NMED/SWQ-07/2

WATER QUALITY ASSESSMENT'S FOR SELECTED NEW MEXICO LAKES

2001

Monitoring and Assessment Section
Surface Water Quality Bureau
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LAKE WATER QUALITY MONITORING, TROPHIC STATE EVALUATION, AND STANDARDS ASSESSMENTS FOR:

McAllister Lake, Storrie Lake, Santa Rosa Reservoir and Blue Hole.

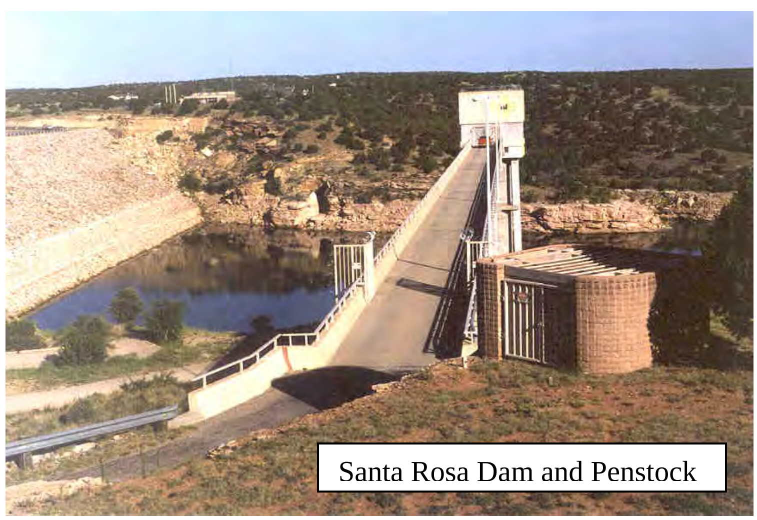
2001

EXECUTIVE SUMMARY

Water quality surveys and assessments were completed in fulfillment of work-plan commitments of the *FY 2000-2001 section 106 Work Program for Water Quality Management.* This program was partially funded by a grant from the U.S. Environmental Protection Agency.

Blue Hole

During 2001 the Surveillance and Standards Section (now Monitoring and Assessment) of the Surface Water Quality Bureau of the New Mexico Environment Department conducted water quality and biological assessment surveys of four lacustrine systems. McAllister Lake, Storrie Lake and Santa Rosa Reservoir were studied concurrently with an intensive Total Maximum Daily Load (TMDL) stream study conducted within the Pecos River watershed. Studying lakes in this way helps to insure a timely return to the lake system as watersheds are revisited, and also add to the understanding of surface waters within the drainage basin. Blue Hole is a sink hole located within the City of Santa Rosa, and was chosen for study because this agency had never conducted an intensive water quality sampling effort of this unique surface water and because numerous uses exist at this waterbody, which require understanding and protection.



Santa Rosa Dam and Penstock

Water quality sampling methods were in accordance with the "Quality Assurance Project Plan for Water Quality Management Programs" (NMED 2001).

The following assessments provide information pertaining to water quality, biological

integrity, trophic state, limiting nutrients, water quality criteria exceedences and water quality standards specific to existing, attainable or designated uses in the State of New Mexico Standards for Interstate and Intrastate Surface Waters (NMAC 2006).

Storrie Lake toward the snow-capped Sangre de Cristo Mountains. Photo by Maureen Wilks.

Water chemistry sampling at lake stations include total and dissolved nutrients, total and dissolved metals, major ions including TDS, hardness and alkalinity, radionuclides, organic scans, cyanide, and microbiological collections. Phytoplankton and benthic diatom samples were collected for analysis. The following assessments do not include all data results, except for those specifically related to general physical nature, trophic state, limiting nutrient or criteria exceedances and consequent standards violations resulting in non-support of a use or uses. All data are available upon request.

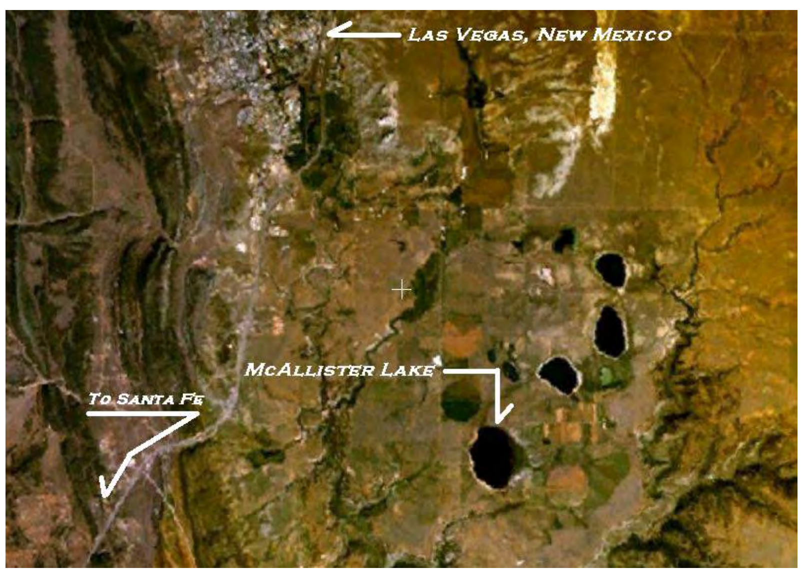
TABLE OF CONTENTS

LAKE SURVEYS

Water Quality and Biological Assessment Survey of McAllister Lake, San Miguel County, March 27, June 26, and October 23, 2001. Danny R. Davis, Principal Investigator

McAllister Lake is a natural playa lake depression that receives water from springs beneath the lake and from water diverted from the Storrie Irrigation Project. The lake is located in north-central New Mexico within the boundaries of the Las Vegas National Wildlife Refuge, and approximately 16 km (10 mi) from the city of Las Vegas, New Mexico. As a natural closed basin playa lake, its immediate watershed is very small suggesting that what flows into this basin, stays in this basin. This lake was one of four lacustrine systems chosen for study to coincide with a watershed study of the Upper Pecos River. Studying lakes located within a watershed assists in insuring that timely return to these systems occurs allowing for periodic checks for use attainment.

