WALNUT RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Water Body: El Dorado Lake
Water Quality Impairment: Eutrophication

Subbasin: Upper Walnut

Counties: Butler and Chase

HUC 8: 11030017

HUC 11 (HUC 14)**:** **030** (010, 020, 030, 040, 050, 060)

Ecoregion: Flint Hills (28)

Drainage Area: Approximately 241.9 square miles.

Conservation Pool: Area = 7,467 acres
Watershed Area:Lake Surface Area = 18:1
Maximum Depth = 15.5 meters (50.9 feet)
Mean Depth = 6.3 meters (21 feet)
Retention Time = 2.4 years (28.8 months)

Designated Uses: Primary and Secondary Contact Recreation; Expected Aquatic Life Support; Drinking Water; Industrial Water Supply Use; Food Procurement

Authority: Federal (U.S. Army Corps of Engineers), State (Kansas Water Office)

1998 303d Listing: Table 4 - Water Quality Limited Lakes

Impaired Use: All uses are impaired to a degree by eutrophication

Water Quality Standard: Nutrients - Narrative: The introduction of plant nutrients into streams, lakes, or wetlands from artificial sources shall be controlled to prevent the accelerated succession or replacement of aquatic biota or the production of undesirable quantities or kinds of aquatic life. (KAR 28-16-28e(c)(2)(B)).

The introduction of plant nutrients into surface waters designated for primary or secondary contact recreational use shall be controlled to prevent the development of objectionable concentrations of algae or algal by-products or nuisance growths of submersed, floating, or emergent aquatic vegetation. (KAR 28-16-28e(c)(7)(A)).

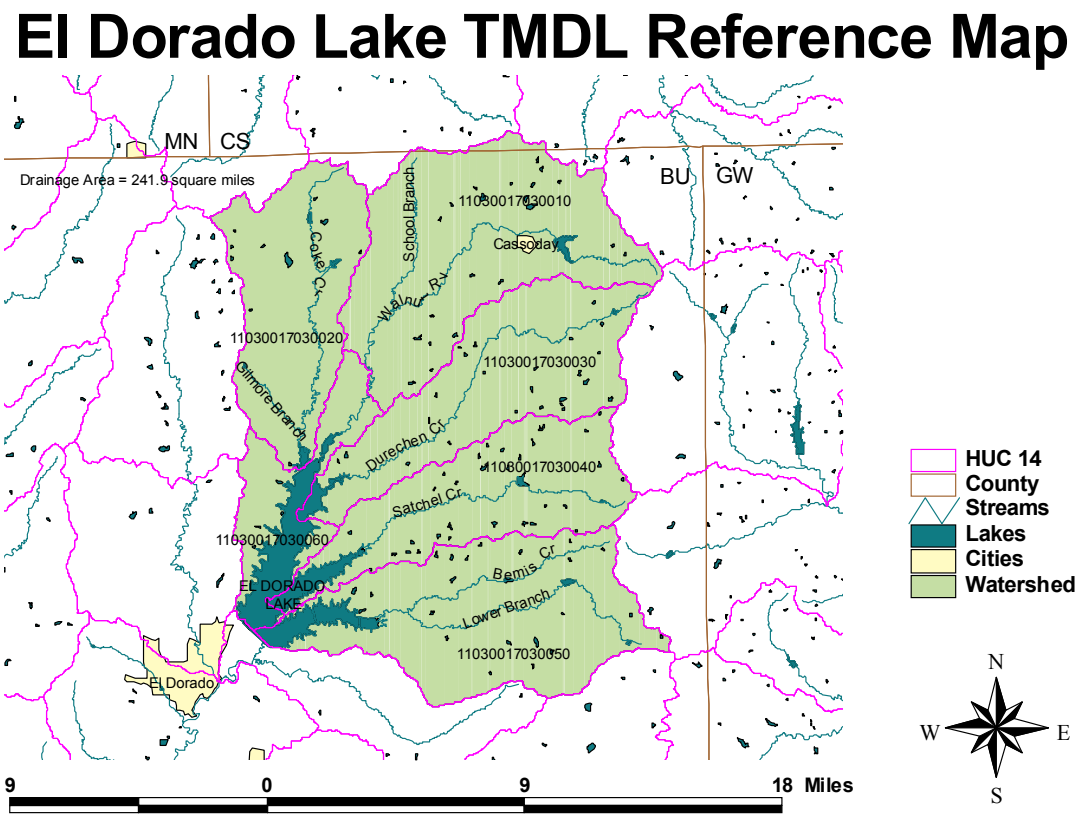
2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Eutrophication: Argillotrophic, Trophic State Index = 42.72

Monitoring Sites: Station 033001 in El Dorado Lake (Figure 1).

Period of Record Used: Five surveys during 1987 - 1999 and Kansas Biological Survey (2000)

Figure 1



Current Condition: El Dorado Lake has chlorophyll a concentrations averaging 3.45 ppb. (Appendix A). This relates to a Trophic State Index of 42.72. Sampling done by KDHE shows that the total phosphorus concentrations have increased over time. The total phosphorus concentration was below the detection limit in 1987, and by 1999, the concentrations had reached an average of 75 ppb. The Total Kjeldahl Nitrogen concentrations average 0.37 mg/L; nitrate concentrations average 0.29 mg/L; and nitrite is often below the detection limit. Light is indicated to be the primary limiting nutrient (Appendix B). Surface water in El Dorado Lake has high turbidity, dominated by inorganic materials because the lake receives a steady inflow of silt.

