Chihuahuan Desert Network
Water Resource Information and Assessment Report

By

William H. Reid and M. Hildegard Reiser
Chihuahuan Desert Network
National Park Service
Las Cruces, New Mexico

Chihuahuan Desert Network Waters. Clockwise from upper left: Santa Elena Canyon in Big Bend NP (© Mark Abraham by permission), Lake Lucero Playa at White Sands NM, Amistad Reservoir at Amistad NRA, Winter morning fog at Rattlesnake Springs, Carlsbad Caverns NP.

ACKNOWLEDGEMENTS

We gratefully acknowledge the help of the many who provided assistance and reviews making this report possible. They include: Betty Alex (NPS BIBE), Gorden Bell (NPS GUMO), Jeffrey Bennett (NPS BIBE), Paul Burger (NPS CAVE), Rachel Conn (Amigos Bravos), Bill Conrod (NPS WHSA retired), Jim Davenport (TCEQ), Vidal Davila (BIBE), John Heiner (NPS FODA), Rick Huff (USGS), John Karges (TNC), Christine Kolbe (TCEQ), Davis Larson (NPS LABE), Mike Matz (NPS WRD), Gopaul Noojibal (NPS CAVE), Ken Rakestraw (IBWC), Dale Pate (NPS CAVE), Dave Roemer (NPS CAVE), Gary Rosenlieb (NPS WRD), Rick Slade (NPS AMIS), and Diane White (NPS WHSA).

Table of Contents

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

This report was prepared to meet the policy and regulatory portion of the water resource information and assessment needs of the Chihuahuan Desert Network (CHDN) under overall authority of the Natural Resource Challenge (NPS 1999a). During the Inventory phase (NPS 2001a) the CHDN created a charter with the guidance of the Board of Directors and Technical Committee. Using these and guidance from the Inventory and Monitoring Program, the NPS Water Resources Division, the Intergovernmental Task Force on Water Quality Monitoring (IGTF 1997), and the NPS Fresh Water Working Group (NPS 2002a) the CHDN will prepare an integrated water quality monitoring plan in consultation with its parks.

National Park Service (NPS) mandates pertaining to water quality and water quality standards of the network states, New Mexico and Texas, were reviewed and summarized. Other materials examined include (1) the NPS Water resources division (WRD) Baseline Water Quality and Analysis Reports for the following parks: Amistad National Recreational Area (AMIS), Big Bend National Park(BIBE) and the Rio Grande Wild and Scenic River (RIGR), Fort Davis National Historic Site (FODA), Guadalupe Mountains National Park (GUMO) and White Sands National Monument (WHSA), (2) WRD data in preparation for Carlsbad Caverns National Park (CAVE), (3) the Water Resources Scoping Report for two parks (AMIS and BIBE), (4) one Water Resources Management Plan (BIBE), (5) park resource management reports, and (6) several Internet sites, including those for state lists of impaired water bodies, federal data, and other resources, including data on Mexican standards and the Rio Grande/Rio Bravo del Norte.

Water is a scarce, precious resource in the CHDN parks. The much-altered Rio Grande and its major tributaries the Pecos and Devils rivers are subject to great flow variation. Water—or its scarcity—is a driving force in park ecosystems adapted to the region’s aridity. Further, since the majority of Chihuahuan Desert precipitation is driven by monsoonal (Ropelewski et al. 2005), intense, local thunderstorms, its occasional, great overabundance is of ongoing management concern. The NPS Strategic Plan 2001-2005 provides goals and guidelines for water quality.

Below are presented for the CHDN parks summary data on (1) impairments, (2) Outstanding Natural Resource Waters, (3) park waters of special interest, (4) threats to park waters, and (5) current park-based water quality monitoring.

I 303(d) IMPAIRMENTS

TEXAS PARK UNITS Amistad NRA, Big Bend NP and Rio Grande WSR have reported impairments. For park units in Texas, data and definitions drawn from TCEQ (2004a) (http://www.tnrcc.state.tx.us/water/quality/04_twqi303d/04_303d/04_303d.html#303d), which supersedes previous lists.

Amistad National Recreation Area The Rio Grande below Amistad Dam has been designated as impaired. Christine Kolbe (TCEQ, pers. omm... 2005) observes that the entire reach is not impaired, and that the impairments in Segment 2304 are from urban discharges from urban areas in the US and Mexico. The impact of this impairment on park management is limited, since (1) the sites where impairment is detected are well below Amistad NRA and (2) only the short (ca. 4.5 km) segment of Amistad NRA below Amistad Dam is included. Thus, we include Segment 2304 for completeness, not from an immediate threat to contamination from NPS managed resources.

Segment ID #**2304: Rio Grande Below Amistad Reservoir.** Category: **5c.** Water body location: From the confluence of the Arroyo Salado (Mexico) in Zapata County to Amistad Dam in Val Verde County

Reach	Parameter	Category	Rank
4.5 miles downstream of Hwy 277	bacteria	5c*	D**
4.5 miles downstream of Hwy 277	chronic toxicity in water to aquatic organisms	5c	D
3 miles downstream of US 277 in Eagle Pass	bacteria	5c	D
Downstream of International Bridge 2 to pipeline crossing	bacteria	5c	D
El Cenizo to San Isidro pump station	bacteria	5c	D
Pipeline crossing to downstream of El Cenizo	bacteria	5c	D
San Isidro pump station to segment boundary	bacteria	5c	D

Φιγυρε 2 Category 5c: The water body does not meet applicable water quality standards or is threatened for one or more designated uses by one or more pollutants. Additional data and information will be collected before a TMDL is scheduled.

** Rank D: Available information on the severity, geographic extent, and cause of non-support of the standard or source of the pollution is not adequate to determine the need for a standards review or a TMDL.

Big Bend National Park and Rio Grande Wild and Scenic River

In 1978, Congress designated a 196 mile portion of the Rio Grande from the Chihuahua/Coahuila state line in Mexico to the Terrell/Val Verde county line in Texas as part of the National Wild and Scenic Rivers System. The upper 69 mile section of this corridor lies within Big Bend National Park, which administers the Wild and Scenic River (http://www.nps.gov/bibe/parkbasics/rgwsr/htm).

Segment ID #2306 Rio Grande Above Amistad Reservoir Category: **5c.** Water body location: From a point 1.8 km (1.1 miles) downstream of the confluence of Ramsey Canyon in Val Verde County to the confluence of the Rio Conchos (Mexico) in Presidio County

Reach	Parameter	Category	Rank
25 miles downstream of upper segment boundary	bacteria	5c	D
25 miles downstream of upper segment boundary	chronic toxicity in water to aquatic organisms	5c	D

TCEQ's additional comments (http://www.tnrcc.state.tx.us/water/quality/tmdl/toxicity.pdf) on this reach are:

> Segment Description: The Rio Grande above Amistad Reservoir is a 313- mile freshwater segment which begins at a point 1.1 miles downstream of the confluence of Ramey Canyon in Val Verde County up to the confluence of the Rio Conchos (Mexico) in Presidio County. This segment receives discharges from domestic and industrial point source discharges, and a small amount of discharge from agricultural sources on both sides of the border.
>
> Test Results and Toxicity Identification: From April 29, 2001, through April 24, 2002, nine sampling events were conducted at Stations 13228 [Rio Grande at Santa Elena Canyon] and 13229 [Rio Grande below Rio Conchos]. The EPA also performed toxicity tests on samples collected by the TCEQ on two other separate events at each of the stations. Lethal toxicity was not observed at any of the events for either of the species. The recorded flow for this segment during each of the

> sampling events was below the levels required for water quality standards to be applicable. As a result, sublethal effects observed in this study are inconclusive since aquatic life uses would not be applicable during extremely low flows.
>
> Toxicity identification evaluations (TIE): were not conducted due to the ambiguous results from the toxicity tests.
>
> Segment Recommendations: Toxicity tests conducted on fish and invertebrates using water samples from Segment 2306 were inconclusive. The interpretation of sublethal responses is complicated by low flow conditions at the time of sampling. Additional toxicity tests are required to fully assess the presence and causes of toxicity in this segment.

Christine Kolbe (TCEQ pers. omm.. 2005) adds this additional analysis:

> "Segment 2307 is listed as impaired for salinity related parameters, chloride and total dissolved solids. But this does not appear to affect Segment 2306. Elevated salinity levels are masked in Segment 2306 when the water quality standards are applied. Chloride and total dissolved [solids] values for an entire segment are averaged, with average values checked against segment criteria. So it stands to reason that the upper portion of Segment 2306 would be affected by flow from 2307. But when you average chloride and total dissolved solids values for 2306 there is no apparent salinity problem. This is due to the spring inflow starting about half way through Big bend NP. One theory is that the toxicity in water observed in the upper portion of Segment 2306 is related to the high salinity coming in from Segment 2307."

The Texas Commission on Environmental Quality (TCEQ) has a program for assessing TMDL in the Rio Grande Basin (http://www.tceq.state.tx.us/implementation/water/tmdl/30-toxicity_project.html) titled Assessing Toxicity in Ambient Water and Sediment in Seven Texas Water Bodies. Summary PDF documents on the 2304 and 2306 segments are at the above URL.

NEW MEXICO PARK UNITS Only Carlsbad Caverns NP had a reported impairment and that marginally within its bounds. For the park units in New Mexico, data are drawn from The 2004-2006 State of New Mexico 303(d) list (New Mexico Water Quality Control Commission 2004 and http://www.nmenv.state.nm.us/wqcc/303d-305b/2004/AppendixB/index.html.

Carlsbad Caverns National Park The New Mexico assessed Stream and River Reaches includes "Black River from its mouth on the Pecos River to the headwaters." It lists the specific pollutant and cause as unknown. All of Carlsbad Caverns NP is within the Upper Pecos-Black basin, though stream flows within the park are ephemeral. This impairment, for which there are little data, is described as:

State Impairment	Parent Impairment	Priority	Rank	Targeted Flag	Anticipated TMDL Submittal
UNKNOWN CAUSE	CAUSE UNKNOWN	8			

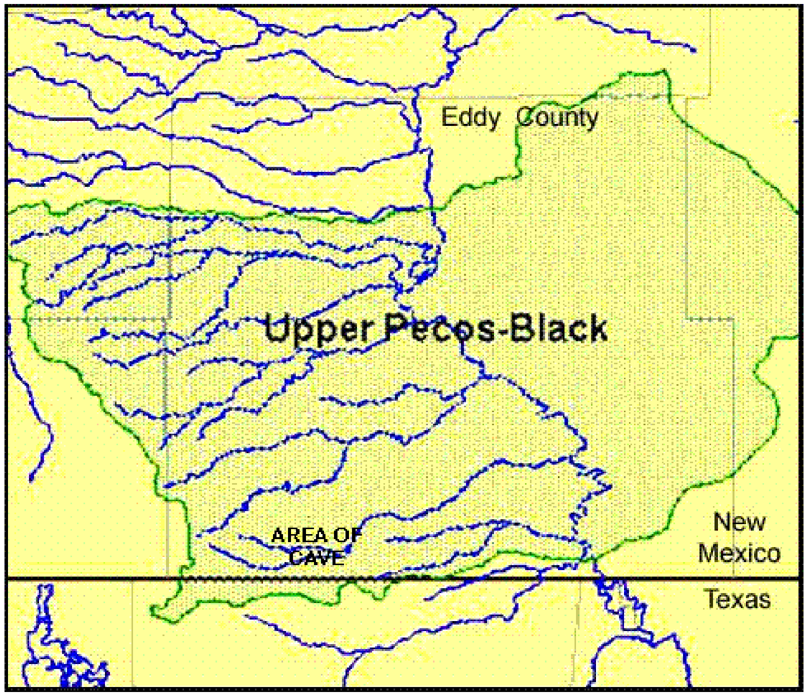

Figure ES-1. Upper Pecos-Black Basin

For the other three parks in the Chihuahuan Desert Network, Fort Davis NHS, Guadalupe Mountains NP and White Sands NM, there are no impairments under Section 303(d) of the Clean Water Act (CWA).

II OUTSTANDING NATURAL RESOURCE WATERS (ONRW)

There are no designated ONRW within Chihuahuan Desert Network parks or their environs (Rachel Conn, Amigos Bravos, pers. omm.., 2005 and Jim Davenport, TCEQ, pers. omm.., 2005).

III PARK WATERS OF SPECIAL INTEREST

The following surface waters, though some not 303(d) designated as impaired or designated as Outstanding Natural Resources Waters, are of special interest to the CHDN I&M Program and the network parks. These waters will be part of an overall monitoring plan for the CHDN.

Amistad National Recreation Area, Big Bend National Park and Rio Grande Wild and Scenic River

Rio Grande/Rio Bravo del Norte. The river forms the International Boundary between the United States and Mexico, with the defined middle of the river marking the actual boundary. United States direct administration is limited to the US side of the river. Thus, the river poses a significant management challenge to the National Park Service. In a generic statement we note that the network and included parks will, as described in some detail below, take active role and in monitoring water and water-related issues for this reach of a great and historic river. This includes portions of Texas River Segments 2305 and 2306, plus, as necessary, that small reach of Segment 2304 within Amistad NRA.

Amistad National Recreation Area

Devils River. This river is one of the highest quality waters in Texas (TCEQ 2004c). It lower reach is currently monitored by TCEQ/IBWC, and The Nature Conservancy is implementing a TCEQ approved monitoring plan for the river upstream of Amistad NRA (John Karges, TNC, pers. omm.. 2005). The Devils River is also without significant impoundments. USGS daily streamflow data at http://nwis.waterdata.usgs.gov/ show spikes of flow of 1000:1 (Station 08499000) and 250:1 (Station 08449400) along the Devils River. Personal accounts (David Larson, NPS, pers. omm...) report that these changes take place within a few hours following extreme rainfall events. Thus, the Devils River perhaps provides an opportunity to study both hydrologic and ecological processes in a comparatively primordial setting.

Big Bend National Park and Rio Grande Wild and Scenic River.

Springs complexes in the bed of Rio Grande are identified as “major springs that are important for water supply and natural resource protection” (King 2005). See, also, Appendix B. Additionally, several springs within the park are of special interest and concern, some being in near-pristine condition. These will be identified later in the water quality monitoring process.

Langford Hot Springs Complex, River Mile 832-808 These springs contribute to the hydrologic function and base flow of the Rio Grande beginning downstream of Marsical Canyon to the entrance of Boquillas Canyon. The orifices in this spring systems emanate on both banks of the river from at least 13 separate locations. In addition, these springs provide habitat for *Gambusia gaigei*, an endangered mosquito fish found only in two ponds in Rio Grande Village. TCEQ stream segment 2306 meets the standards for recreation contact and fish consumption because of the dilution of salinity by the input of this spring system.

Lower Canyons Thermal Springs Complex, River Mile 760-682 These springs emanate in the river channel below the mean high water line and within the management jurisdiction of the National Park Service. The flow from this spring system sustains the hydrologic function, base flow, and diverse species assemblage of the Rio Grande. In written agreements between the National Park Service and the individual land owners, this spring system is recognized as a unique and valuable asset worth protecting. This reach begins near Taylor’s Farm and continues to San Francisco Canyon. The park has written a letter to the West Texas Water Planning group asking that the two springs complexes be designated as significant river and stream segments. No formal action by that group has been taken as of 9//2005.

Carlsbad Caverns National Park

Rattlesnake Springs (NB: Rattlesnake Springs is alternately referred to as Rattlesnake Spring. The USGS Geographic Names Information System (http://geonames.usgs.gov/redirect.html) uses the plural, while the USGS 1:24,000 topographic map for that area is named Rattlesnake Spring. The NPS signage at the site uses both. We use the plural.) The actual number of points of water inflow–one or more–has been obscured by early development and impoundment.) CAVE personnel have identified the location and description of the inflow as a management concern (NPS 2001b). A brief description of the general site is at http://www.nps.gov/cave/ratsprings.htm from which the following was drawn:

> “, a detached unit of Carlsbad Caverns National Park, was acquired by the National Park Service in 1934 for the primary purpose of ensuring a reliable domestic water supply for cavern area development. A water supply pipeline from the spring to the cavern area, which is still in use, was completed in 1935. The water supply for the cavern is from a well that taps the same aquifer as the springs. The springs also provide water for irrigating NPS lands and for water uses on private lands such as the adjacent Washington Ranch…Over the years the 1,000-meter stream and wetland system at has been sustained by the remaining undiverted spring flow. Originally a marsh, this area has been altered by human development. Today this green oasis provides habitat for a wide variety of species…The spring was used by prehistoric peoples and historic Indian groups, soldiers, travelers, and settlers. When Henry Harrison homesteaded the area around the spring in the 1880s, he developed the spring, built an irrigation system for his fields…Following acquisition by the National Park Service, the area was further developed by the Civilian Conservation Corps during 1938 to 1942… was also used by the military during World War II…For its significant role in our nation’s history, this area was placed on the National Register of Historic Places in 1988.”

A recent study of Rattlesnake Springs and non-park Blue Spring (New Mexico Environmental Department 2003) showed that Rattlesnake Springs to have exceptionally high water quality, and ongoing monitoring is regarded as essential. Scott Hopkins, author of the study commented (p. 2):

> "It is rare in this part of New Mexico to find waters of this caliber, and care should be taken to maintain and, where possible improve, their quality, channel integrity and riparian corridors. A powerful tool in that effort would be to have these springs and their outflow streams designated as Outstanding National Resource Waters (ONRW)."

Of special note are earlier studies (Richard 1987, 1988a, 1988b, 1989, Richard and Boehm 1989) examined the impact of 23 gas injection/withdrawal wells (The Washington Ranch Gas Storage Project) on nearby water wells, posing a threat to Rattlesnake Springs. "Elevated concentrations of benzene and polycyclic aromatic hydrocarbons have been documented in the wells along with sulfide contamination and accompanying odor and well corrosion (Richard and Boehm 1989)." While this contamination has ceased, it points to an area of great concern to potable waters from Rattlesnake Springs. Richard makes remediation recommendations should contamination arrive. He notes that elevated sulfides would first be detected.

Richard and Boehm (1989) note that nearby wells respond rapidly to precipitation. They further note, "a rapid recharge of groundwater in the upper Black River Valley near Rattlesnake Springs…groundwater contamination, if present, would be expected to move rapidly through aquifer(s) near Rattlesnake Springs, reaching the springs in less than one year."

Fort Davis National Historic Site None.

Guadalupe Mountains National Park

McKittrick Creek. This creek, one of the few places in the park with perennial flows, is a crucial resource for wildlife, supports a strong riparian ecosystem, and is prized location for visitor hikes along the near-stream trail. An historic site, the Pratt Cabin, is also an attraction. A number of issues prevent the installation of toilet facilities in the canyon. However, some tourists, largely inexperienced with backcountry ways, do defecate near the trail (Buzz Avrutis, pers. omm.., 2004). Monitoring water quality is regarded as very important.

Choza Stream and Springs. This small, perennial stream carries a flow for several hundred meters, supporting a pristine riparian vegetation and rich fauna. Slow growing Texas Madrone (*Arbutus xalapensis*) approaching one meter diameter are along its course. Additionally, there are a number of archeological sites along its banks. The Choza complex is adjacent to and passes under US Highway 62-180 within the park and is therefore sensitive to disturbance and contamination.

McKittrick Creek and Choza Stream and Springs, together with nine Guadalupe Mountains National Park springs, were recently identified as ecologically significant water resources (Far West Texas Regional Water Planning Group 2005 and http://www.twdb.state.tx.us/rwp/e/PDFs/).

White Sands National Monument

Lake Lucero Playa. This ephemeral surface water, rich in sulphates, is the lowest point in the Tularosa Basin. It receives surface runoff primarily from the San Andres Mountains to the west, while ground water enters from the north and east. These waters carry in dissolved gypsum and other salts, which evaporates and provides the source of sand for the dune field. It was once proposed as a NASA extreme environments study site in that agency's study of the origin of life (Bill Conrod, WHSA, pers. omm... 2005) Nearby White Sands Missile Range activity, possible infalling test debris, and surface drainage from adjacent Range Road 7 and upslope test sites suggest Lake Lucero Playa as important to monitor.

Lost River. On occasion, extreme rainfall-induced flows in Lost River through Holloman Air Force Base flood into a basin in the northeast portion of the monument. Water quality in Lost River is therefore of special interest to monument resource management. Earlier studies examined near-stream saltcedar leaf material for translocated perchlorates, one contaminant within the area of probable Lost River corridor and associated ground water (Bill Conrod, pers. omm.., 2005). While Tamarix is distributed throughout the monument, this northeast portion of the monument is notable for both its biota and *Tamarix* infestation (Reid 1979, 1980).

Texas Ecologically Significant River and Stream Segments – The Texas Water Development Board has instructed regional water planning groups to identify ecologically significant river and stream segments (http://www.twdb.state.tx.us/rwpg/twdb-docs/unique_site_process.htm). The criteria include: "Factors such as biological function, hydrologic function, riparian conservation areas, high water quality, exceptional aquatic life, high aesthetic value, threatened or endangered species, or unique communities." Texas Parks and Wildlife Department (http://www.tpwd.state.tx.us/texaswater/sb1/rivers/unique/regions_text/regions_list/region_e.phtml) makes recommendations and administers the database for this process. This designation does not confer additional protection for the designated water bodies: "Only the legislature may take the formal action required to designate a river or stream segment of unique ecological value…and provide the corresponding statutory protections for such areas." As of 2002 two segments were identified for CHDN parks (Figure 2 below).

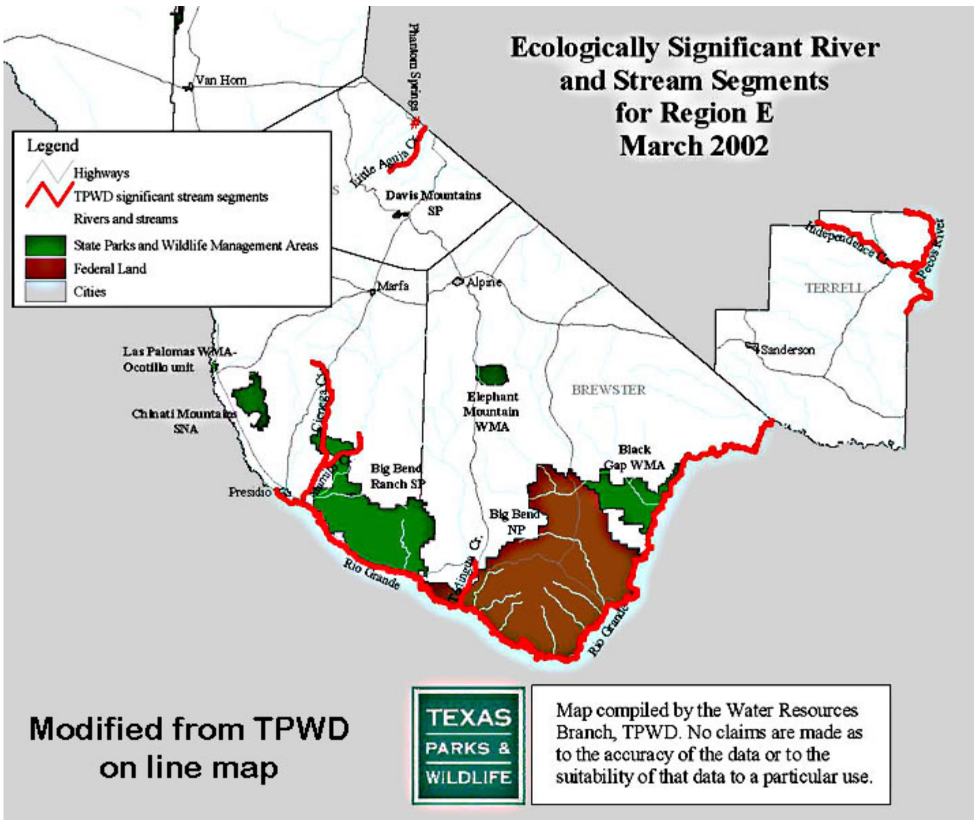

Figure ES-2. Ecologically Significant River and Stream Segments for Region E

King (2005) emphasized to the Far West Texas Water Planning Group the strong, important influence of two spring complexes in the RIGR:

> "Rio Grande – From a point 1.1 miles downstream of the confluence of Ramsey Canyon in Val Verde County to the confluence of the Rio Conchos (Mexico) in Presidio County (TCEQ stream segment 2306). Riparian conservation area: Big Bend National Park; Big Bend Ranch State Natural Area; National Wild and Scenic River. High water quality/exceptional aquatic life/high aesthetic value: diverse benthic macroinvertebrate community (J. Davis, 1998, pers. omm..) Threatened or endangered species/unique communities: Occurrence of species or habitat insufficient to merit designation."

> "Terlingua Creek – From the confluence with the Rio Grande two miles south of Terlingua Abaja in Brewster County upstream to the FM 170 crossing in Brewster County. Riparian conservation

area: Big Bend National Park. High water quality/exceptional aquatic life/high aesthetic value: omm. pin stream (Linam et al., 1999); exceptional aesthetic value (NPS, 1995). Threatened or endangered species/unique communities: omm. pine shiner (SOC/St.T) (Linam et al., 1999)”

In May 2005 Guadalupe Mountains National Park submitted the following nominations to the Far West Texas Water Planning Group (Gorden Bell, GUMO, pers. omm.. 2005).

