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Updating the web-based geographic information system of the Water Resources Institute

Prava Tiwari

UPDATING THE WEB-BASED GEOGRAPHIC INFORMATION SYSTEM OF THE WATER RESOURCES INSTITUTE

A Project

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

in

Computer Science

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5/30/2008

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Dr. Ernesto Gomez

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ABSTRACT

A Geographic Information System (GIS) is a system for creating and managing spatial data and their associated attributes. ArcGIS system (GIS products of ESRI such as ArcMap, ArcCatalog and ArcGIS Server) is used to create map resources and share them with the public by using a GIS server and web server. In this project, applications are developed using the ArcGIS system to share historical information on aerial photos of Santa Ana watershed, well records of San Bernardino county, availability of USGS quad sheets and other documents related to Santa Ana watershed at the Water Resources Institute. A large number of users who do not possess technical GIS knowledge can today use these services over the network to get spatial and non spatial information of the Santa Ana watershed. This project enhances the efficiency of the existing web based archives of the Water Resources Institute by implementing the latest GIS technology. The Internet based map search applications from older versions of ArcGIS server are migrated to the latest version of ArcGIS server 9.2. Also a template is created to give a consistent user interface to all existing applications.

ACKNOWLEDGEMENTS

My deepest gratitude goes to my advisor Dr. David Turner who encouraged me and guided me to the completion of this project. I would like to thank Dr. Ernesto Gomez and Dr. Richard Botting for being my committee member and for guiding me in the project.

I would also like to thank Water Resources Institute at California State University for giving me access to ESRI software's and all the necessary material required for the project. I appreciate the help and valuable feedback provided by Lisa Pierce, GIS Analyst at Water Resources Institute (WRI). I am highly indebted to Vorapong (Patrick) Chinpanich, Equipment Systems Specialist at California State University, San Bernardino for providing me the technical support.

I would like to express my sincere gratitude to my husband and my family who supported me and encouraged me during my study at California State University, San Bernardino.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

The Water Resources Institute at California State University San Bernardino (CSUSB) was established in 1999 with a mission to share the latest watershed related information with academics, students, political leaders, public policy makers, water professionals, business and environmental groups [8]. The Water Resources Institute (WRI) archives consist of digital data, literature, journals, geospatial data and digital books of the Santa Ana River watershed and Colorado River. This project is designed to give a consistent user interface and add extra tools to enhance the functionality of existing applications at the WRI. Additionally, all application will be rewritten to run under the most recent versions of the ESRI GIS products.

1.2 Purpose of the Project

Existing web applications such as Rowe Aerial Photographs, San Bernardino Well Records, USGS Quad Sheets, Yucaipa and Riverside Imagery and Document Search are

running on various servers of the WRI using different types of GIS software and different versions of the same software. Applications running on older versions of GIS do not run on new version of GIS software because ESRI did not provide backward compatibility while producing their recent versions of software. The main purpose of this project is to migrate all applications to a single server (139.182.28.33) and update the applications by using ArcGIS Server 9.2. Also to give a consistent look to the applications and to make them user friendly, the following tasks were performed on WRI digital archival system:

- Rebuild the production server and migrate all web applications to it.
- Add functionality to the existing web applications to better serve client needs.
- Re-engineer all Web applications so they have a consistent architecture and a consistent user interface.
- Migrate GIS-based web applications: Row Aerial Photos Application, San Bernardino Well Records Application, USGS Quad Sheet Application, Yucaipa

and Riverside Imagery Application and Document Search Application to ArcGIS 9.2.

- Improve documentation.

1.3 Scope of the Project

The main scope of this project is to rebuild and deploy web applications that will help share historical artifacts related to the Santa Ana watershed. The task of rebuilding the web applications can be divided into four phases: upgrading the operating system and all necessary subsystems, creating a basic web page template, modifying existing applications to use the template web page, and finally, adding project specific functionalities to each application.

The first phase will require building a new server by installing the latest version of the necessary software such as Windows Server 2003, Visual Studio 2005, ArcGIS Desktop and ArcGIS Server 9.2. In the second phase, a web mapping application template will be created such that it can be used as a base application to develop all other web applications. In the third phase, the base template application will be reused to create all web applications

such that they will have a consistent user interface for common functionalities. In the final phase, additional features will be added to each web application for application specific functionalities.

1.4 Significance of the Project

This project will increase the reliability, maintainability and usability of the WRI GIS web applications. It will give a consistent user interface and add extra functionality to the web archives, thus making the user interfaces simpler and easier to use. Currently users are able to access GIS data on their web browsers through internet. However, the user interfaces of existing applications are not consistent and it takes a long time to load heavy graphics. Applications running on older servers with older versions of GIS software will be migrated to a new machine installed with ArcGIS Server 9.2.

1.5 Project Status and Recommendations

Interactive web based applications of Water Resources Institute that assisted in sharing of information related to Santa Ana watershed area and Colorado River were successfully migrated from older servers to the new

production server. The new production server now has five applications: Rowe Aerial Photos Application, San Bernardino Well Records Application, USGS Quad Sheets Application, Yucaipa and Riverside Imagery Application and Document Search Applications. These applications are running with the latest technology and contain additional tools and simpler user interface. URL addresses for the applications are as follows:

- Rowe Aerial Photos Application.
  http://wrigis.csusb.edu/AerialphotosProject/Default.aspx
- San Bernardino Well Records Application.
  http://wrigis.csusb.edu/wellrecordsProject/Default.aspx
- USGS Quad Sheets Application.
  http://wrigis.csusb.edu/USGSQuadProject/Default.aspx
- Yucaipa and Riverside Imagery Application.
  http://wrigis.csusb.edu/SBYucaipaImagery/Default.aspx
- Document Search Application

http://wrigis.csusb.edu/DocSearchProject/Default.asp

x

CHAPTER TWO

PROJECT DESCRIPTION

The archives of the Water Resources Institute(WRI) has books, newspaper articles, technical journals, government documents, engineering and planning reports, well records, maps and aerial photos related to the Santa Ana River watershed and Colorado River. The WRI archives also include research documents and newspaper articles on important local, regional, state and national water issues. The interactive map based applications are developed to help users perform geographic searches for historical records related to the Santa Ana watershed and Colorado River that are stored in the WRI archives.

The WRI archive search applications have a number of generic GIS tools and specialized query tools. The generic tools provide a consistent interface to all applications. Zoom In, Zoom Out, Zoom to Full Extent, Pan and Identify are the generic map navigation tools, and Query is the specialized tool used to extract information specific to the application. Given below is a brief description of the generic tools and their functions:

- Zoom In

  This tool is used to display the map at a lower scale. The user clicks on the *Zoom In* tool and drags a box in the map control. As a result, the map is redrawn at a lower scale for the given geographic location.

- Zoom Out

  This tool is used to display the map at a higher scale. The user clicks on the *Zoom Out* tool and drags a box in the map control. As a result, the map is redrawn at a higher scale for the given geographic location.

- Zoom Full Extent

  This tool is used to view the full extent of the map. When the user clicks on the *Zoom to Full Extent* button, the map is redrawn to the full geographic extent of the underlying data set.

- Pan

  This tool is used to shift the geographic location of the map in vertical and/or horizontal directions. The user clicks on the Pan tool and drags the map to

any direction. When the mouse is released, the map is redrawn for the new geographic location.

- Identify Features

  This tool is used to query and display attributes of the features selected by the user. The user clicks on the Identify tool, selects the active layer to be identified and clicks on a feature in the map. As a result, attributes of the selected feature are displayed in the result panel.

- Overview Map

  The overview map also known as the inset map is used to display the location of the current extent of the map in the context of a larger geographic location. The overview map generally has fewer layers in order to function as a reference map rather than a full detailed map.

- Map Layers

  A map document is a collection of map elements (map frame with map layers, descriptive text, symbol legend, north arrow, scale bar) laid out and organized on a page. A map document is used to display the geographic information and is saved with

a .mxd extension in ArcMap, which is a map composition tool. Geographic entities such as rivers, roads, political boundaries and watershed areas are presented as series of map layers in a map document. The window showing the series of map layers is also known as Table of Contents. The users can turn on/off the map layers to control the visibility of layers in the map.

- Help Page

  The help page consists of detailed information about the tools used in the web page. The user opens this page by clicking on the *Help* link in the web page.

Query button is a specialized tool used to search data specific to the web application. For instance, it can be used to query the WRI archives for a collection of aerial photos in the Rowe Aerial Photos application.

2.1 Rowe Aerial Photos Application

The Rowe Aerial Photos is a mapping web application to display aerial photos categorized by watersheds. The watershed photos are a part of the WRI Rowe collection and produced by Fairchild Aerial Surveys, Inc. Photographs in

the collection are mainly black and white and dated back to 1927-1965 [8].

The Rowe Aerial Photos application contains the generic map navigation tools as well as the specialized query tool. The navigation tools include Zoom In, Zoom Out, Pan and Zoom Full Extent tools. Query and Identify tools are used to query and display information related to the features in the map. The figures listed below show the use of generic tools in the Rowe Aerial Photos application. Figure 1 shows an example of the zoom in operation. The user clicks on Zoom In tool, drags a box to define the area in map window. The map is then zoomed in to the geographic location defined by the user. Figure 2 shows the result of zoom in.

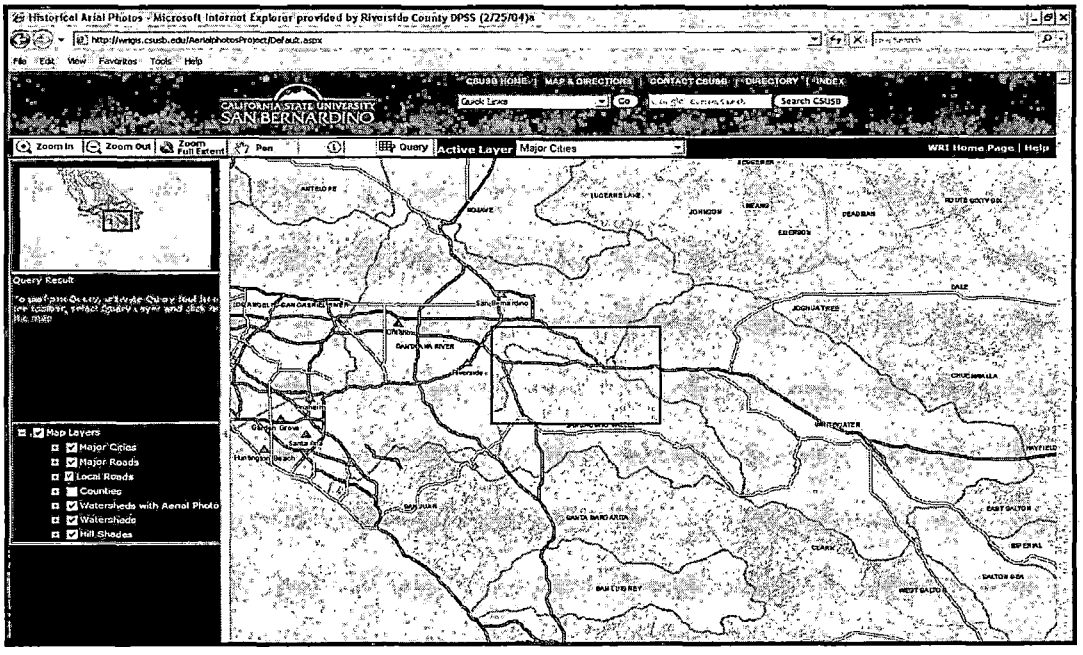


Figure 1. Example Selection Box for Zoom In Operation

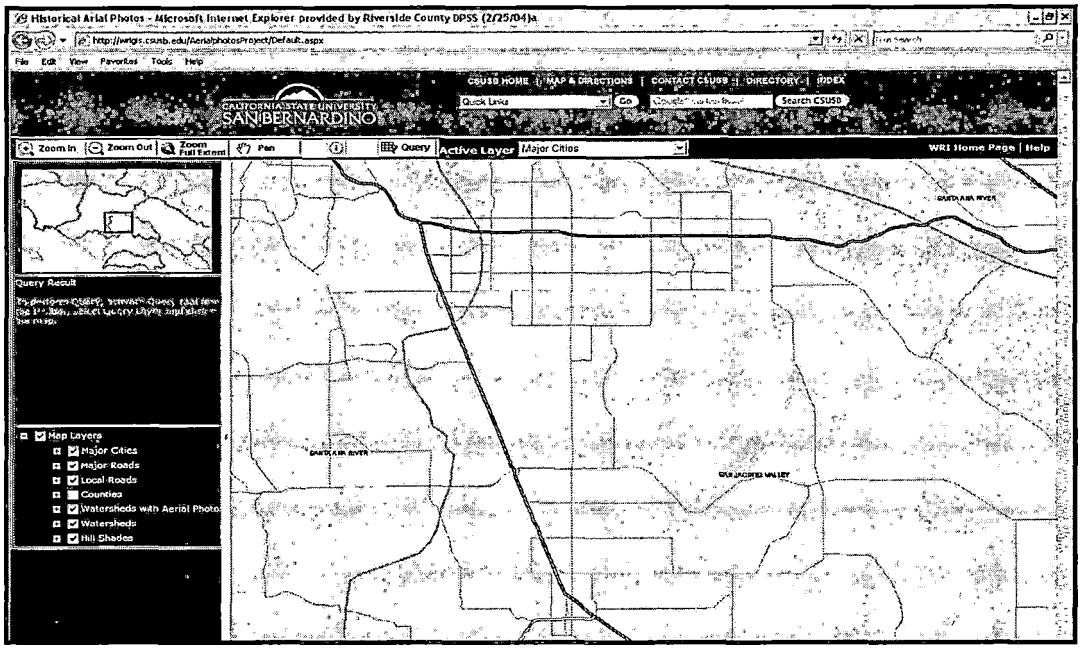


Figure 2. Example Result of Zoom In Operation

Figure 3 shows an example of the zoom out operation. The user clicks the *Zoom Out* tool and drags a box to define the area in map window. The map is then zoomed out to the geographic location defined by the user. Figure 4 shows the result of zoom out.