Bioassays preformed by the Kansas Biological Survey indicate the lake is co-limited by phosphorus and nitrogen. The chlorophyll a to total phosphorus yield is low; the algal production is reduced because light cannot penetrate through the turbid water.

There is an accompanying TMDL for sediment in El Dorado Lake. The chlorophyll a levels will rise when the turbidity decreases and the Secchi disc depth increases, if current phosphorus and nitrogen levels in the lake are not reduced simultaneously. (See the Response Curves in Appendix C). Because the nutrient concentrations in the lake are so elevated, algal blooms may been seen as the clarity improves even though measures are being taken to decrease the nutrient load. If the clarity (Secchi Disc Depth) of the lake does not improve, then a gradual decline in the chlorophyll a concentration will be seen. Assessment of the eutrophication impairment is based on modeling rather than direct measurement.

The Trophic State Index is derived from the chlorophyll a concentration. Trophic state assessments of potential algal productivity were made based on chlorophyll a concentrations, nutrient levels and values of the Carlson Trophic State Index (TSI). Generally, some degree of eutrophic conditions is seen with chlorophyll a concentrations over 7 μg/l and hypereutrophy occurs at levels over 30 μg/l. The Carlson TSI, derives from the chlorophyll concentrations and scales the trophic state as follows:

1. Oligotrophic TSI < 40
2. Mesotrophic TSI: 40 - 49.99
3. Slightly Eutrophic TSI: 50 - 54.99
4. Fully Eutrophic TSI: 55 - 59.99
5. Very Eutrophic TSI: 60 - 63.99
6. Hypereutrophic TSI: $\geq$ 64

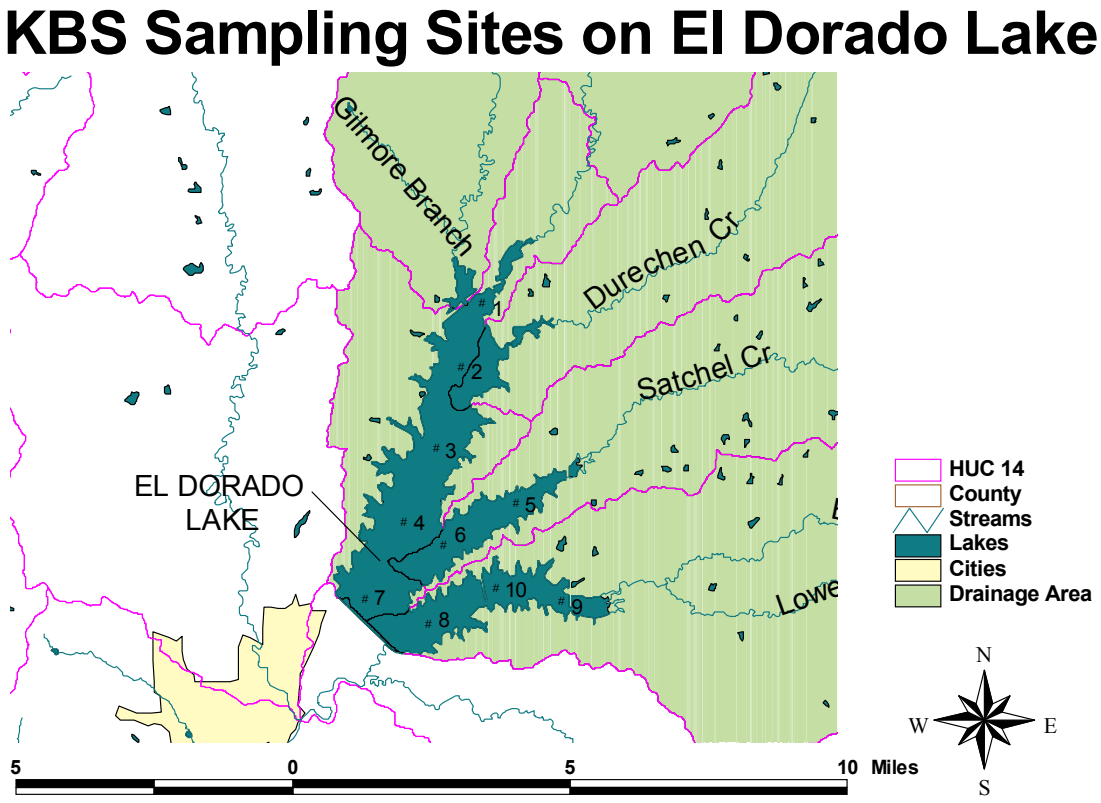
In 2000, the Kansas Biological Survey collected data monthly at ten stations (Figure 2) in El Dorado Lake. A summary of those results is included in the below table.