Maximum storage capacity is 1,363 acre-feet at a corresponding elevation of 1,954 meters (6,412 ft) above mean sea level. The Lake is located within the Arizona/New Mexico Plateau ecoregion contained within Aggregate Ecoregion III (the Xeric West) (Omernik, 1987) and receives an average of 43 cm (16.92 in.) of precipitation per year. Pan evaporation historically averages 84 cm (33.2 in) per year resulting in a deficit of 42 cm (16.58 in) per year. Water quality standards for McAllister Lake are set forth in section 20.6.4.213 of the *New Mexico Standards for Interstate and Intrastate Surface Waters* (NMAC 2006), where designated uses of coldwater aquatic life, secondary contact, livestock watering and wildlife habitat are recognized. The principal fish species present is rainbow trout which are stocked by the New Mexico Department of Game and Fish who manages the lake.



During 1991, the Surface Water Quality Bureau conducted an intensive, multiseasonal survey of McAllister Lake. While water chemistry results from this study resulted in no exceedences of chemistry criteria, high pH, un-ionized ammonia and low dissolved oxygen during some visits indicated high nutrient load. This assessment resulted in non-attainment of the coldwater fishery use. However, oxygen depletions resulting in extensive fish kills had been common in the past suggesting that the wildlife habitat use may greatly contribute to the nutrient contribution in the lake, with consequent impacts to the fishery use. As concluded by Hopkins (1992), "given the lake's dual function as both a fishery and waterfowl habitat, the current situation represents a viable compromise."

McAllister Lake is located within the boundaries of the Las Vegas National Wildlife Refuge, which is managed by the U.S. Fish and Wildlife Service, and is the one lake within the refuge where the public may recreate during the warmer months. The lake is closed to the public during the winter season which corresponds to the presence of migratory waterfowl such as Canada geese, Sandhill Cranes, numerous species of ducks and wintering bald eagles.

Table 1A. Physical Characteristics for McAllister Lake, 2001

Physical Characteristics	Deep Station		Shallow Station	
Secchi (m)	Sp	0.80	Sp	0.75
	Su	3.40	Su	3.40
	Fall	1.95	Fall	1.25
Forel Ule Color	Sp	16	Sp	14
	Su	10	Su	10
	Fall	13	Fall	15
Maximum Depth (m)	Sp	5.6	Sp	3.7
	Su	4.7	Su	4.3
	Fall	4.9	Fall	2.95
Euphotic Zone (m)	Sp	2.2	Sp	2.2
	Su	>4.7	Su	>4.3
	Fall	>4.9	Fall	>2.95
Surface Area (Acres)	Sp	Max 152	Sp	Max 152
	Su	Max 152	Su	Max 152
	Fall	Max 152	Fall	Max 152
Storage Capacity (Ac. Ft.)	Sp	Max 1,363	Sp	Max 1,363
	Su	Max 1,363	Su	Max 1,363
	Fall	Max 1,363	Fall	Max 1,363

Table 1A. con't.

Physical Characteristics	Deep Station		Shallow Station	
Anoxic Hypolimnion (Y/N)	Sp	No	Sp	No
	Su	No	Su	No
	Fall	No	Fall	No
Stratified (Y/N) @ depth (m)	Sp	No	Sp	No
	Su	No	Su	No
	Fall	No	Fall	No
pH (s.u.)	Sp	8.18	Sp	8.36
	Su	8.18	Su	8.34
	Fall	8.0	Fall	8.21
Conductivity (μS)	Sp	4270	Sp	4270
	Su	3954	Su	3938
	Fall	4393	Fall	4390
Turbidity (NTUs)	Sp	9.62	Sp	9.57
	Su	1.58	Su	1.28
	Fall	3.58	Fall	5.52
Integrated Sample surface to (m)	Sp	3.5	Sp	2.5
	Su	4.0	Su	4.0
	Fall	4.5	Fall	2.0
Dissolved Oxygen Surface (mg/L)	Sp	8.8	Sp	8.5
	Su	7.58	Su	7.60
	Fall	6.39	Fall	7.3
Dissolved Oxygen Bottom (mg/L)	Sp	8.5	Sp	7.9
	Su	7.69	Su	7.41
	Fall	6.36	Fall	7.1
Temperature Surface (°C)	Sp	8.2	Sp	9.1
	Su	20.6	Su	20.3
	Fall	12.0	Fall	12.3
Temperature Bottom (°C)	Sp	8.2	Sp	8.4
	Su	20.6	Su	20.2
	Fall	12.0	Fall	12.1
Chlorophyll *a* (μg/L)	Sp	22.1	Sp	23.55
	Su	2.80	Su	3.92
	Fall	22.99	Fall	29.90

Sp = Spring; Su = Summer; MDP = missing data point; (Q) = questionable result.

Table 2A. Trophic State for McAllister Lake, 2001 (Carlson, 1977)

Trophic State Indices	Deep Station		Shallow Station	
Secchi depth	Sp	Eutrophic	Sp	Eutrophic
	Su	Mesotrophic	Su	Mesotrophic
	Fall	Eutrophic	Fall	Eutrophic
Chlorophyll *a*	Sp	Eutrophic	Sp	Eutrophic
	Su	Mesotrophic	Su	Mesotrophic
	Fall	Eutrophic	Fall	Eutrophic
Total Phosphorus	Sp	Oligotrophic	Sp	Oligotrophic
	Su	Oligotrophic	Su	Oligotrophic
	Fall	Oligotrophic	Fall	Oligotrophic
Total Nitrogen	Sp	Eutrophic	Sp	Eutrophic
	Su	Eutrophic	Su	Eutrophic
	Fall	Eutrophic	Fall	Eutrophic
Overall Trophic Condition	**Oligomesotrophic**			

Table 3A.

