NEOSHO RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody Assessment Unit: Lake Kahola
Water Quality Impairment: Eutrophication

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Neosho Headwaters

Counties: Morris and Chase

HUC8: 11070201 **HUC10** (12): 02(09)

Drainage Area: Approximately 15.8 square miles.

Conservation Pool: Surface Area = 363 acres
Watershed Ratio =28:1
Maximum Depth = 10.0 meters
Mean Depth = 3.4 meters
Storage Volume = 2297 acre-feet
Estimated Retention Time = 0.48 years
Mean Annual Precipitation = 33.0 inches/year
Mean Annual Evaporation = 52.4 inches/year
Annual Outflow = 4758.6 acre-feet

Ecoregion: Flint Hills, 28

Designated Uses: Primary Contact Recreation Class A; Expected Aquatic Life Support; Drinking water supply; Food Procurement; Industrial Water Supply; Irrigation Use; and Livestock Watering Use.

303(d) Listings: Lake Kahola is cited as impaired by Eutrophication: 2012 and 2014 Neosho River Basin Lakes.

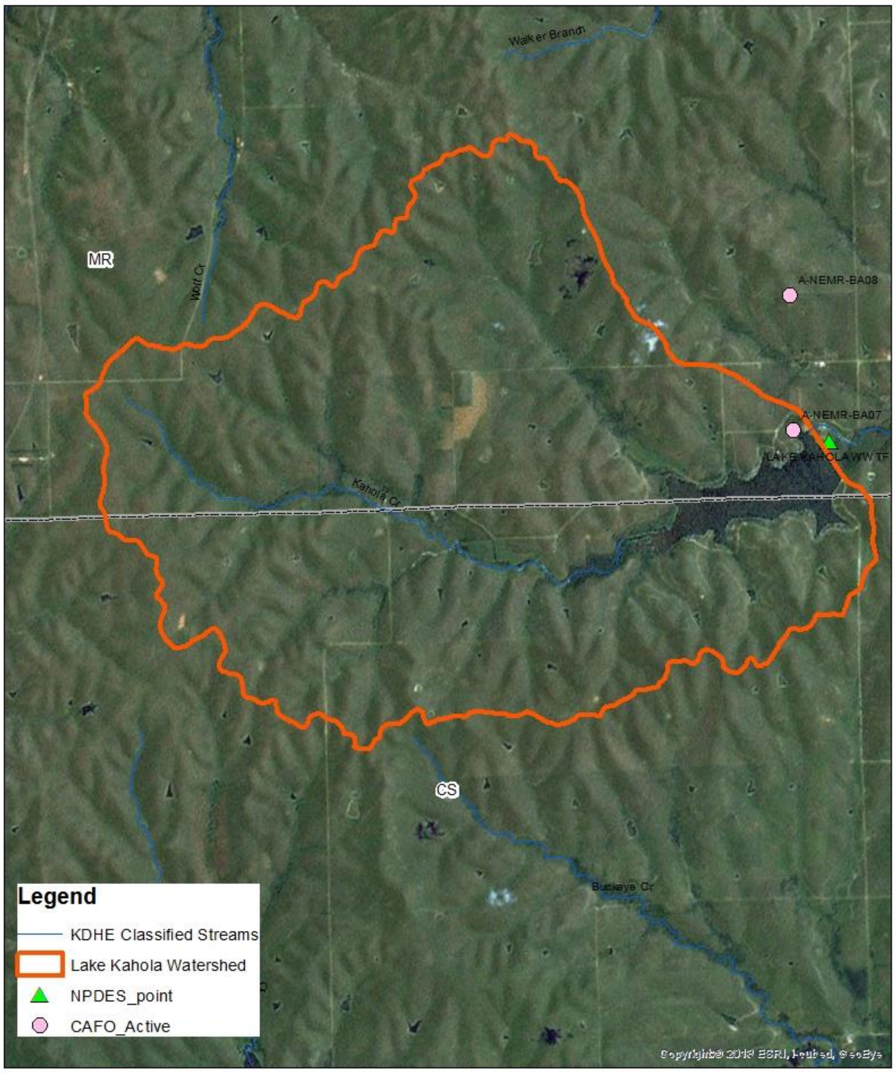
Impaired Use: All uses in Lake Kahola are impaired to a degree by eutrophication.

Water Quality Criteria:
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 (K.A.R. 28-16-28e(c)(2)(A)).

The introduction of plant nutrients into surface waters designated for domestic water supply use shall be controlled to prevent interference with the production of drinking water (K.A.R. 28-16-28e(c)(3)(D)).

The introduction of plant nutrients into surface waters designated for primary or secondary contact recreation 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 (K.A.R. 28-26-28e(c)(7)(A)).

Figure 1. Lake Kahola Base Map.



2. CURRENT WATER QUALITY CONDITIONS AND DESIRED ENDPOINT

Level of Support for Designated Uses under 2014-303(d): Excessive nutrients are not being controlled and are thus impairing aquatic life; domestic water supply; and contributing to objectionable algal blooms that contribute to the eutrophication and impairment of contact recreation within Lake Kahola.

Level of Eutrophication:

Long Term Average (1986-2003) Mesotrophic, Trophic State Index = 49.19
Most Current Survey (2003): Slightly Eutrophic, Trophic State Index = 54.05

The Trophic State Index (TSI) 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 10 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:

