RECLAMATION
Managing Water in the West

Summary Report

Western Water Information Network Project

Douglas R. Clark
Physical Scientist
Denver Technical Services Center

Kurt Wille
Physical Scientist
Denver Technical Services Center

Dennis Kubly
Manager, Adaptive Management Program
UC Region

U.S. Department of the Interior
Bureau of Reclamation

June 2008

7-1596B (9-08)
Bureau of Reclamation

DATE	PEER REVIEW	CODE
Aug 18 2011	Signature: [signature] Printed Name: John Carlson	86-68420
	Signature: Printed Name:	
Author Initials	PEER REVIEW NOT REQUIRED	

OFFICIAL FILE COPY

DATE	SURNAME	CODE
	✓	

Classification:

Project:

Control No.:

Folder I.D.:

Contents

Project Purpose

The Western Water Information Network (WWIN) research project was originally implemented to create both Reclamation-wide and local area geo-spatial water supply information systems that could be used to predict water conflict potential. The need for this information system arose from the Klamath incident beginning in 2001. Reclamation senior managers expressed an interest in exploring ways to avoid sudden “train-wrecks”, i.e. unexpected water crises. As the project evolved, however, the focus shifted from conflict avoidance to the provision spatial data required for the management of water in the West.

Methods

The WWIN project originally grew out of and worked hand in hand with the Water2025 effort. To repeat, it began as an effort to avert water conflict. A panel of Reclamation water scientists and engineers, headed by Chuck Hennig, was given the charge to produce a map of water conflict potential. GIS data for a large number of potential predictors of water conflict were compiled by a team in Reclamation composed of Stanley Conway, David Matthews, Rod Wittler, Douglas Clark, and Christopher Holdren, Rick Martin. These predictor variables were each weighted as to severity by panel consensus, and then variable values were summed across all fields to give a county composite conflictive potential value (sometimes 8-digit HUCs were used instead). These composites were used to produce a west-wide map that showed both low risk areas and potential “hotspots”, i.e. areas that had a high potential for emergent water conflict. Some of the predictor variables included water quality, threatened and endangered species of plants and animals, areas where potential disputes with Native Americans over water rights were in progress, drought frequency, non-native species, and population growth or decline**.**

As originally envisioned, the WWIN project would gather together and make available these indicator data on an bureau-wide, i.e., enterprise basis. They were, of course, made available to the Water2025 senior management team in Washington, D.C. to help that body to make decisions regarding the locations of water conflict hotspots. Figures 1 and 2 are typical maps of a single indicator variable. Indicator data give a snapshot in time. They allow the manager to see the spatial distribution of a particular phenomenon, i.e., where there are deficits and where concentrations and values in between. Location often gives hints about causality. For instance, the concentration of tamarisk in the southwest can be explained in part by the 19th century practice of planting these fast-growing trees to create stream bank instability.

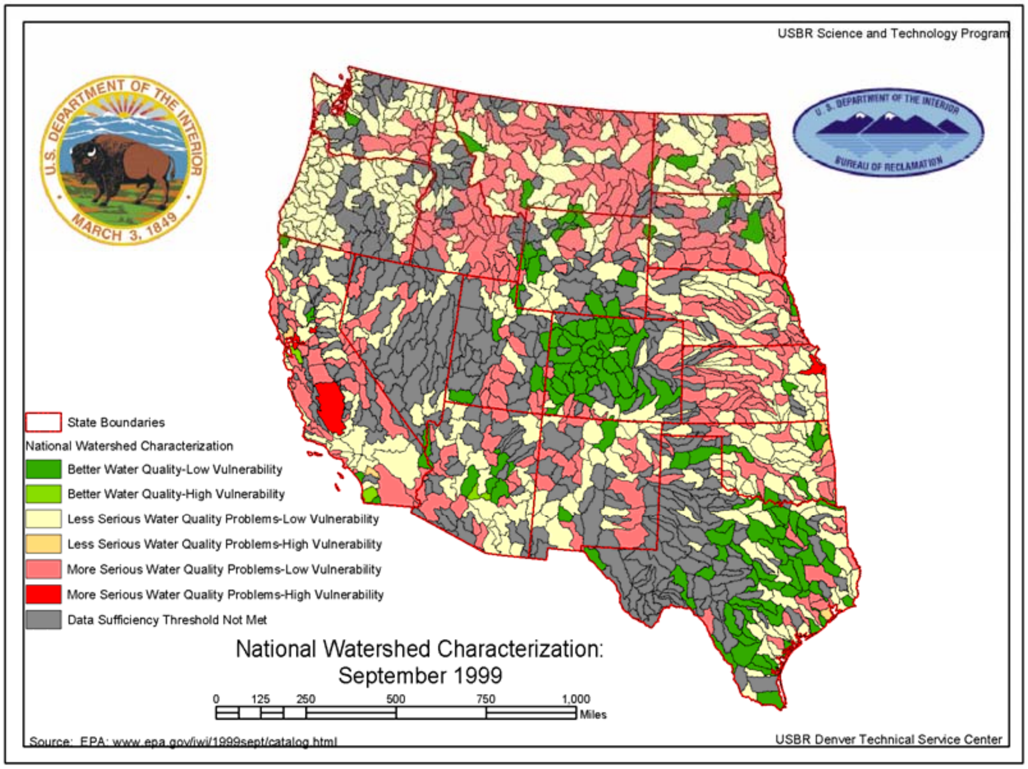

Figure 1: Impaired watersheds in the U.S. West

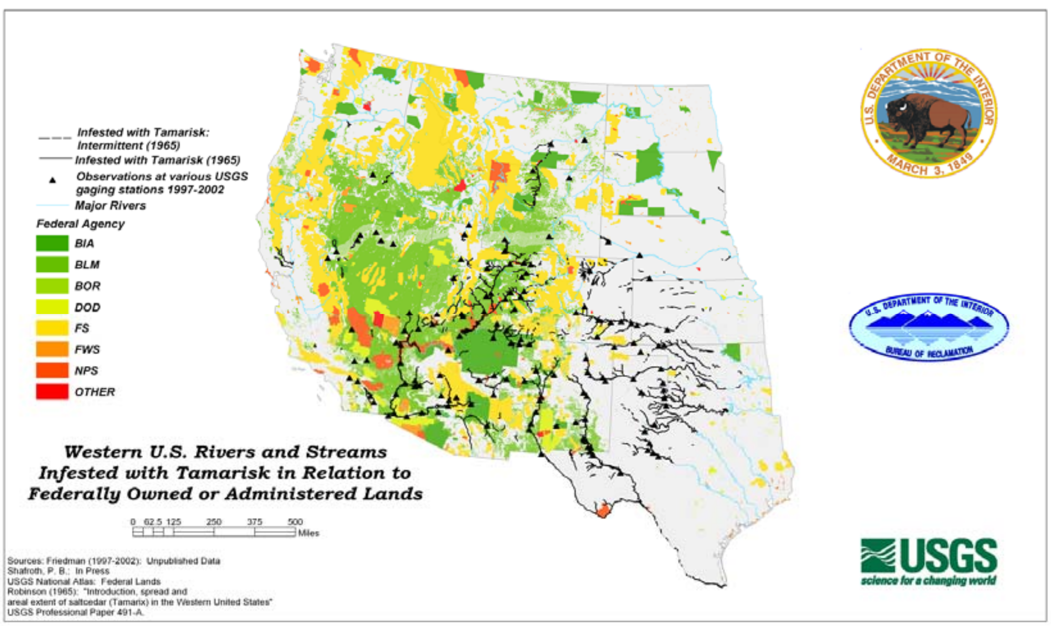

Figure 2: Rivers and streams infested with tamarisk.

Over the course of time, as the project evolved, it became apparent that *trend data* would also be useful for water managers, who must plan for water supply and demand over time. To meet this requirement, temporal data were compiled.   (Figures 2-6)   Figures 3 and 4, for instance, very clearly show the growth of ground water demand in the extreme southwest over time.

