

MISSOURI RIVER BASIN TOTAL MAXIMUM DAILY LOAD

**Waterbody Assessment Unit: Pony Creek Lake
Water Quality Impairment: Eutrophication**

Revision to TMDL Originally Approved August 28, 2001

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Big Nemaha **Counties:** Brown & Nemaha

HUC 8: 10240008 **HUC 11 (HUC 14):** 050 (010)

Drainage Area: Approximately 7.37 square miles

Conservation Pool: Area = 120 acres
Watershed/Lake Ratio: 31:1
Maximum Depth = 10 meters
Mean Depth = 3.4 meters
Estimated Retention Time = 0.75 years

Designated Uses: Primary Contact Recreation; Expected Aquatic Life Support; Domestic Water Supply; Food Procurement; Industrial Water Supply; Irrigation Use; Livestock Watering Use

1998 303(d) 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 28-16-16-28e(c)(2)(A))

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

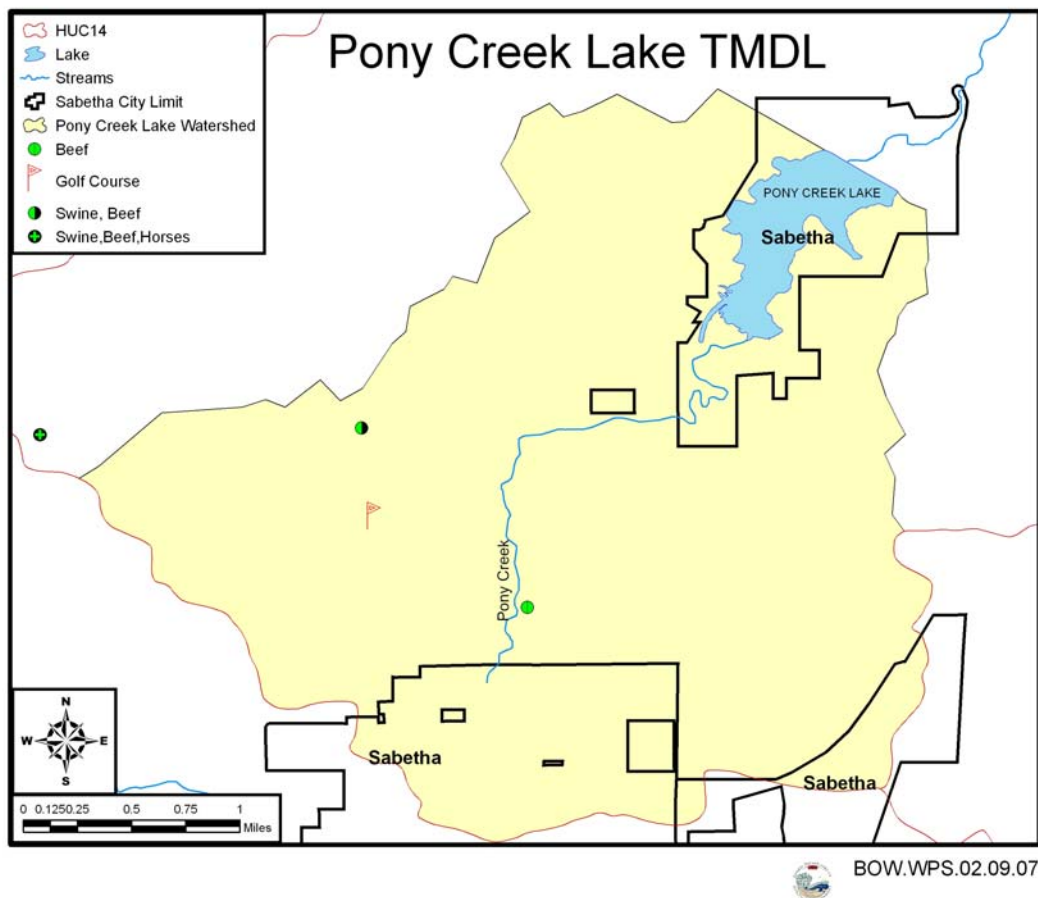
Level of Eutrophication: Very Eutrophic, Trophic State Index = 61.43

The Trophic State Index (TSI) is derived from the chlorophyll *a* concentration (Chla). 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 12 µg/L and hypereutrophy occurs at levels over 30 µg/L. The Carlson TSI derives from the chlorophyll *a* 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: ≥ 64 |

Monitoring Sites: Station 073001 in Pony Creek Lake (Figure 1).

Figure 1. Pony Creek TMDL Reference Map.



Period of Record Used: Six surveys; four conducted by KDHE in calendar years 1994, 1996, 2000, and 2003 & two conducted by the Kansas Biological Survey in calendar years 2002 and 2005.

Current Condition: The overall Chlorophyll *a* concentrations in Pony Creek Lake average 26.1 ppb over the entire period of record. Since the previous TMDL was approved in 2001, the chlorophyll *a* concentration average has been reduced by nearly 50% from 35.1 ppb to 17.14 ppb. The Kansas Biological Survey conducted sampling on Pony Creek Lake in 2002 and 2005.

An index of chlorophyll *a* / total phosphorus was used to evaluate algal use of the phosphorus supply (Carney, 2004). There is a limited response by algae to phosphorus if the index values are less than 0.13, suggesting that nitrogen, light or other factors may be more important. If values are greater than 0.4, a strong algal response to changes in phosphorus is likely. The current condition of the average chlorophyll *a* concentration and the average total phosphorus concentration within Pony Creek yields an index value of 0.65, where algal response is influenced by variations in the phosphorus concentrations.