Nitrogen (N) /Phosphorus (P) Ratio	Deep Station		Shallow Station	
Limiting Nutrient	Sp	P	Sp	P
	Su	P	Su	P
	Fall	P	Fall	P

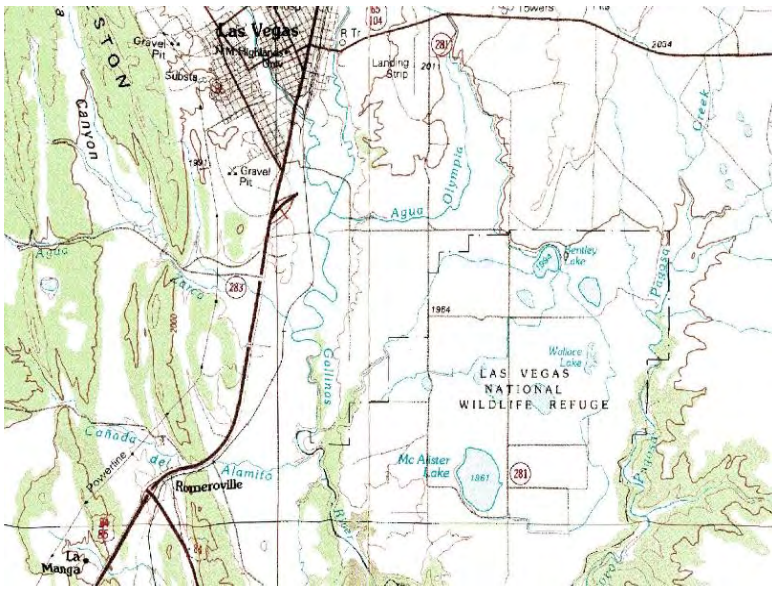
Table 4A.

Designated or Existing Use	Criteria Exceedence	Attainment Status
Coldwater Fishery	None	Fully Supporting
Wildlife Habitat	None	Fully Supporting
Secondary Contact	None	Fully Supporting
Livestock Watering	None	Fully Supporting
Human Health Criteria	4/6 (Arsenic)	Not Supporting

Water Quality Assessment

Physical characteristics of McAllister Lake were measured and are listed in Table 1A. Table 2A shows the trophic state variation observed both seasonally and between stations for Secchi depth, chlorophyll *a*, total phosphorus, and total nitrogen. The overall trophic condition of McAllister Lake in 2001, according to Carlson (1977) and Likens (1975), is oligomesotrophic with phosphorus being limiting during all seasons and at both sampling stations (Tables 2A and 3A).

Phytoplankton community composition consisted mostly of members of the Cryptophyta during the spring visit, the Chlorophyta during the summer run, and the Pyrophyta during the fall visit. Benthic diatom community composition consisted of 21 species in the formal count with an added nine genera identified totaling 30 species. Diversity according to Shannon-Weaver (1949) was high with *Staurosirella pinnata* and *Cocconeis placentula* var. *lineata* making up about 37 percent of the total diatom community.

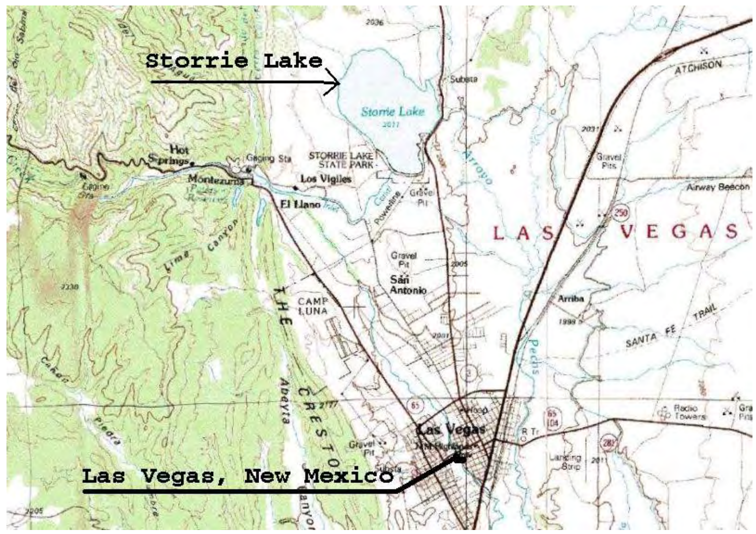


Lake chemistry sampling consisted of total, dissolved and calculated nutrients, anions and cations, total and dissolved heavy metals, synthetic organics, radionuclides, and cyanide, which cover all standards criteria pertinent to the protection of all designated uses. These data are available upon request, though any criteria exceedences are listed in Table 4A and discussed below.

McAllister Lake did not experience stratification during any of the sampling visits nor was anoxic hypolimnetic conditions observed. Physical parameters for dissolved oxygen, temperature and pH were within criteria limits for applicable uses designated for McAllister Lake. All water chemistry results for nutrients, heavy metals, organics, radionuclides, and cyanide were well below levels except for arsenic. In the case of arsenic in water samples collected during the study, two out of three composite samples from both the deep and shallow stations exceeded the 9 μg/L (ppb) human health criteria. Results from the summer and fall deep station samples were 11 and 17 ppb, and shallow station summer and fall results were 9 and 20 ppb. It is believed that the presence of arsenic as a product of the natural geology of the area, but due to possible bioaccumulation potential in the resident trout populations, further investigation into this matter is strongly advised.

Water Quality and Biological Assessment Survey of Storrie Lake, San Miguel County, March 27, June 26, and October 23, 2001.
Danny R. Davis, Principal Investigator

Storrie Lake is located in north-central New Mexico approximately 6.5 km (4 miles) north of the city of Las Vegas, New Mexico, and was chosen to study concurrently with a major Pecos River, Total Maximum Daily Load (TMDL) intensive watershed study. Associated with the lake is the Storrie Lake State Park which was completed in 1960, and provides year-round public camping, fishing and boating. The earthen dam was completed in 1921 and soon after was purchased by the Las Vegas Land and Water Company. Presently, water in storage is owned and managed by the Storrie Project Water Users Association. Water supplying the reservoir is carried by canal from the Gallinas River. During a prolonged drought which occurred between 1988 through 1990, and agreement was reached between the Storrie Project and the nearby city of Las Vegas where 400 acre-feet of water storage was purchased by the city to subsidize the community's water supply (Davis, 1991).



