NMED/SWQ-11/1

WATER QUALITY SURVEY REPORT FOR SELECTED NEW MEXICO LAKES

2009

MONITORING AND ASSESSMENT SECTION
Surface Water Quality Bureau
NEW MEXICO ENVIRONMENT DEPARTMENT
1190 S. St. Francis Drive - N2050
Santa Fe, New Mexico 87505
www.nmenv.state.nm.us/swqb/MAS

Danny R. Davis, Principal Investigator

THIS PAGE LEFT INTENTIONALLY BLANK.

TABLE OF CONTENTS

LAKE WATER QUALITY MONITORING, TROPHIC STATE EVALUATION, AND STANDARDS EVALUATIONS FOR:

Bear Canyon Reservoir, Grant County
Santa Cruz Reservoir, Santa Fe County
East and West Fawn Lakes, Taos County
Goose Lake, Taos County

2009

EXECUTIVE SUMMARY

During 2009, the Monitoring and Assessment Section of the Surface Water Quality Bureau of the New Mexico Environment Department conducted water quality and biological surveys of five lacustrine systems, four located in north-central New Mexico, and the fifth in the southwestern section of the state. These lakes were surveyed concurrently with watershed studies of the Upper Rio Grande and the Mimbres River in fulfillment of work-plan commitments of the *FY 2009 §106 Work Program for Water Quality Management.* Water quality sampling methods used during these surveys were in accordance with the *Quality Assurance Project Plan for Water Quality Management Programs* (NMED/SWQB 2009).

Bear Canyon Reservoir is a popular fishing lake within the Mimbres watershed. This small impoundment provides a popular fishing experience for anglers, but this activity may suffer from increases in sedimentation and nutrient loads associated with the ephemeral watershed. **Santa Cruz Reservoir** is located just below the confluence of two, high quality cold water mountain streams and supports a popular fishing, picnicking and hiking experience for visitors. It is an important irrigation storage impoundment and experiences substantial draw-downs when irrigation demands are high. **East and West Fawn Lakes** are small impoundments fed by water diverted from the Red River a short distance below the town of Red River. Originally created as borrow pits for state road construction, these lakes provide good trout fishing for campers from the nearby Elephant Rock Campground as well as the visiting public. Finally, **Goose Lake** is a high elevation cirque lake formed by the erosional forces of glaciers. This particular lake showed great improvement over the past twenty years due to management changes by the Carson National Forest in which access to the immediate lake shore is now limited to pedestrian travel. Goose Lake may be the only high-mountain cirque lake in New Mexico where access can be attained by way of a rough but manageable forest road. In the past, the public had access to the lake shore in their vehicles, but visitors must now park in a parking area outside the immediate lake basin and walk to the lake shore. This reduced access has resulted in noticeable improvement to the stability of lake shore vegetation as well as improvements in overall water quality.


Bear Canyon Reservoir, 2009.

The following lake survey reports provide information pertaining to water quality, biological integrity, trophic state, limiting nutrients, and the attainment of designated uses in the *State of New Mexico Standards for Interstate and Intrastate Surface Waters* 20.6.4 NMAC (effective date January 14, 2011).

Physical, chemical and biological sampling at lake stations included total nutrients, total and dissolved metals, major ions including total dissolved solids, total suspended solids, hardness and alkalinity, radionuclides, volatile and semi-volatile organic compounds, cyanide, and microbiological collections. Samples were also collected for chlorophyll, phytoplankton and benthic diatom analyses.

Data are assessed against the New Mexico *Standards for Interstate and Intrastate Surface Waters* 20.6.4 NMAC and impaired waters are summarized in the 303(d) List of Assessed Surface Waters (303(d) List; NMED/SWQB 2010). Assessment conclusions presented in this report are based on the water quality standards and assessment protocols in place at the time the data were assessed. Therefore, the impairment conclusions in the most recent 303(d) List supersede assessment conclusions in this survey report if they should differ.

Because of the large amount of data collected, only a pertinent subset is included in this report. All data are available upon request. The following summaries detail those results specifically related to the general physical nature, trophic state, limiting nutrient or criteria exceedences and consequent attainment status for designated or existing uses specific to each lake environment.

1.0 Bear Canyon Reservoir, Grant County
March 25, June 24 and September 30, 2009

Background

A water quality survey was conducted on Bear Canyon Reservoir during spring, summer and fall of 2009 at two established sampling locations: *Bear Canyon Deep* near the dam and *Bear Canyon Shallow* at the western end of the lake from the dam. Bear Canyon Reservoir is located in southwestern New Mexico, approximately 45 kilometers (28 mi) northeast of Silver City via State Highway 152 to the east and State Highway 35 to the north (Davis, 1998). Bear Canyon Reservoir is located on private land adjacent to the Gila National Forest and has a mean surface area of approximately 0.09 km^2 (22 acres) with a corresponding elevation of 1,890 meters (6,200 ft) above mean sea level. Maximum depth encountered at the deep station during this survey was 9.7 meters which was approximately the maximum depth encountered in the 1996 water quality study. Potter (1982) reported a maximum depth of 18.3 meters; however this depth has not been encountered for many years.


Bear Canyon Reservoir, June 2009.

The concrete dam at Bear Canyon Reservoir was constructed by the Works Progress Administration in 1934 to impound Bear Canyon Creek for flood control, irrigation for the Mimbres Valley, and wildlife habitat. The New Mexico Department of Game and Fish (NMDGF) owns water rights to 345,375 m^3 (280 acre feet) and also owns 0.28 km^2 (70 ac) of land for recreational purposes. The basin is located in the Arizona/New Mexico Mountain aggregate ecoregion (Omernik 2006). Precipitation reported by averages 43.4 cm (17.1 in) per year and pan evaporation averages 87.7 cm (34.5 in) per year (Gabin and Lesperance, 1977) resulting in a water deficit of 48.3 cm (19.02 in) per year.

Without the aid of current lake bathymetric measurements, it is not possible to calculate the storage volume of the lake; however, it is important to note that the NMDGF conducted a significant dredging project on the upper portion of the lake in 2002 due to accumulated sediment from years of seasonal rain events. Approximately nine acres were dredged to a depth of 16 feet in an attempt to restore a significant portion of the pool volume (Mike Gustin (NMDGF), personal communication). Included with the sediment removal was the construction of a large gabion dam immediately above the lake, which was designed to capture sediment as it approaches the lake.


Algal bloom at Bear Canyon, 2009.

Bear Canyon Reservoir is classified within water quality segment 20.6.4.806 NMAC with designated uses of coldwater aquatic life, irrigation, livestock watering, wildlife habitat, and primary contact. This study was designed to provide the data needed to determine if these uses are being supported, and to assess whether water quality issues observed in past studies have improved or worsened.

The problems previously encountered at Bear Canyon Reservoir have included high nutrient and sediment loading, low dissolved oxygen levels, and periodic fish kills. Potter (1982) found that Bear Canyon Reservoir suffered from low dissolved oxygen concentrations, which resulted in periodic fish kills. Data collected by New Mexico State University suggests that fish kills in Bear Canyon Reservoir are often associated with seasonal turnovers. The NMDGF attempted to improve and destratify lake conditions through the introduction of an aeration system; however this actually reduced dissolved oxygen concentrations by mixing hypolimnetic waters and increasing the overall biological oxygen demand. The results of this survey indicate that these problems persist.

