UPPER ARKANSAS BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: Concannon State Fishing Lake
Water Quality Impairment: Eutrophication

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Pawnee — **County:** Finney, Gray

HUC 8: 11030005 — **HUC (10) 12:** (01) 03

Ecoregion: Central Great Plains, Rolling Plains and Breaks (27b) and Western High Plains, Flat to Rolling Cropland (25d)

Drainage Area: 46.2 square miles

Conservation Pool: Surface Area = 15 acres
Watershed/Lake Ratio: 1,971:1
Maximum Depth = 3.0 meters
Mean Depth = 1.3 meters
Storage Volume = 61.8 acre-feet
Estimated Retention Time = 0.28 years
Mean Annual Precipitation = 18.9 inches
Mean Annual Evaporation = 70.5 inches
Mean Annual Discharge = 267 acre-feet
Year Constructed = 1952

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

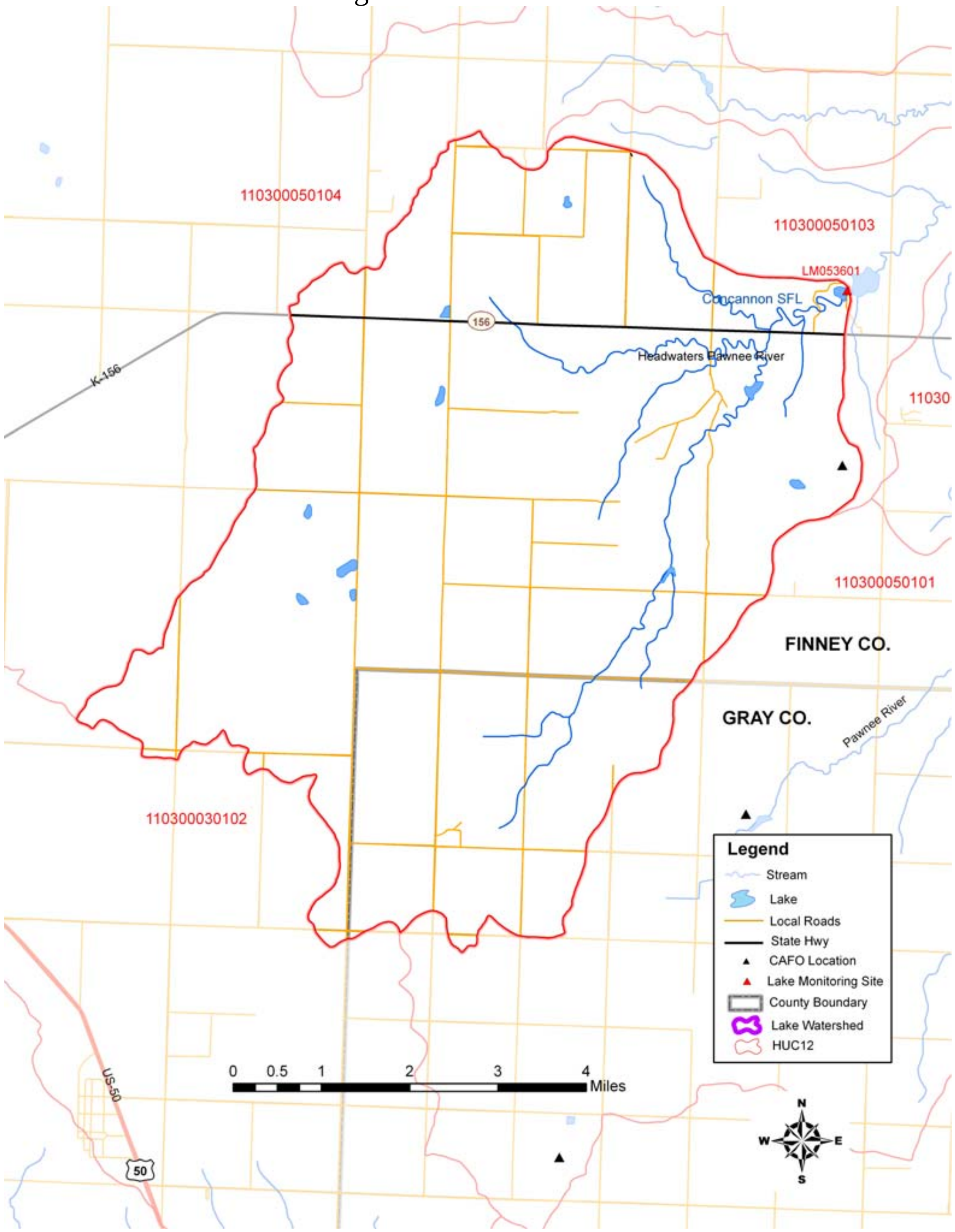
303(d) Listings: Concannon SFL Eutrophication: 2002, 2004, 2008, 2010, 2012 Kansas Upper Arkansas Basin Lakes.

Impaired Use: All uses in Concannon Lake 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 (KAR 28-16-28e(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)).

Figure 1. Concannon State Fishing Lake Watershed.



2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Uses under 2012 303(d): Excessive nutrients are not being controlled and are thus contributing to eutrophication in the lake which is impairing aquatic life use by supporting objectionable types and quantities of algae which also leads to impairment of contact recreation with Concannon State Fishing Lake (SFL). The chlorophyll *a* endpoint of 12 mg/L is appropriate to protect the uses of aquatic life support and contact recreation in Concannon SFL.

Level of Eutrophication: Very Eutrophic, Trophic State Index = 63.9

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*, nutrient levels, and values of the Carlson Trophic State Index (TSI). Generally, some degree of eutrophic conditions is seen with chlorophyll *a* over 12 ppb and hypereutrophy occurs at levels over 30 ppb. The Carlson TSI derives from the chlorophyll *a* concentrations and scales the trophic state as follows:

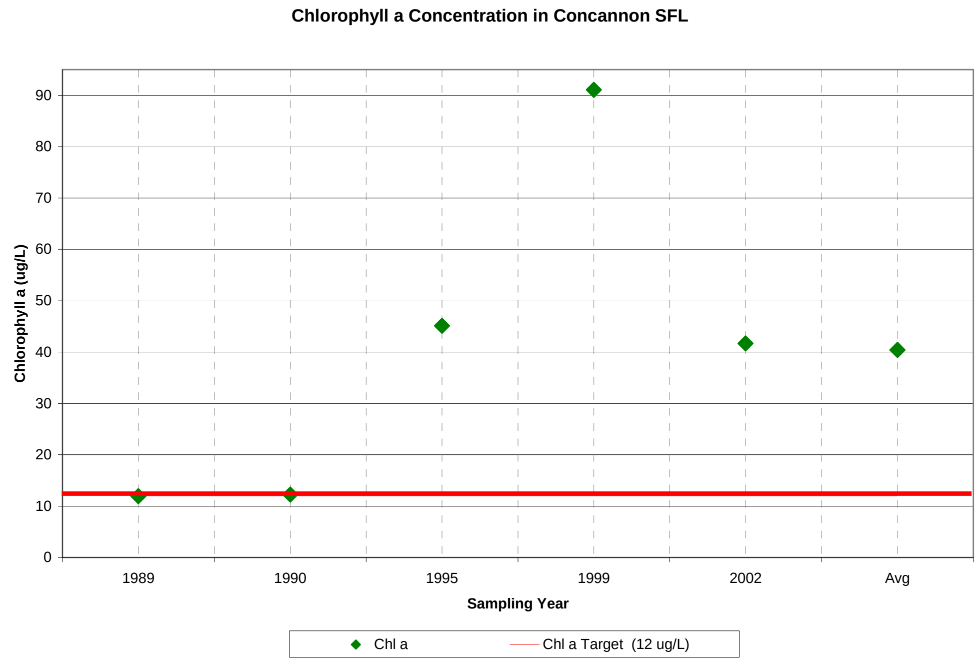
1. Oligotrophic TSI < 40
2. Mesotrophic TSI: 40 - 49.99
3. Slightly Eutrophic TSI: 50 - 54.99
4. Fully Eutrophic TSI: 55 - 59.99
5. Very Eutrophic TSI: 60 - 63.99
6. Hypereutrophic TSI: 64

