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Paso del Norte Watershed Council
Coordinated Water Resources Database Project

Technical Completion Report No. 327
New Mexico Water Resources Research Institute
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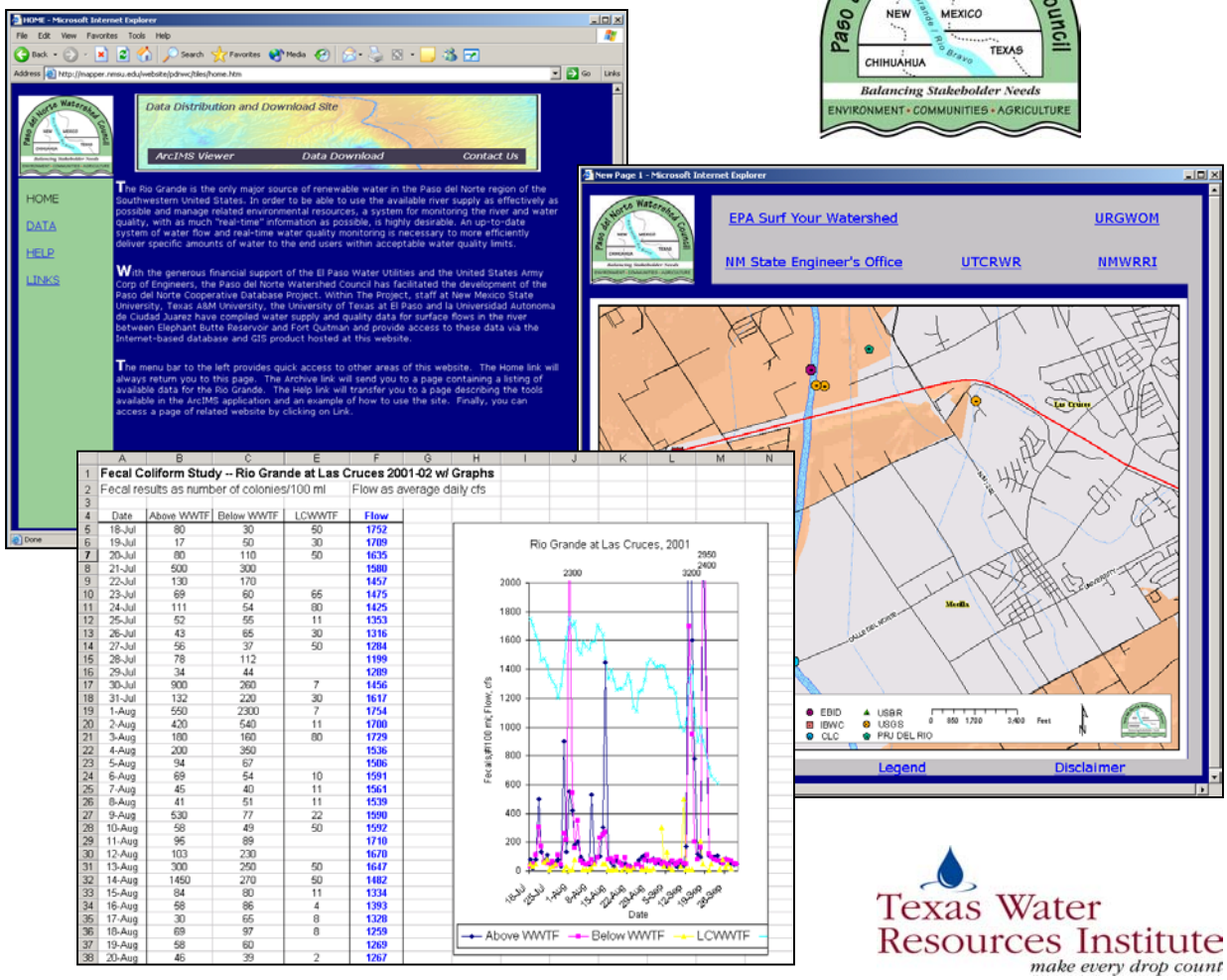

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PASO DEL NORTE WATERSHED COUNCIL
COORDINATED WATER RESOURCES DATABASE PROJECT

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TECHNICAL COMPLETION REPORT

Account Number 01423989

January 2004

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Texas A&M University – Texas Agricultural Experiment Station
Universidad Autónoma de Ciudad Juárez (UACJ) – Centro de Información Geográfica
University of Texas at El Paso (UTEP) – Center for Environmental Resource Management

Compiled on behalf of the Paso del Norte Watershed Council
Cooperative Water Resources Database Technical Committee for
The El Paso Water Utilities

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ABSTRACT

The Paso del Norte Watershed Council (PDNWC) is a quasi-governmental organization that serves in an advisory capacity to the New Mexico-Texas Water Commission regarding the selection, planning, and implementation of environmental enhancements and mitigations associated with the El Paso-Las Cruces Regional Sustainable Water Project. The Council recommends policies for cooperation, coordination, and the sharing of information concerning planning and management activities of projects affecting the Paso del Norte Watershed, this being defined as the Rio Grande Basin between Elephant Butte Dam/Reservoir in southern New Mexico and Fort Quitman, Texas.

