell in integer format (I12).

Value--is the total amount impacted by the model cell in floating format (F12.2).

Weight--is the weight factor for each model cell in floating format (F12.2).

The data in the Value and Weights fields will vary depending on the various output files. The following Table summarizes the data output in the respective output files.

***Table A4. Description of Value and Weight Fields***

| File | Value | Weight |
|---|---|---|
| Canal Leakage | Length (Ft.) of the Canal in the Cell | Relative leakage factor of the Canal in the Cell |
| Rim Inflows | Area (Ac.) of the affected lands in the Cell | Relative infiltration factor for the cell |
| Irrigated Lands | Area (Ac.) of the lands irrigated by the Structure in the Cell | Reserved at this time. (Use 1.0) |
| Irrigated Meadow | Area (Ac.) of the meadow land irrigated by the Structure in the Cell | Reserved at this time. (Use 1.0) |
| ET Zones | Area (Ac.) of the ET zone in the Cell | Reserved at this time. (Use 1.0) |
| PCP Zones | Area (Ac.) of the PCP zone in the Cell | Reserved at this time. (Use 1.0) |

**Output Format (Small Flowing Wells)**

***NumWells***

For each well

**Layer Row Column Capacity Year**

*(One record for each well affected - NumWells.)*

**Explanation of Output Values**

NumWells--is the total number of Small Flowing wells in integer format (I12).

Layer--is the layer number of the model cell in integer format (I12).

Row--is the row number of the model cell in integer format (I12).

Column--is the column number of the model cell in integer format (I12).

Yield--is the yield of the well in floating format.

Year--is the Year the well was first used (Permit Date) in integer format (I12).

**Output Format (Wells)**

*For each ditch system.*

**DitchId NumPar Total_Acreage Weighted_Acreage**

*For each Parcel affected by DitchID*

**Parcel_ID NumWells Area Weighted_Area Irrig_Type**

*(One parcel block for each parcel with wells = NumPar.)*

For each Well serving Parcel_Id

**Layer Row Column Yield Year**

*Next Parcel_Id …*

*Next DitchId …*

**Explanation of Output Values**

DitchID--is the WDID value for the individual Ditch system in character format (12).

NumPar--is the total number of Parcels with wells served by DitchID in integer format (I12).

Total_Acreage – The total area of parcels served by groundwater of the Ditch system in floating format.

Weighted_Area – The sum of the product of individual parcel area and the percentage served by this Ditch_Id in floating format.

Parcel_ID--is the Id number for the individual parcel integer format (I12).

NumWells--is the total number of wells serving Parcel_Id in integer format (I12). Note one well completed in two layers counts as two wells

Area – The total area of parcels served by groundwater of the Ditch system in floating format.

Weighted_Area – The product of individual parcel area and the percentage served by this Ditch_Id in floating format.

Irrig_type – If the parcel is flood irrigated the value is 0, otherwise the value is 1 for sprinklered parcels in integer format (I12).

Layer--is the layer number of the model cell in integer format (I12).

Row--is the row number of the model cell in integer format (I12).

Column--is the column number of the model cell in integer format (I12).

Yield--is the prorated yield of the well for this Ditch_Id, Parcel_Id, and layer for the well in floating format.

Year--is the Year the well was first used (Appropriation or Permit Date) in integer format (I12).

## Example Output

Example output of the canals is as follows:

```
# StateDGI 8/23/00 7:53:13 AM
# StateDGI Canals Output
200505      18   41569.435    4252.549
1     136     62    3367.31     0.1
1     136     63    729.361     0.1
1     133     57    1871.407    0.1
1     133     56    3051.78     0.1
1     133     55    3075.46     0.1
1     133     54    2656.03     0.1
1     133     53    2640.08     0.1
1     133     52    2639.95     0.1
1     133     51    2648.19     0.1
1     134     57    3218.71     0.1
1     137     63    389.505     0.1
1     136     61    2928.23     0.1
1     136     60    2753.81     0.1
1     135     57    1233.87     0.1
1     135     58    3100.43     0.1
1     135     59    1796.35     0.1
1     136     59    1594.34     0.1
1     133     50    1874.622    0.151
200512       6   10388.524   10388.524
1     112     19    1721.67     1
1     114     22    31.474      1
1     113     20    3388.75     1
1     114     21    2789.98     1
1     113     19    1286.67     1
1     113     21    1169.98     1
```