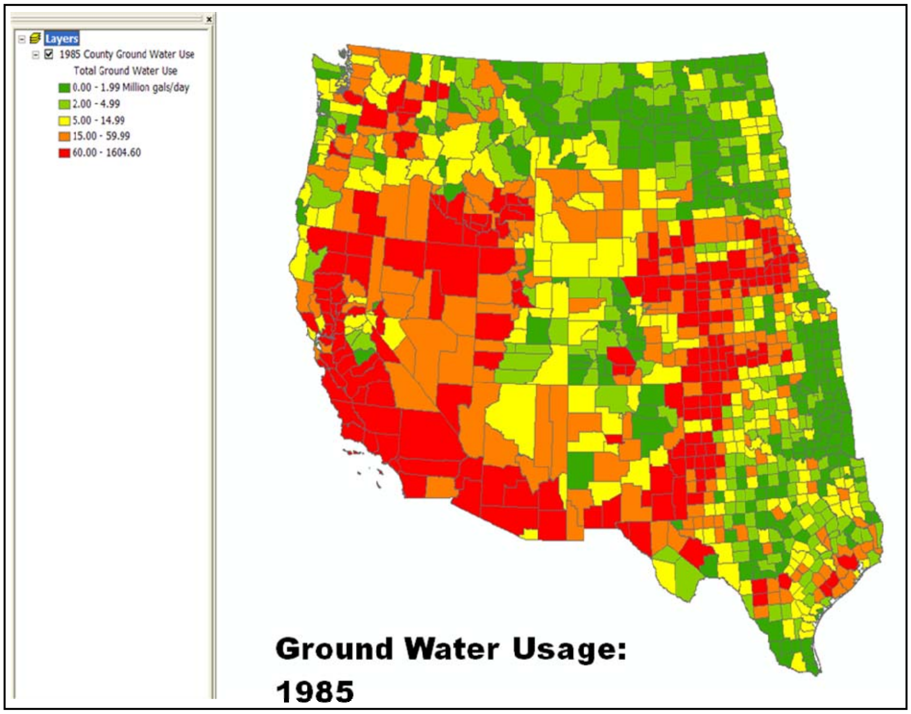

Figure 3: Ground water usage in 1985. Source: USGS.

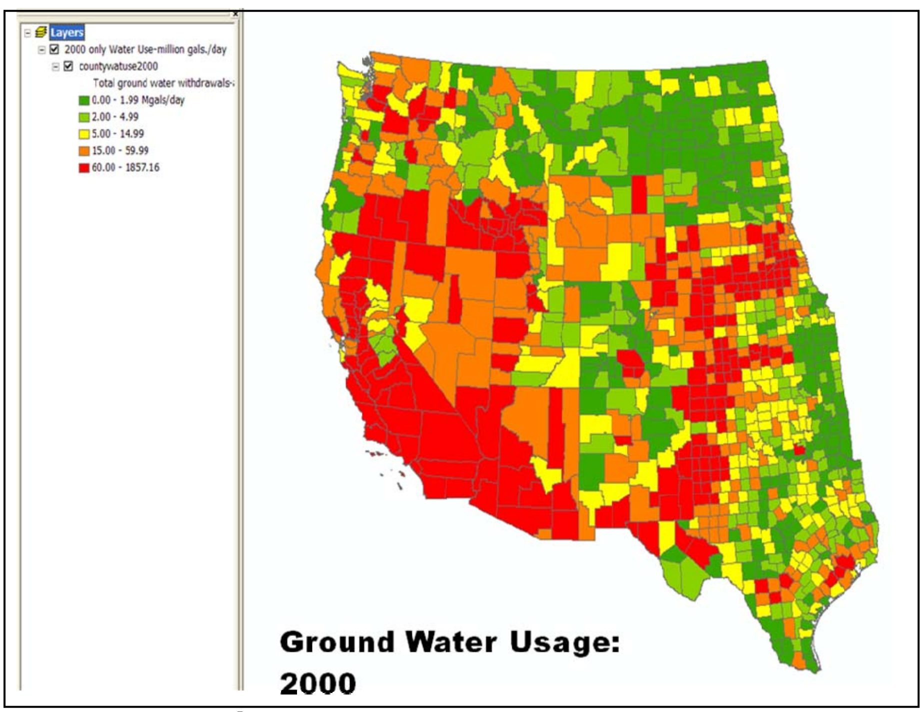

Figure 4: Ground water usage, 2000. Source: USGS.

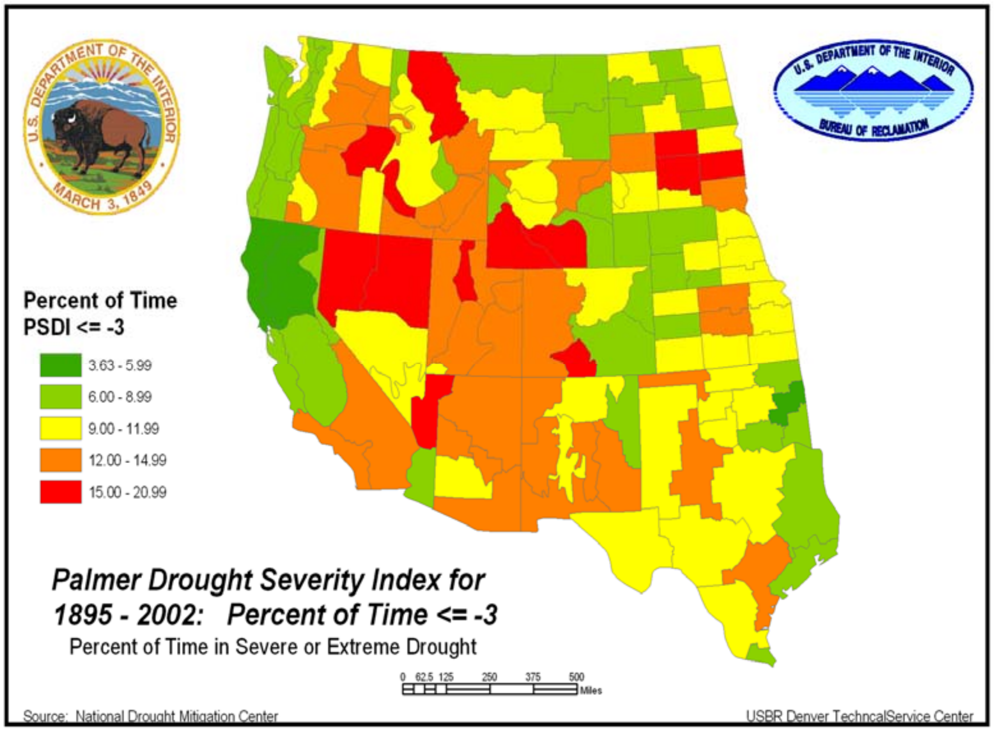

Figure 5. Drought severity in the Western United States, 1999.