Physical / Chemical Data

Lake chemistry sampling consisted of total and dissolved nutrients, anions and cations, total and dissolved heavy metals, volatile and semi-volatile organics, radionuclides, *E. coli* bacteria, and cyanide, which cover a wide variety of water quality parameters pertinent to the protection of designated or existing uses (Table 1.1). Physical measurements collected at Bear Canyon Reservoir include Secchi depth, Forel-Ule color, pH, specific conductance, turbidity, dissolved oxygen, and temperature (Table 1.2).

Table 1.1. Chemical analyses performed seasonally by station.

Samples Collected	Bear Canyon Deep			Bear Canyon Shallow		
	Spring	Summer	Fall	Spring	Summer	Fall
Major Anions and Cations	X	X	X	X	X	X
Total Nutrients	X	X	X	X	X	X
Dissolved Nutrients	X	X	X	X	X	X
Total Mercury and Selenium	X	X	X	X	X	X
Dissolved Metals	X	X	X	X	X	X
Radionuclides	X	X				
Volatile Organics	X	X				
Semi-Volatile Organics	X	X				
Cyanide	X	X				
E. coli	X	X	X			

Table 1.2. Physical characteristics for Bear Canyon Reservoir, 2009

Physical Characteristics		Deep Station	Shallow Station
Secchi Depth (m)	Sp	1.0	0.9
	Su	0.4	0.4
	Fall	0.6	0.35
Forel Ule Color	Sp	15	15
	Su	14	14
	Fall	14	14
Maximum Depth (m)	Sp	9.7	4.25
	Su	7.7	2.5
	Fall	6.0	1.4
Euphotic Zone (m)	Sp	3.23	2.9
	Su	1.3	1.3
	Fall	1.9	1.1
pH (s.u.)	Sp	8.07	8.3
	Su	8.1	8.3
	Fall	7.2	7.3
Conductivity (μS)	Sp	252	251
	Su	203	202
	Fall	254	257
Turbidity (NTUs)	Sp	3.60	3.85
	Su	20.9	30.1
	Fall	18.8	21.3

Physical Characteristics		Deep Station	Shallow Station
Integrated Sample surface to depth (m)	Sp	8	0
	Su	7	2
	Fall	5	0
Dissolved Oxygen ** (mg/L)	Sp	**5.2**	**5.4**
	Su	9.7	10.6
	Fall	10.6	9.7
Dissolved Oxygen ** (% saturation)	Sp	**59.1%**	**62.1%**
	Su	137.9%	155.3%
	Fall	141.9%	128.3%
Dissolved Oxygen Bottom (mg/L)	Sp	0.17	4.85
	Su	0.25	10.46
	Fall	0.15	9.70
Anoxic Hypolimnion * (Y/N)	Sp	Yes	No
	Su	Yes	No
	Fall	Yes	No
Temperature ** (°C)	Sp	11.25	11.6
	Su	**21.82**	**23.2**
	Fall	18.25	17.9
Temperature Bottom (°C)	Sp	8.3	10.99
	Su	12.81	23.03
	Fall	15.60	17.91
Stratified (Y/N) @ depth (m)	Sp	Yes (5-6)	No
	Su	Yes (1-2)	No
	Fall	Yes (1-2)	Yes (1)

Sp = Spring Su = Summer MDP = missing data point
* Anoxia exists when DO < 0.5 mg/L
** According to Subsection C, Paragraph 3 of 20.6.4.14 NMAC, dissolved oxygen and temperature are mean values from the epilimnion or, in the absence of an epilimnion, the upper 1/3 of water column
BOLD values indicate an excursion of the criterion.

Concentrations of all parameters pertinent to the protection of designated uses were consistent with water quality criteria, *except* temperature and dissolved oxygen, which violated their respective criteria of 20°C and 6.0 mg/L (90% saturation), respectively.

Nutrient Data

A draft *Nutrient Assessment Protocol for Lakes and Reservoirs* has been developed by SWQB to implement the narrative criterion for plant nutrients at 20.6.4.13 NMAC; however further analyses on impairment thresholds are being conducted for total nitrogen and total phosphorous. Specifically, these analyses are evaluating the nutrient concentrations required to induce a biological shift (e.g., increase in algae growth, change in community composition, etc.). Until these analyses are complete and thresholds are identified, nutrient assessments should be considered provisional.

Sampling results from Bear Canyon Reservoir were compared to the thresholds identified in the draft AP. Referring to the seasonal results listed in Table 1.3, all six chlorophyll *a* results were greater than the suggested target of 2.3 µg/L; six of six total phosphorus results were outside of the target range of 0.03 – 0.05 mg/L, and six of six total nitrogen results exceeded the upper limit of 0.8 mg/L, the highest being 2.3 mg/L total nitrogen. All Secchi depth measurements were much less than the proposed threshold depth of 1.5 meters indicating more turbid water than what was expected or desired. Likewise, the cyanobacterial community composition exceeded the proposed threshold level of fifty-percent of the total phytoplankton community. Finally, four of six depth profiles had >50% of the profile below the dissolved oxygen criterion of 6.0 mg/L. According to the draft AP, this lake would unquestionably be deemed impaired due to nutrients.

Recreational, livestock, and wildlife uses - Spring 2009

Table 1.3. Nutrient-related indicators for Bear Canyon Reservoir, 2009.

		Deep Station	Shallow Station
Chlorophyll *a* (µg/L)	Sp	**11.03**	**11.21**
	Su	**34.11**	**73.83**
	Fall	**21.60**	**38.50**
Limiting Nutrient (N = nitrogen; P = phosphorus)	Sp	N	N
	Su	N/P	P
	Fall	N	N/P
Total Phosphorus (mg/L)	Sp	**0.097**	**0.70**
	Su	**0.188**	**0.063**
	Fall	**0.153**	**0.083**
Total Nitrogen (mg/L)	Sp	0.08	0.74
	Su	**2.3**	**2.2**
	Fall	**0.99**	**0.88**
Secchi Depth (m)	Sp	**1.0**	**0.9**
	Su	**0.4**	**0.4**
	Fall	**0.6**	**0.35**
% depth profile below D.O. criterion	Sp	**100%**	**100%**
	Su	**86%**	0%
	Fall	**82%**	0%
Cyanobacteria (% Bluegreen Algae)	Sp	0%	
	Su	**78%**	
	Fall	**54%**	
Provisional Assessment		**Non-support**	

BOLD values indicate an excursion of the threshold for coldwater reservoirs.

Table 1.4. Trophic state determinations for Bear Canyon Reservoir, 2009 (Carlson 1977).