- McKittrick Canyon Stream (both north and south branches), including numerous unnamed springheads that feed the system
- Choza Stream including Choza Spring and at least two unnamed springheads that feed the system

IV THREATS TO CHDN PARK WATER RESOURCES

Amistad National Recreation Area – Receives surface flows from all surrounding lands and three significant rivers.

Threats:

- Deposition from atmospheric pollution,
- Sedimentation pollutants or contaminants from Rio Grande inflow,
- Sedimentation pollutants or contaminants from Devils and Pecos River inflow,
- Runoff from Mexican sources to the Rio Grande,
- Runoff from US sources, including adjacent ranches, exterior to the park,
- Hydrocarbons from US and Mexican watercraft,
- Possible fecal matter and debris from undocumented aliens in transit,
- Possible debris and fecal matter from US and Mexican watercraft,
- Hydrocarbons and debris from US and Mexican boat launch sites,
- Camping area runoff.

Big Bend National Park – Receives flow from two major rivers (Rio Grande and Rio Conchos) and several smaller US and Mexican tributaries (Terlingua Creek, Alamito Creek, Arroyo de Fortino). Some of the tributaries are intermittent but contribute a significant amount of sediment loading to the Rio Grande. The Rio Conchos is the only major contributor to the flow of the Rio Grande above Big Bend NP. The cities of El Paso and Juarez ordinarily take all of the Rio Grande. Irrigation return flow and occasional rainfall runoff provides some flow to the river, but the flow reaching Big Bend NP is due in large part to the contributions from the Rio Conchos.

Threats:

- Deposition from atmospheric pollution,
- Sedimentation, pollutants or contaminants from Rio Grande inflow,
- Waste water effluent discharges from Presidio and Ojinaga,
- Permitted wastewater discharge to tributary Terlingua Creek,
- Mexican livestock in and adjacent to the Rio Grande,
- Runoff from in-park concessions and camping areas,
- Fecal matter during flooding of restroom facilities at Santa Elena Canyon,
- Several contaminants possibly released in potential Rio Grande Village flooding,
- Runoff and infiltration from all Panther Junction park facilities,
- Runoff and infiltration from gasoline station west of Panther Junction,
- Runoff and infiltration from all Chisos Basin concessionaire and park facilities,
- Fecal matter from dispersed camping and hiking activities, especially along the Rio Grande and its tributaries,
- Camping debris and fecal matter near springs and seeps,
- Possible fecal matter and debris from undocumented aliens in transit,
- Vandalism by aggressive pothunters and others in and around springs and seeps,
- Hydrocarbons and debris from River Road users.

Carlsbad Caverns National Park – Receives no significant surface flows from surrounding lands.

Threats:

- Deposition from atmospheric pollution,
- Runoff and infiltration to caves from all headquarters area park facilities.
- Oil and gas drilling in the catchment for Rattlesnake Springs has the potential to cause irreparable damage to the Springs. During high flow, there has been trace amounts of toluene detected, indicating that some of the adjacent, subsurface water courses have been contaminated and can spill over into the underground channel that feeds Rattlesnake Springs. Grazing and agriculture within the Rattlesnake Springs catchment also poses a threat to the water from high nitrates and phosphates.

Fort Davis National Historic Site – Receives surface flows from adjacent Davis Mountains State Park

Threats:
- Deposition from atmospheric pollution,
- Groundwater infiltration from adjacent urban sources,
- Groundwater infiltration from park facilities,
- Flood inflows to Hospital Canyon Arroyo (NPS 1999a).

Guadalupe Mountains National Park – In large part receives no significant surface flows from surrounding lands. However, the Salt Basin dune field in the park is hydrologically connected to Basin ground waters.

Threats:
- Deposition from atmospheric pollution,
- Runoff and infiltration from park facility areas,
- Runoff from US 62-180 through park,
- Camping area runoff,
- Hiker fecal matter from trail through McKittrick Canyon,
- Possible groundwater changes from water development in the Salt Basin.

Rio Grande Wild and Scenic River – Receives surface flows from all surrounding lands and tributary streams.

Threats:
- Deposition from atmospheric pollution,
- Sedimentation pollutants or contaminants from Rio Grande inflow,
- Runoff from Mexican sources to the Rio Grande,
- Runoff from US sources exterior to the park,
- Possible fecal matter and debris from river users,
- Possible fecal matter and debris from undocumented aliens in transit.

White Sands National Monument – Receives surface and groundwater flows from surrounding lands.

Threats:
- Deposition from atmospheric pollution,
- Runoff from surrounding military facilities, including range Road 7,
- Groundwater transport into park from surrounding military facilities,
- Infiltration from park headquarters area facilities,
- A park concern is the ecological impact of possible drop of the water table from basin groundwater resource development.
- Isolated cottonwood stands occur at a number of dune field locations. Their presence implies perennial ground water of rather high quality. Precipitation catching clay lenses or local higher quality, subsurface flows have been suggested as reasons for their persistence. This lack of understanding leads, therefore, to no known threats to these subsurface resources, but it suggests a need for better understanding the matter.

V CURRENT WATER QUALITY MONITORING

Current water quality monitoring within the CHDN parks is variable. Activities in three parks (AMIS, BIBE and RIGR) focus on the Rio Grande and its tributaries with participation in the TCEQ/IBWC effort for the reach (part of segments 2305 and 2306) encompassing the parks. Activity in CAVE and GUMO is conducted by park personnel on a part time basis. Occasional groundwater quality monitoring is conducted at WHSA, and FODA has no perennial surface waters.

Amistad National Recreation Area – The park follows NPS guidelines in monitoring water quality within the reservoir (NPS 2001b). Their water quality monitoring plan is included in Appendix A below. TCEQ and IBWC monitor water quality within the park under the auspices of the Texas Clean Rivers Program. Monitoring also occurs under the USGS NASQAN program at stations located near park boundaries on the Rio Grande and Pecos River.

Big Bend National Park and Rio Grande Wild and Scenic River– The park has an Access database for the 300+ springs, seeps and wells that have been monitored for flow and disturbance starting in 1975. The last comprehensive survey was in 1995 (B. Alex, BIBE, pers. omm... 2005).

Recent park-based water quality activity (email from Jeffrey Bennett, BIBE, March 2005) includes:

- Recently gathered data on 109 water wells in the park, including abandoned ones
- Performed an initial survey of some of the springs along the Wild and Scenic River
- Drilled a new water well at Rio Grande Village, performed a 36 hour pump test on the new well, and made observations at nearby springs during the test.
- The USGS/NPS mine tailings study is complete, but the final report is not released. This was a joint project that also received significant contributions from TCEQ and IBWC.
- Initiating the "Hydrology, salinity, and source of nutrients for the Rio Grande/Rio Bravo" project in partnership with USGS, TCEQ and IBWC" PMIS # 105941
- Secured funding for "Determining the history of Rio Grande River Channel Response to Diminishing flows" PMIS # 105965.
- Making public presentations to educate the public on water resource issues in the park.
- Present at all local water planning meetings

Carlsbad Caverns National Park – Water quality monitoring is conducted by park personnel on a part-time basis (Paul Burger, CAVE, pers. omm... 2005). Several surface waters are monitored. Additionally, subsurface waters are monitored as follows:

- Carlsbad Cavern pools with intermittent water chemistry data: Devils Spring, Signature Pool, Green Lake, Big Shelf Pool, Red Pool and Longfellow's Bathtub.

- Lechuguilla Cave water level monitoring: Lake Lechuguilla and Lake of the White Roses – water level loggers; A5 Pool, Nirvana, Lake Louise and Lost Pecos River – spot readings of water level. No ongoing water chemistry done.

Fort Davis National Historic Site -- No water quality monitoring is conducted in the park. The State of Texas does monitor water quality on adjacent Limpia Creek (http://www.tnrcc.state.tx.us/cgi-bin/water/wq/crp/stationquery2.pl?basinid=23) nearby along State Highway 17 north of Fort Davis.

Guadalupe Mountains NP – Performs monthly monitoring of surface water quality at 4 stations in South McKittrick Canyon and one at Choza Spring. Parameters are: temperature, dissolved oxygen, pH, nitrates, sulfates, phosphates, total dissolved solids, and calcium ion concentration. Analysis is conducted in house.

White Sands National Monument – WHSA observation and monitoring of groundwater and wells is on an occasional basis. There are no perennial surface waters in WHSA. Depth to water is measured at several park wells and data recorded in an Excel file (B. Conrod, NPS retired, pers. omm... 2004). No regular monitoring is done for ephemeral water bodies: (1) Surface flows occur occasionally at the west of the monument after flooding rains, with persistence at Lake Lucero Playa. (2) On rare occasions Lost River floods into the northeast portion of the monument. (3) In winter, ephemeral surface waters stand in some interdunal areas. (4) Standing water was earlier observed at two dune field locations during the summer (Reid 1979, 1980).

Φιγυρε 2 INTRODUCTION

This report was prepared to meet the policy and regulatory portion of the water resource information and assessment needs of the Chihuahuan Desert Network (CHDN). National Park Service (NPS) staff reviewed available fisheries, aquatics and toxicology data. The combined data will assist park and network staff and collaborators in determining the aquatic resource monitoring needs for the CHDN parks.

The Chihuahuan Desert Ecoregion has been variously described with small variation between models. The Chihuahuan Desert Network occupies the northern portion of this desert, with Amistad NRA on its margin.

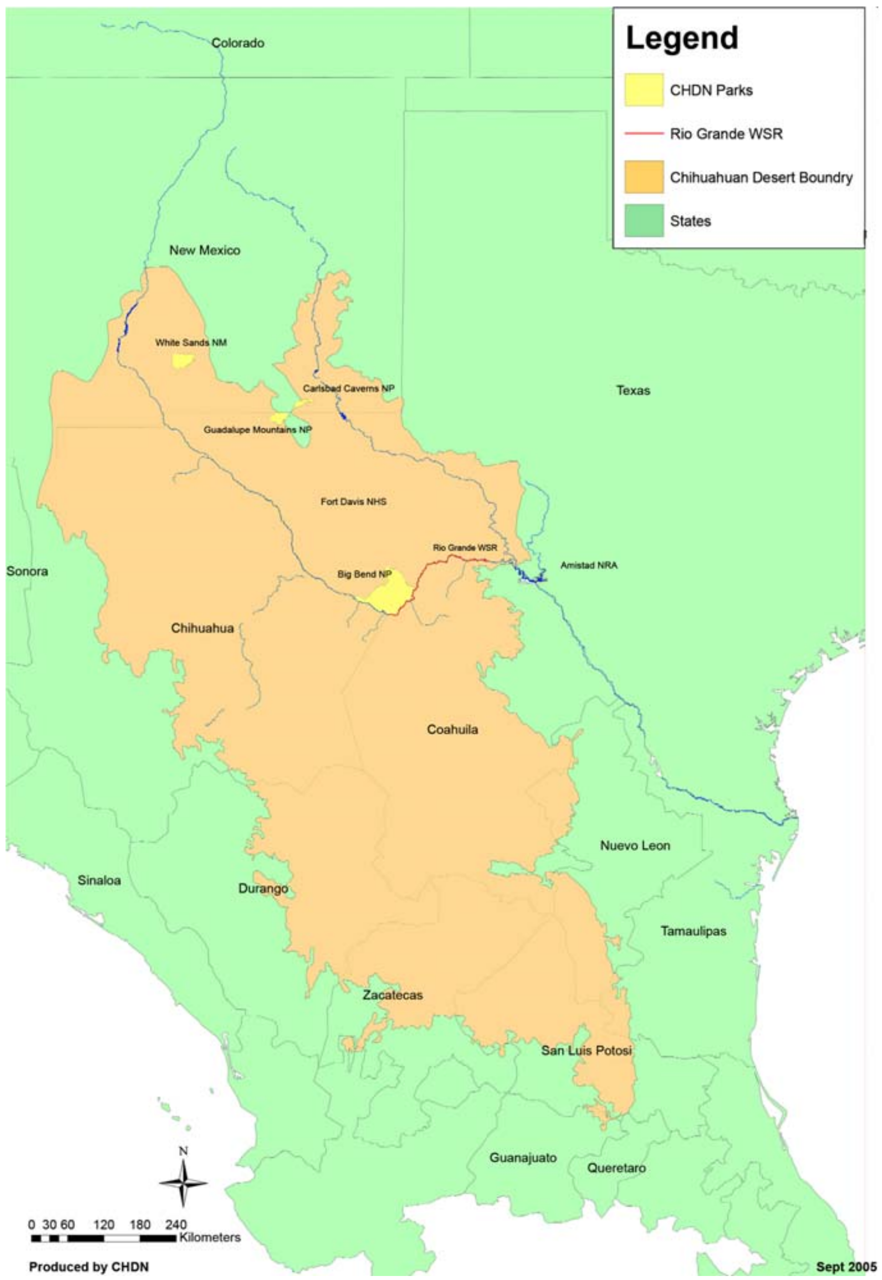

Figure 1. The Chihuahuan Desert and NPS Chihuahuan Desert Network Parks.

There are seven CHDN parks: Amistad National Recreation Area (AMIS), Big Bend National Park (BIBE), Carlsbad Caverns National Park (CAVE), Fort Davis National Historic Site (FODA), Guadalupe Mountains

National Park (GUMO), Rio Grande Wild and Scenic River (RIGR), and White Sands National Monument (WHSA). The Rio Grande Wild and Scenic River, administered by Big Bend National Park, was not originally identified as a separate unit (NPS 2001a). The CHDN Board of Directors (BOD) voted in 2002 to identify the RIGR as a separate entity. A portion of the RIGR overlaps with a portion of BIBE. To avoid database ambiguity, for this and other CHDN reports and actions, the BOD designated that portion of the RIGR downstream from BIBE as that that unit's extent. The CHDN parks vary in area by a ratio of about 1700:1:

Table 1. National Park Service units in the Chihuahuan Desert network.

Unit	Park code	Hectares	Acres
Amistad National Recreation Area	AMIS	23,185	57,292
Big Bend National Park	BIBE	324,232	801,163
Carlsbad Caverns National Park	CAVE	18,926	46,766
Fort Davis National Historic Site	FODA	192	474
Guadalupe Mountains National Park	GUMO	35,272	86,416
Rio Grande Wild and Scenic River	RIGR	ca. 3885*	ca. 9600*
White Sands National Monument	WHSA	58,169	143,733
	Total	464,544	1,145,444

*Park area for the RIGR is approximate and based on an average of a ¼ mile conservation corridor assumed in the legislation (Wild and Scenic Rivers Act P.L. 90-542 as amended). An exact conservation corridor has not been established. The entire RIGR extends from IBWC (1976) river kilometer 1058.18 (mile 657.52) to km 1373.13 (mile 853.22). Note that for CHDN database purposes the CHDN BOD named the portion of the RIGR external to BIBE as the area of consideration. This includes river kilometer 1058.18 (mile 657.52) to km 1262.72 (mile 784.62).

The CHDN parks form a northwest to southeast, 500 km (340 mile) line through southern New Mexico, West Texas and into South Texas. The Chihuahuan Desert is characterized as a cold desert with annual precipitation near 200 mm (8 inches), half of which falls in July to September monsoon thunderstorms. This pattern of precipitation focused in summer and late summer is common to all the park units except AMIS, which has higher, more evenly distributed rainfall. AMIS is not usually considered as within the Chihuahuan Desert Ecosystem (Rickets et al. 1999). However, many Chihuahuan Desert species extend into the park. Schmidt (1979, 1990, 1995) has conducted a detailed, climatic examination of the Chihuahuan Desert. Year to year and place to place precipitation is highly variable.

The CHDN parks are a significant element in the economy of this largely sparsely settled region. Note that in the table below that the vast majority of Dona Ana County population is relatively remote from White Sands National Monument.

Table 2. Regional setting of the CHDN parks (http://quickfacts.census.gov)

State	County	Park	Population*	Area (mi2)	Area (km2)
NM	Eddy	CAVE	51,470	4,182	10,831
NM	Dona Ana	WHSA	182,165	3,807	9,860
NM	Otero	WHSA	63,471	6,626	17,161
TX	Brewster	BIBE & RIGR	9,247	6,193	16,039
TX	Culberson	GUMO	2,570	3,812	9,873
TX	Hudspeth	GUMO	3,193	4,571	11,838
TX	Jeff Davis	FODA	2,236	2,264	5,864
TX	Terrell	RIGR	1,034	2,358	6,107
TX	Val Verde	AMIS	46,569	3,170	8,210
Total			315,386	33,813	87,573

2. PARK DESCRIPTIONS AND THEIR SURFACE WATERS

We present here brief descriptions of the CHDN parks, 8-digit subbasins, their surface waters, threats, and summary surface water matters. In querying the parks, we specified five categories surface waters:

- Perennial Flowing Water
- Significant Ephemeral Flowing Water (Arroyos)
- Perennial Standing Water Bodies
- Ephemeral Standing Water Bodies
- Springs and seeps.

In the park data below we also list some non-significant flowing waters (ephemeral flowing arroyos). Where we have included surface waters outside of the parks, they are so identified. Since the Rio Grande is the dominant surface water in three parks (AMIS, BIBE and RIGR), with a nearly continuous 529 river km, 328 river mile, (IBWC 1976) boundary with Mexico, we also reviewed issues for that river reach in a separate section.

Amistad National Recreation Area (AMIS) – Created with the construction of Amistad Dam (IBWC NPS 1965 and PL 86-605 (1960), park operations began in 1969. Amistad NRA's upper boundary is defined by and altitude (ca. 349 m) in rough terrain. This creates a long, complex boundary. Amistad contains 43,250 water acres and 14,042 land acres subject to great variation with changing river flows and releases. Amistad Dam is administered by the International Boundary and Water Commission (IBWC), a treaty organization, that manages releases from Amistad Reservoir acting on instructions from the United States or Mexico. United States water deliveries are regulated by the Texas Commission for Environmental Quality (TCEQ) Watermaster, and Mexican deliveries are regulated by the Comision Nacional del Aqua (I). The IBWC is responsible for releases during declared Flood Operations (Rick Slade, AMIS, pers. omm.. And Ken Rakestraw IBWC, pers. omm.. 2005). The capacity of the reservoir, including silt and conservation, is 6,827,200 m^3 (5,535,000 acre feet).

The predominant surface drainage is into Amistad Reservoir from surrounding lands. The park is located at a convergence of the Chihuahuan Desert, the Edwards Plateau Savannah, and the Tamaulipan Mezquital Ecoregions (Ricketts et al. 1999). Riparian, shoreline, inundation zone and upland desert ecosystems support a high terrestrial species diversity. A number of aquatic species occur in the lake and sections of the Rio Grande and Devils and Pecos Rivers. The park upper boundary is defined by a fixed altitude of 349 m (1,144.3 feet) (NPS 1987), creating a long, complex boundary in the highly dissected, calcareous terrain. In its upper reaches, the park includes very little land as the rivers pass through steep-walled canyons of the Rio Grande. The park includes 25 miles of the Devils and Pecos Rivers lower reaches (http://www.epa.gov/fedrgstr/EPA-IMPACT/2003/October/Day-22/i26577.htm).

The National Park Service (NPS 1987:9) has noted concern for park water quality: "The reservoir's water may be affected by contamination such as sewage, fuel, or other chemicals. Natural processes my also change clarity, oxygen, or nutrient levels, which would affect…fish and general biotic growth. Benchmark data are not available to measure changes."

TCEQ has designated the reservoir as fully compliant with water quality standards: "Segment 2305- International Amistad Reservoir: from Amistad Dam in Val Verde County to a point 1.8 kilometers (1.1 miles) downstream of the confluence of Ramsey Canyon on the Rio Grande Arm in Val Verde County and to a point 0.7 kilometer (0.4 mile) downstream of the confluence of Painted Canyon on the Pecos River Arm in Val Verde County and to a point 0.6 kilometer (0.4 mile) downstream of the confluence of Little Satan Creek on the Devils River Arm in Val Verde County, up to the normal pool elevation of 1117 feet (impounds Rio Grande). The aquatic life use, contact recreation, public water supply, and general uses are fully supported. Category 1 – Attaining the water quality standard and no use is threatened" (http://www.tnrcc.state.tx.us/water/quality/04_twqi303d/04_wqi/04_riogrande.html).

Table 3. Amistad National Recreation Area Subbasins

Park	Park Name	8-Digit Subbasin	Catalog Unit Basin	Subbasin
AMIS	Amistad NRA	13040212	Rio Grande-Amistad	Amistad Reservoir
AMIS	Amistad NRA	13040302	Devils	Lower Devils
AMIS	Amistad NRA	13070008	Lower Pecos	Lower Pecos
AMIS	Amistad NRA	13080001	Rio Grande-Falcon	Elm-Sycamore

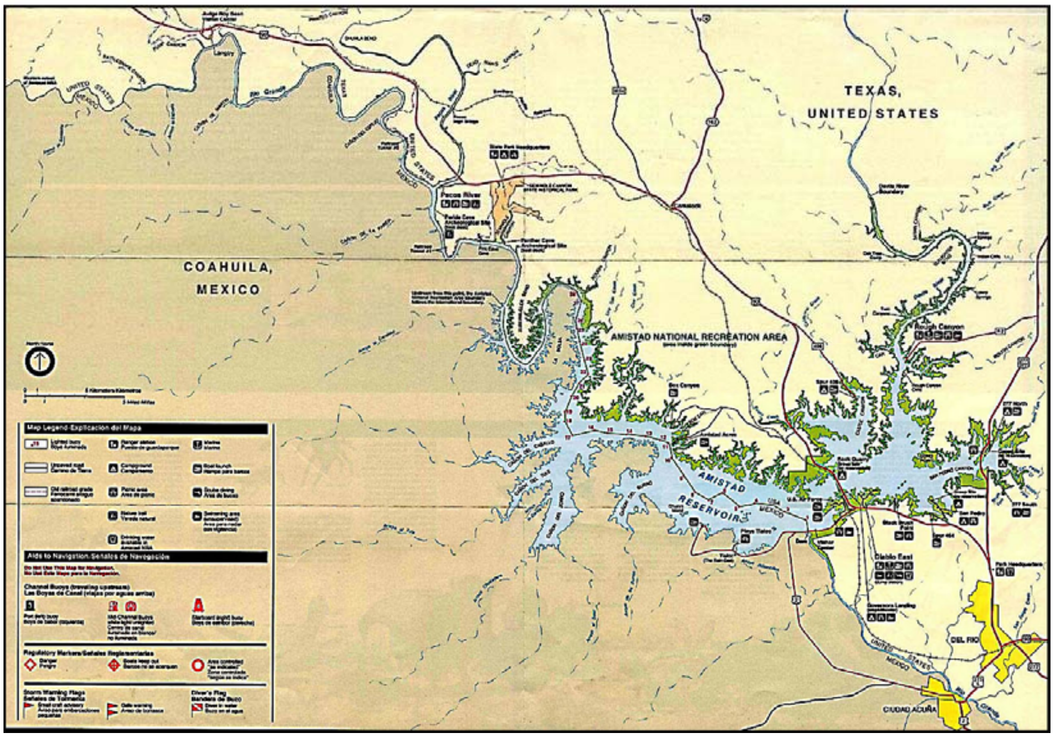

Figure 2 Map of Amistad National Recreation Area (from http://data2.itc.nps.gov/hafe/hfc/carto.cfm)

Amistad Surface Waters

Table 4. AMIS Surface Water Summary Data from NPS WRD last updated 10/20/2004

	Miles	303(d) Impaired Miles	Miles Adjacent	303(d) Impaired Adjacent Miles	Acres	303(d) Impaired Acres	Shoreline Miles	303(d) Impaired Shoreline Miles	Count
Perennial Stream/River	11.56	2.55	0.00	0.00					
Intermittent Stream/River	64.62	0.00	0.00	0.00					
Canal	0.00	0.00	0.00	0.00					
Waterway[1]	76.18	2.55							
Lake/ Reservoir					37,741.31	0.00	576.56	0.00	
Sea/Ocean					0.00	0.00	0.00	0.00	

Waterbody[2]					37,741.31	0.00			
Spring/Seep									1
Waterfall									0

Table 5. Water Body Data Received From AMIS (Rick Slade, NPS, pers. omm.., 2005)

TYPE/NAME	PARK?	Notes	Impairment listed?
PERENNIAL FLOWING			
Rio Grande River	Yes	Headwaters in Colorado	
Pecos River	Yes	Headwaters in New Mexico	303(d)
Devils River	Yes	Headwaters in Texas. Great flow variation.	
EPHEMERAL FLOWING			
Dead Man’s Canyon	Yes	Enters Pecos R.	
Rough Canyon	Yes	Enters Devils R.	
Satan Canyon	Yes	Enters Devils R.	
Rattlesnake Canyon	Yes	Enters Rio Grande	
Pump Canyon	Yes	Enters Rio Grande	
Seminole Canyon	Yes	Passes through Texas Seminole Canyon State Park to Rio Grande	
Rough Canyon	Yes	Enters Rio Grande	
Live Oak Creek	Yes	Enters Rio Grande	
Cow Creek	Yes	Enters Rio Grande	
Evans Creek	Yes	Enters Rio Grande	
California Creek	Yes	Enters Devils R.	
North Fork	Yes	Enters Devils R.	
San Pedro Creek	Yes	Enters Devils R.	
Middle Fork	Yes	Enters Devils R.	
South Fork	Yes	Enters Devils R.	
Arroyo el Soldado	No	Enters Rio Grande	
Arroyo de Espuela	No	Enters Rio Grande	
Arroyo el Borrego	No	Enters Rio Grande	
Canon de Martin	No	Enters Rio Grande	
Canon el Espejo	No	Enters Rio Grande	
Canon de la Parida	No	Enters Rio Grande	
Arroyo la Carabina	No	Enters Rio Grande	
Canon del Caballo	No	Enters Rio Grande	
Arroyo el Tule	No	Enters Rio Grande	
Canon del Zorro	No	Enters Rio Grande	
Arroyo de los Burros	No	Enters Rio Grande	
Arroyo Jaboncillos	No	Enters Rio Grande	
PERENNIAL STANDING			
Amistad Reservoir	Partly	Formed by Amistad Dam in Rio Grande	
EPHEMERAL STANDING			
No significant	n/a		

Table 6. Amistad major springs from NPS (2001b)

Spring Name	Location	Elevation	Spring Flow
Devils River			
Willow Springs	Along Devils River	Slightly above conservation pool	4121 gpm (260 lps) (1971)
Indian Springs	Limestone bluff on east shore of lake	At conservation pool	Range: 4913 gpm (310 lps) (1971) to 20,605 gpm (1,300 lps) (1925)
Satan Springs	Mouth of Big Satan Creek	At conservation pool	54 gpm (3.4 lps)
Lowry Springs	2 miles (3.2 km) south of Indian Springs	Inundated	90 gpm (5.7 lps)
Rio Grande			
Goodenough Springs	Along Rio Grande	Inundated	61,818 gpm (3,900 lps) (average annual flow)
Pump Canyon Springs	1.5 (2.4 km) miles west of Langtry	At conservation pool	135 gpm (8.5 lps) (1939)
Eagle Nest Springs	Upper reach of Rio Grande	Inundated	4.9 gpm (0.31 lps) (1968)
Pecos River			
Dead Man Springs	East side of River, north of railroad	56 feet (17 m) below conservation pool	1902 gpm (120 lps) (1939)
Pecos Springs	2.5 miles (4.0 km) south of Dead Man Springs	Inundated	25.5 gpm (1.61 lps) (1939)

2.2 Big Bend National Park (BIBE) – Established in 1944, Big Bend is the largest protected area representative of northern Chihuahuan Desert ecosystems. Except for some northern areas, surface drainage is from Big Bend into its surroundings. However, the Rio Grande River forms its southern border. The park is a designated Biosphere Reserve (United States Biosphere Reserves Association 2003 and http://www.rmrs.nau.edu/usamab/), includes 533,900 acres of recommended wilderness, and administers the 196-mile Rio Grande Wild and Scenic River. A complex terrain, diverse soil parent materials, and a large span of altitudes support a high species diversity.