The Reservoir is located on the edges of the Southern Rockies and Arizona/New Mexico Plateau ecoregions contained within Aggregate Ecoregion III (the Xeric West) (Omernik, 1987) and receives an average of 41 cm (16 in.) of precipitation per year with pan evaporation averaging 84 cm (33.2 in.) resulting in a water deficit of about 42 cm (16.6 in.) (Gabin and Lesperance, 1977).

Storrie Lake State Park manages the recreational activities and provides an interpretive visitor's center. One boat ramp is provided for recreational boating access, and for those interested in fishing, principal fish species consist of rainbow trout, crappie, and catfish. Water quality standards for Storrie Lake are set forth in section 20.6.4.214 of the *New Mexico Standards for Interstate and Intrastate Surface Waters* (NMAC 2006), where uses of coldwater aquatic life, warmwater aquatic life, primary contact, livestock watering, wildlife habitat, municipal water supply and irrigation storage are protected. Two stations were sampled during the spring, summer, and fall seasons: the deep station near the dam and the shallow station about 50 meters off the western shore.

Table 1B. Physical Characteristics for Storrie Lake, 2001.

Physical Characteristics	Deep Station		Shallow Station	
Secchi (m)	Sp	0.70	Sp	0.55
	Su	0.60	Su	0.20
	Fall	0.70	Fall	0.50
Forel Ule Color	Sp	9	Sp	10
	Su	6	Su	5
	Fall	12	Fall	12
Maximum Depth (m)	Sp	10.1	Sp	3.3
	Su	10.4	Su	1.1
	Fall	8.7	Fall	3.5
Euphotic Zone (m)	Sp	2.9	Sp	2.0
	Su	2.7	Su	1.1
	Fall	2.5	Fall	2.0
Surface Area (Acres)	Sp	Max = 1,080	Sp	Max =1,080
	Su	Max = 1,080	Su	Max = 1,080
	Fall	Max = 1,080	Fall	Max = 1,080
Storage Capacity (Ac. Ft.)	Sp	Max = 22,900	Sp	Max = 22,900
	Su	Max = 22,900	Su	Max = 22,900
	Fall	Max = 22,900	Fall	Max = 22,900

Table 1B. con't.

Physical Characteristics	Deep Station		Shallow Station	
Anoxic Hypolimnion (Y/N)	Sp	No	Sp	No
	Su	No	Su	No
	Fall	No	Fall	No
Stratified (Y/N) @ depth (m)	Sp	No	Sp	No
	Su	No	Su	No
	Fall	No	Fall	No
pH (s.u.)	Sp	8.0	Sp	8.0
	Su	8.35	Su	8.35
	Fall	8.4	Fall	8.38
Conductivity (µS)	Sp	328	Sp	329
	Su	273	Su	273
	Fall	326	Fall	327
Turbidity (NTUs)	Sp	13.2	Sp	19.1
	Su	14.1	Su	MDP
	Fall	17.8	Fall	21.8
Integrated Sample surface to (m)	Sp	3.0	Sp	3.0
	Su	2.7	Su	1.0
	Fall	surface	Fall	3.0
Dissolved Oxygen Surface (mg/L)	Sp	9.4	Sp	9.0
	Su	6.94	Su	7.02
	Fall	7.4	Fall	7.62
Dissolved Oxygen Bottom (mg/L)	Sp	9.50	Sp	9.10
	Su	5.97	Su	6.96
	Fall	MDP	Fall	7.39
Temperature Surface (°C)	Sp	8.4	Sp	8.5
	Su	19.4	Su	19.2
	Fall	12.3	Fall	11.9
Temperature Bottom (°C)	Sp	7.3	Sp	7.2
	Su	18.0	Su	19.2
	Fall	MDP	Fall	11.8
Chlorophyll *a* (µg/L)	Sp	1.34	Sp	2.40
	Su	2.06	Su	14.77
	Fall	4.10	Fall	34.58
Total Phosphorus	Sp	<0.01	Sp	<0.01
	Su	<0.03	Su	<0.03
	Fall	<0.03	Fall	0.31

Sp = Spring; Su = Summer; MDP = missing data point; (Q) = questionable result.

Table 2B. Trophic State for Storrie Lake, 2001 (Carlson, 1977)

Trophic State Indices	Deep Station		Shallow Station	
Secchi depth	Sp	Eutrophic	Sp	Eutrophic
	Su	Eutrophic	Su	Dystrophy
	Fall	Eutrophic	Fall	Eutrophic
Chlorophyll *a*	Sp	OligoMeso	Sp	OligoMeso
	Su	OligoMeso	Su	OligoMeso
	Fall	MDP	Fall	OligoMeso
Total Phosphorus	Sp	Oligotrophic	Sp	Oligotrophic
	Su	Oligotrophic	Su	Oligotrophic
	Fall	Oligotrophic	Fall	Oligotrophic
Total Nitrogen	Sp	OligoMeso	Sp	OligoMeso
	Su	OligoMeso	Su	Mesotrophic
	Fall	OligoMeso	Fall	OligoMeso
Overall Trophic Condition	**Oligomesotrophic**			

Table 3B.

