NMED/SWQ-07/2

WATER QUALITY ASSESSMENTS FOR SELECTED NEW MEXICO LAKES

2005

Monitoring and Assessment Section
Surface Water Quality Bureau
New Mexico Environment Department
1190 St. Francis Drive - P.O. Box 26110
Santa Fe, New Mexico 87502

This page left intentionally blank.

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

Eagle Nest Lake and Fenton Lake

2005

EXECUTIVE SUMMARY

Water quality surveys and assessments were completed in fulfillment of work-plan commitments of the *FY 2004-2005 section 106 Work Program for Water Quality Management.* This program was partially funded by a grant from the U.S. Environmental Protection Agency.

Eagle Nest Lake looking north towards village of Eagle Nest

During 2005 the Monitoring and Assessment Section of the Surface Water Quality Bureau of the New Mexico Environment Department conducted water quality and biological assessment surveys of two lacustrine systems. Eagle Nest Lake and Fenton Lake were studied concurrently with an intensive Total Maximum Daily Load (TMDL) stream study conducted within the Jemez River watershed and upper Canadian River watershed. Studying lakes in this way helps to insure a timely return to the lake system as watersheds are revisited, and also adds to the understanding of surface waters within the drainage basin. Eagle Nest Lake is an impoundment located within the Moreno Valley and is New Mexico's highest large reservoir. It shares the Moreno valley with the village of Eagle Nest and the town of Angel Fire where a major ski area also resides. This lake empties into the Cimarron River, a tributary to the Canadian River.

Fenton Lake State Park

Fenton Lake is a small lake located within the Santa Fe National Forest within the Jemez Mountains west of Santa Fe, New Mexico. It is the only significant impoundment within the Jemez watershed, and though it has been studied extensively in the past, a recent forest fire was located in an area immediate to the lake, and has resulted in serious sediment and water quality problems.

Water quality sampling methods used during these surveys were in accordance with the "Quality Assurance Project Plan for Water Quality Management Programs" (NMED 2005).

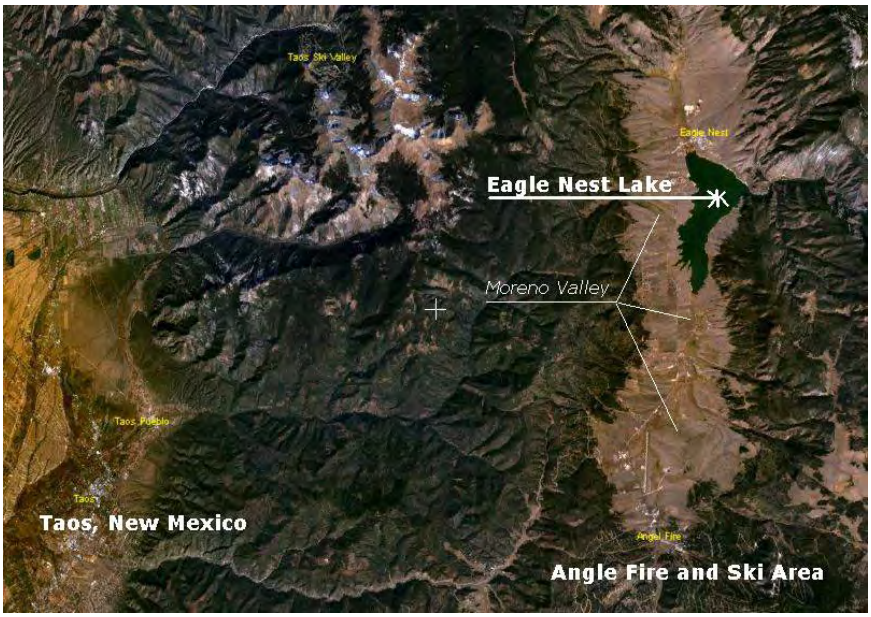
The following assessments provide information pertaining to water quality, biological integrity, trophic state, limiting nutrients, water quality criteria exceedences and water quality standards specific to existing, attainable or designated uses in the State of New Mexico Standards for Interstate and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