The park is addressing (NPS 2003) water quality issues using its Water Resources Management Plan (NPS 1996a), which includes the through-flowing Rio Grande River being studies and monitored by several agencies.

Table 7. Big Bend National Park Subbasins

Park	Park Name	8-Digit Subbasin	Catalog Unit Basin	Subbasin
BIBE	Big Bend NP	13040203	Rio Grande-Amistad	Black Hills-Fresno
BIBE	Big Bend NP	13040204	Rio Grande-Amistad	Terlingua
BIBE	Big Bend NP	13040205	Rio Grande-Amistad	Big Bend
BIBE	Big Bend NP	13040206	Rio Grande-Amistad	Maravillas
BIBE	Big Bend NP	13040207	Rio Grande-Amistad	Santiago Draw

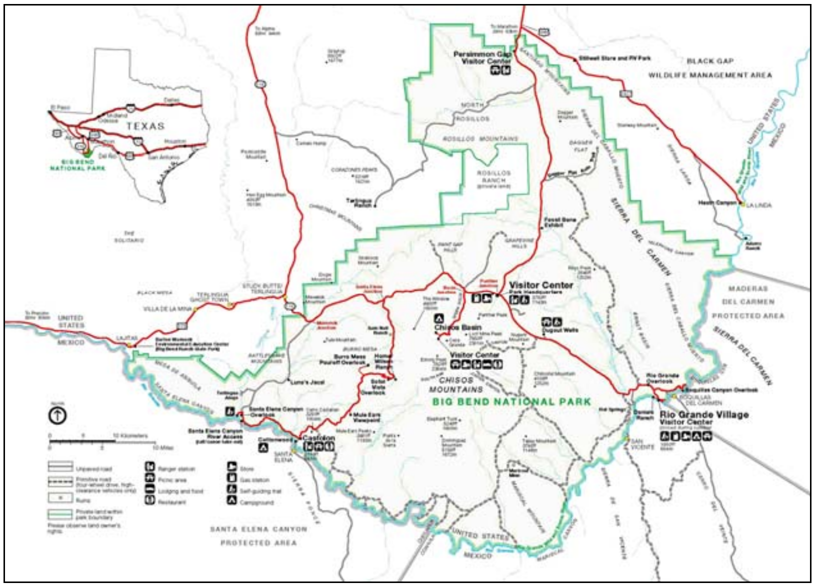

Figure 3. Big Bend National Park (from http://data2.itc.nps.gov/hafe/hfc/carto.cfm)

Big Bend Surface Waters

NPS (1992) reports: In 1976, an initial inventory and survey identified approximately 180 water sources in BIBE including springs, seeps, tinajas, and stock tanks. Follow-up surveys in 1986 and 1990 further refined the inventory so that over 300 water sources have been located and surveyed, including more than 200 springs. A park database identifies a total of 348 identified Big Bend water bodies found and examined in surveys conducted between 1970 and 1995. Of these 14 are wells, 37 are tanks or tinajas, one is a human-managed pond, and one is a river, the Rio Grande. Of the 295 springs and seeps, data is lacking for 25 and 72 were identified as dry in the most recent, 1995 survey. Further, many listed as springs were reported as seeps in 1995. Within the park's 324,000 ha there are many arroyos for which a database needs to be prepared. Of interest to water quality in the Rio Grande is Terlingua Creek to the west of the park, which drains an area with abandoned mercury mines. Springs within the bed of the Rio Grande River add significant flows (King 2005 and Appendix B).

Table 8. BIBE Surface Water Data from NPS WRD (last updated 12/31/2003)

	Miles	303(d) Impaired Miles	Miles Adjacent	303(d) Impaired Adjacent Miles	Acres	303(d) Impaired Acres	Shoreline Miles	303(d) Impaired Shoreline Miles	Count
Perennial Stream/River	5.27	0.00	118.79	118.79					
Intermittent Stream/River	1,414.01	0.00	0.00	0.00					
Canal	0.00	0.00	0.00	0.00					
Waterway[1]	1,538.07	118.79							
Lake/ Reservoir					21.78	0.00	1.89	0.00	
Sea/Ocean					0.00	0.00	0.00	0.00	
Waterbody[2]					21.78	0.00			
Spring/Seep									142
Waterfall									0

Table 9. Sample listing of BIBE surface waters (UTM reference is NAD84, Betty Alex, NPS, pers. comm. 2005)

BIBE ID	NAME	CHARACTERIZATION AT LAST FIELD CHECK	UTM N	UTM E
BONE95	Bone Spring (Well)	Water ca. 20 m down.	3277590	676700
DODS95	Dodson Spring	Small flow	3231980	666780
DOMI95	Dominguez Spring	Flow estimated at 2-4 lpm	3223481	664360
DUWE95	Dugout Wells	Seepage only.	3239350	681270
ERNS95	Ernst Tinaja	Tinaja water is 5' lower than in 1990	3237800	693541
GANO95	Gano Spring	Flow length at least 400m	3243050	653480
GLEN95	Glenn Springs	Flow length 1600m plus	3228790	679180
GOVE95	Government Spring	Pool 20' long x 14' across x 1.5' deep	3246760	669300
JULO95	Lower Juniper Spring	No comment	3234380	667840
JUUP95	Upper Juniper Spring	Small pool of water, no apparent flow	3236670	667360
MCKI95	McKinney Springs	Flow length about 400m.	3254690	685650
MOWE95	Moss Well	Dry well	3226820	654900
MUEA95	Mule Ears Spring	None	3260000	685070
MUSK95	Muskhog Spring	Flow trickling in on location..	3259980	685060
OAKS95	Oak Spring	Past cottonwoods over road.	3240200	661610
PENA951	Pena Spring "1"	None	3232180	645360
PENA952	Pena Spring "2"	Some flow	3229860	658320
SAMS96	Sam Nail Ranch Spring	Dry	3224860	658540
SMOK95	Smoky Spring	Intermittent wet areas for 400 m.	3224900	658540
TRAP95	Trap Spring	None	3226980	653620
WARD95	Ward Spring	2 damp areas	3236020	660260

2.3 Carlsbad Caverns National Park (CAVE) – Established in 1923, Carlsbad Caverns includes 46,766 acres, of which 33,125 acres are Designated Wilderness. The surface drainage is from the park to its surroundings. The park has more than 80 caves. UNESCO World Heritage Site designation indicates the significance of the park's cave and other resources. Surface elevations range from 1096 to 1987 m (3,595 to 6,520 ft) and include fossilized reef uplands and diverse incised canyons. Brooke (1996) and Tallman (1993) provide substantial data on the hydrology of CAVE.

The park's General Management Plan (NPS 1996b) and Carlsbad Cavern Resource Protection Plan (NPS 2002b) address several water issues: water quality protection, water conservation, and flood hazards in flood prone canyons.

Table 10. Carlsbad Caverns National Park Subbasin

Park	Park Name	8-Digit Subbasin	Catalog Unit Basin	Subbasin
CAVE	Carlsbad Caverns NP	13060011	Pecos	Upper Pecos-Black

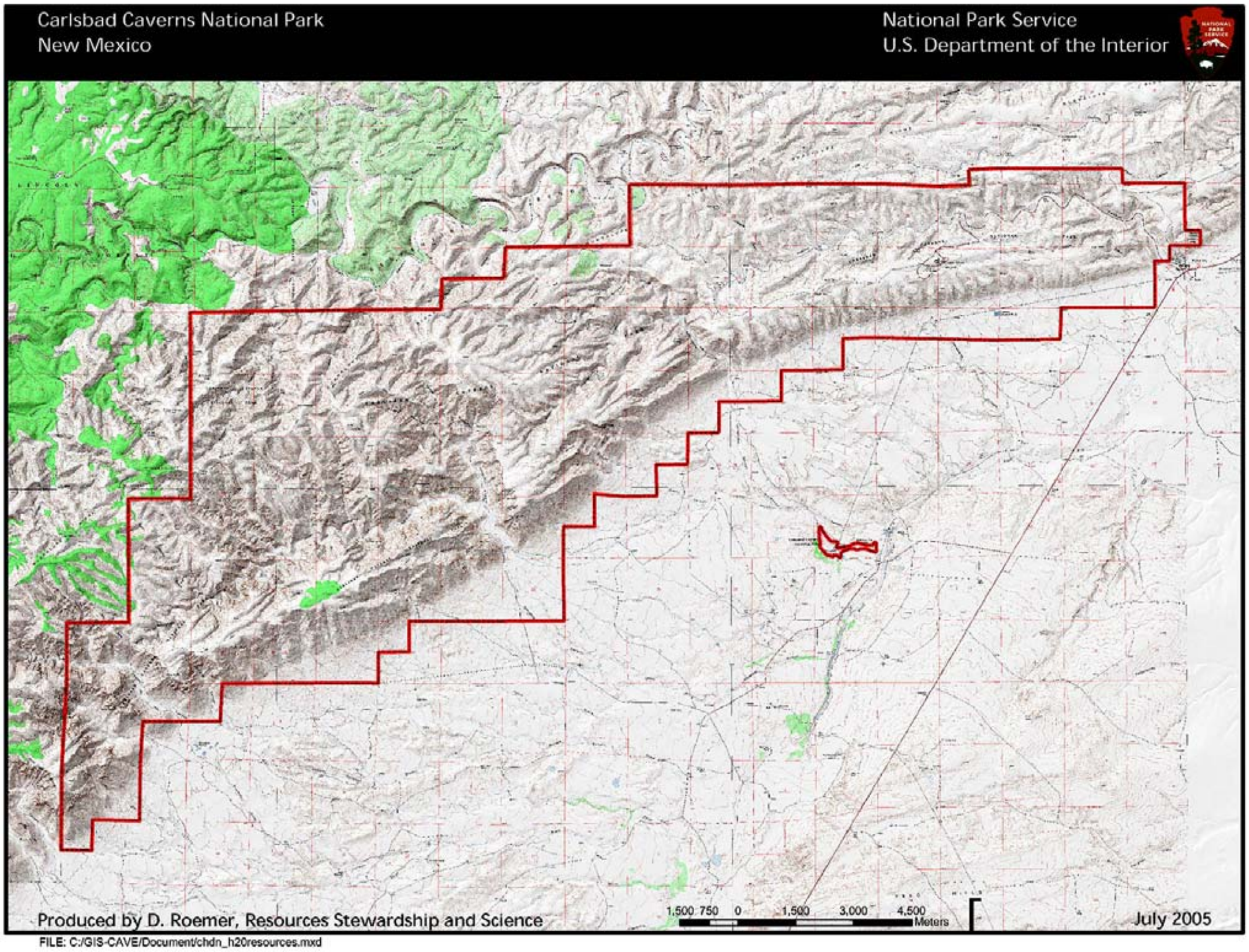

Figure 4. Carlsbad Caverns National Park

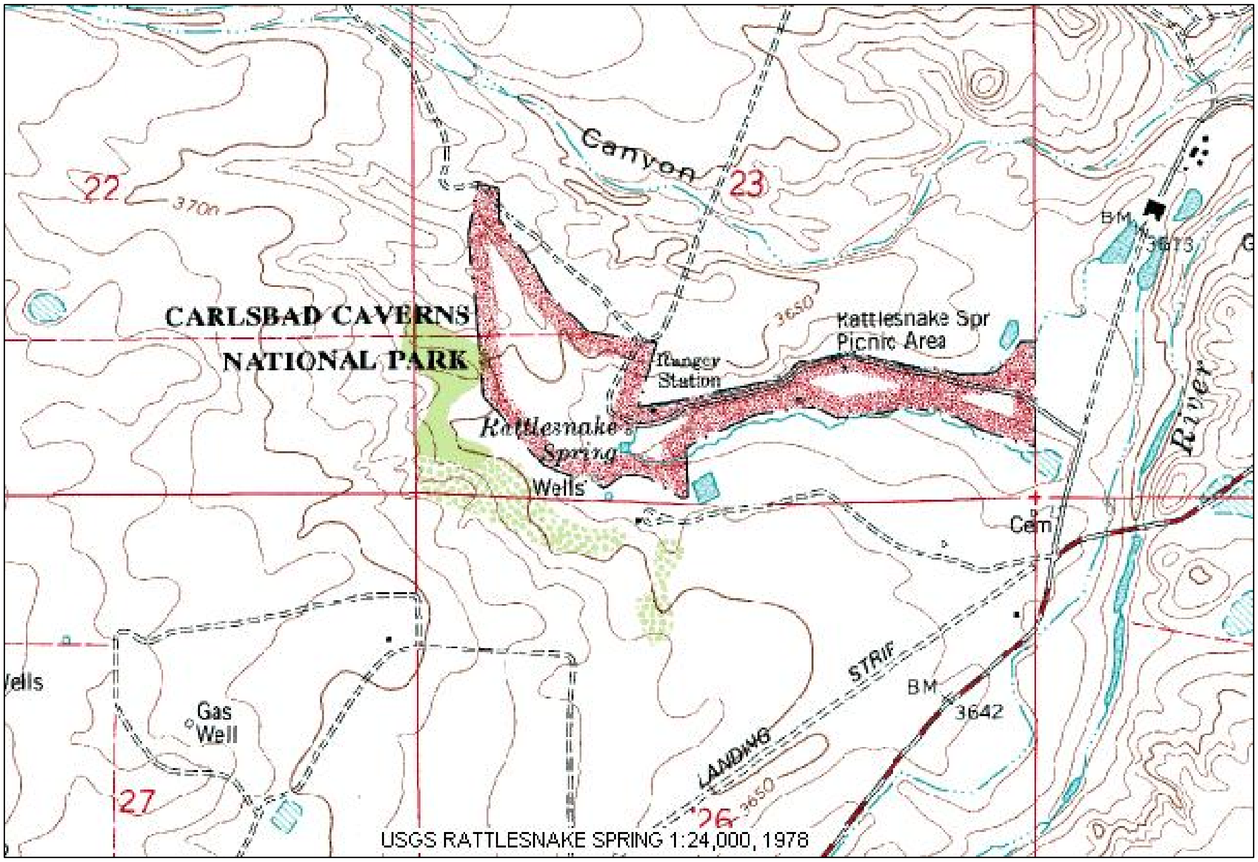

Figure 5. Rattlesnake Springs area (from USGS Rattlesnake Spring 1:2400 topo)

Carlsbad Caverns National Park Surface Waters

Table 11. CAVE Surface Water Data from NPS WRD (last updated 12/1/2004)

	Miles	303(d) Impaired Miles	Miles Adjacent	303(d) Impaired Adjacent Miles	Acres	303(d) Impaired Acres	Shoreline Miles	303(d) Impaired Shoreline Miles	Count
Perennial Stream/River	0.00	0.00	0.00	0.00					
Intermittent Stream/River	190.46	0.00	0.62	0.00					
Canal	0.06	0.00	0.70	0.00					
Waterway[1]	191.83	0.00							
Lake/ Reservoir					0.13	0.00	0.06	0.00	
Sea/Ocean					0.00	0.00	0.00	0.00	
Waterbody[2]					0.13	0.00			
Spring/Seep									6
Waterfall									0

Table 12. Springs and Seeps Data received from CAVE (Dave Roemer, NPS, pers. comm., 2005)

Spring Name	UTM N	UTM E	GPS	Elev.	Drainage
PERMANENT					
Rattlesnake Springs*			No	1106.12	Black River
Kirkland Spring			No	1836.59	Kirkland Canyon
West Lechuguilla Seep	3561918.56	546374.44	Yes	1453.29	Lechuguilla Canyon
Lowe Ranch Spring			No	1356.7	Lowe Spring
Clemond Ranch Seep			No	1829.27	North Slaughter Canyon
Dead Man Seep	3558540.68	546534.69	Yes	1411.34	Rattlesnake Canyon
Stone Ranch Spring	3558027.54	545899.33	Yes	1376.62	Rattlesnake Canyon
Maple Spring			No	1521.3	South Rattlesnake Canyon
Rock Wren			No	1562.2	South Rattlesnake Canyon
Putman Tank	3555365.66	533829.75	Yes	1812.41	Upper Putman Canyon
Log Cabin Seep			No	1670.7	Upper Putman Canyon
East Lechuguilla Seep			No	1439.02	Upper Walnut Canyon
No Name	3560249.16	542991.18	Yes	1479.37	Upper Walnut Canyon
Oak Springs	3560350	552041.2	Yes	1301.9	Walnut Canyon
Big Hill Seep			No	1281.7	Walnut Canyon
Spider Cave Seep	3560028.34	550632.69	Yes	1326.75	Walnut Canyon
Grammer Seep	3561749.3	553387.96	Yes	1284.31	Walnut Canyon
Kids Spring	3561778.5	551358.97	Yes	1374.52	Walnut Canyon
West Upper Grammer Seep	3562001.22	553350.48	Yes	1297.78	Walnut Canyon
Upper Middle Grammer Spring	3562009.88	553627.58	Yes	1261.55	Walnut Canyon
No Name	3559488.78	549147.73	Yes	1336.08	Walnut Canyon
Longview Spring	3551466.28	535777.51	Yes	1776.98	West Slaughter Canyon
Crown Rock (Shortview)			No	1758.5	West Slaughter Canyon
Dog Pen Seep	3551725.85	536263.88	Yes	1805.1	West Slaughter Canyon
Iron Pipe Spring			No	1768.3	West Slaughter Canyon
Cut Log Spring			No	1757.01	West Slaughter Canyon
Pine Cove Spring			No	1741.7	West Slaughter Canyon
INTERMITTENT					
Sewer Lagoon Tank	3558495.91	554387.405	Yes	1130.15	East Escarpment
Upper Lechuguilla Seep	3561977.54	547064.35	Yes	1451.48	Lechuguilla Canyon
Upper Lowe Ranch Spring			No	1402.4	Lowe Spring
Old Quaker	3556027.38	537361.36	Yes	1848.41	Middle Slaughter Canyon
No Name			No	1646.34	Middle Slaughter Canyon
No Name			No	1829.27	Payne Canyon
Stone West Seep			No	1463.4	Rattlesnake Canyon
Stone East Seep			No	1475.61	Rattlesnake Canyon
No Name			No	1365.85	Rattlesnake Canyon
Slaughter Pot Hole			No	1463.4	Upper North Slaughter Canyon
No Name			No	1756.1	Upper North Slaughter Canyon
Able Seep			No	1670.73	Upper Putman Canyon
Wild Cow Seep			No	1890	Upper Thurman Draw
Wild Calf Seep			No	1890	Upper Thurman Draw
No Name	3559878.32	545903.03	Yes	1420.21	Upper Walnut Canyon
No Name			No	1768.29	Upper West Slaughter Canyon

No Name Seep	3559730	549045.9	Yes	1331.14	Walnut Canyon
East Upper Grammer Seep	3562089.08	553771.2	Yes	1268.74	Walnut Canyon
No Name			No	1341.46	Walnut Canyon
No Name			No	1347.56	Walnut Canyon
Forgetful Seep	3561800.58	551925.36	Yes	1368.31	Walnut Canyon
Arc Site Pool			No	1312	Walnut Canyon
Tanaja Pot Holes			No	1829.27	West Slaughter Canyon
No Name			No	1878.41	West Slaughter Canyon
Pothole			No	1548.78	West Slaughter Canyon

*Located in separate land unit of the park providing potable water to the park and irrigation water to other stakeholders. Its water quality was recently examined by New Mexico Environmental Department (2003).

Carlsbad Caverns National Park Subterranean Waters

Several Carlsbad Caverns NP caves carry significant water and have standing pools. The two most significant are the main cavern and Lechuguilla Cave, both of which have be subject to hydrologic, infiltration pathway and water quality research (cf. Brooke, 1996, Tallman 1993, van der Heijde et al. 1997). Infiltration of contaminated waters to Carlsbad Cavern is a major park concern, as is protection of pristine conditions in Lechuguilla Cave.

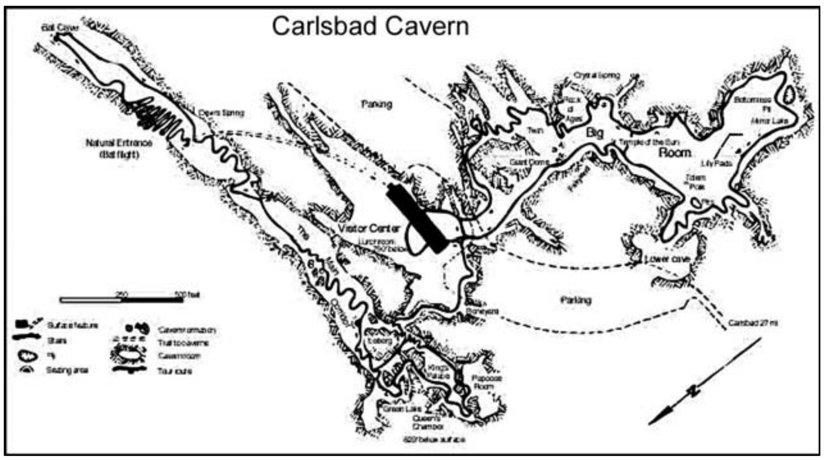

Figure 6. Diagram of Carlsbad Cavern

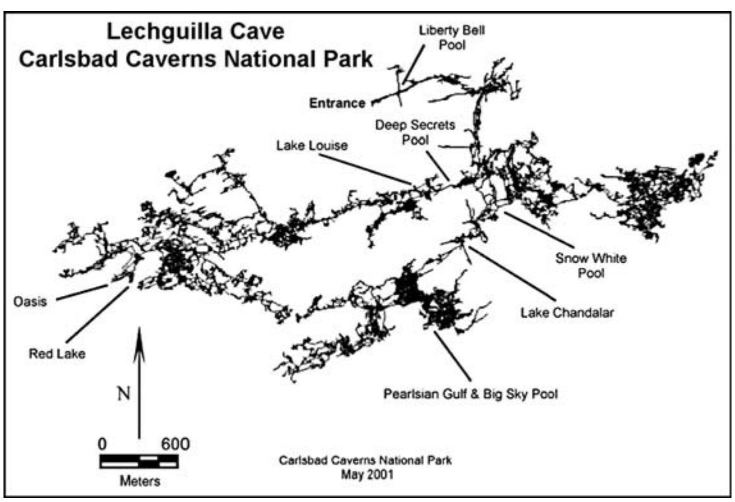

Figure 7. Diagram of Lechguilla Cave.