In the last several years, the Watershed Council has discussed the development of a regional cooperative database project that would provide streamlined access to a range of water resource data in the Paso del Norte region. In August of 2002, the El Paso Water Utilities provided initial funding to the Paso del Norte Watershed Council to develop a pilot cooperative database project, and efforts toward the development of such a project have been ongoing. This document is the final report for this effort. In this report, we detail the following elements of the project, as specified in the initial Scope of Work:

1) The background, motivation, and intended outcomes of the project,
2) The specific tasks that were undertaken in project development efforts,
3) The specific insights that we have gained in this pilot effort,
4) Specific recommendations for new water quality monitoring sites and equipment, and
5) An outline of tasks that should be undertaken in future phases of the project.

All deliverables specified in the project have been completed, and we also note the following recommendations for future project work, as detailed in the latter part of this report:

- Complete migration of the Project website and related databases to the ArcIMS software,
- Installation of new monitoring stations and equipment as detailed above, and inclusion of these monitoring sites in future ArcIMS map products,
- Enhanced levels of funding to be directed to support more active participation of regional volunteer data providers and to bring new providers into the project,
- Exploration of scripting and automated FTP routines or a batch mode of data transfer to allow progress on the “user interface plateau” discussed in the report,
- Inclusion of groundwater data into future phases of the project,
- Linking the EPWU-funded project to USACE-supported database efforts, and
- Additional funding to be provided to lend institutional support to the Watershed Council and also to fund future Cooperative Database Project activities.

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INTRODUCTION TO THE REGION AND RELATED WATER RESOURCE DATA ISSUES

The Rio Grande is the only major source of renewable water in the Paso del Norte region within which El Paso, Texas, Las Cruces, New Mexico, and Ciudad Juárez, Mexico lie. Although the region possesses considerable groundwater resources, present rates of groundwater extraction clearly outpace recharge, making groundwater an important, yet finite and nonrenewable water resource in the region. To use the available river supply as effectively as possible, a system for monitoring the river flow and water quality, with as much "real-time" information as possible, is highly desirable. Several organizations have responsibility or research interest with respect to monitoring, use, and management of the river. These organizations include the International Boundary and Water Commission (IBWC), the U.S. Bureau of Reclamation (USBR), the United States Geological Survey (USGS), Elephant Butte Irrigation District (EBID), El Paso County Water Improvement District #1 (EPCWID #1), the El Paso and Las Cruces Water and Wastewater Utilities, The University of Texas at El Paso (UTEP), Texas A&M University, Agricultural Research and Extension Center at El Paso (TAMU/TAES), New Mexico State University (NMSU), water resource management organizations, health departments, and others. Many of these entities are engaged in monitoring the river, canal, and/or drain waters so that they can discharge their responsibilities effectively. In some cases, this information is gathered using near real-time technology, with each organization collecting and using the information it collects solely for achieving its mission. Even when this information is shared, it is not often done in a timely matter. This absence of real-time data sharing may lead to unnecessary duplication of effort and wasted dollars. For example, there are a number of sites within EPCWID #1 where the exact same parameter (i.e., flow) is measured by three different entities.

In the past, no easy avenue has existed for the compilation of this water quantity and water quality data into a single location or point of contact that serves the region. Currently, it is very difficult to assess water movement through the Paso del Norte region, from Elephant Butte Reservoir through Southern New Mexico and into Hudspeth and El Paso counties in Texas. This problem is particularly acute during storm events when floodwaters enter the river below Caballo Dam. During these flash-flood episodes, the USBR and IBWC are often faced with reacting to over-bank flooding and cresting of flood control levees. Integrated, real-time flood tracking on the Rio Grande during these events would allow for precise preventive actions at diversion dams and spillways to insure containment of floodwaters. The present method of dealing with flood surges involves predictive speculation and conjecture based on historical evidence, a less than reliable method for handling sharp increases in flow rates.

The monitoring and management of year-round flows in the river poses special data access issues. The El Paso-Las Cruces Regional Sustainable Water Project that was the focus of collaborative efforts of the New Mexico-Texas Water Commission (NMTWC) considered year-round release of some of the water stored in Elephant Butte and Caballo reservoirs. Since the completion of Elephant Butte Dam in 1916, very little water has been released to the river during the non-irrigation season, typically from November to March. Consequently, delivering water from Caballo Dam to El Paso for use in the City of El Paso's water treatment facilities during the non-irrigation season will require close monitoring of flow to ensure that proper amounts of water with appropriate quality are delivered at the prescribed times.