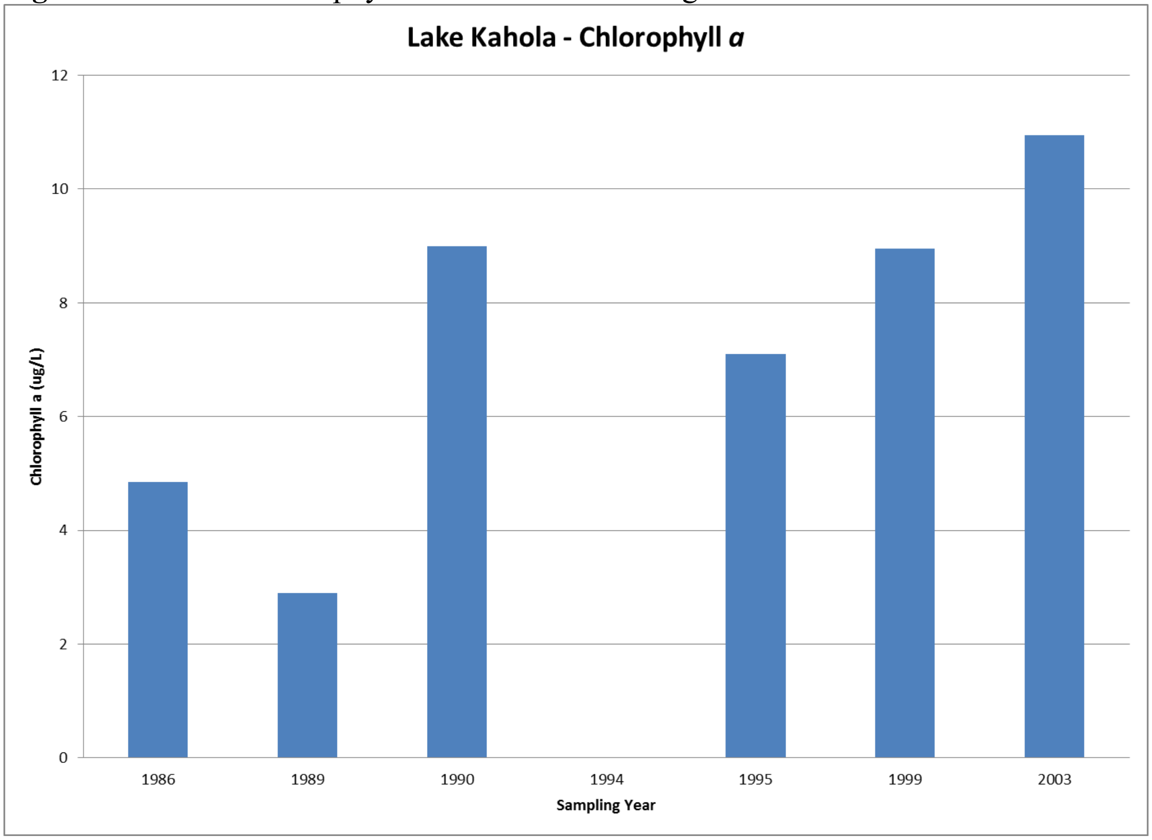
1. Oligotrophic TSI: < 40
2. Mesotrophic TSI: 40-49.99
3. Slightly Eutrophic TSI: 50-54.99
4. Fully Eutrophic TSI: 55-59.99
5. Very Eutrophic TSI: 60-63.99
6. Hypereutrophic TSI: ≥ 64

Lake Chemistry Monitoring Sites: Station LM043401 in Lake Kahola.

Period of Record Used: Six surveys conducted by KDHE in the calendar years of 1986, 1989, 1990, 1995, 1999, and 2003. Five additional supplemental samples were collected in 1994 and 1995.

Current Conditions: Over the period of record for the six years KDHE conducted comprehensive sampling surveys on Lake Kahola the chlorophyll *a* concentration average is 7.29 μg/l, with a corresponding Trophic State Index (TSI) of 50.06. Chlorophyll *a* concentrations were measured in samples taken during a single sampling event in summer of 1986, 1989, 1990, 1995, 1999, and 2003. As indicated in Figure 2, chlorophyll *a* concentrations range from a low of 2.9 μg/l in 1989 to a high of 10.95 μg/l in the most recent sampling year in 2003.

Figure 2. Annual Chlorophyll *a* concentration averages in Lake Kahola.



The ratio of total nitrogen and total phosphorus is a common ratio utilized to determine which of these nutrients is likely limiting plant growth in Kansas aquatic ecosystems (Dzialowski et al. 2005). Typically, lakes that are nitrogen limited have a water column TN:TP ratio < 10 (mass); lakes that are co-limited by nitrogen and phosphorus have a TN:TP ratio between 10 and 17; and lakes that are phosphorus 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 21 µg/l annually for the period of record, with a more recent TP concentration of 36 µg/l for the most current sampling event (2003). TP concentration averages were the same (15 µg/l) in 1990, 1994, and 1995 prior to increasing to the levels observed in the past two sampling years. TP concentrations in Lake Kahola are detailed in Figure 3. The total nitrogen concentration average is 628 µg/l for the years where total nitrogen can be calculated, which include the sampling years that have Kjeldahl nitrogen analysis and include 1994, 1995, 1999, and 2003. Total nitrogen content is primarily influence by the Kjeldahl nitrogen content in Lake Kahola. With the exception of the 1999 sampling year, Lake Kahola was phosphorus limited in 1994,1995 and 2003. During these years phosphorus has a strong influence on algal plant growth and lake conditions rather than total nitrogen concentrations. The lake was nitrogen limited in 1999. The Lake Kahola TN:TP ratio for each sampling year is illustrated in Figure 4.

Figure 3. Annual TP concentration averages in Lake Kahola.