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 Eagle Nest Lake, Colfax County, April 19, July 19 and October 18, 2005.
Danny R. Davis, Principal Investigator



Eagle Nest Lake is one of the oldest reservoirs in New Mexico, and is impounded by a concrete dam, which was completed in June of 1918 (USGS, 2003). Charles and Frank Springer built the lake to store irrigation water derived from three perennial streams that feed the lake. Cieneguilla, Six Mile and Moreno Creeks transport most of the Moreno Valley water into Eagle Nest Lake (Joseph, 1998). The reservoir is located within the Moreno Valley where two communities, Eagle Nest and Angel Fire are located. Angel Fire is also home to the Angel Fire Ski Area where visitors from New Mexico and neighboring States come to enjoy the high elevation recreational opportunities. Both Angel Fire, and Eagle Nest treat or contain domestic waste water from the communities, and in the case of Angel Fire, discharge into Cieneguilla creek which empties into Eagle Nest Lake about ten miles north of the waste water facility. The Moreno Valley is also experiencing growth as a result of development as many find the high elevation valley an attractive location for summer cabins or full time residence.

Maximum storage capacity is about 81,360 acre-feet at maximum pool while lake levels during this study were low due to a prolonged drought period. The elevation of the lake is about 2,499 meters (8,200 ft.) above mean sea level making Eagle Nest Reservoir the highest large lake in New Mexico. The Lake is located within the Southern Rockies ecoregion contained within Aggregate Ecoregion III (the Xeric West) (Omernik, 1987) and receives an average of 37.1 cm (14.61 in.) of precipitation per year with pan evaporation historically averaging 55.4 cm (21.8 in) per year resulting in a deficit of 22.5 cm (8.88 in) per year (Gabin and Lesperance, 1977).


Eagle Nest Lake at Dam

Eagle Nest Lake was purchased by the State of New Mexico, Department of Game and Fish in 2002, and now is managed by the New Mexico State Parks who took control of the recreational facilities at the lake in 2004. A new and improved boat ramp has been built, camping areas developed and a visitor's interpretive center is currently under construction.

Water quality studies have been performed prior to this investigation. In 1975, the Office of Research and Development of the U.S. Environmental Protection Agency included Eagle Nest Lake in a nation-wide study to determine the rate of increased eutrophication in U.S. lakes (USEPA, 1977). In 1988, the author conducted a three seasons, two station study on Eagle Nest Lake and in 1998, Joseph conducted a three season study as well.

Eagle Nest Lake is classified under segment 20.6.4.309 NMAC in New Mexico Water Quality Standards for Interstate and Intrastate Surface Waters (NMAC 2006), where designated uses of high quality coldwater aquatic life, domestic water supply, irrigation, livestock watering, wildlife habitat, municipal and industrial water supply and secondary contact. The principal fish species as recognized and supported by the New Mexico Department of Game and Fish are Kokanee and Coho Salmon, Rainbow and Cutthroat Trout. Perch have been reported to be of catchable size by State Park employees.

Table 1A. Physical Characteristics for Eagle Nest Lake, 2005.

Physical Characteristics	Deep Station		Shallow Station	
Secchi (m)	Sp	0.75	Sp	0.75
	Su	2.5	Su	1.7
	Fall	3.7	Fall	2.4
Forel Ule Color	Sp	12	Sp	13
	Su	13	Su	14
	Fall	14	Fall	14
Maximum Depth (m)	Sp	20.0	Sp	2.3
	Su	22.5	Su	3.7
	Fall	21.7	Fall	4.0
Euphotic Zone (m)	Sp	3.0	Sp	2.25
	Su	5.6	Su	>3.7
	Fall	6.0	Fall	>4.0
Surface Area (Acres)	Sp	MDP	Sp	MDP
	Su	MDP	Su	MDP
	Fall	MDP	Fall	MDP
Storage Capacity (Ac. Ft.)	Sp	MDP	Sp	MDP
	Su	MDP	Su	MDP
	Fall	MDP	Fall	MDP

Table 1A. con't.

