WATER QUALITY SURVEY SUMMARY
FOR THE
RIO HONDO WATERSHED
(Rio Ruidoso and Selected Tributaries)
2003

Prepared by
Surface Water Quality Bureau
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Al	Aluminum
C	Celsius
cfs	cubic feet per second
CWA	Clean Water Act
CWAL	Coldwater Aquatic Life
ELS	Early Life Stage
DO	Dissolved Oxygen
GIS	Geographic Information Systems
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
OLS	Other Life Stage
QAPP	Quality Assurance Project Plan
STORET	EPA's Storage and Retrieval System
SWQB	Surface Water Quality Bureau
USEPA	United States Environmental Protection Agency

1.0 EXECUTIVE SUMMARY

Water quality surveys and assessments are completed in fulfillment of Section 106 of the Clean Water Act (CWA) [33 USC 1251 et seq.], *Work Program for Water Quality Management.* The purpose of the water quality survey is to collect data to identify and prioritize water quality problems within a watershed and to evaluate the effectiveness of water quality based controls. Data are compared to current water quality standards for the State of New Mexico, as approved by the United States Environmental Protection Agency (EPA), to determine if waterbodies are supporting their designated uses.

Water Quality Survey Summary Reports focus on information and data collected by the New Mexico Environment Department's (NMED) Surface Water Quality Bureau (SWQB). All data collected as part of a survey are available upon request to the SWQB and can be downloaded from EPA's computerized environmental data system known as STORET/WQX (http://www.epa.gov/storet/). The data collected as part of this study are later combined with all other readily available or submitted data that meet state quality assurance/quality control requirements to form the basis of designated use attainment determinations summarized in the biennial *State of New Mexico Integrated CWA §303(d)/§305(b) Report* (NMED/SWQB 2006a).

During 2003, the Monitoring and Assessment Section of the SWQB conducted water quality and biological assessments of the Rio Hondo watershed from Riverside, NM, to the headwaters. Tributaries to the Rio Hondo sampled during the survey included the Rio Ruidoso, the Rio Bonito, Eagle Creek and Carrizo Creek. Sampling at stream stations was conducted on a monthly basis from March through November when water was present at the stations. Water quality sampling methods were in accordance with the *Quality Assurance Project Plan for Water Quality Management Programs* (NMED 2003).

Extensive sampling for ions, nutrients, total and dissolved metals, radionuclides, organics, biological indicators (bacteria, aquatic invertebrates, algae/periphyton and fish) and field parameters found exceedences attributable variously to plant nutrients, turbidity, temperature, and bacteria at a number of stations. Of these, the most ecologically significant are the effects of plant nutrients and temperature. One assessment unit on the Rio Ruidoso, Rio Ruidoso (Rio Bonito to US Hwy 70 Bridge), was determined to exceed the plant nutrients criterion. Nutrient inputs, largely attributable to the Ruidoso WWTP (NPDES Permit no. NM0029165), generate large blooms of nuisance algae. These blooms are frequently extensive enough to interfere with the operation of irrigation headgates. Another assessment unit on the Rio Ruidoso, Rio Ruidoso (US Hwy 70 bridge to Mescalero Boundary), was determined to exceed the temperature criterion. Elevated water temperature not only stresses aquatic communities directly by increasing the metabolic rates of fish, thereby increasing food requirements, but indirectly as well, by decreasing oxygen saturation.

Photo 1. Rio Bonito at the BLM Apple Orchard Site.

2.0 INTRODUCTION

The upper Rio Hondo watershed (US Geological Survey [USGS] Hydrologic Unit Code [HUC] 13060008) is located in Lincoln and Otero Counties and the Mescalero Apache Indian Reservation in south central New Mexico (NM). The entire Rio Hondo watershed encompasses approximately 4350 km^2 (1680 mi^2) in Lincoln County. The Rio Hondo watershed consists of two smaller sub-watersheds of about equal area: the Rio Bonito and the Rio Ruidoso. Both sub-watersheds lie east and south of the Capitan and Sacramento Mountains. The Rio Hondo is formed at the confluence of the Rio Bonito and Rio Ruidoso. Landscapes range from forested mountains to desert grasslands to vegetated riparian zones. **Figure 1** presents a map of the study area. The vegetation of the Lincoln County area includes Chihuahuan Desert, Mexican Highlands, Great Plains, and Rocky Mountain floras (Barker et al. 1991).

Samples were taken at 20 sites during the survey period (**Figure 1** and **Table 1**). Some of these sites have been previously studied by NMED (Smolka 1995 and 1999). Flows (discharge) of the Rio Ruidoso during 2003 are graphically represented and compared to long-term mean flows in **Figure 2**. Flows during the survey were less than the historic average with the exception of a few storm events. The Rio Bonito failed to flow at the confluence with the Rio Ruidoso most of the year and Eagle Creek went dry in early summer.

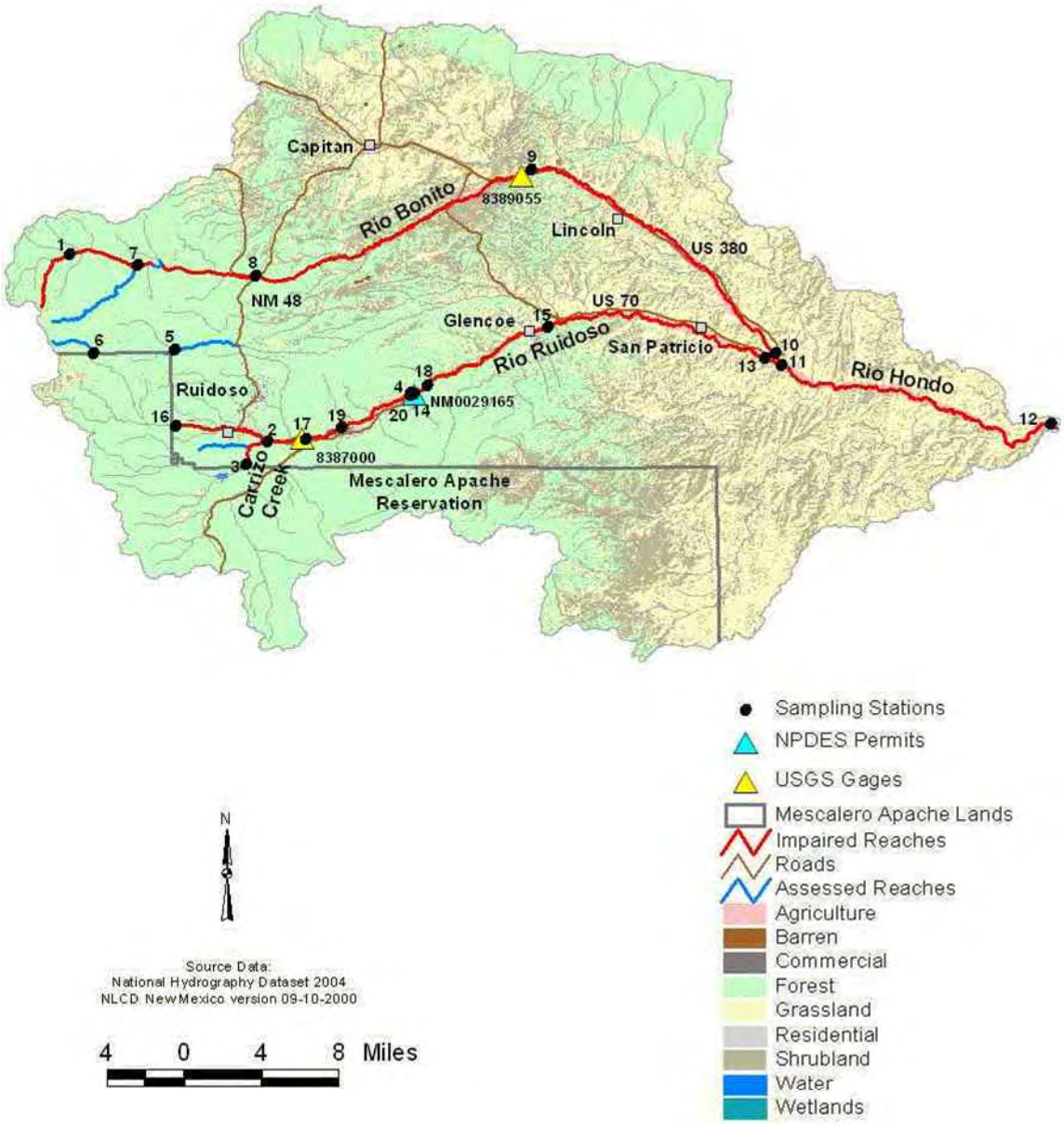

Figure 1. Map of Study Area showing land use/cover and sampling locations.

