



Historical Perspectives of Water Resources

The purpose of this report is to improve understanding of surface and ground-water hydrology, water-quality conditions and trends, and the condition of macroinvertebrate communities in major water resources of the Chihuahuan Desert Network (CHDN) park units. Surface-water quantity describes long-term trends of streamflow at six gaging stations in the Rio Grande and Rio Conchos, comparisons of discharge percentiles at the gaging stations, and analyses of gains and losses of streamflow between river reaches. Surface-water quality describes conditions and seasonal and/or annual trends for water temperature, pH, dissolved oxygen, specific conductance, fecal-indicator bacteria, selected major ions, nutrients, metals, and macroinvertebrate communities. Groundwater quantity investigation provides tables of well-water and groundwater-level information for each CHDN park (except the Rio Grande Wild and Scenic River, where no data were available).

Surface Water Quantity

Streamflow in the Rio Grande is controlled by three major impoundments, Elephant Butte Reservoir in central New Mexico, La Boquilla Reservoir on the Rio Conchos in Mexico, and Amistad International Reservoir near Del Rio, Texas. Since the construction of Elephant Butte Reservoir (in 1915) and La Boquilla Reservoir (in 1916), annual mean flow in the Rio Grande has decreased and peak flows have also been reduced over time, resulting in channel narrowing, changes in channel width-to-depth ratios, and decreases in sediment transport, as well as changes in the abundance and composition of floodplain vegetation, for example, increases in the abundance of invasive plants (e.g., tamarisk).

Analyses of streamflow trends at selected USGS/IBWC gaging stations in the Rio Grande indicate decreases in annual mean discharge between 1900 and the regional drought of the 1950s, followed by increases in annual mean discharge through the 1980s associated with increases in precipitation during the period. Annual mean discharge at the gaging stations has decreased since the early 1990s despite relative increases in precipitation. Analysis of continuous streamflow records over a common period of record (1961-2007) indicates that about 80% of flow in the Rio Grande immediately downstream from the Rio Conchos confluence originates in the Rio Conchos basin. During low-flow conditions, the Rio Conchos provides nearly all of the flow in the Rio Grande downstream from its confluence.

Analyses of changes in flow conditions between Rio Grande gaging stations and from gain-loss studies in the wild and scenic river segment of the Rio Grande were used to provide estimates of groundwater discharges from springs into the Rio Grande. Large gains of discharge in the Rio Grande (100-400 ft³/s) found



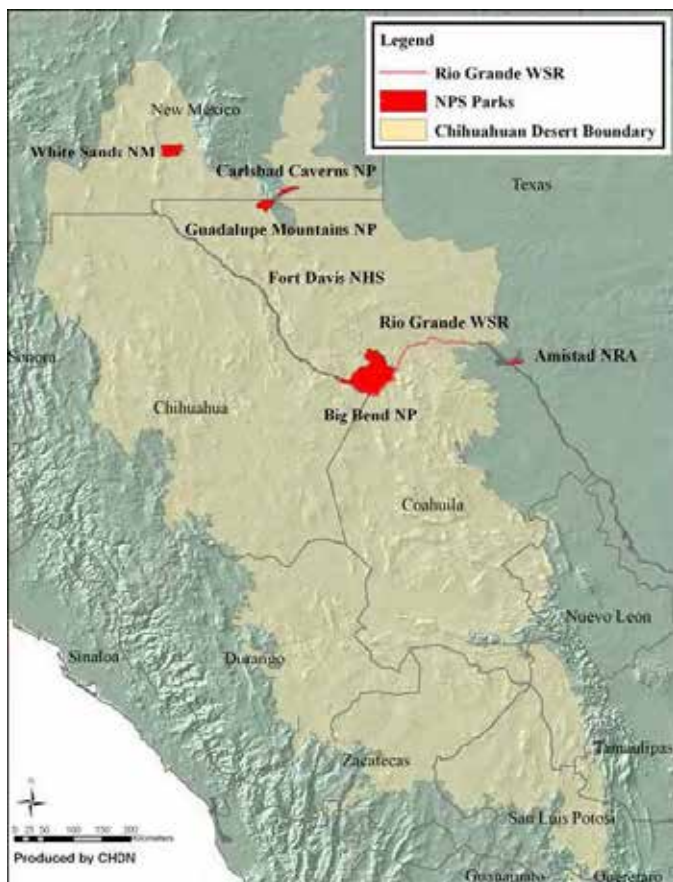
Rio Grand Wild and Scenic River.

along the lower wild and scenic river segment, are presumed to have originated from the Edwards-Trinity (Plateau) aquifer.