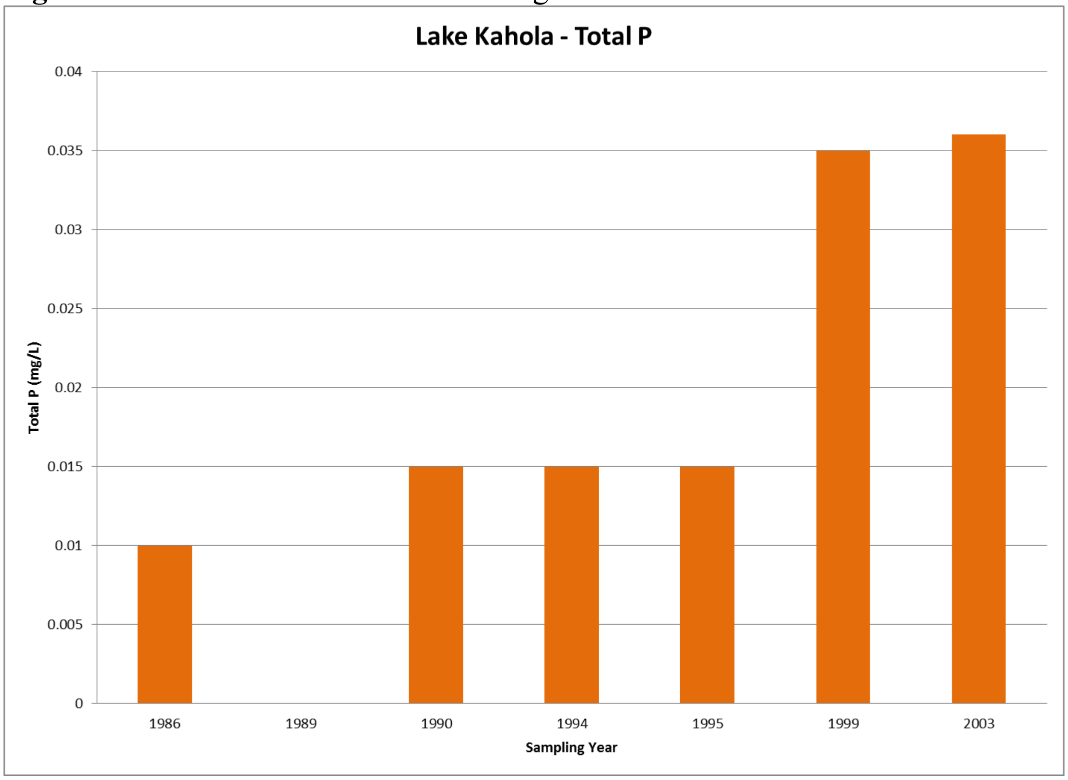
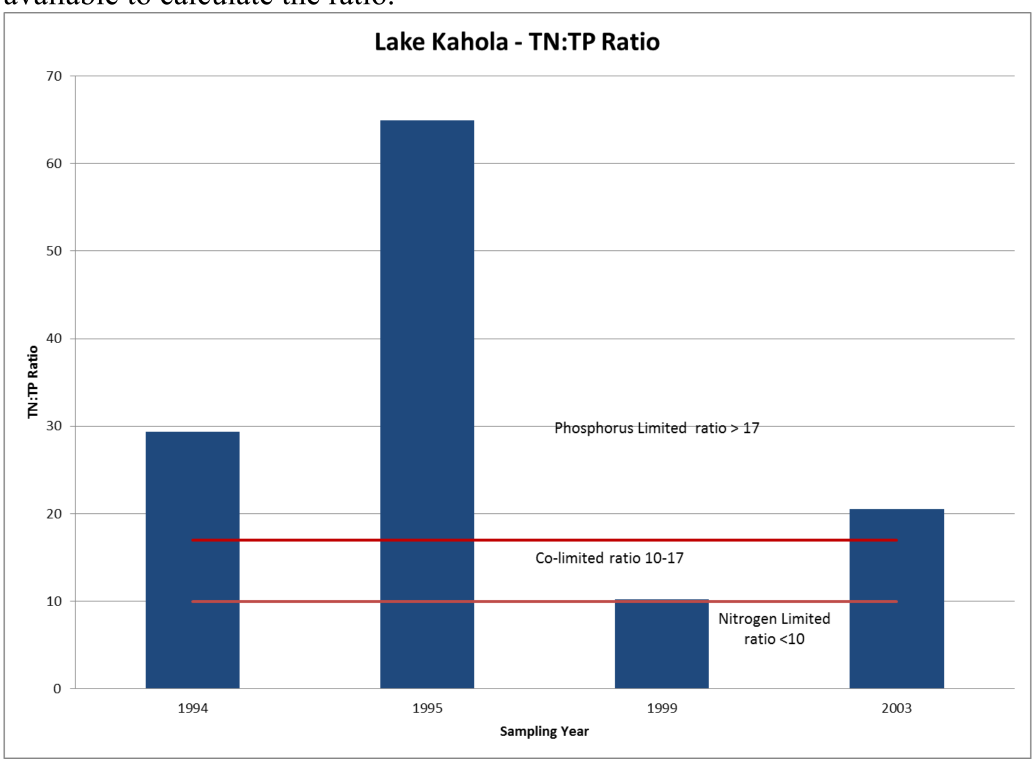


Figure 4. TN:TP ratio on Lake Kahola for select sampling years where TN data was available to calculate the ratio.



The sampling results for each sampling date are detailed in Table 1. The lake was sampled for nutrients only during bimonthly sampling which was conducted from October of 1994 through June of 1995. Table 2 details the annual average summary for each sampling year on Lake Kahola.

Table 1. Sampling results for individual samples in Lake Kahola for select parameters.

Sample Date	Chl *a* (µg/l)	TP (mg/l)	TN (mg/L)	TN:TP Ratio	Field pH	Temp (C)	Secchi Depth (m)
7/15/1986	4.85	0.01			8.4	30	
7/25/1989	2.9					25.2	0.71
7/16/1990	9.0				8.3	23	0.90
7/17/1990		0.015					
10/10/1994		0.02	0.70	35			
12/5/1994		0.01	0.18	18			
2/2/1995		0.01<	1.03	103			
4/3/1995		0.01<	0.81	81			
6/14/1995		0.03	0.44	14.7			
8/7/1995	7.1	0.01<	0.974	97.4	7.56	28	1.1
6/7/1999	8.95	0.035	0.357	10.2	7.36	24	0.6
7/28/2003	10.95	0.036	0.739	20.53	7.48	26.5	1.11

Table 2. Annual concentration averages for select parameters in Lake Kahola.

Sample Date	Chl a (µg/l)	TP (mg/l)	TN (mg/L)	TN:TP Ratio	Field pH	Temp (C)	Secchi Depth (m)
1986	4.85	0.01			8.4	30	
1989	2.9					25.2	0.71
1990	9.0	0.015			8.3	23	0.90
1994		0.015	0.44	29.33			
1995	7.1	0.015	0.974	64.93	7.56	28	1.1
1999	8.95	0.035	0.357	10.2	7.36	24	0.6
2003	10.95	0.036	0.739	20.53	7.48	26.5	1.11
Annual Averages	7.29	0.021	0.628	31.25	7.82	26.12	0.884

Table 3 lists the six metrics measuring the roles of light and nutrients in Lake Kahola. Non-algal turbidity (NAT) values $< 0.4m^{-1}$ indicates there are very low levels of suspended silt and/or clay. The values between 0.4 and $1.0m^{-1}$ indicates inorganic turbidity assumes greater influence on water clarity but would not assume a significant limiting role until values exceed $1.0m^{-1}$.

The depth of the mixed layer in meters (Z) multiplied by the NAT value assesses light availability in the mixed layer. There is abundant light within the mixed layer of the lake and potentially a high response by algae to nutrient inputs when this value is less than 3. Values greater than 6 would indicate the opposite.

The partitioning of light extinction between algae and non-algal turbidity is expressed as chl*a**SD (chlorophyll *a* * Secchi Depth). Inorganic turbidity is not responsible for light extinction in the water column and there is a strong algal response to changes in nutrient levels when this value is greater than 16. Values less than 6 indicate that inorganic turbidity is primarily responsible for light extinction in the water column and there is a weak algal response to changes in nutrient levels.

Values of algal use of phosphorus supply (chl*a*/TP) that are greater than 0.4 indicate a strong algal response to changes in phosphorus levels, where values less than 0.13 indicate a limited response by algae to phosphorus.

The light availability in the mixed layer for a given surface light is represented as Zmix/SD. Values less than 3 indicate that light availability is high in the mixed zone and there is a high probability of strong algal responses to changes in nutrient levels. Values > 6 indicate the opposite.

