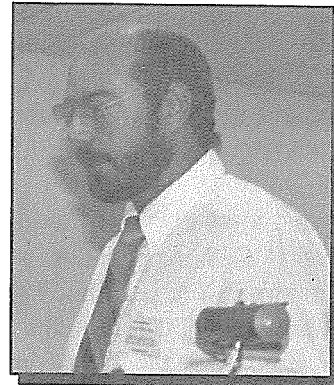
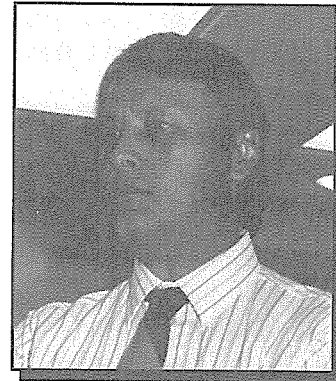


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THE STATEWIDE WATER RESOURCE PLAN INFORMATION SYSTEM: EXPANSION OF THE INVENTORY OF FLOOD PROTECTION NEEDS GIS APPLICATION

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INTRODUCTION

As water resources issues in New Mexico continue to gain attention, information of all

kinds pertaining to spatial relationships, such as administrative districts, existing tabular data, and past and present project reporting, are valuable assets to state water planners and decision

makers. Historically, useful water resources information pertaining to the same community or geographic region might be recorded at several federal and/or state agencies without being pooled as a collective inventory for general access. This paper summarizes the second phase of development of the Statewide Water Resources Plan Information System (SWRPIS), formerly referred to as the "The Flood Protection Needs Inventory GIS Application." Work described in this paper was performed for the Soil Conservation Service's (SCS) Albuquerque office and in conjunction with the New Mexico Interstate Stream Commission. With the expansion of report information contributed by the SCS, and its potential use with the Statewide Water Plan, this application's name was changed to reflect more properly its utility for water planning at all levels, as requested by the state's Water Resource Plan Coordinator.

BACKGROUND

In FY92, the Corps of Engineers (COE) Southwest Division, Albuquerque District completed and delivered the first compilation of the New Mexico Statewide Inventory of Flood Protection Needs, in report and dBaseIII Plus® format, hereinafter referred to as the "Flood Protection Inventory" (FPI) to the New Mexico Interstate Stream Commission as part of the Planning Assistance to States Program established in 1974 (Corps of Engineers 1992). At the request of the Albuquerque District Corps of Engineers Planning Department, the New Mexico Engineering Research Institute (NMERI) was commissioned to convert the FPI database to a menu-driven GIS-based report query application.

The FPI database consists of Study Data reports and Federal Emergency Management Agency (FEMA) Data reports. The Study Data report includes pertinent data from completed Corps of Engineers planning studies conducted for communities, counties, or river basins that identify flooding problems and solutions. The FEMA Data report consists of National Flood

Insurance Program (NFIP) information for New Mexico communities.

NMERI completed and delivered the product of the first phase of the "The Flood Protection Needs Inventory," Geographic Information System application to the Corps of Engineers and the New Mexico Interstate Stream Commission in May 1992. This FPI GIS-based application was a completely menu-driven query tool for accessing Corps of Engineer Flood Control Project and FEMA Reports and Information since 1974 by corresponding geographic parameters, that is, communities, counties, or river basins. The application was prepared using Environmental Systems Research Institute's ARC/INFO® version 5.0.

The task applied the process of geographically linking the original data sets to a spatial reference, making the original data sets suitable for use in a GIS. Geographic linking or "geolinking," is the process of relating a data set with a "soft" spatial reference (e.g., community name) to a data set with a "hard" spatial reference such as latitude and longitude. The link is made through the use of data elements common to both data sets and database techniques known as relational operations. This technique combined the data elements from both data sets to locate and describe a place of interest. In this case the community, county, and river basin names found in a database were used to geolink to the digital USGS Geographic Names Information System, the County Boundary, and aggregated USGS Hydrologic Unit GIS coverages, respectively, for New Mexico. Sample reports from a FPI query session appear in Figures 1-3.

SECOND PHASE OBJECTIVES

The second phase's primary objective of the "SWRPIS GIS Application" was to expand the information base of the FY92 Flood Protection Inventory GIS Application to include four types of SCS water-resources related project report descriptions, which can be queried by their representative geographic reference such as communities, counties, or river basins. A second-

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COE/FEMA Summary Report

Community Code: 0366
Community: RED RIVER
District: CESWA
County Code: 30
County: TAOS
Basin Code: 7
Basin: RIO GRANDE
COE Study: T
FEMA Study: T

(DONE)

Select Type of Report:

(COE Report) (FEMA Report)

Figure 1. Sample Summary Report.

FEMA Report

Community: FORT SUMNER Code: 0165
County: DE BACA Code: 007
Basin: PECOS Code: 06

NFIP Status: R NFIP Map: I
NFIP Date: 02-04-81
Number of NFIP & WYO Policies: 0
NFIP Coverage: \$0 WYO Coverage: \$0
Number of Claims Made: 0
Amount of NFIP Claims Paid: 0
District Code: SWAF025
Number of Reports for this Site: 1
Time/Date Entered: 16:55:48 12-23-91

(DONE)

Figure 2. Sample FEMA Report.