Averages of Kansas Biological Survey Samples at the Ten Stations

Location - Zone	**Total Phosphorus (μg/L)**	**Total Nitrogen (mg/L)**	**Chlorophyll a (μg/L)**
Walnut River Arm (Station 1) - Riverine	**87**	**0.52**	**16.42**
Walnut River Arm (Station 2) - Transitional	**58**	**0.44**	**11.07**
Walnut River Arm (Station 3) - Transitional	**52**	**0.42**	**8.92**
Walnut River Arm (Station 4) - Transitional	**45**	**0.38**	**7.57**
Satchel Creek Arm (Station 5) - Riverine	**60**	**0.42**	**12.56**
Satchel Creek Arm (Station 6) - Transitional	**47**	**0.41**	**7.61**
Main Basin (Station 7) - Lacustrine	**46**	**0.41**	**5.70**

Bemis Creek Arm (Station 8) - Lacustrine	**47**	**0.39**	**3.59**
Bemis Creek Arm (Stations 9) - Riverine	**70**	**0.45**	**12.18**
Bemis Creek Arm (Stations 10) - Transitional	**64**	**0.41**	**12.44**
Lake Average in 2000	**58**	**0.43**	**9.81**

Figure 2



The data are converted to loads by the following method. To determine the inflow into both arms of the lake, the proportion of the subwatershed to the entire watershed was multiplied times the inflow data from the U. S. Army Corps of Engineers. The load was calculated by multiplying the subwatershed inflow times the average concentration times a conversion factor. From this calculation, it is evident that the Walnut River subwatershed is making the greatest contribution to the phosphorus and nitrogen loads. The Bemis Creek subwatershed is a secondary contributor; and the Satchel Creek subwatershed is a tertiary contributor.

Loads Calculated from the Kansas Biological Survey Sample Data

Location - Zone	Drainage Area	Total Phosphorus Load	Total Nitrogen Load
Walnut River Arm (Station 2)	**153 mi^2**	**1.5 lbs/day**	**11.5 lbs/day**
Satchel Creek Arm (Station 5)	**37 mi^2**	**0.4 lbs/day**	**2.7 lbs/day**
Bemis Creek Arm (Stations 9)	**52 mi^2**	**0.6 lbs/day**	**4.0 lbs/day**

Interim Endpoints of Water Quality (Implied Load Capacity) at El Dorado Lake over 2007 - 2011:

In order to improve the trophic condition of the lake from its current Argillotrophic status, the desired endpoint will be to maintain summer chlorophyll a concentrations below 12 μg/L. Total Nitrogen concentration in the lake should be maintained below 0.62 mg/L. A regression of 2000 - 2001 lake data and 1997 - 2000 wetland data was used to determine the current, in-lake nitrogen concentration and to calculate how much of a nutrient reduction was need to meet water quality standards.

To ensure the clarity of the water, the desired Secchi disc depth endpoint will be summer average readings greater than 1 m in the main body of the lake near the dam. Both the chlorophyll a and Secchi disc depth endpoints must be met in order to comply with the Water Quality Standards.

3. SOURCE INVENTORY AND ASSESSMENT

NPDES: Two NPDES permitted facilities are located within the watershed (Figure 3). Both are non-overflowing lagoons that are prohibited from discharging and may contribute a nutrient load under extreme precipitation events (flow durations exceeded under 5 percent of the time). Such events would not occur at a frequency or for a duration sufficient to cause an impairment in the watershed. According to projections of future water use and resulting wastewater, both look to have sufficient treatment capacity available.

Waste Treatment Plants in the El Dorado Lake Watershed

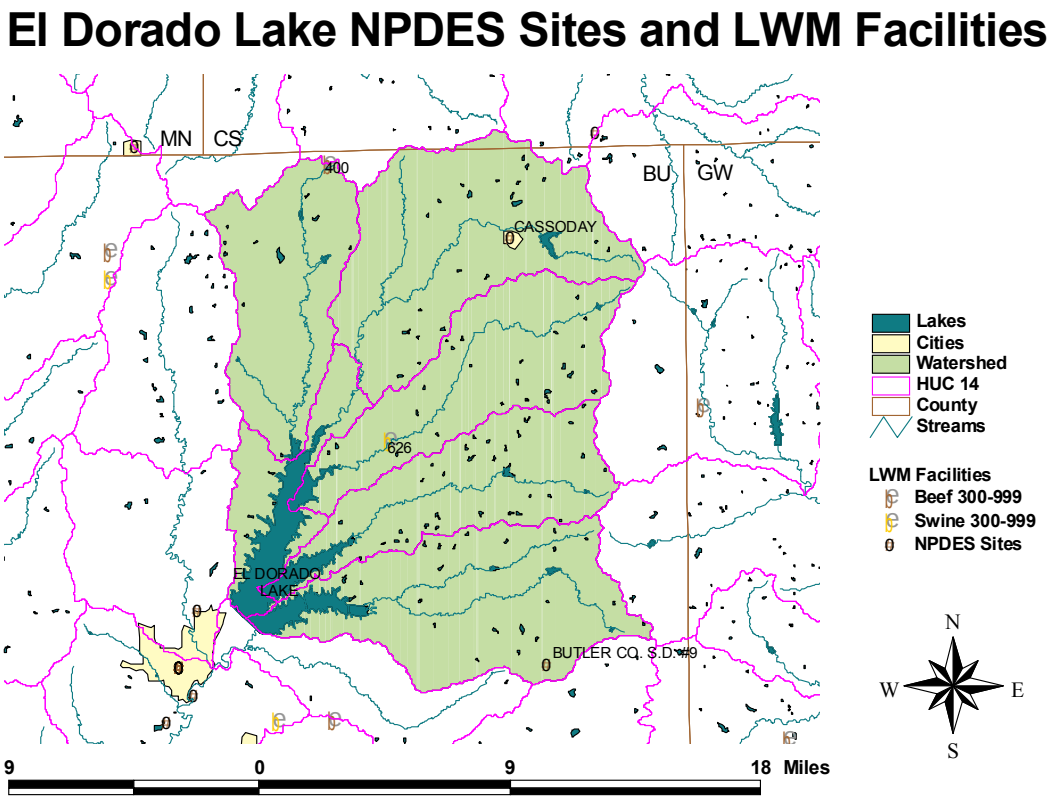
Name	Type	Design Capacity (MGD)	Expiration Date
Cassoday Wastewater Treatment Plant	3-cell lagoon	0.027	2006
Butler County Sewer District No. 9 Wastewater Treatment Facility	4-cell lagoon	0.0275	2006

Land Use: The watershed around El Dorado Lake has a moderate potential for nonpoint source pollutants. An annual phosphorus load of 368,201 pounds per year is necessary to correspond to the concentrations seen in the lake.