The ratio of total nitrogen and total phosphorus is a common ratio utilized to determine which of these nutrients is most likely limiting plant growth in Kansas aquatic ecosystems (Dzialowski et al., 2005). Typically, lakes that are N limited have a water column TN:TP ratio < 10 (mass); lakes that are co-limited by N and P have a TN:TP ratio between 10 and 17; and lakes that are P limited have a water column TN:TP ratio > 17 (Smith, 1998). The total phosphorus concentrations for samples obtained at 0.5 meters or less average 40.2 ppb over the period of record. The total phosphorus average for shallow samples obtained since the previous TMDL was developed average 47 ppb, indicating an increasing trend since the original TMDL was developed, where the total phosphorus average was 33.3 ppb for shallow samples. The total nitrogen average concentration has increased slightly since the previous TMDL was developed as well, which is primarily due to high nitrogen concentrations recorded in 2003. As displayed in Table 1, Nitrogen and Phosphorus display co-limiting ratios in the shallow samples obtained in 2000, 2002, and 2005. The samples obtained in 1996 and 2003 indicate there is a phosphorus limitation for algae above the mixing zone of the lake. Therefore, depending on the month and year of the sample, Pony Creek Lake displays characteristics that algal plant growth is either co-limited by total nitrogen and total phosphorus or limited by total phosphorus.

Overall, the nitrogen and phosphorus ratio of 26.9 for all samples obtained above the hypolimnion has remained similar since the previous TMDL. Since the TN:TP ratios indicate that nitrogen and phosphorus are co-limiting during the majority of the sampling periods, Pony Creek Lake will have loads and concentrations calculated for both nitrogen and phosphorus, however the emphasis will remain with total phosphorus since the chlorophyll *a* / total phosphorus index and the TN:TP ratios clearly indicate a more prevalent limitation associated with total phosphorus. According to the 2003 KDHE Lake and Wetland Monitoring Program Annual Report, the algal communities in Pony

Creek Lake, based on percent composition of cell count, contain 63% blue-green algae (Carney, 2003).

Secchi depths were recorded in 2000 (0.87m) and 2003 (1.36m) and averaged 1.11m. Light is not indicated to be limiting.

Table 1. Total Phosphorus and Total Nitrogen annual averages for Pony Creek Lake at shallow depths.

Year	Chl <i>a</i> (ppb)	TP (ppb)	TN (mg/L)	TN:TP Ratio
1994 (0.5 m)	28.05	15	Na	Na
1996 (0.5m)	48.4	30	1.46	48.7
2000 (0.5m)	28.85	55	0.61	11.1
2002 (0.25m)	22	58.8	0.69	11.7
2003 (0.5m)	8.65	31.5	1.83	58
2005 (0.25m)	20.78	50.6	0.81	15.9
<i>2001 TMDL (≤ 0.5m) Avg.</i>	35.1	33.3	1.03	25.6
<i>Recent (≤ 0.5m) Avg. (2002-2005)</i>	<i>17.14</i>	<i>47</i>	<i>1.11</i>	<i>23.6</i>
All (≤ 0.5m) Data Avg.	26.12	40.2	1.08	26.9

Figure 2. Chlorophyll *a* annual averages in Pony Creek Lake.

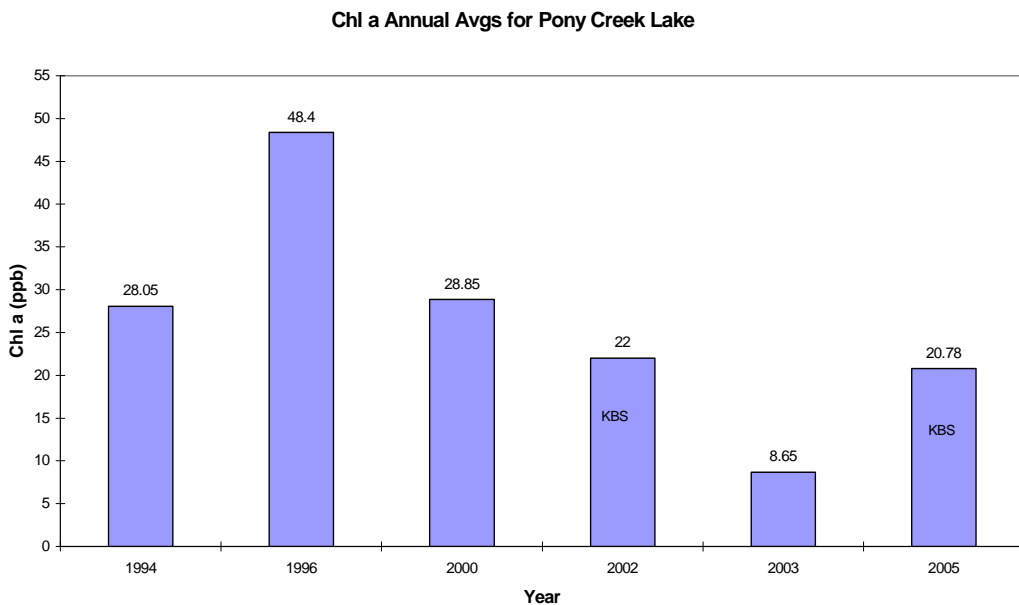


Figure 3. Chlorophyll *a* concentrations in Pony Creek Lake (1994-2005).