COE Report

Community: ABIQUIU 0004 County: RIO ARRIBA 022
Basin: RIO GRANDE 07 District Code: SWAS001
Agency: CESWA Study Type: WCML Sponsor: CORPS OF ENGINEERS ALBQ DIST
Date Initiated: Date Completed: 02/01/82
Original Cost: \$100,000 O&M Cost: \$0 Jan. 1992: \$130,000
Annual Project Benefit: \$1000 Benefit Cost Ratio: 1.2
Number of reports for this site: 1

Report Title: ABIQUIU DAM AND RESERVOIR OPERATED IN ACCORDANCE WITH THE WATER CONTROL MANUAL TITLED ABIQUIU DAM AND RESERVOIR, RIO CHAMA, NEW MEXICO, APPENDIX A TO RIO GRANDE BASIN MASTER REGULATION MANUAL (FEBRUARY 1982).

Project: EARTHFILL STRUCTURE FOR FLOOD AND SEDIMENT CONTROL WITH SPF LEVEL OF PROTECTION. PROJECT IS AUTHORIZED TO STORE 200,000 AF OF SAN JUAN-CHAMA DIVERSION WATER. MAJOR WATER USERS INCLUDE CITY OF ALBUQUERQUE & RIO GRANDE CONSERVANCY DISTRICT.

Study Area: ABIQUIU DAM IS LOCATED ON THE RIO CHAMA NEAR THE TOWN OF ABIQUIU, NM, ABOUT 32 MILES UPSTREAM FROM THE CONFLUENCE OF THE RIO CHAMA AND THE RIO GRANDE. THE RESERVOIR HAS A DRAINAGE AREA OF APPROXIMATELY 2146 SQ.MI.

Remarks: AUTHORIZED BY FLOOD CONTROL ACTS OF 1948 AND 1950. REPORTS INCLUDE ABIQUIU RESERVOIR REALLOCATION-RIO CHAMA STUDY SUMMARY & APPENDICES A,B,C, (1981) AND ABIQUIU RESERVOIR, DM NO. 19, INITIAL RESERVOIR FILLING PLAN/FLOOD EMERGENCY PLAN (OCTOBER 1983).

Status: DAM COMPLETED IN 1963. REC FACILITIES COMPLETED IN 1981. REPORTED FLOOD CONTROL BENEFITS COMPUTED FOR 1991 & CUMULATIVE BENEFITS AMOUNT TO \$230,209,100 TO DATE. B:C RATIO FROM 1960 HOUSE DOCUMENT & THE O&M IS AVERAGE ANNUAL SINCE PROJECT COMPLETION.

Time/Date Enter



Figure 3. Sample COE Report.

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any objective was to enhance the one to many relate functionality of the database retrieval operations by rewriting the SWRPIS in ARC/INFO® version 6.1.

APPROACH

We assessed the added functionality and capabilities possible in a GIS implementation of this database type, then determined the steps needed to develop and implement the GIS with its related software, datasets, data structures and data layers. Finally, we produced a definition of the development schedule and sequence. As with the project's first phase, the methodology was the same:

1. Import files from the SCS Prelude® database system into INFO usable file structures.
2. Condition the SCS data sets, as required, to be suitable for use in ARC/INFO® GIS software.
3. Acquire public domain GIS data sets for use in spatially locating the SCS study sites.
4. Link geographically the SCS data sets with the GIS data sets to allow GIS manipulation of the report data.
5. Design and implement a GIS application to allow spatial query and analysis of the SCS data.
6. Retain, wherever possible, the current functionality of the original FPI and SCS databases.

DATABASE PREPARATION

The GIS database for this task incorporated two primary data types: first, the attribute data, comprised of the study site summaries and reports residing in the SCS databases on a personal computer, and second, the spatial data, comprised of ARC/INFO® coverages available on a UNIX-based workstation. The development and implementation platform chosen for this application was ARC/INFO® GIS software running on a DEC Station 5000/200 workstation. The work-

station required that all data be suitable for this environment.

Attribute Data

The first data type, the attribute data, consisted of four data sets, the Snow/Soil Survey data set (Snow-Soil.Survey), the Watershed Project data set (Watershed.Project), the River Basin Studies data set (River Basin.Studies), and the Resource Conservation and Development Program data set (RCD.Reports). At the onset of this task, these four data sets were contained in a Prelude® database in the internal database format. These data sets were extracted from the Prelude® environment in an ASCII format using internal functions, and transmitted via Local Area Network to the workstation. Once in the workstation environment, the data was conditioned for insertion into the GIS database management system, INFO. Four data structures designed to accommodate the SCS data were then implemented in the GIS and the data were imported into these data structures through the use of ARC/INFO® utilities. This now made the SCS data accessible in a GIS environment.

The SCS maintains four databases which contain information about significant studies and projects. These studies and projects are completed under five programs. The four types of SCS reports which were built into the SWRPIS GIS application and their attribute files containing the SCS databases are described below.