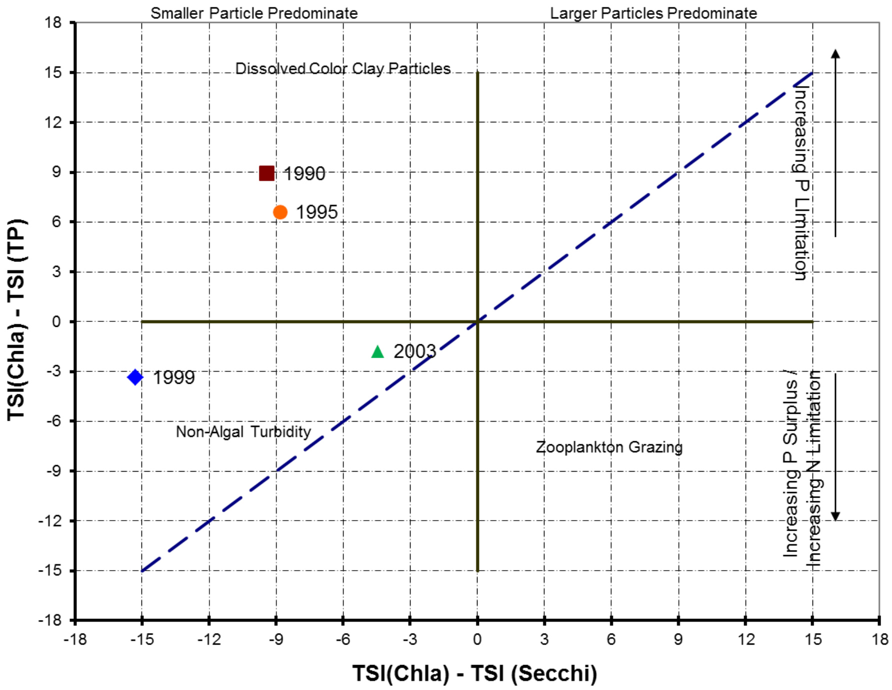
The above metrics indicate that Lake Kahola has moderate to abundant light within the mixed layer. There are moderate to strong influences of inorganic turbidity on water clarity and moderately high responses to algae to nutrient inputs, particularly to changes in phosphorus levels.

Table 3. Limiting factor determinations for Lake Kahola. NAT = non-algal turbidity; TN:TP = nitrogen to phosphorus ratio; Z = depth of mixed layer; Chla = chlorophyll a; and SD = secchi depth. (Carney, 1989, 1990, 1995, 1999, 2003).

Sampling Year	NAT	Z* NAT	Chla*SD	Chla/TP	Z/SD	Chla
1989	1.34	4.58	2.06		4.83	2.9
1990	0.89	3.04	8.1	0.600	3.81	9.0
1995	0.73	2.51	7.81	0.473	3.12	7.1
1999	1.44	4.95	5.37	0.256	5.72	8.95
2003	0.63	2.15	12.15	0.304	3.09	10.95

Another method for evaluating limiting factors is the TSI deviation metrics. Figure 5 summarizes the current trophic conditions at Lake Kahola using a multivariate TSI comparison chart for data obtained in 1990, 1995, 1999, and 2003. Points above TSI(Chla)-TSI(TP), where TSI(Chla) is greater than TSI(TP), indicate situations where phosphorus is limiting chlorophyll *a*, points below would conclude the opposite. TSI(Chla)-TSI(SD) is plotted on the horizontal axis, showing that if the Secchi depth (SD) trophic index is less than the chlorophyll *a* trophic index, than there is dominate zooplankton grazing. Transparency would be dominated by non-algal factors such as color or inorganic turbidity if the Secchi depth index were more than the chlorophyll *a* index. Points near the diagonal line occur in turbid situations where phosphorus is bound to clay particles and therefore turbidity values are closely associated with phosphorus concentrations. For the years plotted in Figure 5, Lake Kahola is limited by phosphorus in 1990 and 1995. Transparency is dominated by non-algal factors and inorganic turbidity during the four sampling surveys on Figure 5.

Figure 5. Multivariate TSI comparison chart of Lake Kahola for



Other Parameter Relationships:
As seen in Figure 6, within Lake Kahola there are positive relationships between chlorophyll *a* and; secchi depth and phosphorus. There are negative relationships between chlorophyll *a* and; turbidity, pH, and NAT values. As seen in Figure 7, there is a positive relationship between phosphorus and NAT and negative relationships between phosphorus and; turbidity, temperature, total nitrogen, and TSS. Figure 8 details secchi depth relationships within Lake Kahola, there are positive relationships between secchi depth and; temperature, total nitrogen, and TSS. There are negative relationships between secchi depth and; turbidity, NAT values and phosphorus.

Figure 6. Relationship between chlorophyll *a* and: Secchi depth, turbidity, pH, TP, and NAT in Lake Kahola.

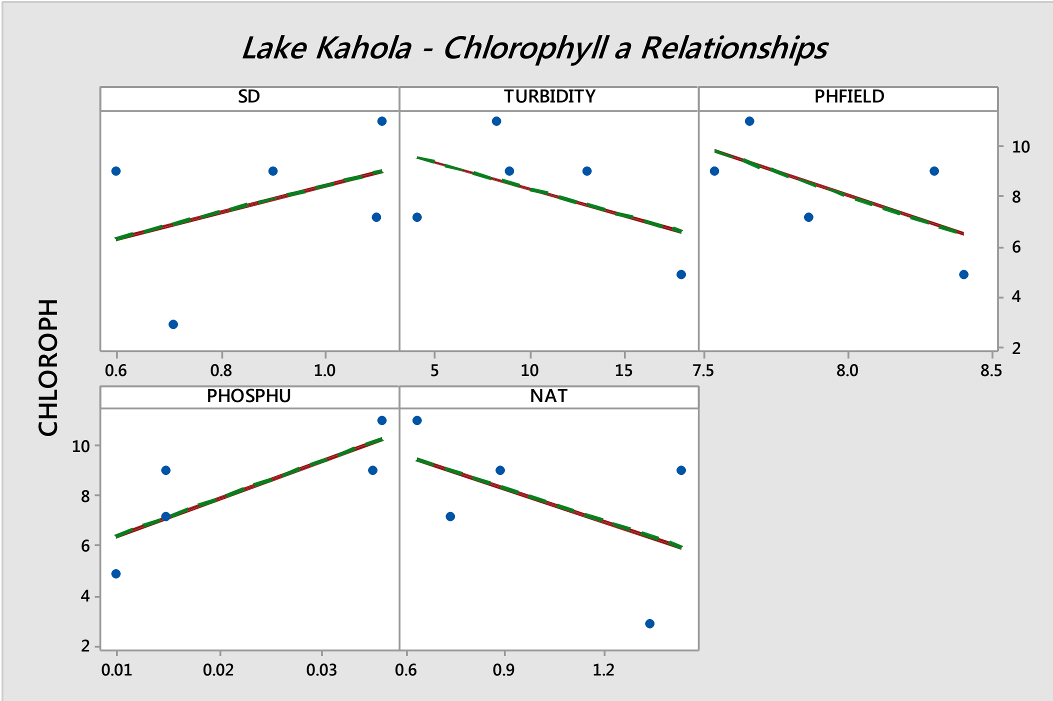


Figure 7. Relationship between TP and: turbidity, temperature, total nitrogen, TSS, and NAT in Lake Kahola.