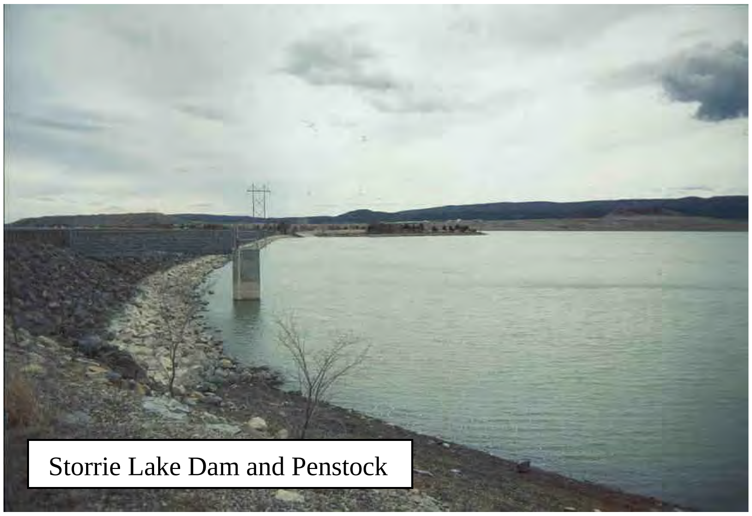
Nitrogen (N) /Phosphorus (P) Ratio	Deep Station		Shallow Station	
Limiting Nutrient	Sp	P	Sp	P
	Su	P	Su	P
	Fall	P	Fall	N

Table 4B.

Designated or Existing Use	Criteria Exceedence	Attainment Status
Coldwater Aquatic Life	Fish Tissue - mercury	Not Supporting
Warmwater Aquatic Life	Fish Tissue - mercury	Not Supporting
Primary Contact	None	Fully Supporting
Livestock Watering	None	Fully Supporting
Wildlife Habitat	None	Fully Supporting
Municipal Water Supply	None	Fully Supporting
Irrigation Storage	None	Fully Supporting

Water Quality Assessment

Physical characteristics of Storrie Lake were measured and are listed in Table 1B. Table 2B shows the trophic state variation observed both seasonally and between stations for Secchi depth, chlorophyll *a*, total phosphorus, and total nitrogen. The overall trophic condition of McAllister Lake in 2001, according to Carlson (1977) and Likens (1975), is oligomesotrophic with phosphorus being limiting during five of the six sampling visits (Tables 2B and 3B). Excessive algal or macrophyte blooms were not evident during sampling visits; however, suspended sediment resulted in decreased secchi depths and increased turbidity readings due to low lake levels and wind mixing of the lake. Overall, nutrient levels and chlorophyll *a* results were low supporting the oligomesotrophic conditions encountered during the survey.



Storrie Lake Dam and Penstock

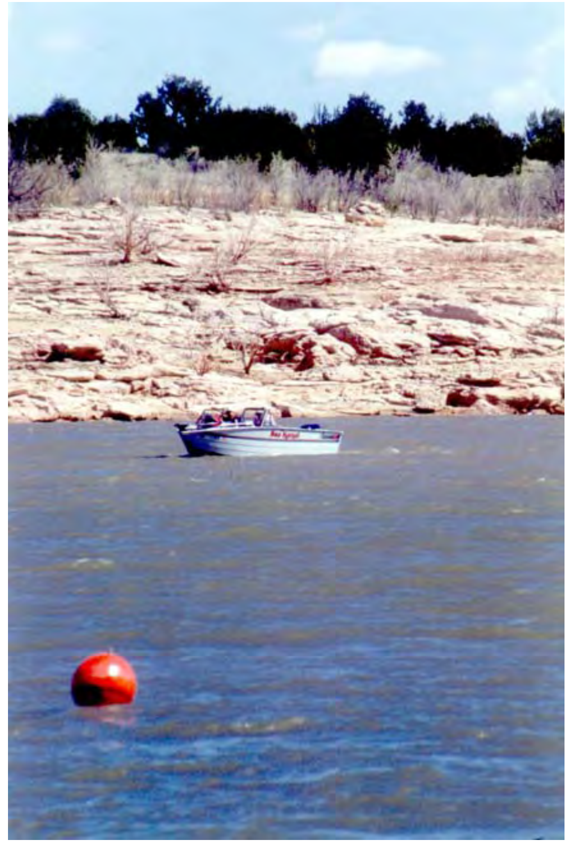
Phytoplankton community composition consisted primarily of members of the Cryptophyta in the spring and Chlorophyta in the summer and fall samples. Diversity was high though species richness appeared low. Diatom community composition was dominated by two members of the genus *Cymbella*, with fewer numbers of other species resulting in a total of 28 species identified. Diversity according to Shannon and Weaver (1949) was high.

Storrie Lake chemistry sampling consisted of total, dissolved and calculated nutrients, anions and cations, total and dissolved heavy metals, synthetic organics, radionuclides, and cyanide, which cover all standards criteria pertinent to the protection of all designated uses. These data are available upon request, though any criteria exceedences listed in Table 4 and discussed below.

Satellite image of Storrie Lake

Table 4 indicates that all designated uses were fully supported except for the cold and warm water aquatic life use designations. Though all physical and chemical analyses would fully support these uses, past identification of mercury in fish tissue from Storrie Lake has resulted in the continued issuance of fish consumption advisories specific to the lake. Until sources are identified and measures taken to reduce levels in fish tissue, the use of aquatic life, specifically the fishery uses, will remain unsupported.

Water Quality and Biological Assessment Survey of Santa Rosa Reservoir, Guadalupe County, April 3, July 10, and October 30, 2001.
Danny R. Davis, Principal Investigator



Santa Rosa Reservoir is located in north-central New Mexico approximately 11 km (7 miles) north of the city of Santa Rosa, New Mexico, and was chosen to study concurrently with a major Pecos River, Total Maximum Daily Load (TMDL) intensive watershed study. The 212 foot high, 1,950 foot long, earth and rock fill dam began storing Pecos River water in April of 1980, and is supplied by a drainage area of approximately 2,430 mi^2 resulting in a watershed to lake size ratio of about 1,037 to 1. The U.S. Army Corp of Engineers manages the lake for flood control, irrigation storage and sediment control (USGS, 2001). Santa Rosa State Park manages the recreational activities where year-round camping, fishing and boating are enjoyed. Anglers enjoy fishing for channel catfish, largemouth and smallmouth bass, walleye, and crappie. There are also sunfish, yellow perch and a few trout occasionally taken by anglers. Swimming is permitted; however, there are no designated swimming beaches and most shoreline areas are rocky.