Table 1. Survey Stations and STORET Codes

SITE#	LATITUDE	LONGITUDE	STATION	STORET_ID
1	33.46431	-105.80153	Bonito Creek @ White Mountain Wilderness boundary	57RBonit066.3
2	33.32434	-105.65397	CARRIZO CREEK ABOVE THE RIO RUIDOSO	57Carriz000.1
3	33.30735	-105.66975	Carrizo Creek at Mescalero Boundary	57Carriz003.0
4	33.36063	-105.54739	CITY OF RUIDOSO NEW WWTP OUTFALL PIPE	NM0029165
5	33.39275	-105.72314	EAGLE CREEK AT USGS GAGE	57EagleC030.0
6	33.39056	-105.78417	N FK RIO RUIDOSO BLW SKI LODGE	57NRuido008.4
7	33.45576	-105.75105	RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S.	57RBonit061.1
8	33.44788	-105.66300	RIO BONITO AT ANGUS BRIDGE	57RBonit053.4
9	33.52732	-105.45749	Rio Bonito at BLM Apple Orchard Site	57RBonit027.7
10	33.38990	-105.27500	Rio Bonito at HWY 70 bridge near HWY 380 bridge	57RBonit001.0
11	33.38170	-105.27034	RIO HONDO 100 YDS BELOW CONFLUENCE	57RHondo131.1
12	33.33766	-105.06892	R. Hondo blw Riverside on R. Hondo Land and Cattle property	57RHondo105.8
13	33.38642	-105.28265	RIO RUIDOSO 1 MI ABV RIO BONITO AT SAN PATRICIO	57RRuido001.3
14	33.36063	-105.54369	Rio Ruidoso 10 feet above WWTP outfall	57RRuido031.0
15	33.41026	-105.44492	Rio Ruidoso 7 miles below WWTP at Glencoe FR 443	57RRuido019.8
16	33.33634	-105.72288	Rio Ruidoso at Mescalero boundary at gage	57RRuido052.4
17	33.32656	-105.62514	Rio Ruidoso at USGS gaging station at Hollywood	57RRuido042.3
18	33.36615	-105.53503	RIO RUIDOSO BELOW NEW WWTP	57RRuido030.2
19	33.33472	-105.59892	Rio Ruidoso below Ruidoso Downs Racetrack Property	57RRuido039.4
20	33.35884	-105.54739	Rio Ruidoso .5 mile above WWTP at HWY 70 bridge	57RRuido031.5

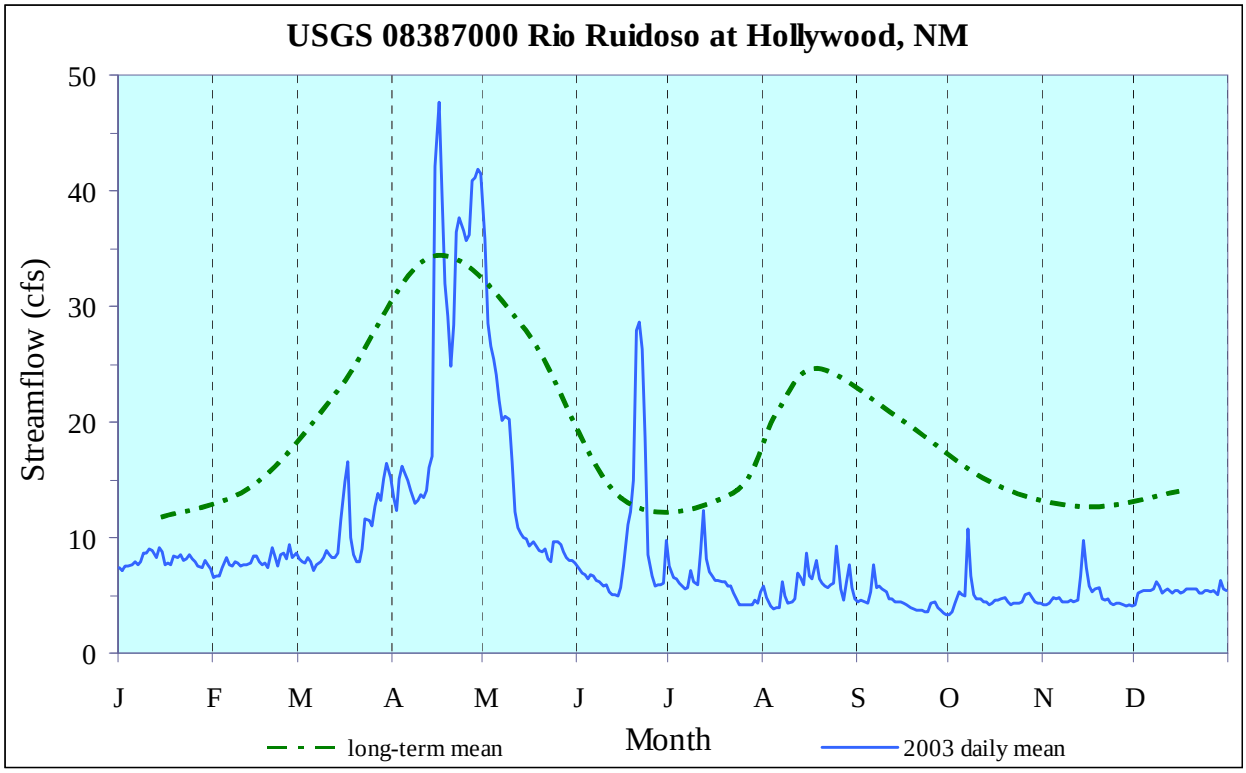

Figure 2. Daily mean streamflow of the Rio Ruidoso, 2003.

Photo 2. Rio Ruidoso at the Mescalero Boundary.

Photo 3. Rio Bonito at the Angus Bridge.

3.0 WATER QUALITY STANDARDS SEGMENTS

General standards and standards applicable to attainable or designated uses for portions of the Rio Hondo Watershed that were surveyed in this study are set forth in sections 20.6.4.13, 20.6.4.97, 20.6.4.98, 20.6.4.99, and 20.6.4.900 of the *State of New Mexico Standards for Interstate and Intrastate Surface Waters* (NMAC 2006). Segment specific standards for the Rio Hondo Watershed are set forth in sections 20.6.4.208 and 20.4.6.209, which state:

> **20.6.4.208 PECOS RIVER BASIN - Perennial reaches of the Rio Peñasco and its tributaries above state highway 24 near Dunken, perennial reaches of the Rio Bonito downstream from state highway 48 (near Angus), the Rio Ruidoso downstream of the U.S. highway 70 bridge near Seeping Springs lakes, perennial reaches of the Rio Hondo, and Agua Chiquita.**
> **A.** Designated Uses: fish culture, irrigation, livestock watering, wildlife habitat, coldwater fishery, and secondary contact.
> **B.** Standards:
> **(1)** In any single sample: pH shall be within the range of 6.6 to 8.8, temperature shall not exceed 30°C (86°F) and total phosphorus (as P) shall be less than 0.1 mg/L. 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).
> [20.6.4.208 NMAC – Rp 20 NMAC 6.1.2208, 10-12-00]
>
> **20.6.4.209 PECOS RIVER BASIN - Eagle creek above Alto reservoir, the Rio Bonito upstream of state highway 48 (near Angus), and the Rio Ruidoso and its tributaries upstream of the U.S. highway 70 bridge near Seeping Springs lakes.**
> A. Designated Uses: domestic water supply, fish culture, high quality coldwater fishery, irrigation, livestock watering, wildlife habitat, municipal and industrial water supply, and secondary contact.
> B. Standards:
> (1) In any single sample: conductivity shall not exceed 600 µmhos in Eagle creek, 1,100 µmhos in Bonito creek, and 1,500 µmhos in the Rio Ruidoso, pH shall be within the range of 6.6 to 8.8, temperature shall not exceed 20°C (68°F), and turbidity shall not exceed 10 NTU. 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).
> [20.6.4.209 NMAC – Rp 20 NMAC 6.1.2209, 10-12-00]

4.0 METHODS

Water quality sampling methods were conducted in accordance with the approved *Quality Assurance Project Plan (QAPP) for Water Quality Management Programs* (NMED/SWQB 2003). Water chemistry samples were collected monthly from March through November of 2003. Certain sites were sampled were sampled less frequently due to the absence of water. Benthic macroinvertebrate and fish sampling methods were in accordance with protocols for EPA's Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (Barbour et al. 1999). Fluvial geomorphologic measurements were in accordance with protocols in the QAPP (NMED/SWQB 2003).