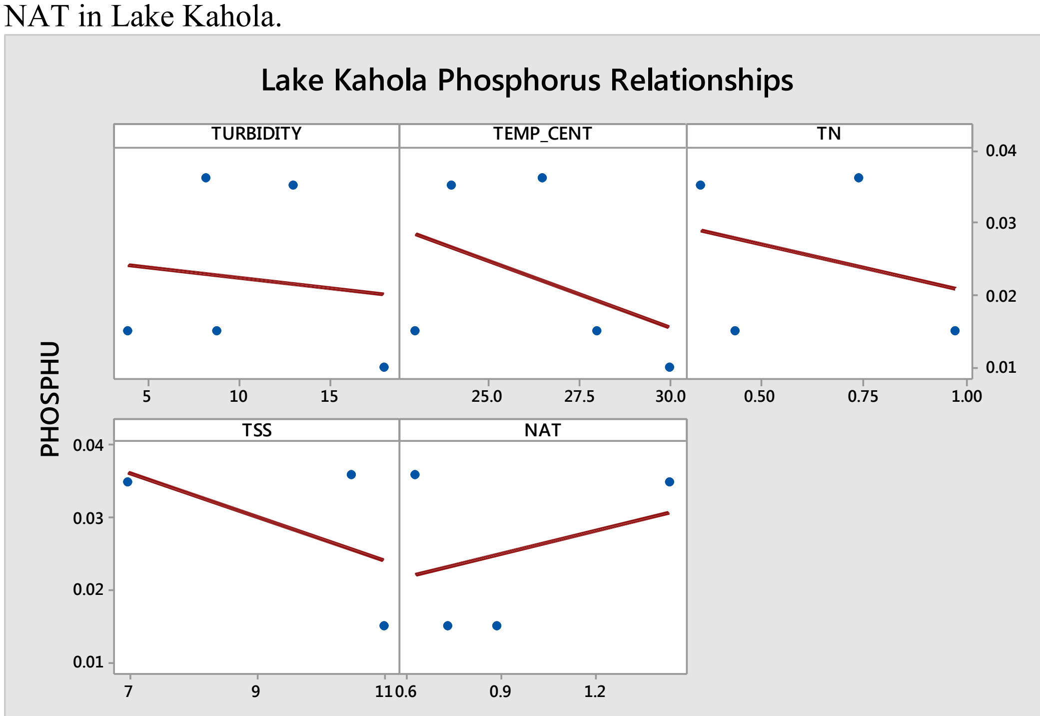
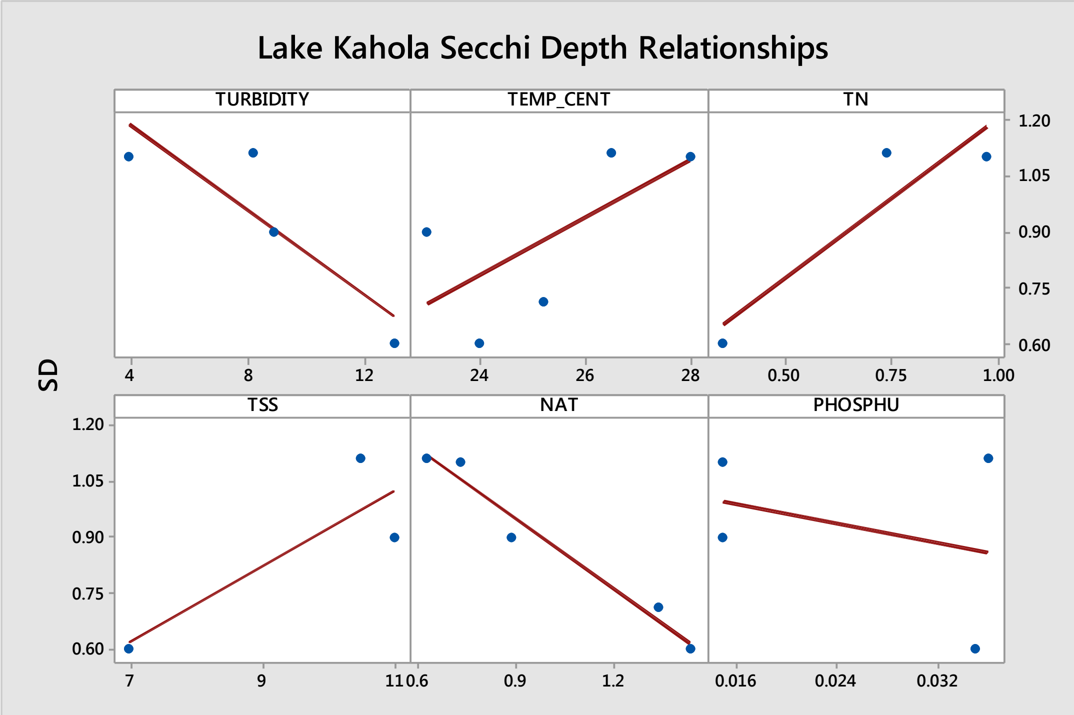


Figure 8. Relationship between secchi depth and: turbidity, temperature, total nitrogen, TSS, NAT and TP in Lake Kahola.



Interim Endpoints of Water Quality (Implied Load Capacity) at Lake Kahola: The ultimate endpoint of the TMDL is to achieve the Kansas Water Quality Standards to fully support all designated uses of Lake Kahola. In order to improve the trophic condition of the lake from its current slightly eutrophic status, the desired endpoint will be to maintain summer chlorophyll *a* concentrations below 10 µg/l, with the initial reductions focused on phosphorus loading to the lake. Reductions in phosphorus loading will address the accelerated succession of aquatic biota and the development of objectionable concentrations of algae and algae by-products as determined by the chlorophyll *a* concentrations in the lake. KDHE established chlorophyll *a* target values in the 303(d) listing methodology for lakes, with the chlorophyll *a* target of 10 µg/l for public water supply lakes. The chlorophyll *a* endpoint of 10 µg/l will also ensure long-term protection to fully support Primary Contact Recreation, Aquatic Life, Food Procurement, Industrial Water Supply, Irrigation and Livestock watering use within the lake.

This TMDL applies across all flow conditions effectively addressing the critical condition brought about by high flow events when nutrient loading in the lake occurs at exaggerated rates. Seasonal variation has been incorporated in this TMDL since the peaks of algal growth occur in the summer months.

Based on CNET reservoir eutrophication model (see Appendix A), the total phosphorus concentrations must be reduced by 22.2% to achieve a phosphorus load reduction of 28.7%. The TMDL as established through the CNET model is detailed in Table 4.

Table 4. Current conditions and reductions for Lake Kahola.