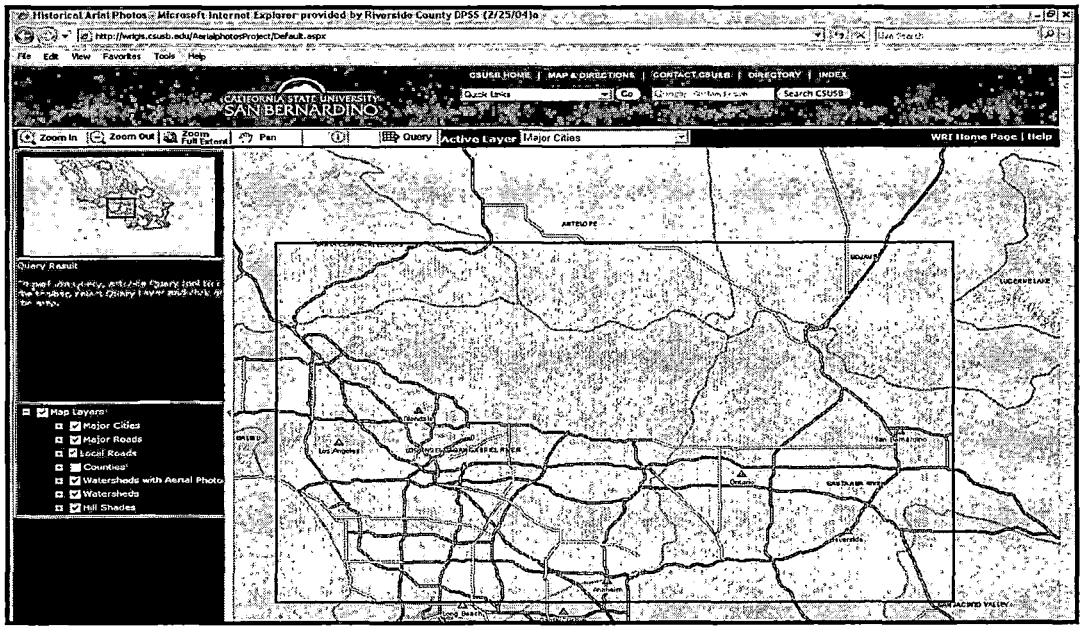


Figure 3. Example Selection Box for Zoom Out Operation

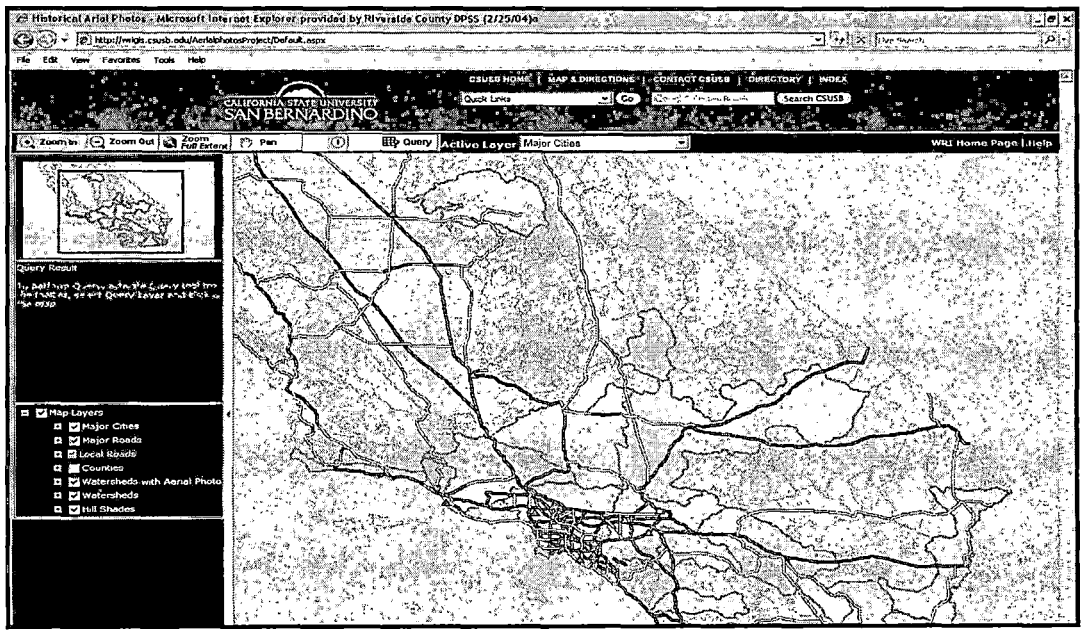


Figure 4. Example Result of Zoom Out Operation

Figure 5 shows the result of *Zoom to Full Extent operation*. The user clicks on the *Zoom to Full Extent* tool to view the full extent of the map (The largest viewable map area).

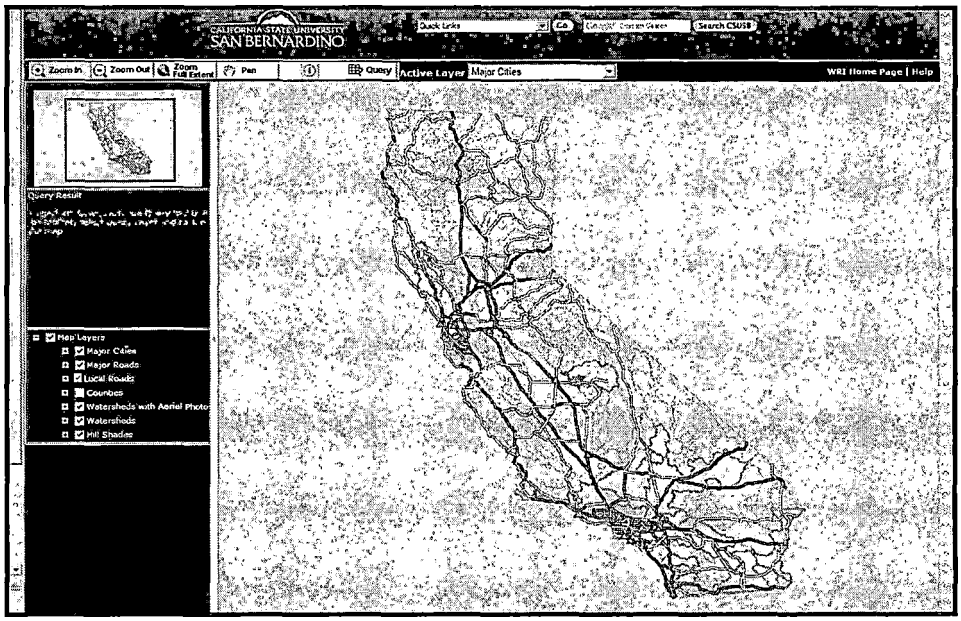


Figure 5. Example Zoom to Full Extent Operation.

Figure 6 shows an example of the pan operation. The user clicks the Pan tool and drags the map in any direction. The map is redrawn for the new geographic extent. Figure 7 shows the result of pan operation.

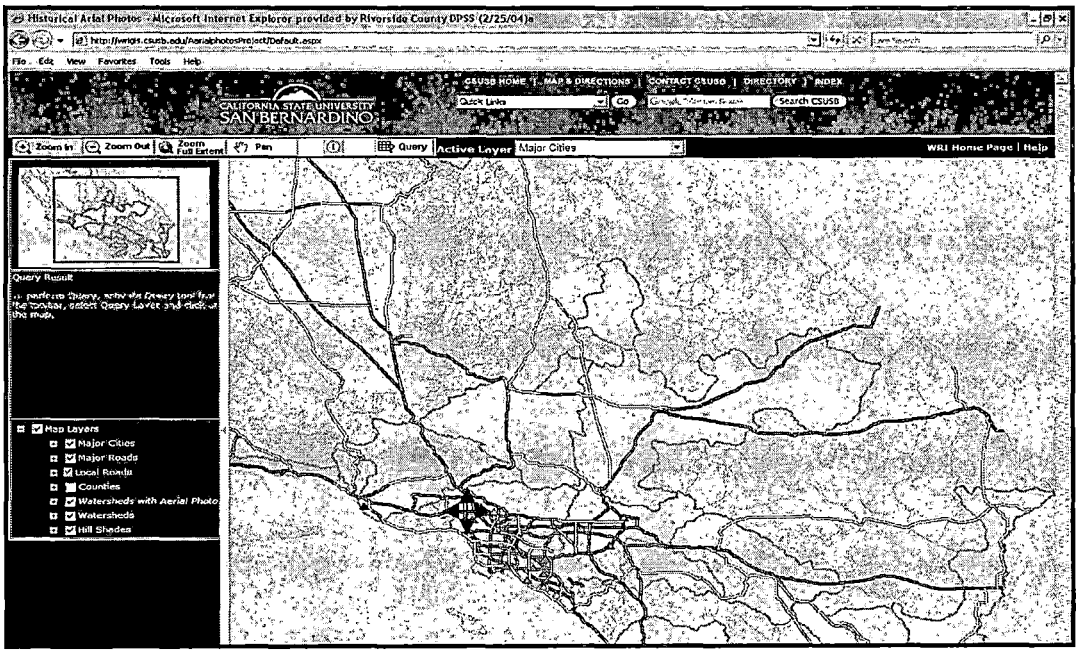


Figure 6. Example Use of Pan Operation

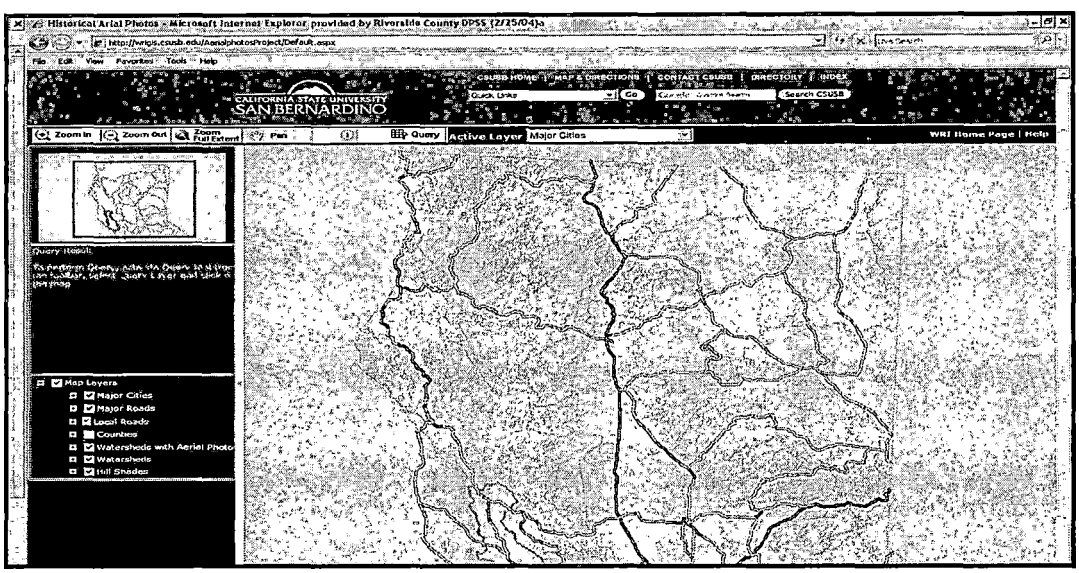


Figure 7. Example Result of Pan Operation

The map data of Rowe Aerial Photos application consists of seven layers: major cities, major roads, local roads, counties, watershed with aerial photos, and watershed and hill shade image of California (Figure 8). The hill shade layer is derived from satellite images of California.

Figure 9 shows the result of identify operation. The user clicks on the identify tool, selects an active layer and clicks on the selected feature on the map. The attributes of the selected features are displayed in the result panel.

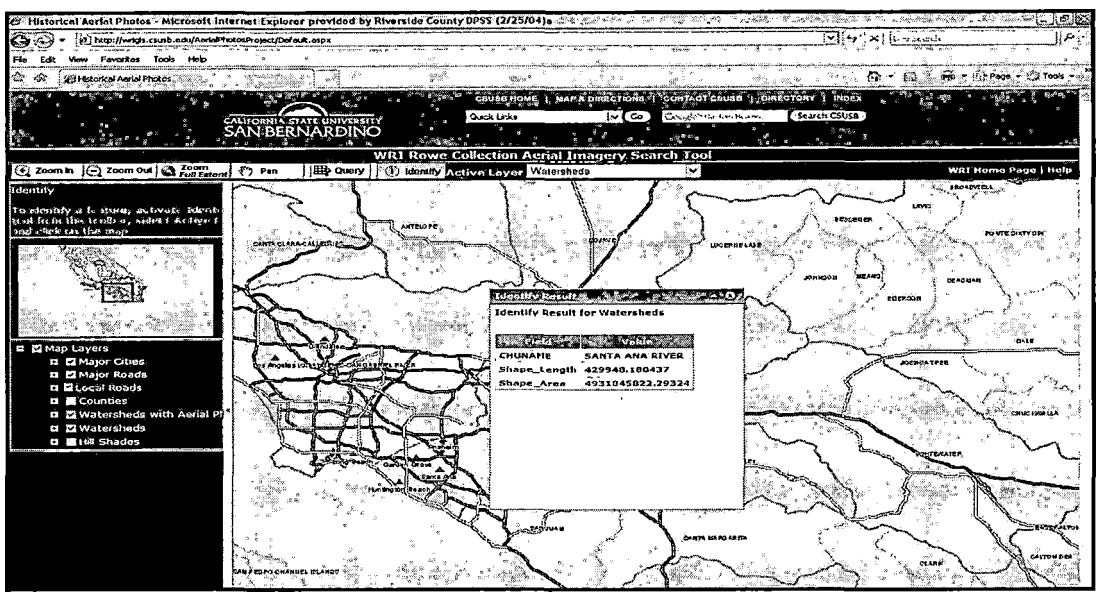
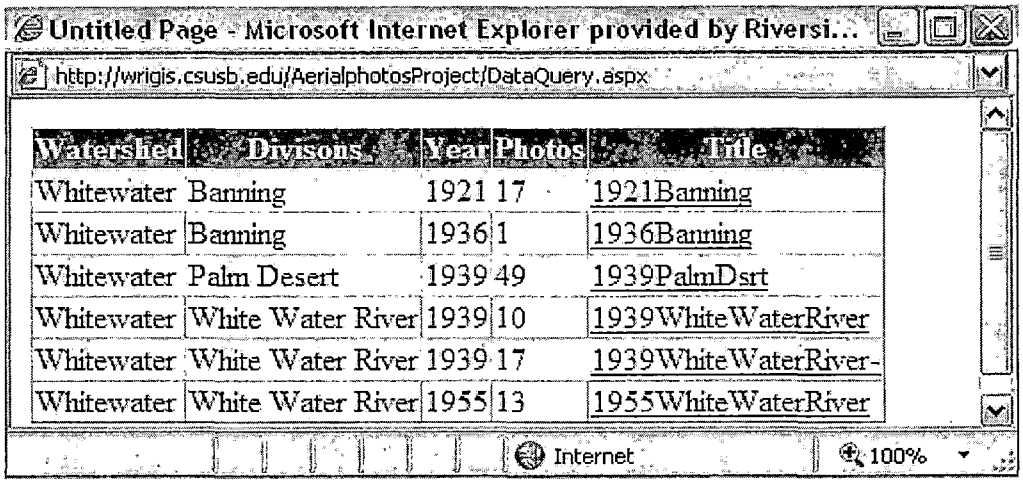


Figure 8. Example Result of Identify Operation

The Query button is the specialized tool used in the Row Aerial Photos application. It is used to view the collection of aerial photos from the Santa Ana watershed area. The user clicks on *Query* tool to make it active and then clicks on the interested watershed area in the map. The result of the query operation is then displayed in the pop up window. The user can click a link in the Title column to see the collection of aerial photos for the selected watershed (Figure 9). The user can click on one of the pictures (Figure 10) to view its larger image (Figure 11).