One source of phosphorus within El Dorado Lake is probably runoff from agricultural lands where phosphorus has been applied. The Walnut River has the greatest amount of cropland (20.9 square miles), while there are 5.6 square miles of cropland in the Bemis Creek subwatershed and

2.2 square miles of cropland in the Satchel Creek subwatershed. Land use coverage analysis indicates that 11.9% of the watershed is cropland (Figure 4).

Figure 3

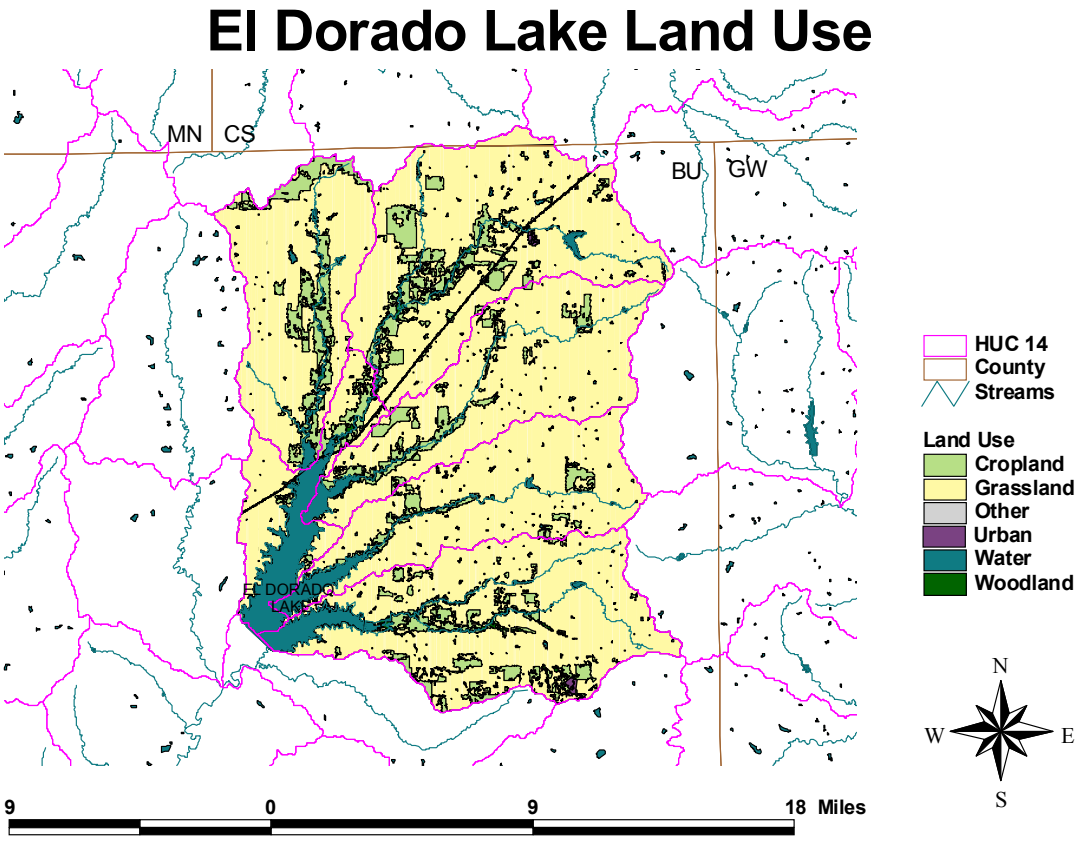


Phosphorus from animal waste is a contributing factor. Eighty-one percent of land around the lake is grassland; the grazing density of livestock is high in winter and low in summer. Animal waste, from confined animal feeding operations, adds to the phosphorus load going into El Dorado Lake (Figure 3). There are one beef and one swine animal feeding operations in the watershed. All permitted livestock facilities have waste management systems designed to minimize runoff entering their operations or detaining runoff emanating from their areas. Such systems are designed for the 25 year, 24 hour rainfall/runoff event, which would be indicative of flow durations well under 10 percent of the time. NPDES permits, also non-discharging, are issued for facilities with more than 1,000 animal units. None of the facilities in the watershed are of this size. Potential animal units for all facilities in the watershed total 1,026. The actual number of animal units on site is variable, but typically less than potential numbers.

The largest town in the watershed is Cassoday. The City of Cassoday anticipates no population growth between 2000 and 2020. Less than one percent of the watershed is urban; stormwater runoff and urban fertilizer applications are a minor contributing factor. All of the urban land is located in the Walnut River (0.14 square mile) and Bemis Creek (0.17 square mile)

subwatersheds. El Dorado Lake is the primary source of drinking water for residents of Butler County.

Figure 4



A potential source is septic systems located around the lake. Failing septic systems can be a significant source of nutrients. The following number of septic systems is present within the counties: Butler(5641) and Chase (716).