Continuous monitoring of water quality parameters that can be reliably measured on a real-time basis will also be useful for both agricultural and municipal planning, and for general watershed management activities. Although a fairly comprehensive compilation of conductivity

and other water quality data exists along the Rio Grande, there has not been a consistent approach to correlating these data to flow measurements, or development of predictive water quality models. This makes it impossible to predict accurately the flow regimes along gaining/losing stretches of the river as water travels more than 100 miles from Caballo Dam to El Paso. It also prevents tracking changes in salinity prior to, during, and after a reservoir release or storm event. An up-to-date system of water flow and real-time water quality monitoring is necessary to deliver more efficiently specific amounts of water to the end users within acceptable water quality limits. Immediate access to flow and conductivity measurements at existing monitoring stations is a logical step in the effort to manage and monitor the passage of Rio Grande flows more efficiently.

With respect to benefits, flood mitigation and water quality management strategies will become more responsive and less reactionary, making it possible to control flood surges better or bypass lower quality pulses. This new ability to retrieve flow and quality data for the entire stretch of the Rio Grande Project area will allow for the development of an integrated management plan by the USBR and IBWC for averting the over-bank flows resulting from storm events. The Federal Emergency Management Agency (FEMA) can utilize this information in their disaster response plans. Also, surface water treatment diversions can be planned and controlled more carefully. These and many other benefits will result from the open sharing of water quantity and quality information among the primary recipients of Rio Grande Project water: Mexico, EBID, EPCWID #1, and El Paso Water Utilities.

Such a cooperative database system also offers more general benefits related to the security, quality, and comprehensiveness of data holdings. Datasets that are more widely distributed will reside at multiple sites, reducing the likelihood of catastrophic loss should the

original dataset become corrupt. Wider dissemination of datasets will also aid in quality control and quality assurance of data, as greater availability of data will provide the opportunity for greater scrutiny by a wide range of users more likely to identify errors of omission and commission. The value of initially creating a set of information is multiplied significantly if that information is shared over a wide area, rather than confined to the dark recesses of one individual's desk drawer or filing cabinet. Lastly, wider distribution of data allows for improvements in the comprehensiveness of the data involved. As a greater number of users access and use data, gaps in data holdings are identified. With this comes the opportunity for these users to enhance the quality and comprehensiveness of datasets through subsequent contributions to the data holdings involved.

During the past several years, variations of an integrated database management system for water resource data in the Paso del Norte region have been proposed through different policy venues (Keyes 2001a and 2001b). As these discussions unfolded, the Paso del Norte Watershed Council (PDNWC) came into existence to provide guidance on environmental mitigation and enhancement activities related to the El Paso-Las Cruces Regional Sustainable Water Project. Past proponents of such a database management system proposed that the PDNWC undertake such an effort, and a Technical Committee representing the PDNWC developed a series of proposals. In August of 2002, the El Paso Water Utilities granted the funds necessary to undertake Phase I of the development of a Cooperative Water Resources Database Project, and a coalition of staff members from regional universities began the development of such a project.

METHODS AND DATA EMPLOYED IN THE PROJECT

In the first stage of the Project, a survey of existing sites on the World Wide Web was undertaken to determine how agencies and organizations that were serving similar data on the Web served these types of data. The goal of this early research was to answer several questions concerning how data were stored, how they were served, how spatial queries were handled, what range of metadata[1] were provided, and how tabular data were served. Results of this preliminary survey are included in Appendix A of this report; the following general trends were uncovered and summarized in Table One in the main body of the text.

1) Most data were centrally housed on a central server.
2) Both spatial and aspatial data were served.
3) Tabular data, including HTML tables and Excel files, are available as downloads.
4) Spatial queries are handled by a keyword mechanism or a spatial area of interest tool that users define through the use of a mouse on some form of map.
5) Metadata being served ranged from those that were fully compliant with the Federal Geographic Data Committee/Spatial Data Transfer Standard to the most basic of elements (source, spatial extent, date of data capture or update, variables or data elements involved, format, and access information). Some sites provided no metadata at all.

[1] Metadata are ancillary information about the core data elements, including date of data collection and update, source of data, and type of data. These elements will be discussed in greater detail later in this document.

Site name	Search capabilities	Data types	Spatial area of interest tool	Download method and format	Database type	ArcIMS Capable	Metadata
PAG Regional Data Center	None	GIS data	None	FTP of Zipped files	Warehouse and distributed	Yes	Basic elements
PDNMapa	Menu driven	GIS data	None	FTP of Zipped files & images	Warehouse and distributed	Yes	None
RGIS	By text and extent with keywords	Tabular and GIS data	None	FTP of Zipped files	Warehouse	Yes	FGDC compliant metadata
SANDAG	None	GIS data	None	FTP of Zipped files	Warehouse and distributed	Yes	Basic elements
TCEQ	Limited text search and online queries	Tabular datasets	None	FTP of Zipped or EXCEL files	Warehouse	Yes	None
TNRIS	By text	GIS data	None	FTP of Zipped files	Warehouse and distributed	Yes	Basic elements
TWDB	None	HTML tables and graphs	None	FTP of tab delimited text files	Distributed	No	None
USGS	None	HTML tables and graphs	None	FTP of tab delimited text files	Warehouse	No	None
PDNWC Website	None	Tabular data, Tables, & EXCEL files	"Clickable" icons and Image Maps	FTP of tab delimited text files	Warehouse and distributed	Yes	Basic Elements