Surface Water Quality

Relatively little change was observed for water temperature, dissolved oxygen (DO) concentrations, and pH values in the Rio Grande over the past 30-35 years. Dissolved oxygen concentrations declined in the Rio Grande downstream from the Amistad International Reservoir dam until the early 2000s. Since that time, dissolved oxygen concentrations have returned to levels typically observed at other Rio Grande sites. Very low DO concentrations associated with early-season flood pulses that have resulted in fish kills in the Rio Grande near Rio Grande Village.





Map of CHDN parks and the Rio Grande Wild and Scenic River.

Median values for fecal-indicator bacteria (fecal coliform and *Escherichia coli*) were similar among sites, correlated positively with streamflow, and were significantly higher during the summer recreational season. The percentage of Rio Grande samples exceeding Environmental Protection Agency (EPA) criteria for contact recreation decreased from about 20% at Santa Elena Canyon to about 10% at Foster Ranch. Over 40% of samples collected from the Rio Grande below Rio Conchos exceeded EPA criteria. Fecal coliform values have been increasing in the Rio Grande at Santa Elena since the early 1990s, consistent with trends at upstream sites near Presidio, Texas. Although *E. coli* samples have been collected only since 2001, values appear to be increasing at sites in the wild and scenic river segment.

Median concentrations of chloride, sulfate, and total dissolved solids, as well as specific conductance values, were relatively high in the Rio Grande at sites near Presidio, Texas and decreased with distance down river. Chloride concentrations exceeded the EPA chronic aquatic-life criterion in 43% to 77% of Rio Grande samples collected at sites near Presidio, 41% of samples from the Rio Grande at Santa Elena, 20% of samples from the Rio Grande near La Linda, and about 8% of samples from the Rio Grande at Foster. No exceedances were found in any samples collected from the Rio Grande below Amistad Reservoir. Chloride concentrations and specific conductance values in the Rio Grande have increased since the early 1970s; however, values at sites below Santa Elena appear to have decreased since the mid-1990s.

Nutrient and biological indicators of eutrophication generally were highest at the Rio Grande sites near Presidio, decreasing with distance downstream. Median nitrate concentrations



Site	Site Name	River Km	TCEQ ID	USGS gage
A	Rio Grande near Presidio, TX (upstream from Rio Conchos)	1551	13230	08371500
B	Rio Grande below Rio Conchos	1529	13229	08374200
C	Rio Grande above Lajitas, TX	1484	18441	-----
D	Rio Grande at mouth of Santa Elena Canyon ₁	1425	13228	-----
E	Rio Grande at Johnson Ranch, TX ₂	1388	13227	08375000
F	Rio Grande above Boquillas Canyon	1260	-----	-----
G	Rio Grande near La Linda, MX ₂	1219	13225-6	-----
H	Rio Grande at Foster Ranch, TX	1058	13223	08377200
I	Rio Grande above Del Rio, TX (below Amistad Reservoir)	920	13209	08450900

₁Water-quality record for site D compiled from TCEQ 13227 (1968-76) + TCEQ 13228 (1974-2007)

₂Water-quality record for site G compiled from TCEQ 13226 (1977-81) + TCEQ 13225 (1988-2007)

Map of surface water quantity and quality monitoring locations.

increased significantly in the Rio Grande sites near Presidio, decreasing with distance downstream. Median nitrate concentrations increased significantly in the Rio Grande downstream from the Rio Conchos confluence, and median concentrations remained about the same at sites downstream to the Rio Grande at the Foster Ranch station. Nitrate concentrations in the Rio Grande have been decreasing at most sites since the late 1980s. Median concentrations of dissolved orthophosphate were highest in the Rio Grande at Santa Elena. Orthophosphate concentrations in the Rio Grande generally have been increasing since the mid-1980s. About 17% of samples from the Rio Grande at Santa Elena exceeded 30 ug/L, a common criterion for eutrophic conditions. Dense growths of filamentous algae (*Cladophora glomerata*) were observed at several Rio Grande sites during a field visit in early April 2008.

Despite historic mining activities in the region, notably mercury mining in the Terlingua mining district, concentrations of metals in water and sediment samples generally were low at all sites, consistent with natural background levels. Metals appear to be accumulating in the bottom sediments of Amistad Reservoir. Concentrations of arsenic, chromium, and nickel in upper layers of sediment cores (more recent years) exceeded biological threshold effect levels. Several recent studies have reported bioaccumulation of mercury in fish tissue samples collected from sites near the mining district as well as in Amistad Reservoir.

The quality of surface waters in other CHDN parks ranges from hypersaline conditions that are unfavorable for most freshwater aquatic life at White Sands National Park (NP) to high-quality, near-pristine waters in Guadalupe Mountains NP and, presumably, Rattlesnake Springs in Carlsbad Caverns NP. Limited data available for Limpia Creek, located at the northern boundary of the Fort Davis National Historic Site (NHS), indicated relatively good water quality; however, low streamflow conditions, presently (2008) and particularly during the late 1880s, have limited the value of this resource.