Physical Characteristics		Deep Station		Shallow Station
Anoxic Hypolimnion (Y/N)	Sp	No	Sp	No
	Su	Yes	Su	Yes
	Fall	No	Fall	No
Stratified (Y/N) @ depth (m)	Sp	Yes (16-17)	Sp	No
	Su	Yes (8-9)	Su	Yes (1-2)
	Fall	No	Fall	No
pH (s.u.)	Sp	6.54	Sp	6.56
	Su	7.93	Su	7.84
	Fall	7.64	Fall	6.72
Conductivity (μS)	Sp	310	Sp	310
	Su	288	Su	296
	Fall	309	Fall	311
Turbidity (NTUs)	Sp	6.21	Sp	4.50
	Su	3.42	Su	4.92
	Fall	2.27	Fall	2.39
Integrated Sample surface to (m)	Sp	3.0	Sp	2.25
	Su	22.0	Su	3.0
	Fall	6.0	Fall	4.0
Dissolved Oxygen Surface (mg/L)	Sp	7.39	Sp	6.69
	Su	5.47	Su	5.34
	Fall	5.46	Fall	5.41
Dissolved Oxygen Bottom (mg/L)	Sp	5.95	Sp	6.68
	Su	0.14	Su	0.33
	Fall	3.94	Fall	4.93
Temperature Surface (°C)	Sp	8.94	Sp	7.53
	Su	19.48	Su	20.4
	Fall	13.46	Fall	13.08
Temperature Bottom (°C)	Sp	5.65	Sp	6.68
	Su	14.57	Su	18.21
	Fall	12.43	Fall	12.54
Chlorophyll *a* (μg/L)	Sp	MDP	Sp	4.30
	Su	19.06	Su	9.91
	Fall	2.24	Fall	0.93

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

Table 2A.

Trophic State (Carlson, 1977)	Deep Station		Shallow Station	
Secchi depth	Sp	Eutrophic	Sp	Eutrophic
	Su	Mesotrophic	Su	Eutrophic
	Fall	Mesotrophic	Fall	Mesotrophic
Chlorophyll *a*	Sp	MDP	Sp	Mesotrophic
	Su	Eutrophic	Su	Eutrophic
	Fall	Oligomeso	Fall	Oligotrophic
Total Phosphorus	Sp	Eutrophic	Sp	Eutrophic
	Su	Hypereutrophic	Su	Hypereutrophic
	Fall	Hypereutrophic	Fall	Hypereutrophic
Total Nitrogen	Sp	Mesotrophic	Sp	Eutrophic
	Su	Mesotrophic	Su	Mesotrophic
	Fall	Eutrophic	Fall	Eutrophic

Overall Trophic Condition	Mesoeutrophic

Table 3A.

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

Table 4A.

Designated or Attainable Use	Criteria Exceedence	Attainment Status
High Quality Coldwater Aquatic Life	Low DO, Hg/Fish	Not Supporting
Domestic water supply	Arsenic, 4/6	Not Supporting
Irrigation	None	Fully Supporting
Livestock Watering	None	Fully Supporting
Wildlife Habitat	None	Fully Supporting
Secondary Contact	None	Fully Supporting
Municipal and Industrial Water Supply	None	Fully Supporting

Water Quality Assessment

Lake chemistry sampling consisted of total, dissolved and calculated nutrients, anions and cations, total and dissolved heavy metals, synthetic organics, radionuclides, bacteria, and cyanide, which cover all standards criteria pertinent to the protection of all designated uses (Table 1A). These data are available upon request, though any criteria exceedences will be discussed below. Eagle Nest Lake may be classified as mesoeutrophic according to Carlson's (1977) indices, and algal community composition (Likens 1975). Table 2A shows the variation observed seasonally and between stations for secchi depth, chlorophyll *a*, total phosphorus and total nitrogen. The nitrogen and phosphorus ratio showed that nitrogen was the limiting nutrient during five of the six visits and co-limiting for the remaining result (Table 3A). Phytoplankton community composition and benthic diatom results remain unavailable at the time of this writing. Data for both of these biological components will be available in the near future.