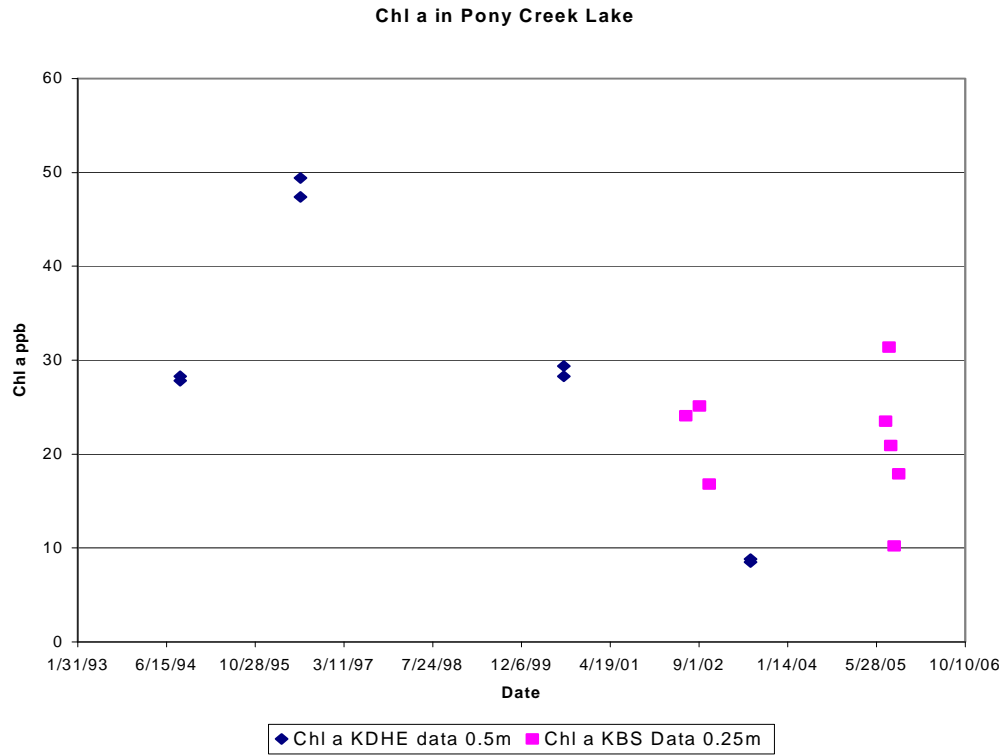
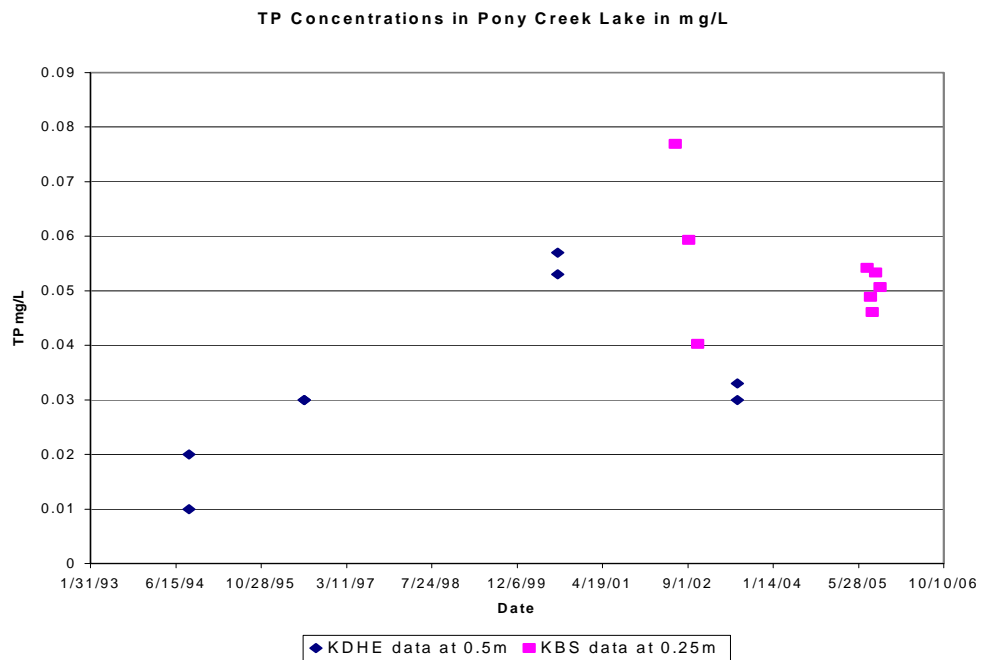


Figure 4. Total Phosphorus Concentrations in Pony Cr Lake at 0.5 meters or less.



Interim Endpoints of Water Quality (Implied Load Capacity) at Pony Creek Lake:

The original TMDL for Pony Creek Lake in 2001 sought a chlorophyll *a* concentration in the lake of 20 ppb or less by 2009 and stated that the endpoints would be refined in 2005. This TMDL will correspond with the state goal of achieving a chlorophyll *a* long-term concentration average of 10 ppb or less. The desired endpoint to improve the trophic condition of the lake from its current “very eutrophic” status will be to maintain a summer chlorophyll *a* concentration below 10 µg/L since the lake serves as a Public Water Supply and is designated for Primary Contact Recreation. Based on the CNET reservoir eutrophication model (see Appendix A), the total phosphorus concentration must be reduced by 47% to achieve a phosphorus load reduction of 55%. The nitrogen concentration must be reduced by 35% to achieve this endpoint, as calculated through a nitrogen model (see Appendix B).

Table 2. Recent Conditions and Reductions for Pony Creek Lake derived from CNET.