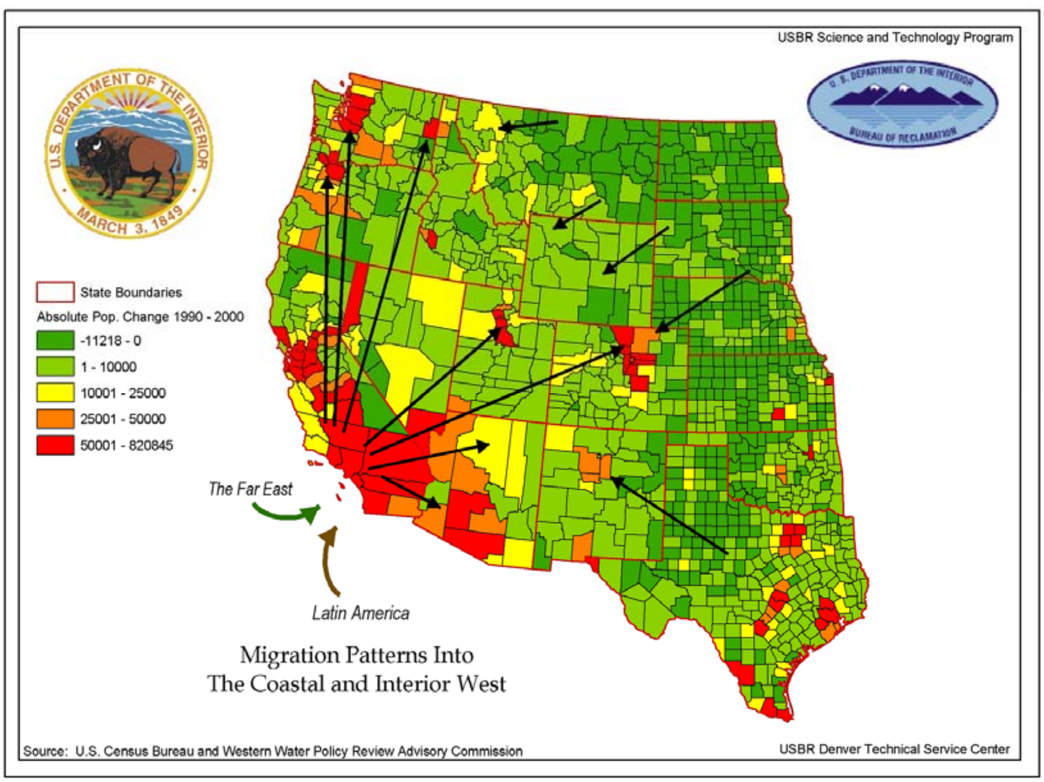

Figure 6. Trends in population migration in the Western US.

A large inventory of trend data were assembled including, but not limited to the following data themes: absolute and percentage population change, changes in irrigated lands over time, drought frequency, dry year surpluses and deficits, watershed health characterization, estimated changes in water withdrawals over time, changes in per capita water use, average annual precipitation, projected changes in water withdrawals in the future, population projections from 2010 to 2030, changes in water usage over time (e.g. domestic, public, industrial, mining, etc.), the spread of numerous types of invasive plants and animals, and changes in the spatial profile of endangered species over time.

In addition to mapping indicator data themes and trend themes, WWIN team compiled hundreds of pages of textual data from a 2002 Region an Area Office survey undertaken by Director of Operations, Jack Garner, to determine the prime predictors of water conflict *as perceived by Reclamation water managers* in Regional and Area offices (Figure 7).

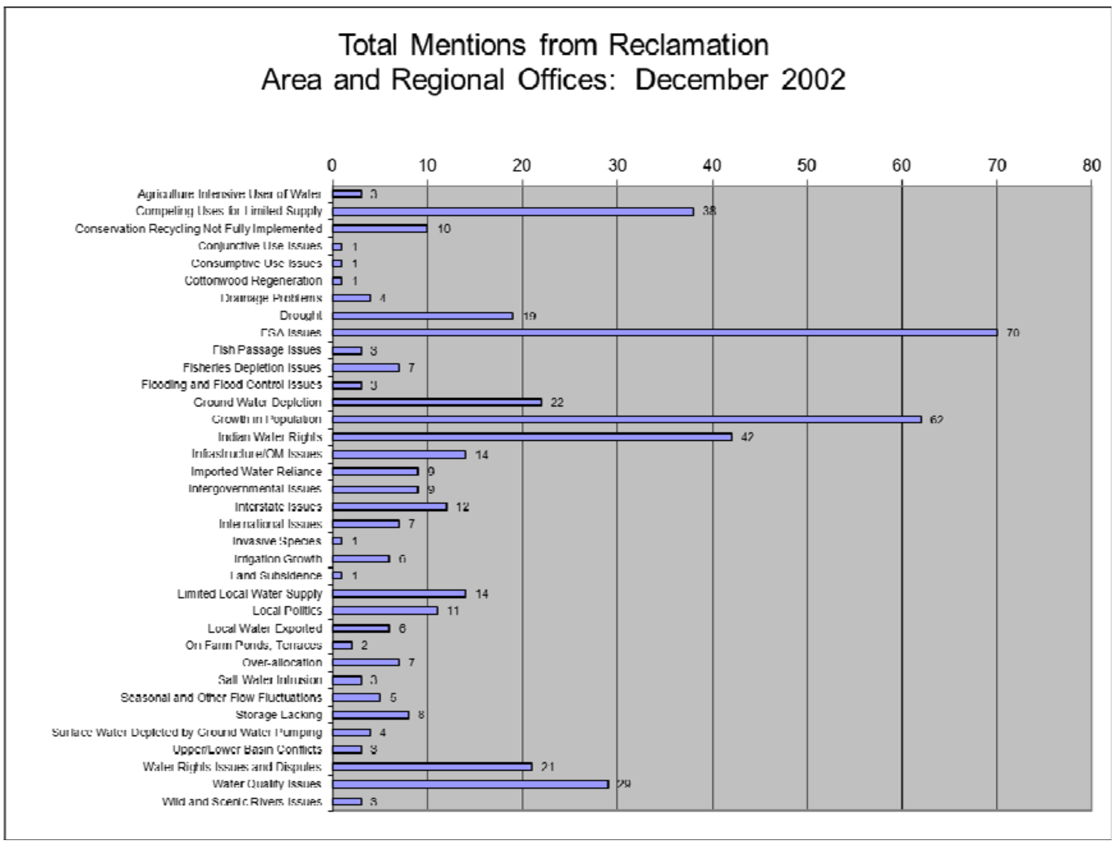

Figure 7: USBR Managers’ predictors of water conflict.

A pin map of locations described in this survey was developed to show the spatial distribution of water conflict in the Western US (Figure 8).

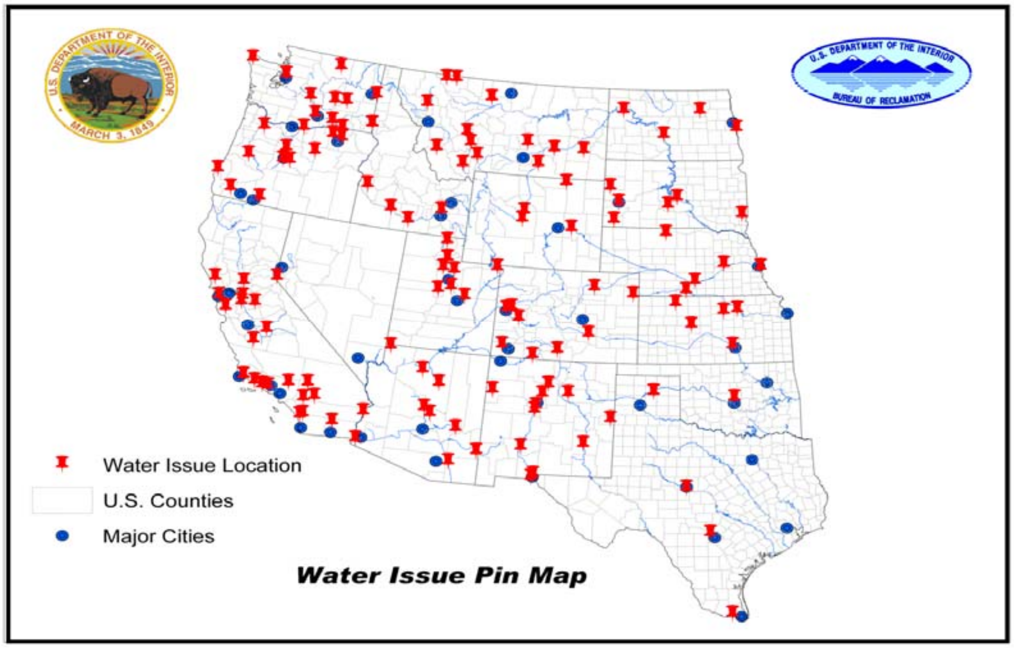

Figure 8: Pin map of water managers' descriptions water conflict in the Western U.S.

In addition, the managers surveyed were asked to graphically portray areas of potential conflict in the Western US by 2025. Figure 9 is a compilation of those graphic portrayals.