Eagle Nest Lake experienced thermal stratification during the summer sampling visit and at the deep station in the spring. Dissolved oxygen fell below criteria for high quality coldwater aquatic life at both stations in the summer and fall sampling visits resulting in non-support of this use. Furthermore, a fish consumption advisory remains in effect for Eagle Nest Lake also resulting in an impairment of the aquatic life use. One exceedence of six measurements for pH were below the 6.6 lower criteria but did not constitute a use impairment. The lower pH was most likely due to heavy spring snow melt. Snow is typically acidic, and reports show that the lake elevation increased by 13 feet during the spring.

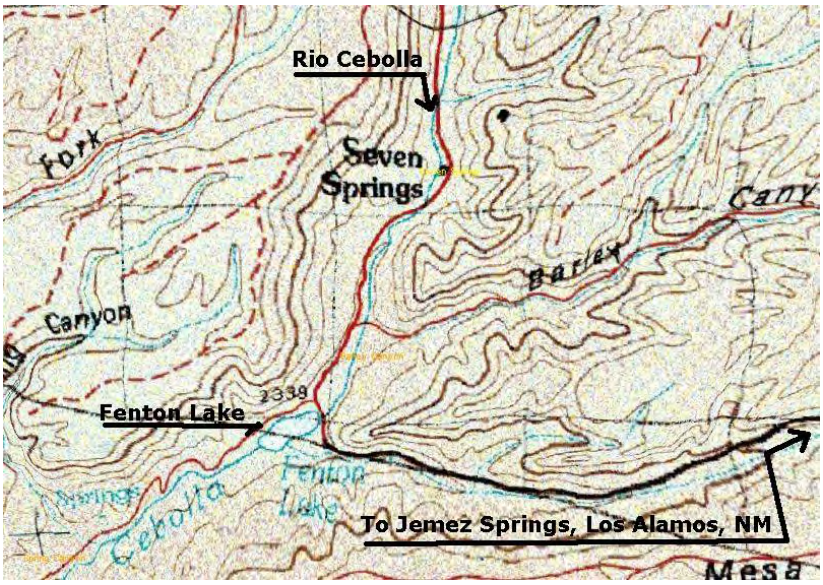
Four of six heavy metals results for arsenic exceeded the 2.3 parts per billion criteria adopted for the protection of the domestic water supply use (Table 4A). The source of the arsenic is unknown, and may be naturally occurring. In 1998, a similar study conducted by this agency showed levels similar to those in 2005, however, water quality standard criterion applicable at the time of the 1998 study were .05 mg/L or 50 ppb (NMAC, 1995). All other uses were fully supported during this study at Eagle Nest Lake.

Water Quality and Biological Assessment Survey of Fenton Lake, Sandoval County, July 13, 2005.