2.4 Fort Davis National Historic Site (FODA) Established in 1963, Fort Davis is in the Davis Mountains, Texas' most extensive mountain range. The 474-acre park preserves fort structures and interprets the era of westward migration and the late 19th century U.S. Army. The park abuts on both the unincorporated town of Fort Davis and Davis Mountains State Park. Limpia Creek passes adjacent to the park's northern boundary. Soil parent materials are basalts and drainage is into the park. Flooding from drainage through Hospital Canyon Arroyo has been assessed by the NPS WRD (NPS 1999b) and park planning has focused on flooding issues (NPS 2002c).

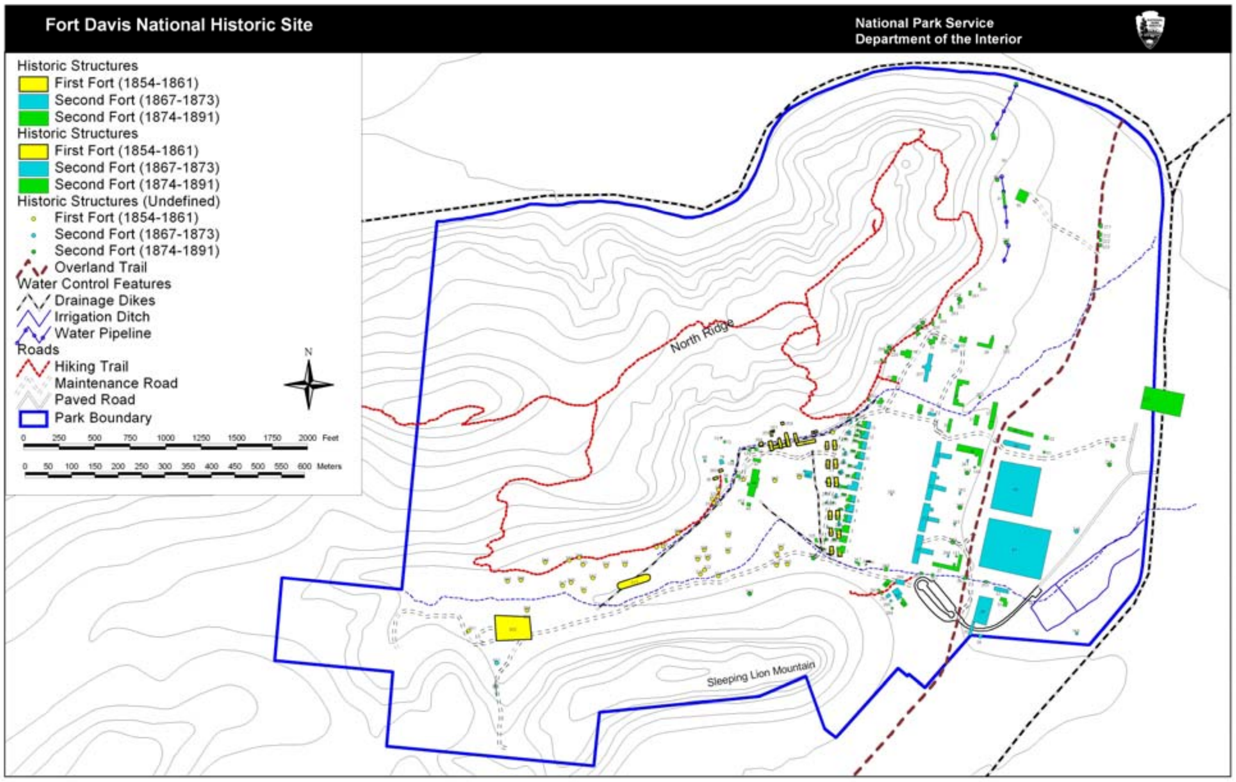

Figure 8. Fort Davis National Historic Site (Received from Fort Davis NHS)

Table 13. Fort Davis National Historic Site Subbasin

Park	Park Name	8-Digit Subbasin	Catalog Unit Basin	Subbasin
FODA	Fort Davis NHS	13070005	Lower Pecos	Barrilla Draw

Fort Davis National Historic Site Surface Waters –

Table 14. FODA Surface Water Data from NPS WRD (last updated 11/1/2004)

	Miles	303(d) Impaired Miles	Miles Adjacent	303(d) Impaired Adjacent Miles	Acres	303(d) Impaired Acres	Shoreline Miles	303(d) Impaired Shoreline Miles	Count
Perennial Stream/River	0.00	0.00	0.00	0.00					
Intermittent Stream/River	1.24	0.00	0.00	0.00					
Canal	0.00	0.00	0.00	0.00					
Waterway[1]	1.24	0.00							

Lake/ Reservoir					0.00	0.00	0.00	0.00	
Sea/Ocean					0.00	0.00	0.00	0.00	
Waterbody[2]					0.00	0.00			
Spring/Seep									0
Waterfall									0

Table 15. Surface Water Data received from FODA (John Heiner, NPS, pers. comm., 2005)

TYPE/NAME	IN PARK?	Notes	Contaminant and source
Ephemeral Flowing			
Hospital Canyon Drainage	Yes	Floods	
Limpia Creek	No	Adjacent	State park visitor use.

2.5 Guadalupe Mountains National Park (GUMO) – Established in 1972 (and authorized by PL 89-667), Guadalupe Mountains includes 86,416 acres, of which 46,850 are Designated Wilderness. The park preserves the world's most significant fossilized reef outcrops of Permian age limestone and is designated an International Benchmark Standard for Geology. Predominant surface drainage is from the park to its surroundings. Elevation-related environmental diversity ranges from lowland salt basin to relict conifer forests, including Texas' highest point at 2667 m (8,749 ft). The General Management Plan (NPS 1976) provides an early indication of the need for protection of its scant surface water resources.

Table 16. Guadalupe Mountains National Park Subbasins

Park	Park Name	8-Digit Subbasin	Catalog Unit Basin	Subbasin
GUMO	Guadalupe Mountains NP	13050004	Rio Grande Closed Basins	Salt Basin
GUMO	Guadalupe Mountains NP	13060011	Upper Pecos	Upper Pecos-Black
GUMO	Guadalupe Mountains NP	13070002	Lower Pecos	Delaware

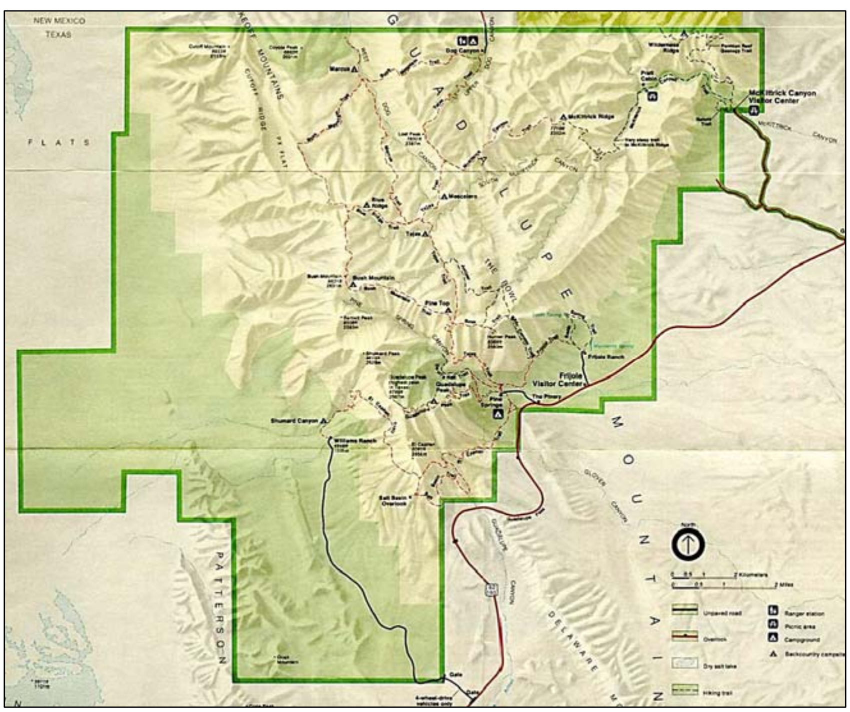

Figure 9. Guadalupe Mountains National Park (from http://data2.itc.nps.gov/hafe/hfc/carto.cfm)

Guadalupe Mountains NP Surface Waters --

Surface waters are sparse in Guadalupe Mountains NP. Early inventories of springs and wells (Reisch and Leggett (1969) and Martin (NPS 1998) remain substantially complete.

Table 17. GUMO Surface Water Data from NPS WRD (late updated 12/31/2003)

	Miles	303(d) Impaired Miles	Miles Adjacent	303(d) Impaired Adjacent Miles	Acres	303(d) Impaired Acres	Shoreline Miles	303(d) Impaired Shoreline Miles	Count
Perennial Stream/River	0.00	0.00	0.00	0.00					
Intermittent Stream/River	107.76	0.00	0.00	0.00					
Canal	0.00	0.00	0.00	0.00					
Waterway[1]	107.76	0.00							
Lake/ Reservoir					0.00	0.00	0.00	0.00	
Sea/Ocean					0.00	0.00	0.00	0.00	
Waterbody[2]					0.00	0.00			
Spring/Seep									11
Waterfall									0

Table 18. Surface Water Data Received from GUMO (Gorden Bell, NPS, pers. comm., 2005)

TYPE/NAME	PARK?	Notes	Flow (gpm)
PERENNIAL FLOWING			
Choza Stream	Yes	From Choza Spring and 2 unnamed springheads.	30 to 36
North McKittriick Canyon Stream	Yes	From numerous unnamed springheads	25
South McKittrick Canyon Stream	Yes	From numerous unnamed springheads	30 to 35
McKittrick Canyon Stream	Yes	Juncture of north and south branches	55 to 60
PERENNIAL STANDING			
Manzanita Pond (Impoundment)	Yes	Historic impoundment fed by Manzanita Spring	
SPRINGS AND SEEPS			
Bone Spring	Yes		2 to 3
Dog Canyon Spring	Yes		<1
Frijole Spring	Yes	Within Frijole Ranch historic structures.	2 to 4
Goat Seep	Yes		1
Guadalupe Spring	Yes		10
Juniper Spring	Yes		<1
Manzanita Spring	Yes		9 to 30
Smith Spring	Yes		27 to 51
Upper Pine Spring	Yes		3 to 4
Pine Spring	Yes	No flow since the 1930s	0
Other	Yes	A few not named or inventoried	Unk.

2.6 Rio Grande Wild and Scenic River (RIGR) – Created in 1976 under the Wild and Scenic Rivers Act, the Rio Grande Wild and Scenic River encompasses 327 river km (199.2 river miles) from the Chihuahua-Coahuila State Line in Mexico to the Terrell Val Verde County Line in the United States. As mentioned above, the extent in CHDN databases leaves out the BIBE-RIGR overlap and is limited to the 160.8 river km (98.1 river miles) between Big Bend and the Terrell Val Verde State Line. This reach through calcareous substrate receives drainage from both United States and Mexican sources, most of them ephemeral. Also, this reach includes Texas State and private lands, and an exact conservation corridor has not been established. For researchers, a nominal ¼ mile limit has been verbally agreed upon by landowners. There are no National Park Service lands other than that portion within Big Bend National Park.

The RIGR is an outstanding resource with very limited access. On the United States side the only access points are at La Linda downstream of Big Bend, the Dryden Pull Out 86 miles below, and Langtry, Texas, somewhat below its lower end. Access from Mexico is even more limited, being confined to primitive access points primarily used by undocumented aliens.

To develop the general management plan (http://www.nps.gov/partnerships/riogrande_riverplan.htm), "A Rio Grande Partnership Team (RGPT) formed to: oversee the planning and public comment process; provide information and ideas on river management for the general plan, and; serve as liaison with the constituents and special interest groups each member represents…The Team represents a wide range of river stakeholders, including representatives from the World Wildlife Fund, Terrell County, Brewster County, Texas Rivers Protection Association, Texas Parks and Wildlife Department, Rio Grande Landowners Association, National Park Service - Denver Service Center, Big Bend National Park, and Commercial Outfitters." The plan was completed (NPS 2004) and released in April 2004 (Federal Register 70(65):17464). The plan strongly states the objectives with regard to water resources:

> "Preserve the river in its natural, free-flowing character and the purposes for which it was designated, and permit historical uses such as boating and fishing...Maintain water quality at, or improve it to, levels consistent with the Clean Water Act and federal or federally approved state water quality standards. "

With regard to sampling it notes:

> "The quality of water in the Rio Grande through the Big Bend region is highly variable. Big Bend National Park employees sample the water for bacterial levels monthly at several locations in the park. An incubation period of 24 hours is required, delaying results and preventing timely notification about poor water quality conditions. Sample results have shown a correlation between river flow levels and high bacteria counts… After rainstorms and when flow levels are rising, the bacterial counts of the water rise and may exceed the recommended levels for contact recreation such as swimming. This probably is caused by runoff from creeks and other tributaries carrying animal waste and other pollutants into the Rio Grande. This occurs primarily during the summer monsoon season, between June and October, but it can happen at any time of year."

While expressing a strong commitment to maintaining and improving water quality, the plan observes that many actual and potential contaminant sources and flow impacts are beyond the jurisdiction of the National Park Service.

Table 19. Rio Grande Wild and Scenic River (downstream of BIBE) Subbasins

Park	Park Name	8-Digit Subbasin	Catalog Unit Basin	Subbasin
RIGR	Rio Grande WSR	13040208	Rio Grande-Amistad	Reagan-Sanderson
RIGR	Rio Grande WSR	13040210	Rio-Grande-Amistad	Lozier Canyon

Rio Grande Wild and Scenic River Surface Waters

The principal perennial flowing water is the Rio Grande. There are numerous, deep-cut canyons entering the river gorge, but flow in most of these is ephemeral. Some of these contain springs, and at least one hot spring on the

Mexican side of the canyon contributes perennial flow. While Mexican lands are not a part of the WSR, many canyons and arroyos add their occasional flows to that of the Rio Grande. Additionally, as with Big Bend, springs in the bed of the Rio Grande contribute significant flow (King 2005 and Appendix B).

Table 20. Major Canyons US Entering the Rio Grande Wild and Scenic River below Big Bend

MAJOR CANYON	IN PARK?	OWNERSHIP
Big Canyon	Yes at Rio Grande interface	Private Property
Reagan Canyon	Yes at Rio Grande interface	Private Property
Jackson Canyon	Yes at Rio Grande interface	Private Property
Kellog Canyon	Yes at Rio Grande interface	Private Property
Barrel Canyon	Yes at Rio Grande interface	Private Property
Panther Gulch	Yes at Rio Grande interface	Private Property
Taylor Canyon	Yes at Rio Grande interface	Private Property
Jabalina Canyon	Yes at Rio Grande interface	Private Property
Britton Canyon	Yes at Rio Grande interface	Private Property
Lozier Canyon	Yes at Rio Grande interface	Private Property

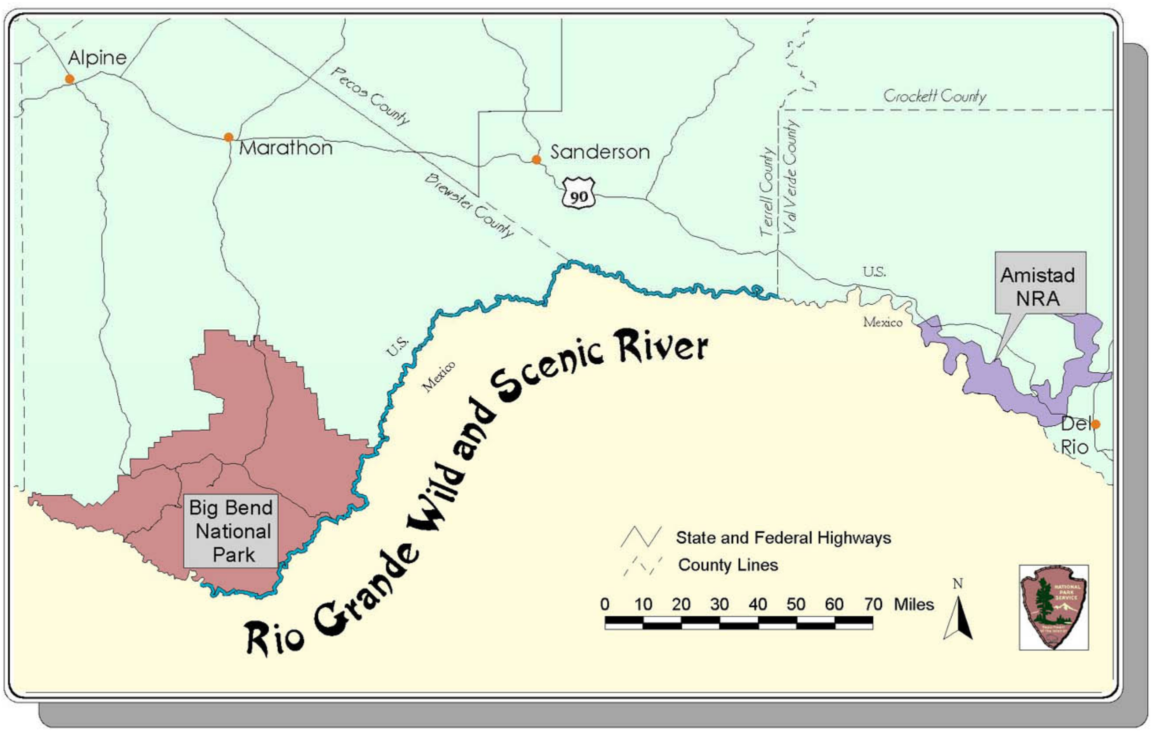

Figure 10, The Rio Grande Wild and Scenic River (from Betty Alex, NPS, pers. comm.. 2005)

White Sands National Monument (WHSA) Established in 1933, imbedded within White Sands Missile Range, and with Holloman Air Force Base on its eastern boundary, White Sands encompasses 143,733 acres of the lowest areas of the closed Tularosa Basin (17,500 sq. km, 6,500 sq. miles) in south central New Mexico. White Sands preserves approximately half of the world's largest gypsum sand dune field. To the west of the dune field is a large, denuded area known as the Alkali Flats. Meinzer and Hare (1915) noted that the wind deflates the flats surface and "the depth to water being everywhere small and generally not more than a few feet."

WHSA is within the Tularosa Basin aquifer (New Mexico Environmental Department 2001) and the area encompassed by the Tularosa Basin and Salt Basin Regional Water Plan (NMSEISC 2002) which examines the water resources of that basin. The above report (p. 16) notes:

> "There are very large quantities of water stored in all three sub-basins of the Tularosa Basin, some in basin fill and some in the bedrock…most of this water has a high TDS content. In terms of recoverable, potable water (defined herein as less than 1,000 parts per million TDS), the northern, western, and eastern sub-basins have stored volumes of water of 5,754,000 acre feet (bedrock only), 6,153,000 acre feet (basin fill only), and 5,789,000 acre feet (bedrock and basin fill), respectively. However, such large quantities of saline water (>1,000 parts per million) exist (124,648,000 acre feet) that, with some type of desalination processing of the water, essentially an infinite supply is available for municipal and other uses. This situation is the motivation for utilizing desalination as a major alternative to deal with drought conditions, to allow for growth, and to isolate the supply of water as much as possible from the variability of precipitation year to year in this area."

Additionally, pilot projects for desalination and aquifer storage and recovery have been initiated (NMSEISC 2004). White Sands has expressed concern for the possibly dramatic (but largely unknown) effects of a lowering water table on the monument's dune field structure and dynamics and biota (Bill Conrod, NPS, pers. comm. 2004). Huff (2004) provides a groundwater flow analysis of the Tularosa Basin that can later contribute to clarification of the matter.

Table 21. White Sands National Monument Subbasin

Park	Park Name	8-Digit Subbasin	Catalog Unit Basin	Subbasin
WHSA	White Sands NM	13050003	Rio Grande Closed Basins	Tularosa Valley

White Sands National Monument Surface Waters

Table 22. WHSA Surface Water Data from NPS WRD (last updated 8/30/2004)

	Miles	303(d) Impaired Miles	Miles Adjacent	303(d) Impaired Adjacent Miles	Acres	303(d) Impaired Acres	Shoreline Miles	303(d) Impaired Shoreline Miles	Count
Perennial Stream/River	0.00	0.00	0.00	0.00					
Intermittent Stream/River	67.75	0.00	0.00	0.00					
Canal	0.00	0.00	0.00	0.00					
Waterway[1]	67.75	0.00							
Lake/ Reservoir					5,412.02	0.00	50.81	0.00	
Sea/Ocean					0.00	0.00	0.00	0.00	
Waterbody[2]					5,412.02	0.00			
Spring/Seep									0
Waterfall									0

Table 23. Surface Water Data received from WHSA (Bill Conrod, NPS retired, pers. comm. 2005)

TYPE/NAME	In Park	Notes	Contaminant and source
PERENNIAL FLOWING			
Lost River	No	Last flood into WHSA 1994	Ammonium perchlorate, Holloman AFB
EPHEMERAL FLOWING			
Andrecito Creek	Yes	Enters WHSA on west after passing under RR 7.	Possible road drainage. WSMR
San Andres Creek	Yes	Enters WHSA on west after passing under RR 7.	Possible road drainage. WSMR
Ash Canyon Creek	Yes	Enters WHSA on west after passing under RR 7.	Possible road drainage. WSMR
Unnamed	Yes	Enter WHSA on west after passing under RR 7.	Possible road drainage. WSMR
PERENNIAL STANDING			
Lake Holloman	No	Seven water bodies for wastewater bioremediation	Drains away from WHSA (Conrod, WHSA)
EPHEMERAL STANDING			
Lake Lucero	Yes	5,412 acres. Source of gypsum sand for park dunes.	Natural salts; receives drainage from WSMR
Unnamed	Yes	At "playa turnout" on Dunes Drive in closed basin.	None known
SPRINGS AND SEEPS			
Garton Pond	Yes	Once large, declining pond from early drilling	None known

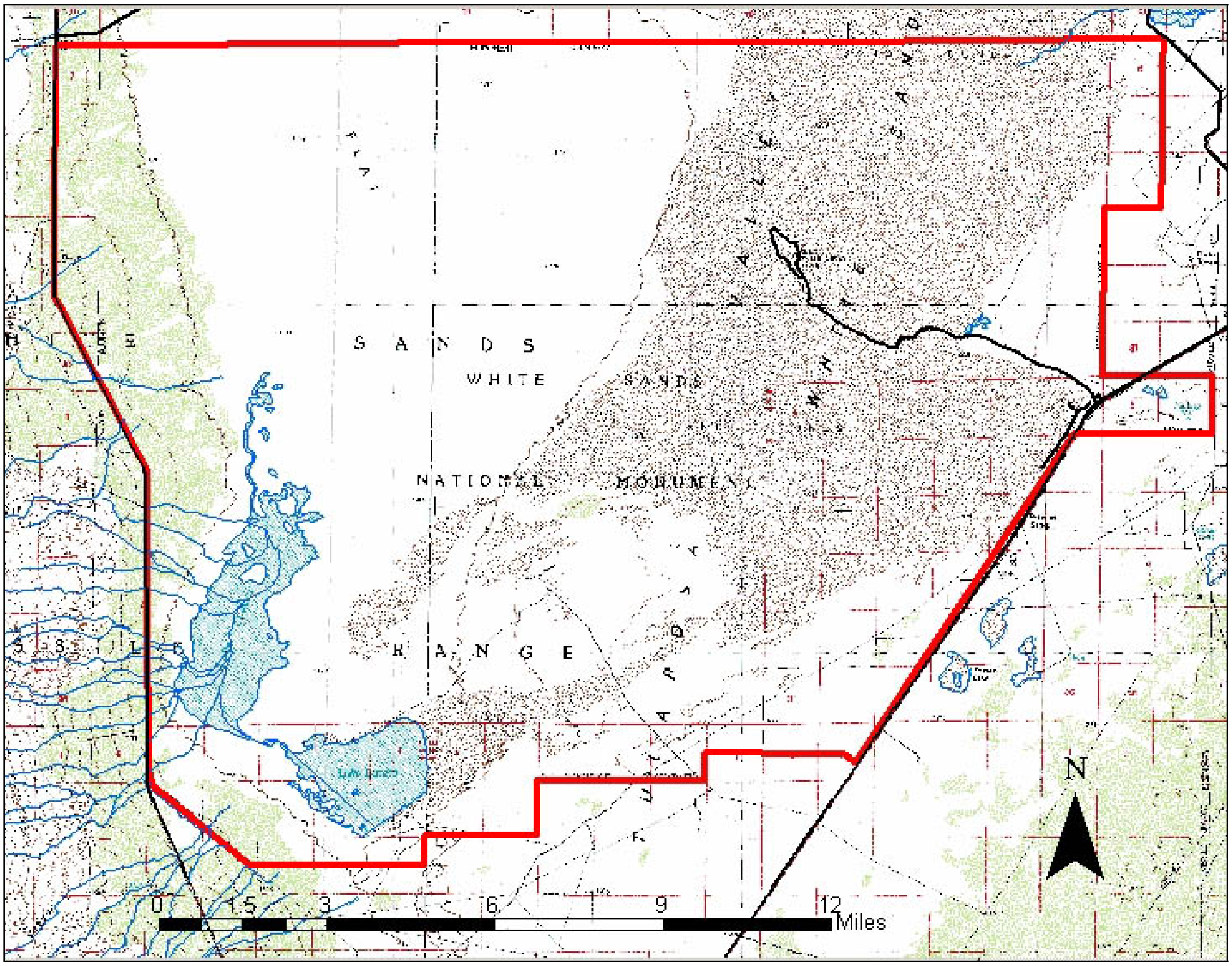

Figure 11. White Sands National Monument (received from D. White, NPS)

2.8 Overview of the Rio Grande/Rio Bravo del Norte System

The Rio Grande is the only river I ever saw that needed irrigation.
--Will Rogers

Three Chihuahuan Desert Parks, Amistad, Big Bend and the Rio Grande Wild and Scenic River contain a nearly continuous 532 km (330 mile) reach of this American Heritage River (http://www.epa.gov/rivers/98rivers/). We review here some of the issues and organizations concerned with the Rio Grande (Rio Bravo del Norte in Mexico).