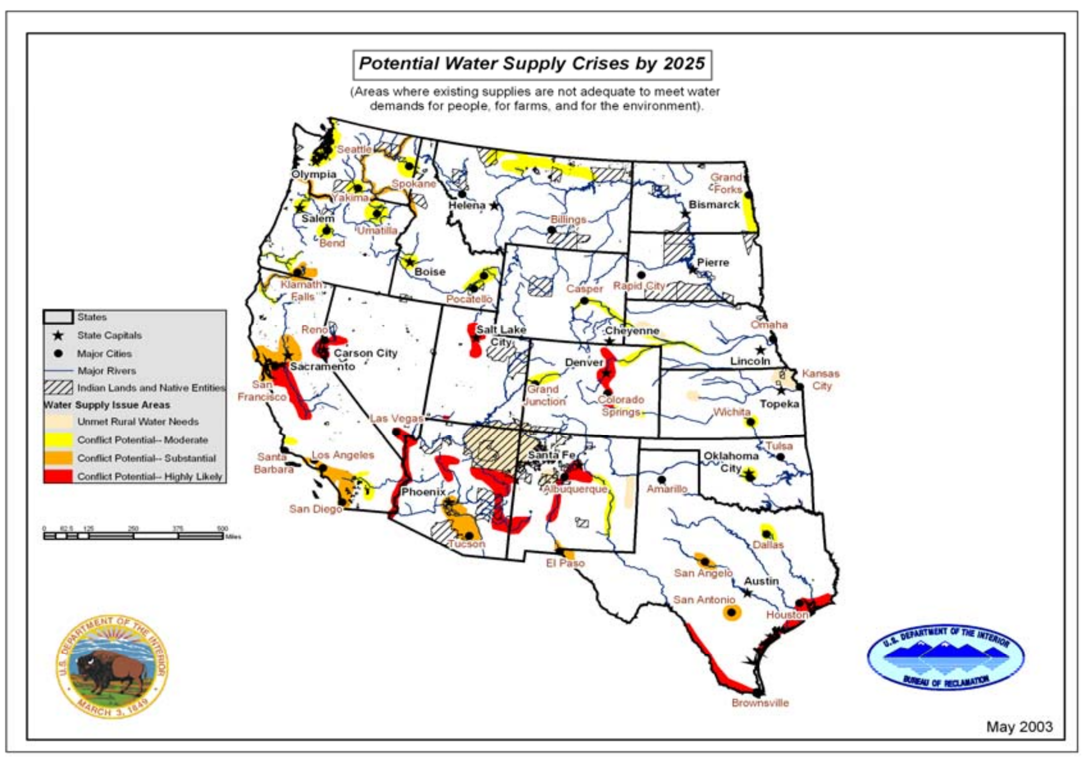

Figure 9: Areas of potential water supply crises by 2025.

During the latter years of the WWIN project, the team compiled massive spatial databases of detailed current and historical data for a more localized areas: the San Juan and Gunnison Rivers. Figure 10 illustrates one of the data themes:

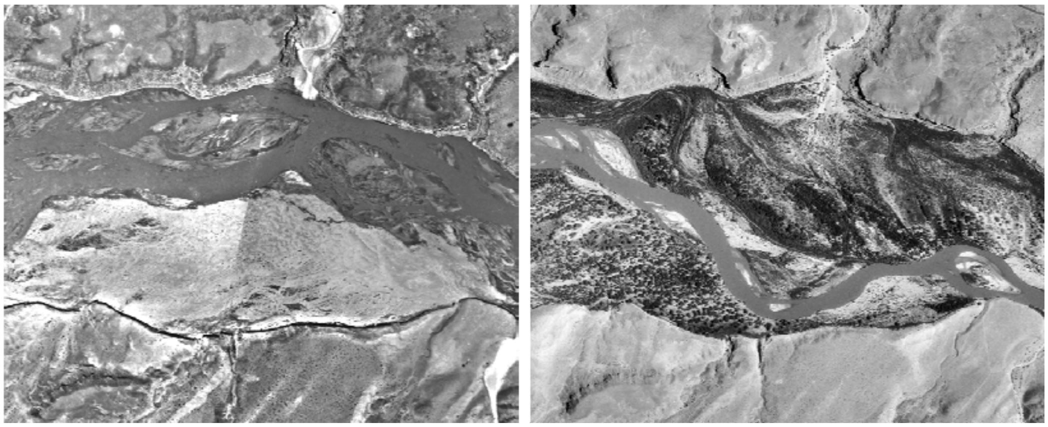

Figure 10: Vegetation on the San Juan River pre-dam (1945-left) and post dam (1990-right).

These databases were delivered to the Upper Colorado Regional Office in Salt Lake City. They contained detailed historical photography, demographic data, T&E and invasive species data, water use profiles, drought data, Reclamation lands, hydrography, ortho-photography (current and historical), climate trends, ground water, Indian water rights issues, land use, TMDLs, fish capture, and night-time imagery, among many others. Taken together, these themes showed the evolution of those basins as extensive human habitation became a reality.

Examination of these data generated numerous questions. For instance, what is the quantitative relationship between the spatial data predictor variables and the phenomenon of water conflict? A way had to be found to join conflict events to spatial data predictors. The first challenge was to scale conflictive and cooperative events related to water resources. Dr. Aaron Wolf of Oregon State University (OSU) had conducted a number of studies that made use of an event scaling system. Over 8000 conflictive or collaborative water-related events appearing in the media that had occurred in the UC Region were coded on the conflict-cooperative scale by a team of scholars at OSU. This data set was joined with the spatial data set. The top 8 boxes of Figure 11 illustrate the processes used for joining together the spatial and the events data. Figure 12 illustrates a typical statistical distribution of conflictive and cooperative events. Notice that the event types for each scale increment are carefully defined at the right.

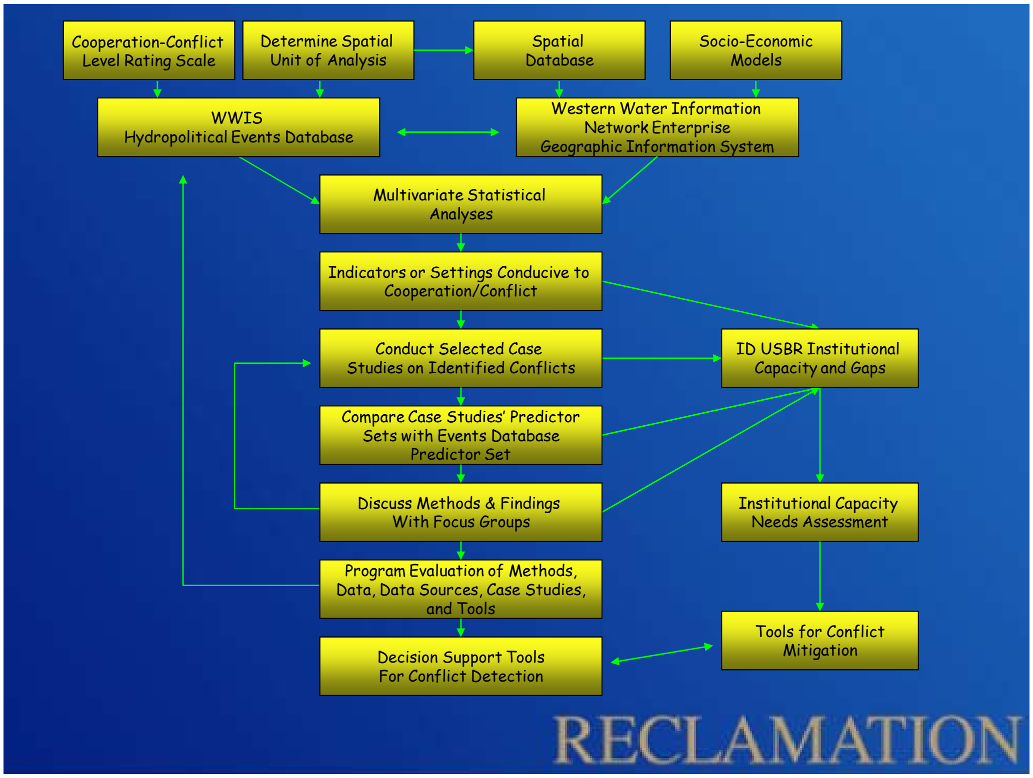

Figure 11: Joining the events and spatial predictor data together.