Parameter	Current Condition	TMDL	Percent Reduction
Total Phosphorus Load (lbs/year)	2355	1057	55 %
Total Phosphorus Daily Load (lbs/day)^	15.42	6.92	55%
Total Phosphorus Concentration (µg/L)	40.2	21.3	47%
Total Nitrogen* Load (lbs/year)	29414	14553	51%
Total Nitrogen Daily Load (lbs/day)^	215.97	106.9	51%
Total Nitrogen* Concentration (mg/L)	1.08	0.700	35%
Chlorophyll <i>a</i> (µg/L)	26.12	<10	62%

^ - See Appendix C for daily load calculations

*Source - E. Carney Nitrogen Models

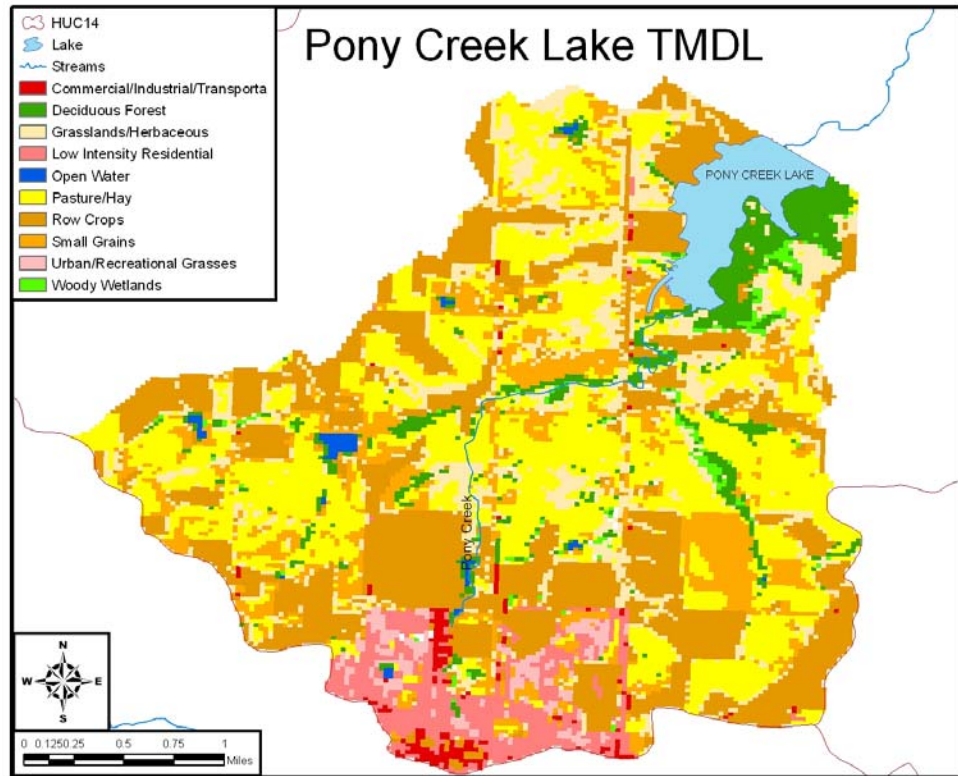
3. SOURCE INVENTORY AND ASSESSMENT

Land Use: Pony Creek Lake is fed by Pony Creek, which originates on the north side of Sabetha approximately 1.7 miles from the lake. The City of Sabetha utilizes Pony Creek Lake as one of their sources for their Public Water Supply. The population of Sabetha according to the 2000 U.S. Census is 2,589. Projected population estimates provided by the Kansas Water Office for the City of Sabetha indicate a slight growth trend through 2030 (KWO).

Pony Creek Lake has a high potential for nonpoint source pollutants. The major source of phosphorus within the Pony Creek Lake is presumably from runoff from agricultural lands where phosphorus has been applied. Land use coverage analysis indicates that 40% of the watershed is utilized for row crops and small grains and 29% of the watershed is utilized for planted and cultivated pasture/hay. About 7.5% of the watershed is forested:

1% is wetlands: 6.2% is developed: 0.5% is open water: 1.75% is urban grassland: and 14% is comprised of native grasslands.

Figure 5. Land Use Map for Pony Creek Lake TMDL Watershed.



Animal waste adds to the phosphorus load going into Pony Creek Lake. The summer grazing density of livestock is low. Animal waste from confined animal feeding operations adds to the nitrogen and phosphorus load going into Pony Creek Lake. There are two active animal feeding operations in the watershed, one of which is a beef facility certified for 300 animal units and the other is a beef and swine facility permitted for 740 animal units. The certified beef operation is located within the same section as Pony Creek and is steeply sloped. Based on KDHE inspection reports, the facility slopes to a series of three ponds and the last pond (about 4 acres) overflows into Pony Creek near the headwaters. Runoff from the feeding operation may significantly contribute nutrients to Pony Creek Lake, particularly during high intensity rainfall events. There is an additional permitted feeding operation that lies adjacent to the watershed that presumably has land within the watershed that is utilized by animals associated with their facility. This facility is permitted for swine, beef, and horses. Potential animal units for the active

certified and permitted facilities in the watershed total 1,780. The actual number of animal units on site is variable.

Table 3. Animal feeding operations in the Pony Creek Lake Watershed.

Permit #	Type	Head
A-MONM-BA02	Beef	300
A-MONM-B001	Swine, Beef	740
A-MONM-S066*	Swine, Beef, Horses	740

*Facility is adjacent to watershed, but lands utilized by animals potentially cross into watershed.

Fertilizer applications to lawns within the drainage and stormwater delivery to the lake are probable loading sources. The land use analysis indicated that six percent of the watersheds is urban. In addition, the Sabetha Country Club, which includes a nine-hole golf course, is located just north of town between the city and Pony Creek Lake. Golf courses could contribute significant nutrient loadings if fertilizer applications and/or runoff are considerable. Sabetha is considering directing a portion of their wastewater to the golf course for irrigation and land application.

Though the City of Sabetha is on public sewers, there potentially are a small number of septic systems located within the watershed. Based on the 1990 census data, about 30% of the households in Nemaha and Brown Counties are on septic systems and there are 16 systems located within the City of Sabetha. Residents outside of the city limits are most likely utilizing septic systems. Faulty septic systems within the drainage basin of Pony Creek may contribute nutrients, particularly nitrogen, to the lake.