*…Continue for each ditch system…*

Example output of the wells is as follows:

```
# StateDGI 4/12/2002 11:52:55 AM
# StateDGI Well Output
200512       4     102.007     101.51
11866        3     10.424      10.424      0
1     115     23     250.09     1958
1     115     23     189.93     1949
1     115     22     149.97     1950
11885        1     20.26       20.26       0
1     115     22     350.22     1962
12078        1     26.133      26.133      0
1     115     25     600        1958
12080        1     45.19       44.693      0
2     115     24     989
200513       1     67.436      33.448
16770        1     67.436      33.448      0
1     104      8     396.41     1946
```

| | | | | | |
|---|---|---|---|---|---|
| 200516 | 2 | 143.663 | 58.29 | | |
| 16605 | 1 | 44.392 | 44.392 | 0 | |
| 0 | 126 | 19 | 227.64 | 1952 | |
| 16621 | 1 | 99.271 | 13.898 | 0 | |
| 0 | 126 | 17 | 24.52 | 1952 | |

*…Continue for each ditch system…*

Note in the above example Structure 200512 has 4 parcels with groundwater, total groundwater acreage of 102.007 acres with 101.51 acres directly under 200512. The four parcels are 11866, 11885, 12078, and 12080. Parcel 11866 has three wells, all in layer 1 with two in row 115, column 23 and one in row 115, column 22.

## APPENDIX B

## StateDGI Access Database Structure

The StateDGI program include an Access database where the results of the spatial process from ArcView is combined, grouped, and processed into the final output format for use by the StatePP program. A series of database queries are included as part of the database which act on the tables populated by the ArcView application. A separate copy of a StateDGI database is maintained for each groundwater model or simulation performed. The current copy of the database to be used for simulation is referenced as an ODBC connection named “StateDGI”. Refer to the users documentation for the StateDGI program for step-by-step instructions to create an ODBC connection.

Eight tables in the database are updated each time a respective program is run in the StateDGI ArcView application. These are summarized in Table B1

**Table B1 – Database Tables**

| Table | Description |
|---|---|
| Canal_cells | Canal segment lengths and weight by cell |
| Ground_cover | Land cover areas and weight by county, HUC, and vegetation type by cell |
| Irr_str | Percentage of parcels served by various Surface Water systems |
| Layers | Percentage of capacity by layer number for each well |
| Location | Row and Column location for each well and parcel |
| Parcel_cells | Parcel areas and weight by cell |
| Riminflow_cells | Rim inflow areas and weight by cell |
| Well_parcel | Well to parcel assignment |

An extensive series of queries exist in the database which act on the tables updated by the ArcView programs. These queries group and summarize the raw data by structure number, compute totals for header lines, and sort for final text output.

The ground cover table is analyzed for both the evapotraspiration file (*.etz) and the precipitation file (*.pcp). The irrigated land uses are ignored and the areas are grouped by vegetation type for output to the *.etz file. For the precipitation file, areas are grouped by county, HUC, and land cover, summarized and sorted for output to the *.pcp file.

The parcel_cell table has areas for each parcel by model cell. The table irr_str is used to distribute the parcel areas to the structures that serve them. The areas are then prorated and grouped by structure and summaries for total area for output to the irrigated lands (*.irr) file.

Analysis well capacity distribution is the most complicated of all the queries. Well capacity is prorated between the parcels they serve based on parcel areas using the well_parcel and irr_str tables. Well capacity is further distributed among model layers using the layers table. Wells assigned to parcels via a type 4 match are analyzed independently of the other wells and then combined with the type 1-3 wells. Finally the well capacity is prorated among structures in the same manner as the parcels using the irr_str table and grouped by structure, summarized and sorted for output to the well (*.wel) file.

Seven queries in the database are the final data for output to StatePP. A Visual Basic module in the StateDGI database add header information to the data and outputs each text output file. These queries and output files are summarized in Table B2

**Table B2. Final Queries**

| Query | Output file | |
|---|---|---|
| Canal_final | Canal Leakage | (*.can) |
| Etz_final | ET Zones | (*.etz) |
| Parcel_final | Irrigated Lands | (*.irr) |
| Meadow_final | Irrigated Meadow | (*.med) |
| Pcp_final | Precipitation Zones | (*.pcp) |
| Rim_final | Rim Inflows | (*.rim) |
| Well_final | Wells | (*.wel) |

The small flowing wells (*.sfw) file is directly output from the ArcView application.