Table One – Summary of on-line database websites serving water resource data (See Appendix A for greater detail on sites)

Based on this research, the Technical Committee established a set of protocols by which the Project would be developed, as detailed below:

1) Project data would be stored and managed through a data warehouse model on a centrally managed server.
2) Tabular data would be handled as downloads of Excel or .dbf files, not HTML tables or "cartoons."
3) The portal to data holdings will be based on an Internet Map Service (IMS), put in place through the use of ESRI ArcIMS software. The ArcIMS will serve a seamless, binational, geographic information system (GIS) water resources dataset previously developed by researchers at the New Mexico Water Resources Research Institute (NMWRRI), la Universidad Autónoma de Ciudad Juárez, and The University of Texas at El Paso, with funding support by the Hewlett Foundation (NMWRRI 2002).
4) The IMS would then page out to pre-clipped map tiles of sub-reaches of the Rio Grande, these map tiles being image maps that would link to actual data holdings via "clickable" spatial features on the GIS map tiles.
5) The key basic metadata elements would also be served on the Project website, these being data source, spatial extent, date of data capture or update, variables or data elements involved, format of data, and access information.

With the above protocols in place, Project staff at NMSU and TAMU/TAES began working with regional data providers to identify data holdings of interest to the Project, to determine how best to access the data, and to make arrangements for such access, either via a direct link to existing webpages or though the actual transfer of data. At this point in the Project, members of the Technical Committee realized that it would be more efficient to employ a portal and distributed database storage model, as opposed to the data warehouse model identified previously. Various data providers have extended a major effort to serve their data holdings on the web, and it was not seen as an efficient use of Project resources to transfer all of these data just to house them internally to the Project. A question was also raised as to whether replication within the Project server of datasets housed elsewhere was an efficient use of Project resources.

As efforts to compile actual data sets of water resource data were ongoing in the region, Project staff began work on the IMS and GIS maps that would provide the ability to reference spatially the datasets involved and also provide a spatial query tool by which data could be

accessed. The manner by which these various data tools and map elements interact to drive the database website are detailed in Figure One in the main body of the text.