The Reservoir is located on the boundary of the Southwestern Tablelands and the Arizona/New Mexico Plateau ecoregions contained within Aggregate Ecoregion III (the Xeric West) (Omernik, 1987) and receives an average of 35.2 cm (13.8 in.) of precipitation per year with pan evaporation averaging 118.4 cm (46.4 in.) resulting in a water deficit of about 83 cm (33 in.) (Gabin and Lesperance, 1977).

The park and surrounding area provide habitat for mule deer, raccoons, skunks, squirrels, foxes and coyote. Rare sightings of bobcats, mountain lions and pronghorn antelope are occasionally seen within the park. Birds which are common to the area are Canada geese, pelicans, ring-billed gulls and many species of ducks. Bald eagles often winter near the lake and swallows, doves, quail and osprey are common (New Mexico State Parks, http://www.emnrd.state.nm.us/PRD/index.htm).

A prolonged drought persisted during this study, which resulted in extremely low lake levels and consequent volumes. Lake levels were drawn down to levels that threatened to close the boat ramp within the park. Maximum storage capacity reported by USGS is about 439,900 acre-ft determined by an area-capacity table effective from October 1997. The maximum volume during the study year was 38,000 acre-ft. with the low pool of 3,170 acre-ft., or less than one percent of maximum pool.

Water quality standards for Santa Rosa Reservoir are set forth in section 20.6.4.211 of the *New Mexico Standards for Interstate and Intrastate Surface Waters* (NMAC 2006), where uses of fish culture, irrigation, marginal warmwater aquatic life, livestock watering, wildlife habitat and secondary contact are applied. This segment is, in fact, a river segment that currently includes Santa Rosa Reservoir. Some of the uses ascribed to the reservoir are applicable to the river, and conversely, there are uses within the lake that should be protected, that do not and should not be expected of the river system. These uses will be discussed further is the assessment discussion. Two stations, the deep station near the dam, and the shallow station located within the vicinity of the Pecos River inlet, were sampled during spring, summer and fall seasons.

Table 1C. Physical Characteristics for Santa Rosa Reservoir, 2001.

Physical Characteristics	**Deep Station**		**Shallow Station**	
Secchi (m)	Sp	1.0	Sp	0.65
	Su	2.75	Su	2.0
	Fall	0.80	Fall	0.65
Forel Ule Color	Sp	14	Sp	16
	Su	11	Su	11
	Fall	15	Fall	13
Depth to Bottom (m)	Sp	15.5	Sp	7.6
	Su	17.4	Su	6.1
	Fall	12.5	Fall	4.5
Euphotic Zone (m)	Sp	3.0	Sp	1.6
	Su	6.3	Su	4.3
	Fall	2.1	Fall	1.85
Surface Area (Acres)	Sp	Max = 1,298	Sp	Max =1,298
	Su	Max = 1,752	Su	Max = 1,752
	Fall	Max = 876	Fall	Max = 876
Storage Capacity (Ac. Ft.)	Sp	Max = 23,170	Sp	Max = 23,170
	Su	Max = 32,944	Su	Max = 32,944
	Fall	Max = 14,421	Fall	Max = 14,421

Table 1C. con't.

Physical Characteristics	Deep Station		Shallow Station	
Anoxic Hypolimnion (Y/N)	Sp	No	Sp	No
	Su	Yes	Su	No
	Fall	No	Fall	No
Stratified (Y/N) @ depth (m)	Sp	No	Sp	No
	Su	Yes (4.0)	Su	Yes (2.5)
	Fall	No	Fall	No
pH (s.u.)	Sp	8.0	Sp	7.7
	Su	8.29	Su	8.4
	Fall	8.11	Fall	8.05
Conductivity (µS)	Sp	768	Sp	751
	Su	469	Su	471
	Fall	627	Fall	620
Turbidity (NTUs)	Sp	10.8	Sp	24.2
	Su	2.96	Su	3.95
	Fall	14.4	Fall	18.8
Integrated Sample surface to (m)	Sp	3.0	Sp	2.0
	Su	17.0	Su	4.3
	Fall	3.0	Fall	3.0
Dissolved Oxygen Surface (mg/L)	Sp	8.4	Sp	8.5
	Su	6.25	Su	6.24
	Fall	7.7	Fall	8.72
Dissolved Oxygen Bottom (mg/L)	Sp	7.30	Sp	8.3
	Su	0.12	Su	4.32
	Fall	6.17	Fall	8.16
Temperature Surface (°C)	Sp	11.6	Sp	11.9
	Su	26.6	Su	26.8
	Fall	13.7	Fall	14.0
Temperature Bottom (°C)	Sp	8.9	Sp	10.6
	Su	18.6	Su	23.6
	Fall	12.94	Fall	13.67
Chlorophyll *a* (µg/L)	Sp	4.11	Sp	5.05
	Su	1.44	Su	1.40
	Fall	10.28	Fall	15.83
Total Phosphorus	Sp	0.05	Sp	0.036
	Su	<0.03	Su	0.045
	Fall	0.03	Fall	<0.03

Sp = Spring; Su = Summer; MDP = missing data point; (Q) = questionable result.

Table 2C. Trophic State for Santa Rosa Reservoir, 2001 (Carlson, 1977)

Trophic State Indices	Deep Station		Shallow Station	
Secchi depth	Sp	Eutrophic	Sp	Eutrophic
	Su	Mesotrophic	Su	Dystrophy
	Fall	Eutrophic	Fall	Eutrophic
Chlorophyll *a*	Sp	Mesotrophic	Sp	Mesotrophic
	Su	OligoMeso	Su	OligoMeso
	Fall	Eutrophic	Fall	Eutrophic
Total Phosphorus	Sp	Oligotrophic	Sp	Oligotrophic
	Su	Oligotrophic	Su	Oligotrophic
	Fall	Oligotrophic	Fall	Oligotrophic
Total Nitrogen	Sp	Eutrophic	Sp	Eutrophic
	Su	Mesotrophic	Su	OligoMeso
	Fall	Mesotrophic	Fall	Mesotrophic
Overall Trophic Condition	**Mesotrophic**			

Table 3C.