1. Snow and Soil Survey Reports - The SNOW-SOIL.SURVEY file summarizes inventory and monitoring efforts of the SCS. The file contains soil survey and snow survey information. In 1896, Congress first authorized soil investigations, and in 1935 (Public Law 74-46) transferred the soil survey program to the SCS. This program inventories the nation's soil resources, records the location of soils, predicts soil performance under defined use and management, and facilitates the transfer of soil information. The program contributes to the knowledge, understanding and proper use of land resources. In 1939, the U.S. Department of Agriculture assigned the snow

survey responsibilities to the SCS under the authority of Public Law 74-46. The snow survey program collects basic hydrometeorological data and issues water supply forecasts. The basic data is available to the public and the scientific community. The forecasts are coordinated with the National Oceanic and Atmospheric Administration.

2. Small Watershed Program Reports - This program provides technical and financial assistance to communities. The assistance helps solve a broad range of water resources problems and related land-resource problems. These projects are limited to areas of 250,000 acres or less. The SCS and the local community share in the cost of installing improvements.
3. River Basin Program Reports - The second program authorized by Public Law 83-566 is the River Basin Program which provides technical assistance to local communities to solve any water resources and related land-resource problems. The program produces reports from: Floodplain Management Studies, in which detailed analyses of flood-prone areas are presented and alternate ways to reduce flood damages are developed; Cooperative River Basin Studies in which specific problems occurring over a large geographic area are defined and analyzed; and Flood Insurance Studies, which can be contracted with the Flood Insurance Administration.
4. Resource Conservation and Development Program Reports - Public Law 97-98 authorized the Resource Conservation and Development Program, which provides technical assistance to rural disadvantaged areas from the entire Department of Agriculture. New Mexico has nine authorized Resource and Conservation and Development Areas. Report summaries contained in the SWRPIS application summarize the program's measures which were installed with USDA financial assistance.

Spatial Data

The second data type, the spatial data, consisted of three ARC/INFO[®] coverages available in the public domain: USGS GNIS, the Hydrologic Unit thematic coverage, and the County Boundary coverage. Also, one converted AutoCad coverage of water planning areas with associated names, provided by the Interstate Stream Commission, was incorporated during the first phase. All mapped coverages used were available at a scale of 1:500,000 and covered the geographic extent of New Mexico. All ARC/INFO[®] coverages used were drawn from the New Mexico Resource Geographic Information System (RGIS) Clearinghouse. The SWRPIS application is built in a Lambert Conic projection in meters with the following parameters:

1st Standard Parallel 33 00 00
2nd Standard Parallel 45 00 00
Central Meridian 106 00 00
Origin of projection 30 00 00

It should be noted that both the GNIS coverage and the USGS Hydrologic Unit coverage required some modifications which are described below.

- Community Names Coverage - The USGS GNIS required some modification to accommodate the use of "unofficial" names in the original FPI data and to correct some deficiencies in the current GNIS such as locating communities not found in the GNIS.
- State Engineer Office/SCS River Basin Coverage - The eight digit USGS Hydrologic Unit coverage required some enhancements to allow aggregation of the units into the State Engineer Office's (SEO) recognized major river basins for basins officially recognized by SCS. This included hand digitizing components of basins recognized by the SEO, which were not included in the USGS line work. The aggregated hydrologic units were then used to generate a river basin coverage. It should be noted that until addressed further for issues of spatial accuracy, the SEO River Basin coverage used in this GIS application should be considered an unverified data set for use in this application only.

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- County Boundary Coverage - The County Boundary coverage was used as it was received.
- Statewide Regional Water Planning Areas Coverage - As was mentioned, the Statewide Regional Water Planning Areas coverage, was obtained from the Interstate Steam Commission in an AutoCAD® format. This coverage was converted into a DXF format using an internal AutoCAD® function and then converted into ARC/INFO® coverages using ARC/INFO® utilities. Two data layers were extracted and converted: the Planning Area boundaries and their names. Figures 4-8 contain maps of the Regional Water Planning Areas coverage, the County Boundaries coverage, the Eight Digit USGS Hydrologic Units and Codes, the COE River Basin coverage, and the SEO River Basin coverage.

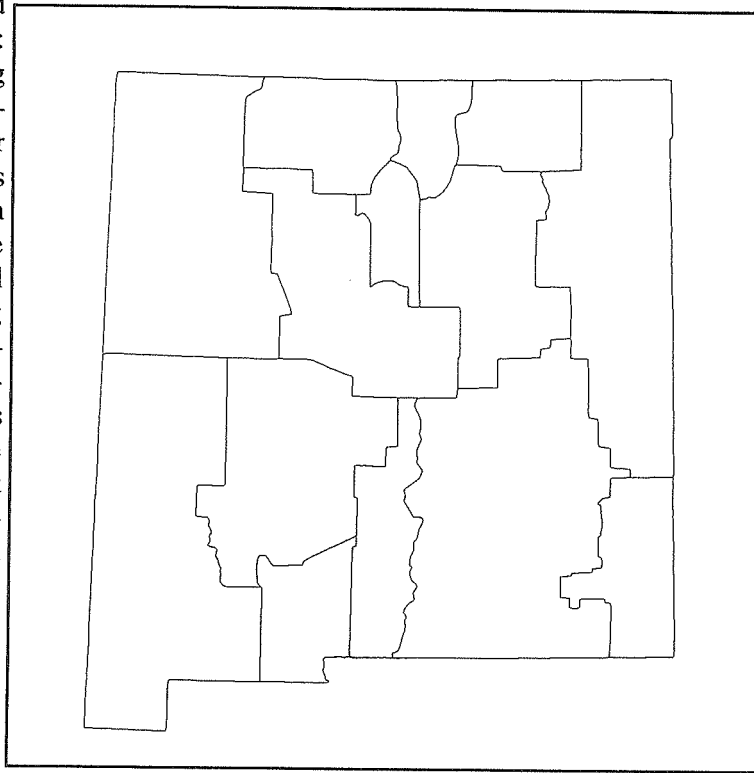


Figure 4. Regional water planning areas.