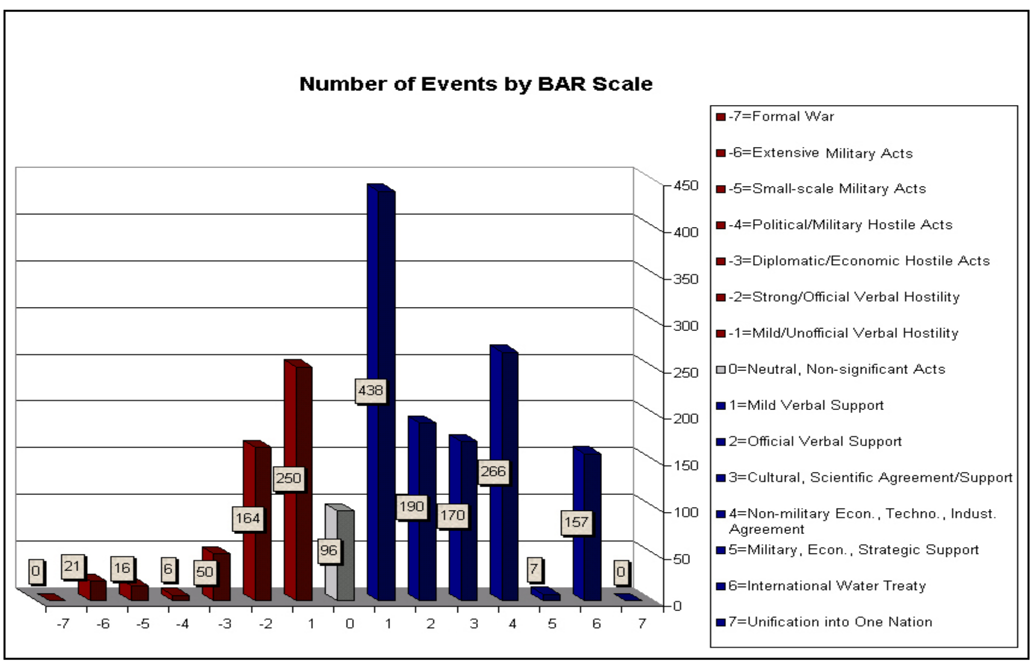

Figure 12: Water conflict event scaling.

Dr. Wolf and Nathan Eidem then used multiple correlation and regression analyses to quantify the relationships between the scores on the 8000 events and the values of the predictor data set and found that (a. most of the events were cooperative, and (b. there were no statistically significant indicators of hydropolitical intensity. This led to the further hypothesis that differences in institutional capacity could explain the spatial distribution of water conflict in the UC, i.e. some basins were better prepared with institutional contingency plans, water basin organizations, interbasin treaties, and the like.

Drought severity was hypothesized to contribute to water conflict. Analysis of timelines, though, which measure the impacts of major turning point events, showed no consistent relationship between drought severity and intensity. In terms of stakeholder involvement, local, state, and federal government agencies each showed the highest percentage of involvement in unique and discrete issue categories. The Federal government showed the highest percentage engagements in water quality issues, while states were showed the highest percentage for water rights issues, and local governments showed the highest involvement with infrastructure issues. Regional governments (i.e. Colorado River Commission) and conservation districts had the highest percent of their involvement in *cooperative* interactions, while the stakeholder groups with the highest percentages of involvement in *conflictive* events were railroads and environmental groups.

Hosted Workshops

The Western Water Information Network research and development group hosted an interagency work shop on March 30 and 31 of 2005 to develop interagency collaborative data sharing and information management mechanisms. Reclamation identified data and information that would enable Western water managers to be more forward-looking in identifying key trends and emerging issues that drive water availability to meet multiple demands. Potentially collaborating agencies included the USGS (National Biological Information Infrastructure, Biological Resources Discipline, Water Resources Discipline, National Center for Earth Resources Observation & Science, National Geospatial Programs Office, National Water Quality Assessment Program), the U.S. Army Corps of Engineers (Remote Sensing/GIS Center, Northwestern Division Water Management, Office of Technology Transfer), and the Bureau of Land Management.

Director Maryanne Bach and Chuck Hennig represented Reclamation’s Science and Technology Program. Kathy Holley attended from the USBR Office of Policy. Members of the TSC and regions also attended. Robert Worrest, Chief Scientist for the National Biological Information Infrastructure, spoke in behalf of his agency, along with John Mosesso, Annie Simpson, and Cara Campbell. William Horak, Associate Regional Hydrologist for the Central Region and Scott McEwen spoke in behalf of the USGS Water Resources Discipline. Bryan Baker, Martha Bullock, Johnette Shockley, and Tim Pangburn represented the Army Corps of Engineers. The Army Corps of Engineers was working on a major enterprise geographic information system application for the Missouri River Basin. Kristine Verdin of the EROS Data Center spoke about the Elevation Derivatives for National Applications program. Dennis Kubly from the USBR UC Region office spoke on the subject of conflict and cooperation in water resource management. Reclamation's Michael Beaty, Greg Gault, Kurt Wille, and Douglas Clark made a joint presentation on the Western Water Information Network. The National Water Quality Assessment Program and the USGS Technology Assessment Team also made a presentation.

Interagency work groups were established to identify and collaborate on mutually beneficial projects to support water supply in the West. The primary workgroups were with the National Biological Information Infrastructure Office of the USGS and the National Institute of Invasive Species Science. The two efforts were designed to provide for the stewardship of Reclamation biological data, specifically data related to threatened and endangered species and invasive species.

Portals provide a single focus point of access on the web to information assembled on specific topics. The WWIN team, in conjunction with the USGS, presented a subsequent workshop on USGS/NBII implementation of portal technology for the biological and natural resources community, and also discussed opportunities for collaboration between the agencies. The sessions focused on public portals, various tools, case studies, and strategies for acquiring capabilities.

The National Institute of Invasive Species Science (NIISS), a consortium of governmental and nongovernmental partners, led by the USGS, aims to provide reliable information and advanced decision support tools for documenting, understanding, predicting, assessing, and addressing the threat of invasive species in the United States (see: www.NIISS.org). The Western Water Information Network (WWIN) group worked with this institute to make geographic data on non-native and invasive species available to water managers in the West using enterprise geographic information technology. A meeting at the TSC was held to further this work.

The NIISS website is a forum for land and water managers to share information for the management of non-native species. Users can upload their data using the website tools, use the website as a data management system with the ability to edit data and create metadata, integrate their data with others, conduct analyses on data or the merged data, create maps to save or print, and download any subset of the data. The WWIN project worked on ways both to harvest data from the site and to contribute Reclamation-generated studies and geographic data to the site. In fact, Reclamation was successful in uploading biological data from the San Juan project to its portal.

Reclamation generates immense amounts of T&E species and invasive species data that require stewardship. The NBII and the NIISS are organizations that can provide for the final disposition of these data; however policy is required to implement this measure.

Reclamation Lands Data

The WWIN effort succeeded in developing the very first graphic representation of Reclamation lands, a process that took several years and was finished after the WWIN Project reached completion. Real property information was originally maintained as tabular databases. The WWIN project contracted with Premier Data Services to convert the land records in the Foundation Information for Real Property Management (FIRM) database to GIS compatible, polygons on a 1:100,000 Public Land Survey System (PLSS) grid. Besides the map, this initiative also produced a summary report on the FIRM data conversion effort that identified problems encountered, an error log analysis, and suggested methods to reduce deficiencies in the data. WWIN also provided an updated FGDC standard metadata record. By then end of the effort more than 75,000 lands polygons had been mapped.