Lake Monitoring Sites: KDHE Station LM053601 at Concannon SFL.
Period of Record: Five surveys conducted by KDHE during calendar years 1989, 1990, 1995, 1999, and 2002.

Long-Term Hydrologic Conditions: There is not a registered stream that flows into Concannon SFL and, although it is positioned at the headwaters to the Pawnee River, the lake occasionally goes dry. CNET reservoir eutrophication modeling estimates inflow to the lake at 705 acre feet per year, based on the drainage area. According to the USGS Lake Hydro data, the mean runoff in the watershed is 0.30 inches/year; the mean precipitation in the watershed is 18.9 inches/year; the mean loss due to evaporation for the lake is 70.5 inches/year; and the calculated mean annual outflow for the lake is 267 acre feet/year.

Current Condition: Over the period of record, Concannon SFL has chlorophyll *a* concentrations averaging 40.4 μg/L. Chlorophyll *a* concentrations are variable over the period of record ranging from a low value of 12.0 μg/L in 1989 to a high value of 91.1 μg/L in 1999 (Figure 2). The lake is periodically dry and “murky water conditions and extreme water-level fluctuations restrict the fishery of the lake to the stocking of channel catfish” (KDWP).

Figure 2. Chlorophyll *a* concentrations in Concannon SFL during 1989– 2002 sampling years.



The average Secchi depth in Concannon SFL is 0.32 meters with a low reading of 0.18 meters in 1989, and improved to 0.48 meters in 2002 (Figure 3). Total phosphorus (TP) concentrations are available for all sampling years with the exception of 1989 and average196 μg/L, ranging from 162 μg/L in 1999 to 230 μg/L in 1995 (Figure 4). Total nitrogen concentrations are available for the sampling years of 1995, 1999 and 2002 which average 4.56 mg/L with a high value of 7.08 mg/L recorded in 2002 (Figure 4). Turbidity in Concannon SFL averaged 18.7 NTU with a range of 10.3 to 25.0 NTU, while total suspended solids ranged from 15.0 mg/L to 61.0 mg/L (Table 1).

Figure 3. Secchi Depth at Concannon SFL for the period of record.

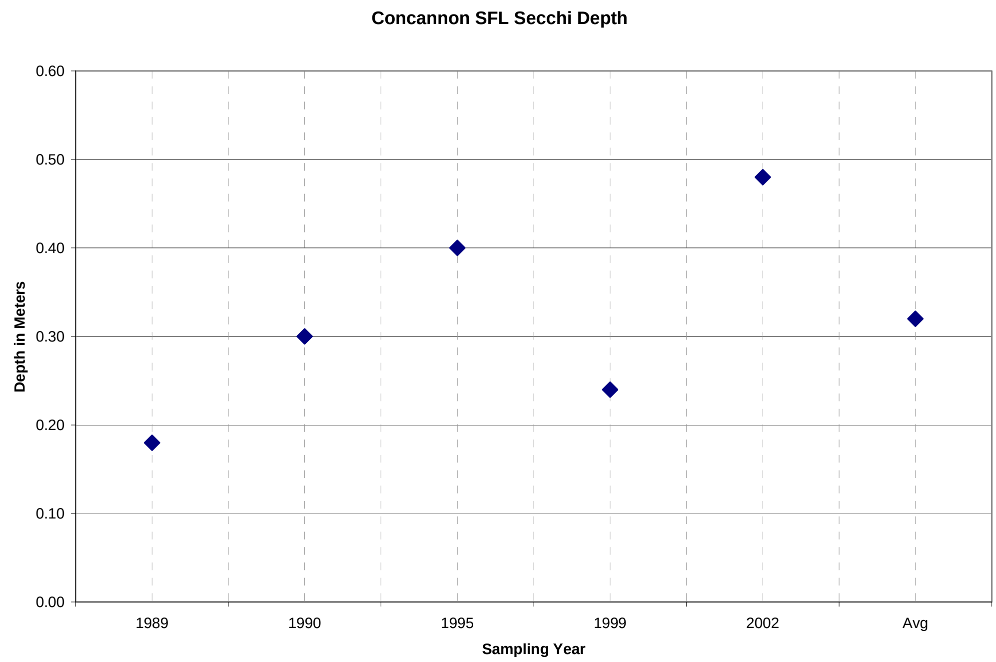
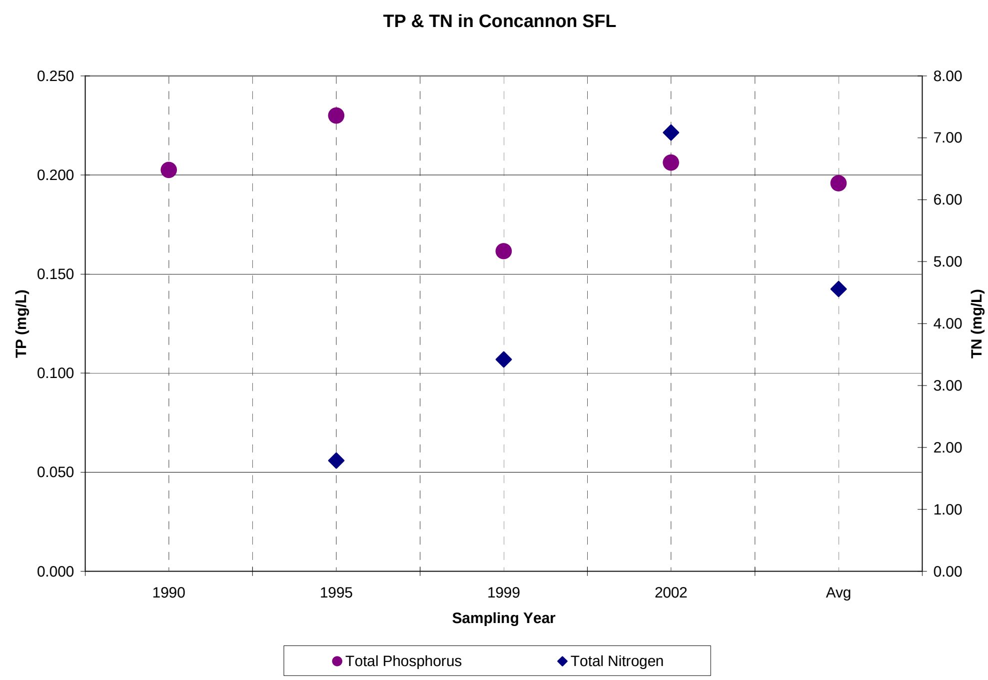


Figure 4. Total Phosphorus and Total Nitrogen levels in Concannon SFL.