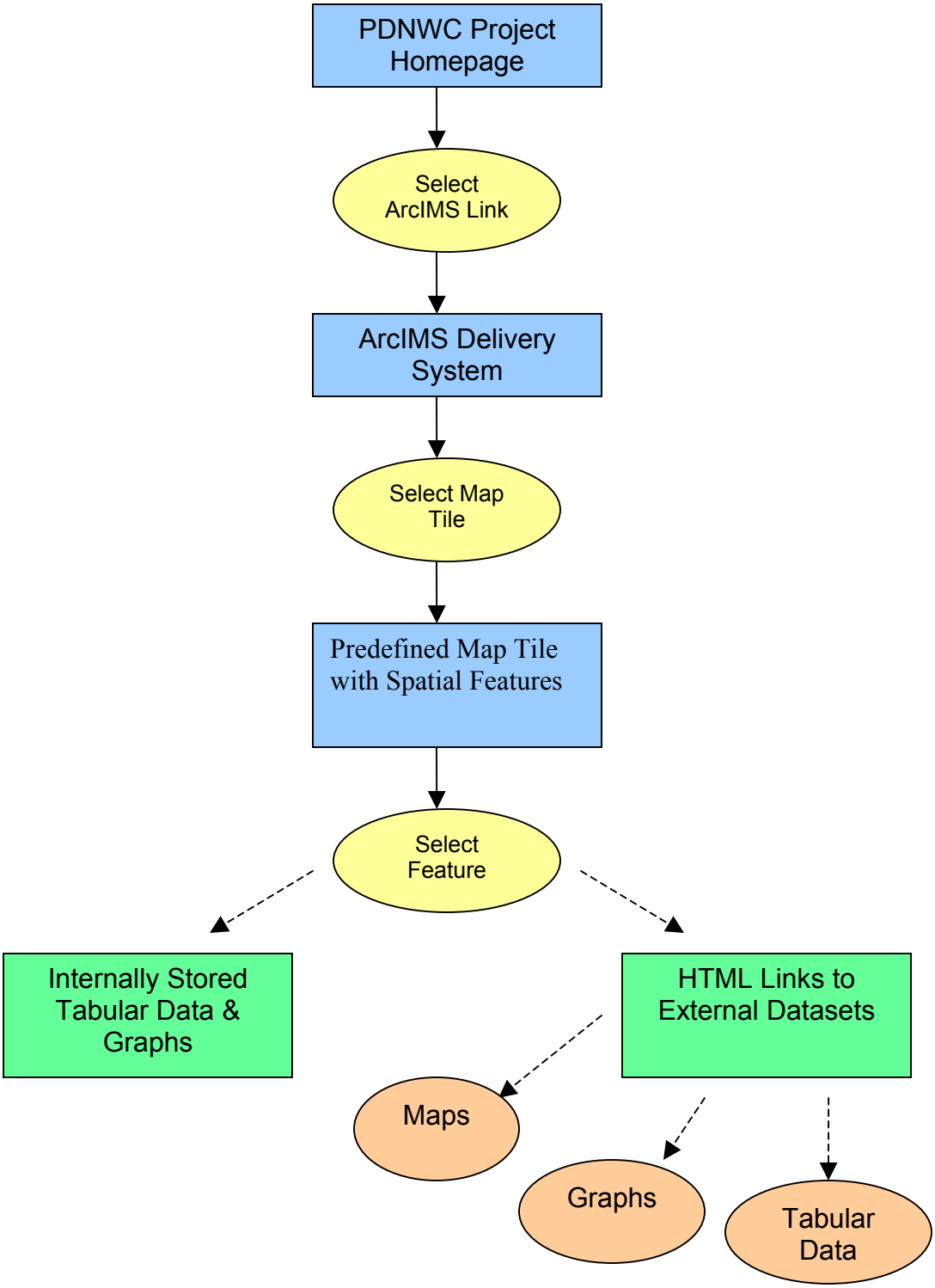

Figure One – Flowchart of ArcIMS-based access to project data.

The previously mentioned Hewlett Binational GIS Map Project data were used as the spatial background on which the portal to datasets was built, and the study area of the Project was linked to this map. See Figure 1 in Appendix B for a sample of the Hewlett map data that are used as the front page for the Project website. We then examined the distribution of spatial features to which water resource data would be referenced to see how best to clip the smaller map tiles from the larger study area maps. The delineation of these tiles was not based on any previously advanced hydrological modeling framework; rather the tiles were clipped based on how the map elements could best be displayed and some commonly accepted boundaries of certain sub-regions. See Figure 2 in Appendix B for detail of how these map tiles are linked to the Hewlett map data.

Once these map tiles were delineated, the smaller GIS maps produced were then converted to image maps, whereby specific sub-regions of the clipped maps were made "clickable" through a series of hyperlinks. Specific spatial features were thereby linked to data files housed within the server or to URLs for other websites that contained relevant data. The coding of these linkages was done so that the original map portal was always viewable by the database user when the links to other websites or internal data files were initiated. The intent of this coding was to insure that database users would not "get lost" when the initial map portal would get displaced by links to other data files or websites of interest. See Figures 3 through 5 in Appendix B for detail of how these elements link together.

With the underlying ArcIMS front end and smaller GIS map tiles in place, Project staff worked with regional data providers to insure all desired data were accessible via HTML calls to other websites or loaded into the Project server. Considerable efforts were extended to clarify irregularities among the data elements, check the general positional accuracy of the spatial

elements on the map, and insure the correct linkages to data elements were in place. We also worked with researchers at la Universidad Autónoma de Ciudad Juárez (UACJ) and UTEP to include data holdings that were housed at these institutions into the Project. Due to the late stage of the Project at which these efforts were undertaken, data from UACJ and UTEP are not included in the final map elements of the Project; however metadata for the UACJ and UTEP and project data holdings are detailed in Appendix C. Metadata for the Project data are also summarized in Table Two in the main body of the text. We anticipate being able to bring these data elements into latter stages of the Project, as discussed in detail below.

The final stage of work on the Project was to document Project tasks by hosting a PDNWC Cooperative Database Project Workshop and by completing this Final Project Report, which provides details of preliminary research efforts, Project development, and related metadata. The Workshop provided opportunities to share the results of the Project with members of the PDNWC, a wide array of interested stakeholders, and regional data providers who have shared access to various data sources. An important outcome of this workshop was the valuable input that participants provided for future phases of the Project.

Name of dataset	Data elements	Spatial extent	Date gathered	Restrictions	Additional metadata
City of Las Cruces gauge sites	Water quality data	Rio Grande from Picacho to Calle del Norte Bridge	July 2001 – March 2002	None	None
IBWC gauge sites	Water flow and water quality data	Rio Grande from El Paso, TX to Ft. Quitman TX	Daily	None	None
USBR gauge sites	Gauge height and discharge data	Rio Grande from Elephant Butte, NM to Ft. Quitman, TX	Daily	None	None
USGS gauge sites	Water flow and water quality data	Rio Grande from Elephant Butte, NM to Ft. Quitman, TX	Daily	None	None
Project del Rio	Water quality sample sites	Elephant Butte Reservoir to Tornillo, TX	1991-2002	None	None
EBID gauge sites	Water level and water flow data	EBID Service Area	Daily	None	None

Table Two – Summary of Metadata related to Project data providers.