The Rio Grande drains parts 341,800 square km of three states in the Unites States and 314,300 square km in four Mexican states. The total basin area is 608,023 square km (Revenga et al. 1998). There are a number of major reservoirs on the river regulating flow through the three parks: Rio Grande (CO), La Jara (CO), Platoro (CO), Continental (CO), San Luis Lake (CO), Elephant Butte (NM), Caballo (NM) and Amistad (TX). Indeed, little flow passes the El Paso/Juarez area, and agricultural drainage is the major addition above the Rio Conchos and CHDN Parks. The ecological implications of its much-altered flow, including periods of no flow in some reaches, have only begun to be investigated.

There is evidence that humans were present on the Rio Grande as much as 10,000 years ago (Vidal Davila, NPS, pers. comm.. 2005). Certainly, the river has been utilized by Europeans for over 400 years and has been a source of contention for much of that time. Schmidt et al. (2003) tabulates changes from 2000 to present. Since the mid 19th century these have been peacefully resolved. The draft fisheries plan for Amistad (United States and Mexico 2004) provides one recent example, while Hardberger (2004) provides an example of water issues to be resolved. And the several treaties creating the IBWC illustrate long term successful efforts (http://www.ibwc.state.gov) to amicably manage this international resource. Agencies of the United States and Mexican government now engage in a number of cooperative efforts on the river. Water issues—use, allocation, environmental protection and restoration—continue to mount, with many people, organizations, agencies, seven states and two countries having a stake in each decision. Horgan (1984) provides a comprehensive social history of the river basin.

The Rio Grande is the subject of much research. The IBWC (1994, 1997, 2004) has completed studies of toxic substances. The USGS (1963, 2002, 2003, 2004) has an active, ongoing interest in the river and its environs. The scientific literature includes many studies of the river and its biota. Water quality concerns in the Rio Grande prompted a multiphase study of toxic substances in the Rio Grande. The effort was supported by the United states and Mexico and funded by Region 6 of the US Environmental Protection Agency. The TCEQ is the lead agency in monitoring within Texas and, by agreement, Mexican waters entering the Rio Grande.

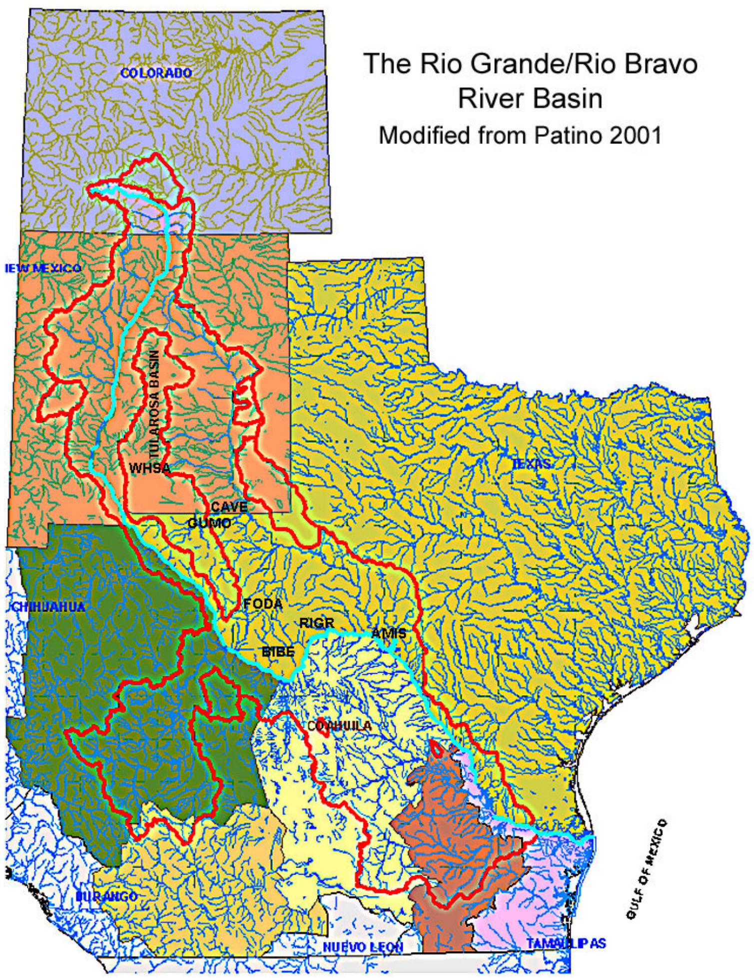

Figure 12. The Rio Grande/Rio Bravo River Basin (Modified from Patino 2001)

In February 1992, the United States and Mexico issued the Integrated Environmental Plan for the Mexican/US Border Area (IBEP). The plan called for the two countries to work together to solve environmental problems in the border region. Specifically, the plan called for the two countries to identify boundary water resources that might be contaminated or have potential for contamination. Implementation of this plan requires the work be done through diplomatic channels and the Treaty of February 3, 1944, *Utilization of Waters of the Colorado and Tijuana Rivers and the Rio Grande.*

The US and Mexican sections of the International Boundary and Water Commission (IBWC) are responsible for implementing border treaties and other activities that require joint activities by the countries. Approvals and recommendations subject to the approval of both governments are recorded as *Minutes* to the 1944 treaty. These Minutes become binding obligations for both the countries. In November 1992, the IBWC developed Minutes No. 289c, *Observation of the quality of Waters Along the United States and Mexico Border*. This document makes joint water quality investigations possible.

Several non-governmental organizations (NGO) with an interest in the Rio Grande and its basin. These include in part:

- World Wildlife Fund http://www.worldwildlife.org/
- The Nature Conservancy http://www.nature.org/
- Rio Grande Institute http://www.riogrande.org/
- Amigos Bravos (Rio Grande in New Mexico) http://www.amigos,bravos.org
- Rio Grade Rio Bravo Basin Coalition http://www.rioweb.org/
- Natural Heritage Institute Rio Grande Program http://www.n-h-i.org/
- Forest Guardians http://www.fguardians.org/
- America's River Communities http://www.rivercommunities.org/
- International Network of Basin Organizations http://www.riob.org/f
- The River Network http://www.rivernetwork.org/
- World Resources Institute http://www.wri.org/

Schools with an interest in the Rio Grande and its basin include:

- New Mexico State U., Water Resources Research Center http://wrri.nmsu.edu/
- Sul Ross State U., Rio Grande Research Center http://www.sulross.edu/
- Texas A& M U., Texas Water Resources Center http://twri.tamu.edu/
- U. Texas, Center for Research in Water Resources http://www.crwr.utexas.edu/
- Oregon State U. Transboundary Freshwater Dispute DB http://www.transboundarywaters.orst.edu/
- Colorado State U. (Rio Grande in Colorado) http://waterknowledge.colostate.edu/

State based agencies with an interest in water quality and quantity:

New Mexico

- New Mexico Environmental Department http://www.nmenv.state.nm.us/
- Office of the State Engineer http://www.ose.state.nm.us/

Texas

- Texas Commission on Environmental Quality http://www.tceq.state.tx.us/
- Far West Texas
  Water Planning Group http://www.texaswatermatters.org/region_e.htm
- Texas Compact Commission
- Texas Water Master

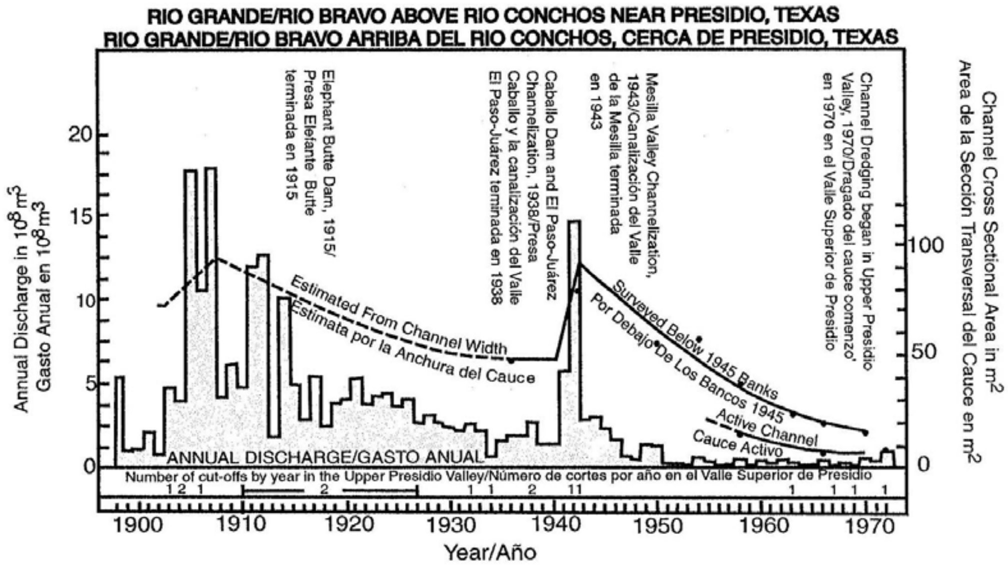

Figure 13. Graph showing time series of change in annual discharge and cross section in the gauging station above Rio Conchos, near Presidio, 1933-1974 (from Everitt 1993).

The two largest border tributaries of the Rio Grande, the Pecos and Conchos Rivers, are the focus of much administrative and political attention.

The Pecos with a basin area of 118,000 km^2 (39,000 mi^2), rises in New Mexico and enters Amistad Reservoir in Amistad NRA. Delmar J Hayter in the Handbook of Texas (http://www.tsha.utexas.edu/handbook/online/l), provides a summary of Pecos River history (bracketed [] item added):

> "From below Sheffield in eastern Pecos County to the river's confluence with the Rio Grande, it passes through a deep gorge…which has prevented irrigation from this part of the lower Pecos. Elsewhere along the course of the river, however, the diversion and impoundment of its water has radically altered its appearance in Texas. Early-day travelers described the river as generally sixty-five to a hundred feet wide and seven to ten feet deep, with a fast current…Completion of the Red Bluff Reservoir…and a hydroelectric power plant in 1936 made possible the creation of water-improvement districts in the lower valley. By the mid-1980s there were more than 400,000 acres under irrigation…For many years the amount of water available for irrigation was a matter of contention between New Mexico and Texas. Around 1948 the two states entered into an agreement known as the Pecos River Compact [New Mexico and Texas State Government 1948, TCEQ 2004a, http://wrri.nmsu.edu/wrdis/compacts/Pecos-River-Compact.pdf], which required New Mexico to maintain deliveries of water depending on the amount of water reaching the river in New Mexico by natural causes. Texas for years considered New Mexico to be deficient in living up to the terms of the contract and in 1974 filed suit. The United States Supreme Court ruled in June 1987 that New Mexico owed Texas 340,000 acre-feet of water for the period between 1950 and 1983, and ordered that New Mexico repay with deliveries of 34,000 acre-feet of water a year for ten years. "

The Rio Conchos, entering the Rio Grande from Mexico above Big Bend and Presidio, Texas drains 64,000 square km and has six major impoundments (Kelly 2001). There are four major dams on the Rio Conchos. In recent years Rio Conchos flows have declined precipitously from drought and agricultural development, creating a 1,460,000 acre foot water delivery deficit (as of 8/30/2003 per http://www.lrga.org/H2owe.html). Mexican President Fox has asserted they will meet this obligation, essential to United States farmers on the lower Rio Grande.

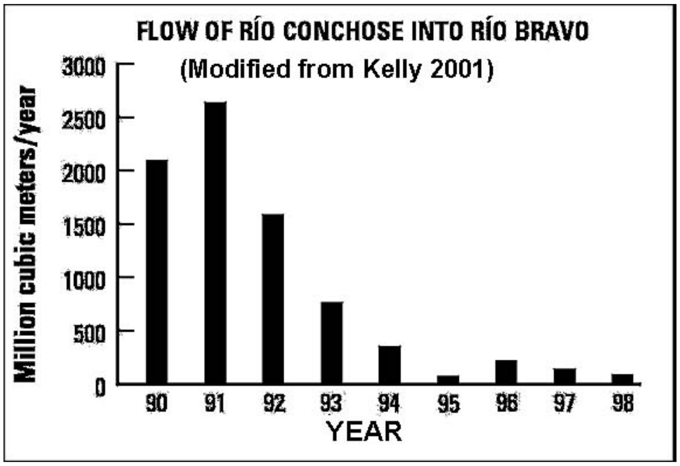

Figure 14 (after Kelly 2001, spelling per author)

IBWC (1994, 1997, 2004) has conducted studies of Rio Grande water quality and contaminants in sediments. Flows and water quality are monitored by several parties at a number of stations along the Rio Grande from its headwaters to the Gulf of Mexico. TCEQ administering the 1991 Texas Clear Rivers Act has entered into a contract with IBWC (http://www.ibwc.state.gov/CRP/Welcome.htm) for monitoring stations in Texas

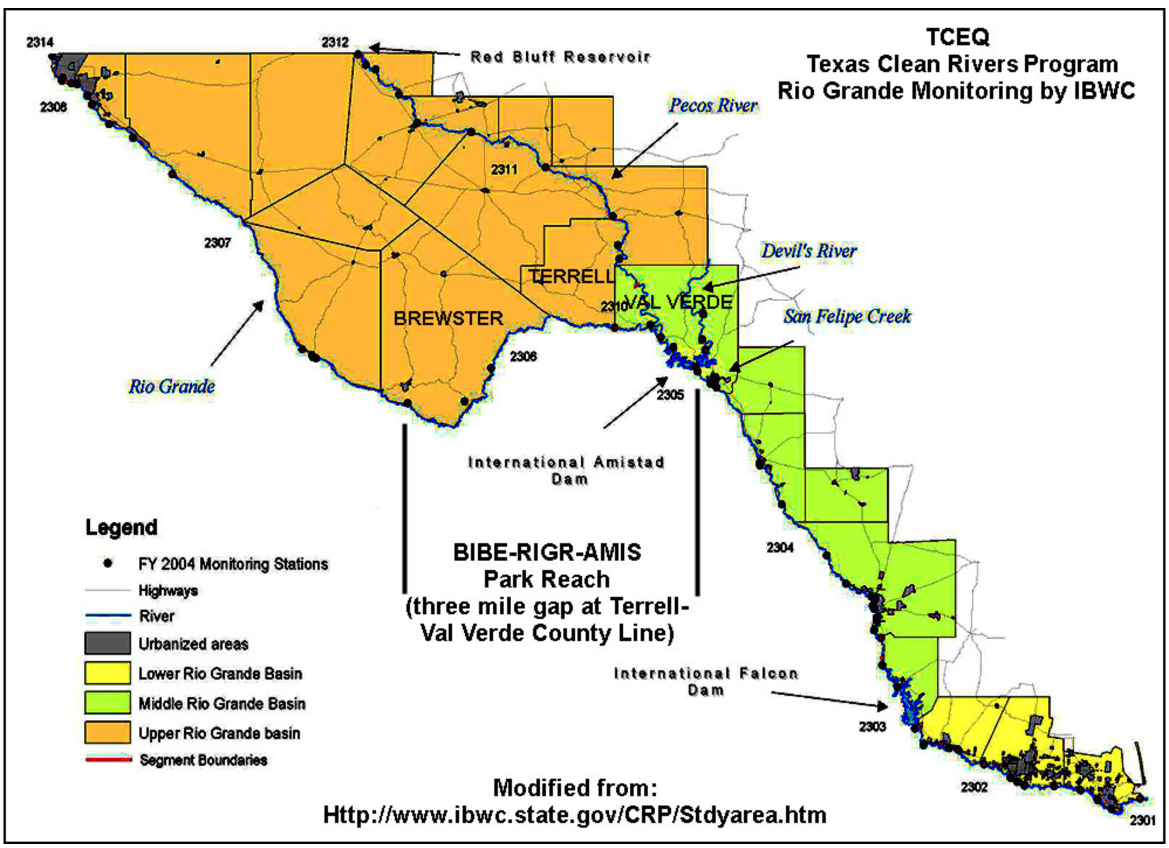

Figure 15 TCEQ Monitoring Stations (modified from downloaded TCEQ map)

Table 24. Active Water Quality Monitoring Stations for the AMIS, RIGR, BIBE Rio Grande Reach (Pers. comm. C. Kolbe, TCEQ, 2005)

Station Name	Agency	Station ID	# Samples per year	Parameters[1]
Rio Grande Below Rio Conchos near Presidio	TCEQ	13229	4	Field Parameters, Metals, Major Ions, Nutrients, Bacteria, Chlorophyll a
	USGS		8	Field Parameters, Nutrients, Major Ions, Trace Elements, Dissolved Pesticides
	IBWC		8	Field Parameters, Metals, Major Ions, Nutrients, Bacteria, Chlorophyll a
Rio Grande at Mouth of Santa Elena Canyon	NPS	13228	8	Field Parameters, Metals, Major Ions, Nutrients, Bacteria, Chlorophyll a
	TCEQ	13228	4	Field Parameters, Metals, Major Ions, Nutrients, Bacteria, Chlorophyll a
Rio Grande at Rio Grande Village Boat Ramp, BIBE	NPS	16730	8	Field Parameters, Metals, Major Ions, Nutrients, Bacteria, Chlorophyll a
Rio Grande at FM 2627 (Gerstacker Bridge) Below Big Bend	TCEQ	13225	4	Field Parameters, Metals, Major Ions, Nutrients, Bacteria, Chlorophyll a
Rio Grande at Foster Ranch near Langtry*	USGS	8377200	8	Field Parameters, Nutrients, Major Ions, Trace Elements, Dissolved Pesticides
	TCEQ	13223	2	Field Parameters, Metals, Major Ions, Nutrients, Bacteria, Chlorophyll a
Pecos River at Gauging Station at Langtry *	USGS	8447410	8	Field Parameters, Nutrients, Major Ions, Trace Elements, Dissolved Pesticides
	TCEQ	13240	2	Field Parameters, Metals, Nutrients, Major Ions Bacteria, Chlorophyll a
Devils River at Pafford Crossing near Comstock *	TCEQ	13237	4	Field Parameters, Nutrients, Major Ions, Bacteria, Chlorophyll a
Rio Grande 3.4 km downstream of Amistad Dam, (above weir dam) *	USGS	8450900	6	Field Parameters, Nutrients, Major Ions, Trace Elements, Dissolved Pesticides
	TCEQ	15340	2	Field Parameters, Nutrients, Major Ions, Bacteria
Amistad Reservoir - Devils River Arm at Buoy DRP	TCEQ	15893	4	Field Parameters, Nutrients, Major Ions, Bacteria, Chlorophyll a
Amistad Reservoir - Rio Grande Arm at Buoy 28	TCEQ	15892	4	Field Parameters, Nutrients, Major Ions, Bacteria, Chlorophyll a
Amistad Reservoir - at Buoy #1	TCEQ	13835	4	Field Parameters, Nutrients, Major Ions, Bacteria, Chlorophyll a

See http://cms.lcra.org for complete 2006 coordinated monitoring schedule for the Rio Grande and USGS NASQAN website (http://water.usgs.gov/nasqan).
* Gauging Station

1 Field Parameters include Temp, Turbidity, Specific Conductance, D.O., pH, CO3, HCO3, Alkalinity, % fines, and total suspended solids (TSS), TDS. Field parameters for TCEQ, IBWC, Clean Rivers Program Partners are flow, water temperature, specific conductance, pH, DO, TDS, TSS, alkalinity, etc are lab parameters for the state program.
Nutrients include: Organic Carbon, Ammonia, Nitrite+Nitrate, Othophosphorus and Total Phosphorus
Major Ions include: Chloride, Sulfate, Calcium, Sodium, and Potassium.
Trace Elements analysis detects small amounts of metals.

3 LAWS AND MANDATES

Table 25. Summary of Legislation, National Park Service Policy and Guidance Relevant to Development and Implementation of Natural Resources Monitoring in CHDN National Parks.

This table was download on 2/13/2005 and slightly modified from http://science.nature.nps.gov/im/monitor/LawsPolicy.htm

PUBLIC LAWS	SIGNIFICANCE TO INVENTORY AND MONITORING
National Park Service Organic Act (16 USC 1 et seq. [1988], Aug. 25, 1916).	The 1916 National Park Service Organic Act is the core of park service authority and the definitive statement of the purposes of the parks and of the National Park Service mission. The act establishes the purpose of national parks: . To conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.
General Authorities Act of 1970 (16 USC 1a-11a-8 (1988), 84 Stat. 825, Pub. L. 91-383	The General Authorities Act amends the Organic Act to unite individual parks into the National Park System. The act states that areas of the National Park System, though distinct in character, are united through their inter-related purposes and resources into one national park system as cumulative expressions of a single national heritage; that individually and collectively, these areas derive increased national dignity and recognition of their superb environmental quality through their inclusion jointly with each other in one national park system preserved and managed for the benefit and inspiration of all the people of the United States.
Redwood National Park Act (16 USC 79a-79q (1988), 82 Stat. 931, Pub. L. 90-545	This act includes both park-specific and system-wide provisions. This act reasserts system-wide protection standards for the National Park System. This act qualifies the provision that park protection and management "shall not be exercised in derogation of the values and purposes for which these areas have been established by adding except as may have been or shall be directed and specifically provided for by Congress. Thus, specific provisions in a parks enabling legislation allow park managers to permit activities such as hunting and grazing.
National Environmental Policy Act of 1969 (42 USC 4321-4370)	The purposes of NEPA include encouraging harmony between [humans] and their environment and promote efforts which will prevent or eliminate damage to the environment and stimulate the health and welfare of [humanity]. NEPA requires a systematic analysis of major federal actions that includes a consideration of all reasonable alternatives as well as an analysis of short-term and long-term, irretrievable, irreversible, and unavoidable impacts. Within NEPA the environment includes natural, historical, cultural, and human dimensions. Within the NPS emphasis is on minimizing negative impacts and preventing impairment of park resources as described and interpreted in the NPS Organic Act. The results of evaluations conducted under NEPA are presented to the public, federal agencies, and public officials in document format (e.g. EAs and EISs) for consideration prior to taking official action or making official decisions.
Clean Water Act (33 USC 1251-1376)	The Clean Water Act, passed in 1972 as amendments to the Federal Water Pollution Control Act, and significantly amended in 1977 and 1987, was designed to restore and maintain the integrity of the nation's water. It furthers the objectives of restoring and maintaining the chemical, physical and biological integrity of the nation's waters and of eliminating the discharge of pollutants into navigable waters by 1985. Establishes effluent limitation for new and existing industrial discharge into U.S. waters. Authorizes states to substitute their own water quality management plans developed under S208 of the act for federal controls.