Watershed	Divisons	Year	Photos	Title
Whitewater	Banning	1921	17	1921Banning
Whitewater	Banning	1936	1	1936Banning
Whitewater	Palm Desert	1939	49	1939PalmDsrt
Whitewater	White Water River	1939	10	1939WhiteWaterRiver
Whitewater	White Water River	1939	17	1939WhiteWaterRiver-
Whitewater	White Water River	1955	13	1955WhiteWaterRiver

Figure 9. Example Result of Query Operation

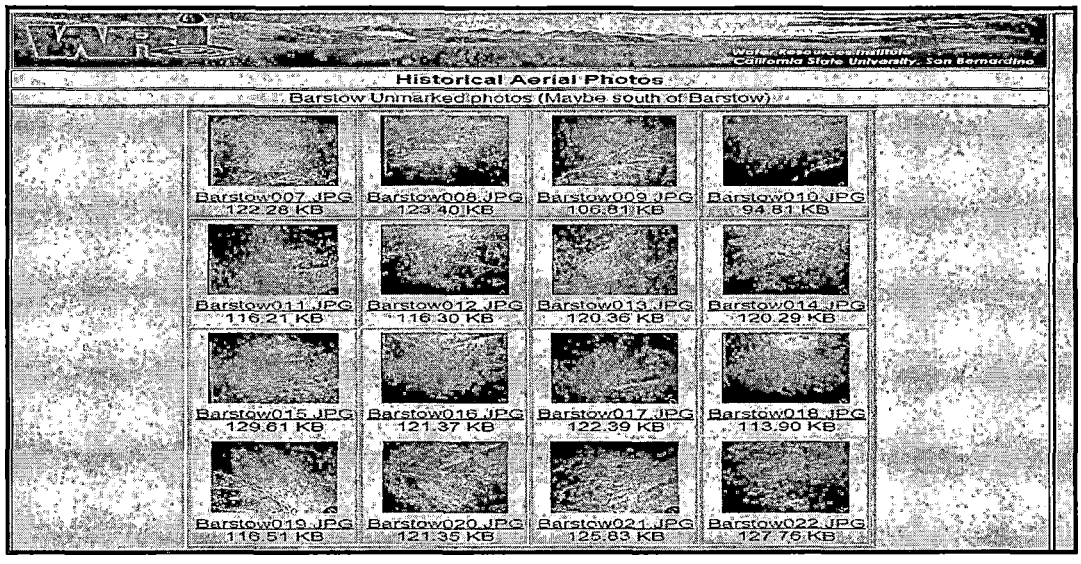


Figure 10. Example Collection of Rowe Aerial Photos

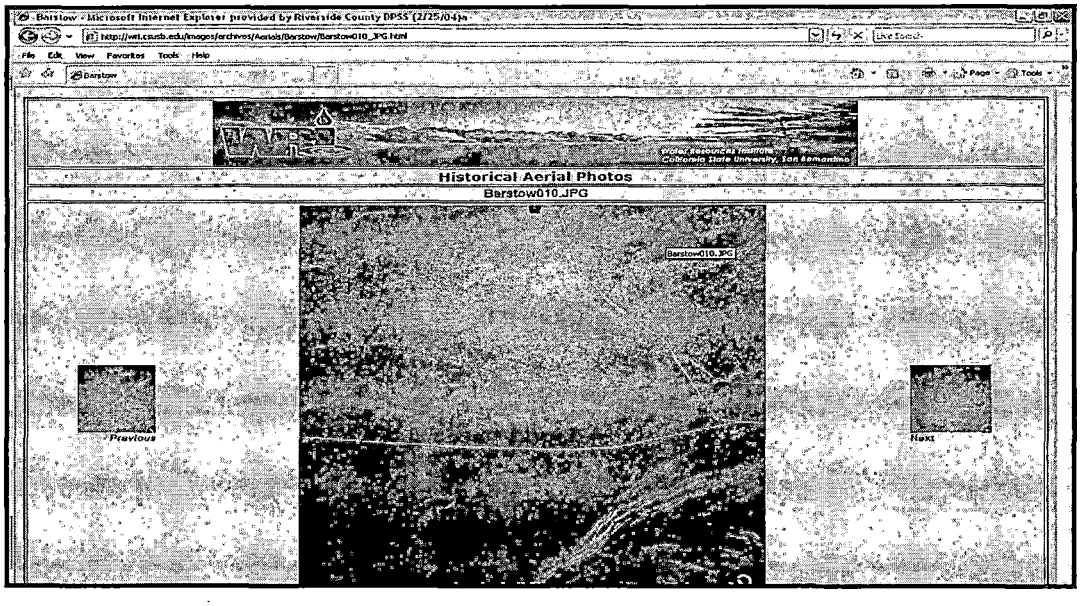


Figure 11. Example Detailed View of Aerial Photo

The help page for the Rowe Aerial Photos application consists of the detailed information on GIS tools used in the web application. It describes how to use the navigation tools and query tool to view geographic and non-geographic data of the Santa Ana watershed and Colorado River (Figure 12).

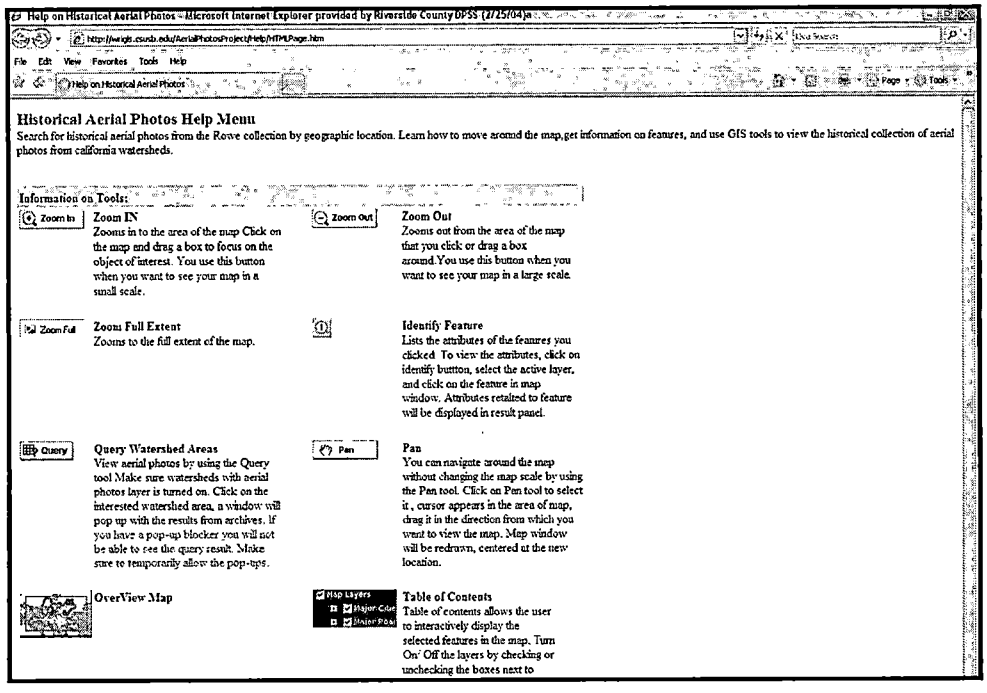


Figure 12. Example Help Menu

2.2 San Bernardino Well Records Application

The San Bernardino Well Records application displays information related to the historical well records of San Bernardino city. Historical records of well data dated between 1901 and 1969 are organized based on township, range and section. A section is a small unit of geographic area.

San Bernardino Well Records application consists of nine layers: highways, local roads, watershed, township and ranges, sections, cities, private water agencies, SAWPA water agencies and hill shade image of Santa Ana Watershed area (Figure 13).

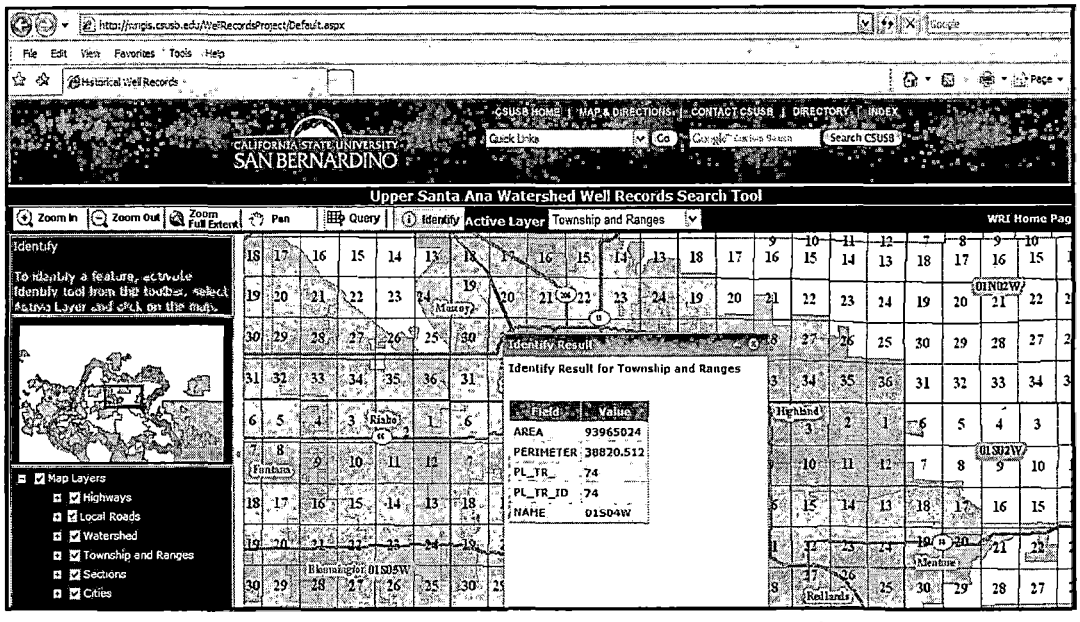


Figure 13. Example Result of Identify Operation

San Bernardino Well Records application consists of generic GIS tools (Zoom In, Zoom Out, Zoom Full Extent and Pan) and a specialized Query tool. The generic tools have the same functionalities as in the Rowe Aerial Photos application. The Query tool in the San Bernardino Well Records application is used to view historical well records of San Bernardino Area and surrounding cities. The Query result is based on the section, range and township values. To use this tool, the user turns on the sections layer, clicks on Query tool to make it active and clicks on the selected sections in the map. As a result, query result for the selected sections and state well numbers associated with those sections will appear in the result window (Figure 14). The user clicks on the link to see a list of well records (Figure 15). The user can clicks on one of the items in the list to view the historical well records for a given location (Figure 16).