The ratio of total nitrogen and total phosphorus has been used to determine which of these nutrients is most likely limiting plant growth in Kansas aquatic ecosystems. Generally, lakes that are nitrogen limited have water column TN:TP ratios < 8 (mass); lakes that are co-limited by nitrogen and phosphorus have water column TN:TP ratios between 9 and 21; and lakes that are phosphorus limited have water column TN:TP ratios > 29 (Dzialowski et al., 2005). Total phosphorus and total nitrogen data was available for 1995, 1999 and 2002 with an obvious trend toward phosphorus limitation in Concannon SFL (Figure 5).

Figure 5. TN/TP Ratio in Concannon SFL. Data available for 1995, 1999 & 2002 sampling years.

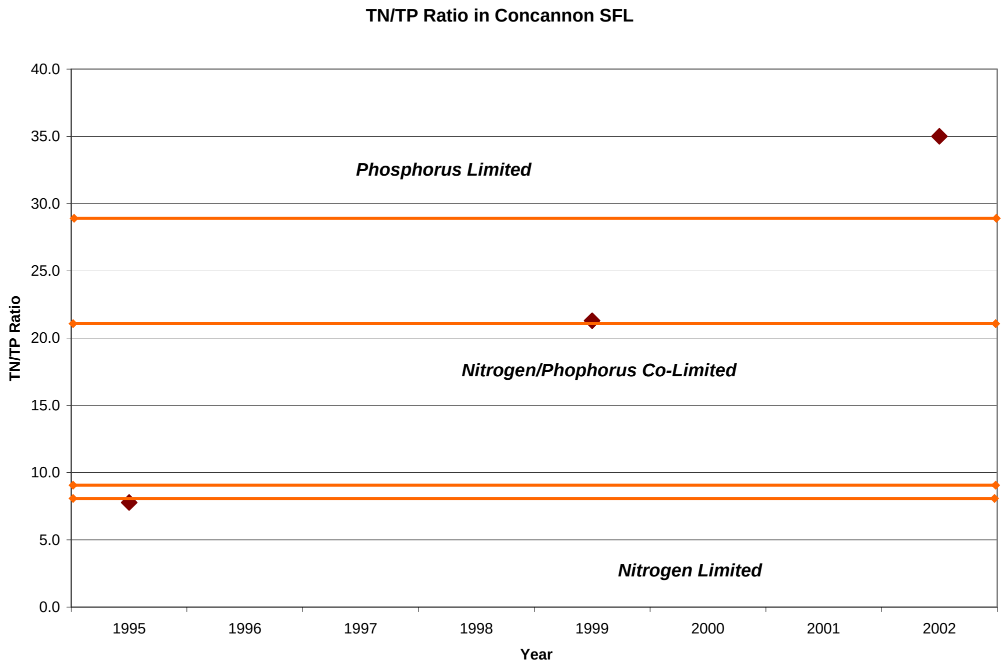


Table 1. Concentration averages for Concannon SFL for the period of record.

Sampling Year	Chl-a (µg/L)	TN (mg/L)	TP (mg/L)	TN:TP ratio	Secchi Depth (m)	Turbidity (NTU)	TSS (mg/L)
1989	12.0	*	*	*	0.180	*	*
1990	12.3	*	0.203	*	0.300	22.9	15.0
1995	45.1	1.79	0.230	7.77	0.400	14.7	27.0
1999	91.1	3.42	0.162	21.3	0.240	25.0	61.0
2002	41.7	7.08	0.206	35.0	0.480	10.3	38.5
Average	*40.4*	*4.56*	*0.196*	*24.1*	*0.320*	*18.7*	*36.6*

* Data not available.

Table 2 lists the six metrics that measure the roles of light and nutrients in Concannon SFL. 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 $1.0m^{-1}$ indicate inorganic turbidity assumes greater influence on water clarity but would not assume a significant limiting role until values exceed $1.0m^{-1}$.

Table 2. Concannon SFL limiting factor metrics.

Sampling Year	Non-algal Turbidity	Light Availability in the Mixed Layer	Partitioning of Light Extinction between Algae & Non-algal Turbidity	Algal use of Phosphorus Supply	Light Availability in the Mixed Layer for a Given Surface Light	Shading in Water Column due to Algae and Inorganic Turbidity	Chl-*a* (µg/L)
	NAT	**Zmix*NAT**	**Chl-a*SD**	**Chl-a/TP**	**Zmix/SD**	**Shading**	
1989	5.26	6.20	2.15	No Data Available	6.56	4.47	12.0
1990	3.03	3.57	3.68	0.060	3.93	3.19	12.3
1995	1.37	1.62	18.0	0.196	2.95	3.37	45.1
1999	1.89	1.70	21.9	0.564	3.75	4.29	91.1
2002	1.04	0.298	20.0	0.202	0.596	1.17	41.7

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.

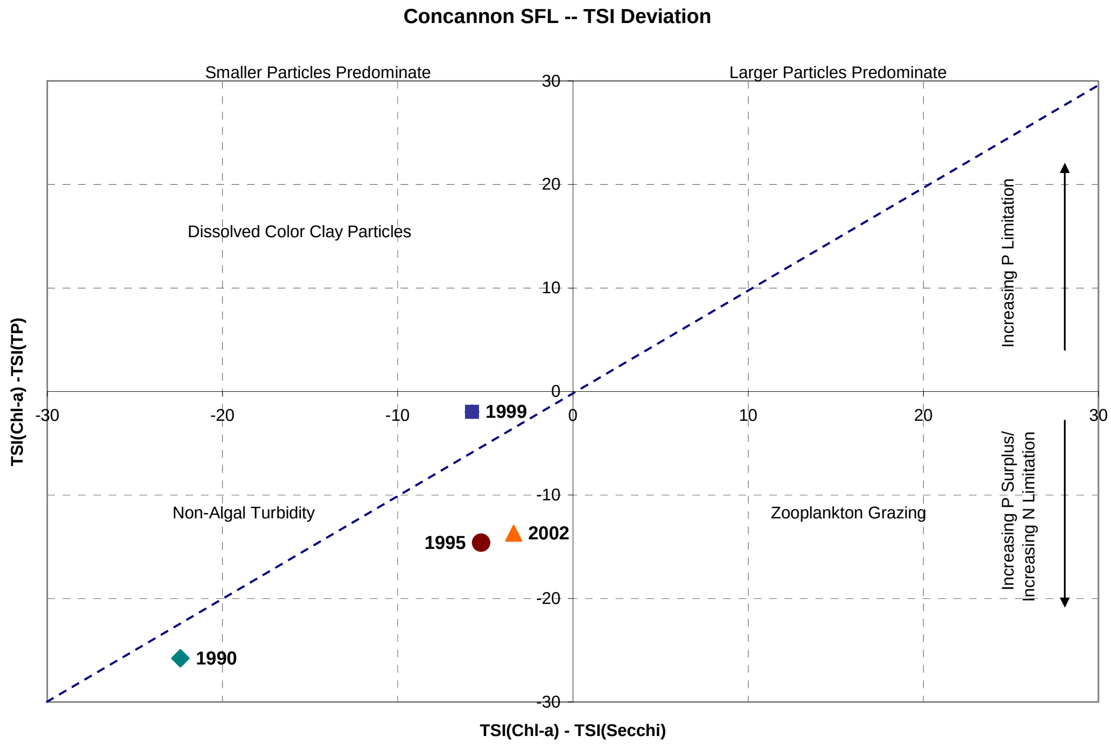
The light availability in the mixed layer for a given surface light is represented as Zmix/SD. Values less than 3 indicate that light availability is high in the mixed zone and there is a high probability of strong algal responses to changes in nutrient levels.