Threatened and Endangered Species Locator

Using project funds, the WWIN project purchased data from NatureServe showing the spatial extent of threatened and endangered species in the Western United States. Project staff also conducted a survey to determine which Reclamation operations could potentially impact endangered species. These two data types were combined in a map application to create the T&E Species Locator. This tool allowed a manager to click on a species of interest and then map the spatial extent of that species.

Lessons Learned

A variety of data quality issues arose during the course of this project. The first had to do with authoritative data. What agency, for example, maintains the authoritative data for impaired waters? Native American water rights disputes? Endangered species? There are many sources for water quality data at many levels of government. The WWIN team had to rely on a single individual to explain which counties were involved in Indian rights disputes. And many individuals and organizations track endangered species.

The second issue that arose had to do with the compatibility of the data. State demographers, for instance, conduct population projection analyses. But, each state has its own methodology and time horizons and so it is difficult to compare projection with projection. USGS water use data provides another example of this problem. The data are obtained from the states. Each state has, again, its own way of collecting data and each has its own way of determining exactly what uses domestic supply, public supply, industrial supply, etc. encompass. Some collect data for each USGS category of use, and some do not. So, inter-comparison is problematic.

Data perishability is another important issue. Human, plant, and animal populations are dynamic. The lithosphere, hydrosphere, and atmosphere are also dynamic. But, data sets are snapshots for a single period of time. So, data must constantly be replenished. Replenishment incurs sometimes great cost, time, and effort. New teams of scientists must be dispatched to the field. New aerial photography must be flown. Data bases must be created or updated. And, then, of course, once the data sets are compiled by one agency, they must be discovered and acquired by a user, put into a common projection, and maintained. All of this is labor intensive.

Finally, data sets are gathered at different times. So in a GIS application one might have invasive species data, T&E species data, demographic data, climate data, water use data, and water quality data all gathered at slightly or significantly different times. To be useful for water managers, an enterprise database dedicated to understanding and managing water conflict needs to resolve these various data quality issues.

But other challenges also exist. Overall, conflict exists between Reclamation needs-wants and agency IT standards. Lack of consistency in Reclamation IT standards, processes, and decision-making can complicate and impede the design and implementation of a major application. The development of IT systems or changes to existing systems needs to be coordinated through the CIO's office. Development of standards for and refreshing content requires designated data steward. Obviously, content is not owned by BORGIS; it is owned by programs. Dam Safety has been exemplary in this regard.

Another issue arose with biological resources data. The world of biological resources data is much more complex and more extensive than ever anticipated. As USGS NBII, NatureServe, and other sources of information and expertise mature in their enterprise strategies, data sharing and technology transfer opportunities increase. Reclamation needs to further develop its capacity to apply enterprise strategies to managing biological resources data. For Reclamation, this will entail developing a bureau wide biological and ecological sciences community that includes subject matter experts in these areas and data stewards to develop data standards and implement data management best practices. The bureau wide Lands, GIS, and Surveying Workgroup is a good example of such a community at work. Lack of geospatial standards limits data reusability.

DataSpace

In the wake of the WWIN Project and using lessons learned from that project, Reclamation began deploying and operating a bureau wide system based on WWIN prototype system. The team developed prototype system architecture for Reclamation-wide (enterprise) distributed GIS system. It deployed web services technologies for delivery of geospatial data and imagery content; acquired technical expertise and developed organizational capacity through the Bureau of Reclamation Geographic Information System (BORGIS) to support continued development and deployment of distributed architecture; implemented BORGIS Bureau Tier node with hardware and software acquired and installed at the Denver Office.

As of fall 2007, BORGIS Regional Tier nodes were installed at Pacific Northwest and Lower Colorado Regional Offices, with planning and development underway for the Great Plains, Mid-Pacific, and Upper Colorado nodes. The WWIN prototype led the development of the BORGIS Node Architecture and Geospatial Library for acquiring, managing, and distributing multi-scale (resolution) geospatial data and imagery bureau wide; Geospatial Library deployment was initiated Fall 2007 and included work processes and data management tools (DataSpace and Enterprise Data Manager), along with applicable user support, guides and training modules, for GIS users at Bureau, Regional, and Local (Area and Field Office) organizational tiers.

Beginning in FY2008, this bureau wide effort was sustained through CFOC approved Business Cases for the BORGIS and NSDI (National Spatial Data Infrastructure) Working Capital Funds. The BORGIS Geospatial Library also included USBR Interests, a geospatial database model and prototype developed through WWIN to include Reclamation projects, irrigation districts, lands, dams, and facilities; this effort is coordinated with and supported (in part) by Reclamation's Land Resources Management (LRM) Program and the Regional Realty

Officer's chartered Lands, GIS, and Survey Workgroup. A detailed description of the DataSpace capability can be found at: Users Guide .

Putting together an GIS application showing the basins in question and related information is now a simple matter. Most relevant data sets are part of the DataSpace console. Possible data layers might include: topography, wetlands, hydrography, Federal lands (including Reclamation lands), climate and meteorological data, geologic data (including soils), PLSS boundaries, ground water data, water quality data, political boundaries, demographic data, and transportation corridors.

All of these data layers are readily available through the Reclamation capability called the BORGIS Dataspace Console. A list of Dataspace layers is listed in Appendix I. To set up Dataspace in a Reclamation office where it does not currently exist, contact the BORGIS System Management Team:

Kurt Wille: 303-445-2285
Bruce Whitesell: 303-445-3387
Greg Gault: 208-378-5325

APPENDIX I: DATASPACE LAYERS

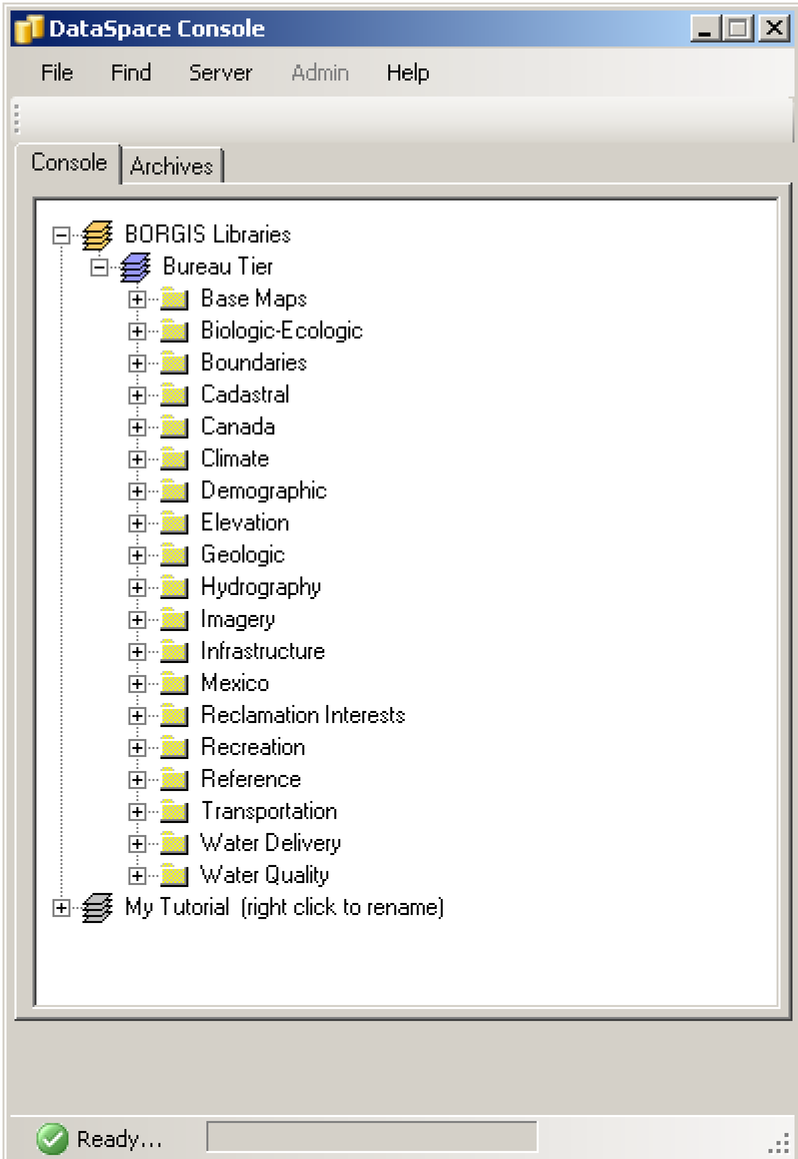

Figure 1: Overall look

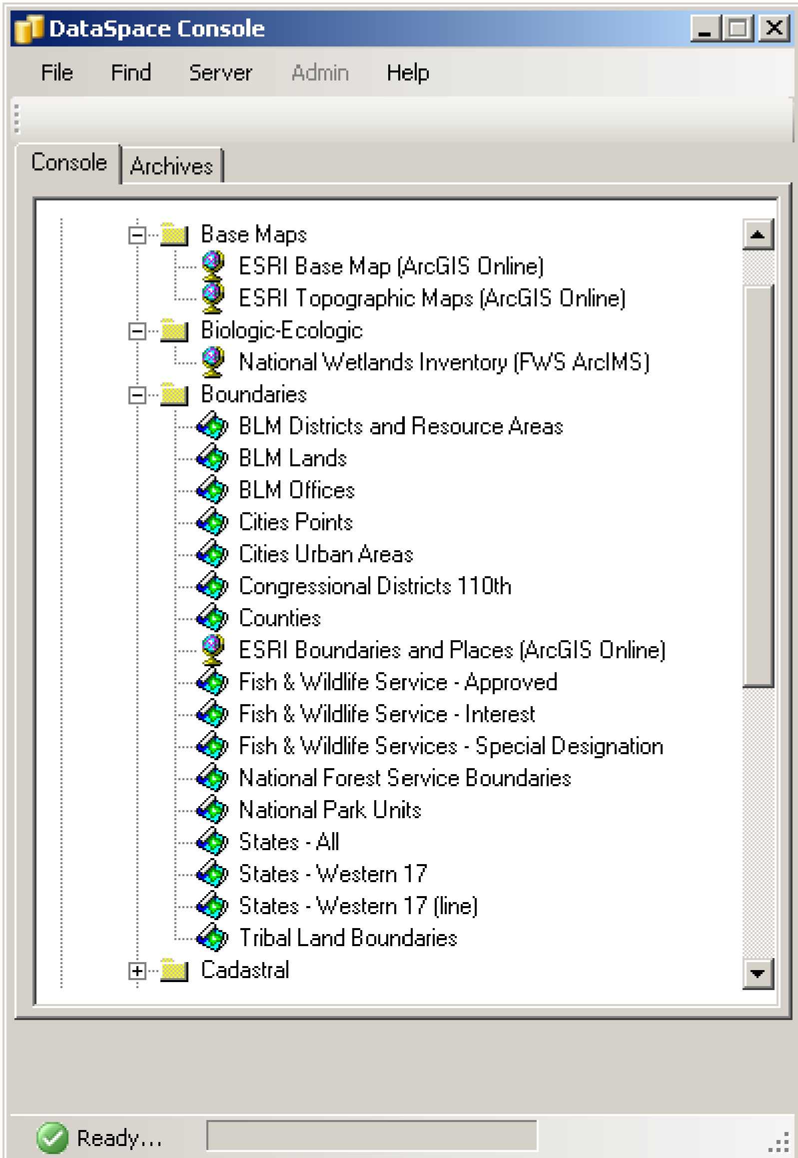

Figure 2: Base Maps and Political entities

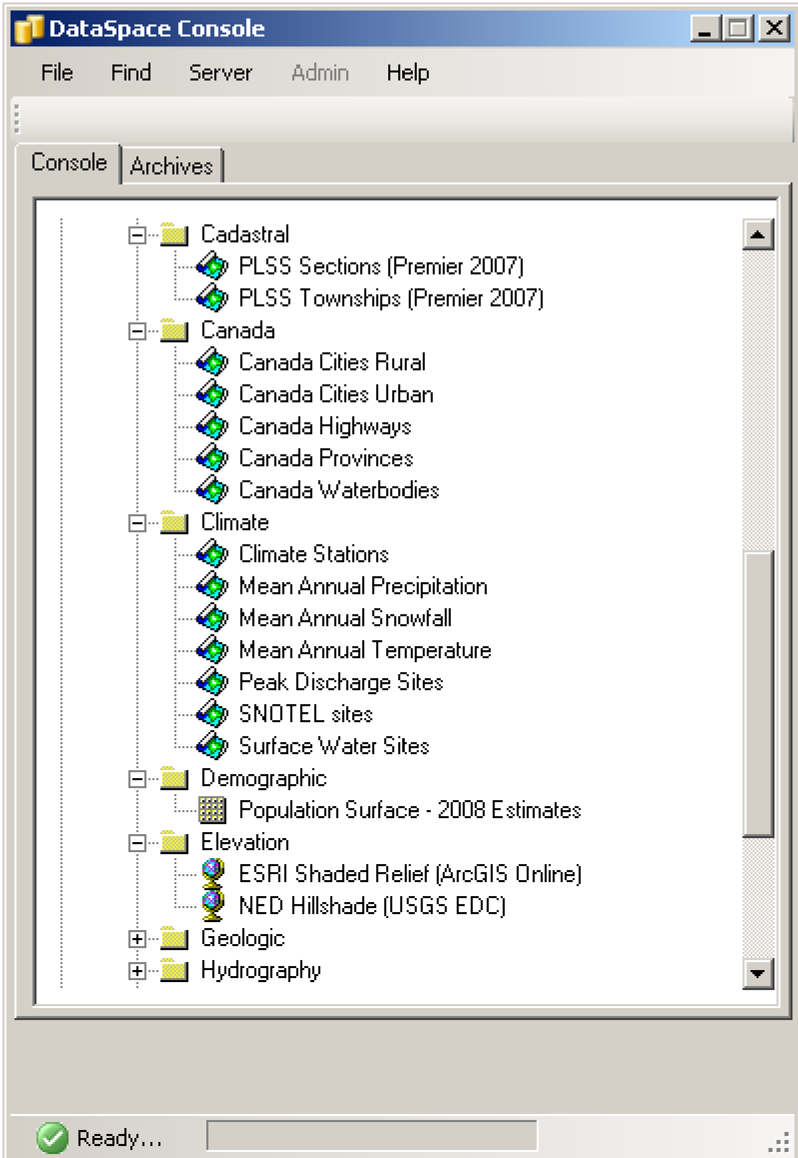

Figure 3: Cadastral, International, Climate, Demographic, and Elevation Data