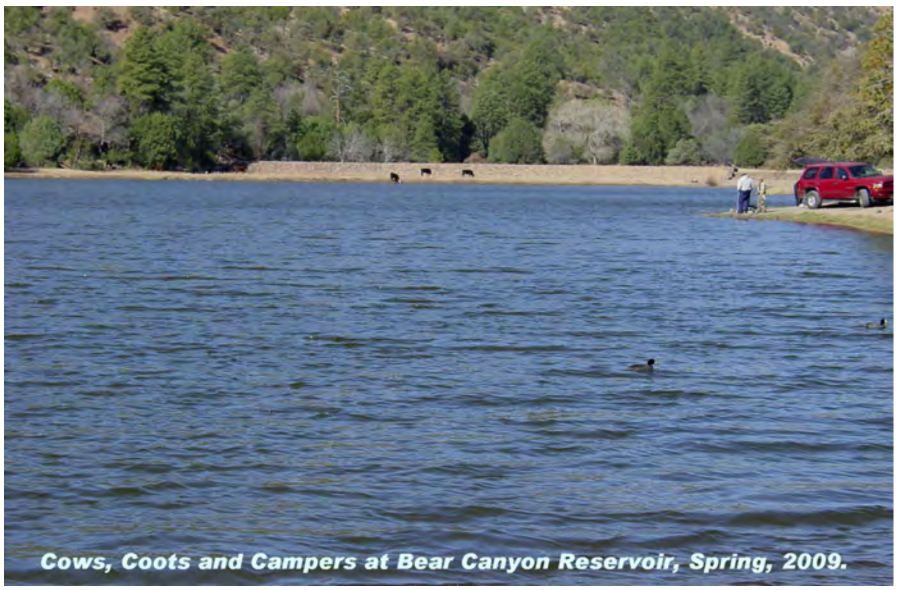
		Deep Station	Shallow Station
Secchi Depth	Sp	Eutrophic	Eutrophic
	Su	Hypereutrophic	Hypereutrophic
	Fall	Eutrophic	Hypereutrophic
Chlorophyll *a*	Sp	Eutrophic	Eutrophic
	Su	Eutrophic	Hypereutrophic
	Fall	Eutrophic	Eutrophic
Total Phosphorous	Sp	Eutrophic	Eutrophic
	Su	Hypereutrophic	Eutrophic
	Fall	Hypereutrophic	Eutrophic
Total Nitrogen	Sp	Eutrophic	Eutrophic
	Su	Eutrophic	Eutrophic
	Fall	Eutrophic	Eutrophic
Overall Trophic Condition		**Eutrophic**	

Trophic State

Data collected during the 2009 study indicate that Bear Canyon Reservoir may be classified as strongly eutrophic according to Carlson's (1977) indices for Secchi depth, chlorophyll *a*, total phosphorus, total nitrogen, and algal community composition (Table 1.4; Likens 1975). Chlorophyll, nitrogen and phosphorous results were strongly indicative of nutrient enriched conditions resulting in some hypereutrophic determinations especially during the summer. Eutrophic conditions were observed and measured during all seasons and for all components of the trophic determination suggesting that these conditions persist throughout the year. Nitrogen was the limiting nutrient for algal productivity during both spring and fall visits (Table 1.3).

Biological Data

Phytoplankton



Cows, Coots and Campers at Bear Canyon Reservoir, Spring, 2009.

Phytoplankton samples were collected at the deep lake station during spring, summer and fall visits. The spring sample was dominated by the diatom *Cyclotella atomus* Hust. var. *atomus*, which comprised 61% of the phytoplankton community followed by *Fragilaria crotonensis* Kitton (8%), *Cryptomonas* sp. (6%), *Cyclotella* sp. (5%), and *Komma* sp. (5%) being the other common taxa. No cyanobacteria, commonly known as blue-green algae, were detected in the spring sample; however, major shifts in community composition occurred in both summer and fall collections. *Aphanizomenon flos-aquae* (L.) Ralfs. and a species of *Anabaena*, both cyanobacteria species common in nutrient enriched lakes, comprised about 56% of the summer phytoplankton community followed by two diatoms, *Cyclotella* (18%) and *Stephanodiscus* (16%). Thirty-nine percent of the fall sample consisted of an "unknown blue-green filament" followed by *Cryptomonas* sp. (14%) and *Oocystis* sp. (6%).

Cyanobacteria genera comprised about 78% of the summer community and 54% of the fall sample composition. These numbers are consistent with the high nitrogen and phosphorus concentrations which can cause a cyanobacterial bloom and the low dissolved oxygen values that were observed and would result from such a bloom. Diversity for the spring, summer, and fall phytoplankton communities measured 1.53, 2.03 and 2.22, respectively, according to the Shannon–Weaver Index (Shannon and Weaver 1949) suggesting low to moderate diversity with a gradual increase in species richness and evenness over the three seasons.

Periphyton Diatom Community Composition

A multiple substrate diatom sample was collected during the June sampling visit to Bear Canyon Reservoir, where forty-five species were identified during the six-hundred valve count. Most common was the diatom *Fragilaria crotonensis* Kitton var. *crotonensis* which comprised 35% of the community followed by the planktonic diatom *Asterionella formosa* Hassall var. *formosa* (15%), *Navicula cryptotenella* Lange-Bertalot (4%), *Achnanthes minutissima* Kütz. var. minutissima (3%), and *Synedra ulna* (Nitz.) Ehr. var. ulna (3%). Diversity according to Shannon–Weaver Index (Shannon and Weaver 1949) was calculated to be 2.71 indicating a moderately high level of diversity with a calculated evenness or equitability of 0.712. In addition, a majority of the diatom community are known to withstand or require elevated concentrations of nitrogen and are moderately to very tolerant of pollution.

Water Quality Evaluation

Many reservoirs constructed in arid environments with a high watershed to lake size ratio experience an increasing concentration of nutrients over time providing the perfect conditions for excessive algal development. The dredging project completed in 2002 on the upper 3.6 hectare (9 acres) of the lake has reduced the presence of macrophytes because the resulting depth makes rooting impossible. However, with the sparseness of macrophytes, nutrients are available to fuel the growth of excessive algal blooms which are followed by changes in other parameters such as dissolved oxygen that ultimately threaten aquatic life and overall water quality.

Assessment of physical and chemical data collected during 2009 indicate that primary contact, irrigation, wildlife habitat, and livestock watering uses are fully supported (Table 1.5). The coldwater aquatic life use is not supported due to exceedences of both the temperature and dissolved oxygen criteria (Table 1.2, Table 1.5). Temperatures exceeded the 20ºC criterion during the summer when there are longer days with increased solar radiation. Elevated temperatures are also probably the result of the darkened water color due to algae blooms, which absorb more energy thus increasing temperatures in the lake. Dissolved oxygen was below the concurrent minimum values of 6.0 mg/L and 90% saturation during the spring (Table 1.2) indicative of conditions prior to spring turnover.

It is unlikely that Bear Canyon Reservoir will see better overall water quality unless some changes in management are implemented. Continued grazing in the immediate watershed, including the lake shore, remains a source of bank destabilization and nutrient load. Removing cattle from the surrounding area and restricting their access to the shoreline would likely reduce the overall nutrient and sediment input to the lake by allowing the reestablishment of vegetation, which acts as a natural filtering mechanism for both sediment and nutrients.

Table 1.5. Summary of attainment status for Bear Canyon Reservoir.

Designated Use	Impairment	Attainment Status*
Coldwater Aquatic Life	Temperature, Dissolved Oxygen	Not Supporting
Primary Contact	None	Fully Supporting
Irrigation	None	Fully Supporting
Livestock Watering	None	Fully Supporting
Wildlife Habitat	None	Fully Supporting

* Attainment status is based on the water quality standards and assessment protocols in place at the time the data were assessed. Therefore, the impairment conclusions in the most recent 303(d) List (NMED/SWQB 2010) supersede attainment status in this report if they should differ.

Santa Cruz Reservoir, Santa Fe County
April 28, July 26 and November 4, 2009

Background

In 2009, SWQB conducted a three-season water quality survey on a 40.5 hectare (100 ac) reservoir located above the village of Chimayo in Santa Fe County, New Mexico. Santa Cruz Reservoir is located in north-central New Mexico, approximately 48 kilometers (30 mi) north of Santa Fe via U.S. 285 to NM State Highway 503, and then to State road 596, which ends at the lake. The reservoir's recreational facilities are managed by the Bureau of Land Management, while the water stored at the lake is managed by the Santa Cruz Irrigation District. A boat ramp is provided to serve non-motorized craft. The New Mexico Department of Game and Fish lists Santa Cruz Reservoir as a rainbow and brown trout fishery.