Shading values less than 16 indicate that self-shading of algae does not significantly impede productivity. This metric is most applicable to lakes with maximum depths of less than 5 meters (Carney, 2004).

The above metrics indicate a steady decline in light limitation in Concannon SFL over the period of record. Inorganic turbidity has declined and there remains abundant light within the mixed layer causing a high response to the nutrient inputs as indicated by the increase in chlorophyll *a* levels. Self shading of algae does not appear to be impeding productivity.

Another method for evaluating limiting factors is the TSI deviation metrics. Figure 6 (Multivariate Deviation Graph) summarizes the current trophic conditions at Concannon SFL using a multivariate TSI comparison chart for the period of record. Where TSI(Chl-a) is greater than TSI(TP), the situation indicates phosphorus is limiting chlorophyll *a*, whereas negative values indicate turbidity limits chlorophyll *a*. Where TSI(Chl-a)-TSI(SD) is plotted on the horizontal axis, if the Secchi depth (SD) trophic index is less than the chlorophyll *a* trophic index, then there is dominant 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.

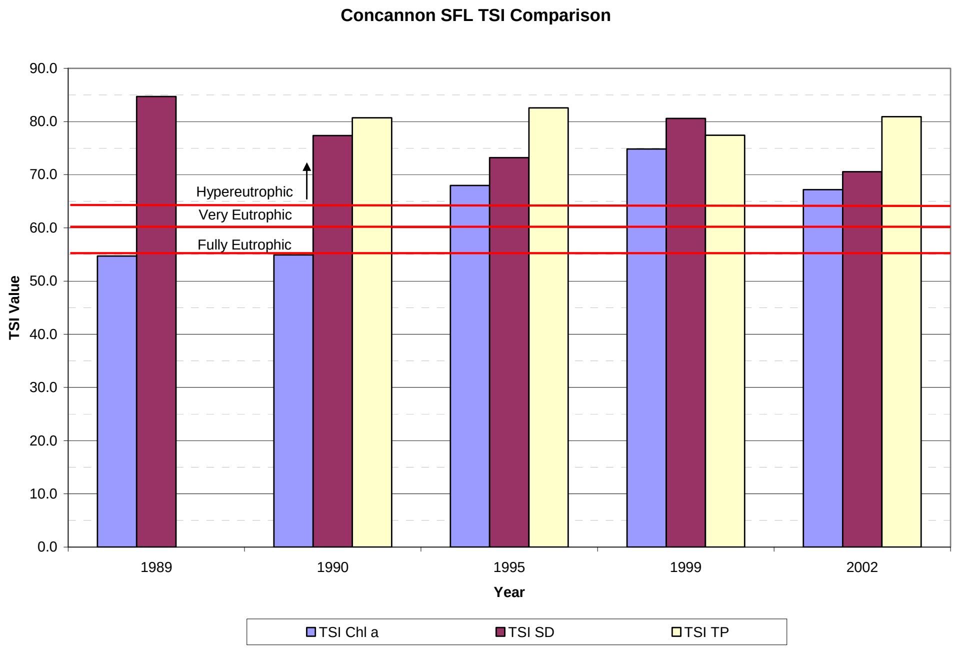
Figure 6. Multivariate TSI comparison chart for Concannon SFL.



The multivariate TSI comparison chart in Figure 6 indicates non-algal turbidity may be limiting chlorophyll *a* production in Concannon State Fishing Lake. Figure 6 also indicates phosphorus may have been bound to the clay particles during the 1995, 1999 and 2002 samplings while turbidity may have been limiting Chlorophyll *a* production during the 1990 sampling.

The Carlson Trophic State Indices for Chlorophyll *a*, Secchi depth and total phosphorus in Concannon SFL (Figure 7) show the lake’s trophic condition has been in a hypereutrophic state for each of the indicators beginning in 1995.

Figure 7. Concannon SFL Trophic State Indices (TP TSI not available for 2010).



The median trophic conditions within Concannon SFL compared to Federal lakes in the state are summarized in Table 3. The trophic indicator values within Concannon SFL fail to meet any of the benchmarks established for the Federal Lakes, the Central Great Plains Lakes and Kansas Lakes.

Table 3. Median trophic indicator values of Concannon SFL in comparison with federal lakes and draft nutrient benchmarks in Kansas. The nutrient benchmarks were derived from 47-58 lakes and reservoirs, based on the data collected between 1985-2002 (Dodds et al., 2006).

Trophic Indicator	Concannon SFL	Federal Lake	Central Great Plains	Statewide Benchmark
Secchi Depth (cm)	30	95	117	129
TN (μg/L)	3530	903	695	625
TP (μg/L)	205	76	44	23
Chlorophyll *a* (μg/L)	41.7	12	11	8