5.0 SAMPLING SUMMARY

A map of the study area is provided in **Figure 1**. The station numbers, STORET identification codes, and location descriptions of sampling stations selected for this survey are provided in **Table 1.** The rationales for station selection are listed below in **Table 2.**

Table 2. Survey Stations rationales.

SITE#	STORET_ID	STATION	RATIONALE
1	57RBonit066.3	Bonito Creek @ White Mountain Wilderness boundary	Bracket corral at Bonito riding stables, USFS campgrounds and old mines above confluence with S. Fork of Bonito Creek.
2	57Carriz000.1	CARRIZO CREEK ABOVE THE RIO RUIDOSO	Major Tributary to the Rio Ruidoso. Also below Grindstone Creek. Historic Site.
3	57Carriz003.0	Carrizo Creek at Mescalero Boundary	Concerns about nutrient loading. Major tributary to the Rio Ruidoso.
4	NM0029165	CITY OF RUIDOSO NEW WWTP OUTFALL PIPE	Monitor WWTP effluent; historic site.
5	57EagleC030.0	EAGLE CREEK AT USGS GAGE	Downstream from Ski Apache; historic site; above Alto Lake.
6	57NRuido008.4	N FK RIO RUIDOSO BLW SKI LODGE	Concerns of sediment and nutrients leaving Ski Apache, and destabilization of streams within the ski area. Site is USFS property, leased to the Mescalero Apaches.
7	57RBonit061.1	RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S.	Top of segment; evaluate contribution from S. Fork.
8	57RBonit053.4	RIO BONITO AT ANGUS BRIDGE	Historic Site between two water quality segments.
9	57RBonit027.7	Rio Bonito at BLM Apple Orchard Site	Site Midway Between Bonito Dam and Confluence with Rio Ruidoso. Near USGS gage and Salazar Canyon Site. Not open to public access. Fish and benthic macroinvertebrate data collected by NMSU. Good candidate for a bio reference site. Lowest perennial site.
10	57RBonit001.0	Rio Bonito at HWY 70 bridge near HWY 380 bridge	Historic site at bottom of water quality segment. Above the confluence of a major tributary (Rio Ruidoso)
11	57RHondo131.1	RIO HONDO 100 YDS BELOW CONFLUENCE	Historic site directly below the confluence of the Rio Bonito and Rio Ruidoso. Top of stream WQS segment.
12	57RHondo105.8	R. Hondo blw Riverside on R. Hondo Land and Cattle property	Lower end of the perennial reach of the Rio Hondo. Stream is intermittent except for the last mile above the Pecos River. May be a candidate for a reference site.
13	57RRuido001.3	RIO RUIDOSO 1 MI ABV RIO BONITO AT SAN PATRICIO	Historic Site above the confluence with the Rio Bonito.
14	57RRuido031.0	Rio Ruidoso 10 feet above WWTP outfall	Brackets potential inputs into the River between WWTP outfall and Hwy 70.
15	57RRuido019.8	Rio Ruidoso 7 miles below WWTP at Glencoe FR 443	Historic site, approximately half the distance below the Ruidoso WWTP and the confluence with the Rio Bonito. Upstream of ephemeral confluence

SITE#	STORET_ID	STATION	RATIONALE
			with Eagle Creek.
16	57RRuido052.4	Rio Ruidoso at Mescalero boundary at gage	Historical site just below Mescalero Boundary. Good background site with a newly installed gage at old City Water Plant Building.
17	57RRuido042.3	Rio Ruidoso at USGS gaging station at Hollywood	Above the race track near gaging station. Historic site
18	57RRuido030.2	RIO RUIDOSO BELOW NEW WWTP	Below WWTP - evaluate contribution of WWTP effluent.
19	57RRuido039.4	Rio Ruidoso below Ruidoso Downs Racetrack Property	Concerns of citizens in public meeting to have a site below racetrack; consultant firm (Livingston & Associates) will be sampling here for the Village of Ruidoso to determine nutrient loading, if any, from track
20	57RRuido031.5	Rio Ruidoso .5 mile above WWTP at HWY 70 bridge	Nutrient assessment. Below the race track at the bottom of stream standard segment and above the Ruidoso WWTP.

Table 3 summarizes data collected in each assessment unit and at each station. The number of samples for each parameter is indicated. Field data include temperature, specific conductance, pH, dissolved oxygen, and turbidity. In the case of stream discharge, some of the data are estimated or calculated.

Table 3. SWQB Sampling Summary

Assessment Unit / Stations	**Field Data**	**Ions**	**Total Nutrients**	**Mercury/Selenium**	**Dissolved Metals**	**Cyanides**	**Fecal Coliform**	**Radionuiclides**	**Organics (SVOCs)**	**Sonde**	**Thermograph**	**Discharge**	**Macroinvertebrates**	**Electro-fished**	**Geomorph**
Rio Bonito (NM 48 near Angus to headwaters)															
Bonito Creek @ White Mountain Wilderness boundary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RIO BONITO ABV BONITO LK AT FR 107	9	8	8	8	8	1	9	-	1	-	1	8	Yes	-	Yes
RIO BONITO AT ANGUS BRIDGE	4	4	4	4	4	1	4	-	-	-	2*	8	-	-	Yes
Rio Bonito (Rio Ruidoso to NM 48 near Angus)															
Rio Bonito at BLM Apple Orchard Site	9	8	8	8	8	-	8	-	1	-	2*	8	Yes	Yes	Yes
Rio Bonito at HWY 70 bridge near HWY 380 bridge	-	-	-	-	-	-	-	-	-	-	-	7+	-	-	-
Eagle Creek (Alto Reservoir to Mescalero Apache bnd)															
EAGLE CREEK AT USGS GAGE	1	1	1	1	1	-	-	-	-	-	-	1	-	-	-
Carrizo Creek (Rio Ruidoso to Mescalero Apache bnd)															
Carrizo Creek at Mescalero Boundary	8	8	8	-	-	-	-	-	-	-	-	8	-	-	-
CARRIZO CREEK ABOVE THE RIO RUIDOSO	8	8	8	8	8	1	8	1	1	-	1	8	-	-	Yes
Rio Ruidoso (North Fork abv Mescalero Apache bnd)															
N FK RIO RUIDOSO BLW SKI LODGE	3	3	3	3	3	-	-	-	-	-	-	3	-	-	-
Rio Ruidoso (US Hwy 70 Bridge to Mescalero Apache bnd)															
Rio Ruidoso at Mescalero boundary at gage	8	8	8	8	8	1	8	1	1	-	2*	8	Yes	-	Yes
Rio Ruidoso at USGS gaging station at Hollywood	9	9	9	8	8	-	2	-	1	-	1	9	-	-	Yes
Rio Ruidoso below Ruidoso Downs Racetrack Property	9	9	8	-	-	-	-	-	-	-	-	9	-	-	-
Rio Ruidoso .5 mile above WWTP at HWY 70 bridge	11	9	10	8	8	1	9	1	1	Yes	2*	9	-	-	Yes
Rio Ruidoso (Rio Bonito to US Hwy 70 Bridge)															
Rio Ruidoso 10 feet above WWTP outfall	8	8	8	-	-	-	-	-	-	-	-	6	-	-	-
CITY OF RUIDOSO NEW WWTP OUTFALL PIPE	9	9	9	8	8	-	4	-	-	-	-	1	-	-	-
RIO RUIDOSO BELOW NEW WWTP	11	9	10	8	8	1	9	1	1	Yes	-	9	-	-	Yes
Rio Ruidoso 7 miles blw WWTP at Glencoe FR 443	8	8	8	-	-	-	-	-	-	-	1	8	-	-	Yes
Rio Ruidoso 1 mi abv Rio Bonito at San Patricio	8	8	8	8	8	1	8	1	1	-	1	8	Yes	-	Yes
Rio Hondo (Pecos R to Rio Ruidoso)															
RIO HONDO 100 YDS BELOW CONFLUENCE	9	8	8	8	8	1	8	-	1	-	2*	8	Yes	-	Yes
R.Hondo blw Riverside on R.Hondo Land and Cattle property	9	8	8	8	8	1	5	1	1	-	2*	8	Yes	-	-

NOTES: * Water plus air thermographs
+ Rio Bonito at HWY 70 bridge near HWY 380 bridge was dry during every visit.