OUTCOMES AND LESSONS LEARNED

The most prominent deliverable to be produced in this project is an operational web site for the Paso del Norte Watershed Council Coordinated Water Resources Database Project. This deliverable is available under the Projects section of the Paso del Norte Watershed Council's website, www.pdnwc.org, that is housed on a server at the NMWRRI as discussed in the original Scope of Work. As this project was proposed as a demonstration or pilot project, important insights emerged that are useful for future work to enhance the existing Web-based data portal. These insights deal with map updates, the "user interface plateau," and data formats and consistency, as discussed below.

Map Update Issues

We employed a mixture of ArcIMS and image map tools to deliver map products that would provide a spatial portal or reference to water resource data of interest. As development of the various map elements of the Project proceeded, we realized that this deployment presented significant barriers to updating these map elements. Changes to the ArcIMS front end of the portal required system administration access to the server on which the Project was hosted, and the necessary remote access to this server that we had initially envisioned was not something we could put in place. Changes to the smaller image map tiles required each of the underlying GIS map tiles to be recreated in the ArcGIS software where they were initially produced, and this has proved to be very time consuming. Creating these map tiles completely within ArcIMS would have allowed changes to be made more easily through simple changes to the underlying data tables. This has clearly emerged as one of the more important "lessons learned," and we strongly suggest that future stages of this project be advanced completely within the ArcIMS software.

The "User Interface Plateau"

Owing to the portal data structure we employed, users face a range of different user interfaces when data are accessed at different distributed sites. Some of these interfaces only provide real-time data on a limited basis, other interfaces provide access to historical datasets, and some of the data are served directly on the Project server. To standardize these interfaces, one of two options would need to be employed; the data would need to be routinely transferred to the Project server by regional data providers, or scripts would need to be written and installed on regional data providers' servers to send data regularly to the Project server via some form of automated file transfer protocol (FTP). Such an FTP arrangement would most likely require formal memorandums of understanding (MOUs) between the PDNWC and regional data providers. Extensive discussions between the Technical Committee and EPWU management very early in the Project examined this issue, and a consensus was reached that the Project should proceed without MOUs because these MOUs would unduly delay the Project. In addition, security concerns in the post-911 era would most likely have made the installation of automated scripts on government data servers very difficult, if not impossible.

Data Format and Consistency Issues

Somewhat related to the interface plateau is the issue of consistent data formats and data quality. In some cases, we compiled different GIS data for the same spatial feature from different data sources, and finding the most accurate set of data proved to be very challenging. Locational attributes were the most troublesome to resolve, and at times, we would map features based on initial spatial coordinates, only to find the mapped location of these features would be quite distant from their actual locations. We also encountered instances where agencies to which

the Project was linked would change the structure of their data websites, and this posed problems in accessing the underlying data.

We also found that the manner by which the ArcIMS software handled the map extent of areas of interest posed problems with the ArcIMS display. Owing to its importance as an inflow gauge to Elephant Butte Reservoir, the San Marcial gauge station was thought to be a key spatial data point to be included on the map. Data at this gauge station are critical in the generation of projections of water allocations made by the U.S. Bureau of Reclamation, and we thought these data were of great interest to users of the database. When we included enough map extent in the ArcIMS front end to include the gauge, the result was a much smaller display of the other areas of interest in the map display.

RECOMMENDATIONS FOR UPDATING FLOW AND WATER QUALITY MONITORING CAPABILITY

The last deliverable under the contract for this project is a set of recommendations for enhanced field instrumentation that would support a more comprehensive data collection effort. The Technical Team conducted a preliminary survey with different agencies including EBID, EPCWID #1, EPWU, IBWC, USGS, and USBR. According to the survey, several federal agencies (including the IBWC, USGS, and USBR), some local agencies, irrigation districts, and water utilities measure and monitor flows and water quality in the surface water delivery systems. The data collected serve different purposes. Table 3 lists the agencies that monitor water flows and water quality, and the type of data collected by each agency. Additional information is included in the metadata detail included in Appendix C.

Table 3 - Agencies and Data Collected

Agencies	**Data Collected**	**Notes**
International Boundary and Water Commission	Water Flow & Water Quality	Historic flow data since 1915 and real-time monitoring; historic quality data since 1990
U.S. Bureau of Reclamation	Flow	Daily update on local website (Dataweb stores historic data)
USGS	Flow	Historic data and real-time monitoring
Elephant Butte Irrigation District	Flow	Recent historic data and real-time monitoring
El Paso County Water Improvement District #1	Flow	Historic data since 1997 and real-time monitoring
El Paso Water Utilities	Water Flow & Water Quality	Intakes into the water treatment plants and discharges from wastewater treatment plant
City of Las Cruces	Water Quality	Short-term water quality monitoring related to review of surface water contact standards

Based on survey results, the Watershed Council Technical Committee recommends the following steps be taken to improve real-time monitoring of flow and salinity in the surface water delivery system.