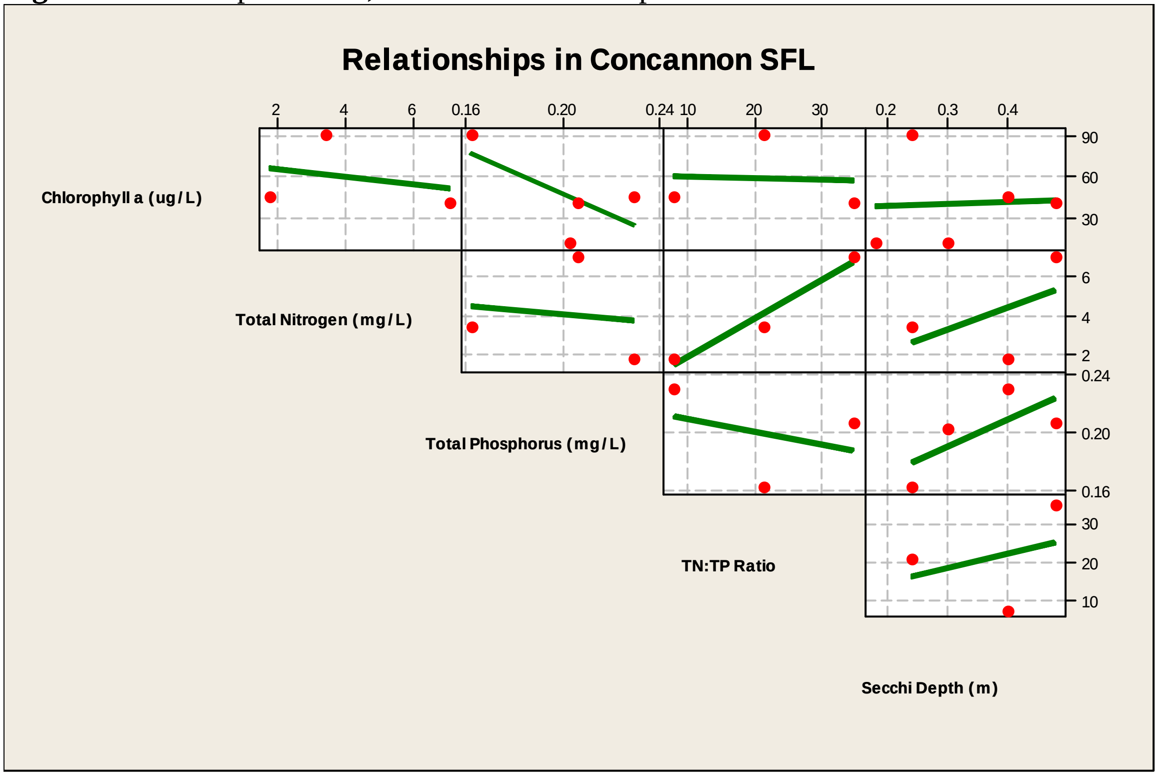
Algal Communities: As seen in Table 4, algal communities in Concannon SFL have been dominated by blue-green algae, or cyanobacteria since at least 1999. An increasing supply of nutrients, especially phosphorus and possibly nitrogen, will often result in higher growth of blue-green algae because they possess certain adaptations that enable them to out compete true algae (Soil and Water Conservation Society of Metro Halifax, 2007). Several of the cyanobacteria species possess gas vacuoles that allow them to move within the water column vertically. This selective advantage allows for some species to move within the water column to avoid predation and reach optimal primary productivity. Their movement within the water column may influence chlorophyll *a* levels within the lake at various depths during the diel cycle.

Table 4. Algal communities observed in Concannon SFL.

Sampling Date	Total Cell Count cells/mL	Percent Composition				Chl-*a* µg/L
		Green	Blue-Green	Diatom	Other	
1995	169160	1	43	56	0	45.1
1999	228659	0	99	0	1	91.1
2002	225225	3	97	<1	<1	41.7

Relationships: Within Concannon SFL there are poor relationships between: chlorophyll *a* and total nitrogen; chlorophyll *a* and the TN:TP ratio; chlorophyll *a* and secchi depth; total nitrogen and total phosphorus; total phosphorus and secchi depth; and TN:TP ratio and secchi depth. There is a minor relationship between total nitrogen and secchi depth, a moderate inverse relationship between chlorophyll *a* and total phosphorus and a moderate direct relationship between total phosphorus and secchi depth (Figure 8). It is likely phosphorus is attached to the particles creating turbidity in the lake.

Figure 8. Matrix plot of TP, Chl *a* and Secchi depth in Concannon SFL.



Stream Data: There are no registered streams flowing into Concannon SFL; hence, there is no stream data available.

Desired Endpoints of Water Quality (Implied Load Capacity) in Concannon SFL:

In order to improve the trophic condition of Concannon SFL from its current Very Eutrophic status, the desired endpoint will be to maintain summer chlorophyll *a* average concentrations below 12 μg/L, which is comparable to the 1990 concentration in Concannon SFL, with reductions focused on phosphorus loading in the lake. The chlorophyll *a* concentration of 12 μg/L corresponds to a TSI value of 55.0 and 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. The chlorophyll *a* endpoint of 12 μg/L will ensure long-term protection to fully support Primary Contact Recreation and Aquatic Life Use within the lake.

Based on the CNET reservoir eutrophication model (Appendix A), the total phosphorus concentration entering the lake must be reduced by 94%. With this reduction, the endpoint for Concannon SFL will be met. This reduction at the inflow to Concannon SFL will result in an 87% reduction of total phosphorus, and a 70% reduction of Chlorophyll *a* within the lake (Table 5). Achievement of the endpoint indicates loads are within the loading capacity of the lake, the water quality standards are attained, and full support of the designated uses of the lake has been achieved. Seasonal variation has been incorporated in this TMDL since the peaks of algal growth occur in the summer months. The current average condition for Concannon SFL utilized in the model input was based on data from KDHE station LM053601 for the period of record (Appendix A).

Table 5. Concannon SFL current average condition and TMDL based on CNET.

	Current Avg. Condition	TMDL	Percent Reduction
Total Phosphorus – Annual Load (lbs/year)	1,423	88.0	94%
Total Phosphorus – Daily Load* (lbs/day)	10.5	0.647	94%
Total Phosphorus – Lake Concentration (μg/L)	196	26.4	87%
Chlorophyll *a* Concentration (μg/L)	40.4	12	70%