Parameter	Current Condition	TMDL	Percent Reduction
Total Phosphorus Annual Load (lbs/year)	1797.21	1281.81	28.7%
Total Phosphorus Daily Load (lbs/day)*	13.20	9.41	28.7%
Total Phosphorus Concentration (µg/l)	36	28	22.2%
Chlorophyll a Concentration (µg/l)	10.95	9.5	13.2%

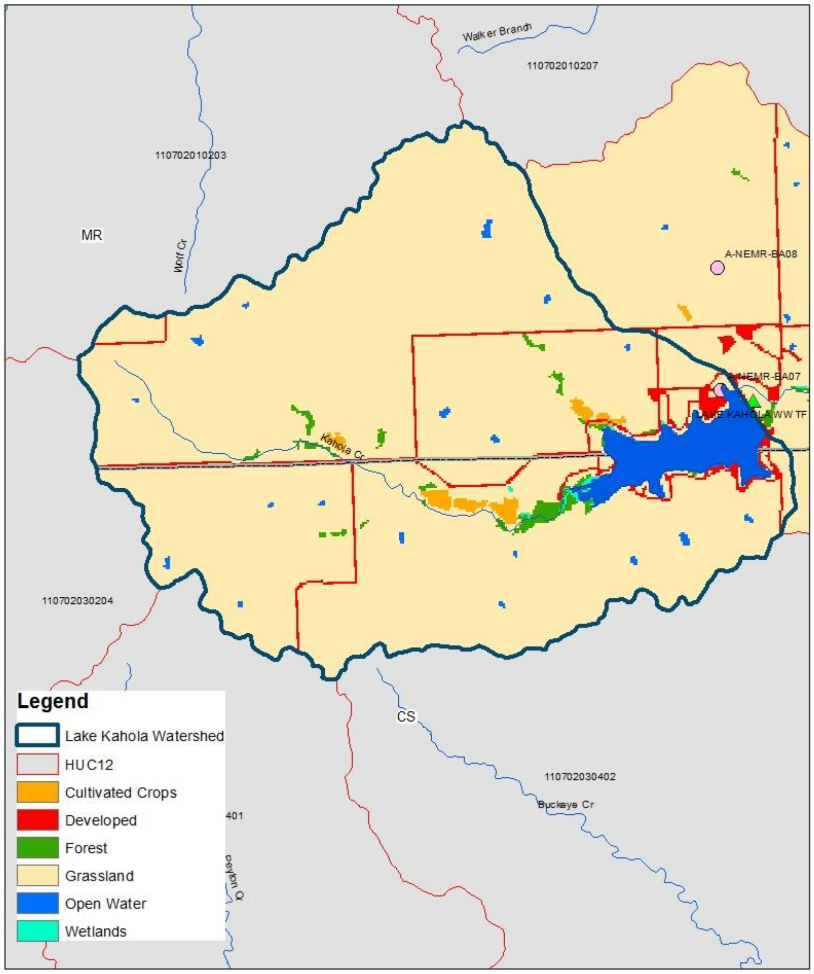
3. SOURCE INVENTORY

Land Use: The predominant land cover in the watershed around Lake Kahola includes grassland (91%) according to the 2001 National Land Cover data. Table 5 details the respective landuse acres and percentages for the entire watershed. As seen in Figure 9, the landuse map details the location of the corresponding landuses within the watershed.

Table 5. Landuse acres and percentages in the Lake Kahola watershed (2001, NLCD).

Landuse	Percentage	Acres
Grassland	91.28%	9277.83
Open Water	4.24%	430.55
Developed	2.42%	245.97
Forest	1.07%	108.53
Cultivated Crops	0.83%	84.73
Wetlands	0.16%	16.68

Figure 9. Lake Kahola Landuse Map.



Point Sources: There are no NPDES permitted facilities within the watershed.

Livestock: There is one certified confined animal feeding operation located within the watershed. This is a beef facility with 660 total animals. This facility is partially located at the lower edge of the lake near the dam. The majority of the area associated with this facility drains to areas below the lake. The livestock facility contains waste management systems designed to minimize runoff entering their operation and detains runoff emanating from their facilities. Facilities with waste management systems are designed to retain a 25-year, 24-hour rainfall/runoff event as well as an anticipated two weeks of normal wastewater from their operations. Typically, this rainfall event coincides with streamflow that occurs less than 1-5% of the time. It is unlikely TP loading would be attributable to properly operating permitted facilities, though extensive loading may occur if any of these facilities were in violation and discharged. Table 6 details the facility within the watershed.

Table 6. Certified Animal Feedin Operations in the watershed.

KS Permit #	County	Animal Total	Permit Type	Animal Type
A-NEMR-BA07	Morris	660	Certification	Beef

According to the United State Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) Kansas Farm Facts 2012 report, there were 55,000 and 38,000 head of cattle (including calves) in Morris and Chase counties respectively. The 2007 Census of Agriculture reported there were 768 horses in Morris and 824 horses in Chase counties respectively.

Population and On-Site Waste Systems: Households within the watershed are either served by the Lake Kahola wastewater treatment plant, which is located past the outlet of the lake, or on-site septic systems. The Spreadsheet Tool for Estimating Pollutant Load (STEPL) was utilized to identify the number of septic systems within the HUC12 encompassing the watershed. According to STEPL, there are approximately 110 septic systems in the HUC12 containing the watershed with an anticipated failure rate of 0.93%. Failing on-site septic systems do not likely contribute to the eutrophication impairment within the watershed since the majority of the households in the watershed are associated with the 178 cabins served by the Lake Kahola wastewater treatment lagoon. There is no connection to the collection system and each cabin is served by a privately owned containment vault which is emptied by hauling the wastewater to the treatment lagoon. If there is a failure to one of the containment systems, nutrient loading to the lake would likely occur.

The population in the watershed has seasonal variation since a large proportion of the residences around the lake are utilized as vacation properties during the warmer months. According to the 2010 U.S. Census block information there are 142 people residing in the watershed and another 148 people that are seasonal occupants.

Nonpoint Sources: Due to the lack of point sources in the watershed the impairment within the Lake Kahola watershed is attributed to nonpoint sources. Phosphorus within the watershed may be attributed to fertilizer or manure application to the agricultural lands as well as ranging livestock. Additionally, fertilizer applications to the lawns and gardens of the lakeside properties may be attributed to phosphorus loading.

Contributing Runoff: The watershed of Lake Kahola has a mean soil permeability value of 0.45 inches/hour, ranging from 0.01 to 1.29 inches/hour according to the NRCS STATSGO database. According to a USGS open-file report (Juracek, 2000), the threshold soil permeability values that represents very high, high, moderate, low, very low, and extremely low rainfall intensity, were set at 3.43, 2.86, 2.29, 1.71, 1.14, and 0.57 inches/hour respectively. The lower rainfall intensities generally occur more frequently than the higher rainfall intensities. The higher soil-permeability thresholds imply a more intense storm during which areas with higher soil permeability may potentially contribute runoff. Runoff is chiefly generated as infiltration excess with rainfall intensities greater than the soil permeability. As soil profiles become saturated, excess overland flow is produced. The entire watershed has a low soil permeability value, which will produce runoff with rainfall events that produce 1.29 inches/hour of rain. Runoff generated from cropland and grassland likely contributes to the impairment within Lake Kahola.