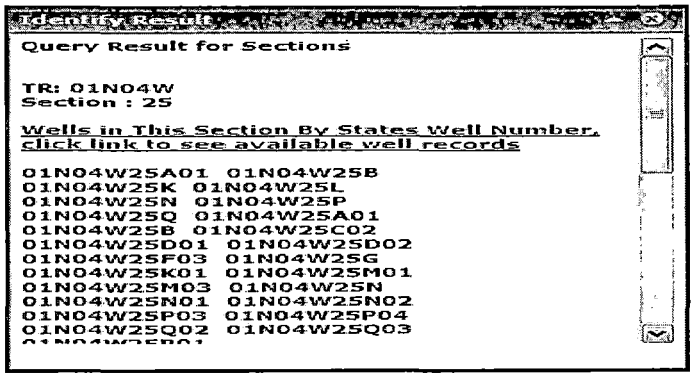


Figure 14. Example Result of Query Operation

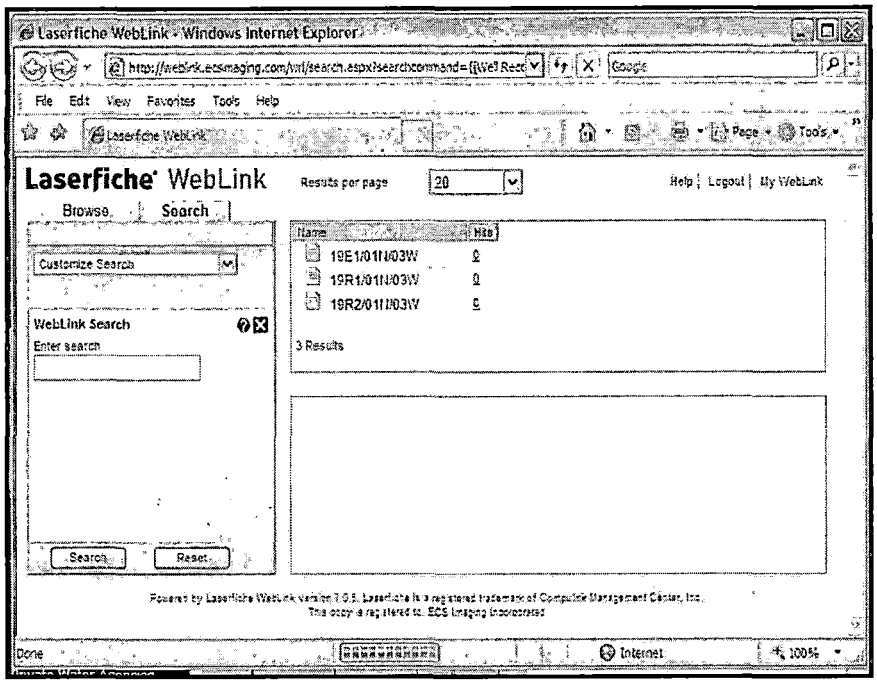


Figure 15. Example List of Well Records

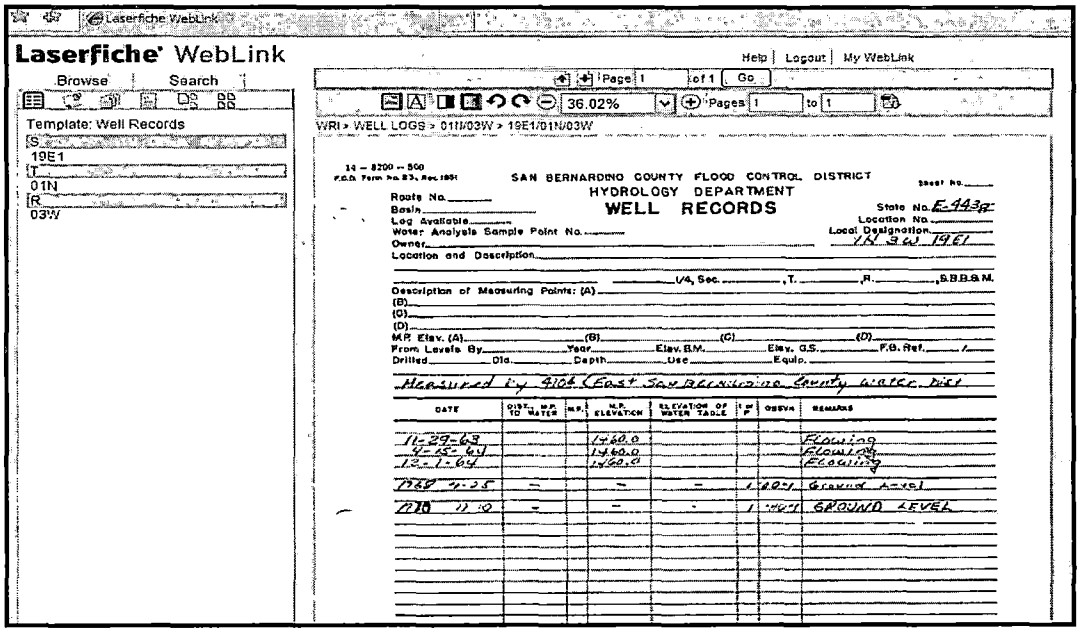


Figure 16. Example Historical Well Record

2.3 United States Geographical Survey Quad Sheets Application

The USGS Quad Sheets application has generic GIS tools (Zoom In, Zoom Out, Zoom Full Extent, and Pan) and a specialized Identify tool. The generic tools work just like previous applications. The Identify tool is used to query about the availability of USGS quad sheets at the Water Resources Institute.

This application consists of ten layers : regional highways, hydrological sub area, hydrological area name, lakes, reservoirs, cities, Santa Ana watershed boundary,

USGS 10 Meter DEM, USGS Quad sheets 7.5 minute and USGS Quad Sheets 15 minute (Figure 17). The attribute table of USGS 10 Meter DEM, USGS Quad Sheets 7.5 minute and USGS QUAD Sheets 15 minute has information on the year and the number of quad sheets available for that year in a particular geographic area. To use the identify tool to query USGS Quad sheets, the user selects the Identify tool, turns on one of the USGS Quad sheet layers, selects that layer as the active layer and click on particular features in the map. The result window shows the years and the number of quad sheets available for those years for the selected features (Figure 18).

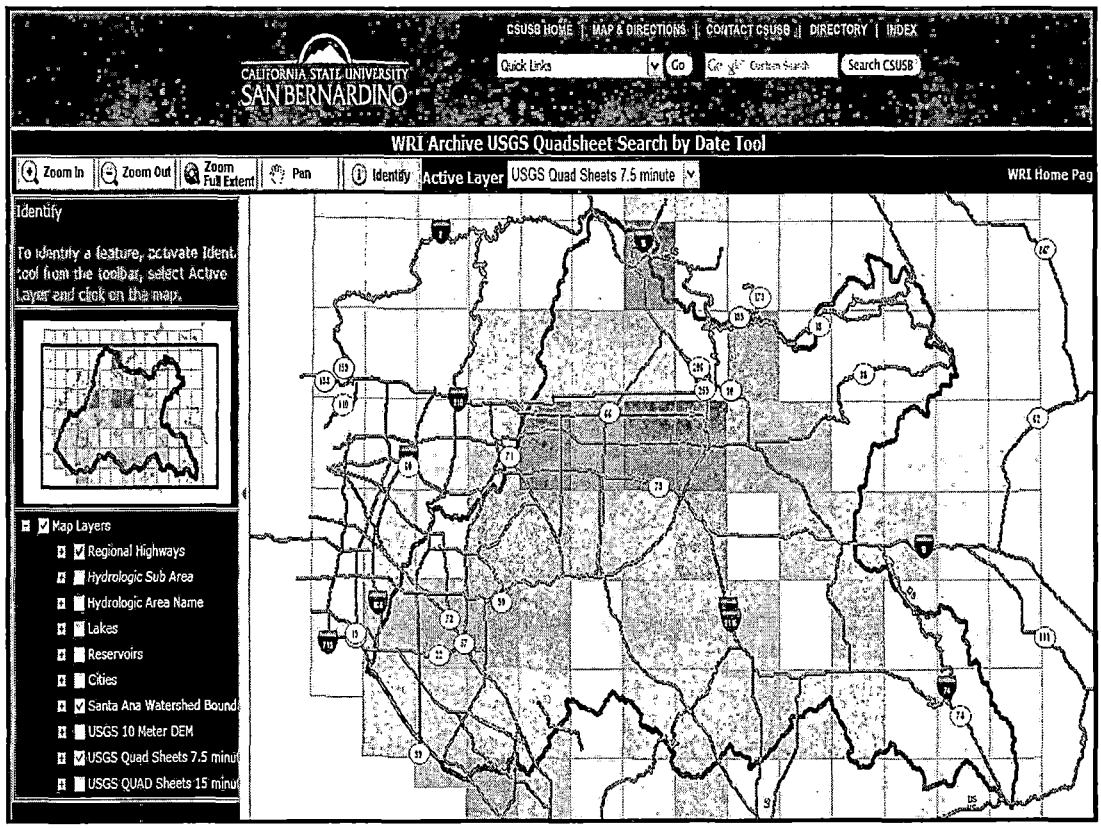


Figure 17. Example Identify Operation

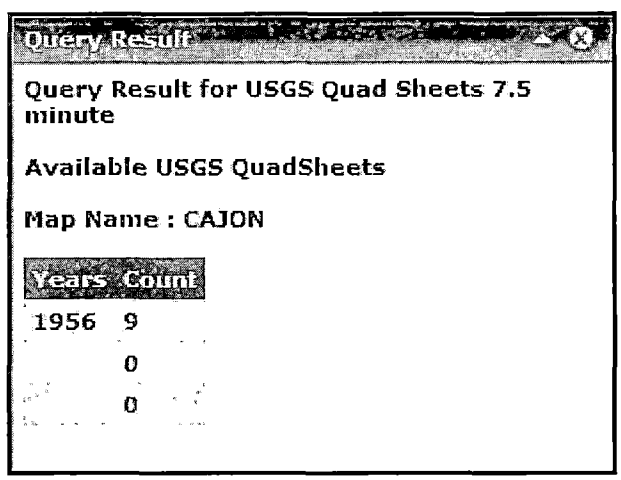


Figure 18. Example Result of Identify Operation

2.4 Yucaipa and Riverside Imagery Application

The Yucaipa and Riverside Imagery application displays the aerial photos of the Riverside and Yucaipa areas. This application uses the geo-referenced aerial photos from the Rowe collection for the year 1967. The map data of the Yucaipa and Riverside Imagery application consists of six layers: local roads, study areas, interstate highways, aerial photos and counties (Figure 19).

This application contains the generic GIS tools (Zoom In, Zoom Out, Zoom Full Extent, and Pan) for map navigation and an Identify button to query selected features from a particular layer.

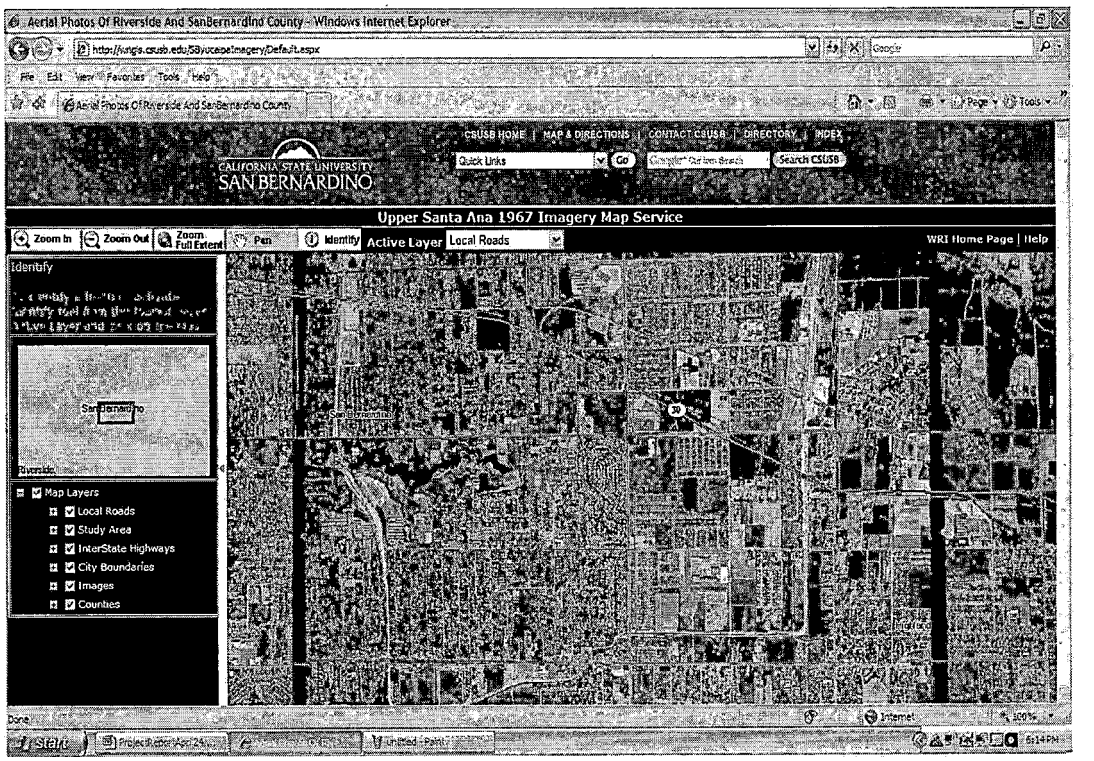


Figure 19. Example Yucaipa and Riverside Imagery

2.5 Document Search Application

The Document Search application is used to query documents such as reports, magazines, books, journals, photos, multimedia and articles from the Water Resources Institute Pfau library archives based on document type, geographic location and time frame.

The Document Search application contains generic GIS tools (Zoom In, Zoom Out, Zoom Full Extent, and Pan) for map navigation and an Identify tool to query selected

features from an active layer. It also contains a specialized Query tool to search for documents. The generic tools perform similarly to the previous web applications.

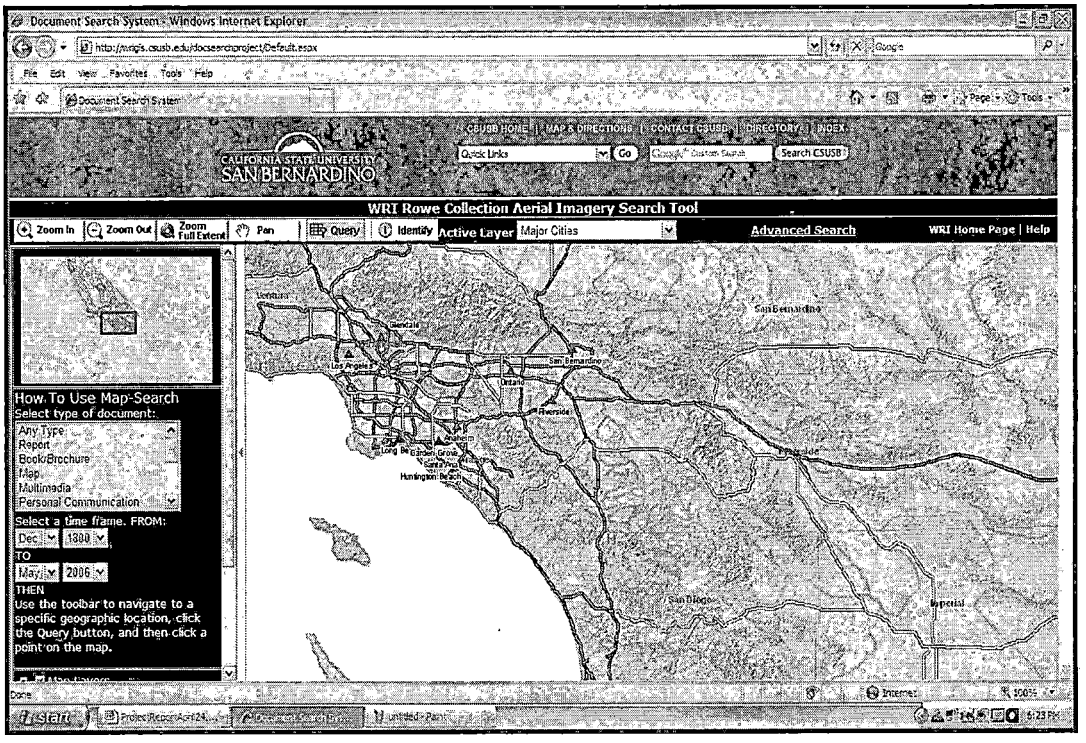


Figure 20. Example Spatial Query Operation

The Query tool is used to get a list of documents for the selected geographic area from the WRI archives. To view a list of documents, the user selects the document type and time frames. The user then clicks the query button in the

toolbar. Finally, the user clicks on the selected watershed area (Figure 20). The result of this query operation is then displayed in a new pop-up browser. The result contains the zoomed-in map of the selected hydrological unit and a list of available documents based on the query (Figure 21).