	Provides an enforcement procedure for water pollution abatement. Requires conformance to permit required under S404 for actions that may result in discharge of dredged or fill material into a tributary to, wetland, or associated water source for a navigable river.
Clean Air Act (42 USC 7401-7671q, as amended in 1990)	Establishes a nationwide program for the prevention and control of air pollution and establishes National Ambient Air Quality Standards. Under the Prevention of Significant Deterioration provisions, the act requires federal officials responsible for the management of Class I Areas (national parks and wilderness areas) to protect the air quality related values of each area and to consult with permitting authorities regarding possible adverse impacts from new or modified emitting facilities. The act establishes specific programs that provide special protection for air resources and air quality related values associated with NPS units. The EPA has been charged with implementing this act.
Endangered Species Act of 1973, as amended (ESA) (16 USC 1531-1544)	The purposes of the ESA include providing a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved. According to the ESA all federal departments and agencies shall seek to conserve endangered species and threatened species and each federal agency shall insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species. The USFWS (non-marine species) and the National Marine Fisheries Service (NMFS) (marine species, including anadromous fish and marine mammals) administers the ESA. The effects of any agency action that may affect endangered, threatened, or proposed species must be evaluated in consultation with either the USFWS or NMFS, as appropriate.
Environmental Quality Improvement Act of 1970 (42 U.S.C. 56 4371)	Directs all Federal agencies, whose activities may affect the environment, to implement policies established under existing law to protect the environment.
National Historic Preservation Act of 1966, as amended (16 USC 470 et seq.)	Congressional policy set forth in NHPA includes preserving the historical and cultural foundations of the Nation and preserving irreplaceable examples important to our national heritage to maintain cultural, educational, aesthetic, inspirational, economic, and energy benefits. NHPA also established the National Register of Historic Places composed of districts, sites, buildings, structures, and objects significant in American history, architecture, archeology, engineering, and culture. NHPA requires federal agencies take into account the effects of their actions on properties eligible for or included in the National Register of Historic Places and to coordinate such actions with the State Historic Preservation Offices (SHPO).
Wilderness Act of 1964 (16 USC 1131 et seq.)	Establishes the National Wilderness Preservation System. In this act, wilderness is defined by its lack of noticeable human modification or presence; it is a place where the landscape is affected primarily by the forces of nature and where humans are visitors who do not remain. Wilderness Areas are designated by Congress and are composed of existing federal lands that have retained a wilderness character and meet the criteria found in the act. Federal officials are required to manage Wilderness Areas in a manner conducive to retention of their wilderness character and must consider the effect upon wilderness attributes from management activities on adjacent lands.
Forest and Rangeland Renewable Resources Planning Act of 1974 (16	Mandates that the Secretary of Agriculture inventory and monitor renewable natural resources in National Forests, and has been cited as

U.S.C. 36 1642	congressional authorization for the inventory and monitoring of natural resources on all federal lands. While this is not specifically directed in the act it is perhaps indicative of a national will to account for and manage the nations natural heritage in manner that sustains these resources in perpetuity.
Surface Mining Control and Reclamation Act	The Surface Mining Control and Reclamation Act was enacted in 1977. It establishes a nationwide program to protect the environment from adverse effects of surface coal mining operations, establishes minimum national standards for regulating surface coal mining, assists states in developing and implementing regulatory programs, and promotes reclamation of previously mined areas with inadequate reclamation. Under the Act, the Secretary of the Interior is directed to regulate the conduct of surface coal mining throughout the United States for both federally and non-federally owned rights. The Act establishes the Abandoned Mine Reclamation Fund, which is for the reclamation of land and water affected by coal mining. Eligibility for reclamation under this program requires that the land or water had been mined for coal, or affected by coal mining, and had been inadequately reclaimed prior to the enactment of this act in 1977. Both public and private lands are eligible for funding. Sections 522(e)(1) and 533(e)(3) of the act specifically prohibit surface mining within the National Park Service, National Wildlife Refuge System, National System of Trails, National Wilderness Preservation System, or Wild and Scenic Rivers System. The act also prohibits surface mining that adversely impacts any publicly-owned park or place included in the National Register of Historic Sites. These prohibitions are subject to valid existing rights at the time of the Act, the exact definition of which remains the subject of administrative and legal action. How valid existing rights are ultimately defined will affect the ability of mineral owners to mine in the Recreation Area.
Geothermal Steam Act 1988	This act specifically calls for a monitoring program for certain parks with thermal resources: (1) The Secretary shall maintain a monitoring program for significant thermal features within units of the National Park System. (2) As part of the monitoring program required by paragraph (1), the Secretary shall establish a research program to collect and assess data on the geothermal resources within units of the National Park System with significant thermal features. Such program shall be carried out by the National Park Service in cooperation with the U.S. Geological Survey and shall begin with the collection and assessment of data for significant thermal features near current or proposed geothermal development and shall also include such features near areas of potential geothermal development.
Federal Advisory Committee Act	Creates a formal process for federal agencies to seek advice and assistance from citizens. Any council, panel, conference, task force or similar group used by federal officials to obtain consensus advice or recommendations on issues or policies fall under the purview of FACA.
National Parks Omnibus Management Act, 1998 (P.L. 105-391)	Requires Secretary of Interior to continually improve NPS ability to provide state-of-the-art management, protection, and interpretation of and research on NPS resources. Secretary shall assure the full and proper utilization of the results of scientific study for park management decisions. In each case where an NPS action may cause a significant adverse effect on a park resource, the administrative record shall reflect the manner in which unit resource studies have been considered. The trend in NPS resource conditions shall be a significant factor in superintendent's annual performance evaluations. Section 5939 states that the purpose of this legislation is to:

	(1) More effectively achieve the mission of the National Park Service; (2) Enhance management and protection of national park resources by providing clear authority and direction for the conduct of scientific study in the National Park System and to use the information gathered for management purposes; (3) Ensure appropriate documentation of resource conditions in the National Park System; (4) Encourage others to use the National Park System for study to the benefit of park management as well as broader scientific value, and (5) Encourage the publication and dissemination of information derived from studies in the National Park System.
Lechuguilla Cave Protection Act , 1993 (PL 103-169)	Asserts that congress finds Lechuguilla Cave and adjacent public lands to have internationally significant scientific, environmental and other values and should be…protected against…activities presenting threats to the areas.
Government Performance and Results Act (GPRA)	Requires the NPS to set goals (strategic and annual performance plans) and report results (annual performance reports). The NPS Strategic Plan contains four GPRA goal categories: park resources, park visitors, external partnership programs, and organizational effectiveness. In 1997, the NPS published its first GPRA-style strategic plan, focused on measurable outcomes or quantifiable results.
EXECUTIVE ORDERS	
Off-Road Vehicle Use (Executive Orders 11644 and 11989)	Executive Order 11644, enacted February 8, 1972 and amended by Executive Order 11989 on May 24, 1977, regulates off-road vehicle use. If the enabling legislation allows the use of off-road vehicles, NPS is required to designate specific areas for off-road vehicle use. These areas must be located to minimize damage to soil, watershed, vegetation, or other resources (Section (3)(a)(1)). If it is determined that such use is adverse to resources, the NPS is to immediately close such areas or trails until the impacts have been corrected.
Floodplain Management (Executive Order 11988)	Executive Order 11988 was enacted May 24, 1977. It requires all federal agencies to reduce the risk of flood loss,... minimize the impacts of floods on human safety, health and welfare, and ... restore and preserve the natural and beneficial values served by flood plains. To the extent possible, park facilities, such as campgrounds and rest areas, should be located outside floodplain areas. Executive Order 11988 is implemented in the National Park Service through the *Floodplain Management Guidelines* (National Park Service, 1993b). It is the policy of the National Park Service to 1) restore and preserve natural floodplain values; 2) to the extent possible, avoid environmental impacts to the floodplain by discouraging floodplain development; 3) minimize the risks to life and property when structures and facilities must be located on a floodplain; and, 4) encourage nonstructural over structural methods of flood hazard mitigation.
Protection of Wetlands (Executive Order 11990)	Executive Order 11990 was enacted May 24, 1977. It requires all federal agencies to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands. Unless no practical alternative exists, federal agencies must avoid any activities that have the potential to adversely affect wetland ecosystem integrity. NPS guidance pertaining to this Executive Order is stated in *Floodplain and Wetland Protection Guidelines* (National Park Service, 1980).
Invasive Species (Executive Order 13112)	This executive order was signed into law on February 3, 1999, to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts

	that invasive species cause. Among other things, this Executive Order It established the National Invasive Species Council and required the preparation of a National Invasive Species Management Plan to recommend specific, performance-oriented goals and objectives and specific measures of success for Federal agency efforts concerning invasive species.
NPS POLICIES AND GUIDANCE	
NPS Management Policies 2001 (NPS Directives System)	This is the basic NPS servicewide policy document. It is the highest of three levels of guidance documents in the NPS Directives System. The Directives System is designed to provide NPS management and staff with clear and continuously updated information on NPS policy and required and/or recommended actions, as well as any other information that will help them manage parks and programs effectively.
NPS Directors Orders	Second level of NPS Directives System. Directors Orders serve a vehicle to clarify or supplement *Management Policies* to meet the needs of NPS managers. Relevant Directors Orders: DO-2.1 Resource Management Planning DO-12 Environmental Impact Assessment DO-14 Resource Damage Assessment & Restoration DO-24 Museum Collections Management DO-41 Wilderness Preservation & Management DO-47 Sound Preservation & Noise Management DO-77 Natural Resource Protection
NPS Handbooks and Reference Manuals	This is the third tier in the NPS Directives System. These documents are issued by Associate Directors. These documents provide NPS field employees with a compilation of legal references, operating policies, standards, procedures, general information, recommendations and examples to assist them in carrying out *Management Policies* and Director's Orders. Level 3 documents may not impose any new servicewide requirements, unless the Director has specifically authorized them to do so. Relevant Handbooks and Reference Manuals: NPS-75 Natural Resources Inventory & Monitoring NPS-77 Natural Resources Management Guidelines NPS Guide to Fed. Advisory Committee Act Website: Monitoring Natural Resources in our National Parks, http://science.nature.nps.gov/im/monitor

Table 26. Federal law relevant to RIGR including its reach within BIBE

Wild and Scenic Rivers Act (P.L. 90-542 as amended) (16 U.S.C. 1271-1287)	Provides for a National Wild and Scenic Rivers System and their administration.

Table 27. Treaties and conventions impinging on water quality monitoring and resource management activity on the Rio Grande/Rio Bravo del Norte within AMIS, BIBE and RIGR.

(This table derives from a list presented by the International Boundary and Water Commission and obtained on 2/2/2005 from:http://www.ibwc.state.gov)

TREATY OR CONVENTION	SIGNIFICANCE
Treaty of February 2, 1848	Established the United States–Mexico Boundary
Treaty of December 30, 1853	Established the United States-Mexico Boundary as it exists today.
Convention of November 12, 1884	Established the rules for location of the boundary when meandering rivers transferred tracts of land from the one bank of the river to the other.
Convention of March 1, 1889	Established the International Boundary Commission (IBC) to apply the rules in the 1884 Convention, and was modified by the Banco Convention of March 20, 1905 to retain the Rio Grande and Colorado River as the international boundary.
Treaty of February 3, 1944	Water treaty for "Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande." Distributed the waters in the international section of the Rio Grande From Fort Quitman, Texas to the Gulf of Mexico. Changed the name of the IBC to the International Boundary and Water Commission (IBWC), and entrusted the IBWC to give preferential attention to the solution of all border sanitation problems.
Treaty of November 23, 1970	Resolved all pending boundary differences. Provides procedures designed to avoid the loss and gain of territory by either country incident to future changes in the river.

Other United States-Mexico Border Cooperative Arrangements and Multinational Institutions Influencing Water Quality Monitoring and Park Resource Management Activity.

The U.S. Environmental Protection Agency (EPA) formally began working with its counterparts in the Mexican government under the La Paz agreement in 1983 to protect, improve and conserve the environment of the border region. In 1992 the environmental authorities of the U.S. and Mexico released the Integrated Environmental Plan for the Mexican-United States Border Area (IBEP). The next phase of binational planning was launched with the Border XXI Program. There are nine binational working groups developing cooperative activities. These are: Air, Water, Hazardous Waste, Pollution Prevention, Emergency Response, Environmental Health, Natural Resources, Environmental Information, and Cooperative Enforcement and Compliance Work Groups. This organization was reinitiated as the Border 2012 Framework <http://www.epa.gov/usmexicoborder/intro.htm>.

EPA U.S.-Mexico Border 2012 Framework: - Mission Statement: As a result of the partnership among federal, state and local, governments in the United States and Mexico, and with U.S. border tribes, the mission of the Border 2012 program is: To protect the environment and public health in the U.S.-Mexico border region, consistent with the principles of sustainable development. *(*In this program, sustainable development is defined as "conservation-oriented social and economic development that emphasizes the protection and sustainable use of resources, while addressing both current and future needs and present and future impacts of human actions.")

The North American Agreement on Environmental Cooperation (NAAEC) was approved as a side agreement to NAFTA. The Commission for Environmental Cooperation (CEC) was established under this agreement to address regional environmental concerns, help prevent potential trade and environmental conflicts, and to promote the effective enforcement of environmental law. The CEC is made up of a governing body 3/4 the Council 3/4 composed of one cabinet level representative from each of the three countries; a Secretariat, located in Montreal, which implements the annual work program; and a Joint Public Advisory Committee which is composed of fifteen citizens, five from each of the three countries.

Established in 1993 under an agreement between the U.S. and Mexico, were two institutions to help deal with the extensive environmental problems on the U.S.-Mexico border. The Border Environment Cooperation Commission (BECC) is an autonomous, binational organization which supports local communities and other project sponsors in developing and implementing environmental infrastructure projects related to the treatment of water and wastewater, and the management of municipal solid waste. As such, the BECC identifies, assists and certifies projects for financing consideration from the North American Development Bank (NADBank) and other sources. Recognizing the limited ability of many communities to develop quality projects, EPA has granted $10 million to the BECC for technical assistance for water-related projects in the U.S. and Mexico. The NAD Bank is a sister institution to the BECC and was established to provide loans and loan guarantees to projects certified by the BECC.

Table 28. Mexican laws (leyes) and standards (NOMs) possibly impinging on water quality monitoring and resource management actions along the Rio Grande/Rio Bravo del Norte in AMIS, BIBE and RIGR (http://www.natlaw.com/mexico/topical/environment/environm.htm)

Law or Standard	Subject
Ley de Aguas Nacionales Law of National Waters	Water quality standards
Ley General para las Prevención y Gestión Integral de los Residuos General Law for the Prevention and Integral Management of Residues (Waste)	Water quality protection
Ley General del Equilibrio Ecológico y la Protección al Ambiente General Law for the Ecological Balance and Environmental Protection	Environmental protection
Norma Oficial Mexicana NOM-001-SEMARNAT-1996 Mexican Official Norm NOM-001-SEMARNAT (Secretariat of the Environment and Natural Resources)-1996	Discharge contaminant standard
NOM-087-ECOLOGIA-2002 Mexican Official Norm NOM-087-ECOLOGIA (ECOLOGY)-2002	Environmental protection

4. STATE WATER QUALITY STANDARDS

Under the Water Quality Act of 1965, each state is required to develop water quality standards to achieve water quality goals for interstate waters. The Federal Water Pollution Control Act Amendments of 1972 (also known as the Clean Water Act) established the National Pollutant Discharge Elimination System (NPDES), which requires each point source discharger to waters of the United States to obtain a discharge permit. These amendments also extended the water quality standards program to intrastate waters, required the establishment of technology-based effluent limitations for NPDES permits, and required permits to be consistent with applicable state water quality standards. The original intent of this legislation was to protect water quality and improve polluted United States waters to at least “fishable and swimmable” quality.

Water quality standards are the basis for a water quality-based approach to pollution control and are a fundamental part of watershed management. The basic components of water quality standards are the designated uses defining the goals for a water body, numeric criteria adopted or established to protect the uses, antidegradation policy to protect existing uses and high quality waters, and implementation policy. States must consider public drinking supply, fish and aquatic life, agriculture, industrial and navigation uses, and other needs when designating water body uses. The federal guidelines provide policy and implementation guidance to protect uses that states must meet. Section 303(c) of the Clean Water Act established the basis for the current water quality standards program, including oversight of state standards by the EPA.

The Water Quality Act of 1987 amended the Water Quality Act to require states to identify waters that do not meet water quality standards, adopt numeric criteria for pollutants in such waters, and establish effluent limitations for individual discharges to such water bodies. These amendments recognized the EPA's antidegradation policy to protect the level of water quality necessary to sustain existing uses and provide a means for assessing the need for developments that may lower water quality in high quality waters.

Under Section 305(b) of the Clean Water Act, each state is required to conduct water quality surveys to determine the overall health of the waters of the state, including whether or not designated uses are being met. States report to the EPA every two years. When impaired water bodies are identified through 305(b) assessments, they are included in 303(d) lists for ranking of priority sites and Total Maximum Daily Load (TMDL) development in order to limit discharges of specific pollutants to that water body.

New Mexico and Texas It is of marginal significance to the CHDN parks, but the Pecos River Compact has one provision dealing with water quality. Allocation of water from the Pecos River is governed by a joint agreement between New Mexico and Texas, the Pecos River Compact (New Mexico and Texas State Government 1948 and wrri.nmsu.edu/wrdis/compacts/Pecos-River-Compact.pdf). Article IV (b) states: "New Mexico and Texas shall cooperate with agencies of the United States to devise and effectuate means of alleviating the salinity conditions of the Pecos River."

New Mexico New Mexico environmental legislation is at http://www.nmenv.state.nm.us/LawCenter/index.html. Matters of water utilization, development and water rights are detailed in the New Mexico State Water Plan (NMSEISC 2003). Progress is reported in the State Water Plan Implementation Report (NMSEISC 2004). Water quality matters in New Mexico fall under the cognizance of the New Mexico Environmental Department (NMED, http://www.nmenv.state.nm.us/). The basic authority for surface water quality management in New Mexico is provided through the State Water Quality Act (§§ 74-6-1 et seq., NMSA 1978).

The Office of the New Mexico State Engineer and Interstate Stream Commission (http://www.ose.state.nm.us/) closely coordinates on these matters and is primarily concerned with flows and allocations: "The agencies have power over the supervision, measurement, appropriation and distribution of almost all surface and ground water in New Mexico, including streams and rivers that cross state boundaries. The State Engineer is also secretary to the Interstate Stream Commission and oversees the staff of both agencies."

Standards are defined in 20.6.4 NMAC and the Statewide Water Quality Management Plan (NM 2003). New Mexico established the Water Quality Control Commission (WQCC,) with specific duties and powers. The commission is the state water pollution control agency for this state for all purposes of the federal Clean Water Act and the wellhead protection and sole source aquifer programs of the federal Safe Drinking Water Act [§ 74-6-3.E, NMSA 1987]. The duties and powers of the commission include adoption of a comprehensive water quality management plan (NM 2003 and http://www.nmenv.state.nm.us/swqb/Planning/Water_Quality_Management_Plan/index.html), the development of a continuing planning process, the administration of loans and grants from the federal government, the adoption of water quality standards, and the adoption of regulations "to prevent or abate water pollution in the state or in any specific geographic area or watershed of the state...or for any class of waters." Surface water quality including TMDLs are managed by the Surface Water Quality Bureau (http://www.nmenv.state.nm.us/swqb/index.html).

The New Mexico standard (TITLE 20 ENVIRONMENTAL PROTECTION CHAPTER 6 WATER QUALITY PART 1 STANDARDS FOR INTERSTATE AND INTRASTATE SURFACE WATERS 20.6.4.1 ISSUING AGENCY: Water Quality Control Commission. [20.6.4.1 NMAC – Rp 20 NMAC 6.1.1001, 10-12-00] includes a supplementary standard for the waters that include the Black River Basin:

> 20.6.4.202 PECOS RIVER BASIN - The main stem of the Pecos river from the mouth of the Black river upstream to lower Tansil dam (diversion for irrigation frequently limits summer flow in this reach to that contributed by springs along the watercourse), including the Black river, the Delaware river and Blue spring.
>
> **A.** Designated Uses: industrial water supply, irrigation, livestock watering, wildlife habitat, secondary contact, and warmwater fishery.
>
> **B.** Standards:

(l) In any single sample: pH shall be within the range of 6.6 to 9.0, and temperature shall not exceed 34°C (93.2°F). The use-specific numeric standards set forth in 20.6.4.900 NMAC are applicable to the designated uses listed above in Subsection A of this section.

(2) The monthly geometric mean of fecal coliform bacteria shall not exceed 200/100 ml; no single sample shall exceed 400/100 ml (see Subsection B of 20.6.4.13 NMAC).
(3) At all flows above 50 cfs: TDS shall not exceed 8,500 mg/L, sulfate shall not exceed 2,500 mg/L, and chloride shall not exceed 3,500 mg/L. [20.6.4.202 NMAC – Rp 20 NMAC 6.1.2202, 10-12-00]

The closed basins of New Mexico include the Tularosa Basin. The following standard, while is defines an area remote from White Sands National Monument, may have some limited applicability to waters such as Lost River, which on occasion enters White Sands National Monument:

20.6.4.801 CLOSED BASINS - Rio Tularosa lying east of the old U.S. highway 70 bridge crossing east of Tularosa, and all perennial tributaries to the Tularosa basin except Three Rivers.

A. Designated Uses: coldwater fishery, fish culture, irrigation, livestock watering, wildlife habitat, municipal and industrial water supply, and secondary contact.
B. Standards:
(1) In any single sample: pH shall be within the range of 6.6 to 8.8, and temperature shall not exceed 20°C (68°F). The use-specific numeric standards set forth in 20.6.4.900 NMAC are applicable to the designated uses listed above in Subsection A of this section.
(2) The monthly geometric mean of fecal coliform bacteria shall not exceed 100/100 mL; no single sample shall exceed 200/100 mL (see Subsection B of 20.6.4.13 NMAC).
[20.6.4.801 NMAC – Rp 20 NMAC 6.1.2801, 10-12-00]

The New Mexico standard recognizes ephemeral, intermittent and perennial waters that are not classified waters. Both Carlsbad Caverns National Park and White Sands National Monument have such waters. It is included here for completeness:

20.6.4.97 EPHEMERAL WATERS - All ephemeral surface waters of the state that are not included in a classified water of the state in 20.6.4.101 through 20.6.4.899 NMAC.
A. Designated Uses: livestock watering, wildlife habitat, limited aquatic life and secondary contact.
B. Criteria:
(1) The use-specific criteria in 20.6.4.900 NMAC, with the exception of the chronic criteria for aquatic life, are applicable for the designated uses listed in Subsection A of this section.
(2) The monthly geometric mean of E. coli bacteria shall not exceed 548 cfu/100 mL, no single sample shall exceed 2507 cfu/100 mL (see Subsection B of 20.6.4.14 NMAC).
[20.6.4.97 NMAC - N, 05-23-05]

20.6.4.98 INTERMITTENT WATERS - All intermittent surface waters of the state that are not included in a classified water of the state in 20.6.4.101 through 20.6.4.899 NMAC.
A. Designated Uses: livestock watering, wildlife habitat, aquatic life and secondary contact.
B. Criteria:
(1) The use-specific criteria in 20.6.4.900 NMAC.
(2) The monthly geometric mean of E. coli bacteria shall not exceed 548 cfu/100 mL, no single sample shall exceed 2507 cfu/100 mL (see Subsection B of 20.6.4.14 NMAC).
[20.6.4.98 NMAC - N, 05-23-05]

20.6.4.99 PERENNIAL WATERS - All perennial surface waters of the state that are not included in a classified water of the state in 20.6.4.101 through 20.6.4.899 NMAC.
A. Designated Uses: aquatic life, livestock watering, wildlife habitat and secondary contact.

B. Criteria:

(1) Temperature shall not exceed 34°C (93.2°F). The use-specific criteria in 20.6.4.900 NMAC are applicable to the designated uses listed in Subsection A of this section.

(2) The monthly geometric mean of E. coli bacteria shall not exceed 548 cfu/100 mL, no single sample shall exceed 2507 cfu/100 mL (see Subsection B of 20.6.4.14 NMAC).
[20.6.4.99 NMAC - N, 05-23-05]

Texas In 1991 the Texas Legislature passed the Texas Clean Rivers Act in response to growing concerns that water resource issues were not being addressed in a holistic manner. This legislation requires that water quality assessments be conducted for each river basin in Texas using an approach that integrates water quality issues within a river basin or watershed. To fund the program, the TCEQ assesses a fee from permit holders for water use and wastewater discharges. The TCEQ implements the Program by contracting with 15 partner agencies, including 12 river authorities, one water district, one federal agency, and one council of government, to conduct water quality monitoring and assessments in the 23 river and coastal basins of Texas. Each river or coastal basin is assigned to one of the designated partner agencies. (http://www.tnrcc.state.tx.us/water/quality/data/wmt/tcrp.html)

Surface water quality matters are managed by the Texas Commission on Environmental Quality (TCEQ), formerly the Texas Natural Resource Conservation Commission (TNRCC). The Texas Water Code as amended (Texas State Government 2001) is the master law. EPA data on Texas water quality standards are at http://www.epa.gov/ost/standards/wqslibrary/tx/tx.html. Current Texas water quality standards are in CHAPTER 307 : TEXAS SURFACE WATER QUALITY STANDARDS §§307.1-307.10 Effective August 17, 2000 (http://www.epa.gov/ost/standards/wqslibrary/tx/tx.html, TNRCC 1997, TCEQ 2004d and http://www.tnrcc.state.tx.us/permitting/waterperm/wqstand/). The EPA has not yet approved the standard for the Rio Grande through AMIS, BIBE and RIGR (segments 2305 and 2306).