Contributing Runoff: The watershed's average soil permeability is 0.5 inches/hour according to NRCS STATSGO database. About 99.1% of the watershed produces runoff even under relatively low (1.5''/hr) potential runoff conditions. Runoff is chiefly generated as infiltration excess with rainfall intensities greater than soil permeabilities. As the watersheds' soil profiles become saturated, excess overland flow is produced. Generally, storms producing less than 0.5"/hr of rain will generate runoff from 94.5% of this watershed, chiefly along the stream channels.

Background Levels: One percent of land in the watershed is woodland; leaf litter may be contributing to the nutrient loading. The atmospheric phosphorus and geological formations (i.e.,

soil and bedrock) may contribute to phosphorus loads. Carp may cause some resuspension of sediment.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

While light is the limiting factor in El Dorado Lake, Total Phosphorus is allocated under this TMDL, because a phosphorus reduction will have a large effect on the managing the algal community. The Load Capacity is 70,798 pounds per year of phosphorus and was calculated using the CNET model. More detailed assessment of sources and confirmation of the trophic state of the lake must be completed before detailed allocations can be made. The general inventory of sources within the drainage does provide some guidance as to areas of load reduction. Because of atmospheric deposition, initial allocations of nitrogen will be based on a proportional decrease in nitrogen between the current condition and the desired endpoint.

Point Sources: A current Wasteload Allocation of zero is established by this TMDL because of the lack of discharging point sources in the watershed. Should future point sources be proposed in the watershed and discharge into the impaired segments, the current Wasteload Allocation will be revised by adjusting current load allocations to account for the presence and impact of these new point source dischargers. As previously noted in the inventory and assessment section, sources such as non-discharging permitted municipal and agricultural facilities located within the watershed do not discharge with sufficient frequency or duration to cause an impairment in the lake.

Nonpoint Sources: Water quality violations are predominantly due to nonpoint source pollutants. Background levels may be attributed to leaf litter and geological sources. The assessment suggests that cropland and animal waste contribute to the elevated total phosphorus concentrations in the lake. Generally a Load Allocation of 63,718 pounds of total phosphorus per year, leading to an 80.8% reduction, is necessary to reach the endpoint. A proportional decrease of 6% in nitrogen loading will allow the total nitrogen endpoint to be achieved.

Defined Margin of Safety: The margin of safety provides some hedge against the uncertainty of variable annual total phosphorus load and the chlorophyll a endpoint. Therefore, the margin of safety will be 7,080 pounds per year of total phosphorus taken from the load capacity subtracted to compensate for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality. For nitrogen, the margin of safety will be an additional 1% reduction in nitrogen to ensure that the endpoint is reached.

State Water Plan Implementation Priority: Because El Dorado Lake is a federal reservoir with a relatively small watershed and a large regional benefit for recreation and municipal water supply, this TMDL will be a High Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Upper Walnut (HUC 8: 11030017) with a priority ranking of 44 (Medium Priority for restoration).

Priority HUC 11s: The watershed is within HUC 11 (030). The Walnut River subwatershed should take priority. Secondary focus should be placed the Bemis Creek subwatershed, and tertiary focus should be placed the Satchel Creek subwatershed.

5. IMPLEMENTATION

Desired Implementation Activities

There is a very good potential that agricultural best management practices will allow full use support to take place in El Dorado Lake. Some of the recommended agricultural practices are as follows:

1. Implement soil sampling to recommend appropriate fertilizer applications on cropland.
2. Maintain conservation tillage and contour farming to minimize cropland erosion.
3. Install grass buffer strips along streams.
4. Reduce activities within riparian areas.
5. Implement nutrient management plans to manage manure application to land.

Implementation Programs Guidance

Nonpoint Source Pollution Technical Assistance - KDHE

a. Support Section 319 demonstration projects for reduction of sediment runoff from agricultural activities as well as nutrient management, including the El Dorado Lake Water Quality Protection Project.
b. Provide technical assistance on practices geared to establishment of vegetative buffer strips.
c. Provide technical assistance on nutrient management in vicinity of streams.
d. Update and implement nutrient and sediment abatement strategies.
e. Develop a Watershed Restoration and Protection Strategy for HUC 11030017.

Butler County Conservation District

a. Continue to educate residents and landowners about nonpoint source pollution.

Water Resource Cost Share Nonpoint Source Pollution Control Program - SCC

a. Apply conservation farming practices, including terraces and waterways, sediment control basins, and constructed wetlands.
b. Provide sediment control practices to minimize erosion and sediment and nutrient transport.

Riparian Protection Program - SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.
b. Develop riparian restoration projects.
c. Promote wetland construction to assimilate nutrient loadings.

Buffer Initiative Program - SCC

a. Install grass buffer strips near streams, particularly by the Walnut River subwatershed.

b. Leverage Conservation Reserve Enhancement Program to hold riparian land out of production.

Extension Outreach and Technical Assistance - Kansas State University

a. Continue to educate residents and landowners about nonpoint source pollution.

b. Educate agricultural producers on sediment, nutrient, and pasture management.

c. Educate livestock producers on livestock waste management and manure applications and nutrient management planning.

d. Provide technical assistance on livestock waste management systems and nutrient management plans.

e. Provide technical assistance on buffer strip design and minimizing cropland runoff.

f. Encourage annual soil testing to determine capacity of field to hold phosphorus.

Time Frame for Implementation: Pollutant reduction practices should be installed within the priority subwatersheds during the years 2002-2007, with minor followup implementation, including other subwatersheds over 2007-2011.