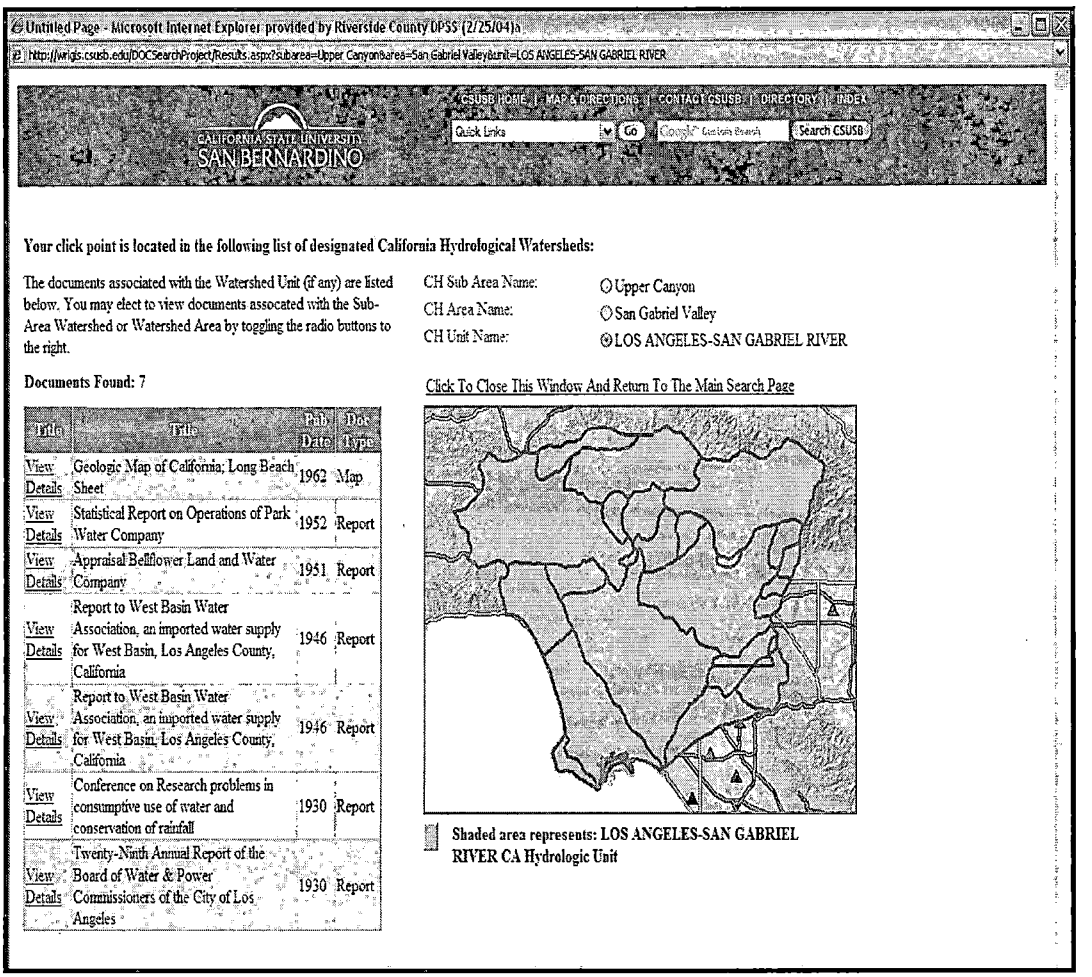


Figure 21. Example Result of Query Operation

CHAPTER THREE

SYSTEM OVERVIEW

This chapter focuses on GIS technology, database, documentation and procedures used in the process of hosting web applications on a publicly accessible production server. Figure 22 shows the communication links between the components of the WRI web applications.

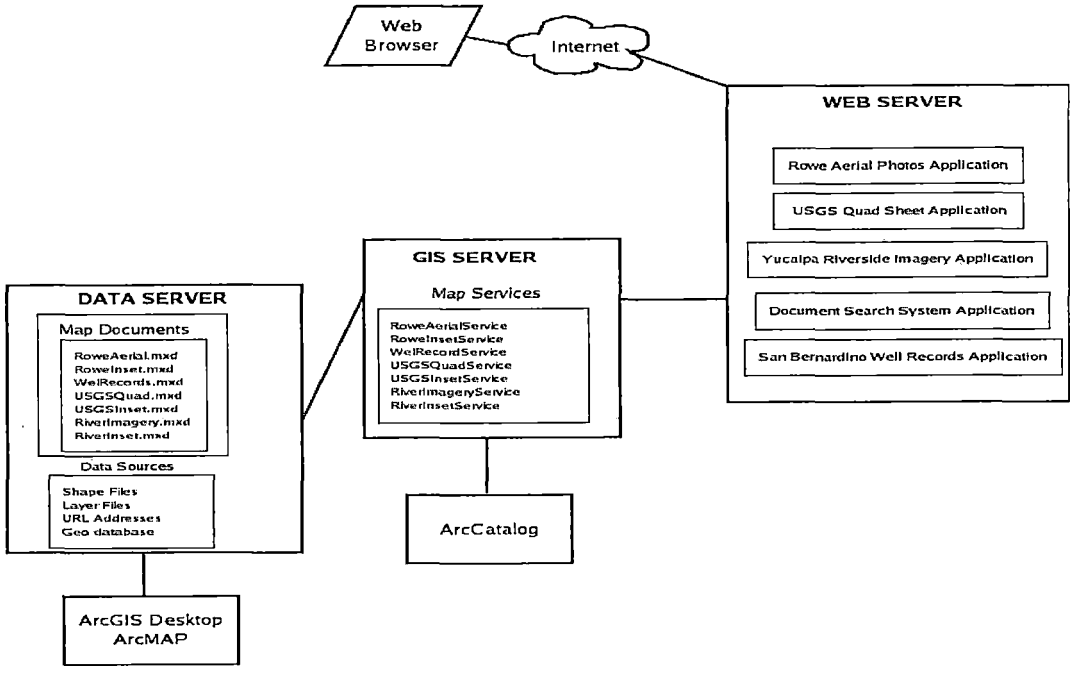


Figure 22. Water Resources Institute Web Application Components and their Communication Links

3.1 System Architecture

The WRI digital archival system consists of five main components: GIS server, web server, clients, data Server, authoring tools and administrative tools (Figure 22).This section contains the description of the components.

Geographic Information System Server

ArcGIS Server can be used to share GIS information across the web. This technology makes GIS data easily accessible by users since they do not need to install the GIS software nor have to acquire the data from local storage. In order to publish GIS data through an ARcGIS server, first we need to author map documents (.mxd file) in the ArcMap application. The map documents created for WRI web applications are as follows: RoweAerialphoto.mxd, SBWellRecords.mxd, RiversideImagery.mxd, SearchArchives.mxd, USGSQuadsheets.mxd. These documents are then published to the server as AerialPhotos, SBWellRecords, RiversideImagery, USGSQuadsheets and SearchArchives map services, respectively.

The inset maps for the web applications are published on the server as InsetRoweAerial, InsetWellrecord, InsetRiver, InsetUSGS and InsetSearch map services.

Web Server

A Web server such as Microsoft Internet Information services (IIS) is used for hosting the web applications that consume the map services running on the GIS server [1]. The following Visual Studio web applications were created: RoweAerialPhotos, USGSQuadSheets, SanBernardinoWellRecords, RiversideImagery, DocumentSearchSystem. These web applications are currently hosted on the WRI production server.

Data Server

A data server stores GIS and attribute data that are to be published in GIS servers. GIS data includes shape files, geodatabases and satellite images. A shape file is a geospatial vector data format recognized by GIS software. Shape files spatially describe geometries such as: points, lines and polygons. A geodatabase is a common data storage and management framework designed to store, query and manipulate geographic information and spatial data. Attribute data includes Access and SQL Server databases. The mxd files for Rowe aerial application, San Bernardino Well Records application, Riverside Imagery, USGS Quad Sheets application and Document Search application are also stored in the file system of the data server. This document

refers to the production server as the data server. Usually the data server is a different machine than the GIS server and the web server. However, due to resource constraints all three of these systems are run on a single machine.

Authoring Tools

ArcMap is an authoring tool used to author maps. ArcCatalog is also an authoring tool used to establish the connection to the data server and to generate map caches. A map cache is a collection of pre-rendered map tiles that can be used for quick display of a map service [3]. ArcMap is used to author RoweAerialphoto.mxd, SBWellRecords.mxd, RiversideImagery.mxd, SearchArchives.mxd, USGSQuadsheets.mxd and their inset maps.

Administrative Tools

ArcCatalog is an administrative tool that can be used to manage the GIS services. ArcCatalog includes a GIS server node through which we publish and manage the GIS services. It allows the administrator to stop, start, delete and create services in the server. ArcGIS Server manager can also be used to manage GIS services and create web applications.

Clients

The web mapping applications are the clients that consume the services managed in the GIS server. These applications connect to ArcGIS Server over a network using HTTP [5].