6.0 WATER QUALITY ASSESSMENT

6.1 Water Quality Standards Exceedences

For many water quality parameters, the State of New Mexico has adopted numeric water quality standards. However, for several parameters (e.g., plant nutrients, stream bottom deposits), only narrative standards exist. Data are assessed for designated use attainment status for both numeric and narrative water quality standards by application of the Assessment Protocol and associated appendices (NMED/SWQB 2006b).

The purpose of this section of the report is to provide the reader with information on where current water quality standards are being exceeded within the watershed. These exceedences are used to determine designated use impairment status. It should be noted that a single exceedence of a given criterion may not generate a violation of standards, triggering a listing on the 303(d) list. Final assessment determinations as to whether or not a stream reach is considered to be supporting its designated uses depends on either the total number of exceedences or the ratio of exceedences to all available data. Refer to NMED/SWQB's Assessment Protocol for additional information on the assessment process, NMED/SWQB 2006b. When available, outside sources of data that meet quality assurance requirements are combined with data collected by SWQB during intensive watershed survey to determine final impairment status. Final designated use impairment status is housed in the Assessment Database (ADB) and is reported in the biennial *State of New Mexico Integrated Clean Water Act §303(d)/§305(b) Report* (NMED/SWQB 2006a).

6.1.1 Physicochemical Data

Extensive sampling for major ions, nutrients, total and dissolved metals, radionuclides, organics, biological indicators (bacteria, aquatic invertebrates), and field parameters found exceedences attributable to plant nutrients, turbidity, temperature, and bacteria at various stations (**Table 4**).

6.1.2 Data from Continuous Monitoring Devices

As it is not reasonable to list a waterbody as not supporting on the basis of a few exceedences out of several hundred, or several thousand, data points, SWQB has developed special protocols to handle large datasets generated by continuous monitoring instruments that take measurements of pH, temperature, DO and turbidity. Details of large dataset assessment procedures are available in the *Assessment Protocol* (NMED/SWQB 2006b).The pH and temperature protocols are tied to *State of New Mexico Standards for Interstate and Intrastate Surface Waters* (NMAC, 2006). Dissolved oxygen assessment criteria are linked to the presence of sensitive, *i.e.* early life stages, aquatic organisms and designated use, *i.e.* high quality coldwater aquatic life use.

Temperature data loggers (thermographs) were deployed at 11 stations in the Rio Hondo watershed to assess attainment of the aquatic life designated use. Additionally, six thermographs were deployed in the air to examinee the relationship of air temperature on water temperature. The thermographs were programmed to record hourly. **Table 5** summarizes these datasets.

Multi-parameter data loggers (sondes) were deployed at two stations to evaluate pH, DO, temperature, conductivity and turbidity. **Tables 6a and 6b** summarize the pH and DO data.

Table 4. Water quality impairments documented in the 2006-2008 303d list of impaired waters (NMED/SWQB, 2006a) and the associated exceedence ratios (#exceedence / #samples) resulting in the listing. An (X) indicates the AU is impaired for this parameter.

Assessment Unit / Station	Plant Nutrients	Turbidity	Long Term Temperature	Bacteria
Carrizo Creek (Rio Ruidoso to Mescalero Apache bnd)				**X**
CARRIZO CREEK ABOVE THE RIO RUIDOSO				**2/8**
Rio Bonito (NM 48 near Angus to headwaters)				**X**
RIO BONITO ABV BONITO LK AT FR 107 & RIO BONITO AT ANGUS BRIDGE				**2/13**
Rio Hondo (Perennial reaches Pecos R to Rio Ruidoso)				**X**
RIO HONDO 100 YDS BELOW CONFLUENCE & R.Hondo blw Riverside on R.Hondo Land and Cattle property				**6/13**
Rio Ruidoso (Rio Bonito to US Hwy 70 Bridge)	**X**			
Rio Ruidoso 10 feet above WWTP outfall; RIO RUIDOSO BELOW NEW WWTP; Rio Ruidoso 7 miles blw WWTP at Glencoe FR 443; Rio Ruidoso 1 mi abv Rio Bonito at San Patricio	**See Table 8**			
Rio Ruidoso (US Hwy 70 Bridge to Mescalero Apache bnd)		**X**	**X**	
Rio Ruidoso at Mescalero boundary at gage; Rio Ruidoso at USGS gaging station at Hollywood; Rio Ruidoso .5 mile above WWTP at HWY 70 bridge		**14/36**	**See Table 5**	

Table 5. Summary of Thermograph Data.

Station Name	Data Collection Interval	WQS Criterion (°C)	Maximum Recorded Temperature (°C)	Total # of Data Points	# / % of Exceedence
CARRIZO CREEK ABOVE THE RIO RUIDOSO 57Carriz000.1	5/20/03-9/15/03	20	21.2	2835	9/0.3
RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S. 57RBonit061.1	5/20/03-9/17/03	20	22.9	2871	97/3.4
RIO BONITO AT ANGUS BRIDGE 57RBonit053.4	5/20/03-8/20/03	20	21.7	1591	38/2.4
Rio Bonito at BLM Apple Orchard Site 57RBonit027.7	5/20/03-9/15/03	30	21.0	2826	0/0
Rio Ruidoso at Mescalero boundary at gage 57RRuido052.4	5/20/03-9/16/03	20	25.1	2854	289/10.1
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD 57RRuido042.3	5/20/30-9/15/03	20	23.7	2830	185/6.5
Rio Ruidoso .5 mile abv WWTP, Hwy 70 bridge abv Seeping Springs 57RRuido031.5	5/20/03-9/16/03	20	23.7	2852	362/12.7
RIO RUIDOSO 7 MILES BELOW WWTP AT GLENCOE-FR 443 57RRuido019.8	5/20/03-9/16/03	30	19.6	2831	0/0
Rio Ruidoso at CR 16 Bridge near Hondo 57RRuido001.3	5/20/03-9/15/03	30	18.2	2829	0/0
RIO HONDO 100 YDS BELOW CONFLUENCE 57RHondo131.1	5/20/03-9/16/03	30	25.8	2851	0/0
Rio Hondo below Riverside on Rio Hondo Land and Cattle property 57RHondo105.8	5/20/03-9/16/03	30	30.1	2848	1/0.04

Table 6a. Summary of pH Data Collected from Sondes.

Station (Station ID)	Designated Use	Criterion SU	Deployment Dates (2003)	Min/Max SU	# / % of Exceedences	Magnitude Violation	Frequency Violation
Rio Ruidoso .5 mile abv WWTP, Hwy 70 bridge abv Seeping Springs	HQCWAL	6.6-8.8	9-11 Sep	7.76/8.34	0/0	No	No
Rio Ruidoso blw new WWTP, mile-marker 267.5, Hwy 70	HQCWAL	6.6-8.8	9-11 Sep	7.15/8.13	0/0	No	No

NOTES: HQCWAL = High Quality Coldwater Aquatic Life

Table 6b. Summary of DO Data Collected from Sondes.