Contributing Runoff: The watershed of Pony Creek Lake has a mean soil permeability value of 0.46 inches/hour, ranging from as high as 1.29 inches/hour to as low as 0.25 inches/hour, according to the Kansas Mean Soil Permeability database from the Kansas Geological Survey. Runoff is primarily generated as infiltration excess with rainfall intensities greater than soil permeability. As the watersheds' soil profiles become saturated, excess overland flow is produced.

Background: Leaf litter and wastes derived from natural wildlife may add to the nutrient load. Atmospheric and geological formations (i.e. soil and bedrock) may also contribute to the nutrient loads. Fish feeding stations add an insignificant amount of nutrients to the load.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

Phosphorus and nitrogen are predominately co-limiting nutrients in Pony Creek Lake and allocated under this TMDL. The general inventory of sources within the drainage area indicates load reductions should be focused on nonpoint source runoff contributions attributed to livestock facilities and fertilizer applicators.

Point Sources: A current Wasteload Allocation of zero is established by this TMDL because of the lack of discharging NPDES point sources in the watershed. Should future point sources be proposed in the watershed and discharge into the impaired lake, 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. All livestock facilities have a wasteload allocation of zero. If Sabetha directs any of its wastewater to the golf course a Wasteload Allocation will be designated and some offset of nonpoint source loads will need to accompany the discharge.

Nonpoint Sources: The assessment suggests that cropland, animal waste, and urban sources contribute to the very eutrophic state of the lake. Load reductions should be focused on nonpoint source runoff contributions attributed to the livestock facilities and fertilizer applicators within the watershed. Water quality violations are partially due to leaf litter and geology. A Load Allocation of 951 lbs/year of total phosphorus, accounting for a 61% reduction, is necessary to reach the endpoint. The nitrogen load allocation is 13,100 lbs/year, a 55% reduction from its current condition. The average nitrogen concentration should be reduced by 35% from the current average seen in Pony Creek Lake to achieve the endpoint. The daily load allocation is calculated in Appendix C and is 6.23 lbs/day of total phosphorus and 96.2 lbs/day of total nitrogen.

Defined Margin of Safety: The margin of safety provides some hedge against the uncertainty of variable annual total phosphorus loads and the chlorophyll *a* endpoint. Therefore, the margin of safety will be 10% of the original calculated total phosphorus and total nitrogen load allocations, which have been subtracted from the assigned load allocations to compensate for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality. The margin of safety is 106 lbs/year of total phosphorus and 1,455 lbs/year of total nitrogen.

State Water Plan Implementation Priority: Because the Pony Creek Lake is used for public drinking water and Primary Contact Recreation, this TMDL will be a High Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Big Nemaha (HUC 8 102400008) with a priority ranking of 37 (Medium Priority for restoration).

5. IMPLEMENTATION

Desired Implementation Activities:

There is potential that agricultural best management practices will improve the condition of Pony Creek 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 and drainage channels in the watershed.
4. Reduce activities within riparian areas.
5. Implement nutrient management plans to manage manure land applications and runoff potential.
6. Adequately manage fertilizer utilization at the golf course and implement runoff control measures, including any potential use of Sabetha wastewater.

Implementation Programs Guidance:

Fisheries Management – KDWP

- a. Assist evaluation in-lake or near-lake potential sources of nutrients to lake.
- b. Advise county on applicable lake management techniques, which may reduce nutrient loading and cycling in lake.

NPDES Permits – Municipal Program

- a. Revise Sabetha NPDES permit with appropriate calculations should land application of wastewater to the golf course be considered.

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.
- b. Provide technical assistance on practices geared to the establishment of vegetative buffer strips.
- c. Provide technical assistance on nutrient management for livestock facilities in the watershed.
- d. Assist evaluation of stormwater quality from urbanized areas of watershed.
- e. Guide federal programs such as the Environmental Quality Improvement Program, which are dedicated to priority subbasins through the Unified Watershed Assessment, to priority watersheds and stream segments within those subbasins identified by this TMDL.
- f. Incorporate lake protection and restoration in the plan for the Missouri Basin WRAPS.

Water Resource Cost Share and Nonpoint Source Pollution Control Programs – SCC

- a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.

- b. Apply conservation farming practices and/or erosion control structures, including no-till, terraces and contours, sediment control basins, and constructed wetlands.
- c. Provide sediment control practices to minimize erosion and sediment and nutrient transport.
- d. Re-evaluate nonpoint source pollution control methods.

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 lake construction to assimilate nutrient loadings.

Buffer Initiative Program – SCC

- a. Install grass buffer strips near streams.
- b. Leverage Conservation Reserve Enhancement Program to hold riparian land out of production.

Extension Outreach and Technical Assistance – Kansas State University

- a. Educate agricultural producers on sediment, nutrient, and pasture management.
- b. Educate livestock producers on livestock waste management and manure applications and nutrient management planning.
- c. Provide technical assistance on livestock waste management systems and nutrient management planning.
- d. Provide technical assistance on buffer strip design and minimizing cropland runoff.
- e. Encourage annual soil testing to determine capacity of field to hold phosphorus.
- f. Continue to educate residents, landowners, and watershed stakeholders about nonpoint source pollution.

Time Frame for Implementation: Pollution reduction practices should have been initiated since 2002 as stated in the original TMDL as well as part of the original protection under the Multipurpose Small Lakes Program. These practices should continue to be installed and/or improved within the priority subwatersheds during the years 2008-2012.