The general policy (§307.1) is: “It is the policy of this state and the purpose of this chapter to maintain the quality of water in the state consistent with public health and enjoyment, propagation and protection of terrestrial and aquatic life, operation of existing industries, and economic development of the state; to encourage and promote development and use of regional and area-wide wastewater collection, treatment, and disposal systems to serve the wastewater disposal needs of the citizens of the state; and to require the use of all reasonable methods to implement this policy.” Procedures for implementing the standards are in TCEQ (2003), and TCEQ (2004e) provides a surface water quality management reference guide.

Basin Specific Standards. Basin specific total hardness and pH for the Rio Grande Basin for use in criteria computations: 250, 7.7.

The following are the formal Segment Descriptions for segments relevant to CHDN parks in Texas:

2304 Rio Grande Below Amistad Reservoir - from the confluence of the Arroyo Salado (Mexico) in Zapata County to Amistad Dam in Val Verde County

2305 International Amistad Reservoir - from Amistad Dam in Val Verde County to a point 1.8 kilometers (1.1 miles) downstream of the confluence of Ramsey Canyon on the Rio Grande Arm in Val Verde County and to a point 0.7 kilometer (0.4 mile) downstream of the confluence of Painted Canyon on the Pecos River Arm in Val Verde County and to a point 0.6 kilometer (0.4 mile) downstream of the confluence of Little Satan Creek on the Devils River Arm in Val Verde County, up to the normal pool elevation of 1117 feet (impounds Rio Grande).

2306 Rio Grande Above Amistad Reservoir - from a point 1.8 kilometers (1.1 miles) downstream of the confluence of Ramsey Canyon in Val Verde County to the confluence of the Rio Conchos (Mexico) in Presidio County.

2309 Devils River - from a point 0.6 kilometer (0.4 mile) downstream of the confluence of Little Satan Creek in Val Verde County to the confluence of Dry Devils River in Sutton County

2310 Lower Pecos River - from a point 0.7 kilometer (0.4 mile) downstream of the confluence of Painted Canyon in Val Verde County to a point immediately upstream of the confluence of Independence Creek in Crockett/Terrell County

For these segments, the following additional standards are defined:

Segment	Name	Cl^{-1} (mg/L)	SO_4^{-2} (mg/L)	TDS (mg/L)	Dissolved Oxygen (mg/L)	pH Range (SU)	Indicator Bacteria[1] (#/100 ml)	Temp. (^oF)
2304	Rio Grande Below Amistad Reservoir	200	300	1,000	5.0	6.5-9.0	126/200	95
2305	International Amistad Reservoir	150	270	800	5.0	6.5-9.0	126/200	88
2306	Rio Grande Above Amistad Reservoir	300	570	1,550	5.0	6.5-9.0	216/200	93
2309	Devils River	50	50	300	6.0	6.5-9.0	126/200	90
2310	Lower Pecos River	1,700	1,000	4,000	5.0	6.5-9.0	126/200	92

1 The indicator for freshwater is E. coli (126). Fecal coliform is an alternate (200).

5. NPS WRD PARK WATER QUALITY DOCUMENTS

Five Water Quality Data Inventory and Analysis Reports (WQDIAR) have been completed, including Amistad NRA (NPS 1995a), Big Bend NP a (NPS 1995b), Fort Davis NHS(NPS 1999b), Guadalupe Mountains NP (NPS 1997a) and White Sands NM (NPS 1997b). These documents present the results of surface-water-quality data retrievals for parks in the Chihuahuan Desert Network. The report for the Rio Grande Wild and Scenic River will be initiated late in 2005. The Chihuahuan Desert Network has received additional, preliminary data for Carlsbad Caverns National Monument (G. Rosenlieb, NPS WRD, pers. comm.. 2005). Analysis of those data is not included here.

The WQDIAR provide inventories of retrieved water quality data, stations, and entities responsible for data collection. Descriptive statistics, plots characterizing seasonal tendencies and trends, and a comparison of each park's water quality to the Environmental Protection Agency (EPA) and WRD water quality screening criteria are included. An Inventory Data Evaluation and Analysis (IDEA) to determine which Servicewide I&M Program Level I water quality parameters were measured in the study area is also included. Industrial/municipal discharges, drinking water intakes, impoundments, and active/inactive United States Geological Survey (USGS) gages are also mapped.

Each report notes parameters that exceeded screening criteria at least once. The data review by WRD acknowledges the impossibility of separating natural conditions from anthropogenic factors, including errors in the field and/or laboratory or recording procedures at this level of review. These are summarized here, showing the percent of different tests at parks which exceeded criteria. Note that the most comprehensively examined parks (AMIS, BIBE-RIGR) focus on the Rio Grande and its perennial tributaries.

Table 29. Park water quality testing stations and % of measurements exceeding EPA/CWA standards.

	AMIS	BIBE	FODA	GUMO	WHSA
Stations	84	29	4	33	21
Stations in park	36	15	0	30	9
Barium	1.00	2.05	2.00	--	--
Beryllium (dissolved)	1.39		--	--	--
Cadmium	3.01	0.82	--	--	0.38
Chloride	22.83	29.72	--	--	100.00
Chromium	1.28	3.57	--	--	5.00
Coliform (fecal)	13.68	39.51	12.76	--	--
Coliform (total)	20.16	42.22	--	--	--
Copper	3.57	9.56	--	18.18	80.00
Dissolved O2	4.13	3.39	--	0.92	25.00
Fluoride	--	1.22	--	--	10.00
Lead	5.73	27.74	16.67	--	--
Mercury	0.26	2.02	--	--	--
Nitrate	0.38	--	--	0.13	--
pH	0.36	1.39	1.85	0.62	5.55
Radium 226, 228	--	--	--	--	66.67
Silver	--	--	--	--	18.75
Sulphate	40.60	29.73	--	0.52	100.00
Turbidity	16.78	65.44	17.37	--	14.14
Uranium (dissolved)	--	--	--	--	25.00
Zinc	6.30	--	--	--	26.67

The Executive Summary for each report notes overall conditions of the surface water resources in the study area for each park.

Amistad National Recreation Area The report notes the substantial impact of anthropogenic sources on park water quality.

Big Bend National Park The report notes that anthropogenic sources and, probably, mineralized springs as sources for contaminants. In particular, high levels of dissolved sodium, sulphate and chloride are noted.

Carlsbad Caverns National Park Report in progress.

Fort Davis National Historic Site The report notes the scant data from waters within the study area, which, as with other parks, extended beyond park boundaries.

Guadalupe Mountains National Park The report notes the generally good quality of the park's scant surface waters, with some impacts from anthropogenic sources.

White Sands National Monument The report notes the general lack of data, especially recent data, within the study area. Surrounding military operations are the primary source of contaminants.

Earlier Studies Three earlier park reports were completed.

Amistad National Recreation Area The Amistad Water Resources Scoping Report (NPS 2001b) provides a superb overview of the park. Their recommendations, some of which are in process of implementation, are cogent to the objectives of the CHDN Inventory and Monitoring Program:

- •Increased participation in The Texas Clean Rivers water quality monitoring program, specifically for the Devils and Pecos Rivers.
- •Develop a spring protection strategy and design an inventory and long-term monitoring program for critical spring sites.
- •Support the development of a bi-national fisheries management plan.
- •Enhance interagency relationships for developing research proposals focused upon water-related synoptic research studies identified throughout this scoping process.
- •Assess the potential of current and potential development / land use change in the Devils river watershed on sensitive park resources.
- •Develop a park wide spill prevention control and counter-measure plan.
- •Assess the effects of sedimentation on visitor facilities.
- •Survey for and initiate cooperative efforts for the control of exotic species.
- •Survey for karst features found on park lands.
- •Acquire complete knowledge of water quantity issues to be faced over the next 20 years.
- •Assess the effects of motorized vessels on park resources.

For Big Bend National Park two studies were completed. The Water Resources Scoping Report (NPS 1992) and a Water Resources Management Plan (NPS 1996).

The scoping report (NPS 1992) focuses on current and developing potable water needs at the several park facilities. It does note one author's observations of heavy organic substances in the Rio Grande, and also describes other contaminants qualitatively:

> Irwin (1989) conducted a survey of contaminants and toxic chemicals in fish and wildlife along the Rio Grande in the vicinity of Castolon in BIBE. The study measured residues of 67 chemical contaminants including organochlorines, PCB's, heavy metals, aliphatic hydrocarbons, and polycyclic aromatic hydrocarbons (PAHs), many of which can be related to urban, agricultural, mining, or industrial activities.
>
> DDE, a breakdown product of DDT, was found in concentrations exceeding predator concern levels in aquatic insect samples and several small birds from the Rio Grande area (Irwin, 1989). This is an issue since eggshell thinning, an effect of DDE, has been a probable cause of the declining Peregrine Falcon *(Falco peregrinus)* populations along the Rio Grande. The DDE-contaminated aquatic insects which emerge from the river constitute a portion of the food base for a number of small bird species which are prey for the Peregrine Falcon. Thus, DDT/DDE contamination is probably affecting this endangered species.

The management plan (NPS 1996) is a comprehensive examination of regional and park-specific water quality matters. A series of water resource projects are defined and budgets developed. The possible effect of changing flow regimes, from primordial flood-drought to the current flows is examined. The management plan (p. 104) voices concern at one of several points in the document:

> Water-related diseases remain a major problem in the Rio Grande Basin. Water-borne diseases in the area may be related in part to the large fraction of people living in houses without piped water and adequate sewage disposal systems. Improvements in wastewater facilities and public education are important in the eradication of water-related diseases. The United States and Mexico must place special emphasis on the protection of the quality of surface and underground waters in the basin and early detection of water-borne disease outbreaks in order to prevent their spread...
>
> High fecal coliform levels in water are unacceptable for public water supply, recreation, and irrigation, especially of food crops…Water exhibiting fecal coliform concentrations above 1,000

colonies/100 milliliters may adversely affect human health when used to irrigate crops which would be consumed by humans…It is generally agreed, however, that the occurrence of these substances in water used for public water supplies, livestock watering, and irrigation can be harmful depending on the level of the contamination.

Human activity is also increasingly shaping the faunal composition in the Rio Grande Basin. According to Edwards and Contreras-Balderas (1991), a combination of decreasing stream flow, increasing water pollution, and the proliferation of exotic species has resulted in a change in the ichthyofauna of the international portion of the Rio Grande. Reservoirs on the Rio Conchos and the Rio Grande have led to a loss of stream habitat, an increase in pooled habitats which often are unavailable for colonization, and additional impacts which influence the fish communities of much of the Rio Grande.

6 CLEAN WATER ACTION PLANS

New Mexico has 139 approved TMDLs (http://oaspub.epa.gov/waters/state_rept.control?p_state=NM). None of these involve CHDN park waters.

Texas has 12 TMDLs implemented to deal with 59 impairments (http://www.tnrcc.state.tx.us/water/quality/tmdl/index.html). None of these involve waters of CHDN parks. As described above, the Texas Clean Rivers Program (http://www.tnrcc.state.tx.us/water/quality/data/wmt/) is concerned with the Rio Grande Reach (segment 2304-6) involving AMIS, BIBE and RIGR,

7 PRELIMINARY ANALYSIS OF WATER QUALITY MONITORING NEEDS

7.1 General Considerations -- According to NPS mandates and policy, parks must characterize and monitor water quality and plan for the protection of their water resources. Ground water, while not the focus of this report, but where appropriate will be included in monitoring plans. GUMO's sand dunes and WHSA's shallow water table near possible pollution sources are two parks where inclusion will be productive. The completeness of current monitoring and historic water data for each CHDN park varies widely. The three parks that include the Rio Grande (AMIS, BIBE, RIGR) must address a situation different from the others. Also, WHSA, surrounded by intensive military and contractor activity, poses special issues.

The NPS Freshwater Workgroup Subcommittee draft recommendations (NPS 2002) include five core parameters considered necessary for the Vital Signs program: water column temperature, specific conductance, pH, dissolved oxygen (DO), and some documentation of flow. These parameters are general indicators of water system health, inexpensive tests, and important field study information useful for the interpretation of other studies. Standardization of water quality monitoring at this level will enable data sharing and comparison among parks and with other jurisdictions. Water quality monitoring using these parameters is achievable through the use of commercially available multiprobes for direct reading measurements in surface water.

Flowing waters and permanent impoundments are not common in CHDN parks. There are, however, a number of older, earthen diversions in Big Bend National Park. The Rio Grande, Pecos River, Devils River and McKittrick Creek are the primary examples of flowing, nearly-perennial waters. There are no natural standing water bodies, though there are many small, ephemeral tinajas.) A survey of ephemeral watercourses (arroyos), especially those that drain human contaminant sources (e.g. mines) and geological deposits of toxic substances, will clarify the need for monitoring flow events.

Current monitoring by TCEQ/IBWC on the Rio Grande will be reviewed. Chemical, physical, and biological data are all important in characterizing water ecosystem health as these aspects are inter-related. Chemical data require flow data for load calculations. Biological communities depend on dissolved oxygen. Erosion of stream banks can alter water chemistry and habitat. Macroinvertebrate or zooplankton monitoring are examples of programs that yield data on long-term water quality. Physical monitoring of a stream is important to understanding its dynamics. Indicators must be chosen that provide the information necessary to the monitoring objective (NPS 2002).

Once a month samplings with occasional high flow sampling can be used to estimate the annual variation in basic chemistry of some water bodies. The USGS and the Intergovernmental Task Force on Monitoring (ITFM 1997) recommends long-term monitoring to characterize water quality and analyze trends. The USGS National Water Quality Assessment Program (http://water.usgs.gov/nawqa/) sampling networks are set up so that periods of intensive sampling for three to four years alternate with seasonal or biennial sampling for six years. (The Rio Grande in Texas is not currently a NAWQA basin.) However, extensive guidance is available for the full range of protocols (http://water.usgs.gov/nawqa/protocols/doc_list.html).

CHDN park sampling sites will be determined on an individual park basis. Sampling sites should include sites of impact within the park (wastewater discharge, public use) and high quality and special interest waters. This will help the NPS document water characteristics, identify potential threats, assess impacts, and document whether park management activity maintaining the quality of water resources.

Monitoring plans will derive from data quality objectives, standard operating procedures, quality assurance project plans, the collection of associated data to meet the requirements of the NPS database and training of personnel responsible for taking water samples. Some parameters will require laboratory analysis . Commercial laboratories provide bottles, chain of custody forms, basic instructions, and shipment coolers along with analytical costs, which can help improve the efficacy of a sampling project. States require similar laboratory protocols as established by federal guidelines. Good coordination with outside entities including responsible state departments and the USGS will enable data compatibility. The NPS core set of parameters is the most widely monitored parameters useful to the interpretation of overall system health, and they are consistent with states and other agencies.

7.2 Immediate Steps -- The water quality monitoring needs identified at this time in the Chihuahuan Desert Network include:

- Plan, in coordination with the parks, in-park monitoring requirements meeting both park-specific and Inventory and Monitoring Program objectives. This will include planning later implementation by common protocols meeting professional standards. It is noted that where groundwater issues are a significant park concern, these will be included in water quality monitoring plans.

- Investigate extant methodologies and protocols (and their cost) for monitoring of submerged riverbed and reservoir springs in Amistad National Recreation Area, Big Bend National Park and the Rio Grande Wild and Scenic River.

- Investigate appropriate protocols (and their cost) for adequate monitoring of subterranean waters in (1) caves open to public use and (2) caves protected from visitor contamination at Carlsbad Caverns.

- Continued support and participation at the network level in the TCEQ/IBWC monitoring for the Rio Grande Segments 2305-6, including portions of the Pecos and Devils rivers.

- Building on already important interaction with Mexico by Amistad National Recreation Area and Big Bend National Park, the Chihuahuan Desert Network with participate in other already extant programs by state and federal agencies.

- Develop and maintain ongoing network-level communication with the several state and federal agencies involved with water quality and quantity matters in and near the network parks. Some specific matters include: (1) Increased communication between CHDN/FODA and TCEQ/TPWD on waters adjacent to the park (Limpia Creek) or entering the park (Hospital Canyon). (2) Ongoing CHDN/WHSA communication with Holloman Air Force Base on water quality monitoring of Lost River and other nearby waters. (3) CHDN/WHSA interaction with WSMR on issues relating to surface water runoff and groundwater monitoring.

- Develop a detailed, network-level procedure for entry of new park water quality data on the NPS database.

- Develop a detailed, network-level database detailing park water bodies. With more that 500 water bodies (albeit, mostly springs and seeps) such a database is essential to further monitoring planning. The flows of many of these have profoundly declined in recent decades according to (often anecdotal) reports. In the decades ahead it is important to understand and document ongoing changes.

8. LITERATURE CITED

Brooke, M. 1996. Infiltration pathways at Carlsbad Caverns National Park determined by hydrogeologic and hydrochemical characterization and analysis. M.S. Thesis, Colorado School of Mines, Golden. 182 pp.

[EPA] Environmental Protection Agency. 2004. Mexico Border Ecosystems In the U.S.-Mexico Border Region, sustain and restore community health and preserve the ecological systems that support them. Draft Implementation Plan, 4/1/04, Goal 4: Healthy Communities and Ecosystems, Subobjective 4.2.4 Sustain and Restore U.S.-Mexico Border Ecosystems. Pp. 5.

Everitt, B. 1993. Channel Response to declining flow on the Rio Grande between Fort Quitman and Presidio, Texas. Geomorphology 6:225-242.

Far West Texas Regional Water Planning Group. 2005. Far West Texas Regional Water Plan (Draft). 400 pp with appendices.

Hardberger, Amy. 2004. What lies beneath: determining the necessity of international groundwater policy along the United States—Mexico Border and a roadmap to an agreement. Texas Tech Law Review 35:1211-1257.

Horgan, P. 1984, Great River, the Rio Grande in North American History. Wesleyan University Press, Hanover, 1020 pp.

Huff, GF. 2004. Ground-Water Flow in the Basin-Fill Aquifer of the Tularosa Basin, South-Central New Mexico, Predevelopment through 2040. USGS Scientific Investigations Report 2004-5197.

[IBWC] International Boundary and Water Commission. 2004. Third Phase of the Binational Study Regarding the Presence of Toxic Substances of the Upper Portion of the Rio Grande/Rio Bravo Between the United States and Mexico, 142 pp. (http://www.ibwc.state.gov/html/environment.html)

[IBWC] International Boundary and Water Commission. 1997. Second Phase of the Binational Study Regarding the Presence of Toxic Substances in the Upper Portion of the Rio Grande/Rio Bravo and its Tributaries Along the Boundary Portion Between the United States and Mexico. 136 pp + appendices.

[IBWC] International Boundary and Water Commission. 1994. Binational Study Regarding the Presence of Toxic Substances of the Upper Portion of the Rio Grande/Rio Bravo and its Tributaries Along the Boundary Portion Between the United States and Mexico, 274 pp. (http://www.ibwc.state.gov/html/environment.html)

[IBWC] International Boundary and Water Commission. 1976. Distances along the Rio Grande Taken from the International Boundary maps approved by the Commission in Minute Number 253, September 23, 1976. 10 pp.

[IBWC NPS] International Boundary and Water Commission and National Park Service. 1965. Memorandum of Agreement between The United States Section, International Boundary and Water Commission and the National Park Service relating to the development and administration of recreation on the United States side of Amistad International Dam and Reservoir. 16 pp.

[IGTF] Intergovernmental Task Force on Monitoring Water Quality. 1997. Conceptual Frameworks for Ground Water Quality Monitoring, 112 pp.

Kelly, ME. 2001. The Rio Conchos: A Preliminary Overview. Texas Center for Policy Studies. Austin. 28pp. http://www.texascenter.org/borderwater/rioconchos.htm (2/20/2005)

King, JH (Superintendent, Big Bend National Park). 2005. Letter to Tom Beard, Chair, Far West Texas Water Planning Group. 3 pp.

Meinzer, OE and RF Hare. 1915. Geology and Water Resources of the Tularosa Basin, NM and adjacent areas. USGS Water Resources Report.

[NPS] National Park Service. 2005. Amistad National Recreation Area Water Quality Monitoring Plan. Word document received from Rick Slade, March 2005.

[NPS] National Park Service. 2004. General Management Plan/Environmental Impact Statement, Rio Grande Wild and Scenic River, Brewster and Terrell Counties, Texas.

[NPS] National Park Service. 2003. Draft General Management Plan/Environmental Impact Statement Big Bend National Park.

[NPS] National Park Service, Fresh Water Working Group. 2002. Recommendations for Core Water Quality Monitoring Parameters and Other Key Elements of the NPS Vital Signs Program Water Quality Monitoring Component.

[NPS] National Park Service. 2002b. Carlsbad Cavern Resource Protection Plan: Implementation Plan and Environmental Assessment.

[NPS] National Park Service. 2002c Fort Davis National Historic Site Final Environmental Impact Statement General Management Plan.

[NPS] National Park Service. 2001a. Full Study Plan for Vertebrate and Vascular Plant Inventory of the Chihuahuan Desert Network,87 pp. + appendices.

[NPS] National Park Service. 2001b. Guadalupe Mountains NP and Carlsbad Caverns NP Geological Resources Inventory Workshop, March 6-8, 2001. 12 pp.

[NPS] National Park Service. 2001c. Amistad National Recreation Area, Texas. Water Resources Scoping Report. Water Resources Division, National Park Service, United States department of the Interior Technical Report NPS/NRWRD NRTR-2001/295, 98 pp. + appendices.

[NPS] National Park Service. 1999a. Natural Resource Challenge, The National Park Service's Action Plan for Preserving Natural Resources, 28 pp.

[NPS] National Park Service. 1999b. Flood Hazard Assessment for Fort Davis National Historic Site. Memorandum Michael Martin (WRD) to Superintendent dated June 17, 1999, 7 pp.

[NPS] National Park Service, Water Resources Division. 1999c. Baseline Water Quality Inventory and Analysis Fort Davis National Historic Site. Technical Report NPS/NRWRD/NRTR-99/237, 291 pp.

[NPS] National Park Service, Water Resources Division. 1999. Water Supply Wells at Guadalupe Mountains National Park. 21 pp.

[NPS] National Park Service, Water Resources Division. 1997a. Baseline Water Quality Inventory and Analysis Guadalupe Mountains National Park Technical Report NPS/NRWRD/NRTR-97 133, 407 pp.

[NPS] National Park Service, Water Resources Division. 1997b. Baseline Water Quality Inventory and Analysis White Sands National Monument. Technical Report NPS/NRWRD/NRTR-97 139, 233 pp.

[NPS] National Park Service. 1996a. Water Resources Management Plan, Big Bend National Park, Texas. Department of Hydrology and Water Resources, University of Arizona, Tucson, Big Bend National Park, Texas and National Park Service Water Resources Division. 163 pp. plus appendices.

[NPS] National Park Service. 1996b. General Management Plan Carlsbad Caverns National Park, New Mexico.

[NPS] National Park Service, Water Resources Division. 1995a. Baseline Water Quality Inventory and Analysis Amistad National Recreation Area. Technical Report NPS/NRWRD/NRTR-95/72, 653 pp.

[NPS] National Park Service, Water Resources Division. 1995b. Baseline Water Quality Inventory and Analysis Big Bend National Park. Technical Report NPS/NRWRD/NRTR-95/51, 403 pp.

[NPS] National Park Service, Water Resources Division. 1992. Big Bend National Park Water Resources scoping Report. Technical report NPS/NRWRD/NRTR-92/08,. 35 pp.

[NPS] National Park Service. 1987. General Management Plan Development Concept Plan Amistad Recreation Area, Texas.

[NPS] National Park Service. 1976. Master Plan Guadalupe Mountains National Park, Texas.

[NPS] National Park Service. 1969. Well and spring inventory information, 6 pp. Compiled by R. Reisch and ER Leggatt. Appendix A to Martin, L. 1998. Water Supply Wells at Guadalupe Mountains National Park. National Park Service, Water Resources Division. 21 pp.

New Mexico Environmental Department. 2003. Special Water Quality Investigation of Rattlesnake and Blue Springs in the vicinity of Carlsbad Caverns National Park. Prepared by Scott Hopkins, Surface Water Quality Bureau. 14 pp.

New Mexico Environmental Department. 2001. Geology and Major Aquifers. 1 pp. Plate 5 from New Mexico Water Resources Assessment 2001. At http://www.nmenv.state.nm.us/fod/LiquidWaste/NM.aquifers.pdf.

New Mexico and Texas State Government. 1948. Pecos River Compact, 8 pp.

[NMSEISC] New Mexico State Engineer and Interstate Stream Commission. 2004. 2004 State water Plan Implementation Report, Strategies Set Forth in 2003 State Water Plan. Presented to the New Mexico Interstate Stream Commission, December 10, 2004, 18 pp.

[NMSEISC] New Mexico State Engineer and Interstate Stream Commission. 2003. New Mexico State Water Plan, December 23, 2003, 85 pp.

[NMSEISC] New Mexico State Engineer and Interstate Stream Commission. 2002. Tularosa Basin and Salt Basin Regional Water Plan 2000-2040, Executive Summary. 35 pp.