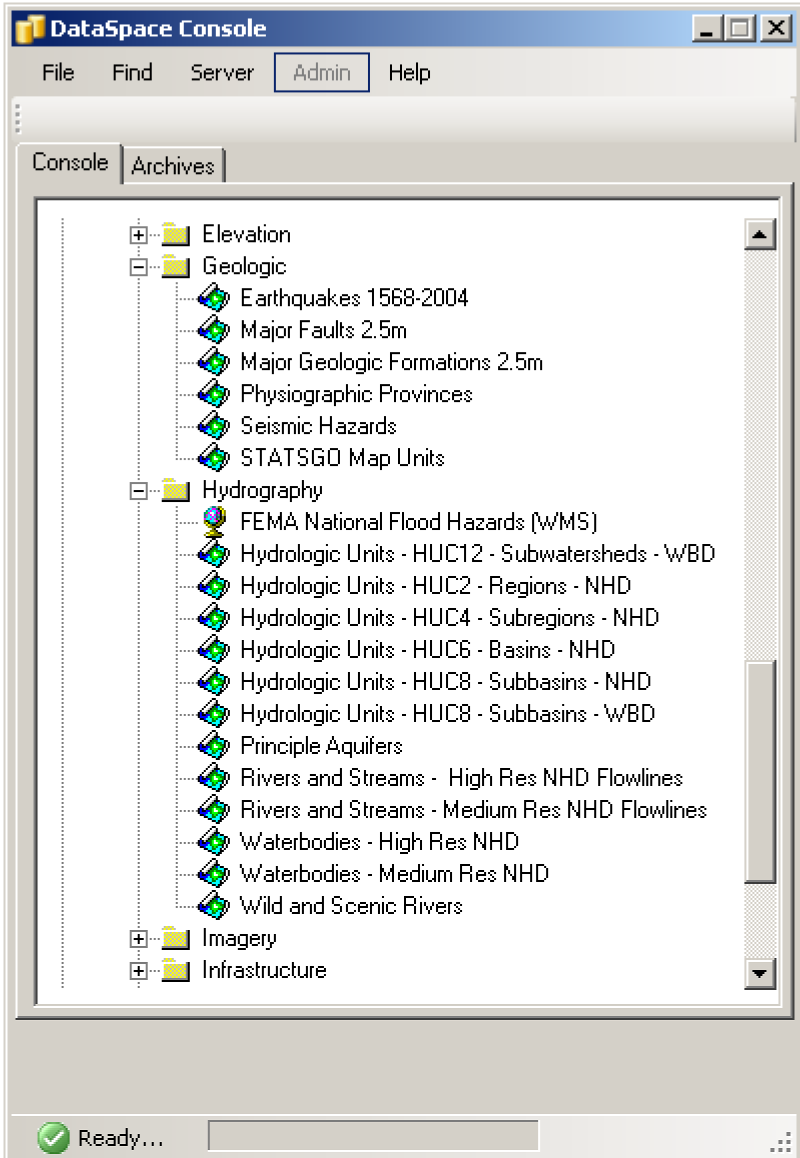

Figure 4: Geologic and Hydrographic Data

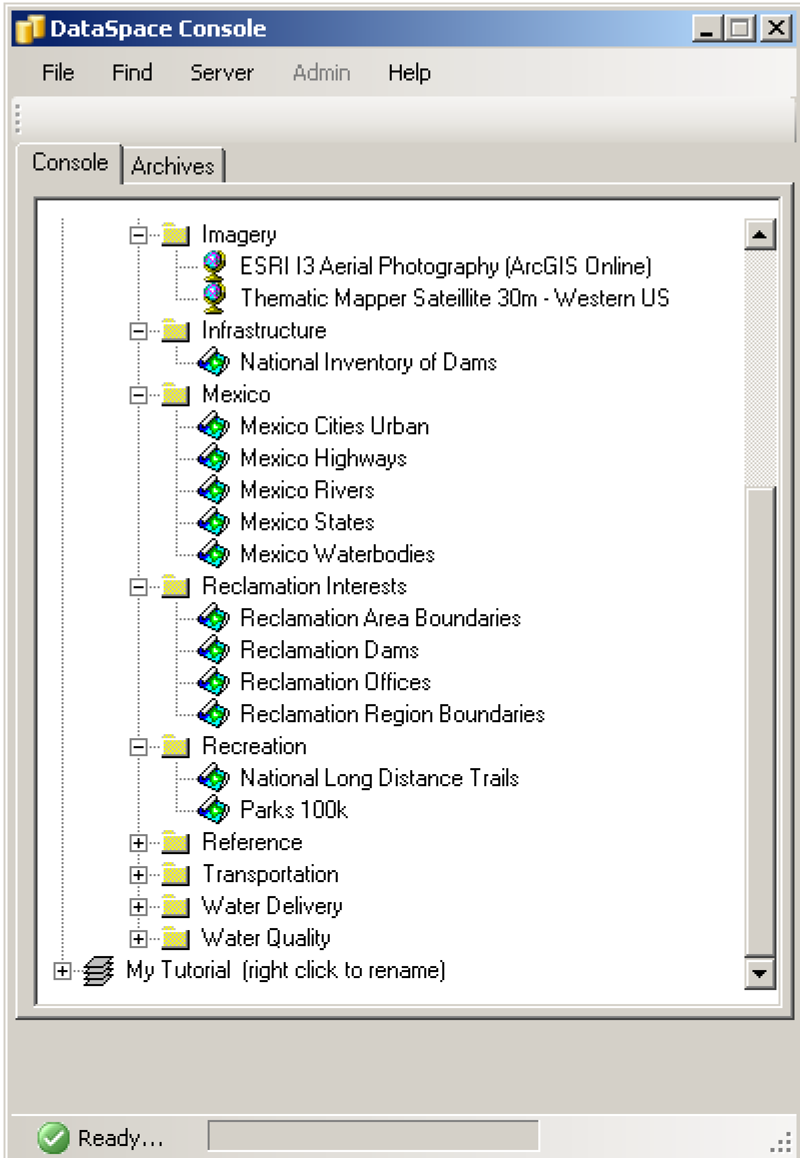

Figure 5: Imagery, Infrastructure, International, Reclamation Interests, Recreation

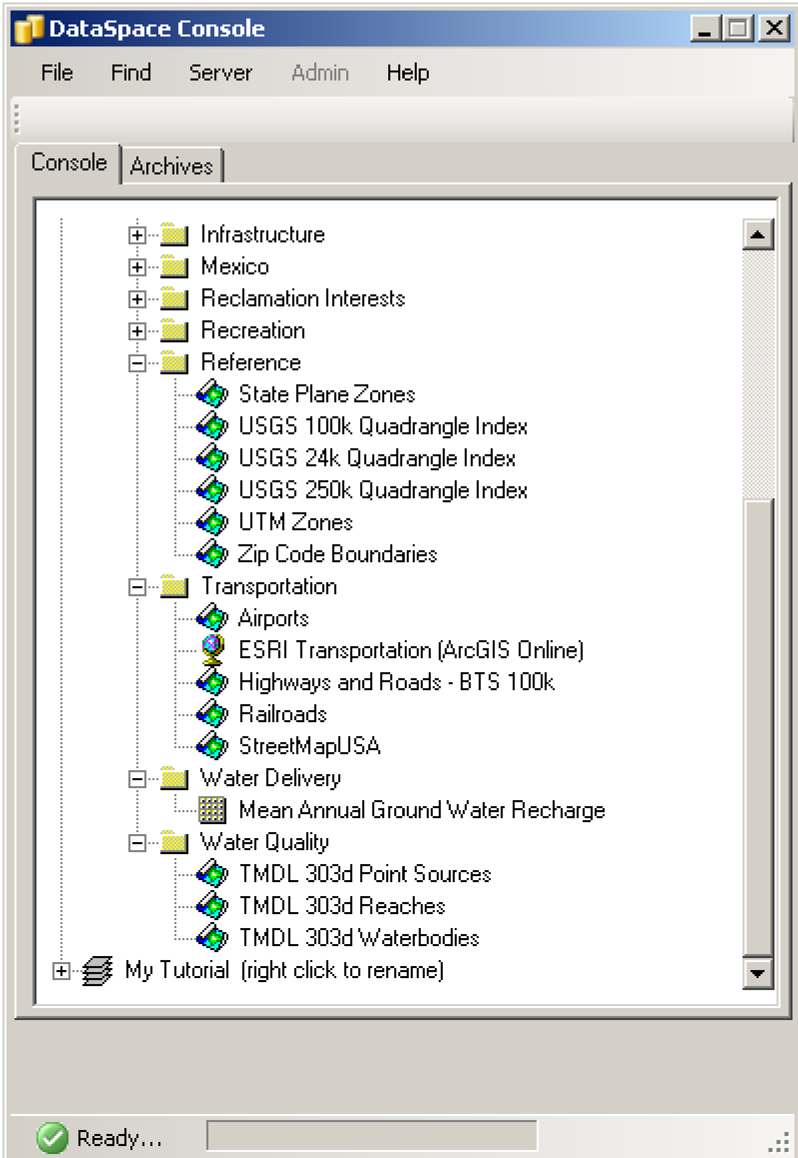

Figure 6: Reference, Transport, Water, and Water Quality Data Sets