Targeted Participants: Primary participants for implementation will be agricultural producers within the drainage of the lake. Initial work in 2002 should include local assessments by conservation district personnel and county extension agents to locate within the lake drainage:

1. Total row crop acreage
2. Cultivation alongside lake
3. Drainage alongside or through animal feeding lots
4. Livestock use of riparian areas
5. Fields with manure applications

Milestone for 2007: The year 2007 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, sampled data from El Dorado Lake should indicate evidence of reduced phosphorus levels in the conservation pool elevations relative to the conditions seen over 1987-1999.

Delivery Agents: The primary delivery agents for program participation will be conservation districts for programs of the State Conservation Commission and the Natural Resources Conservation Service. Producer outreach and awareness will be delivered by Kansas State Extension and the Butler County Conservation District.

Reasonable Assurances:

Authorities: The following authorities may be used to direct activities in the watershed to reduce pollutants.

1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

3. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.

4. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan.*

6. The *Kansas Water Plan* and the Walnut Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a High Priority consideration.

Effectiveness: Nutrient control has been proven effective through conservation tillage, contour farming and use of grass waterways and buffer strips. The key to success will be widespread utilization of conservation farming and installation of buffer strips within the watersheds cited in this TMDL.

6. MONITORING

Additional data, to establish nutrient ratios, source loading and further determine mean summer lake trophic condition, would be of value prior to 2007. Further sampling and evaluation should

occur once before 2007 and twice between 2007 and 2011. Some monitoring of tributary levels of nutrients will help direct abatement efforts toward major contributors.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Walnut Basin were held January 10 and March 7, 2002 in Augusta. An active Internet Web site was established at http://www.kdhe.state.ks.us/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Walnut Basin.

Public Hearing: A Public Hearing on the TMDLs of the Walnut Basin was held in Augusta on June 5, 2002.

Basin Advisory Committee: The Walnut Basin Advisory Committee met to discuss the TMDLs in the basin on October 4, 2001, January 10, March 7, and June 5, 2002.

Discussion with Interest Groups: Meetings to discuss TMDLs with interest groups include:

Kansas Farm Bureau: February 27 in El Dorado
Walnut Basin Ecosystem Restoration Feasibility Study Meetings in Whitewater, Winfield, and Augusta

Milestone Evaluation: In 2007, evaluation will be made as to the degree of implementation which has occurred within the watershed and current condition of El Dorado Lake. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

Consideration for 303(d) Delisting: The lake will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2007-2011. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the ten-year implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

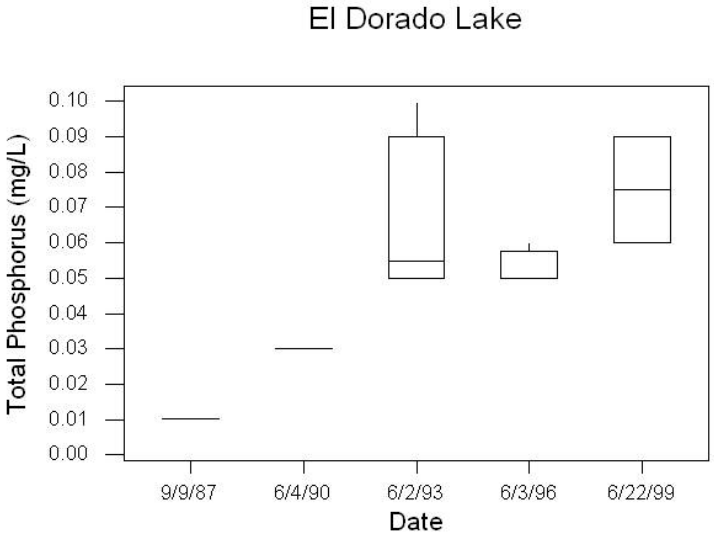
Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision will come in 2003 which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2003-2007.

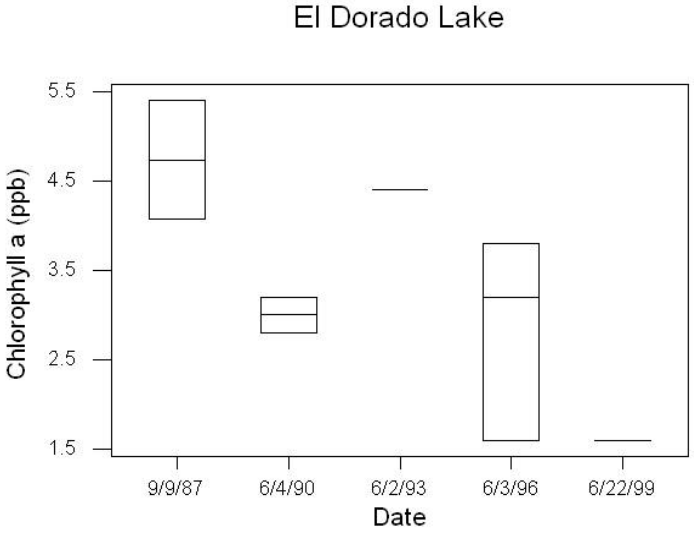
Bibliography

Lim, Niang Choo. "Assessment of Reservoir Water Quality and Its Application to Reservoir Management in the Central Plains." Thesis. University of Kansas. 2001.