Station (Station ID)	Designated Use	WQS Criterion (mg/L)	Deployment Dates (2003)	Min/Max Conc. (mg/L)	Min Sat. (% local)	Assessment Criterion	Combined Conc./Sat. Exceedences (# / % / >3 hrs)	% Sat Exceedences (# / % / >3 hrs)
Rio Ruidoso .5 mile abv WWTP, Hwy 70 bridge abv Seeping Springs	HQCWAL	6.0	9-11 Sep 2003	5.92/ 10.93	75.2	OLS	3/2.4/No	0/0/No
Rio Ruidoso blw new WWTP, mile-marker 267.5, Hwy 70	HQCWAL	6.0	9-11 Sep 2003	6.44/ 9.69	84.2	OLS	0/0/No	0/0/No

NOTES: HQCWAL = High Quality Coldwater Aquatic Life
OLS refers to Other Life Stages, as opposed to the more sensitive ELS, Early Life Stages

6.1.3 Stream Channel Morphology

Extensive stream morphology data, following the methods of Rosgen and Silvey (1996), was collected at 11 stations in the study area. This data is summarized in **Tables 7a and 7b**.

Table 7a. Site-specific stream channel morphology

Station Name	Watershed Area sq mi	X-Sectional Area sq ft	Channel Width ft	Mean Depth ft	Max Depth ft	Width/Depth Ratio	Flood Prone Width ft*	Entrenchment Ratio	Slope %	Sinuosity
CARRIZO CREEK ABOVE THE RIO RUIDOSO *	24.34	11.2	16	0.7	1.4	22.85	28	1.75	1.04	1.1
EAGLE CREEK AT USGS GAGE	8.14	11.52	15.78	0.73	1.4	2.62	30	1.90	2.17	1.12
RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO	26	13.9	14.3	1.0	1.5	14.8	183.7	12.8	1.73	1.0
RIO BONITO AT ANGUS BRIDGE	48.42	20.0	20.0	1.0	1.6	20	60.0	3.0	1.6	1.1
Rio Bonito at BLM Apple Orchard Site	223	30.6	21.5	1.4	2.1	15.1	92.0	4.3	0.87	1.1
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD	120	35.1	27	1.3	2.53	20.4	54.9	2.03	0.66	1.01
Rio Ruidoso at Mescalero boundary at gage	18	29.04	26.4	1.1	1.5	24	35.5	1.34	3.62	1.01
Rio Ruidoso .5 mile abv WWTP, Hwy 70 bridge abv Seeping Springs	184	39.26	30.2	1.3	2.6	23.23	144.5	4.78	0.81	1.2
Rio Ruidoso at CR 16 Bridge near Hondo	292.9	46.64	21.2	2.2	2.7	9.64	44	2.08	0.83	1.0
RIO HONDO 100 YDS BELOW CONFLUENCE	590.6	43.9	23.4	1.9	2.4	12.5	58	2.5	1	1.1
Rio Hondo below Riverside on Rio Hondo Land and Cattle property	881	74.4	27.3	2.7	3.42	10.0	48.9	1.79	0.44	1.0

* Flood Prone Width is that elevation on the flood plain equal to the elevation of the water surface at twice the mean depth at bank full.

Table 7b. Site-specific stream channel particle characteristics

Station Name	D84 mm	D50 mm	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Shaded	Stream Type
CARRIZO CREEK ABOVE THE RIO RUIDOSO	16	0.4	0.0	1.0	10.0	25.0	64.0	73.0	Bc 5
EAGLE CREEK AT USGS GAGE	119	30.2	0.0	2.0	31.0	44.0	23.0	--	B 4
RIO BONITO ABV BONITO LK AT FR 107 BLW BONITO S.	84	27	0	0	28	65	8	88	C4/ E4
Rio Bonito at BLM Apple Orchard Site	144	66.6	0	4	48	27	21	65	C4
RIO BONITO AT ANGUS BRIDGE	123	16	0	2.0	33.0	19.0	46.0	--	C 4
Rio Ruidoso at Mescalero boundary at gage	228	69.7	0	12	39	33	16	62	B3
RIO RUIDOSO AT USGS GAGING STATION AT HOLLYWOOD	77	7.6	0	3	18	36	43	45	Bc 4
Rio Ruidoso .5 mile abv WWTP, Hwy 70 bridge abv Seeping Springs	36	0.3	0	0	8	36	57	1	C 5
Rio Ruidoso blw new WWTP, mile-marker 267.5, Hwy 70	46	12.6	0	0	8	59	33	--	--
Rio Ruidoso at CR 16 Bridge near Hondo	146	0.3	0	3	32	12	54	84	Bc 5
RIO HONDO 100 YDS BELOW CONFLUENCE	74	13	0	2	17	43	37	27	C 4
Rio Hondo below Riverside on Rio Hondo Land and Cattle property	141	16	0	1	34	34	30	63	Bc 5

6.1.4 Periphyton Community and Nutrient Assessment

The periphyton community is a biological indicator that can express aquatic ecosystem health. The use of periphyton community data is still in early stages of development and does not provide conclusive information on stream health at this time. A Level 1 nutrient screen is performed at each survey station to determine if excess nutrients may be present in the reach. If necessary, a series of data is collected for the nutrient Level 2 survey to determine impairment status. Periphyton is collected for community composition analysis and for the quantification of chlorophyll *a* for this second level of nutrient assessments.

Table 8. Nutrient Assessments for the Rio Hondo Watershed

Assessment Unit Station (Station ID)	**Ecoregion – Aquatic Life Use**	**DO & pH – long term datasets**	**DO %Sat. – grab** (# and % of exceedences)	**pH – grab** (# and % of exceedences)	**DO conc – grab** (# and % of exceedences)	**Total Nitrogen** (# and % of exceedences)	**Total Phosphorus** (# and % of exceedences)	**Ash Free Dry Mass (µg/cm^2)**	**Chlorophyll a (µg/cm^2)**	**Nutrient Assessment**
Rio Ruidoso (Rio Bonito to US Hwy 70 bridge)	AZ/NM Mountains – Coldwater	**NS for D.O.** FS for pH	**6/35 = 17%**	0/35 = 0%	**6/35 = 17%**	**18/34 = 53%**	**13/34 = 38%**	**6653**	3.77	**NS**
Rio Ruidoso (US Hwy 70 bridge to Mescalero Apache bnd)	AZ/NM Mountains – Coldwater	FS for D.O. and pH	**11/42 = 26%**	0/42 = 0%	0/42 = 0%%	3/38 = 8%	1/38 = 3%	**7623**	0.33	FS
Carrizo Creek (Rio Ruidoso to Mescalero Apache bnd)	AZ/NM Mountains - Coldwater	N/A	0/16 = 0%	0/16 = 0%	0/16 = 0%	0/16 = 0%	0/16 = 0%	N/A	N/A	FS
Rio Ruidoso (North Fork abv Mescalero Apache bnd)	AZ/NM Mountains - Coldwater	N/A	0/3 = 0%	0/3 = 0%	0/3 = 0%	**2/3 = 67%**	0/3 = 0%	N/A	N/A	FS
Rio Bonito (Rio Ruidoso to NM 48 near Angus)	AZ/NM Mountains - Coldwater	N/A	1/9 = 11%	0/9 = 0%	0/9 = 0%	0/8 = 0%	0/8 = 0%	N/A	N/A	FS
Rio Bonito (NM 48 near Angus to headwaters)	AZ/NM Mountains - Coldwater	N/A	1/12 = 8%	0/12 = 0%	**2/12 = 17%**	1/12 = 8%	1/12 = 8%	N/A	N/A	FS
Rio Hondo (Perennial reaches Bonney Canyon to Rio Ruidoso)	Southwestern Tablelands – Coldwater	N/A	6/16 = 38%	0/16 = 0%	0/16 = 0%	0/16 = 0%	0/16 = 0%	N/A	N/A	FS

NOTES: **Bolded Cells** indicate parameters that exceed the threshold value
FS = Fully Supporting (i.e. not impaired)
NS = Not Supporting (i.e. impaired)
µg/cm^2 = micrograms per cubed centimeter

Nutrient Level 2 Assessment

Level 2 nutrient surveys were conducted at sites that were previously listed as impaired due to plant nutrients or that the Level 1 nutrient screening indicated the possibility of nutrient impairment. The Level 2 nutrient survey consists of collecting total phosphorus, total nitrogen, dissolved oxygen, pH, and periphyton chlorophyll *a* data. Chlorophyll *a* is a quantitative measure of algal biomass which is the cause of most problems associated with nutrient impairment. The indicators are compared to the applicable criterion or threshold values to generate an exceedence ratio, or the number of exceedences divided by the total number of times the parameter was measured (**Table 8**). For the Rio Hondo watershed, the threshold value for chlorophyll *a* depends on the ecoregion and designated aquatic life use, whereas the threshold values for total phosphorus and total nitrogen depend on segment-specific criteria.