Relate Tables

The last significant data preparation task was the generation of a data table which allowed the GIS to relate the spatial data to the attribute data. These so called "relate tables" define the six SCS and six original Corps of Engineer data table relationships required for geolinking. This relate table is an original data set developed for this application (Table 1).

The attribute databases provided to NMERI by the Corps of Engineers and the SCS were

geolinked via the relate tables to the spatial data. To spatially access the COE and SCS data, a user-friendly interface was developed.

USER INTERFACE

The user interface for this application is a menu-driven combination of graphic and text windows displayed simultaneously on the user terminal. The user interacts with the menus and display windows through the use of a mouse-activated cursor. Menu selection or study-site designation is achieved by pointing and clicking

on the particular selection. To select an area for zooming, the user points and clicks on two diagonal points bounding the area of interest. User options may be used in any order or combination and for either the entire state or for any portion of the state, that is, any zoomed area. Table 2 specifies and describes user options. Tables 2-4 outline the lists of user options presently available in the SWRPIS.

CONCLUSIONS AND FUTURE POSSIBILITIES

In accordance with the stated objective, the four SCS data report files were incorporated as part of the SWRPIS GIS application. Also in the best interests of this application's utility, the FPI Application, originally written in ARC/INFO version 5.0, was rewritten in version 6.1 to take advantage of its added functionality. With this project's successful completion, it is clear that GIS is well suited to this application of access to

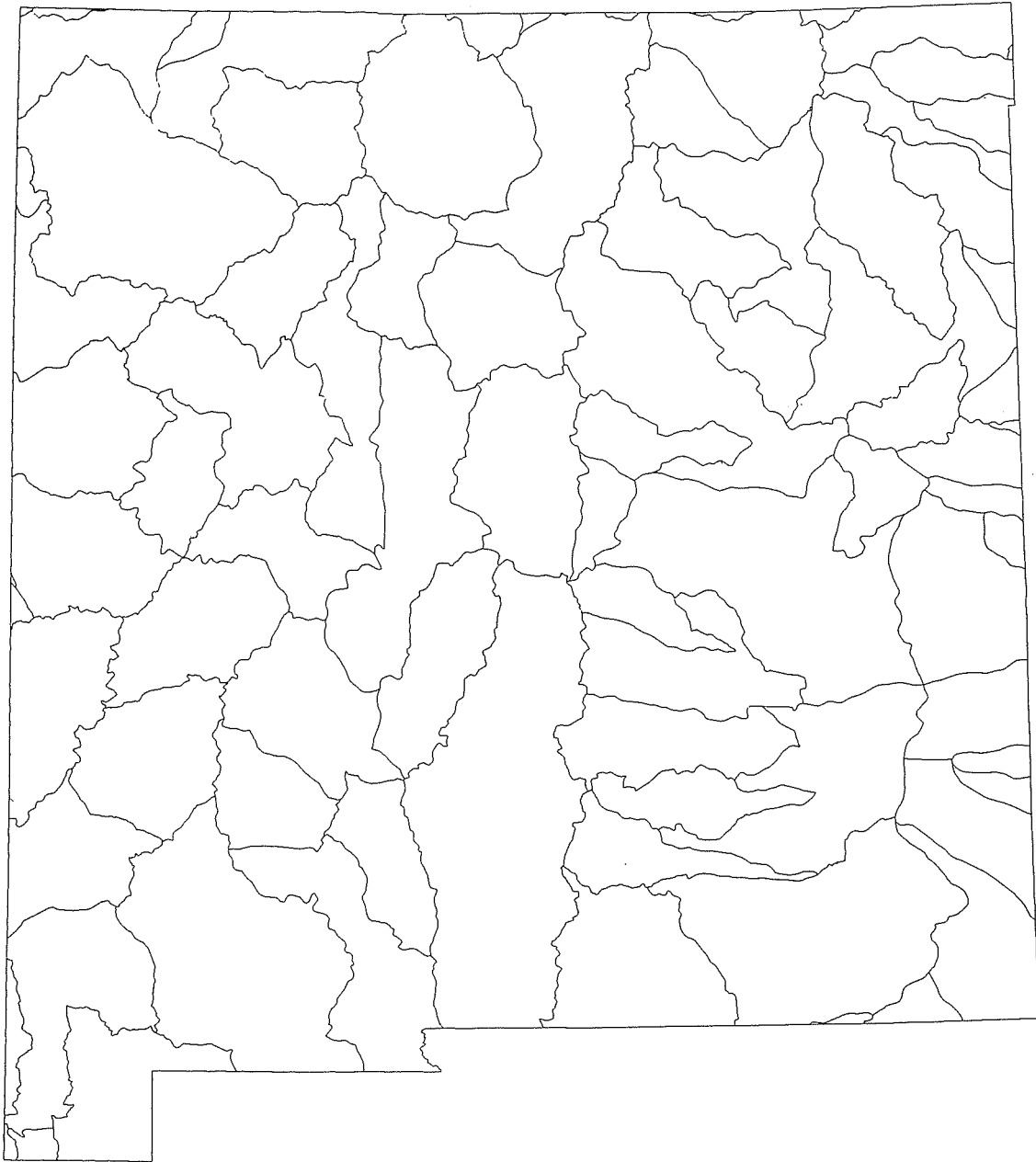


Figure 5. New Mexico state hydrologic units.