*See Appendix B for Daily Load Calculations

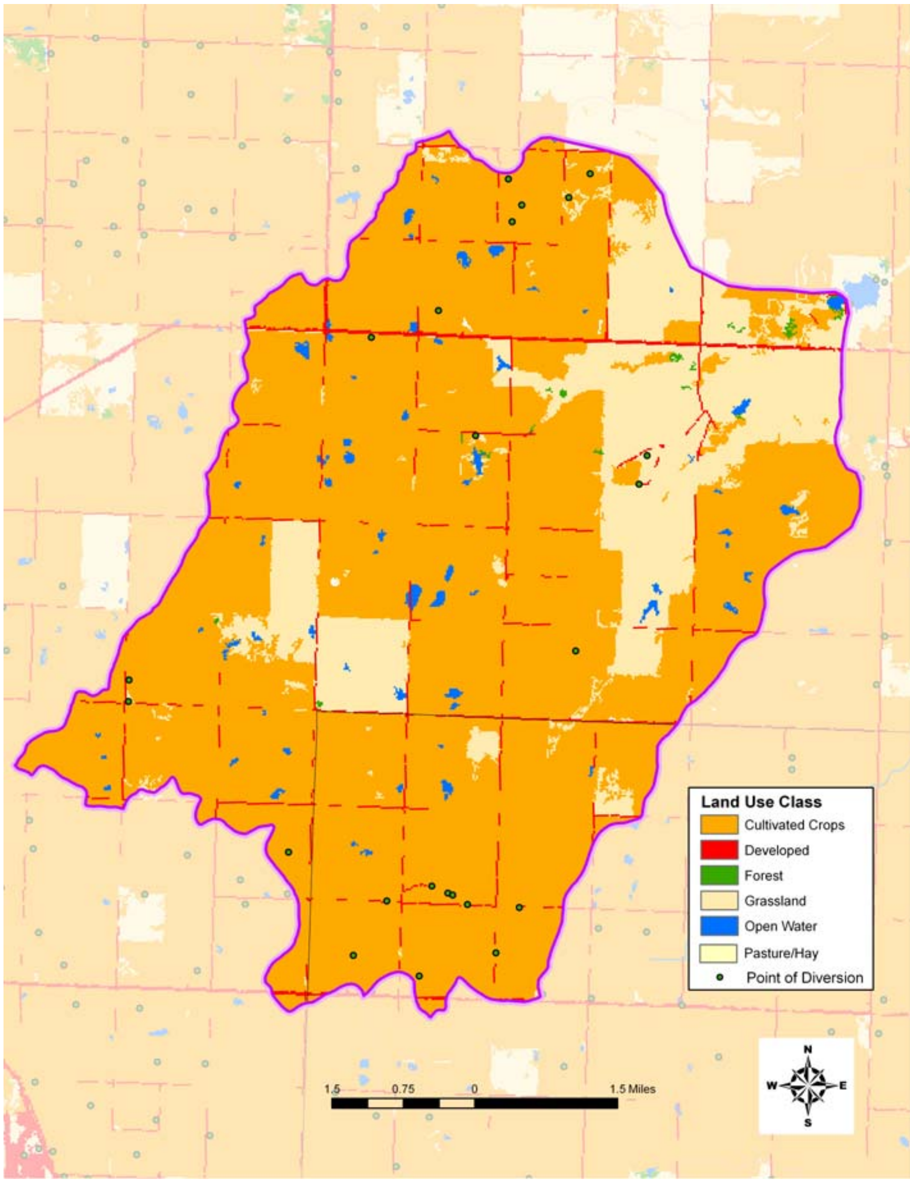
3. SOURCE INVENTORY AND ASSESSMENT

Point Sources: There are no NPDES permitted facilities in the Concannon SFL watershed.

Livestock Waste Management Systems: There are no active permitted or certified confined animal feeding operations (CAFOs) in the Concannon SFL watershed, however, there may be small, unregistered, livestock facilities operating in the watershed. These operations may contribute to the phosphorus load in Concannon SFL depending on the presence and condition of waste management systems and the proximity to and activity along the unregistered creek above the lake.   According to the USDA National Agricultural Statistics Service, on January 1, 2012, cattle inventory for Finney and Gray Counties was 255,000 and 240,000 head, respectively.

Land Use: The predominant land uses in the Concannon SFL watershed are cultivated cropland (77.8%) and grassland/pasture (18.8%), according to the 2001 National Land Cover Data. Together they account for 96.6% of the total land area in the watershed with the remaining land area comprised of developed land (2.2%), open water (1.0%), and forest (0.15%) (Figure 9). Depending on the proximity to the creek above the lake, runoff from fertilizer applications to cultivated cropland in the watershed is a potentially significant source of phosphorus loading to the lake.

Figure 9. Land Use (2001 NLCD) & Unique Points of Diversion in the Concannon SFL watershed.

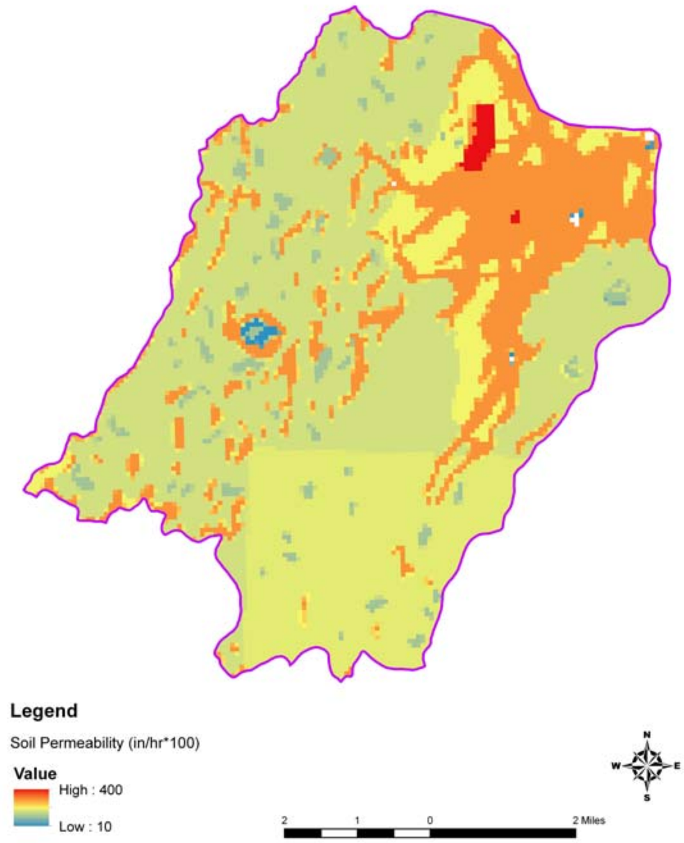


Unique Points of Diversion: The Concannon Lake watershed contains thirty five unique points of diversion that are made up of a water right and point of diversion combination. Twenty two are located in the portion of the watershed that lies in Finney County while thirteen are in the portion of the watershed that lies in Gray County. All thirty five unique points of diversion are wells tied to groundwater rights with five points designated for use in watering livestock and thirty points designated for use in irrigating for a total authorized quantity of 8,873 acre-feet per year (Figure 9).

Population and On-Site Waste Systems: The Concannon SFL watershed is a rural agricultural area located in Finney and Gray Counties. According to the 2010 census data from the U.S. Census Bureau, the population within the watershed is approximately 27 people (0.6 people/mi^2). The 2010 U.S. Census registered a 9.2% decrease in the population of Finney County and a 1.7% increase in the population of Gray County since the 2000 census indicating population in the area surrounding the Concannon SFL watershed is on the decline. Although the STEPL model does not indicate there are any septic systems located in the watershed, the1990 census data shows nearly 19% of households in Finney County and 33% of the households in Gray County utilize septic or other on-site systems. Failing on-site septic systems may contribute significant nutrient loadings and aggravate eutrophication problems.

Contributing Runoff: The watershed of Concannon SFL has a mean soil permeability value of 0.89 inches/hour, ranging from 0.10 inches/hour to 4.00 inches/hour according to NRCS STATSGO database (Figure 10). Most of the watershed is considered to have very low to low soil permeability with 97% of the watershed having a permeability of 1.29 inches/hour or lower. According to a USGS open-file report (Juracek, 2000), the threshold soil-permeability values are set at 3.43 inches/hour for very high, 2.86 inches/hour for high, 2.29 inches/hour for moderate, 1.71 inches/hour for low, 1.14 inches/hour for very low, and 0.57 inches/hour for extremely low soil-permeability. Runoff is primarily generated as infiltration excess when rainfall intensities are greater than soil permeability. As the watershed's soil profile becomes saturated, excess overland flow is produced.