[NMSE] New Mexico State Engineer. 1956. Climatological Summary, New Mexico Precipitation, 1849-1954. (By S. E. Reynolds), 407 pp.

[NMSE] New Mexico State Engineer. no date. New Mexico Regional Water Planning Areas. 1 pp at http://www.ose.state.nm.us/water-info/NMWaterPlanning/RegionalPlans.html

New Mexico State University, Agricultural Experiment Station. 1984. Limnology of a shallow, brackish, Hypereutrophic reservoir in southern New Mexico, 54 pp.

New Mexico Water Quality Control Commission. 2004. 2004-2006 State of New Mexico Integrated Clean Water Act 303(d)/305z(b) Report. (Contains links to different drainages.)

New Mexico Water Quality Control Commission. 2002. State of New Mexico Standards for Interstate and Interstate Surface Waters, 20.6.4 NMAC as amended through October 11, 2002,. XXXX pp.

Parsons. 2003. Interim Assessment of the Presence and Causes of Ambient Water Toxicity in the Rio Grande Above Amistad Reservoir, Segment 2306, 175 pp.

Paso del Norte Council. 2004. Paso Del Norte Watershed Council Coordinated Water Resources Database Project, 35 pp.

Patino, C. 2001. Analysis of information related to hydraulic and geographic data in the Rio Grande Basin on the Mexican Side, Final Report. University of Texas at Austin, Department of Civil Engineering, Environmental and Water Resources Engineering.

Reid, WH. 1980. White Sands National Monument Natural Resources Inventory and Analyses. Final report CX702900001, National Park Service. 104 pp.

Reid, WH. 1979. White Sands National Monument Natural Resources Inventory and Analyses. Final report CX70298023, National Park Service. 409 pp.

Reisch, R and ER Leggatt. 1969. Well and spring inventory information. (Appendix A in NPS 1988). 6 pp.

Richard, M. and A. Boehm. 1989. Natural Gas Contamination at Rattlesnake Springs, Carlsbad Caverns National Park: Final summary of the investigation. Report 4 of 4, NPS Contract RFQ 7029-9-0025. 16 pp.

Richard, M. 1989. Natural Gas Contamination at Rattlesnake Springs, Carlsbad Caverns National Park: Report of the second field investigations. Report 3 of 4, NPS Contract RFQ 7029-9-0025. 18 pp.

Richard, M. 1988a. Natural Gas Contamination at Rattlesnake Springs, Carlsbad Caverns National Park: Report of the first field investigations. Report 2 of 4, NPS Contract RFQ 7029-9-0025. 19 pp.

Richard, M. 1988b. Natural Gas Contamination at Rattlesnake Springs, Carlsbad Caverns National Park: Review of the Geohydrology in the vicinity of Rattlesnake Springs and the Contamination Problem. Report 1 of 4, NPS Contract RFQ 7029-9-0025. 19 pp + appendices.

Richard, M. 1987. Consultant's letter report on natural gas contamination of groundwater near Rattlesnake Springs. 8 pp.

Ricketts, TH, E. Dinerstein, DM Olson, CJ Loucks, W Eichbaum, D DellaSalla, K Kavanagh, P Hedao, PT Hurley, KM. Carney, R Abell, and S. Walters. 1999. Terrestrial ecoregions of North America: a conservation assessment. World Wildlife Fund. Island Press, Washington D.C., 485pp.

Ropelewski, CF, DS Gutzler, RW Higgins and CR Mechoso. 2005. The North American Monsoon System. Naval Postgraduate School, School of Engineering and Applied Sciences. Regional Monsoon Topics, Review Topic A-4. 12 pp.

Schmidt, RH, Jr., 1995, The climate of Trans-Pecos Texas. Pp. 122-137 in Norwine, JR, GR North, JB Valez, and JR Giardino (eds.), Changing Climate of Texas: Predictability and Implications for the Future: GeoBooks, Texas A & M Univ., College Station.

Schmidt, RH, Jr. 1990, The Mega-Chihuahuan Desert. Pp. 105-115 in Powell, AM, RR Hollander, JC Barlow, WB McGillivray, and DJ Schmidly (eds.), Symposium on Resources of the Chihuahuan Desert Region: Chihuahuan Desert Research. Institute.

Schmidt, RH, Jr. 1979. A climatic delineation of the "real" Chihuahuan Desert. Journal of Arid Environments 2:243-250.

Schmidt, JC, BL Everitt and GA Richard. 2003. Hydrology on geomorphology of the Rio Grande and implications for river rehabilitation. Pp. 26-45 in Garrett, GP and NL Allen eds., Aquatic Fauna of the Northern Chihuahuan Desert, contributed papers from a special session within the Thirty-third Annual Symposium of the Desert Fishes Council, November 17, 2001. Special Publications, Museum of Texas Tech University, Number 26.

Tallman, RS. 1993. Conceptualization and characterization of the hydrologic system in the Carlsbad Caverns National Park region, New Mexico. M.S. Thesis, Colorado School of Mines, Golden. 121 pp.

[TCEQ] Texas Commission on Environmental Quality. 2004a. DRAFT 2004 Texas 303(d) list, 23 November 2004, 65 pp.

[TCEQ] Texas Commission on Environmental Quality. 2004b. Summary and contact data for the Pecos River Compact Commission in Texas, 2 pp.

[TCEQ] Texas Commission on Environmental Quality. 2004c. An Assessment of Water Quality of Segment 2309 (Devils River), AS-193 . (Prepared by Augustine De La Cruz.) 35 pp.

[TCEQ] Texas Commission on Environmental Quality. 2004d. Revisions to Chapter 307 – Texas Surface Water Quality Standards, 150 pp.

[TCEQ] Texas Commission on Environmental Quality. 2004e. Surface Water Quality Data Management Reference Guide, 115 pp.

[TCEQ] Texas Commission on Environmental Quality. 2003. Procedures to implement the Texas Surface Water Quality Standards, RG-194, 200pp.

[TNRCC] Texas Natural Resource Conservation Commission. 1997. Texas Surface Water Quality Standards 307.1-307.7 Adopted by the Commission: March 19, 1997, 130 pp.

Texas State Government. 2001. Water Code - Chapter 26. (Acts 2001, 77th Leg., ch. 965, § 12.02, eff. Sept. 1, 2001. Pp. 146.

Texas Water Resources Institute. 2004. The Pecos River Ecosystem Project Progress Report. (By Charles R. Hart), 10 pp.

United States Biosphere Reserves Association. 2003. United States Biosphere Reserves Survey 2003, 28 pp.

United States and Mexico. 2005. Draft binational fisheries plan for Amistad Reservoir.. United States Agency Cooperators: Texas Parks and Wildlife Department, National Park Service, US Fish & Wildlife Service; Mexico Agency Cooperators: Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Instituto Nacional de Pesca. Comisión Nacional del Agua. Secretaria de Turismo, SCT, Gobierno del Estado de Coahuila, 73 pp.

[USGS] United States Geological Survey. 2004. Suggestions for Monitoring Fish Communities in the Rio Grande and Major Tributaries from Big Bend National Park to the Confluence with the Pecos River at Amistad International Reservoir. Memo to Hildy Reiser, NPS CHDN, from R. Bruce Moring, USGS, 3 pp.

[USGS] United States Geological Survey and National Park Service. 2003. Project Implementation Plan: Water Quality and Biological Assessment of Fluvial Sections of the Rio Grande, Pecos River and Devils River in the Amistad National Recreation Area, Texas. (NPS PMIS #60196, AMIS-N-059.001), 15 pp.

[USGS] United Sates Geological Survey. 2002. Baseline Assessment of Instream and Riparian-Zone Biological Resources on the Rio Grande in and Near Big Bend National Park, Texas. USGS Water resources Investigations Report 02-4106. (By J. Bruce Moring), 33 pp.

[USGS] United States Geological Survey. 1963. Effects of Drought on the Rio Grande Basin, Geological Survey Professional Paper 372-D, 80 pp.

van der Heijde, PKM, KE Kolm, H Dawson and M Brooke. 1997. Determining water infiltration routes from structures located above Carlsbad Cavern, Carlsbad Caverns National Park, Carlsbad, New Mexico. IGWMC – GWMI 97-01. International Ground Water Modeling Center, Colorado School of Mines. 88 pp + associated data files.

9. ACRONYMS

AMIS	Amistad National Recreation Area
BIBE	Big Bend National Park
BR	Bureau of Reclamation
CAVE	Carlsbad Caverns National Park
CHDN	Chihuahuan Desert Network
CNA	Commission Nacional de Aguas (Mexico)
CWA	Clean Water Act
DB	Database
EPA	Environmental Protection Agency
FODA	Fort Davis National Historic Site
GUMO	Guadalupe Mountains National Park
IBEP	Integrated Environmental Plan for the Mexican/US Border Area
IBWC	International Boundary and Water Commission
IFTM	Intergovernmental Task Force on Monitoring Water Quality
ISC	Interstate Stream Commission
NAWQA	USGS National Water Quality Assessment Program
NMEQ	New Mexico Department of Environmental Quality
NPS	National Park Service
NPDES	National Pollutant Discharge Elimination System
OSE	New Mexico Office of the State Engineer
RGPT	Rio Grande Partnership Team
RIGR	Rio Grande Wild and Scenic River
TCEQ	Texas Commission on Environmental Quality (replaces TNRCC)
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TNRCC	Texas Natural Resource Conservation Commission
TPWD	Texas Parks and Wildlife Department
USGS	United States Geological Survey
WHSA	White Sands National Monument
WQCC	New Mexico Water Quality Control Commission
WSMR	White Sands Missile Range
WWF	World Wildlife Fund

APPENDIX A: Amistad NRA Water Quality Monitoring Plan

Introduction

Water quality in the Rio Grande has been the subject of many studies and monitoring efforts by several agencies. A long enough period of record exists to be able to detect trends, particularly the rising salinity and increases in several trace metals. Pecos River water quality has also been fairly well studied. The Devils River has less information available, although the existing data indicates the water quality is excellent with a low risk of future contamination.

Current Water Quality Monitoring Programs

Both the Texas Commission on Environmental Quality (TCEQ) and the U.S. Geological Survey (USGS) have active water quality monitoring programs in and around Amistad Reservoir. Figure 16 gives the locations of these monitoring sites. Both agencies sample the major tributaries to the reservoir; the Pecos, Devils and Rio Grande rivers, as well as the Rio Grande below the dam. TCEQ also samples the reservoir at three locations for field parameters, nutrients, chlorophyll and bacteria. Table 3 lists the constituents and sampling frequency for these sites.

The USGS sites on the Pecos River near Langtry, and Rio Grande at Foster Ranch have been part of the Rio Grande NASQAN (National Stream Quality Accounting Network) monitoring program since 1996. The Rio Grande 3.4 miles (5.5 km) below Amistad Dam station has been part of the NASQAN program since 1997. These sites are sampled 6 to 8 times a year for a variety of constituents, including nutrients, major ions, water soluble pesticides and trace elements. The Rio Grande NASQAN Program for 2001 - 2005 will continue to monitor these sites (Lurry, 2000). The Devils River at Pafford Crossing near Comstock, TX site is a recently discontinued USGS hydrologic benchmark station. This station was sampled four times a year for major nutrients, major ions and trace elements. This station is currently sampled by TCEQ Surface Water Quality Monitoring Program (SWQM) staff; the flow gauge is now operated by the IBWC.

Monitoring sites that are part of TCEQ's SWQM Program are funded by the U.S. Environmental Protection Agency (USEPA) grant money. TCEQ and USGS have collected water quality data at most of these stations since the 1970's, although the parameters collected and sampling frequency have varied. These stations have been sampled for the parameters listed in Table 3 since 1997.

Through the Texas Clean Rivers Program (CRP) funds, the IBWC coordinates monitoring activities in the Rio Grande Basin by supporting efforts of monitoring partners including: IBWC, TCEQ, USGS, NPS, Upper Pecos Soil and Water Conservation District, Cities of Del Rio, Laredo and Brownsville and the Rio Grande International Study Center at Laredo. This program supports special projects, acts as a clearing house for data (except for TCEQ and USGS data), provides a point of contact for issues in the Rio Grande Basin and provides annual summary reports. These activities are generally carried out by river authorities in other parts of Texas. As a part of the CRP, IBWC funds lab analysis and shipping costs for water quality samples collected upstream in Big Bend National Park.

Each year the IBWC Texas CRP staff coordinates meetings with monitoring partners to generate a coordinated monitoring schedule for the Rio Grande Basin. This effort allows for better monitoring coverage, reduces duplicate monitoring activities and supplements existing monitoring programs of TCEQ, USGS and IBWC. Information on this program can be found on the Rio Grande CRP website: www.ibwc.state.gov/crp/welcome.htm.

Planned and Ongoing Water Quality Studies

Two special studies are planned as part of the USGS Rio Grande NASQAN Program for 2001-2005 (Lurry, 2000). One study will determine seasonal patterns in thermal and density stratification in the Amistad and Falcon Reservoirs with additional monitoring for mercury deposition. This study will sample water quality at different depths and locations around the reservoir to determine the thermal and salinity characteristics.

Another study will collect continuous conductivity measurements to better understand salt flux in the Pecos River, Rio Grande at Foster's Ranch and Rio Grande at Presidio. This will provide additional information needed to estimate salt loading into Amistad Reservoir.

TCEQ is developing biocriteria for the Rio Grande between El Paso and Brownsville as part of a USEPA funded project. This project is scheduled for completion in 2002. In an effort to make these biocriteria binational, a working group with Mexico is being planned for winter of 2002.

A joint TCEQ and Texas Department of Health project collected fish for consumption risk in the Rio Grande between Presidio and Amistad Reservoir in April 2001. Fish collection occurred downstream of Presidio, TX and in Big Bend National Park.

Currently, there is an on-going USGS study of aquatic life and riparian areas covering the Rio Grande from Big Bend National Park downstream to Foster's Ranch. This study will develop baseline conditions for aquatic life and help examine the effects of prolonged low flows. The study is being conducted by Dr. Bruce Moring of the USGS Texas District (Austin) and is being partially funded by NPS-USGS partnership funds.

The USGS, NPS, TCEQ and IBWC are currently working together to design and seek funding for a study of metals in the Rio Grande above Amistad. This multi-year study would analyze the amount of metals and other contaminants from historical mining which reach the Rio Grande in the Big Bend area.

Current Sampling Locations

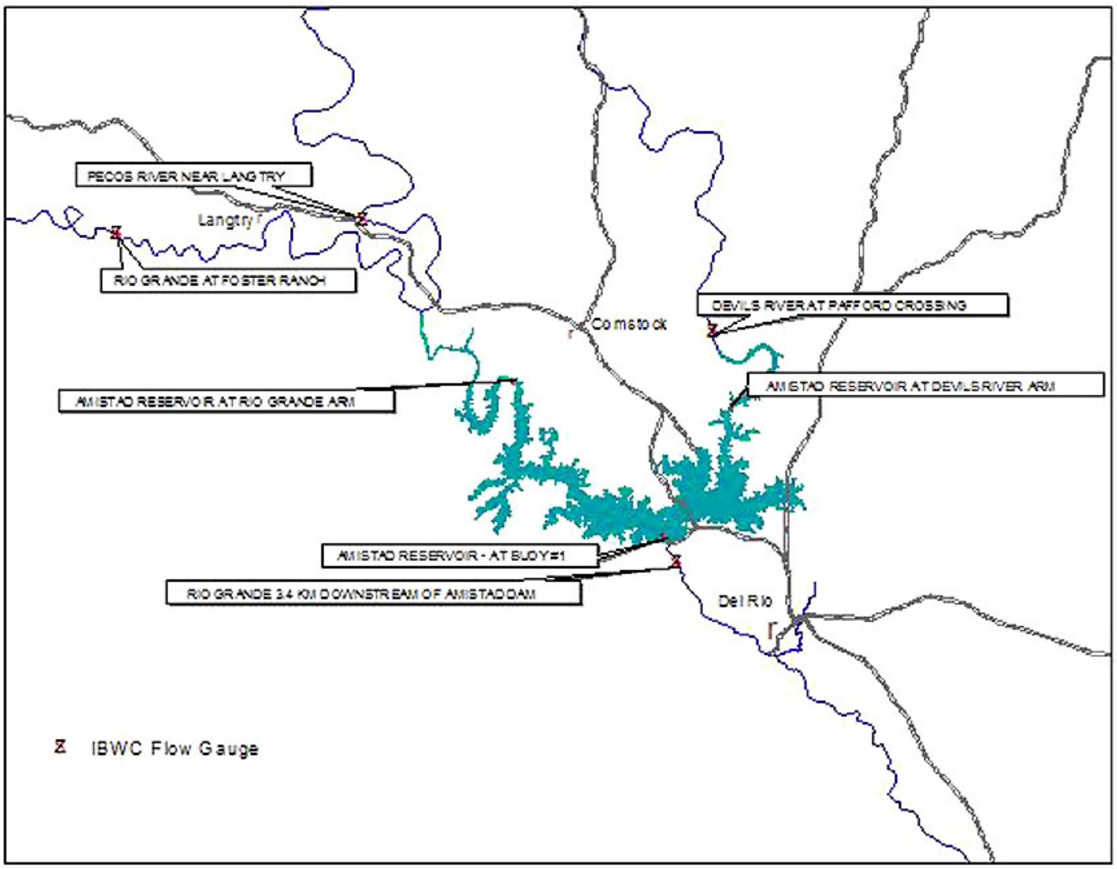

Table 1. Active Water Quality Monitoring Stations

Station Name	Agency	Station ID	# Samples per year	Parameters[2]
Rio Grande at Foster Ranch near Langtry*	USGS	8377200	8	Field Parameters, Nutrients, Major Ions, Trace Elements, Dissolved Pesticides
	TCEQ	13223	2	Field Parameters, Metals, Chloride, Sulfate, Nutrients, Bacteria, Chlorophyll a
Pecos River at Gauging Station at Langtry *	USGS	8447410	8	Field Parameters, Nutrients, Major Ions, Trace Elements, Dissolved Pesticides
	TCEQ	13240	2	Field Parameters, Metals, Nutrients, Chloride, Sulfate, Bacteria, Chlorophyll a
Devils River at Pafford Crossing near Comstock *	TCEQ	13237	4	Field Parameters, Nutrients, Chloride, Sulfate, Bacteria, Chlorophyll a
Rio Grande 3.4 km downstream of Amistad Dam, (above weir dam) *	USGS	8450900	6	Field Parameters, Nutrients, Major Ions, Trace Elements, Dissolved Pesticides
	TCEQ	15340	2	Field Parameters, Nutrients, Chloride, Sulfate, Bacteria
Amistad Reservoir - Devils River Arm at Buoy DRP	TCEQ	15893	4	Field Parameters, Nutrients, Chloride, Sulfate, Bacteria, Chlorophyll a
Amistad Reservoir - Rio Grande Arm at Buoy 28	TCEQ	15892	4	Field Parameters, Nutrients, Chloride, Sulfate, Bacteria, Chlorophyll a
Amistad Reservoir - at Buoy #1	TCEQ	13835	4	Field Parameters, Nutrients, Chloride, Sulfate, Bacteria, Chlorophyll a

From 2001 Texas Clean Rivers Program Schedule and USGS NASQAN website (http://water.usgs.gov/nasqan).
* Gauging Station

[1] Field Parameters include Temp, Turbidity, Conductance, D.O., pH, CO^3, HCO^3, Alkalinity, % fines, and Suspended Sediment (TSS), TDS.
Nutrients include: Organic Carbon, Ammonia, Nitrite+Nitrate, Othophosphorus and Total Phosphorus
Major Ions include: Chloride, Sulfate, Calcium, Sodium, and Potassium.
Trace Elements analysis detects small amounts of metals.

Appendix B Regional groundwater resources important to Big Bend National Park and the Rio Grande Wild and Scenic River

Jeffrey Bennett, NPS Big Bend National Park

River regulation, agricultural and municipal withdrawals and drought have diminished and altered the discharge patterns for the lower Rio Grande in far west Texas. The physical and ecological system, once adapted to large and rapid fluctuations in flow, is now adapted to lower and more constant flows. The 250 mile reach of the Rio Grande managed by the National Park Service is the only free flowing reach in the lower Rio Grande. A significant portion of the base flows are provided by groundwater contributions from four spring complexes located in Big Bend National Park and along the Rio Grande Wild and Scenic River. Management Plans for both NPS entities list the protection of springs as critical management concerns. The following four spring complexes have been identified by NPS staff.

1. Gambusia Hot Springs Complex

River miles	804	814
UTM Coordinates N	3233835	3226468
UTM Coordinates E	702647	694388
Zone 13		

This reach includes hot springs between Mariscal Canyon and Boquillas Canyon. Easily delineated orifices with significant flow include: Gravel Pit, Langford Hot Springs, Lower Hot Springs (a.k.a. VD Springs or Leper Springs), Rio Grande Village Springs 3 and 4, and numerous unnamed springs. Springs on the Mexican side include Ojo Caliente and Boquillas Hot Springs. These springs issue from the upper Cretaceous Rock units, the Boqullas and Santa Elena Limestones. Rio Grande Village currently gets its water supply from one of these springs. In addition, this same spring and another nearby spring feed two ponds that contain the world's only population of *Gambusia gaigei*.

2. Outlaw Flats Spring Complex

River miles	748	762
UTM Coordinates N	3292773	3296392
UTM Coordinates E	725582	716672
Zone 13		

Springs issue from the Glen Rose Limestone. Generally of low volume; however, there is evidence of historical use at a spring on the Texas side (approximately 749.5) near the confluence with Big Canyon. Historical use includes the remains of a spring box.

3. Las Palmes Spring Complex

River miles	735	742
UTM Coordinates N	3293228	3293608
UTM Coordinates E	737565	732013
Zone 13		

Large volume springs in Del Carmen Limestone. Historical use at Asa Jones waterworks, a withdrawal and distribution system for a candelilla wax camp located on the canyon rim east of Silber Canyon. The system includes pumps, piping, and several rock tanks, one of which is located over a spring emanating from a rock joint. Park Service personnel estimated the spring discharge at 300 gpm. This joint can be followed in both directions beyond the rock walls where additional water discharges. Water enters the river on both sides along a reach approximately 200 feet long. This area is used by undocumented Mexican emigrants frequently, as indicated by the presence of discarded clothing and bedrolls. Directly below the Asa Jones Waterworks, on the Texas side is Spigot Spring. This spring is used by river runners as a water source. Two miles downstream on the Coahilla, Mexico, side is Hot Springs, a very popular river camp due to the presence of several warm pools. A road on the Mexican side provides access to the area for the Mexican Army (reports from River District Ranger). Another spring below and on the Texas side is commonly used as a water source for river runners.

4. Madison Fold Spring complex.

River miles	720	723
UTM Coordinates N	3298065	3296092
UTM Coordinates E	753147	751786
Zone 13		

Low volume springs discharging from the Del Carmen Limestone and the Maxon Sandstone. As these are the last discharges along the river, river runners commonly use the spring on the Texas side and below Lower Madison Falls as a water source.

Flows in the Rio Grande are normally at the lowest in late winter and early spring. Normal peak flows for the Rio Grande occur during the mid to late summer during the Monsoon season and are generated as local runoff. Historically, peak flows came from the Rio Conchos drainage in Mexico. Pre-regulation spring freshets from the northern branch were diminished by losing reaches in southern New Mexico and west Texas basins (Shcmidt,2000). In April of 2004, we measured discharge above and below the Las Palmas/Madison fold Spring complexes with a Marsh-Mcbirney, Inc. Flo-Mate Model 2000 portable flowmeter. Channel conditions, flow velocities and depth, and available time were determining factors in choosing the number of velocity measurements to make (table 1). We found ideal conditions (i.e. bedrock bottom) at only the Reagan Canyon site. All other sites had channel bottoms of irregular sized cobbles and boulders.

Flows in the Rio Grande at this time of the year are normally near base flow conditions (Figure 1) and were so preceding this trip. IBWC gage data indicates that the reach between Johnson's Ranch and Foster's Ranch is a gaining reach with and average of 6.7 cms gained during the period of February 26 through March 9, 2004. Total measured spring flow contribution for the reach investigated here was 4.3 cms (cubic meters per second).

Table 1. Discharge data for March 2004. River miles from "The Lower Canyons of the Rio Grande" (Aulbach and Butler, 1993).

Location	River Mile	Date	Zone	Location Easting	Location Northing	Number of measurements	Width of Channel (ft)	Maximum Depth (ft)	Total Q (cms)
Taylor Farms	23	3/8/04	13R	722806.27	3284701.56	25	120	1.7	4.3
Reagan canyon	28	3/9/04	13R	724708	3292529	18	68	2.95	4.4
Hot springs	41	3/9/04	13R	737174	3293082	16	72	3.5	7.2
56.5 mile	56.5	3/11/04	na	na	na	21	78	1.78	8.6
Spring at Asa Jones	38.5R	3/9/04	13R	735536	3295584	22	11	1.5	0.17

Figure 1. Discharge reported by the International Boundary Waters Commission for gages along the Middle Rio Grande.