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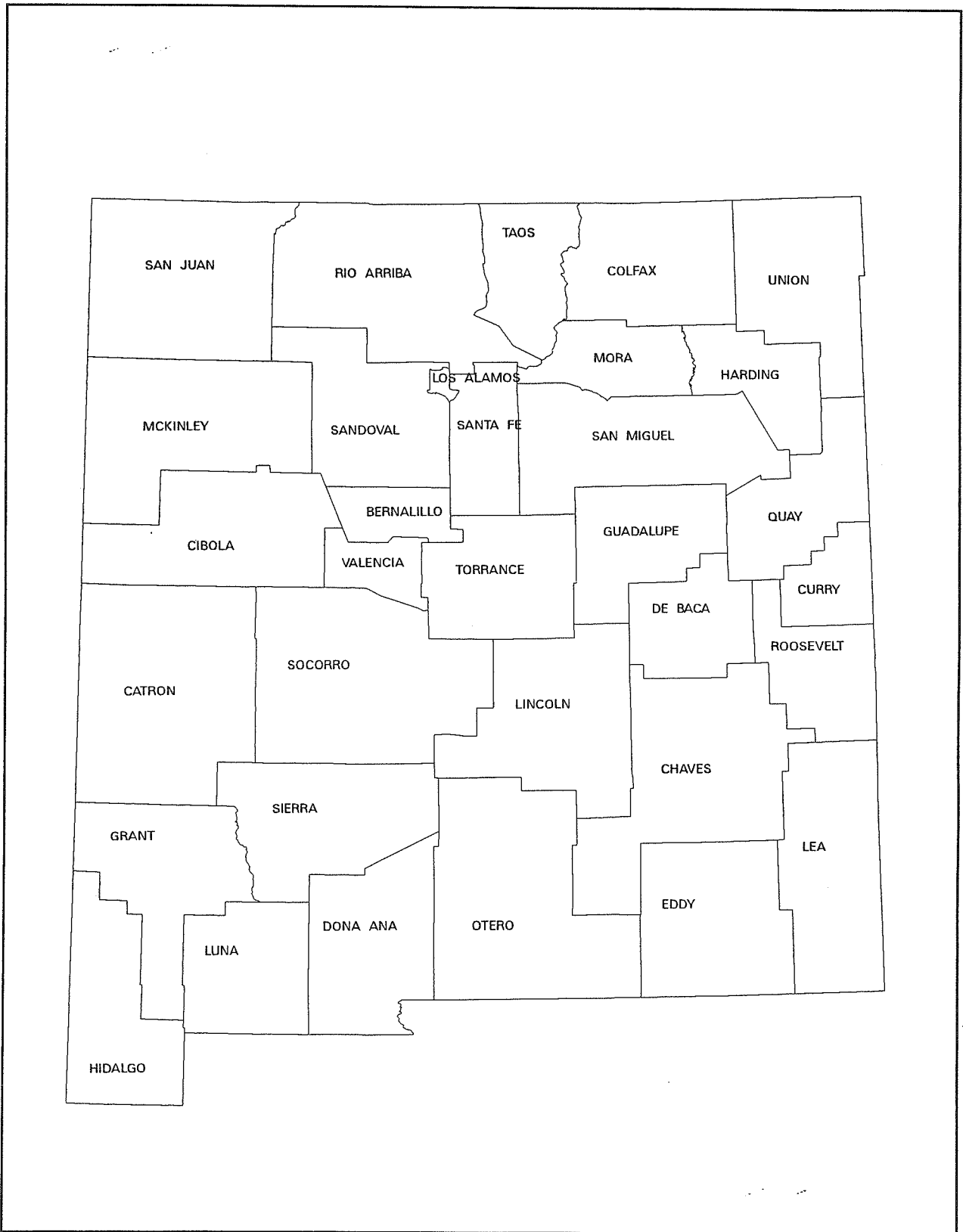


Figure 6. New Mexico counties.