Macroinvertebrate Communities

Although macroinvertebrate data have been collected at various Rio Grande sites since the late 1970s, differences in study design and location, antecedent hydrologic conditions, sample-collection methods, and, particularly, levels of taxonomic resolution (e.g., order/family compared with genus/species) confound analyses of stream condition, much less changes over time. Because some of the available data sets provided only rapid bioassessment metric values, more complex data

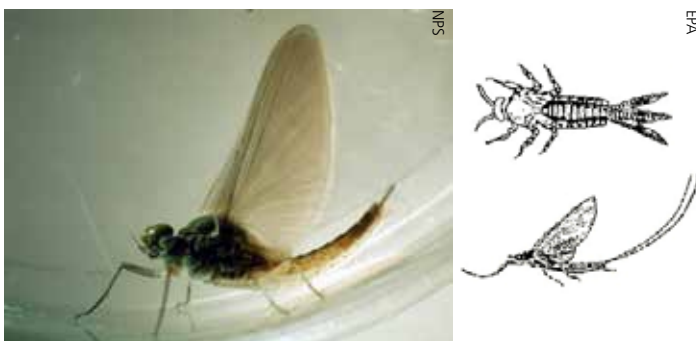
sets (e.g., with taxa names and counts) were reduced to a set of two common metrics, taxa richness (number of all taxa in a sample) and E+T richness (number of mayfly + caddisfly taxa in a sample)—an estimate of the number of pollution-sensitive taxa. Taxa and E+T richness generally increase with improvements in water-quality and (or) habitat conditions.

Median taxa richness (about 10) and E+T richness (5 or less) were lowest at Rio Grande sites above Rio Conchos, at Santa Elena Canyon, and near La Linda, Mexico, indicating degraded ecological conditions. Median taxa richness (20-40) and E+T richness (7-10) at sites downstream from each of the impaired sites were considerably higher. Results from a recent (1999) study indicated that, while overall taxa richness increased from 42 to 58 in the wild and scenic river segment between the Santa Elena Canyon and La Linda sites, E+T richness decreased from 9 to 5 in the same river segment. Increases in taxa richness with downstream distance in the wild and scenic river segment primarily are associated with increases in the number of tolerant taxa rather than improvements in water quality. Based on similarities in taxa richness, E+T richness, and the distribution of species between macroinvertebrate data reported from the late 1970s and late 1990s, there is no compelling evidence to suggest that the condition of macroinvertebrate communities in the Rio Grande has changed appreciably.

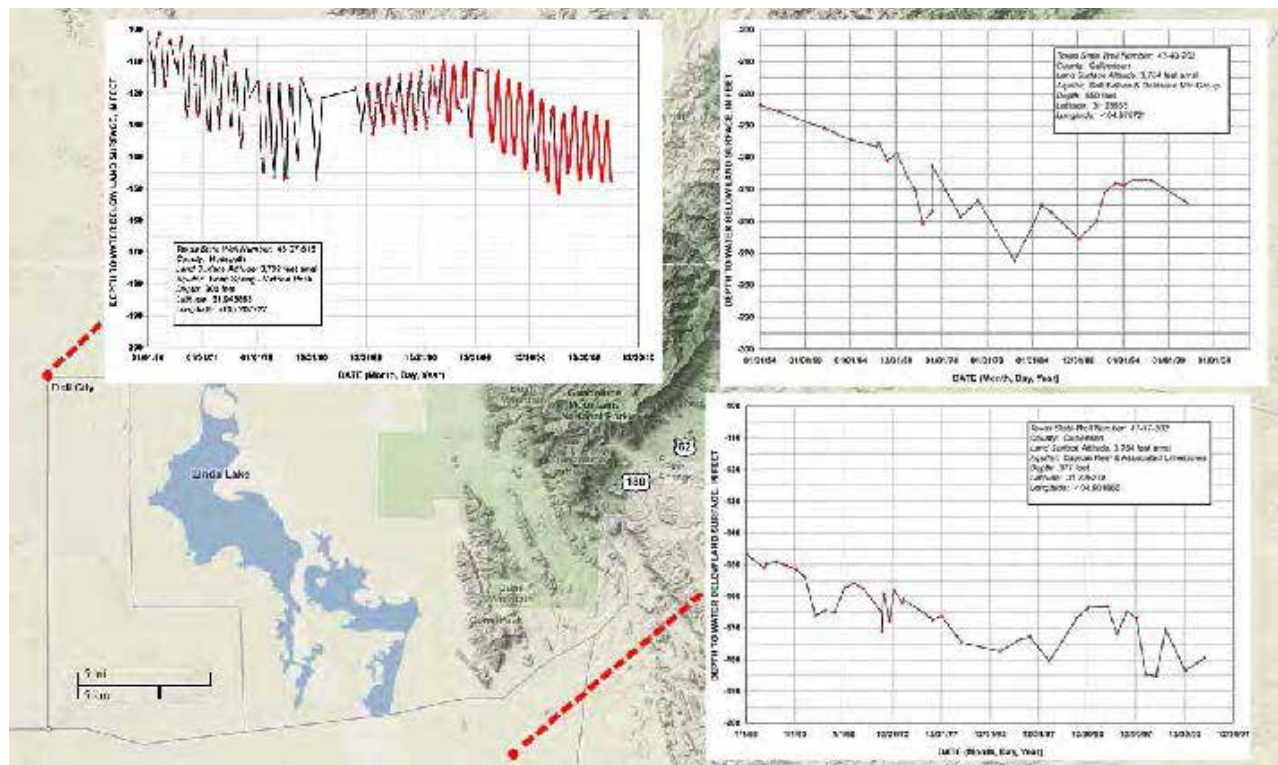
Macroinvertebrate communities in smaller streams within the CHDN were variable and somewhat a function of the relative permanency of stream flow. For example, taxa richness in intermittent streams within Big Bend NP was generally low, despite reasonably good water quality at times the streams were flowing. Water-quality conditions limited macroinvertebrate richness to 7 salt-tolerant taxa in the Lost River (at White Sands NP). By contrast, taxa richness in the McKittrick Creek system (in Guadalupe Mountains NP) varied from 35 to 82, whereas E+T richness ranged from 10 to 18, reflecting greater streamflow permanency in addition to outstanding water quality and habitat conditions.