- For all existing sites, equipment should be calibrated and validated on a regular basis to obtain consistent, accurate water flow and water quality data.
- New sites should be established to collect additional data and to furnish real-time control and monitoring. Specific recommendations on new sites follow below.

Specific Recommendations for Additional Monitoring Locations and Equipment

The following provides recommendations for additional locations and immediate equipment needs for real-time monitoring of flow and water quality within the Paso del Norte Watershed. **Flood Control Gauge Stations (EBID and IBWC):** The EBID contains 33 flood control dams that are either the responsibility of EBID or IBWC. These dams provide flood control for downstream municipalities such as Hatch, the City of Las Cruces, and the City of El Paso, and supply water for livestock and wildlife habitat in the Paso del Norte Watershed. Thirty-three radio telemetry systems should be installed on the dams located in EBID to gauge flows from storm events and resulting flows entering the Rio Grande through the EBID system. The data recorded by these systems can be used to reconstruct flood and storm events, can be input into watershed modeling, and can provide insight into rehabilitation or design of future flood control structures. All telemetry systems will be placed on EBID property, and EBID would add the telemetry to their current data collection system used to monitor flows in the irrigation district.

In conjunction with the dam gauging, a weir structure with radio telemetry should be installed on the Rincon Arroyo, which is the largest arroyo entering the Rio Grande with no sediment control or damming structures. This weir would allow collection of flow data from the arroyo and monitoring of storm events. If possible, the weir would be located on EBID

property. EBID is also considering development of a monitoring network of groundwater quality. With integrated surface water and groundwater monitoring, EBID and the City of Las Cruces would gain a better understanding of surface water and groundwater interaction as well as groundwater availability. Electrical conductivity (EC) probes and data loggers will be needed at the selected well sites, and a detailed plan for this equipment will be developed in the next phase of this project.

Water Operation Gauge Stations (EPCWID #1 and USBR): EPCWID #1 is operating and maintaining over 30 gauge stations. Most of them are connected to their respective computer system through telemetry units. However, some of these stations are not well equipped and not connected to the flow monitoring system. In addition, several new sites are recommended to obtain flow data; these data can be used to develop strategies for improvement of delivery efficiency and to facilitate water operations.

Specific Recommendations for New Monitoring Sites and Equipment

The following group of sites is recommended to be equipped first. It is anticipated that EPCWID #1 would provide in-kind contributions for installation and maintenance of equipment.

1) New equipment including pressure transducers and a data logger (f-recorder) are required at the Ascarate Wasteway Heading and the Tornillo Canal Heading.
2) EPCWID #1 is requesting to relocate a gauge station below the Mesilla Dam so that the radio signal can reach the monitoring station, allowing replacement of the existing cellular phone connection. Additional wiring and upgrade of equipment may be needed.
3) Currently, EPCWID #1 is upgrading its gate control system for spillways. Radio telemetry systems are needed for Wasteway No. 1 and No. 2 on the Riverside Canal.
4) Radio telemetry units are required at several laterals - Malone, Grandview and Lee. It is expected that additional water quality monitoring would also be needed for salinity management within the district.

Water Quality Monitoring Stations (IBWC): As part of the Clean Rivers Program, IBWC is collecting water quality samples from 14 sites along the Rio Grande from the East Drain to

above the Rio Conchos. An immediate need exists to install real-time monitoring of water salinity systems at two sites, one at the Rio Grande at Courchesne Bridge, and the other above the Rio Conchos. The equipment includes two EC sensors and additional wiring for connecting sensors with the existing telemetry unit. IBWC will provide in-kind contributions including installation and maintenance of the equipment. IBWC is also operating and maintaining six gauging stations with real-time flow monitoring for flood control. Other water quality probes for chloride and sulfate may also be installed at IBWC sites as needed.

CLOSING COMMENTS AND FUTURE WORK

The activities described in this report related to the development of the Paso del Norte Watershed Council Cooperative Water Resources Database Project have generated outcomes and results of considerable interest to stakeholders in the Paso del Norte region. The outcomes discussed above point to some specific areas of work to be advanced in future efforts. Although funding and staff limitations in Phase I of the Project prevented us from doing so, we strongly recommend that future efforts focus on converting the Project mapping functions completely into the ArcIMS software. The update problems detailed above would be solved by this migration, and greater opportunities to link the existing website to other data projects in the region could be advanced.

Several technical issues should also be examined in future work, including the "user interface plateau" discussed above. We suggest elevating discussions with our regional and national data providers to explore the possibility of some form of scripting and automated FTP routine allowing regular update and transfer of data, or a batch variation whereby data providers would send data to the Project server on a regular basis. We also suggest some additional QA/QC work for certain data sources to eliminate inconsistencies among datasets.