The concrete dam, originally constructed for flood control, irrigation, and recreation, was completed in 1928 and had an original capacity of approximately 12,000 acre-feet; however according to recent figures, Santa Cruz Reservoir now has an estimated capacity of about 3,000 acre-feet (Joe Maestas, personal communication). Over the years, sediment from the watershed has reduced the storage capacity of this lake. In 1989, the dam was rebuilt and reinforced resulting in an increased capacity of almost 100 vertical feet; however recent fires which occurred in the watershed in 2003, further loaded the lake with ash and sediment.

Two mountain streams, the Rio En Medio and the Rio Frijoles, merge to form the Rio Santa Cruz a short distance upstream from the lake. The watershed supplying the lake is about 252.52 square kilometers (98 mi^2) in size, resulting in a 624:1 watershed to lake size ratio (Davis, 2007). The lake is located at 1,916 meters (6,285 ft) above sea level within the Level III Ecoregion 22 (the Arizona/New Mexico Plateau) contained within Aggregate Ecoregion III (the Xeric West) (Omernik, 1987) and receives an average of 23.1 cm (9.1 in) of precipitation per year based on a 13-year record (Gabin and Lesperance, 1977). Maximum depth reported during this study occurred during the spring sampling run and was 24 meters (79 ft) measured at the deep station near the dam. By the fall run, the depth at the deep station had dropped to 17.1 meters (56 ft).

Water quality standards for Santa Cruz Reservoir are set forth in section 20.6.4.121 NMAC with designated uses of domestic water supply, high quality coldwater aquatic life, irrigation, livestock watering, wildlife habitat, and primary contact. This study was designed to provide the data needed to determine if these uses are being supported and to assess whether water quality issues observed in past studies have improved or worsened.

Physical / Chemical Data

Lake chemistry sampling consisted of total and dissolved nutrients, anions and cations, total and dissolved heavy metals, volatile and semi-volatile organics, radionuclides, bacteria, and cyanide, which cover many water quality parameters pertinent to the protection of designated or existing uses (Table 2.1). Physical measurements collected at Santa Cruz Reservoir included Secchi depth, Forel-Ule color, pH, specific conductance, turbidity, dissolved oxygen, and temperature (Table 2.2).

Table 2.1. Chemical analyses performed at Santa Cruz Reservoir – 2009.

Samples Collected	Santa Cruz Deep			Santa Cruz Shallow		
	Spring	Summer	Fall	Spring	Summer	Fall
Major Anions and Cations	X	X	X	X	X	X
Total Nutrients	X	X	X	X	X	X
Dissolved Nutrients	X	X	X	X	X	X
Total Mercury and Selenium	X	X	X	X	X	X
Dissolved Metals	X	X	X	X	X	X
Radionuclides	X	X				
Volatile Organics	X	X				
Semi-Volatile Organics	X	X				
Cyanide	X	X				
E. coli	X	X	X			

Table 2.2. Physical characteristics for Santa Cruz Reservoir, 2009

Physical Characteristics		Deep Station	Shallow Station
Secchi Depth (m)	Sp	1.3	1.1
	Su	3.75	3.25
	Fall	3.00	1.25
Forel Ule Color	Sp	15	15
	Su	9	8
	Fall	11	11
Maximum Depth (m)	Sp	24	5.6
	Su	22	5.5
	Fall	17	1.25
Euphotic Zone Depth (m)	Sp	2	3.5
	Su	6	>5.5
	Fall	10.5	>1.25
pH (s.u.)	Sp	6.4	6.9
	Su	7.17	7.30
	Fall	6.22	6.58
Conductivity (μS)	Sp	73	70
	Su	83	84
	Fall	117	120
Turbidity (NTUs)	Sp	10.1	12.8
	Su	5.17	2.35
	Fall	2.70	1.17
Integrated Sample surface to depth (m)	Sp	5.0	3.0
	Su	20	4.5
	Fall	10	1.0
Dissolved Oxygen ** (mg/L)	Sp	9.63	9.33
	Su	6.81	6.95
	Fall	9.18	9.65
Dissolved Oxygen ** (% saturation)	Sp	114.1%	103.7%
	Su	100.3%	104.0%
	Fall	105.8%	114.5%
Dissolved Oxygen Bottom (mg/L)	Sp	6.52	9.26
	Su	**0.79**	**5.14**
	Fall	8.00	9.70
Anoxic Hypolimnion * (Y/N)	Sp	No	No
	Su	No	No
	Fall	No	No
Temperature ** (°C)	Sp	11.18	8.72
	Su	**22.43**	**24.09**
	Fall	10.24	11.06

Physical Characteristics		Deep Station	Shallow Station
Temperature Bottom (°C)	Sp	6.28	7.07
	Su	11.03	19.55
	Fall	8.68	10.82
Stratified (Y/N) @ depth (m)	Sp	Yes (1-2)	No
	Su	Yes (3-4)	Yes (2-3)
	Fall	No	No

Sp = Spring Su = Summer MDP = missing data point
* Anoxia exists when DO < 0.5 mg/L
** According to Subsection C, Paragraph 3 of 20.6.4.14 NMAC, dissolved oxygen and temperature are mean values from the epilimnion or, in the absence of an epilimnion, the upper 1/3 of water column
BOLD values indicate an excursion of the criterion.

Nutrient Data

A draft *Nutrient Assessment Protocol for Lakes and Reservoirs* has been developed by SWQB to implement the narrative criterion for plant nutrients at 20.6.4.13 NMAC; however further analyses on impairment thresholds are being conducted for total nitrogen and total phosphorous. Specifically, these analyses are evaluating the nutrient concentrations required to induce a biological shift (e.g., increase in algae growth, change in community composition, etc.). Until these analyses are complete and thresholds are identified, nutrient assessments should be considered provisional.

Sampling results from Santa Cruz Reservoir were compared to the thresholds identified in the draft AP. Referring to the nutrient variables found in Table 2.3, four of the six chlorophyll results exceeded the proposed upper threshold limit of 2.3 µg/L, however all total phosphorus and total nitrogen results were well below the suggested upper limits. Secchi depth was slightly below the 1.5 meter depth during the spring sampling run possibly due to sediment input from spring snowmelt. The nutrient related target for cyanobacteria or blue-green algae is fifty-percent or greater. Phytoplankton analyses resulting from the three seasonal samples collected were well below this threshold. The last suggested target is associated with the percentage of water column that falls below the associated dissolved oxygen criterion for fifty-percent or greater of the water complete profile. In only one instance did the profile fall below the dissolved oxygen criterion of 6.0 mg/L, which was during the summer sampling effort at the deep station. It was here that at seven meters, dissolved oxygen fell below the criterion; though at no point did the water column become anoxic.

Table 2.3. Nutrient-related indicators for Santa Cruz Reservoir, 2009.

		Deep Station	Shallow Station
Chlorophyll *a* (µg/L)	Sp	**6.74**	**3.49**
	Su	1.03	1.31
	Fall	**6.09**	**5.48**
Limiting Nutrient	Sp	N	N
	Su	N	P
	Fall	N	N

		Deep Station	Shallow Station
Total Phosphorus (mg/L)	Sp	**0.05**	**0.06**
	Su	**0.04**	0.01
	Fall	0.04	0.03
Total Nitrogen (mg/L)	Sp	0.36	0.22
	Su	0.33	0.23
	Fall	<0.1	0.20
Secchi Depth (m)	Sp	**1.3**	**1.1**
	Su	3.75	3.25
	Fall	3.0	1.25
% depth profile below D.O. criterion	Sp	0%	0%
	Su	**76%**	20%
	Fall	0%	0%
Cyanobacteria (%)	Sp	1.6 %	
	Su	0%	
	Fall	18.4%	
Provisional Assessment		**Fully Supporting**	

BOLD values indicate an excurision of the threshold for coldwater reservoirs.