Figure 10. Soil permeability in the Concannon SFL watershed.



Background & Natural Sources: Atmospheric deposition from geological formations may also contribute to nutrient loads. The suspension of sediment and nutrients may be influenced by the wind and bottom feeding fish may also re-suspend sediment and contribute to available nutrients in the lake. Because Concannon SFL is a small lake, nutrient cycling of the sediment is likely contributing available nutrients to the lake for algal uptake. Nutrients from wildlife waste are also likely contributors to the phosphorus load in the lake.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

Data for the period of record indicate total phosphorus is limiting the production of algal growth in Concannon SFL; therefore, total phosphorus will be allocated under this TMDL. The general inventory of sources within the drainage area of the lake indicates load reductions should be focused on nonpoint source runoff contributions attributed to fertilizer applicators and smaller livestock facilities. Because of atmospheric deposition, the allocation of phosphorus will include a proportional decrease in phosphorus between the current condition and the desired endpoint (Table 6).

Point Sources: A current Wasteload Allocation of zero is assigned for phosphorus under this TMDL because of the lack of point sources in the watershed. Should future sources be proposed in the watershed, the current wasteload allocations will be revised by adjusting current load allocations to account for the presence and impact of these new point source dischargers.

Nonpoint Sources: The assessment suggests that runoff from fertilized pasture and cropland and animal waste from smaller livestock facilities and grazing operations in the watershed along with 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. According to the CNET reservoir eutrophication modeling worksheet (Appendix A), a 94% reduction in total phosphorus entering the lake is necessary to reach the chlorophyll *a* endpoint of 12 μg/L which translates to a loading capacity of 88.0 lbs/year of total phosphorus into Concannon SFL (Table 6).

Table 6. Concannon SFL TMDL

Description	Allocations (lbs/year)	Allocations (lbs/day)*
Total Phosphorus Atmospheric Load Allocation	1.32	0.00971
Total Phosphorus Nonpoint Source Load Allocation	77.8	0.572
Total Phosphorus Load Allocation	79.1	0.582
Total Phosphorus Waste Load Allocation	0	0
Total Phosphorus Margin of Safety	8.80	0.0647
Total Phosphorus TMDL	88.0	0.647

*See Appendix B for Daily Load Calculations

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 is explicitly set at 10% of the original calculated total phosphorus load capacity, which compensates for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality. The margin of safety is expressed in Table 6.

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

Unified Watershed Assessment Priority Ranking: Concannon State Fishing Lake lies within the Pawnee Subbasin (HUC 8: 11030005) which is classified as Category II (Watershed Meeting Goals, Including Those Needing Action to Sustain Water Quality).

Priority HUC 12: The entire watershed is within HUC 12: 110300050103.

5. IMPLEMENTATION

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

1. Implement soil sampling to recommend appropriate fertilizer applications on cultivated cropland.
2. Maintain conservation tillage and contour farming to minimize cropland erosion.
3. Promote and adopt continuous no-till cultivation to increase the amount of water infiltration and minimize cropland soil erosion and nutrient transports.
4. Install grass buffer strips along streams and drainage channels in the watershed.
5. Reduce activities within riparian areas.
6. Implement nutrient management plans to manage manure land applications and runoff potential.
7. Adequately manage fertilizer utilization in the watershed and implement runoff control measures.

Implementation Program Guidance:

Watershed Management Program – KDHE

a. Support selected Section 319 project activities including demonstration projects and outreach efforts dealing with erosion and sediment control and nutrient management.
b. Provide technical assistance on practices geared to the establishment of vegetative buffer strips.
c. Provide technical assistance on nutrient management in the vicinity of streams.

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 nutrients.

Time Frame for Implementation: Initial implementation will proceed over the years from 2012-2020. Additional implementation may be required over 2021-2030 to achieve the endpoints of this TMDL.

Targeted Participants: Primary participants for implementation will be agricultural producers and stakeholders within the Concannon SFL watershed. A detailed assessment of sources conducted over 2012-2013 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 and fertilizer application rates,
2. Cultivation alongside lake,
3. Livestock use of riparian areas,
4. Fields with manure applications.

Milestone for 2016: In accordance with the TMDL development schedule for the State of Kansas, the year 2016 marks the next cycle of 303(d) activities in the Upper Arkansas Basin. At that point in time, sample data from Concannon SFL will be reexamined to assess conditions in the lake. Should the impairment remain adjustments to source assessment, allocation, and implementation activities may begin.

Delivery Agents: The primary delivery agents for program participation will be the Kansas Department of Health and Environment, the Kansas Department of Wildlife and Parks, the Kansas Department of Agriculture – Division of Conservation, the Natural Resources Conservation Service, the Kansas State University Extension Service, and the Finney County Conservation District. Producer outreach and awareness will be delivered by Kansas State University Extension Office.

Reasonable Assurances:

Authorities: The following authorities may be used to direct activities in the watershed to reduce pollutants and to assure allocations of pollutant to point and nonpoint 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.A.R. 28-16-69 to 71 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.

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.

7. The Kansas Water Plan and the Upper Arkansas 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.

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

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 Low Priority consideration for funding.

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 resume collecting samples at Concannon SFL once hydrologic conditions return the lake where it functions as a recreation site over multiple years. Sampling will occur over multiple years in order to assess the status of impairments within the lake. Based on these sampling results, the 303(d) list will be evaluated initially in 2022. The desired endpoints under this TMDL may be refined and sampling conducted over the period 2021-2025 to assess progress in improving the quality of the lake. As resources allow, KDHE will sample the lake every three years until the TMDL endpoint is achieved.

7. FEEDBACK

Public Notice: An active Internet Web site was established at www.kdheks.gov/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Upper Arkansas Basin.

Public Hearing: A Public Hearing was held on September 20th, 2012 in Garden City to receive comments on this TMDL. None were received throughout the August 20, 2012 through September 26, 2012 comment period.

Basin Advisory Committee: The Upper Arkansas River Basin Advisory Committee met to discuss these TMDLs on April 4th, 2012 in Jetmore and September 20th 2012 in Garden City.

Milestone Evaluation: Milestones will be evaluated once favorable conditions in support of the recreation function return to Concannon SFL. Given the paucity of inflow in the lake in recent years; any 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 delisting cycle for this basin in 2022 with consultation from local stakeholders.

Consideration for 303d Delisting: Concannon SFL will be evaluated for delisting under Section 303d, based on any monitoring data over 2012-2021. Therefore, the decision for delisting will come about in the preparation of the 2022-303d 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 2012. Recommendations of this TMDL will be considered in the Kansas Water Plan implementation decisions under the State Water Planning Process for Fiscal Years 2012-2021.