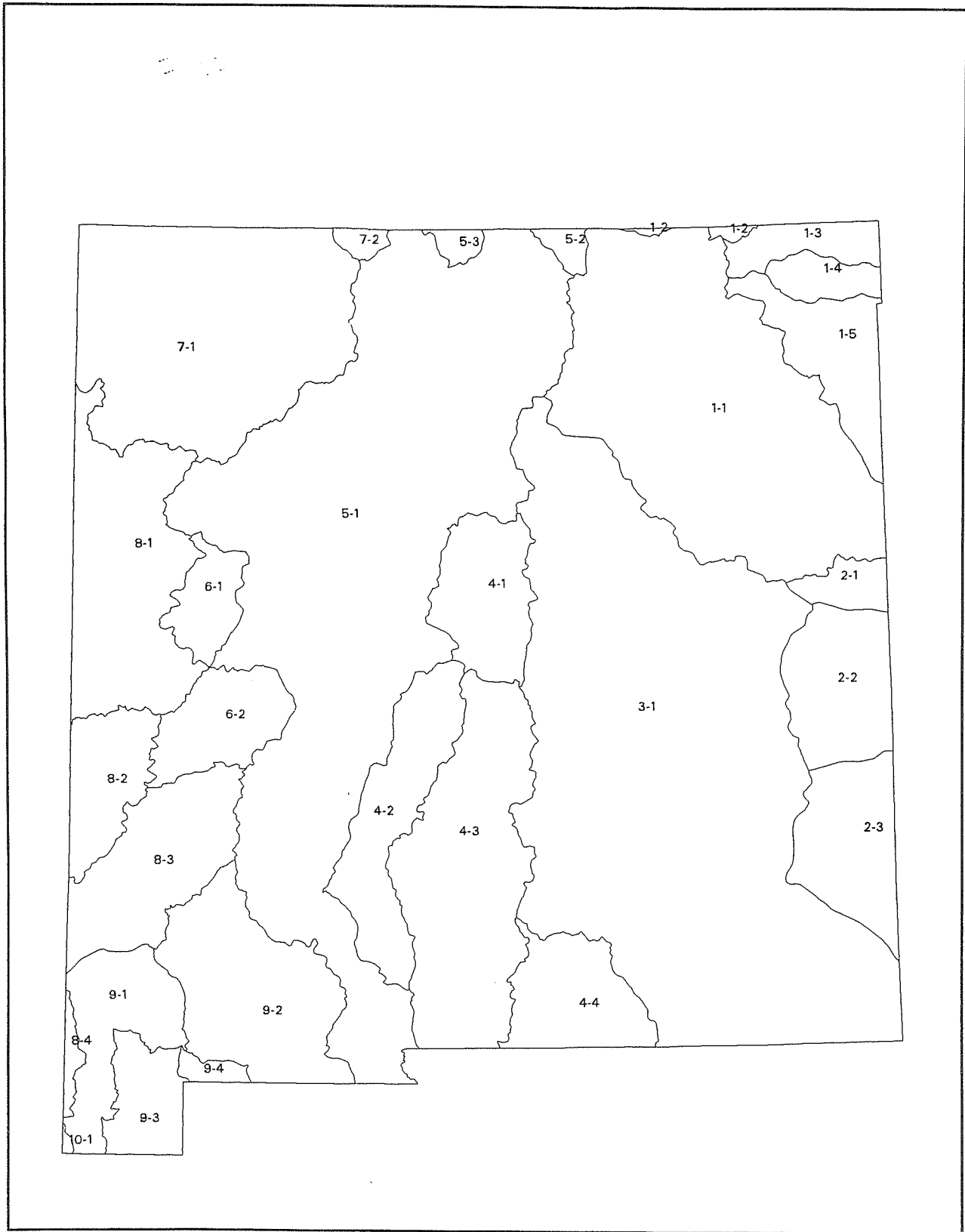


Figure 7. New Mexico State Engineer Office/SCS New Mexico river basins.

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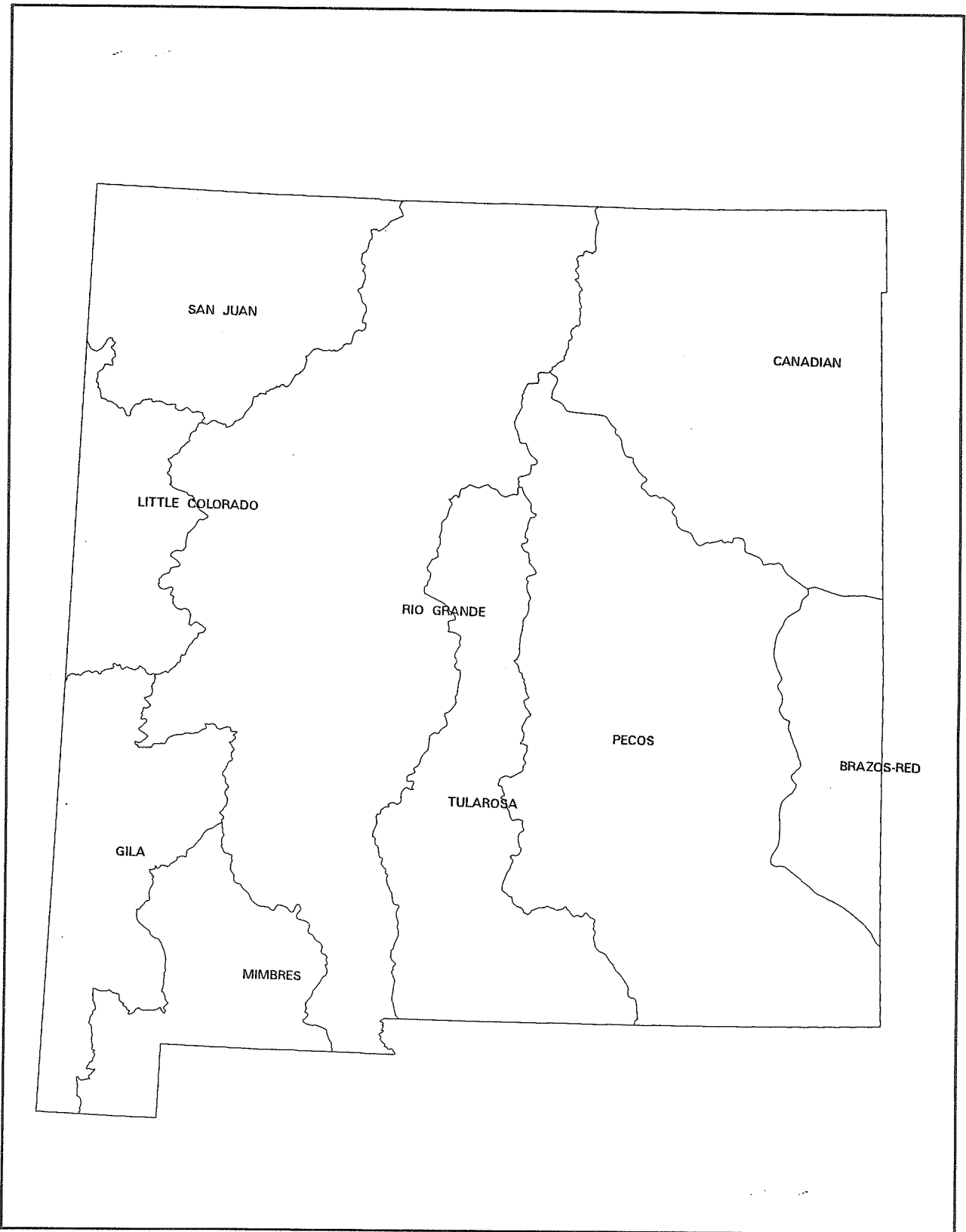