Danny R. Davis, Principal Investigator

Fenton Lake and dam with burnt forest in background

Fenton Lake is located in north-central New Mexico approximately 65 km (40 mi) west of Los Alamos, and about 114 km (70 mi) northwest of Albuquerque, New Mexico. Fenton Lake State Park manages the lake and provides fishing access, camping, hiking and non-motorized boating within the 700 acre park. The 37 acre lake is fed by the Rio Cebolla, a perennial stream that drains a 123.6 mi^2 (79,232 acre) watershed resulting in a 2,140/1 watershed to lake size ratio. This huge watershed to lake size ratio helps to explain why Fenton Lake continues to suffering from nutrient enrichment. In August of 2002, a 4,600 acre forest wildfire scorched the mountains to the east of Fenton Lake resulting in high sediment and ash input to the lake. The photo above shows some of the burnt forest in the background. As would be expected, the maximum depth has been significantly reduced due to sediment input from the burnt areas. Early estimates by Potter (1983) calculated a maximum volume of Fenton Lake at about 264 acre feet; however, this has been significantly reduced since her classification study occurred. Potter also examined the nutrient load contributed by the village of Seven Springs, and the New Mexico Department of Game and Fish operated Seven Springs Fish Hatchery, the latter known to contribute nutrients to Cebolla Creek. The image above also shows the very green condition during the sampling visit, an indication of heavy nutrient load.



Fenton Lake sedimentation concerns are not new, nor only caused by the forest fire, but date back many years. In 1989, the New Mexico State Legislature appropriated moneys targeted at dredging Fenton Lake in an attempt to return original lake volume, reduce macrophyte

coverage and improve fishing conditions. After careful analyses, it was determined that dredging the lake would have very deleterious effects on water quality in the lake and the Rio Cebolla downstream of the lake. After additional legislative funding was provided, the dam was raised two feet, which accounted for the lost storage capacity, and as directed by the State Engineer's Office, the emergency overflow canal was improved and enlarged to accommodate a fifty year storm event. Additional funds allowed for the construction of fishing platforms along the shoreline and wheelchair access. The benefits from raising the dam have certainly been compromised by the sediment input consequent to the 2002 forest fire.

Fenton Lake is addressed by water quality segment 20.6.4.108 where designated uses of high quality coldwater aquatic life, domestic water supply, fish culture, irrigation, livestock watering, wildlife habitat and secondary contact are recognized. The fishery provided by the New Mexico Department of Game and Fish consists solely of rainbow trout, though some native brown trout find their way into the lake from the upper Cebolla Creek.

Table 1B. Physical characteristics for Fenton Lake.

Physical Characteristics	Fenton Lake
Secchi Depth (m)	0.30
Forel Ule Color	15
Maximum Depth (m)	4.3
Euphotic Zone (m)	1.0
Surface Area (Acres)	Est. 24
Anoxic Hypolimnion (Y/N)	N
Stratified (Y/N) @ (m)	Y
pH (s.u.) Surface	7.19
Conductivity (µS) (Surface)	115
Turbidity (NTUs)	26.5
Integrated sample surface to (m)	3.5
Dissolved Oxygen Surface (mg/L)	9.43
Dissolved Oxygen Bottom (mg/L)	2.99
Temperature Surface (°C)	19.96
Temperature Bottom (°C)	16.69
Chlorophyll *a* (µg/L)	66.87

Table 2B. Trophic State (Carlson, 1977)

Trophic State Indices	Deep Station	
Secchi depth	Su	Hypereutrophic
Chlorophyll *a*	Su	Hypereutrophic
Total Phosphorus	Su	Eutrophic
Total Nitrogen	Su	Eutrophic

Overall Trophic Condition	**Eutrophic**

Table 3B. Nitrogen/Phosphorus Ratio

	Deep Station
Limiting Nutrient	**P**

Table 4B. Section 20.6.4.108 designated uses and existing uses for Fenton Lake.

Designated or Attainable Use	Criteria Exceedence	Attainment Status
Domestic Water Supply	None	Fully Supporting
Fish Culture	None	Fully Supporting
High Quality Coldwater Aquatic Life	None	Fully Supporting
Irrigation	None	Fully Supporting
Livestock Watering	None	Fully Supporting
Wildlife Habitat	None	Fully Supporting
Secondary Contact	None	Fully Supporting

Water Quality Assessment

Lake chemistry sampling consisted of total and dissolved nutrients, anions and cations, total and dissolved heavy metals, synthetic organics, radionuclides, cyanide and bacteriological, which covers all standards criteria pertinent to the protection of all designated uses. Phytoplankton, diatom and chlorophyll analyses were also performed (Table 1B). These data are available upon request, though any criteria exceedences will be discussed below.