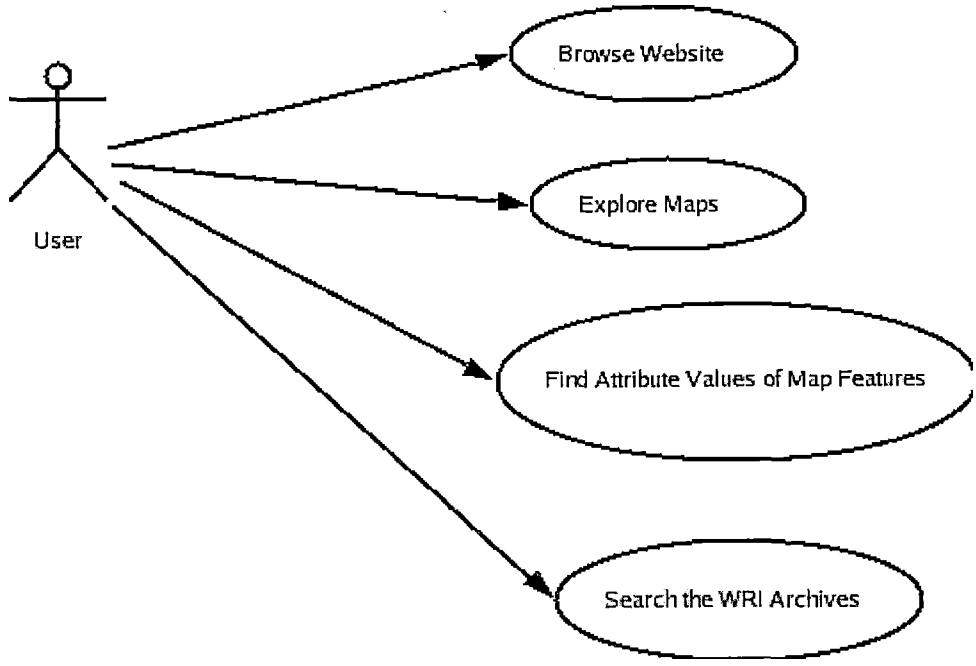


Figure 23. Use Case Diagram for Web Applications

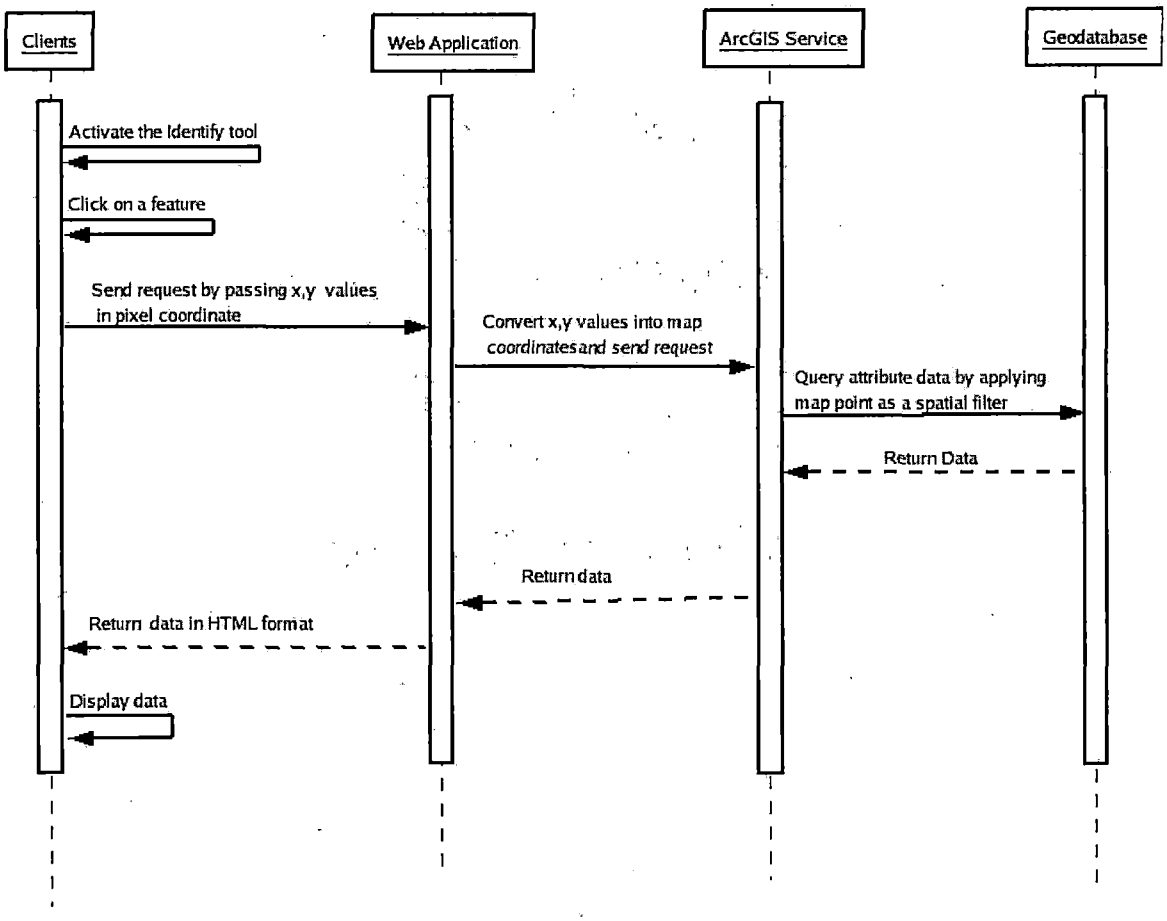


Figure 24. Sequence Diagram of Identify Operation

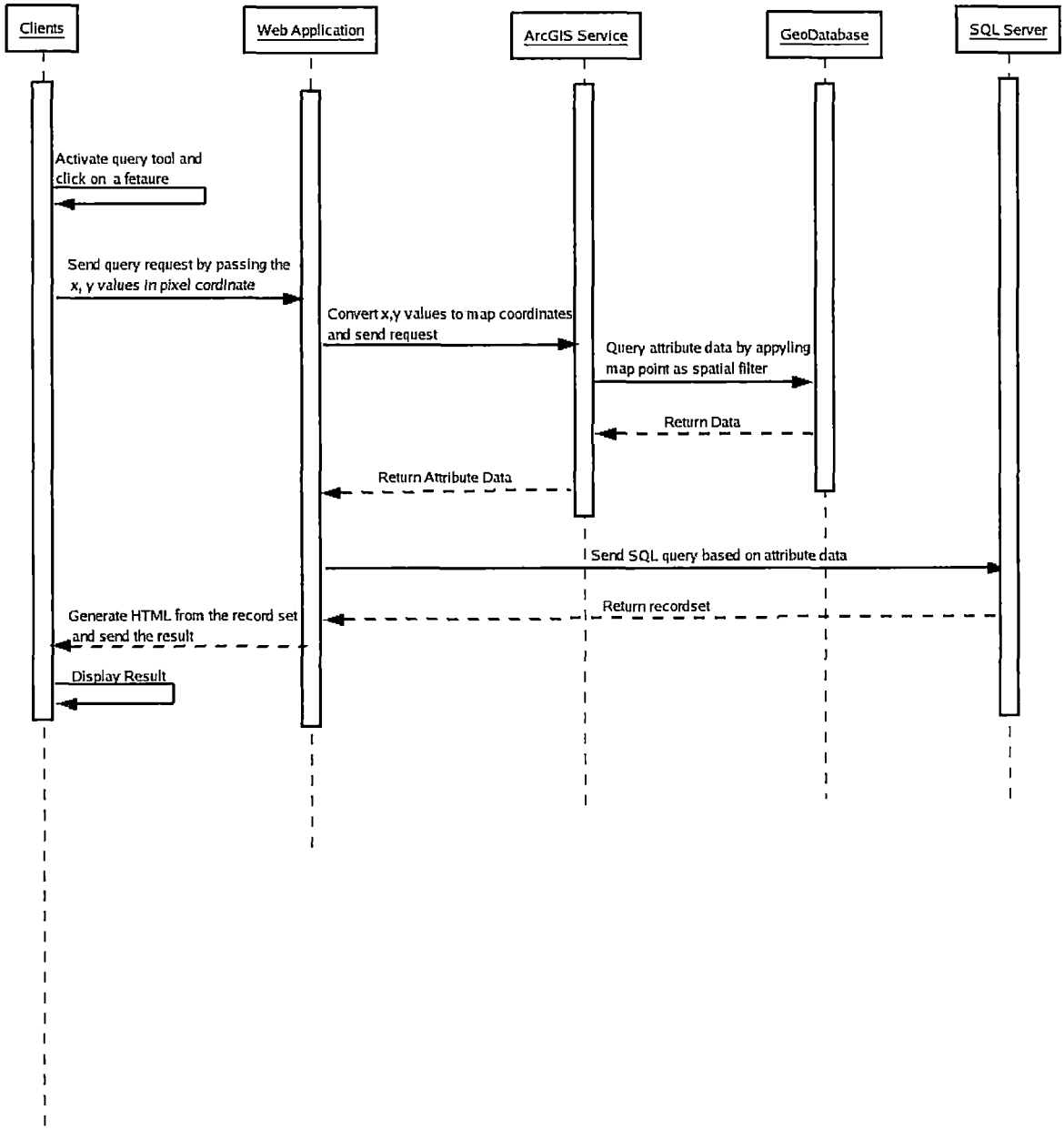


Figure 25. Sequence Diagram of Query Operation

Users access the web applications in their web browsers and interact with them to make use of their GIS functions (Figure 23). The user's browser then constructs an HTTP request and sends it to the web application. The web application connects to ArcGIS Server and makes a request to the map service being used in the application using DCOM protocol. The map service makes query to the geodatabase and gets the spatial data. The spatial data is processed to generate an image or attribute data depending on the request. If the request is from the navigation tools such as zoom in, pan etc, the map service generates an image data. For the request from identify or query tool, it generates attribute data. The map service then sends the resulting data back to the web application through DCOM protocol. For all tools except Query, the web application generates an HTTP response at this time and sends it to the browser (Figure 24). For Query tool however, the web application further generates a SQL query based on the result from the map service and makes the query to the SQL Server database. The web application uses the result set from SQL Server to construct and send HTTP response to the browser (Figure 25). Finally, the user's browser updates its content with the response returned from the web

application. In case of the navigation tools, the image data is used to update the map. The result of the query and identify tool is the attribute data that is displayed in the result panel.

3.2 Development of Map Resources

GIS data in Shape files or feature classes are used to create maps in ArcMap. The Map created in ArcMap is published as a map service through ArcGIS server.

Authoring Map

A map document is authored to create a map with the desired data. ArcMap is used to author RoweAerialphoto.mxd, SBWellRecords.mxd, YucaipaandRiversideImagery.mxd, and USGSQuadsheets.mxd and their inset maps. The steps for creating a map document with ArcMap are as follows:

- Identify the map layers and their sources required for authoring the map. For example, the data required for the Rowe Aerial Photos application are stored in different format in several files.
- Click on *Start -> ArcGIS ->ArcCatalog*. Once the ArcCatalog opens, click on the *Connect to* tool. Navigate to the folder with various data files and

click on it. Now the connection is established to the file system.

- Click on *ArcMap* on menu bar to create an empty map document.
- Click the Add data button and navigate to the folder where your data is stored. Select data files and click *Open*. This adds the feature classes required for the Rowe Aerial Photos project.
- Customize the features according to project requirements.
- Right click on each feature and click on the *Properties* option. You will see tabs for general, symbols, display and labels.
- Symbolize the layers with the standard styles created for the project.
- Name the layers with appropriate terminology.
- Label the features.
- Set the scale dependency.
- Save the map document as *RoweAerialphoto.mxd.*

Repeat the above steps to create map documents for the remaining applications.

Publishing Map Services

Map resources produced in ArcMap are served as Map services in the GIS server. Data accessibility is an important consideration while serving a map document on the GIS Server. Features that are visible in ArcMap may not be accessible when served on a GIS server. To make sure that the data is accessible, the account running ArcGIS Server must have read permissions on the data server [5]. The services published on WRI production server are AerialPhotos, SBWellRecords, RiversideImagery, SearchArchives and USGSQuadsheets. The steps required to create a map service in ArcGIS Server are described below:

- Open *ArcCatalog* and click on *GIS Server*.
- Click on *Add ArcGIS Server*. In Add ArcGIS Server wizard select *Manage GIS Services* and click Next. Enter the field values for Server URL and Host Name and click *Finish*. The URL address for production server is *http://wrigis.csusb.edu* and Host Name is *WRIIMS*. This process creates an administrative connection called "WRIIMS (admin)" to the ArcGIS Server.

- Right click on *WRIIMS (admin)* Server and click on *Add new service*.
- Provide the service name, such as *RoweAerial*, and select service as the Map service. Press *Enter* button.
- Click on *Browse* and find the RoweAerialPhoto.mxd file from the file system.
- Accept the default settings and click *Next* until you hit the *Finish* button.
- *Start* the map service. Select the map service and right click. Click on *Service properties* and on the *Caching* tab. Click on the *Generate* button. Give the number of cache levels to be generated and select *Diffused* caching option.
- Similarly, create services and caches for the other applications.

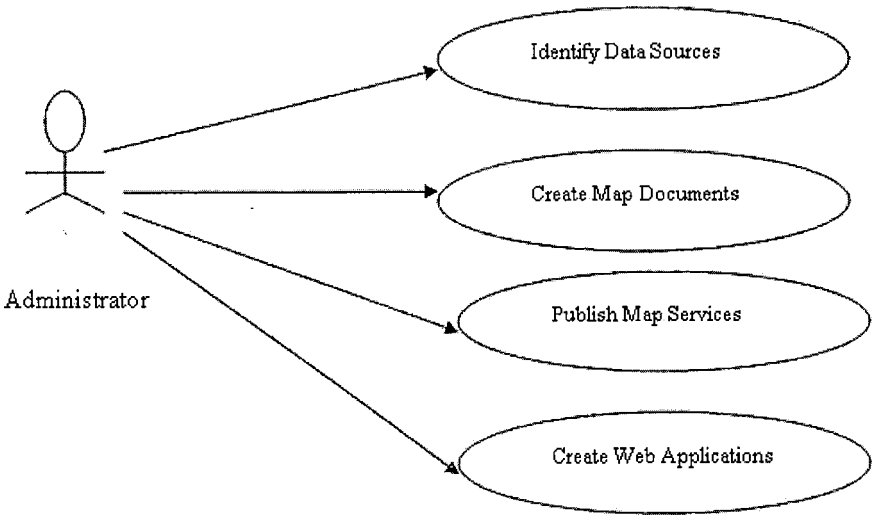


Figure 26. Use Case Diagram of Administrator

CHAPTER FOUR

SYSTEM ADMINISTRATION

This chapter focuses on the installation and maintenance of the operating system, web server and ArcGIS software. To set up a GIS Server, the following items need to be installed first: Windows Server 2003, Internet Information Services 6.0 and ArcGIS Desktop 9.2.

4.1 Windows Server 2003 Installation

Windows server 2003 is the operating system produced by Microsoft and is used to manage all other programs such as ArcGIS Desktop, SQL Server, Web Server, etc. It is a platform on top of which other applications run. To begin the installation of Windows Server 2003, insert the windows 2003 installation CD in the CD-ROM drive and boot directly from CD. On *welcome to setup* screen press *Enter*. Next it will display this message: "Select one of the options to set up the program; *Set up windows now*, *Repair windows* or *Quit set up without installing windows.*" Select *Set up windows now*. The installation starts by asking you to set various configurations. In regional and language options, select *None*. Personalize your software by entering values

for the *Name* and *Organization* field. Enter the *Product key* and click *Next*. Then select the *Per server* licensing option and click *Next*. Create an administrator's account by entering the *Computer name* and *Password*. In date and time settings, change the *Time zone* if needed and select the *Automatic adjust clock for daylight saving* changes, then click *Next*. In network settings dialog box, select *Typical* settings and click *Next*. Click *Next* in workgroups or computer domain. The server then restarts the operating system from hard drive.

Next, configure the server by using manage your server wizard. Open this wizard by clicking *Start ->All Programs ->Administrative Tools -> manage your Server Menu Item*. In manage your server window, Click *Add or remove role* and click *Next*. Click on *Custom configuration*. To customize your TCP/IP settings, click *Next*, select *Internet protocol (TCP/IP)* and then click on *Properties*. Enter the appropriate values for IP address, Subnet Mask, Default gateway, Preferred DNS server and Alternate DNS server. Enter the IP address of the production server (WRIIMS) as *139.182.28.33*, the Subnet Mask as *255.255.255.0*, the Default gateway as *139.182.28.1*, the Preferred DNS server as *139.182.28.8*, the Alternate DNS server as *139.182.28.1*.

In the IP address section, click on the *Advance* tab and in the DNS section, select *Append primary and connection specific DNS suffixes*, *Append parent suffixes of primary DNS suffix*. Register the connection address in DNS. Select *Enable LMHOSTS lookup* and enter the value for WINS server by clicking the *Add* button and inserting *139.182.28.33*. This ensures that LMHOSTS file is read to resolve domain names. Select *Default* for NetBIOS setting. Finish the TCP/IP settings by clicking *Ok* and then click *Next*. Create a workgroup by giving a workgroup name as *WRIIMS*. Once the installation is complete, the machine reboots and loads Windows Server 2003. After the computer reboots, press *ctrl+Alt+Del* and log on to server by entering the administrator username and password.

4.2 Internet Information Services 6.0 Installation

Internet Information Services (IIS) is a set of internet based services like File Transfer Protocol (FTP), Hypertext Transfer Protocol (HTTP), Network News transfer Protocol(NNTP)for servers using Microsoft windows. Reliable, manageable and scalable web application infrastructure can be created using IIS for Windows Server. To install Internet Information Services using *Configure*

your server wizard, go to *Start* menu and click *Manage your server*. Click *Add or remove a role* under *Managing your server roles*. Click *Next* and under *Server role* click on *Application Servers (IIS, ASP.Net)*. The wizard by default installs the IIS, COM+ and DTC. Under the *Application server options* page, select the check boxes next to ASP.NET and click *Next*. Complete the wizard and click *Finish*. This will install IIS Server.