Data collected during the 2009 study indicate that Santa Cruz Reservoir may be characterized as mesotrophic according to Carlson's (1977) indices for Secchi depth, chlorophyll *a*, total phosphorus, total nitrogen, and algal community composition (Table 2.4; Likens 1975) . Nitrogen was the primary limiting nutrient for algal productivity during all survey visits except for one result from the summer shallow station result (Table 2.3).

Table 2.4. Trophic State determinations for Santa Cruz Reservoir, 2009 (Carlson, 1977).

		Deep Station	Shallow Station
Secchi Depth	Sp	Eutrophic	Eutrophic
	Su	Mesotrophic	Mesotrophic
	Fall	Mesotrophic	Mesotrophic
Chlorophyll *a*	Sp	Mesotrophic	Mesotrophic
	Su	Oligomeso	Oligomeso
	Fall	Mesotrophic	Mesotrophic
Total Phosphorous	Sp	Eutrophic	Eutrophic
	Su	Eutrophic	Oligomeso
	Fall	Eutrophic	Eutrophic
Total Nitrogen	Sp	Oligomeso	Oligomeso
	Su	Oligomeso	Oligomeso
	Fall	Oligotrophic	Oligomeso
Overall Trophic Condition		**Mesotrophic**	

Biological Data

Phytoplankton

Phytoplankton samples were collected at the deep lake station during the spring, summer, and fall visits. The spring sample was dominated by the Chrysophyte, *Cryptomonas,* which comprised 41% of the phytoplankton community followed by a member of the genus *Komma* (26%), and the diatom *Fragilaria crotonensis* (19%). Only four individual cyanobacteria were identified in the spring comprising just 1.6% of the total count. The summer sample was similar except the most common member was the diatom *Asterionella formosa* (27%) with *Komma* (24%) and *Fragilaria crotonensis* (14%) being the next most dominant taxa. No blue-green algae were detected in the summer sample; however, a slight shift in community composition occurred in the fall collection. The diatom genus *Aulacoseira* was the most common taxon comprising 19% of the fall community followed by an unknown crysophyte (12%), *Cryptomonas* (11%), *Stephanodiscus* (11%), and the blue-green alga *Anabaena circinalis* var. *crassa* (8%). Eighteen percent of the fall community was blue-green algae, mainly due to the occurrence of *Anabaena circinalis* var. *crassa*. Diversity for the spring, summer, and fall phytoplankton communities measured 1.62, 2.11, and 2.54, respectively, according to the Shannon–Weaver Index (Shannon and Weaver 1949) suggesting low to moderate diversity with a gradual increase in species richness and evenness over the three seasons.

Fishing at Santa Cruz Reservoir, November 2009.

Periphyton Diatom Community Composition

A single multiple substrate shoreline periphyton sample was collected from Santa Cruz Reservoir on July 28th and analyzed to determine community composition. Of the six-hundred valves counted, the most common taxon was the diatom *Fragilaria crotonensis* Kitton var. *crotonensis,* which comprised about 29% of the community followed by *Achnanthes minutissima* Kütz. var. *minutissima* (18%), *Nitzschia agnita* (9%), *Nitzschia palea* Grun. var. *debilis* (7%), and *Navicula trivialis* Lange-Bertalot (3%). Diversity according to the Shannon-Weaver Index (Shannon and Weaver, 1949) was calculated to be 2.65 indicating a moderately high level of diversity with a calculated evenness, or equitability, of 0.714. In addition, a majority of the diatom community are known to withstand moderately polluted conditions with equal number of taxa being moderately tolerant of (36%) or, conversely, sensitive or intolerant to (36%) pollution.

Water Quality Status Assessment

All water quality sampling results for total and dissolved metals, radionuclides and organics were below detection or below established criteria, therefore the domestic water supply, irrigation, livestock watering, wildlife habitat and primary contact uses were assessed as fully supported (Table 2.5). Nevertheless, the high quality coldwater aquatic life use is not supported due to elevated summer temperatures (Table 2.2, Table 2.5). Temperatures exceeded the 20ºC criterion during the summer when there are longer days with increased solar radiation.

This condition of elevated summer temperature within Santa Cruz Reservoir was also observed during previous summer sampling events conducted in 1988 and 2000 suggesting that seasonal temperature exceedences may be common in this lake. NMED is reviewing the appropriateness of the high quality coldwater aquatic life use and the associated temperature criterion for this lake.

Table 2.5. Summary of attainment status for Santa Cruz Reservoir.

Designated or Existing Use	Impairment	Attainment Status*
Domestic Water Supply	None	Fully Supporting
High Quality Coldwater Aquatic Life	Temperature	Not Supporting
Irrigation	None	Fully Supporting
Livestock Watering	None	Fully Supporting
Wildlife Habitat	None	Fully Supporting
Primary Contact	None	Fully Supporting

* Attainment status is based on the water quality standards and assessment protocols in place at the time the data were assessed. Therefore, the impairment conclusions in the most recent 303(d) List (NMED/SWQB 2010) supersede attainment status in this report if they should differ.

East and West Fawn Lakes, Taos County
July 21 and October 6, 2009

Background

In 2009, SWQB conducted a two-season water quality survey on two small, off channel lakes located about 3.2 kilometers (2 mi) west of the town of Red River, and about 14 km (8.5 mi) east of the town of Questa, New Mexico, via State Road 38. Both East and West Fawn Lakes are supplied by water diverted from the Red River a short distance from both lakes, which first enters the east lake before flowing out and down to the western most lake. Access to the lakes is by foot path from either the parking area adjacent to State Road 38 or from the Elephant Rock Campground by way of a wheelchair accessible path to lakes. The lakes and adjoining campground are managed and maintained by the Questa Ranger District of the Carson National Forest and are located at an elevation of about 2,574 meters (8,438 ft) above mean sea level.


Lower (West) Fawn Lake, 2009.

East and West Fawn Lakes are located within the Southern Rockies of the Xeric West aggregate ecoregion (Omernik 2006). Average snowfall for the 102-year period of record is 374 cm (147.2 in) per year (WRCC 2009). Precipitation averages 53.4 cm (21.01 in) per year and pan evaporation averages 54.2 cm (21.3 in) per year resulting in a deficit of 15.6 cm (6.13 in) per year (Gabin and Lesperance, 1977). The New Mexico Department of Game and Fish stocks rainbow trout in the lakes for public enjoyment, and past collections of fish from East Fawn Lake in the early 1990s produced some cutthroat trout of significant size.

The lakes are located within water quality segment 20.6.4.123 NMAC with designated uses of domestic water supply, high quality coldwater aquatic life, irrigation, livestock watering, wildlife habitat and primary contact. This study was designed to provide the data needed to determine if these uses are being supported and to assess whether water quality issues observed in past studies have improved or worsened.

Physical / Chemical Data

Two seasonal sampling visits were performed on each of the Fawn Lakes. Lake chemistry sampling consisted of total and dissolved nutrients, anions and cations, total and dissolved heavy metals, volatile and semi-volatile organics, radionuclides, bacteria, and cyanide, which cover all water quality parameters pertinent to the protection of designated or existing uses (Table 3.1). Physical measurements collected at East and West Fawn Lakes included Secchi depth, Forel-Ule color, pH, specific conductance, turbidity, dissolved oxygen, and temperature (Table 3.2).