Fenton Lake may be classified as eutrophic to hypereutrophic according to Carlson's (1977) indices, and algal community composition (Likens 1975). Table 2B shows trophic variation observed during the single summer visit for Secchi depth, chlorophyll *a*, total phosphorus and total nitrogen. The N/P ratio indicated that phosphorous was the limiting nutrient on the day of sampling (Table 3B).

For over 60 years, Fenton Lake has provided a desirable destination for fisherman and those attracted to high elevation, mountain recreational activities. However, as with many impoundments in New Mexico, the huge watershed continually supplies nutrient load to this tiny lake. Add to this the impacts of forest roads, community development at Seven Springs, and nutrient input from the Seven Springs Fish Hatchery, and you have the conditions for increasing enrichment and subsequent deterioration of water quality. The 4,600 acre forest fire only added to these stresses, and may have changed the overall nature of the lake, until such time as extensive remediation is considered.

Table 4B indicates that all designated uses were fully supported during the sampling visit, however, a stream sampling study of the Jemez River and tributaries resulted in some exceedences of temperature in the Rio Cebolla below Fenton Lake. This could not be possible unless Fenton Lake also exceeded temperature criteria at that time. Though this condition was not observed during this study, the condition would be expected considering the shallow nature of the lake caused by the huge sediment input following the forest fire, and the huge algal community and resulting biomass as shown in the images above. The intense green color of the lake would serve to absorb heat during the day resulting in temperature exceedences and possible dissolved oxygen and pH problems.

REFERENCES

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

Carlson, R.E. 1980. More Complications in the Chlorophyll-Secchi Disk Relationship. Limnol. Oceanogr. 25(2):379-382.

Davis, D.R. 1989. Reconnaissance Surveys of Eagle Nest Lake in Colfax County New Mexico, 1989. New Mexico Clean Lakes Program: Lake Water Quality Assessment for FY 89. 90 p.

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.

Joseph, S.J. 1998. Water quality and biological assessment survey of Eagle Nest Reservoir, Colfax County, New Mexico, April 23, July 15, and October 21, 1998. *In* Water Quality Assessment's for Selected New Mexico Lakes. 1998. NMED/SWQ-03/1. 4 p.

Joseph, S.J. 1998. Water quality and biological assessment survey of Fenton Lake, Sandoval County, New Mexico, August 27, 1998. *In* Water Quality Assessment's for Selected New Mexico Lakes. 1998. NMED/SWQ-03/1. 20 p.

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

New Mexico Environment Department. 2004. Quality Assurance Project Plan for Water Quality Management Programs.

New Mexico Administrative Code (NMAC). 2006. *State of New Mexico Standards for Interstate and Intrastate Surface Waters.* 20.6.4. New Mexico Water Quality Control Commission. As amended through February 16. (20.6.4 NMAC)

New Mexico Administrative Code (NMAC). 1995. *State of New Mexico Standards for Interstate and Intrastate Streams.* 20.6.4. New Mexico Water Quality Control Commission.

New Mexico State Parks. http://www.emnrd.state.nm.us/PRD/index.htm.

Omernik, J.M., and Griffith, G. 2005. Level III & IV Ecoregions of New Mexico. U.S. EPA National Health and Environmental Effects Laboratory, Corvallis, Or.

Potter, D.U. 1983. New Mexico Clean Lakes Program Classification Phase II: Restoration and Management Recommendations for Selected Priority Lakes. EID/WPC-83/9.

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

U.S. Environmental Protection Agency. 1977. National Eutrophication Survey, Working Paper Series: Report on Eagle Nest Lake, Colfax County New Mexico, Working paper No. 820.

U.S. Department of Interior, USGS. 2001. Water Resources Data New Mexico Water Year 2001. Water Data Report NM-01-1.