6.2 Biological Data Collection and Assessment

6.2.1 Macroinvertebrate Community

The macroinvertebrate community is generally the first to show a response to certain stressors such as excess fine sediment. By collecting data on the macroinvertebrate communities that are present in a stream reach SWQB can identify changes that may impair the community. This was done by utilizing the Rapid Bioassessment Protocol (RBP) approach (Plafkin et. al 1989, Barbour et. al 1999). Biological assessment, or degree of impairment, is determined as a percentage comparison of the sum of selected metric scores at the study site to a reference site. For example, a study site achieving a biological assessment score greater than 83 percent of the reference site would be deemed non-impaired (full-support). If the score is less than 79 percent of the reference site, it can be concluded that there is stress on that community and it would be deemed impaired (i.e. non-support) (**Table 9**). **Table 10** provides the results of this biological assessment of the macroinvertebrate community from six sites in this study.

6.2.2 Fish Community Data

The characteristics and habits of fish can be correlated with physical habitat to provide information about how conditions may be impacting the fish community. Fish community data are collected for one or more of the following reasons:

- Development and/or refinement of water quality standards, particularly for designated aquatic life uses and/or temperature criteria.
- Development of fish-based biocriteria and/or bioassessment procedures. Once fish-based bioassessment procedures have been developed, fish community data will then be used as a basis for bioassessment.
- To document and characterize a given water's fish community for comparison with future or past records.

Fish were collected at four stations on two dates in 2003. On 15 September, fish were collected from the Rio Bonito at the BLM Apple Orchard and from the Rio Ruidoso above the confluence with the Rio Bonito. On 16 September, collections were made from the Rio Hondo at Riverside and the Rio Ruidoso above the US 70 bridge.

At all of these locations, specific conductivity ranged from 1476 to 1951 µS/cm. The effectiveness of the Smith-Root 12-B electrofisher that was used for these collections becomes limited at around 1500 µS/cm and above. Thus, many fish escaped capture at these locations. Nevertheless, as the conductivity was similar at all locations, there is a reasonable basis for comparison, at least within these four stations, if not with other locations with similar conductivities.

All of the locations were dominated by native fish species (longnose dace, Rio Grande chub, and white sucker), with only a few nonnative species (**Table 11 & 12**). Of the nonnatives, almost all were salmonids (brown and rainbow trout) and these represented the only cold water species present. All other fishes collected were cool water species, which is consistent with expectations given the elevation (1454 – 1845 m) and other characteristics of the stream locations sampled.

Table 9. Biological Integrity Attainment Matrix using the RBP Index

% Comparison to Reference Site(s)	Biological Condition Category [2]	Attributes [1]
>83%	Non-impaired (Full Support)	Comparable to best situation to be expected within ecoregion (watershed reference site). Balanced trophic structure. Optimum community structure (composition & dominance) for stream size and habitat quality.
79 – 54%	Slightly Impaired (Non Support)	Community structure less than expected. Composition (species richness) lower than expected due to loss of some intolerant forms. Percent contribution of tolerant forms increases.
50– 21%	Moderately Impaired (Non Support)	Fewer species due to loss of most intolerant forms. Reduction in EPT index.
<17	Severely Impaired (Non Support)	Few species present. Densities of organisms dominated by one or two taxa.

[1] RBP Index, percentages, and biological attributes are taken from Plafkin *et al.,* 1989. Percentage values obtained that are in between the above ranges will require best professional judgment as to the correct placement.

[2] New Mexico has combined all but the "non-impaired" category into "Non Support" per USEPA Region 6 suggestion.

Table 10. Macroinvertebrate biological evaluations

Station	Biological condition score	% of reference	Biological Assessment
RIO BONITO ABV BONITO LK AT FR 107	**32**	55%	Non-support
Rio Bonito at BLM Apple Orchard Site*	**42**	100%	Full-support
Rio Ruidoso at Mescalero boundary at gage*	**58**	100%	Full-support
Rio Ruidoso 1 mi abv Rio Bonito at San Patricio	**50**	86%	Full-support
RIO HONDO 100 YDS BELOW CONFLUENCE	**50**	86%	Full-support
R.Hondo blw Riverside on R.Hondo Land and Cattle property	**42**	72%	Non-support

* These stations were determined to be reference sites.

Table 11. Characteristics of Fish Species found in the Rio Hondo watershed, 2003

Species	Common Name	Native	Temperature	Gravel Spawner	Feeding Guild	Water Quality Tolerance
Catostomus commersoni	White sucker	Yes	Cool	Yes	Omnivore	Tolerant
Catostomus (Pantosteus) plebeius	Rio Grande sucker	No	Cool	Yes	Omnivore	Intermediate
Gila pandora	Rio Grande chub	Yes	Cool	Unknown	Insectivore	Intermediate
Oncorhynchus mykiss	Rainbow trout	No	Cold	Yes	Insectivore, Piscivore	Sensitive
Rhinichthys cataractae	Longnose dace	Yes	Cool	Yes	Insectivore	Intermediate
Salmo trutta	Brown trout	No	Cold	Yes	Insectivore, Piscivore	Sensitive

Table 12. Fish Community Data from the Rio Hondo watershed, 2003

Station:			Rio Bonito @ BLM apple orchard	Rio Hondo @ Riverside	Rio Ruidoso abv Rio Bonito	Rio Ruidoso abv US 70 bridge
Scientific name	**Common name**	**Temperature**				
Catostomus commersoni	White sucker	Cool	0	2	3	0
Catostomus (Pantosteus) plebeius	Rio Grande sucker	Cool	3	0	0	0
Gila pandora	Rio Grande chub	Cool	110	42	30	21
Oncorhynchus mykiss	Rainbow trout	Cold	3	0	0	0
Rhinichthys cataractae	Longnose dace	Cool	80	53	1	24
Salmo trutta	Brown trout	Cold	0	0	0	4
		No. of Individuals	196	97	34	49
		Total No. of Taxa	4	3	3	3
		% Native	97	100	100	92
		% Non-native	3	0	0	8
		% Cold water	2	0	0	8
		% Cool water	98	100	100	92
		% Warm water	0	0	0	0

7.0 DISCUSSION

A summary of the status for each designated uses for this watershed, based on the results of this survey, is provided in **Table 13**. Existing Total Maximum Daily Loads (TMDLs) for the Rio Hondo Watershed are listed in **Table 14**.

Table 13. Summary of 2006-2008 Integrated List.

Assessment Unit	Domestic Water Supply	Coldwater Fishery	H Q Cold Water Fishery	Irrigation	Livestock Watering	Municipal Water Supply	Secondary Contact	Wildlife Habitat	Warmwater Fishery
Eagle Creek (Alto Reservoir to Mescalero Apache bnd)	FS	--	NS	FS	FS	FS	NA	FS	--
Carrizo Creek (Rio Ruidoso to Mescalero Apache bnd)	FS	--	FS	FS	NA	FS	NS	FS	--
Rio Bonito (Angus Canyon to headwaters)	FS	--	NS	FS	FS	FS	NS	FS	--
Rio Ruidoso (North Fork abv Mescalero Apache bnd)	FS	--	FS	FS	FS	FS	NA	FS	--
Rio Bonito (Rio Ruidoso to Angus Canyon)	--	NS	--	FS	FS	--	FS	FS	FS
Rio Ruidoso (Rio Bonito to US Hwy 70 Bridge)	--	NS	--	FS	FS	--	FS	FS	--
Rio Ruidoso (US Hwy 70 Bridge to Mescalero Apache bnd)	FS	--	NS	FS	FS	FS	FS	FS	--
Rio Hondo (Perennial reaches Pecos R to Rio Ruidoso)	--	FS	--	FS	FS	--	NS	FS	--

FS: Full Support; NS: Non-Support; NA: Not Assessed, --: Not Applicable

Table 14. TMDLs for the Rio Hondo Watershed.