Table 3.1. Chemical analyses performed at East and West Fawn Lakes, 2009.

Analyses Performed	East Fawn Lake		West Fawn Lake	
	Summer	Fall	Summer	Fall
Major Anions and Cations	X	X	X	X
Total Nutrients	X	X	X	X
Dissolved Nutrients	X	X	X	X
Total Mercury and Selenium	X	X	X	X
Dissolved Metals	X	X	X	X
Radionuclides	X	X	X	X
Volatile Organics	X		X	
Semi-Volatile Organics	X		X	
Cyanide	X	X	X	X
E. coli	X	X	X	X

Table 3.2. Physical characteristics for East and West Fawn Lakes, 2009.

Physical Characteristics		East Fawn Lake	West Fawn Lake
Secchi Depth (m)	Summer	1.5	1.15
	Fall	1.3	0.9
Forel Ule Color	Summer	11	11
	Fall	13	13
Maximum Depth (m)	Summer	2.4	2.5
	Fall	2.1	2.1
Euphotic Zone Depth (m)	Summer	>2.4	>2.5
	Fall	>2.1	>2.1
pH (s.u.)	Summer	6.84	**6.37**
	Fall	8.76	**8.90**
Conductivity (µS)	Summer	225	224
	Fall	252	247
Turbidity (NTUs)	Summer	4.62	5.05
	Fall	5.79	7.00
Integrated Sample surface to depth (m)	Summer	1.5	2.0
	Fall	2.0	2.0
Dissolved Oxygen ** (mg/L)	Summer	7.44	7.45
	Fall	11.05	10.82
Dissolved Oxygen ** (% saturation)	Summer	100.4%	104.2%
	Fall	129.2%	127.4%
Dissolved Oxygen Bottom (mg/L)	Summer	7.95	7.67
	Fall	10.91	10.82
Anoxic Hypolimnion * (Y/N)	Summer	N	N
	Fall	N	N
Temperature ** (°C)	Summer	14.77	16.15
	Fall	8.74	8.8
Temperature Bottom (°C)	Summer	12.13	14.52
	Fall	8.45	8.8
Stratified (Y/N) @ depth (m)	Summer	Y (1-2)	N
	Fall	N	N

* Anoxia exists when DO < 0.5 mg/L

** According to Subsection C, Paragraph 3 of 20.6.4.14 NMAC, dissolved oxygen and temperature are mean values from the epilimnion or, in the absence of an epilimnion, the upper 1/3 of water column

MDP = missing data point

BOLD values indicate an excursion of the criterion.

Nutrient Data

A draft *Nutrient Assessment Protocol for Lakes and Reservoirs* has been developed by SWQB to implement the narrative criterion for plant nutrients at 20.6.4.13 NMAC; however further analyses on impairment thresholds are being conducted for total nitrogen and total phosphorous. Specifically, these analyses are evaluating the nutrient concentrations required to induce a biological shift (e.g., increase in algae growth, change in community composition, etc.). Until these analyses are complete and thresholds are identified, nutrient assessments should be considered provisional.

Sampling results from East and West Fawn Lakes were compared to the thresholds identified in the draft AP. Referring to the nutrient variables found in Table 3.3, during the summer both East and West Fawn Lakes had chlorophyll *a* values below the threshold value (2.3 µg/L), but exceeded this threshold in the fall. In addition, total phosphorus concentrations in East Fawn Lake were relatively high and exceeded the threshold of 0.05 mg/L during both seasons. Secchi depths were below the 1.5 meter threshold; however this was probably due to algal turbidity especially in the fall. There were no blue-green algal species identified in any of the samples collected (see *Biological Data* section below for more details). All other nutrient results within the limits identified in the draft AP.

Table 3.3. Nutrient-related indicators for East and West Fawn Lakes, 2009.

Indicator	Month	East Fawn Lake	West Fawn Lake
Chlorophyll *a* (µg/L)	Summer	1.96	1.96
	Fall	**9.35**	**11.21**
Total Phosphorus (mg/L)	Summer	**0.06**	0.047
	Fall	**0.290**	0.041
Total Nitrogen (mg/L)	Summer	0.30	0.260
	Fall	0.170	0.150
Limiting Nutrient	Summer	N	N
	Fall	N	N

Indicator	Month	East Fawn Lake	West Fawn Lake
Secchi Depth	Summer	1.5	**1.15**
	Fall	**1.3**	**0.9**
% depth below DO criterion	Summer	0%	0%
	Fall	0%	0%
Cyanobacteria (%)	Summer	No BG found	No BG found
	Fall	No BG found	No BG found
Provisional Assessment		**Fully Supporting**	**Fully Supporting**

BOLD values indicate an excursion of the threshold for coldwater reservoirs.

Data collected during the 2009 study indicate that both East and West Fawn Lakes may be characterized as mesotrophic according to Carlson's (1977) indices for Secchi depth, chlorophyll *a*, total phosphorus, total nitrogen, and algal community composition (Table 3.4; Likens 1975). Nitrogen was the primary limiting nutrient for algal productivity during both survey visits (Table 3.3).

Table 3.4. Trophic State (Carlson 1977)

	Month	East Fawn Lake	West Fawn Lake
Secchi Depth	Summer	Eutrophic	Eutrophic
	Fall	Eutrophic	Eutrophic
Chlorophyll *a*	Summer	Oligomesotrophic	Oligomesotrophic
	Fall	Eutrophic	Eutrophic
Total Phosphorous	Summer	Eutrophic	Eutrophic
	Fall	Eutrophic	Dystrophic
Total Nitrogen	Summer	Oligomesotrophic	Oligomesotrophic
	Fall	Oligotrophic	Oligotrophic
Overall Trophic Condition		**Mesotrophic**	**Mesotrophic**

Biological Data

Phytoplankton

The July phytoplankton community composition for **East Fawn Lake** was dominated by the diatom *Diatoma,* which totaled over 37% of the count followed by the diatom *Fragilaria* (15%), the chrysophyte or golden algae genus *Mallomonas* (12%), the diatom *Encyonopsis krammeri* Reichardt (11%), and *Cryptomonas* (7%). The October phytoplankton sample was dominated by non-descript "small nano-flagellates," which comprised 39% of the community. Species of *Cryptomonas* (13%), *Komma* (12%), *Chlamydomonas* (11%) and *Synura* (9%) completed the top five most common taxa present. No blue-green algae were detected in either the summer or fall sample. Diversity for the spring and fall phytoplankton communities measured 2.04 and 1.94, respectively, according to the Shannon–Weaver Index (Shannon and Weaver, 1949) suggesting moderate to low diversity with a gradual decrease in species richness over time.

The **West Fawn Lake** phytoplankton community composition from the July sample resulted in twenty-two species again with a predominance of the non-defined "small nano-flagellates," which totaled 19% of the community identified followed by *Mallomonas* (16%), *Diatoma* (11%), *Komma* (9%), and *Cryptomonas* (7%). The October phytoplankton sample was dominated by a species of *Komma* representing over 28% of the community. The next most abundant taxa were *Chlamydomonas* (18%), small nano-flagellates (16%), a diatom species of *Fragilaria* (13%) and another from the genus *Nitzschia* (6%). No blue-green algae were detected in either the summer or fall sample. Diversity for the spring and fall phytoplankton communities measured 2.51 and 2.05, respectively, according to the Shannon–Weaver Index (Shannon and Weaver, 1949) suggesting moderate to low diversity with a gradual decrease in species richness over time.