Developed 12/19/12

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Appendix A – CNET Eutrophication Model for Concannon SFL.
Input for CNET Model

Parameter	**Value Input into CNET Model**
Drainage Area (km^2)	119.7
Precipitation (m/yr)	0.48
Evaporation (m/yr)	1.79
Unit Runoff (m/yr)	0.007
Surface Area (km^2)	0.061
Mean Depth (m)	1.3
Depth of Mixed Layer (m)	1.23
Depth of Hypolimnion (m)	0.50
Observed Phosphorus (ppb)	196
Observed Chlorophyl *a (*ppb)	40.4
Observed Secchi Disc Depth	0.32

Output from CNET Model

Parameter	**Output from CNET Model**
Load Capacity (LC)*	88.0 lbs/year
Waste Load Allocations (WLA)	0 lbs/year
Atmospheric Air Deposition (LA)	1.32 lbs/ year
Other Nonpoint (LA)	77.8 lbs/year
Total Load Allocation (LA)	79.2 lbs/year
Margin of Safety (MOS)	8.80 lbs/year

*LC=WLA + LA + MOS

RESERVOIR EUTROPHICATION MODELING WORKSHEET TITLE -> Concannon SFL

Based on CNET.WK1 VERSION 1.0

VARIABLE	UNITS	Current	LC
WATERSHED CHARACTERISTICS...		Latitude	38
Drainage Area	km2	119.7	119.7
Precipitation	m/yr	0.48	0.48
Evaporation	m/yr	1.79	1.79
Unit Runoff	m/yr	0.007	0.007
Stream Total P Conc.	ppb	771	47
Stream Ortho P Conc.	ppb	154.2	9.4
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	0.0
Total P Conc	ppb	0	0.0
Ortho P Conc	ppb	0	0
RESERVOIR CHARACTERISTICS...			
Surface Area	km2	0.061	0.061
Max Depth	m	3	3
Mean Depth	m	1.3	1.3
Non-Algal Turbidity	1/m	2.12	0.48
Mean Depth of Mixed Layer	m	1.23	1.23
Mean Depth of Hypolimnion	m	0.50	0.50
Observed Phosphorus	ppb	196	26.4
Observed Chl-a	ppb	40.4	12.0
Observed Secchi	meters	0.32	1.29
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	0.077351	0.064599
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	0.03	0.03
NonPoint Flow	hm3/yr	0.84	0.84
Point Flow	hm3/yr	0.00	0.00
Total Inflow	hm3/yr	0.87	0.87
Evaporation	hm3/yr	0.11	0.11
Outflow	hm3/yr	0.76	0.76

VARIABLE	UNITS	Current	LC
AVAILABLE P BALANCE...			
Precipitation Load	kg/yr	0	0
NonPoint Load	kg/yr	398	24
Point Load	kg/yr	0	0
Total Load	kg/yr	398	25
Sedimentation	kg/yr	250	5
Outflow	kg/yr	148	20
PREDICTION SUMMARY...			
P Retention Coefficient	-	0.627	0.185
Mean Phosphorus	ppb	195.9	26.4
Mean Chlorophyll-a	ppb	24.6	12.0
Algal Nuisance Frequency	%	96.9	43.1
Mean Secchi Depth	meters	0.25	0.80
Hypol. Oxygen Depletion A	mg/m2-d	1189.7	831.7
Hypol. Oxygen Depletion V	mg/m3-d	2379.4	1663.4
Organic Nitrogen	ppb	876.9	467.0
Non Ortho Phosphorus	ppb	89.9	28.7
Chl-a x Secchi	mg/m2	6.1	9.6
Principal Component 1	-	3.33	2.53
Principal Component 2	-	0.60	0.78
	Observed	Pred	Target
Carlson TSI P	80.3	80.3	51.4
Carlson TSI Chl-a	66.9	62.0	55.0
Carlson TSI Secchi	76.4	80.1	63.3
OBSERVED / PREDICTED RATIOS...			
Phosphorus		1.00	1.00
Chlorophyll-a		1.64	1.00
Secchi		1.29	1.62
OBSERVED / PREDICTED T-STATISTICS...			
Phosphorus		0.00	0.00
Chlorophyll-a		1.83	0.00
Secchi		0.93	1.78
ORTHO P LOADS...			
Precipitation	kg/yr	0	0
NonPoint	kg/yr	129	8
Point	kg/yr	0	0
Total	kg/yr	129	8
Total	#/year	284	17

VARIABLE	UNITS	Current	LC
RESPONSE CALCULATIONS...			
Reservoir Volume	hm3	0.0793	0.0793
Residence Time	yrs	0.1046	0.1046
Overflow Rate	m/yr	12.4	12.4
Total P Availability Factor		1	1
Ortho P Availability Factor		1.93	1.93
Inflow Ortho P/Total P		0.200	0.197
Inflow P Conc	ppb	525.4	32.4
P Reaction Rate - Mods		4.5	0.3
P Reaction Rate - Model 2		7.4	0.5
P Reaction Rate - Model 3		5.5	0.3
1-Rp Model 1 - Avail P		0.373	0.815
1-Rp Model 2 - Decay Rate		0.306	0.743
1-Rp Model 3 - 2nd Order Fixe(		0.345	0.789
1-Rp Model 4 - Canfield & Bacl		0.363	0.747
1-Rp Model 5 - Vollenweider 1!		0.756	0.756
1-Rp Model 6 - First Order De(		0.905	0.905
1-Rp Model 7 - First Order Set		0.926	0.926
1-Rp Model 8 - 2nd Order Tp O1		0.373	0.815
1-Rp - Used		0.373	0.815
Reservoir P Conc	ppb	195.9	26.4
Gp		0.283	0.283
Bp	ppb	282.8	18.2
Chla vs. P, Turb, Flusl	2	24.6	12.0
Chla vs. P Linear	4	54.8	7.4
Chla vs. P 1.46	5	179.8	9.6
Chla Used	ppb	24.6	12.0
m1 - Nuisance Freq Calc.		3.1	2.4
z		-1.873	0.173
v		0.069	0.393
w		0.616	0.946
x		0.031	0.431

TOTAL P LOADS...			
BAF Override (KS)	OrP %		
0.5	0%	0.6	0.6
0.23	20%	646.0	39.4
0.8	0%	0.0	0.0
		646.6	40.0
		1423	88.0

Appendix B. Conversion to Daily Loads as Regulated by EPA Region VII

The TMDL has estimated annual average loads for 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 $\sigma^2 = \ln\left(CV^2 + 1\right)$

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 lbs/year	CV	$e^{[Z\sigma - 0.5\sigma^2]}$	MDL lbs/day	Atm LA lbs/day	Non-Point LA lbs/day	Waste LA lbs/day	MOS (10%) lbs/day
TP	88.0	0.5	2.68	0.647	0.00971	0.572	0	0.0647

Maximum Daily Load Calculation

Annual TP Load = 88.0 lbs/yr

Maximum Daily TP Load = [(88.0 lbs/yr)/(365 days/yr)]*$e^{[2.326*(0.472) - 0.5*(0.472)^2]}$

= 0.647 lbs/day

Margin of Safety (MOS) for Daily Load

Annual TP MOS = 8.80 lbs/yr

Daily TP MOS = [(8.80 lbs/yr)/(365 days/yr)]*$e^{[2.326*(0.472) - 0.5*(0.472)^2]}$

= 0.0647 lbs/day

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