Nitrogen (N) / Phosphorus (P) Ratio	Deep Station		Shallow Station	
Limiting Nutrient	Sp	N/P	Sp	P
	Su	N	Su	N
	Fall	N/P	Fall	P
Overall Limiting Nutrient	**Co-limiting**			

Table 4C.

Designated or Existing Use	Criteria Exceedence	Attainment Status
[1] Marginal Coldwater Aquatic Life	Fish Tissue - mercury	Not Supporting
[1] Warmwater Aquatic Life	Fish Tissue - mercury	Not Supporting
[2] Marginal Warmwater Aquatic Life	Fish Tissue - mercury	Not Supporting
[1] Primary Contact	None	Fully Supporting
Secondary Contact	None	Fully Supporting
[2] Fish Culture	None	Fully Supporting
Livestock Watering	None	Fully Supporting
Irrigation Storage	None	Fully Supporting
Wildlife Habitat	None	Fully Supporting

1 = Existing and attainable use. 2 = Designated uses currently recognized but not applicable to Santa Rosa Reservoir.

Water Quality Assessment

Physical characteristics of Santa Rosa Reservoir were measured and are listed in Table 1C. Table 2C shows the trophic state variation observed both seasonally and between stations for Secchi depth, chlorophyll *a*, total phosphorus, and total nitrogen. The overall trophic condition of Santa Rosa Reservoir in 2001, according to Carlson (1977) and Likens (1975), is mesotrophic with phosphorus and nitrogen being co-limiting when averaged for the multiseasonal study (Tables 2C and 3C). Excessive algal or macrophyte blooms were not evident during sampling visits; however, suspended sediment resulted in decreased secchi depths and increased turbidity readings due to low lake levels and wind mixing of the lake. Overall, nutrient levels and chlorophyll *a* results were low during the summer sampling visit, possibly due to dilution from watershed inflow. Spring and fall nutrient indicators were relatively high supporting the mesotrophic determination.

Phytoplankton community composition consisted primarily of members of the Cryptophyta and Chlorophyta in the spring. The same was true in summer and fall samples except the presence of Euglenophyta and Cyanophyta entered the mix. Diversity was high though species richness appeared low in spring and summer samples. The green and blue-green algae dominated the fall phytoplankton community. Fifty-four percent of the diatom community consisted of three species, *Achnanthes minutissima* Kütz. var. *minutissima*, *Diatoma vulgare* var. *linearis* V.H. and *Cymbella affinis* Kütz. var. *affinis*. A total of 40 species were identified and diversity according to Shannon and Weaver (1949) was high.

Santa Rosa Lake chemistry sampling consisted of total, dissolved and calculated nutrients, anions and cations, total and dissolved heavy metals, synthetic organics, radionuclides, cyanide, and physical measurements which cover all standards criteria pertinent to the protection of all designated uses. These data are available upon request, though any criteria exceedences are listed in Table 4C and discussed below.

All physical and chemical criteria were well within acceptable limits resulting in full support of all designated uses (Table 4C), except for the case of aquatic life uses. A continuing fish consumption advisory remains in effect until such time as fish tissue levels for mercury fall to acceptable levels.

Also note that in Table 4C that some uses are labeled as existing and attainable, while two others are indicated as being designated uses under current water quality standards. This is because the reservoir is not classified as its own water quality segment but is included within standards segment 20.6.4.211, which is applicable to the Pecos River, and not the lake. For example, the use of marginal warmwater aquatic life applies to the river, but is inappropriate for the lake. Based on literature from the New Mexico Department of Game and Fish, and the New Mexico State Parks, warmwater aquatic life, and to a very small degree, marginal coldwater aquatic life uses exist. In addition, although swimming beaches are not provided by the park, the public does swim and water ski at the lake, requiring that the use of primary contact be recognized and protected.

Existing uses are noted in the SWQB Assessment Database in order to afford waters, such as Santa Rosa Reservoir, more protection than that given by their respective criteria. According to NM's Antidegradation Policy (20.6.4.8), "Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected in all surface waters of the state." Therefore, during assessment procedures, it is the more protective uses (in this case, the existing uses of marginal coldwater aquatic life and primary contact) that are assessed against the criteria.

Even though NM's water quality standards protect existing uses, it is strongly recommended that Santa Rosa Reservoir be removed from Standards segment 20.6.4.211 and placed within its own segment where its lake characteristics can be recognized and protected.

Water Quality and Biological Assessment Survey of Blue Hole, Guadalupe County, June 8, 1999.

Seva J. Joseph, Principal Investigator

Blue Hole is located in the east-central part of New Mexico approximately 183.5 km (114 mi) east of Albuquerque, New Mexico. Blue Hole is within the city limits of Santa Rosa, New Mexico, and is a favorite point of interest for local and traveling visitors. Blue Hole is a natural surface water feature formed by the collapse of subterranean geological formations. The waterbody is fed with groundwater, which enters from the bottom at a rate of 11.4 m^3 / minute (3000 gal/min), or about 16,353 m^3/day (4,320,000 gal/day), which completely replaces the water in Blue Hole every six hours. The diameter of the sinkhole is about 24.6 meters (80 ft) at the surface, and 39.6 meters (130 ft) at the bottom with a maximum depth of 24.7 meters (81 ft.). The water temperature remains between 16 ºC (61 ºF) and 18 ºC (64 ºF) throughout the year. The altitude at the sinkhole is about 1,402 meters (4,600 ft) above mean sea level.