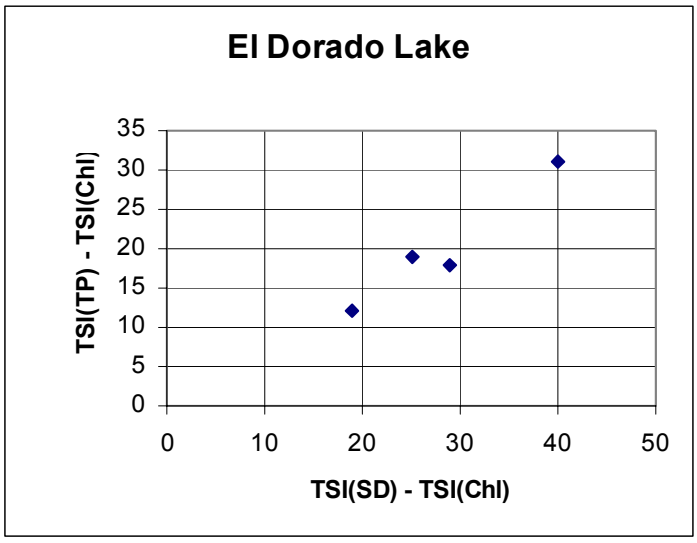
Liscek, Bonnie C. Methodology Used in Kansas Lake TMDLs [web page] Jul. 2001; http://www.kdhe.state.ks.us/tmdl/eutro.htm [Accessed 17 May 2002].

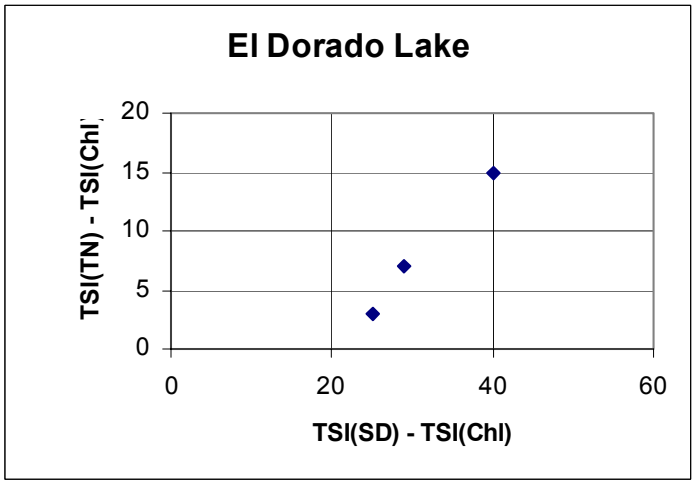
Appendix A - Boxplots





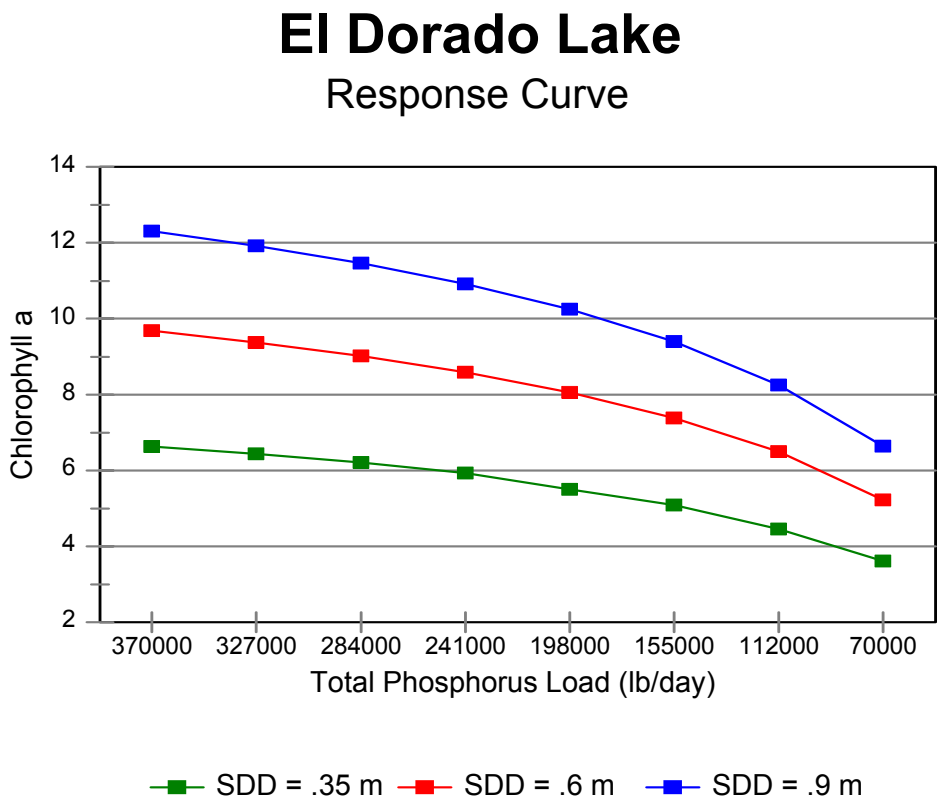
Appendix B - Trophic State Index Plots





The Trophic State Index plots indicate that light is the primary limiting factor, due to clay turbidity. This is inferred by examining the relationship between the TSI(SD)-TSI(Chl) and TSI(TP)-TSI(Chl) or TSI(TN)-TSI(Chl). The deviation of chlorophyll a from the sediment load indicates the degree of light penetration, while the difference between chlorophyll a and phosphorus, or chlorophyll a and nitrogen indicates the level of phosphorus or nitrogen limitation. Therefore, if the final plot is in the first quadrant, it shows that the transparency of the water is impaired due to the presence of small particles, and that phosphorus and nitrogen do not limit algae growth. The positive slope of the graph also indicates a correlation between phosphorus and transparency which is found when phosphorus is bound to non algal particles.