4.3 ArcGIS Desktop 9.2 Installation

ArcGIS Desktop is an integrated application that allows management, editing, analysis and mapping of geographic data. To install ArcGIS Desktop, insert ArcGIS Desktop 9.2 DVD in DVD drive and click on *ArcGIS Desktop*. Click on *Install ArcGIS Desktop*. On the option to license manager window click on *Define license Manager later*. To install software that has all ArcEditor capabilities, select ArcInfo and click *Next*. In the installation window, select *Complete installation* and click *Next*. Give a destination folder to install the software into and click *Next* to start installation. Once the installation is complete, a screen appears with a software installation

completed message. Click the *Finish* button to end the installation process.

Use Desktop administrator to set the license manager. Go to *Start* menu -> *All Programs* -> *ArcGIS* ->*Desktop Administrator*. Click on *License manager* folder, click on *Change* button on right side of the window. Provide the IP address of the license server located in campus as 139.182.28.32 and then click *Ok*. Reboot machine once the installation is complete. ArcGIS Desktop 9.2 is now ready for use.

CHAPTER FIVE

SET UP OF DEVELOPMENT ENVIRONMENT

The development environment is used by a developer to create applications and test them. This chapter describes the installation, configuration and maintenance of the software comprising the development environment for this project. This includes Visual Studio .Net 2005, Dot Net Framework Development Kit, ArcGIS Server 9.2 and ArcGIS Server Application Development Framework.

5.1 Visual Studio .NET 2005 Installation

Visual studio .Net is an integrated development environment used to develop web applications. To install it, insert the Visual Studio .Net 2005 CD into the CD drive. The installation process begins automatically. If it does not auto run, explore the contents of the CD and click on *setup.exe*. In the Visual Studio set up wizard, click on *Install Visual Studio*. The set up starts by copying the files to a temporary folder and then begins the process of installation.

Enter your name in *Name* field and click *Continue*. In options page, select features to be installed in your

computer and define the path of installation. Accept default settings to install all features in boot drive. Click the *Install* button. It takes some time to complete the installation process and then the system restarts.

5.2 Dot Net Framework Development Kit Installation

Dot Net Framework Development Kit is a software component of Microsoft that has a large library of pre - coded solutions to common programming problems. These class libraries are used for the execution of new programs written for the windows platform. Developers include these class libraries within their code to develop applications. To install .Net Framework Development Kit, double click the SDK setup program (Net2Framework.exe). Click *Next* on the welcome screen and accept the license agreement and click *Next*. Select the check boxes next to *Quickstart samples*, *Tools* and *debugger* and *Product documentation* to install them and click *Next*. Specify the installation directory and click *Next*. The installation process starts. It takes some time to finish. The .Net framework 2.0 SDK is now installed.

5.3 ArcGIS Server 9.2 Installation

ArcGIS Server is a platform for building GIS applications. GIS resources like maps, tools and geodatabases can be shared across the web by using ArcGIS Server. ArcGIS Server setup process consists of two parts: installation and post installation. During the installation phase, the core components of the software are installed. In the post installation, the software is configured and necessary user accounts are created. To install ArcGIS Server for Microsoft .NET framework, insert the ArcGIS Server 9.2 CD in CD drive. Auto run program executes the installation process. If the installation process does not start, open the CD drive and run the setup.exe. Select all features under *Server object manager*, *Server object container* and *Software development kit* to be installed in the server. *Click* on *Browse* button and give the destination location to store these features and click *Next*. It takes several minute to finish the installation. Once the installation is completed, click the *Finish* button.

After completing the installation of ArcGIS Server for Microsoft .Net Framework, you need to perform following steps for post installation. Select *Configure ArcGIS Server* and *Authorize ArcGIS Server* on ArcGIS Server post install

dialog box and click *Next*. Specify the account names and passwords for ArcGIS SOC and ArcGIS SOM and click Next. The accounts created in the previous step will be used to run the ArcGIS Server processes. Create a user account name and password for GIS Server *Web services* and click *Next*. This account will be used by web services running in the web server to authenticate with the Map Services running on GIS Server. Specify the GIS Server directories by clicking the *Browse* button or accept the default location. This is the location where GIS Server stores output images, geo processing jobs and map caches. Next, select *Do not use a proxy server for ArcGIS Server connection* and click *Next*. In GIS server post install summary dialog box click on *Install* button. Click *Next* to start software authorization wizard. On registration option dialog box select *I have installed software and need to register it* option and click *Next*. On dialog box for registration method Select *Register now using the internet*. Enter the registration number and click *Next*. Select .Net as development platform and in number of users to be served field select *0-50*, select *Yes* on field value for *Do you plan on working with external information systems*. For *Primary deployment plan* field select both *Intranet* and *Internet* and click *Next*. In ARCGIS

server option registration dialog box, select *I do not want to register any options at this time*, and then click *Next*. ArcGIS server installation is now complete.

Once the post installation is complete, you need to specify the user accounts that have administrative access to the server. Use windows computer manager to add users in the agsadmin user group. Add members to agsadmin group to give administrative privilege so that they have the rights to add, start, stop the server objects as well as add host machines on the server[1]. To add users to the agsadmin group, click *Start* > *Control panel* > *Administrative tools*. In computer management expand *System tools*, then expand *Local users and groups* then expand *Groups*. Right click the ArcGIS Server administrative group titled *agsadmin* and click *Properties*. On the property page click *Add*. Specify the account to be added to the group. You need to log off and log back in for the above changes to take into effect.

CHAPTER SIX

ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE

TEMPLATE BASED WEB APPLICATIONS

ArcGIS Server .Net web ADF contains a number of .Net web controls that encapsulate GIS functionalities in a web page. One can easily drag and drop these controls into an empty web page and set their required properties to construct a web application. However, it requires much more effort to construct the web page with desired layout, look and feel and advanced functionalities such as dynamic resizing of the controls as the browser is resized. As an alternative, one can use the ArcGIS Server .Net Web ADF template to create a web application first and then customize it further to change the existing features or add new features.

The .Net Web Application development Framework (ADF) template is integrated with the Visual Studio 2005 .Net environments which makes it easy to create and configure a web mapping application. See chapter 5.1 for the instructions on how to install Visual Studio. This chapter describes how to create a map - based web application using

the .Net Web ADF template and customize further to add or modify its functionalities.

6.1 Developing Web Applications with Web ADF

The web mapping application template provides a predefined layout and user interface of the web page. The map display in the template makes maximum use of the browser space and is resized dynamically as the browser size changes (Figure 27). It also contains a number of commonly used GIS functionalities already integrated to it. The web application created from the ESRI template consists of a main map, table of contents, toolbar and an identify window [5]. The template can be used as a starting point to build an application which can be customized by modifying the existing user interface and functionalities as well as by creating new functionalities.

The steps used for creating a web application from the Web ADF template are described below:

- Start Visual Studio 2005. Click the *File* menu. Click *New* and select *Web Site*.
- In the New Web Site dialog box, set the location value to *HTTP* and Language to *C#*.

- Under Visual Studio installed templates, click on *Web Mapping Application*
- Enter the name for the web application as Customized_MapTemplate and click *Ok*. This will create a web application using the template.
- The web application needs to authenticate with the ArcGIS Server to be able to access the map service. The user account used to authenticate to ArcGIS Server must be a part of agsuser group. To provide authentication information, right click on solution explorer and select *Add ArcGIS Identity*. Set the *Username* and *Password* of the account that is added to agsuser group.
- The start page of the web application is Default.aspx which contains a number of web controls in a defined layout. Open the *Default.aspx* page and select the *Design* view.
- Click the *MapResourceManager* control to select it. The MapResourceManager control is used to add and manage GIS Server map resources used in the web application. Click on *Edit Resources* option and *Add* button to add a new map resource item.

- Click on *Definition property* and set values for Type, DataSource and Resource fields on Map Resource Editor dialog box. For example, in Rowe Aerial Photos application, the values for Type, DataSource and Resource are *ArcGIS Server Local,* Host name of ArcGIS Server machine (WRIIMS) and the name of the map service *AerialPhotos* respectively. Click OK to close the dialog.
- Choose the Build menu and Build application option to build the solution.
- Choose Debug menu and Start to run the application. This will open the web page in the browser. Test the web page by using the tools provided on the interface. The web application created from web ADF looks as in Figure 5.
- Close the browser.

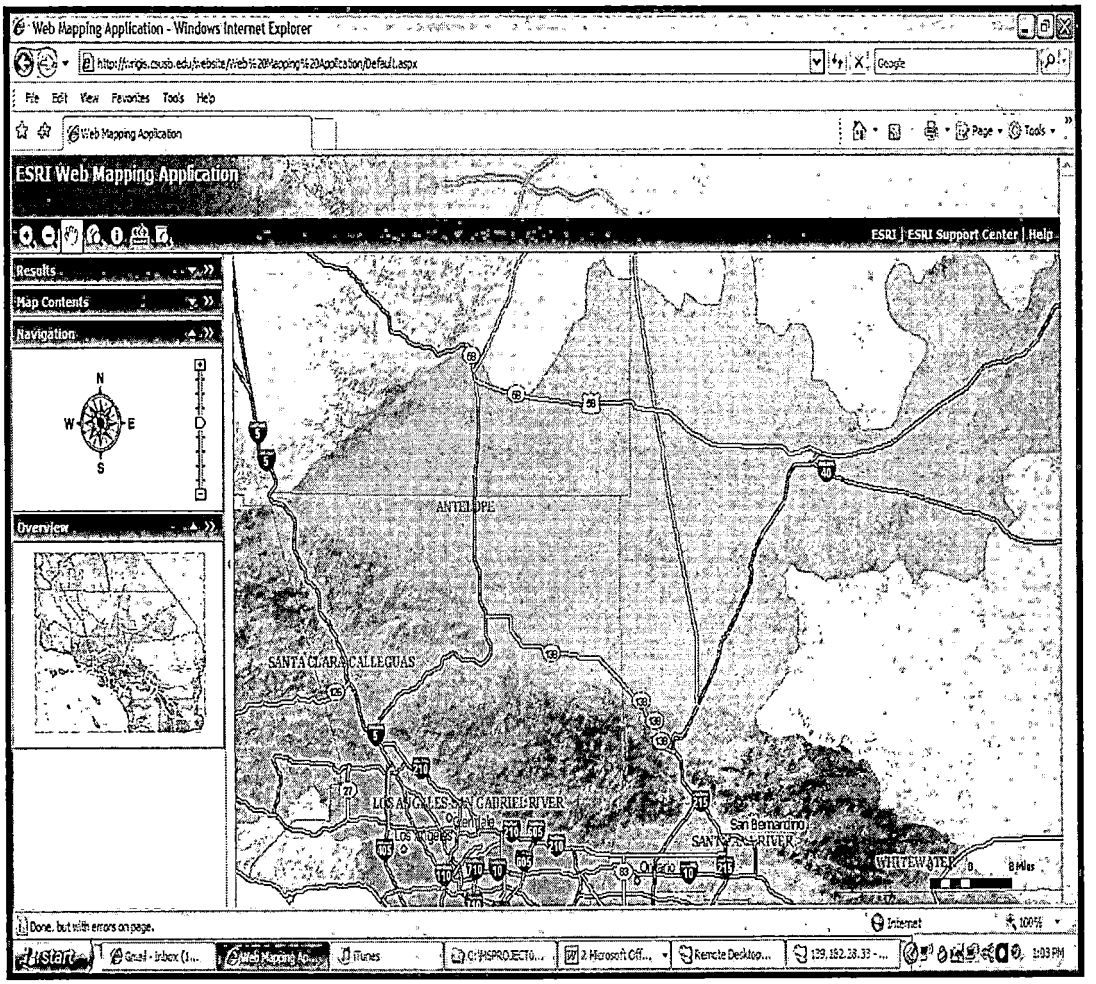


Figure 27. Web Application Created with Template

6.2 Customizing Template Based Web Applications

Although the web mapping template provides a number of useful tools and functionalities, it may not fulfill the requirements of a specific project. In the case of WRI projects, the web template was further customized to create a base mapping application first. The base mapping

application contained a minimum set of functionalities required by all web applications and was simplified to make it easy to use and understand. The base application was then used to create project specific applications such that they all have a common look and feel for common features. Finally, the application was further customized separately to add project specific features. This section discusses about the creation of the base mapping application used by all WRI web applications.

Modifying the Web Page Title

The .Net ADF template application contains its own title that is displayed on top of the web page. To give a consistent look with other CSUSB web pages, the base web application is modified to use the CSUSB banner as the web page title. To make this modification, open Default.aspx page in Visual studio 2005 and switch from Design view to Source view. In the source code, examine the code for the title banner. Delete the entire .. section and add new code. Figure 28 shows the CSUSB title banner HTML code used for the WRI web applications.

```
<!--    <div style="top: 0px; float: right;">
                    <asp:HyperLink ID="CloseHyperLink"
runat="server" Style="color: White; font-family: Verdana; font-
size: 8pt;" NavigateUrl="JavaScript: CloseOut()" Visible="False"
ToolTip="Close Application" >Close</asp:HyperLink>  
                </div>
                 
                 <asp:Label ID="MapViewer_TitleTextShadowLabel"
runat="server" Font-Size="10pt" Font-Names="Verdana"
ForeColor="White" Font-Bold="True" style="position: absolute;
left: 5px; top: 5px;"><b>Water Resources Institute</b> <br/>
California State University San Bernardino</asp:Label>
            -->
   For the new Title banner, add the flowing lines of code

            <iframe src ="http://www.csusb.edu/banner2007"
width="100%" frameborder="0" height="90" scrolling="No"
title="CSUSB banner">
<p>If you can see this text, your browser does not support
iframes.
<a href="http://www.csusb.edu/banner2007">Follow this link to
view the content of this inline frame</a> within your
browser.</p>
</iframe>
```

Figure 28. California State University, San Bernardino Title Banner HTML

Making Left Panel Static

The left panel of the .Net web template consists of a number of collapsible windows that could hide the content of the windows unless expanded. This could confuse the users of WRI web pages. So the user interface in the left panel was simplified to make the content static and visible all the time.