Targeted Participants: Primary participants for implementation will be the City of Sabetha, the Sabetha Country Club, the Kansas Department of Wildlife and Parks, livestock producers and agricultural producers within the drainage of the lake. Initial work in 2008 should include local assessments by conservation district personnel and county extension agents to survey, locate, and assess the following within the lake drainage area:

1. Total row crop acreage

2. Cultivation alongside lake
3. Livestock use of riparian areas
4. Fields with manure applications

Milestone for 2012: The year 2012 marks the next cycle of 303(d) activities in the Missouri Basin. At that point in time, sampled data from Pony Creek Lake should indicate evidence of reduced in lake concentrations of total phosphorus, total nitrogen and chlorophyll *a* from those seen from 1994-2005.

Delivery Agents: The primary deliver agents for program participation will be the City of Sabetha, the Kansas Department of Wildlife and Parks, conservation districts for programs of the State Conservation Commission, and the Natural Resources Conservation Service. The Kansas State University Extension Service will deliver producer outreach and awareness.

Reasonable Assurances:

Authorities: The following authorities may be used to direct activities in the watershed to reduce pollutants and to assure allocations of pollutants to point and non-point sources can be attained.

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*, including selected Watershed Restoration and Protection Strategies.
6. K.S.A 82a-1601, et seq. creates the Multipurpose Small Lakes Program to protect smaller lakes that serve multiple functions, including adequate land treatment measures that will provide protection from pollution and siltation.

7. The *Kansas Water Plan* and the Missouri 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. In addition, the proper implementation of comprehensive livestock waste management plans has proven effective at reducing nutrient runoff associated with livestock facilities. The key to success will be widespread utilization of conservation farming and proper livestock waste management within the watershed cited in this TMDL.

6. MONITORING

KDHE will continue sampling Pony Creek Lake once every four years in order to assess the impairment that drives this TMDL. Based on the sampling results, the impairment status of the lake will be evaluated in 2012. Should the impairment status be verified, the desired endpoints under this TMDL may be refined and call for more intensive sampling conducted over the period 2013-2015 to assess progress in this TMDL's implementation.

7. FEEDBACK

Public Notice: Public meetings to discuss TMDLs in the Missouri Basin have been held since 2001. An active Internet Web site was established at www.kdheks.gov/tmdl/ to convey information to the public on the general establishment of TMDLs in the Missouri Basin and these specific TMDLs.

Public Hearing: A Public Hearing on the Missouri Basin TMDLs was held in Hiawatha on May 30, 2007.

Basin Advisory Committee: The Missouri Basin Advisory Committee met to discuss these TMDLs on June 26, 2006 in Atchinson, December 1, 2006 and January 26, 2007 in Highland, March 16, 2007 in Atchison, and May 14, 2007 in Hiawatha.

Milestone Evaluation: In 2012, evaluation will be made as to implementation of management practices to minimize the nonpoint source runoff contributing to this

impairment. Subsequent decisions will be made regarding the implementation approach, priority of allotting resources for implementation and the need for additional or follow up implementation in this watershed at the next TMDL cycle for this basin in 2012.

Consideration for 303d Delisting: Pony Creek Lake will be evaluated for delisting under Section 303d, based on the monitoring data over the period 2008-2015. Therefore, the decision for delisting will come about in the preparation of the 2016 303d list. Should modifications be made to the applicable water quality criteria during the 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 would come in 2007 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 2008-2015.

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Revised October 16, 2007

Appendix A – CNET Eutrophication Model

Input for CNET Model

Parameter	Value Input into CNET Model
Drainage Area (km²)	19.09
Precipitation (m/yr)	0.8
Evaporation (m/yr)	1.13
Unit Runoff (m/yr)	0.16
Surface Area (km²)	0.486
Max Depth (m)	10.0
Mean Depth (m)	3.4
Depth of Mixed Layer (m)	3.39
Depth of Hypolimnion (m)	1.35
Observed Phosphorus (ppb)	40.2
Observed Chlorophyll <i>a</i> (ppb)	26.12
Observed Secchi Disc Depth	1.11

Output from CNET Model

Parameter	Output from CNET Model
Load Capacity (LC)*	1057 lbs/year
Waste Load Allocations (WLA)	0 lbs/year
Load Allocation (LA)	951 lbs/year
Margin of Safety (MOS)	106 lbs/year

* - $LC = WLA + LA + MOS$

RESERVOIR EUTROPHICATION MODELING WORKSHEET TITLE ->

VARIABLE	UNITS	Current	IC
WATERSHED CHARACTERISTICS...			
		Latitude	37
Drainage Area	km2	19.09	19.09
Precipitation	m/yr	0.8	0.8
Evaporation	m/yr	1.13	1.13
Unit Runoff	m/yr	0.16	0.16
Stream Total P Conc.	ppb	350	150
Stream Ortho P Conc.	ppb	0	0
Atmospheric Total P Load	kg/km2-yr	46	46
Atmospheric Ortho P Load	kg/km2-yr	0	0
POINT SOURCE CHARACTERISTICS...			
Flow	hm3/yr	0	0.0
Total P Conc	ppb	0	0.0
Ortho P Conc	ppb	0	0
RESERVOIR CHARACTERISTICS...			
Surface Area	km2	0.486	0.486
Max Depth	m	10	10
Mean Depth	m	3.4	3.4
Non-Algal Turbidity	1/m	0.25	0.25
Mean Depth of Mixed Layer	m	3.39	3.39
Mean Depth of Hypolimnion	m	1.35	1.35
Observed Phosphorus	ppb	40.2	40.2
Observed Chl-a	ppb	26.12	26.1
Observed Secchi	meters	1.11	1.11
MODEL PARAMETERS...			
BATHTUB Total P Model Number (1-8)		1	1
BATHTUB Total P Model Name		AVAIL P	
BATHTUB Chl-a Model Number (2,4,5)		2	2
BATHTUB Chl-a Model Name		P L Q	
Beta = 1/S vs. C Slope	m2/mg	0.034491	0.034491
P Decay Calibration (normally =1)		1	1
Chlorophyll-a Calib (normally = 1)		1	1
Chla Temporal Coef. of Var.		0.35	0.35
Chla Nuisance Criterion	ppb	12	12
WATER BALANCE...			
Precipitation Flow	hm3/yr	0.39	0.39
NonPoint Flow	hm3/yr	3.05	3.05
Point Flow	hm3/yr	0.00	0.00
Total Inflow	hm3/yr	3.44	3.44
Evaporation	hm3/yr	0.55	0.55
Outflow	hm3/yr	2.89	2.89