Appendix C - Response Curves



Secchi Disc Depth (SDD) is a measure of clarity in a lake. As more light is able to penetrate the water column, the growth rate of the algae and thus the chlorophyll a concentration increases. The Total Phosphorus load must be reduced simultaneously to keep the algal community from increasing to nuisance levels.

Appendix D - Input for CNET Model

Parameter	Value Input into CNET Model
Drainage Area (km^2)	626.57
Precipitation (m/yr)	0.81
Evaporation (m/yr)	1.43
Unit Runoff (m/yr)	0.17
Surface Area (km^2)	30.22
Mean Depth (m)	6.30
Depth of Mixed Layer (m)	5.34
Depth of Hypolimnion (m)	1.72
Observed Phosphorus (ppb)	43.33
Observed Chlorophyl-a (ppb)	3.447
Observed Secchi Disc Depth (m)	0.58

Output from CNET Model

Parameter	Output from CNET Model
Load Capacity (LC)*	**70,798 lb/yr**
Waste Load Allocation (WLA)	**0 lb/yr**
Load Allocation (LA)	**63,718 lb/yr**
Margin of Safety (MOS)	**7,080 lb/yr**

***LC = WLA + LA + MOS**

Approved September 30, 2002

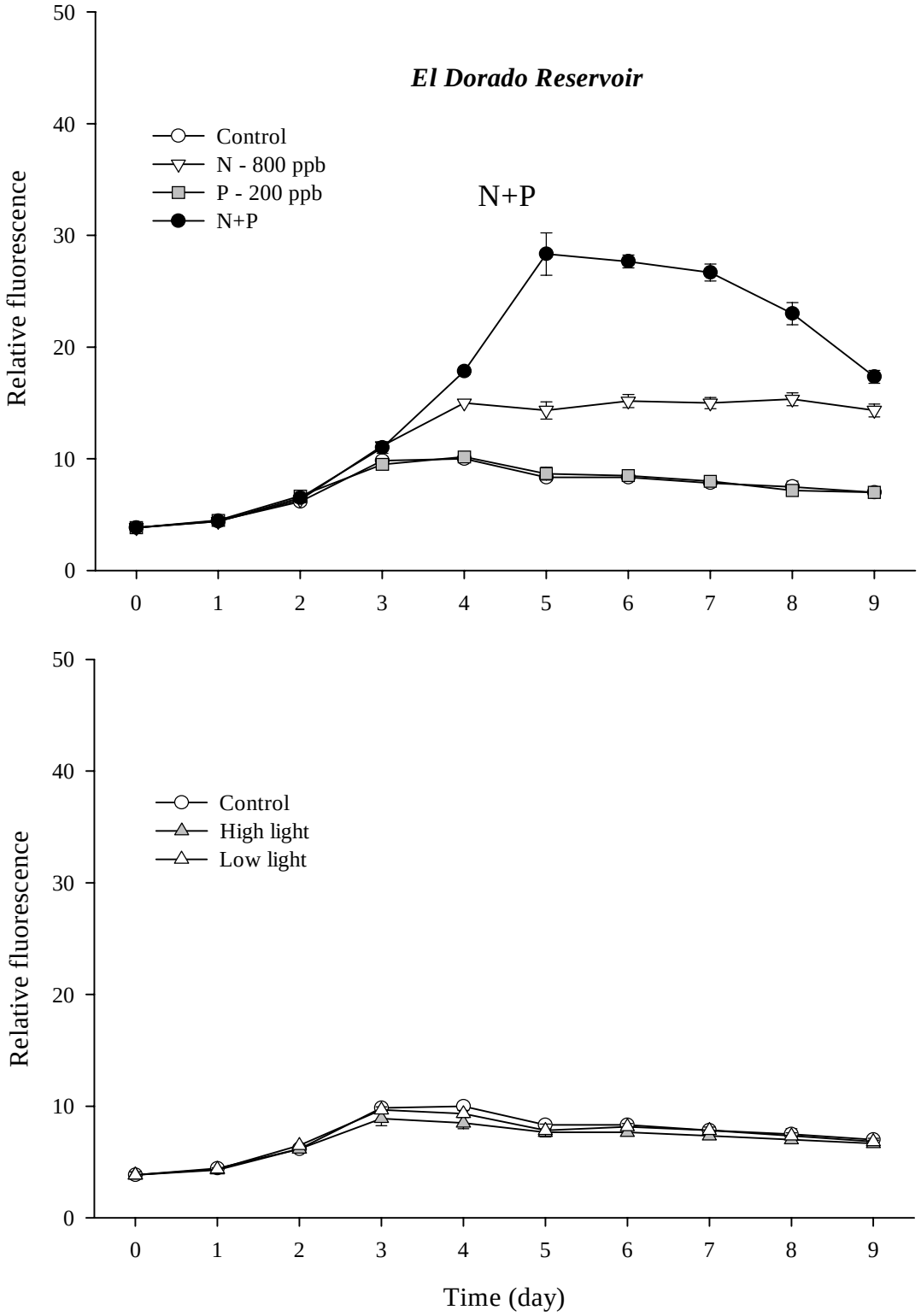


Figure 29. Kansas Biological Survey