Periphyton Diatom Community Composition

A single multiple substrate shoreline composite sample (periphyton) was collected from each of the Fawn Lakes during the July visit to determine their diatom community composition. Of the twenty-nine species identified from **East Fawn Lake**, the most common taxon was *Fragilaria capucina* var. *mesolepta* (Rabenhorst) which comprised about 40% of the community followed by *Achnanthes minutissima* (Kütz) Czarnecki (16%), *Diatoma moniliformis* Kützing (7%), *Fragilaria vaucheriae* (Kütz.) Peterson (7%) and *Fragilaria capucina* Desm (6%). Together, these five species comprised about seventy percent of the total community. Diversity according to the Shannon-Weaver Index (Shannon and Weaver, 1949) was calculated to be 2.18 indicating a moderate level of diversity with a calculated evenness, or equitability, of 0.647. In addition, a majority of the diatom community in **East Fawn Lake** is known to withstand moderately polluted conditions; however roughly 20% of the community is also sensitive or intolerant to pollution.

West Fawn Lake diatom community composition consisted of forty-four species with Fragilaria sepes Ehrenberg comprising 15% of the community followed by Fragilaria brevistriata Grun. (14%), Diatoma tenuis C. Agardh (9%), Achnanthes minutissima (Kütz.) Czarnecki (8%) and Staurosirella pinnata (Ehrenb.) D.M. Williams et Round (1987) (5%). Together, these five species comprised about 52% of the community. Diversity according to the Shannon-Weaver Index (Shannon and Weaver, 1949) was calculated to be 3.01 indicating a moderately high level of diversity with a calculated evenness, or equitability, of 0.795. In addition, a majority of the diatom community in **West Fawn Lake** is known to withstand moderately polluted conditions; however roughly 34% of the community is also sensitive or intolerant to pollution.

Water Quality Status Assessment

Based on the sampling results, all designated uses are fully supported in both lakes (Tables 3.5a and b). In the case of West Fawn Lake, measured pH concentrations in July and October were 6.4 and 8.9 respectively, slightly outside the acceptable pH range of 6.6 – 8.8 standard units. Under the current assessment protocol (NMED/SWQB 2011), a departure from the established pH range by less than 0.5 pH units is not considered grounds for a determination of aquatic life use impairment. However, these results are curious especially in light of the fact that East Fawn Lake, which discharges into the lower lake, showed no exceedences of the pH criterion.

Table 3.5a. Summary of attainment status for East Fawn Lake.

Designated Use	Impairment	Attainment Status*
High Quality Coldwater Aquatic Life	None	Fully Supporting
Domestic Water Supply	None	Fully Supporting
Irrigation	None	Fully Supporting
Wildlife Habitat	None	Fully Supporting
Livestock Watering	None	Fully Supporting
Primary Contact	None	Fully Supporting

Table 3.5b. Summary of attainment status for West Fawn Lake.

Designated Use	Impairment	Attainment Status*
High Quality Coldwater Aquatic Life	None	Fully Supporting
Domestic Water Supply	None	Fully Supporting
Irrigation	None	Fully Supporting
Wildlife Habitat	None	Fully Supporting
Livestock Watering	None	Fully Supporting
Primary Contact	None	Fully Supporting

* Attainment status is based on the water quality standards and assessment protocols in place at the time the data were assessed. Therefore, the impairment conclusions in the most recent 303(d) List (NMED/SWQB 2010) supersede attainment status in this report if they should differ.

4.0 Goose Lake, Taos County
July 22 and October 7, 2009

Background

In 2009, the SWQB conducted a two-season water quality survey on a high elevation cirque lake located within the Sangre de Cristo Mountains of northern New Mexico. This lake may be the only high elevation cirque lake in New Mexico where access can be attained with the aid of a four-wheel drive vehicle. To access the lake from the town of Red River, take forest road 486 which begins about 0.8 kilometers (0.5 mi) south of the town and proceed about 13 km (8 mi) by way of the four-wheel drive road to the parking area located a short walk from the lake.

Goose Lake is a 2.4 hectare (6 acre) lake that sits within a glacial cirque at an elevation of 3,546 meters (11,635 ft) where annual precipitation is estimated to average about 90 cm (36 in) per year (NRCS, SNOTEL). The lake is located in the Southern Rockies of the Xeric West aggregate ecoregion (Omernik 2006).


October snow at Goose Lake, 2009.

Goose Lake is classified in water quality segment 20.6.4.123 NMAC with designated uses of domestic water supply, high quality coldwater aquatic life, irrigation, livestock watering, wildlife habitat and primary contact. This study was designed to provide the data needed to determine if these uses are being supported, and to assess whether water quality issues observed in past studies have improved or worsened.

Goose Lake was last studied by NMED in September of 1985. At that time, it was concluded that unabated lake shore access to camping and vehicular traffic was a probable cause for the eutrophic condition. In recent years, the U.S. Forest Service (Questa Ranger District) has excluded vehicular traffic to the lake shore to protect vegetation and riparian habitat. A path along the lakeshore also limits bank destabilization and protects vegetation. Seasonal stocking of trout by the New Mexico Department of Game and Fish provide fishing opportunities that have been enhanced through the construction of small fishing platforms around the lake. The results of this survey suggest that management strategies are improving water and habitat quality.

Physical / Chemical Data

Lake chemistry sampling consisted of total and dissolved nutrients, anions and cations, total and dissolved heavy metals, volatile and semi-volatile organics, radionuclides, bacteria, and cyanide, which cover all water quality parameters pertinent to the protection of designated or existing uses (Table 4.1). Physical measurements collected at Goose Lake included Secchi depth, Forel-Ule color, pH, specific conductance, turbidity, dissolved oxygen, and temperature (Table 4.2).

Table 4.1. Chemical analyses performed at Goose Lake, 2009.

Goose Lake	Summer	Fall[1]
Major Anions and Cations	X	X
Total Nutrients	X	X
Dissolved Nutrients	X	X
Total Mercury and Selenium	X	X
Dissolved Metals	X	X
Radionuclides	X	X
Volatile Organics	X	
Semi-Volatile Organics	X	
Cyanide	X	
E. coli	X	X

1 Fall water samples and field data were collected from shore due to weather conditions at time of sampling

Table 4.2. Physical characteristics for Goose Lake, 2009.

Characteristic	Goose Lake Summer	Goose Lake Fall[1]
Secchi Depth (m)	>2.0	MDP
Forel Ule Color	9	8
Maximum Depth (m)	2.0	Est 3.0
Euphotic Zone (m)	>2.0	Est >3.0
pH (s.u.)	7.77	7.52
Conductivity (µS/cm)	73	82
Turbidity (NTUs)	1.32	0.96
Integrated Sample surface to depth (m)	1.5	0.25
Dissolved Oxygen ** (mg/L)	6.48	9.43
Dissolved Oxygen ** (% saturation)	91.3%	101.6%
Dissolved Oxygen Bottom (mg/L)	6.65	MDP
Anoxic Hypolimnion * (Y/N)	N	MDP
Temperature ** (°C)	11.74	1.4
Temperature Bottom (°C)	11.26	MDP
Stratified (Y/N) @ depth (m)	N	MDP

1 Fall water samples and field data were collected from shore due to weather conditions at time of sampling
* Anoxia exists when DO < 0.5 mg/L
** According to Subsection C, Paragraph 3 of 20.6.4.14 NMAC, dissolved oxygen and temperature are mean values from the epilimnion or, in the absence of an epilimnion, the upper 1/3 of water column
MDP = missing data point
Est = visually-estimated value
BOLD values indicate an exceedence of the criterion.