Waterbody	Watershed	Pollutant TMDL	Status
Carrizo Creek	Lower Pecos River	Bacteria	*Rio Hondo TMLDs* WQCC Approved 12-14-05 EPA Approved 2-10-06
Rio Ruidoso	Lower Pecos River	Plant Nutrients, Temperature and Turbidity	
Rio Hondo	Lower Pecos River	Bacteria	
Rio Bonito	Lower Pecos River	Bacteria	

Due to the large volume of data collected during this survey, it will not be included in this report. A complete dataset or data from a specific site can be obtained by searching EPA's STORET/WQX database at: http://www.epa.gov/STORET/ or by contacting the Surface Water Quality Bureau.

Sampling for major ions, nutrients, total and dissolved metals, radionuclides, organics, biological indicators (bacteria, aquatic invertebrates, algae/periphyton and fish) and field parameters found exceedences attributable variously to plant nutrients, turbidity, temperature, and bacteria at a number of stations. Of these, the most ecologically significant are the effects of plant nutrients and temperature.

Nutrient inputs, largely attributable to the Ruidoso WWTP (NPDES Permit no. NM0029165), generate large blooms of nuisance algae. These blooms are frequently extensive enough to interfere with the operation of irrigation headgates. In an effort to mitigate these anthropogenic algal blooms, a segment specific numeric criterion of 0.1 mg/L was established for phosphorus in WQ segment 20.6.4.208 NMAC. One assessment unit on the Rio Ruidoso, Rio Ruidoso (Rio Bonito to US Hwy 70 Bridge), was determined to exceed the plant nutrients criterion. Consequently TMDLs for total phosphorus and total nitrogen were developed for that reach (see **Table 14**). It is unlikely that these target loads can be met, however, until the Village of Ruidoso completes construction of a major upgrade to its WWTP which is currently underway.

Elevated water temperature not only stresses aquatic communities directly by increasing the metabolic rates of fish, particularly salmonids, thereby increasing food requirements; but indirectly, by decreasing oxygen saturation. One assessment unit on the Rio Ruidoso, Rio Ruidoso (US Hwy 70 bridge to Mescalero Boundary), was determined to exceed the temperature criterion. Consequently a TMDL for temperature was developed for that reach (see **Table 14**).

Fecal coliform data showed several exceedences of the secondary contact use criterion for several assessment units. These data were combined with other sources of data to determine overall impairment for these assessment units. As a result, three assessment units in the Rio Hondo watershed were listed on the 2006-2008 Integrated CWA §303(d)/§305(b) list (NMED/SWQB 2006a) with fecal coliform as the pollutant of concern (see **Table 13**). Presence of fecal coliform bacteria is an indicator of the presence of other pathogens that may present human health concerns.

Finally, one segment of the Rio Ruidoso, Rio Ruidoso (US Hwy 70 bridge to Mescalero Boundary), was determined to exceed the turbidity criterion then in place. A TMDL has been prepared to address this issue (see **Table 14**). Turbidity impacts the aquatic environment in several ways: by attenuating insolation, thereby limiting primary production and truncating the base of the food web; sediments causing turbidity (Total Suspended Solids), and associated bedload, can settle to the substrate restricting the habitat available for aquatic invertebrates and periphyton.

8.0 REFERENCES

Barker, J.M., B.S. Kues, G.S. Austin, and S.G. Lucas, 1991. *Geology of the Sierra Blanca, Sacramento, and Capitan Ranges, New Mexico-NMGS 42nd Annual Field Conference*, New Mexico Geological Society, Socorro, New Mexico.

Barbour, Michael T., Jeroen Gerritsen, Blain D. Snyder and James B. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish*. Second Edition. EPA 841/B-99002. Office of Water, Washington, DC. http://www.epa.gov/bioindicators/html/rbps.html

New Mexico Administrative Code (NMAC). 2006. *State of New Mexico Standards for Interstate and Intrastate Surface Waters*. 20.6.4. New Mexico Water Quality Control Commission. February 16. http://www.nmcpr.state.nm.us/nmac/parts/title20/20.006.0004.pdf

New Mexico Environment Department Surface Water Quality Bureau (NMED/SWQB). *Quality Assurance Project Plan for Water Quality Management Programs*, 2003 (QAPP).

New Mexico Environment Department Surface Water Quality Bureau (NMED/SWQB). 2006a. *Integrated Clean Water Act §303(d)/ §305(b) Report*. Santa Fe, NM. http://www.nmenv.state.nm.us/swqb/303d-305b/2006-2008/

New Mexico Environment Department - Surface Water Quality Bureau (NMED/SWQB). 2006b. State of New Mexico *Procedures for Assessing Standards Attainment for the Integrated §303(d)/§ 305(b) Water Quality Monitoring and Assessment Report* (Assessment Protocols). http://www.nmenv.state.nm.us/swqb/protocols/index.html

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughs. 1989. *Rapid bioassessment protocols for use in streams and rivers.* USEPA. Office of Water Regulations and Standards. EPA/444/4-89-001. Washington, D.C

Rosgen, D. and Hilton Lee Silvey. 1996. *Applied River Morphology*. Printed Media Companies, Minneapolis, Minnesota.

Smolka, L.R., 1999. Special Water Quality Survey of the Rio Bonito and Rio Hondo, Lincoln County, NM, April 14 – October 9, 1997. Pp. 1 – 36. *In* Intensive Water Quality Stream Surveys, 1997. NMED/SWQ-99/1 90 p.

Smolka, L.R., 1995. Special Water Quality Survey of the Rio Ruidoso, Lincoln County, NM, February 15 – September 22, 1993, pp115-151. *In* Intensive Water Quality Stream Surveys, 1993. NMED/SWQ-95/1. 154 pp.

Appendix: Geology and History of the Rio Hondo Watershed

The geology of the Rio Hondo watershed consists of a complex distribution of Cretaceous intrusive rocks, Permian sedimentary rocks, and Cretaceous sedimentary rocks (Table A.1, Figure A.1). The high dome of Sierra Blanca is an intrusion of Tertiary igneous rocks associated with many nearby faults and dikes (Chronic 1987). Sierra Blanca is separated from the smaller Tertiary intrusions of the Carrizo and Capitan Mountains by the valley of soft, Cretaceous shale around its north end (Chronic 1987). The Cenozoic igneous rocks of Sierra Blanca and the northwestern part of the Mescalero Apache Reservation include intrusive plugs, stocks, and dikes of the Sierra Blanca volcanic pile (Ahlen and Hanson 1986). Breccias and purplish-green porphyrys are commonly exposed on Sierra Blanca towards the Ski Area on Sierra Blanca Peak. Cenozoic rocks are also exposed on Sierra Blanca including igneous intrusive, volcanic, and sedimentary rocks. There are also glacial deposits in the cirque on the northeast slopes of the Peak at the head of the North Fork of the Rio Ruidoso (Ahlen and Hanson 1986). San Andres Limestone forms the surface between Tularosa and Ruidoso; the stream valleys in this watershed cut down into the red and yellow soil zone of the Yeso Formation (Chronic 1987). Cub Mountain Formation consists of white sandstone, multicolored siltstone, and light-colored igneous rocks (Ash and Davis 1964). The Yeso formation consists of beds of siltstone, sandstone, shale, limestone, anhydrite, gypsum, and salt and does not readily transmit water (Mourant 1963). The Yeso Formation was formed by the precipitation of gypsum and salt from an evaporating inland sea (Chronic 1987). The San Andres Limestone forms the aquifer for Roswell's water (Chronic 1987). The upper part of the San Andres Limestone consists of dolomite and chert-limestone, as well as siltstone, sandstone, gypsum, anhydrite, and shale. The Artesia Formation consists of similar sedimentary rocks (Mourant 1963). The Cretaceous Dakota Sandstone consists of quartzose sandstone interbedded with grey shale and conglomerate (Mourant 1963). Mancos Shale is black shale, limestone and sandstone while the Mesaverde Formation is grey, yellow, and buff quartzose sandstone, grey shale, and coal (Mourant 1963).