Groundwater Quantity

To satisfy potable (drinking) water needs, every CHDN park is dependent on groundwater that discharges from springs, is pumped from local aquifers, or both. The availability of groundwater is continually adjusting to the effects of weather, well withdrawals (pumping), and land use. Understanding the nature and effects of weather, pumping, and land use is important toward maintaining viable sources of potable groundwater;



Mayflies (left) and caddisflies (right) are used to measure species richness in the macroinvertebrate community. Shown here are the adults (color photos) and larval stages (drawings).



Groundwater hydrograph for wells near Guadalupe Mountains National Park.

monitoring groundwater quantity is vital toward tracking the availability and sustaining the future of groundwater supplies.

Groundwater recharge to CHDN parks is restricted by the limited and sporadic nature of precipitation and high evapotranspiration rates; consequently, water supply wells are vulnerable to seasonal water-level drawdown, if not long-term decline. For this reason, the systematic observation of groundwater levels is essential toward evaluating long-term trends in area aquifers, as well as providing a means of effectively managing specific aspects of any park's dependency on water. With the exceptions of recently activated observation wells in Big Bend NP and a network of eight groundwater-monitoring wells in White Sands NP, no CHDN park is currently collecting groundwater-quantity data on a systematic basis.

The water levels in most long-term observation wells tapping aquifers underlying CHDN parks appear to respond relatively quickly to both precipitation on nearby recharge areas and to variations in pumping stress. The water levels in most nearby observation wells appear particularly vulnerable to the effects of drought—most notably those of decreasing recharge and increasing withdrawals of groundwater for irrigation. Except for GUMO, with its dependency on the Capitan Reef and Associated Limestones aquifer and this park's potential interest in the status of adjacent Bone Spring-Victorio Peak and Salt Bolson and Delaware Mountain Group aquifers, none of the CHDN parks appear affected by long-term water-level declines of immediate consequence.

Despite the fact that observations wells near Big Bend, Carlsbad Caverns, Fort Davis, and Guadalupe Mountains tap different aquifers at distant locations, their individual water-level trends appear to track the effects of similar hydrogeologic controls. Amistad NRA and White Sands NP, on the

other hand, exhibit the effects of comparatively unique hydrogeologic settings. Since the early 1970s, the groundwater-level variations near Amistad have been distinctly buffered by water levels in Lake Amistad; and the shallow groundwater regime at White Sands is perched above and hydraulically isolated from the regional, basin-fill aquifer of the larger Tularosa basin by an extensive remnant of an ancient (Pleistocene) lake bed.

For More Information

Porter, S. D., R. A. Barker, R. M. Slade, Jr., and G. Longley. 2009. Historical Perspective of Surface Water and Groundwater Resources in the Chihuahuan Desert Network, National Park Service, Edwards Aquifer Research and Data Center, R1-09.