Nutrient Data

A draft *Nutrient Assessment Protocol for Lakes and Reservoirs* has been developed by SWQB to implement the narrative criterion for plant nutrients at 20.6.4.13 NMAC; however further analyses on impairment thresholds are being conducted for total nitrogen and total phosphorous. Specifically, these analyses are evaluating the nutrient concentrations required to induce a biological shift (e.g., increase in algae growth, change in community composition, etc.). Until these analyses are complete and thresholds are identified, nutrient assessments should be considered provisional.

Sampling results from Goose Lake were compared to the thresholds identified in the draft AP. Referring to the nutrient variables found in Table 4.3, nutrient concentrations in Goose Lake were well below the thresholds identified in the Draft AP. In addition, all of the response variables (i.e., chlorophyll *a*, Secchi depth, % depth profile below DO criterion, and % cyanobacteria) were well below levels of concern or, in the case of blue-green algae, not detected.

Table 4.3. Nutrient-related indicators for Goose Lake, 2009.

	Summer	Fall[1]
Chlorophyll *a* (µg/L)	0.28	0.56
Total Phosphorus (mg/L)	0.008	0.034
Total Nitrogen (mg/L)	0.16	0.10
Limiting Nutrient	P	N
Secchi Depth	>2.0	Est. 3.0
% depth profile below DO criterion	0%	MDP
Cyanobacteria (%)	No BG observed	MDP
Provisional Assessment	**Fully Supporting**	

1 Fall water samples and field data were collected from shore due to weather conditions at time of sampling

Data collected during the 2009 study indicate that Goose Lake may be characterized as oligo-mesotrophic according to Carlson's (1977) indices for Secchi depth, chlorophyll *a*, total phosphorus, total nitrogen, and algal community composition (Table 4.4; Likens 1975). Phosphorus was the limiting nutrient during the July sampling visit, but nitrogen was the primary limiting nutrient for algal productivity during the October survey visit (Table 4.3).

Table 4.4. Trophic State (Carlson 1977)

	Summer	Fall
Secchi Depth	Oligomesotrophic	Oligomesotrophic
Chlorophyll *a*	Oligotrophic	Oligotrophic
Total Phosphorous	Oligomesotrophic	Eutrophic
Total Nitrogen	Oligotrophic	Oligotrophic
Overall Trophic Condition		**Oligomesotrophic**

Biological Data

Phytoplankton

The summer phytoplankton community for Goose Lake was dominated by what is reported as "small nano-flagellates," which comprised almost 56% of the twenty-three species identified, followed by two diatoms: a species of *Staurosira* (7%) and a member of the genus *Diatoma* (5%), and two members of the Cryptophyta: *Komma* (5%) and a species of *Cryptomonas* (4%). No cyanobacteria, or blue-green algae, were observed in the sample. Diversity measured 1.89 according to the Shannon–Weaver Index (Shannon and Weaver, 1949) suggesting low diversity.

Periphyton Diatom Community Composition

A single multiple substrate shoreline sample (periphyton) was collected from Goose Lake during the July visit to determine community composition. Almost 50% of the diatom community consisted of *Staurosirella pinnata* (Ehrenb.) D.M. Williams et Round (formerly *Fragilaria pinnata*) followed by *Fragilaria construens* (Ehrenberg) Grunow (11%), *Cymbella silesiaca* Bleisch (8%), *Achnanthes minutissima* (Kütz) Czarnecki (6%), and an undetermined species of *Gomphonema* Ehrenberg (1832) (3%). Together, these five species comprised about 78% of the total community identified. Diversity according to the Shannon-Weaver Index (Shannon and Weaver, 1949) was calculated to be 2.13 indicating a moderate level of diversity with a calculated evenness, or equitability, of 0.586. In addition, a majority of the diatom community in Goose Lake is known to withstand moderately polluted conditions; however roughly 28% of the community is also sensitive or intolerant to pollution.

Water Quality Status Assessment

All physical and chemical water quality sampling results were below detection or consistent with applicable water quality criteria. All designated uses are fully supported (Table 4.5). Management practices such as the exclusion of traffic from the immediate lakeside area and convenient fishing platforms that regulate access to specific sites have benefited this natural, high mountain cirque lake.

Table 4.5. Summary of attainment status for Goose Lake.

Designated Use	Impairment	Attainment Status*
High Quality Coldwater Aquatic Life	None	Fully Supporting
Domestic Water Supply	None	Fully Supporting
Irrigation	None	Fully Supporting
Primary Contact	None	Fully Supporting
Livestock Watering	None	Fully Supporting
Wildlife Habitat	None	Fully Supporting

* Attainment status is based on the water quality standards and assessment protocols in place at the time the data were assessed. Therefore, the impairment conclusions in the most recent 303(d) List (NMED/SWQB 2010) supersede attainment status in this report if they should differ.

REFERENCES

Carlson, R.E. 1977. A Trophic Index for Lakes. Limnol. Oceanogr. 22: 361-369.

Davis, D.R. 1998. Water Quality and Biological Assessment Survey of Bear Canyon Reservoir in Grant County, New Mexico, April 15, July 15 and October 21, 1996, p. 1-21. *In* Lake Water Quality Assessment Surveys for Selected New Mexico Lakes, 1996. NMED/SWQ-98/2. 88 p.

Davis, D.R. 2007. Water Quality and Biological Assessment Survey of Santa Cruz Reservoir, Santa Fe County, New Mexico, April 4, July 12, and September 26, 2000, p. 8-13. *In* Water Quality Assessments for Selected New Mexico Lakes, 2000. NMED-SWQ-07/01.

Gabin, V.L., and L.E. Lesperance. 1977. New Mexico Climatological Data: Precipitation, Temperature, Evaporation, and Wind. Monthly and Annual Mean 1850-1975. W.K. Summers and Associates.

Gustin, Michael. New Mexico Department of Game and Fish. Personal communication.

Likens, G. 1975. Primary Production of Inland Aquatic Ecosystems. *In* Primary Productivity of the Biosphere. Leath, H., and R.H. Whittaker [eds].

Maestas, J. 2009. Santa Cruz Irrigation District. Personal communication.

New Mexico Environment Department/Surface Water Quality Bureau (NMED/SWQB). 2009. Quality Assurance Project Plan for Water Quality Management Programs. Surface Water Quality Bureau. Santa Fe, NM.

NMED/SWQB. 2010. 2010-2012 State of New Mexico Clean Water Act §303(d)/§305(b) Integrated Report. Santa Fe, NM.

NMED/SWQB. 2011. *Procedures for Assessing Water Quality Standards Attainment for the State of New Mexico CWA §303(d)/§305(b) Integrated Report: Assessment Protocol*. Santa Fe, NM. May 31, 2011.

NRCS, SNOTEL. http://www.wcc.nrcs.usda.gov/snotel/New_Mexico/new_mexico.html

Omernik, J.M. and Griffith, G. 2006. Level III & IV Ecoregions of New Mexico. U.S. EPA National Health and Environmental Effects Laboratory, Corvallis, Or.

Potter, D. U. 1982. New Mexico clean lakes program classification Phase I Final report. EID/WPC-82/4. 75 p. plus appendix.

Shannon, C.E. and W. Weaver. 1949. The Mathematical Theory of Communication. University Press, Cambridge.

Western Regional Climate Center – Desert Research Institute (WRCC – DRI) 2009. (http://www.wrcc.dri.edu/summary/Climsmnm.html).