Figure 8. U.S. Army Corps of Engineers, New Mexico river basins.

TABLE 1. DATABASE RELATE TABLES

Relate Table : CEO.REL

GNIS
 COMMUNITY.SUMMARY
 INFO
 NAME
 COMMUNITY
 ORDERED
 FSWA
 FSWA.REPORTS
 INFO
 NAME
 COMMUN
 LINEAR
 SSWA
 SSWA.REPORTS
 INFO
 NAME
 COMMUN
 LINEAR
 C_FSWA
 FSWA.REPORTS
 INFO
 COUNTY_NAME
 COUNTY
 LINEAR
 C_SSWA
 SSWA.REPORTS
 INFO
 COUNTY_NAME
 COUNTY_NAME
 LINEAR
 B_SSWA
 SSWA.REPORTS
 INFO
 BASIN_NAME
 BASIN
 LINEAR

Relate Table: SCS.REL

WATERSHE
 WATERSHED.PROJECTS
 INFO
 NAME
 COMMUN
 LINEAR
 RO
 RIVBAS_A
 RIVER_BASIN.STUDIES
 INFO
 NAME
 COMMUN
 LINEAR
 RO
 RCD
 RCD.REPORTS
 INFO
 NAME
 COMMUN
 LINEAR
 RO
 RIVBAS_B
 RIVER_BASIN.STUDIES
 INFO
 BASIN_NUMBER
 BASIN_NUMBER
 LINEAR
 RO
 RIVBAS_C
 RIVER_BASIN.STUDIES
 INFO
 COUNTY_NAME
 COUNTY_NAME
 LINEAR
 RO
 SNOWSOIL
 SNOW_SOIL.SURVEY
 INFO
 COUNTY_NAME
 COUNTY_NAME
 LINEAR
 RO

bibliographic information. Databases like those found in the SWRPIS, when converted to a GIS application, hold tremendous potential uses for water resource and other natural resource managers.

1. Currently the SWRPIS is divided into two parallel yet separate query systems: Corps

of Engineers and SCS. This means that to retrieve a comprehensive picture for all reports for a level of geography (community, county, or river basin), the user must toggle the search between the two agency's databases. As the number of agencies participating in the SWRPIS increase, it is

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- likely that a user would want to acquire a comprehensive summary of reports in one search operation. To better serve a user interested in accessing all reports available for a defined geography, the SWRPIS query logic should be adjusted to facilitate comprehensive report retrieval in a single operation.
2. Expand the applications query capability to include other units of geography such as searches by regional planning districts, soil and water conservation districts, other political boundaries, such as state and congressional districts, and others.
 3. Investigate the feasibility of "snapshot" printing of reports and maps to postscript printers and plotting devices.
 4. Include additional water resource and base theme GIS layers, that is, surface hydrography, Roads, SCS 11 digit code watersheds, USGS groundwater site inventory of wells, and others, for enhanced geographic reference and visual analysis.
 5. Explore PC/Software based mechanisms and Wide Area Networks for remotely accessing the water resource information found in the SWRPIS by non-ARC/INFO[®] based users.
 6. Continue to add pertinent federal, state, and special institutes' water resource information to the SWRPIS.
 7. Breakout Real Property Infrastructure, that is, channels, dams, etc., from non-infrastructure producing studies.

REFERENCES

- Peterson J.L., T.A. Moore, and G.M. Olson, NMERI OC 92/33, *The Flood Protection Needs Inventory Geographic Information System Application*, Final Report to the US Dept. of Interior, Fish and Wildlife Service, Region 2 Water Rights Program Manager, Albuquerque, NM, May 1992.
- Corps of Engineers, Albuquerque District, *New Mexico Statewide Inventory of Flood Protection Needs*, Final Report to the Interstate Stream Commission, January, 1992.