Customizing Tools

The existing tools in the toolbar contain icons only. This could confuse the non-GIS users of the web applications. Thus, the new icons are created with both texts and images to describe the tools clearly. To use custom icons for the tools, replace the existing images for the tools with the new ones at *D:\Inetpub\wwwroot\<web_application>\images* folder.

Remove Unwanted Tools from Tool Bar

The toolbars from mapping template contains Measure and Magnify tools that are not required for the WRI projects. These tools were removed to simplify the toolbar. Follow the steps given below to remove these tools from the tool bar. An example of the customized web application template is shown in Figure 29.

- Click the *ellipsis* in the ToolbarItems property and open the *ToolbarCollectionEditorForm* dialog box.
- Click the *Magnify* tool, in the *Current Toolbar Contents* list.
- Click the *Remove* button.
- Repeat Step II and Step III to remove Measure tool.

- Click *Ok* button to close the ToolBarCollectionEditor dialog box.
- Close the Toolbar Properties window.

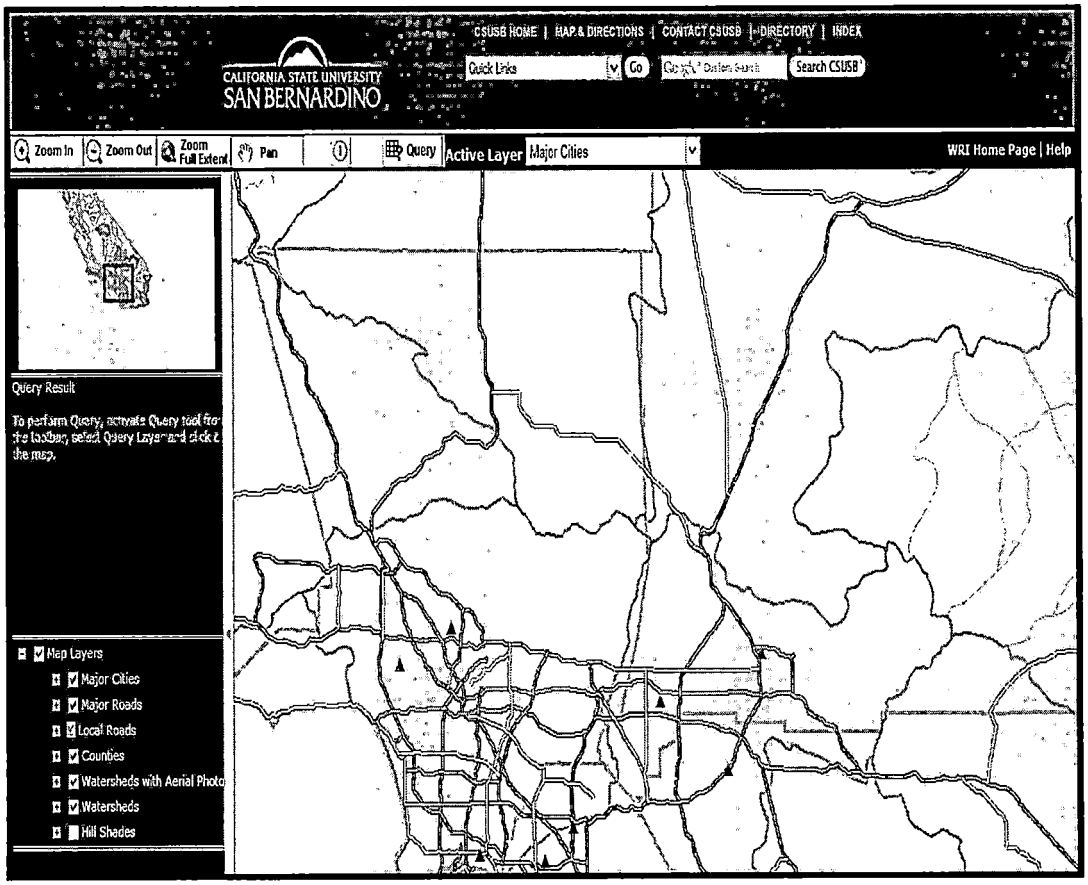


Figure 29. Customized Web Application Template

How to Reuse the Water Resources Institute Web Template for Building New Applications

The Base web application created above contains common sets of tools, features and user interface. This base application was reused to create all other WRI web applications to provide a consistent user interface and functionalities for the common features. The project specific application was then customized further to add functionalities specific to that project. Future developers can also use this base application to create more web applications. The procedures to reuse the base application are given below:

- Make a copy of the web application folder Customized_MapTemplate created above in to IIS root folder, for example: *D:\Inetpub\wwwroot*. Rename the folder with desired application name, for example: *SBWellRecords*.
- Open the folder *C:\Documents and Settings\<user account>\My Documents\Visual Studio 2005\Projects.*
- *Make a copy* of *Customized_MapTemplate* folder inside your account for visual studio *C:\Documents and Settings\useraccount\My Documents\Visual Studio*

2005\Projects. *Rename* it to application name - *SBWellRecords*.

- Open the renamed folder, i.e *SBWellrecords*. You will see Customized_MapTemplate.sln and Customized_MapTemplate.suo files. *Delete* the Customized_MapTemplate.suo file. *Rename* the Customized_MapTemplate.sln with the application name i.e *SBWellRecords.sln*.
- Open the *SBWellRecords.sln* file with notepad.
- Click the edit toolbar and replace the term *Customized_MapTemplate* in the .sln file with the new application name, i.e. *SBWellRecords.*
- Save the file and close it.
- Click *Start>Control panel>Administrative tools> Internet information services*. Expand *WRIIMS*, click on *web sites* and click on *WRIGIS*. You will see a list of applications.
- Right click the *SBWellRecords* folder and click on *properties* to open the SBWellRecords properties dialog box. Modify the value for Execute permissions field to *Script Only* or *.Net* whichever

is available. Click the *Create* button. Click *Ok*. This will create a new application in IIS.

- Open the application *SBWellRecords* in Visual Studio 2005. Open the *default.aspx* page and switch to design view.
- Click on *Map resource manager* and on Map resource manager tasks window, click on *Edit resources*.
- On the SBwellRecords properties dialog box, set the name of the application and click on ellipsis to set the properties to point to map service.
- Click the *ellipsis* for resources on Map Resource definition editor dialog box, which opens ArcGIS Definition editor dialog box. Set the values to point to your map service and click *Ok*. Click *Ok* in the Map resource definition editor and Map resource item collection editor.
- Click on *Debug>Start without debugging option*.
- Once the build is finished, test your application. It is now ready for use or further customization (Figure 13).

CHAPTER SEVEN

TESTING

This chapter focuses on quality assurance of existing WRI web applications. Each application is tested to make sure all tools are functioning correctly.

7.1 Rowe Aerial Photos Application

Table 1 lists the tests for the Rowe Aerial Photos application.

Table 1. Tests for the Rowe Aerial Photos Application

Test ID	User Action	Expected Output	Result (P / F)
1	User uses the Zoom In tool to zoom to a new extent.	Map redraws by zooming into the new extent and at smaller scale.	Pass
2	User uses Zoom Out tool to see the map at a larger scale.	Map is redrawn with a larger scale.	Pass
3	User uses the pan tool to navigate around the map.	Map shifts horizontally/vertically as per user navigation.	Pass
4.	User clicks the Zoom to Full extent tool.	Map redraws showing the full extent of map.	Pass
5.	User uses the Identify tool to	Information on selected city is displayed in	Pass

	see attributes about cities.	Result panel.	
6.	User clicks on Query tool and clicks on one of the watershed areas.	A pop window displays with information on watershed area and a list of URL links.	Pass
7	User clicks one of the title links.	A page is displayed with a collection of aerial photos. When an image is clicked, a larger view of the picture is shown.	Pass
8	User turns on / off a layer in the Table of Contents.	The visibility of the selected layer is changed.	Pass
9	User clicks on help menu.	A help page pops up.	Pass
10	Users drags the red box in Over View map	Main map is redrawn with the new extent.	Pass

7.2 United States Geographical Survey Quad Sheets Application

Table 2 lists tests for the Historical USGS Quad Sheets interactive map application.

Table 2. Tests for the United States Geographical Survey Quad Sheets Application

Test ID	User Action	Expected Output	Result (P / F)
1	User uses the Zoom In tool to zoom to	Map redraws by zooming into the new extent and	Pass

	a new extent.	at smaller scale.	
2	User uses Zoom Out tool to see the map at a larger scale.	Map is redrawn with a larger scale.	Pass
3	User uses the pan tool to navigate around the map.	Map shifts horizontally/vertically as per user navigation.	Pass
4.	User clicks the Zoom to Full extent tool.	Map redraws showing the full extent of map.	Pass
5.	User uses the Identify tool to see attributes about cities.	Information on selected city is displayed in Result panel.	Pass
6.	User uses Identify tool to view availability of USGS Quad sheet 15 minute at WRI.	Information on year and the number of quad sheets available is displayed in Result panel.	Pass
8	User turns on / off the layer in the Table of Contents.	The selected layer is visible on map window if it's turned on, else it is invisible.	Pass
9	User clicks on help menu.	A help page pops up.	Pass

7.3 San Bernardino Well Records Application

Table 3 lists tests for the San Bernardino Well Records application.

Table 3. Tests for the San Bernardino Well Records Application

Test ID	User Action	Expected Output	Result (P / F)
1	User uses the Zoom In tool to zoom to a new extent.	Map redraws by zooming into the new extent and at smaller scale.	Pass
2	User uses Zoom Out tool to see the map at a larger scale.	Map is redrawn with a larger scale.	Pass
3	User uses the pan tool to navigate around the map.	Map shifts horizontally/vertically as per user navigation.	Pass
4.	User clicks the Zoom to Full extent tool.	Map redraws showing the full extent of map.	Pass
5.	User uses the Identify tool to see attributes about cities.	Information on selected city is displayed in Result panel.	Pass
6	User activates the Query tool to view historical well records.	Information of well records for the selected section is displayed in Result panel.	Pass
7	User follows the link displayed hyperlink in the result panel.	List of Historical information on well record is displayed in a pop up window.	Pass
8	User clicks on section.	A message is displayed in results panel saying no well records found.	Pass
9	User turns on / off the layer in the Table of Contents.	If the layer is turned on, the selected layer is visible on map window otherwise it is invisible.	Pass
10	User clicks on help menu.	A help page pops up.	Pass

7.4 Yucaipa and Riverside Imagery Application

Table 4 lists tests for the for Yucaipa and Riverside Imagery interactive map application.

Table 4. Tests for the Yucaipa and Riverside Imagery Application

Test ID	User Action	Expected Output	Result (P / F)
1	User opens the application	Application opens by displaying the aerial images of Riverside and Yucaipa area.	Pass
2	User uses the Zoom In tool to zoom to a new extent.	Map redraws by zooming into the new extent and at smaller scale.	Pass
3	User uses Zoom Out tool to see the map at a larger scale.	Map is redrawn with a larger scale.	Pass
4.	User uses the pan tool to navigate around the map.	Map shifts horizontally/vertically as per user navigation.	Pass
5.	User clicks the Zoom to Full extent tool.	Map redraws showing the full extent of map.	Pass
6	User uses the Identify tool to see attributes about cities.	Information on the selected city is displayed on Result panel.	Pass
7	User turns on / off the layer in Table of contents.	The selected layer is visible in map window if its turned on, else it is invisible.	Pass
8	User clicks on help menu.	A help page pops up.	Pass

7.5 Document Search Application

Table 5 lists tests for the for Document Search interactive map application.

Table 5. Tests for the Document Search Application

Test ID	User Action	Expected Output	Result (P / F)
1	User uses the Zoom In tool to zoom to a new extent.	Map redraws by zooming into the new extent and at smaller scale.	Pass
2	User uses Zoom Out tool to see the map at a larger scale.	Map is redrawn with a larger scale.	Pass
3	User uses the pan tool to navigate around the map.	Map shifts horizontally/vertically as per user navigation.	Pass
4.	User clicks the Zoom to Full extent tool.	Map redraws showing the full extent of map.	Pass
5.	User uses the Identify tool to see attributes about cities.	Information on the selected city is displayed in Result panel.	Pass
6.	User clicks on Query tool and clicks on one of the watershed area.	A pop window displays with Query results.	Pass
7	User selects the radio buttons to query based on watershed area or Sub watershed area or watershed unit	Query result displays on left side of window. Map redraws showing the interested watershed area.	Pass
8	User turns on /	The selected layer is	Pass

	off the layer in Table of Contents.	visible on map window if it's turned on, else it is invisible.	
9	User clicks on help menu.	A help page pops up.	Pass
10	User clicks the link for advanced search.	A pop up window displays with several options for Text Search, Spatial Search and Data Entry.	pass
11	User clicks on the Text Search tool and enters the field values.	Documents matching the query parameters are listed.	Pass

CHAPTER EIGHT

CONCLUSION

Web applications running on the WRI web application server provide visual interfaces to the end users to search information related to the Santa Ana watershed and the Colorado River. These applications share the geographic data with the end user and provide various tools to access GIS as well as non-GIS data.

The users can view the historical collection of aerial photos in the Aerial Photos application. They can search for historical well records in the San Bernardino Well Records application. The USGS Quad Sheets application can be used to view the availability of quad sheets at the Water Resources Institute. Similarly, the Yucaipa and Riverside Imagery application can be used to view aerial images of Riverside and Yucaipa area. The Document Search application allows the users to find the documents from WRI archives either through spatial query or through text search.

A template was created to give a consistent look and feel to the web applications. The template can also be reused to create any new applications in the future. Since

all of the GIS processing is done on the server, the end users do not need to have any GIS software installed on their machines. Anyone with a web browser and internet connection can access these web applications and perform GIS tasks.

Despite giving a consistent look and easier user interface to the migrated applications, there are additional improvements that can be implemented. Listed below are some recommendations for future improvements to the WRI web applications.

- Implement map tips, so that the user can easily view attributes related to feature classes.
- Store all data sources in ArcSDE. ArcSDE serves as the gateway between GIS clients and Relational Database Management System (RDBMS). ArcSDE allows the user to easily store, access and manage GIS data in a central database such as Oracle or Microsoft SQL Server, and supports concurrent multi-user editing.

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