We also offer suggestions for broadening the participation of data providers in future work. Due to the late stage of the Project when we were able to include UTEP, EPWU, and UACJ in Project work, we were not able to incorporate their datasets fully into the final product. These institutions have expressed interest in future stages of work, and we suggest that efforts be made to capitalize on this interest, and the datasets and expertise that EPWU, UACJ, and UTEP can contribute. Greater participation of regional data providers such as the El Paso County Water Improvement District #1 in future phases of the Project would greatly improve the

comprehensiveness and utility of the Project, and we recommend that this effort continue to be pursued. We also strongly suggest that funds be sought in future stages of the Project to compensate regional data providers for their time and effort in working with Project staff.

As recommended, new monitoring equipment will be installed at some existing sites and also at new sites. In cooperation with data collection agencies, we will provide assistance in design and upgrading of the monitoring network, and the calibration of equipment for enhanced data quality control and quality assurance (QC/QA).

As this database project progresses and the Upper Rio Grande Water Operations Model (URGWOM) being developed cooperatively among the U.S. Section of the International Boundary and Water Commission, U.S. Bureau Of Reclamation, U.S. Geological Survey, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, Bureau of Indian Affairs, and others, is further refined to include water storage and delivery operations in addition to flood control operations, more access to daily operations data will be possible. Specifically, the data collected for the URGWOM project can be loaded into the Paso del Norte Watershed Council Cooperative Water Resources Database after QC/QA of the URGWOM project data has been conducted. Also, the Project Database can be linked to the URGWOM website to provide access to flood control operations data available from the URGWOM model, which is currently functional below Elephant Butte Reservoir to El Paso, Texas. Such configurations will assist interested parties in communicating more efficiently with access to daily monitoring information and model projections.

Summary Recommendations

The following summary of recommendations for future work has emerged from Project experience and discussion with Project staff and the Technical Committee, and we recommend that these guide future proposals for Project work:

- Complete migration of the Project website and related databases to the ArcIMS software,
- Installation of new monitoring stations and equipment as detailed above, and inclusion of these monitoring sites in future ArcIMS map products,
- Enhanced levels of funding to be directed to support more active participation of volunteer regional data providers and to bring new providers into the Project,
- Exploration of scripting and automated FTP routines or a batch mode of data transfer to allow progress on the "user interface plateau" discussed above,
- Inclusion of groundwater data into future phases of the Project,
- Linking the EPWU-funded project to USACE-supported database efforts,
- Inclusion of the URGWOM data discussed above into future versions of the Project database, and
- Additional funding to be provided to lend institutional support to the Watershed Council and also to fund future Cooperative Database Project activities.

REFERENCES AND DATA SOURCES

City of Las Cruces, 2002. Water quality data gathered by the City of Las Cruces Water Utilities in conjunction Elephant Butte Irrigation District to aid in evaluating proposed changes to surface water contact standards.

Elephant Butte Irrigation District (EBID), 2003. Surface water flow data in the Rio Grande and select canals in the EBID, housed at http://www.ebid-nm-org. Accessed 10 September 2003.

International Boundary and Water Commission, 2003. Clean Rivers Program water quality data, housed at http:www.ibwc.state.gov. Accessed 10 September 2003.

Keyes, C. 2001a. Coordinated Rio Grande Project Source Water Protection Measurements Project. Proposal written for the Paso del Norte Watershed Council by Conrad Keyes.

Keyes, C. 2001b. Database Management Program, Middle and Lower Rio Grande of Mexico. Proposal written for the U.S. Army Corps of Engineers/Upper Rio Grande Water Operations Model by Conrad Keys.

Lyndon B. Johnson School of Public Affairs, 1999**.** Navigating the Waters of the Paso del Norte: A People's Guide*.* Austin, Texas: The University of Texas at Austin.

New Mexico Water Resources Research Institute (NMWRRI), 2002. Creating a Single Map: Regional Geographic Information System to Support Water Planning in the Paso del Norte Region. NMWRRI Technical Report No. 322, prepared for the Paso del Norte Water Task Force by NMWRRI, el Centro de Información Geográfica at la Universidad Autónoma de Ciudad Juárez (UACJ), and the Pan American Center for Earth and Environmental Sciences at The University of Texas at El Paso. New Mexico State University, Las Cruces, NM.

Project del Rio, 2003. Surface water quality data for the Rio Grande, available at http://wrri.nmsu.edu/arcims/pdnwcmap/tiles/home.htm. Accessed 10 September 2003.

United States Bureau of Reclamation, 2003. Surface water flow data for the Rio Grande, housed at http://www.usbr.gov/uc/elpaso/water/RioGrandeProject/CurrentData/WFlow/daily.html. Accessed 10 September 2003.

United States Geological Survey, 2003. Surface water flow and water quality data for the Rio Grande, housed at http://waterdata.usgs.gov. Accessed 10 September 2003.