Pony Creek Lake

VARIABLE	UNITS	Current	IC
AVAILABLE P BALANCE...			
Precipitation Load	kg/yr	11	11
NonPoint Load	kg/yr	246	105
Point Load	kg/yr	0	0
Total Load	kg/yr	257	117
Sedimentation	kg/yr	141	48
Outflow	kg/yr	116	68
PREDICTION SUMMARY...			
P Retention Coefficient	-	0.547	0.414
Mean Phosphorus	ppb	40.2	23.6
Mean Chlorophyll-a	ppb	15.9	9.8
Algal Nuisance Frequency	%	73.3	22.6
Mean Secchi Depth	meters	1.25	1.70
Hypol. Oxygen Depletion A	mg/m2-d	956.0	751.6
Hypol. Oxygen Depletion V	mg/m3-d	708.2	556.8
Organic Nitrogen	ppb	537.6	399.5
Non Ortho Phosphorus	ppb	30.1	19.3
Chl-a x Secchi	mg/m2	19.9	16.7
Principal Component 1	-	2.50	2.17
Principal Component 2	-	1.02	0.98
	Observed	Pred	Target
Carlson TSI P	57.5	57.5	49.8
Carlson TSI Chl-a	62.6	57.7	53.0
Carlson TSI Secchi	58.5	56.7	52.4
OBSERVED / PREDICTED RATIOS...			
Phosphorus		1.00	1.70
Chlorophyll-a		1.65	2.66
Secchi		0.89	0.65
OBSERVED / PREDICTED T-STATISTICS...			
Phosphorus		0.00	1.96
Chlorophyll-a		1.83	3.60
Secchi		-0.45	-1.57
ORTHO P LOADS...			
Precipitation	kg/yr	0	0
NonPoint	kg/yr	0	0
Point	kg/yr	0	0
Total	kg/yr	0	0
Total	#/year	0	0

Based on CNET.WK1 VERSION 1.0

VARIABLE	UNITS	Current	IC
RESPONSE CALCULATIONS...			
Reservoir Volume	hm3	1.6524	1.6524
Residence Time	yrs	0.5710	0.5710
Overflow Rate	m/yr	6.0	6.0
Total P Availability Factor		1	1
Ortho P Availability Factor		1.93	1.93
Inflow Ortho P/Total P		0.000	0.000
Inflow P Conc	ppb	88.8	40.3
P Reaction Rate - Mods		2.7	1.2
P Reaction Rate - Model 2	#DIV/0!	#DIV/0!	#DIV/0!
P Reaction Rate - Model 3		5.1	2.3
1-Rp Model 1 - Avail P		0.453	0.586
1-Rp Model 2 - Decay Rate	#DIV/0!	#DIV/0!	#DIV/0!
1-Rp Model 3 - 2nd Order Fixed		0.356	0.477
1-Rp Model 4 - Canfield & Back		0.448	0.564
1-Rp Model 5 - Vollenweider 19		0.570	0.570
1-Rp Model 6 - First Order Dec		0.637	0.637
1-Rp Model 7 - First Order Set		0.856	0.856
1-Rp Model 8 - 2nd Order Tp Or		0.453	0.586
1-Rp - Used		0.453	0.586
Reservoir P Conc	ppb	40.2	23.6
Gp		0.669	0.669
Bp	ppb	32.3	15.6
Chla vs. P, Turb, Flusl		2	15.9
Chla vs. P Linear		4	11.3
Chla vs. P 1.46		5	17.8
Chla Used	ppb	15.9	9.8
ml - Nuisance Freq Calc.		2.7	2.2
z		-0.623	0.751
v		0.328	0.301
w		0.828	0.800
x		0.267	0.226
TOTAL P LOADS...			
BAF Override (KS)			
		OrP %	
Precipitation	kg/yr	0%	22
NonPoint	kg/yr	0%	1069
Point	kg/yr	0%	0
Total	kg/yr		1091
Total	#/year		2401

Appendix B – Carney Nitrogen Models

Nitrogen Current Load

Acres of Landuse		Nitrogen Loading Coefficients			Nitrogen Annual Loads		
		Low kgN/ac/yr	Mean kgN/ac/yr	High kgN/ac/yr	Low kgN/yr	Mean kgN/yr	High kgN/yr
Cropland	2271.04	1.4325	2.865	5.73	3253.2648	6506.5296	13013.0592
Grassland	1352.04	0.7	1.4	2.8	946.428	1892.856	3785.712
Urban	250.14	1.9185	3.837	7.674	479.89359	959.78718	1919.57436
Feedlot (Barnyards)	0	17.604	35.208	70.416	0	0	0
Woodland	273.64	0.3945	0.789	1.578	107.95098	215.90196	431.80392
Lake (atmospheric)	179.6	10.488	20.976	41.952	1883.6448	3767.2896	7534.5792
Total	4146.86 acres						
			Effective N-Load		5713.67	11427.35	22854.70
			Total N-Load		6671.18	13342.36	26684.73
		Current Condition	Total N-Load	lb/yr		29414.57642	