Mining activity in Lincoln County has produced a number of minerals and metals including: gold, coal, iron, lead, copper, zinc, fluorite, gypsum, tungsten, and bastnaesite (Griswold 1959). Spaniards likely performed the earliest mining in Lincoln County, but no evidence of their activity exists. However, the first mining in Lincoln County by Americans appears to be a gold vein at the Helen Rae and American mines in 1868 (Griswold 1959).

Three Rivers Petroglyphs (west of Sierra Blanca) is a mile-long display of pictures carved into the volcanic rock mostly made by prehistoric Native Americans and may be contemporary with the nearby Mimbres site dating from 900-1,000 A.D. (Ash and Davis 1964). Hale Springs (south of Ruidoso Downs) once fed a Native American irrigation ditch and the caliche formed in this ditch is used to line the driveways in the area (Ash and Davis 1964). One of the first battles of the Lincoln County War occurred at Blazer's Mill (southwest of Ruidoso) on April 5, 1878 when Billy the Kid and the McSween faction attempted to make an arrest (Ash and Davis 1964). The 116-mile Bonito pipeline built in 1908 supplied water for railroad and domestic use from Nogal Lake (Ash and Davis 1964). Bonito Lake was built in the 1930's to store the water from Nogal Lake when the first lake started leaking (Barker *et al.* 1991). As a cub, Smokey the Bear was rescued from a forest fire in Capitan Gap in 1950, nursed back to health, and flown to Washington, D.C. to become the mascot for the U.S. Forest Service's fire prevention program (Ash and Davis 1964).

Table A.1 Geologic Unit Definitions for the Rio Hondo

Geologic Unit Code	Description
Kd	Dakota Sandstone; includes Oak Canyon, Cubero, and Paguate Tongues plus Clay Mesa Tongue of Mancos Shale; Cenomanian.
Km	Mancos Shale; divided into Upper and Lower parts by Gallup Sandstone
Kmv	Mesaverde Group includes the Gallup Sandstone, Crevasse Canyon Formation, Point Lookout Sandstone, Menelee Formation, and Cliff House Sandstone
Pal	Lower part of the Abo Formation
Pat	Artesia Group; shelf facies forming broad south-southeast trending outcrop from Glorieta to Artesia area; includes Grayburg, Queen, Seven Rivers, Yates, and Tansill Formations; Guadalupian. May locally include Moenkopi Formation (Triassic) on top.
Psa	San Andres Formation; limestone and dolomite with minor shale; Guadalupian in south, in part Leonardian to north.
Py	Yeso Formation; sandstones, siltstones, anhydrite, gypsum, halite, and dolomite; Leonardian.
QTp	Older piedmont alluvial deposits and shallow basin till; includes Quemado formation and in northeast, high level piedmont gravels.
Qal	Alluvium, middle and upper Quaternary.
TKi	Paleogene and Upper Cretaceous intrusive rocks; includes Hanover, Fierra, Tyrone, and Lordsburg granediorite-quartz manzonile porphyries.
TR	Triassic rocks, general.
Tbc	Tertiary sediments, including Baca Formation and Cub Mountain Formation
Tvl	Tertiary volcanics
pC	Precambrian rocks, undifferentiated.

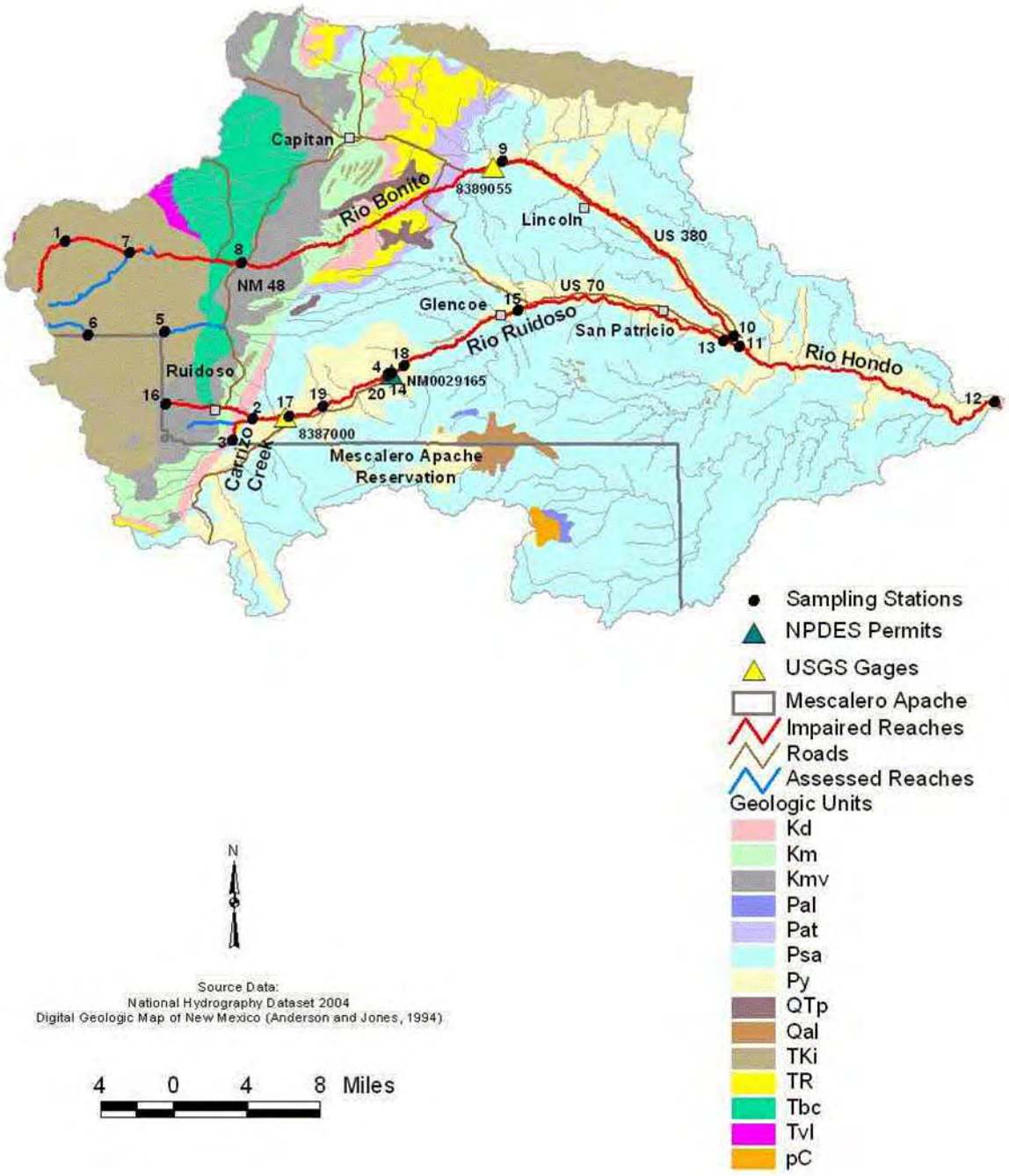

Figure A.1. Rio Hondo Watershed Geology

REFERENCES

Ahlen, J.L, and M.E. Hanson, 1986. *Southwest Section of AAPG Transactions and Guidebook of 1986 Convention, Ruidoso, New Mexico*. New Mexico Institute of Mining and Technology, Socorro, NM.

Ash, S.R, and L.V. Davis, 1964. *Guidebook of the Fifteenth Field Conference-Ruidoso Country.* New Mexico Geological Society, Socorro New Mexico.

Barker, J.M., B.S. Kues, G.S. Austin, and S.G. Lucas, 1991. *Geology of the Sierra Blanca, Sacramento, and Capitan Ranges, New Mexico-NMGS 42nd Annual Field Conference*, New Mexico Geological Society, Socorro, New Mexico.

Chronic, Halka. 1987. *Roadside Geology of New Mexico*. Mountain Press Publishing Company, Missoula.

Griswold, G.B. 1959. *Mineral Deposits of Lincoln County, New Mexico*. New Mexico Institute of Mining and Technology, Socorro, NM.

Mourant, W.A., 1963. *Water Resources and Geology of the Rio Hondo Drainage Basin, Chaves, Lincoln, and Otero Counties, New Mexico*. New Mexico State Engineer, Santa Fe, NM.