Internal Loading: Undissolved nutrients bound to suspended solids in the inflow to Lake Kahola are potentially moderate sources of nutrients that may endure in the sediment layer until they are removed by dredging. Internal nutrients can undergo remineralization and resuspension and may be a continuing source of nutrients in Lake Kahola.

Background: Leaf litter and wastes derived from natural wildlife may add to the nutrient load of Lake Kahola. Atmospheric and geological formations (i.e. soil and bedrock) may also contribute to the nutrient loads. Atmospheric loading is accounted for in the CNET model and atmospheric deposition of nutrients is accounted for in this TMDL. The suspension of sediment and nutrients may be influenced by the wind and bottom feeding fish, which may also re-suspend sediment and contribute to available nutrients in the lake. Fish feeding operations additionally contribute variably seasonal loads to the nutrient load within the lake.

4. ALLOCATIONS OF POLLUTANT REDUCTION RESPONSIBILITY

Phosphorus is the primary limiting nutrient in Lake Kahola and allocated under this TMDL. The general inventory of sources within the drainage does provide some guidance as to areas of load reduction.

Point Sources: A current Wasteload Allocation of zero is established under this TMDL because of the lack of 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.

Nonpoint Sources: Water quality violations are predominantly due to nonpoint source pollutants. Background levels may be attributed to nutrient recycling and leaf litter. The assessment suggests that runoff transporting nutrient loads associated with animal wastes and land where fertilizer has been applied, to include pasture and hay, contribute to the elevated phosphorus loads entering the lake. The load allocation is 1153.63 lbs/year of total phosphorus. The load allocation accounts for a 36% TP load reduction to reach the TMDL endpoint. The calculated daily load allocation (see Appendix B) is 8.47 lbs/day of total phosphorus. Allocations for this TMDL are detailed in Table 7.

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 load allocation, which has been subtracted from the assigned load allocation to compensate for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality. The margin of safety is 128.18 lbs/year, or 0.94lbs/day (see Appendix B), of total phosphorus.

Table 7. Lake Kahola Eutrophication TMDL.

	TMDL	Load Allocation	Margin of Safety
Annual TP Loads (lbs/year)	1281.81	1153.63	128.18
Daily TP Loads (lbs/day)*	9.41	8.47	0.94

*see Appendix B for Daily Load Calculations

State Water Plan Implementation Priority: This TMDL will be a Medium Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Neosho Headwaters with a priority ranking of 38 (Medium Priority for restoration).

5. IMPLEMENTATION

Desired Implementation Activities: There is a very good potential that agricultural best management practices will improve the condition of Lake Kahola. Some of the recommended agricultural practices are as follows:

1. Implement soil sampling to recommend appropriate fertilizer applications.
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 in the watershed and implement runoff control measures.

Implementation Program Guidance:

Fisheries Management – KDWP

1. Assist evaluation in-lake or near-lake potential sources of nutrients to lakes.
2. Apply lake management techniques, which may reduce nutrient loading and cycling in lake.

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. Incorporate the provisions of this TMDL into the Neosho Headwaters WRAPS.

Water Resource Cost Share and Nonpoint Source Pollution Control Programs – KDA Division of Conservation

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

Riparian Protection Program – KDA Division of Conservation

a. Establish, protect or re-establish 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 – KDA Division of Conservation

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: Continued monitoring over the years from 2015-2022.

Targeted Participants: Primary participants for implementation of best management practices will be agricultural producers and lake residents within the drainage of the lake.

Milestone for 2022: In accordance with the TMDL development schedule for the State of Kansas, the year 2022 marks the next cycle of the 303(d) activities in the Neosho Basin. At that point in time lake data should show indications of declining concentrations relative to the last sampling event at Lake Kahola. Sampling data will be reexamined to confirm the impaired status of the lake. Should impairment remain, more aggressive techniques will be examined to remove potential sources of nutrients from the lake.

Delivery Agents: The primary delivery agents for program participation will be the Neosho Headwaters WRAPS and the Kansas Department of Wildlife and Parks. Producer outreach and awareness will be delivered by Kansas State Extension. The Kansas Department of Health and Environment shall monitor lake conditions.

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.A.R. 28-16-69 through 71 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.

3. 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.

4. 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.

5. 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.

6. 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.

7. K.S.A. 32-807 authorizes the Kansas Department of Wildlife and Parks to manage lake resources.

8. The *Kansas Water Plan* and the Missouri River 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 pollution 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 watershed and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection and restoration through the WRAPS program. This watershed and its TMDL are a **Medium** Priority consideration for funding.

Effectiveness: The key to success will be widespread utilization and maintenance of conservation farming and proper livestock waste management within the watershed cited in this TMDL.

6. MONITORING

KDHE will resume sampling Lake Kahola once every three or four years in order to assess the impairment that drives this TMDL. Based on the sampling results, the priority status of the 303(d) listing will be evaluated in 2022. Lake Kahola should be scheduled for sampling in 2015, 2018, and 2021.

7. FEEDBACK

Public Meetings: An active internet web site was established at http://www.kdheks.gov/tmdl/planning_mgmt.htm to convey information to the public on the general establishment of TMDLs and specific TMDLs in the Neosho Basin.

Public Hearing: Public comments for this TMDL were held open from August 19 through September 19, 2014. A public hearing on this TMDL was held on August 28, 2014 in Emporia to receive comments. No comments were received.

Basin Advisory Committee: The Neosho Basin Advisory Committee met to discuss these TMDLs on March 6, 2014 in Marion.

Milestone Evaluation: In 2022, evaluation will be made as to the degree of implementation that occurred within the watershed. 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.

Consideration for 303(d) Delisting: Lake Kahola will be evaluated for delisting under Section 303(d), based on the monitoring data over 2014-2023. Therefore, the decision for delisting will come about in the preparation of the 2024-303(d) 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 2015 which will emphasize implementation of WRAPS activities. At that time, incorporation of this TMDL will be made into the WRAPS. Recommendations of this TMDL will be considered in the *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2015-2023.