Nitrogen TMDL Load

Acres of Landuse		Nitrogen Loading Coefficients			Nitrogen Annual Loads		
		Low kgN/ac/yr	Mean kgN/ac/yr	High kgN/ac/yr	Low kgN/yr	Mean kgN/yr	High kgN/yr
Native Grassland	3873.22	0.338	0.676	1.352	1309.14836	2618.29672	5236.59344
Woods	273.64	0.3945	0.789	1.578	107.95098	215.90196	431.80392
Lake (atmospheric)	179.6	10.488	20.976	41.952	1883.6448	3767.2896	7534.5792
Total	4146.86 acres						
			Effective N-Load		3017.32	6034.65	12069.30
			Total N-Load		3300.74	6601.49	13202.98
		Reduction	Total N-Load	lb/yr		14553.64106	
					% change	49.48%	
					%reduction	50.52%	
			MOS			1455.364106	
			LA			13098.27696	

Carney Nitrogen Model for Estimating Chlorophyll *a* Concentration and TMDL Nitrogen Concentration. Model for blue-green algal dominance.

Regression Statistics

Multiple R	0.840453439
R Square	0.706361983 TP+TN/Chl-a Data for Blue-Green Data
Adjusted R Square	0.703395942
Standard Error	0.271497255
Observations	201

Analysis of Variance

	<i>df</i>	<i>Sum of Squares</i>	<i>Mean Square</i>	<i>F</i>	<i>Significance F</i>
Regression	2	35.10840578	17.55420289	238.1498	2.05786E-53
Residual	198	14.59473035	0.073710759		
Total	200	49.70313612			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Statistic</i>	<i>P-value</i>	<i>Lower 95.00</i>	<i>Upper 95.00</i>
Intercept	-0.863721662	0.192346712	-4.490441525	1.2E-05	-1.243032739	-0.48441059
x1	0.776811253	0.060706036	12.79627694	0	0.657097889	0.896524617
x2	0.275863867	0.084500019	3.264660412	0.001289	0.109228353	0.442499381

If TP = 21.3 ppb, Then Chl-a = 8.98 ppb most likely
 and TN = 700 ppb 0.87 ppb lower 95th %ile
 92.36 ppb upper 95th %ile

$$\text{LogChl-a} = 0.7768 * \text{Log(TP)} + 0.2759 * \text{Log(TN)} - 0.86372$$

Appendix C – Conversion to Daily Loads as Regulated by EPA Region VII

The TMDL has estimated annual average loads for TN and TP that if achieved should meet the water quality targets. A recent court decision often referred to as the “Anacostia decision” has dictated that TMDLs include a “daily” load (Friend of the Earth, Inc v. EPA, et al.).

Expressing this TMDL in daily time steps could be misleading to imply a daily response to a daily load. It is important to recognize that the growing season mean chlorophyll *a* is affected by many factors such as: internal lake nutrient loading, water residence time, wind action and the interaction between light penetration, nutrients, sediment load and algal response.

To translate long term averages to maximum daily load values, EPA Region 7 has suggested the approach describe in the Technical Support Document for Water Quality Based Toxics Control (EPA/505/2-90-001)(TSD).

$$\text{Maximum Daily Load (MDL)} = (\text{Long-Term Average Load}) * e^{[Z\sigma - 0.5\sigma^2]}$$

$$\text{where } \sigma^2 = \ln(CV^2 + 1)$$

CV = Coefficient of variation = Standard Deviation / Mean

Z = 2.326 for 99th percentile probability basis

LTA= Long Term Average

LA= Load Allocation

MOS= Margin of Safety

Parameter	LTA	CV	$e^{[Z\sigma - 0.5\sigma^2]}$	MDL	LA	MOS (10%)
TP	1057 lbs/yr	0.43	2.39	6.92 lbs/day	6.23 lbs/day	0.69 lbs/day
TN	14,553 lbs/year	0.5	2.68	106.9 lbs/day	96.2	10.7

Maximum Daily Load Calculation

$$\text{Maximum Daily Load} = (\text{Long-Term Average Load}) * e^{[Z\sigma - 0.5\sigma^2]}$$

$$\text{where } \sigma^2 = \ln(CV^2 + 1)$$

CV = Coefficient of variation

Z = 2.326 for 99th percentile probability basis

$$\text{Annual TN Load} = 14,553 \text{ lbs/yr}$$

$$\begin{aligned} \text{Maximum Daily TN Load} &= [(14,553 \text{ lbs/yr}) / (365 \text{ days/yr})] * e^{[2.326*(0.472) - 0.5*(0.472)^2]} \\ &= 106.9 \text{ lbs/day} \end{aligned}$$

$$\text{Annual TP Load} = 1057 \text{ lbs/yr}$$

$$\begin{aligned} \text{Maximum Daily TP Load} &= [(1057 \text{ lbs/yr}) / (365 \text{ days/yr})] * e^{[2.326*(0.412) - 0.5*(0.412)^2]} \\ &= 6.92 \text{ lbs/day} \end{aligned}$$

Margin of Safety (MOS) for Daily Load

$$\text{Annual TN MOS} = 1455 \text{ lbs/yr}$$

$$\begin{aligned} \text{Daily TN MOS} &= [(1455 \text{ lbs/yr}) / (365 \text{ days/yr})] * e^{[2.326*(0.472) - 0.5*(0.472)^2]} \\ &= 10.7 \text{ lbs/day} \end{aligned}$$

$$\text{Annual TP MOS} = 106 \text{ lbs/yr}$$

$$\begin{aligned} \text{Daily TP MOS} &= [(106 \text{ lbs/yr}) / (365 \text{ days/yr})] * e^{[2.326*(0.412) - 0.5*(0.412)^2]} \\ &= 0.69 \text{ lbs/day} \end{aligned}$$

Source- *Technical Support Document for Water Quality-based Toxics Control (EPA/505/2-90-001)*