During the 1960's, water from Blue Hole was used in a federal fish hatchery. Later, the City of Santa Rosa took over the site and included it within the community park. Uses observed while conducting the one-time sampling study included primary contact by citizens cooling off on a hot summer day. One famous use of the sinkhole is by divers and students working towards their diving certification. Two platforms are located within Blue Hole to assist in training exercises. Water from Blue Hole eventually flows into the Pecos River south of Santa Rosa. Gold Fish and some small minnows were observed suggesting that some fish species survive within the sinkhole. Though temperatures suggest a cold water fishery potential, the dissolved oxygen concentration is naturally low due to the groundwater that supplies Blue Hole.

Water quality standards in 20.6.4.212 NMAC apply to Blue Hole as the 4.3 million gallons of water flowing from the sink hole enters the Pecos River a short distance south of the discharge point. Uses ascribed to this segment are irrigation, coldwater aquatic life, livestock watering, wildlife habitat and primary contact. The final discussion will show that Blue Hole may need specific treatment to acknowledge actual existing and attainable uses with criteria required to protect this unique environment.

Table 1D. Physical characteristics for Blue Hole, 2001.

Physical Characteristics	Blue Hole
Secchi Depth (m)	>16
Forel Ule Color	2
Maximum Depth (m)	24.7
Euphotic Zone (m)	24.7
Surface Area (Acres)	< 1/8th acre
Anoxic Hypolimnion (Y/N)	N
Stratified (Y/N) @ (m)	N
pH units (s.u.) Surface	7.18
Conductivity (µS) (Surface)	2,482
Turbidity (NTUs)	0.45
Integrated sample surface to (m)	6.0
Dissolved Oxygen Surface (mg/L)	2.39
Dissolved Oxygen Bottom (mg/L)	0.26
Temperature Surface (°C)	18.32
Temperature Bottom (°C)	17.75
Chlorophyll *a* (µg/L)	0.44

Table 2D. Trophic State for Blue Hole, 2001 (Carlson, 1977)

Trophic State Indices	Season	Deep Station
Secchi depth	Summer	Oligotrophic
Chlorophyll *a*	Summer	Oligotrophic
Total Phosphorus	Summer	Oligotrophic
Total Nitrogen	Summer	Oligotrophic
Overall Trophic Condition	**Oligotrophic**	

Table 3D. Nitrogen (N) /Phosphorus (P) Ratio

	Deep Station
Limiting Nutrient	**N**

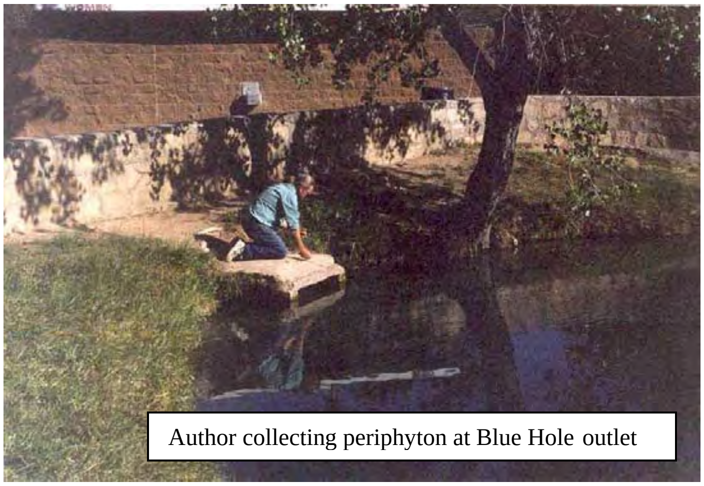
Table 4D. Section 20.6.4.212 designated uses and existing uses for Blue Hole.

Designated or Existing Use	Criteria Exceedence	Attainment Status
[2] **Coldwater Aquatic Life**	Low Dissolved Oxygen	Not Supporting
[1] **Marginal Coldwater Aquatic Life**	Low Dissolved Oxygen	Not Supporting
Primary Contact	None	Fully Supporting
Livestock Watering	None	Fully Supporting
Irrigation Storage	None	Fully Supporting
Wildlife Habitat	None	Fully Supporting

1 = Existing and attainable use. 2 = Designated uses currently recognized but not applicable to Blue Hole.

Water Quality Assessment

Physical characteristics of Blue Hole were measured and are listed in Table 1D. Table 2D shows the trophic state variation observed both seasonally and between stations for Secchi depth, chlorophyll *a*, total phosphorus, and total nitrogen. The overall trophic condition of Blue Hole in 2001, according to Carlson (1977) and Likens (1975) is oligotrophic with nitrogen being the limiting nutrient on the day of sampling (Tables 2D and 3D).



Author collecting periphyton at Blue Hole outlet

Only one phytoplankton species of the Cryptophyta was identified from the sample. This low species richness is most probably due to the rapid exchange of water within Blue Hole, which is replaced every six hours. This would prohibit the development of any substantial phytoplankton community. Conversely, benthic diatom communities were well established. Qualitative diatom community analyses from multiple substrates yielded a total of forty-two species. Diversity according to Shannon-Weaver (1949) was high.

Lake chemistry sampling consisted of total and dissolved nutrients, anions and cations, total and dissolved heavy metals, synthetic organics, and radionuclides, which covers all standards criteria pertinent to the protection of all designated uses. Phytoplankton, diatom and chlorophyll analyses were also performed. These data are available upon request, though any criteria exceedences are listed in Table 4D and discussed below.

Blue Hole is a premier scuba diving training area visited by enthusiasts of the sport from neighboring states as well as New Mexico. The public use this local attraction to cool off during hot summer days. Primary contact continues to be fully supported at Blue Hole. Water temperature would allow for a cold water fishery under flowing conditions, but low dissolved oxygen concentrations naturally associated with the groundwater inflow would not support most coldwater species, therefore, Blue Hole does not support the current aquatic life designation due to the low dissolved oxygen. If Blue Hole was given site specific considerations, a marginal coldwater aquatic life use could recognize the naturally low oxygen concentrations. Water leaving the sink-hole travels to the Pecos River where uses of irrigation, wildlife habitat and livestock watering are fully supported by the contribution from Blue Hole. It is recommended that Blue Hole be placed within its own site specific segment where the unique qualities of this natural lake can be appreciated and protected.

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