Revised October 16, 2014

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Appendix A – CNET Eutrophication Model for Lake Kahola

Input for CNET Model

Parameter	Value Input into CNET Model
Drainage Area (mi^2)	15.8
Precipitation (in/yr)	33
Evaporation (in/yr)	52.4
Unit Runoff (in/yr)	6.83
Surface Area (acre)	363
Mean Depth (m)	3.4
Depth of Mixed Layer (m)	3.39
Observed Phosphorus (ppb)	36
Observed Chlorophyl *a* (ppb)	10.95
Observed Secchi Disc Depth (m)	1.11

Output from CNET Model

Parameter	Output from CNET Model (lbs/year)
Load Capacity (LC)*	1281.81
Waste Load Allocations (WLA)	0
Atmospheric Air Deposition (LA)	32.34
Other Nonpoint (LA)	1121.29
Total Load Allocation (LA)	1153.63
Margin of Safety (MOS)	128.18

* - LC=WLA + LA + MOS

RESERVOIR EUTROPHICATION MODELING WORKSHEET — TITLE -> **Lake Kahola** — Based on CNET.WK1 VERSION 1.0

VARIABLE	UNITS	Current	LC
WATERSHED CHARACTERISTICS...	drop down select unit - conversion is automatic	Latitude	38
Drainage Area	mi2	15.8	15.8
Precipitation	in/yr	33	33
Evaporation	in/yr	52.4	52.4
Unit Runoff	in/yr	6.83	6.83
Stream Total P Conc.	ppb	113	80
Stream Ortho P Conc.	ppb	22.6	16
Atmospheric Total P Load	kg/km2-yr	10	10
Atmospheric Ortho P Load	kg/km2-yr	0	0
POINT SOURCE CHARACTERISTICS...			
Flow	hm3/yr	0.000	0.000
Total P Conc	ppb	0.000	0.000
Ortho P Conc	ppb	0	0
RESERVOIR CHARACTERISTICS...			
Surface Area	acre	363	363
Max Depth	m	10.0	10.0
Mean Depth	m	3.4	3.4
Non-Algal Turbidity (1/m)	Dzialowski	0.41	0.38
Mean Depth of Mixed Layer	m	3.39	3.39
Mean Depth of Hypolimnion	m	1.35	1.35
Observed Phosphorus	ppb	36	28.0
Observed Chl-a	ppb	10.95	9.5
Observed Secchi	m	1.11	1.20
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)	Default	0.0823	0.0877
P Decay Calibration (normally =1)		1	1
Chlorophyll-a Calib (normally = 1)		1.26	1.26
Chla Temporal Coef. of Var.		0.35	0.35
Chla Nuisance Criterion	ppb	10	10
WATER BALANCE...			
Precipitation Flow	hm3/yr	1.23	1.23
NonPoint Flow	hm3/yr	7.10	7.10
Point Flow	hm3/yr	0.00	0.00
Total Inflow	hm3/yr	8.33	8.33
Evaporation	hm3/yr	1.96	1.96

VARIABLE	UNITS	Current	LC
AVAILABLE P BALANCE...			
Precipitation Load	kg/yr	7.35	7.35
NonPoint Load	kg/yr	494.16	349.85
Point Load	kg/yr	0.00	0.00
Total Load	b	501.51	357.20
Sedimentation	kg/yr	271.65	173.50
Outflow	kg/yr	229.87	183.70
PREDICTION SUMMARY...			
P Retention Coefficient	-	0.542	0.486
Mean Phosphorus	ppb	36.1	28.8
Mean Chlorophyll-a	ppb	11.0	9.4
Algal Nuisance Frequency	%	53.5	36.4
Mean Secchi Depth	meters	0.76	0.83
Hypol. Oxygen Depletion A	mg/m2-d	794.6	736.4
Hypol. Oxygen Depletion V	mg/m3-d	588.6	545.5
Organic Nitrogen	ppb	437.8	400.3
Non Ortho Phosphorus	ppb	25.1	21.7
Chl-a x Secchi	mg/m2	8.4	7.8
Principal Component 1	-	2.50	2.40
Principal Component 2	-	0.74	0.72
	Observed	Pred	Target
Carlson TSI P	55.9	55.9	52.7
Carlson TSI Chl-a	54.1	54.1	52.6
Carlson TSI Secchi	58.5	63.9	62.7
OBSERVED / PREDICTED RATIOS...			
Phosphorus		1.00	0.97
Chlorophyll-a		1.00	1.01
Secchi		1.46	1.45
OBSERVED / PREDICTED T-STATISTICS...			
Phosphorus		-0.01	-0.11
Chlorophyll-a		0.00	0.03
Secchi		1.38	1.36
ORTHO P LOADS...			
Precipitation	kg/yr	0.00	0.00
NonPoint	kg/yr	160.44	113.59
Point	kg/yr	0.00	0.00
Total	kg/yr	160.44	113.59
Total	lbs/yr	352.97	249.89

VARIABLE	UNITS	Current	LC
RESPONSE CALCULATIONS...			
Reservoir Volume	hm3	4.99851	4.99851
Residence Time	yrs	0.7841	0.7841
Overflow Rate	m/yr	4.3	4.3
Total P Availability Factor		1.00	1
Ortho P Availability Factor		1.93	1.93
Inflow Ortho P/Total P		0.196	0.195
Inflow P Conc	ppb	78.7	56.0
P Reaction Rate - Mods 1 & 8		2.6	1.8
P Reaction Rate - Model 2		4.3	3.1
P Reaction Rate - Model 3		6.2	4.4
1-Rp Model 1 - Avail P		0.458	0.514
1-Rp Model 2 - Decay Rate		0.379	0.429
1-Rp Model 3 - 2nd Order Fixed		0.330	0.377
1-Rp Model 4 - Canfield & Bach		0.433	0.483
1-Rp Model 5 - Vollenweider 19		0.530	0.530
1-Rp Model 6 - First Order Dec		0.561	0.561
1-Rp Model 7 - First Order Set		0.813	0.813
1-Rp Model 8 - 2nd Order Tp On		0.458	0.514
1-Rp - Used		0.458	0.514
Reservoir P Conc	ppb	36.1	28.8
Gp		0.662	0.662
Bp	ppb	27.8	20.5
Chla vs. P, Turb, Flush	2	11.0	9.4
Chla vs. P Linear	4	12.7	10.2
Chla vs. P 1.46	5	19.1	13.8
Chla Used	ppb	11.0	9.4
m1 - Nuisance Freq Calc.		2.3	2.2
z		-0.087	0.347
v		0.397	0.376
w		0.972	0.896
x		0.465	0.364

TOTAL P LOADS... BAF Override (KS) (see below)	OrP %	Current	LC
0.5	0%	14.70	14.70
0.23	20%	802.21	567.94
0.8	0%	0.00	0.00
		816.91	582.64
		1797.21	1281.81

Appendix B – 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).

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

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	1281.81 lbs/yr	0.5	2.68	9.41 lbs/day	8.47 lbs/day	0.94 lbs/day

Maximum Daily Load Calculation

Annual TP Load = 1281.81 lbs/yr

Maximum Daily TP Load $= [(1281.81 \text{ lbs/yr})/(365 \text{ days/yr})]*e^{[2.326*(0.6013)-0.5*(0.6013)^2]}$
$= 9.41$ lbs/day

Margin of Safety (MOS) for Daily Load

Annual TP MOS = 128.18 lbs/yr

Daily TP MOS $= [(128.18 \text{ lbs/yr})/(365 \text{ days/yr})]*e^{[2.326*(0.6013)-0.5*(0.6013)^2]}$
$= 0.94$ lbs/day

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