TABLE 2. LIST OF MAIN MENU OPTIONS

<u>Menu Option</u>	<u>Description/Purpose</u>
Hydrologic Units	Draw the Hydrologic Unit Boundaries
COE River Basins	Activate the drop down menu to draw the COE River Basins
Brazos-Red	Draw the Brazos-Red river basin
Canadian	Draw the Canadian river basin
Gila	Draw the Gila river basin
Little Colorado	Draw the Little Colorado river basin
Mimbres	Draw the Mimbres river basin
Pecos	Draw the Pecos river basin
Rio Grande	Draw the Rio Grande river basin
San Juan	Draw the San Juan river basin
Tularosa	Draw the Tularosa river basin
All	Draw all river basins
Boundaries	Draw the River Basin Boundaries
Basin Names	Draw the River Basin Names
SCS River Basins	Activate the drop down menu to draw the SCS River Basins
Animas Basin	Draw the Animas river basin
Brazos River	Draw the Brazos river basin
Canadian River	Draw the Canadian river basin

TABLE 2. LIST OF MAIN MENU OPTIONS (CONTINUED)

<u>Menu Option</u>	<u>Description/Purpose</u>
SCS River Basins (cont.)	
Carrizo Creek	Draw the Carrizo creek river basin
Costilla Creek	Draw the Costilla creek river basin
Dry Cimarron River	Draw the Dry Cimarron river basin
Estancia Basin	Draw the Estancia river basin
Gila River	Draw the Gila river basin
Jornado del Muerto	Draw the Jornada del Muerto river basin
Lea Plateau	Draw the Lea Plateau river basin
Little Colorado	Draw the Little Colorado river basin
Mimbres Basin	Draw the Mimbres river basin
Navajo River	Draw the Navajo river basin
North Canadian River	Draw the North Canadian river basin
North Plains	Draw the North Plains river basin
Pecos River	Draw the Pecos river basin
Playas Basin	Draw the Playas river basin
Purgatoire River	Draw the Purgatoire river basin
Red River	Draw the Red river basin
Rio Grande	Draw the Rio Grande river basin
Rio San Antonio	Draw the Rio San Antonio river basin
Rio Yaqui	Draw the Rio Yaqui river basin
Salt Basin	Draw the Salt Basin river basin
San Augustine Plains	Draw the San Augustine Plains river basin
San Francisco River	Draw the San Francisco river basin
San Juan River	Draw the San Juan river basin
San Simon Creek	Draw the San Simon Creek river basin
Tularosa Basin	Draw the Tularosa river basin
Wamel Basin	Draw the Wamel river basin
All	Draw all river basins
Boundaries	Draw the River Basin Boundaries
Basin Names	Draw the River Basin names
Counties	Activate the drop down menu to draw the Counties
Borders	Draw the county borders
Names	Draw the county names
Water Planning Areas	Activate the drop down menu to draw the Water Planning Areas
Borders	Draw the Water Planning Area borders
Names	Draw the Water Planning Area names
COE Study Sites	Activate the menu to query and display the COE Reports
SCS Study Sites	Activate the menu to query and display the SCS Reports
Tools	Activate the Tools drop down menu
Zoom	Zoom the display
Reset	Reset the display to the statewide coverage
Clear	Clear the display
Quit	Quit the application

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TABLE 3. COE QUERY AND DISPLAY MENU OPTIONS

<u>Menu Option</u>	<u>Description/Purpose</u>
Communities	
COE Studies Only	Display the COE Community Study Sites
FEMA Studies Only	Display the FEMA Community Study Sites
Both Studies	Display Both Study Sites
All Study Sites	Display All Study Sites
Summary	Query/Display the Report
Counties	
COE Studies Only	Display the COE County Study Sites
FEMA Studies Only	Display the FEMA County Study Sites
All Study Sites	Display all County Study Sites
Report	Query/Display the Report
River Basins	
Study Sites	Display the River Basin River Sites
Report	Query/Display the Report
Tools	
Zoom	
Reset	
Clear	
County Borders	
County Names	
COE Basin Boundaries	
COE Basin Names	
SCS Basin Boundaries	
SCS Basin Names	
Water Planning Area Borders	
Water Planning Area Names	
Return	

TABLE 4. SCS QUERY AND DISPLAY MENU OPTIONS

<u>Menu Option</u>	<u>Description/Purpose</u>
Communities	
Watershed Projects	Display the SCS Watershed Community Study Sites
River Basin Studies	Display the SCS River Basin Community Study Sites
RCD Reports	Display the SCS RCD Report Community Study Sites
Summary	Query/Display the Report
Counties	
River Basin Studies	Display the SCS River Basin County Study Sites
Snow/Soil Survey	Display the SCS Snow/Soil Survey County Study Sites
Summary	Query/Display the Report
River Basins	
Study Sites	Display the River Basin Study Sites
Report	Query/Display the Report
Tools	
Zoom	
Reset	
Clear	
County Borders	
County Names	
COE Basin Boundaries	
COE Basin Names	
SCS Basin Boundaries	
SCS Basin Names	
Water Planning Area Borders	
Water Planning Area Names	
Return	