MARAIS DES CYGNES RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: Pleasanton Reservoir
Water Quality Impairment: Eutrophication

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Lower Marais des Cygnes **Counties:** Linn

HUC 8: 10290102 **HUC 10 (12):** 04 (01)

Ecoregion: Central Irregular Plains, Wooded Osage Plains (40c)

Drainage Area: 1.88 square miles

Conservation Pool: Surface Area = 98.8 acres
Watershed/Lake Ratio: 12:1
Maximum Depth = 8.6 meters
Mean Depth = 3.1 meters
Storage Volume = 1,083 acre-feet
Estimated Retention Time = 1.5 years
Mean Annual Inflow = 1,265 acre-feet (CNET)
Mean Annual Discharge = 869 acre-feet
Constructed: 1935

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

303(d) Listings: 2002, 2004, 2008, 2010 & 2012 Marais Des Cygnes River Basin Lakes

Impaired Use: All uses in Pleasanton Reservoir are impaired to a degree by eutrophication.

Water Quality Criteria:

General – Narrative: Taste-producing and odor-producing substances of artificial origin shall not occur in surface waters at concentrations that interfere with the production of potable water by conventional water treatment processes, that impart an unpalatable flavor to edible aquatic or semiaquatic life or terrestrial wildlife, or that result in noticeable odors in the vicinity of surface waters (KAR 28-16-28e(b)(7)).

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 domestic water supply use shall be controlled to prevent interference with the production of drinking water (K.A.R. 28-16-28e(c)(3)(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 Support for Designated Uses under 2012 303(d): Excessive nutrients are not being controlled and are thus contributing to eutrophication which could interfere with domestic water supply. The excessive nutrients are also impairing aquatic life use by supporting objectionable types and quantities of algae which also leads to impairment of contact recreation with Pleasanton Reservoir. A chlorophyll *a* endpoint of 10 μg/L is assigned to address the domestic water supply use; however, all other uses will be met when the chlorophyll *a* endpoint of 10 μg/L is met.

Level of Eutrophication: Fully Eutrophic, Trophic State Index = 56.9

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 condition is seen with chlorophyll *a* 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:

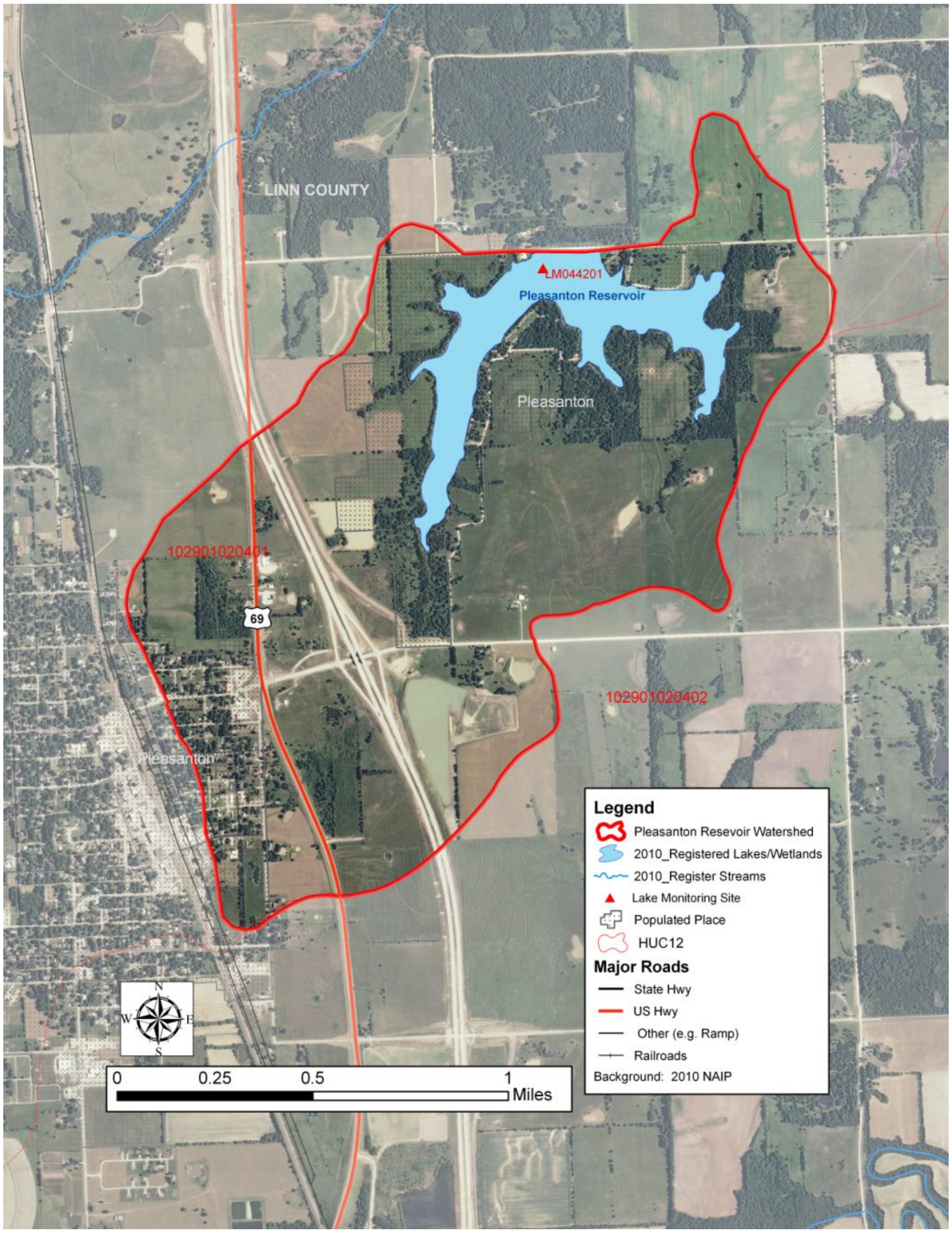
1. Oligotrophic TSI < 40
2. Mesotrophic TSI: 40 - 49.99
3. Slightly Eutrophic TSI: 50 - 54.99
4. Fully Eutrophic TSI: 55 - 59.99
5. Very Eutrophic TSI: 60 - 63.99
6. Hypereutrophic TSI: $\geq$ 64

Lake Chemistry Monitoring Sites: KDHE Station LM044201 in Pleasanton Reservoir (Figure 1).

Period of Record Used: Eight surveys conducted by KDHE in calendar years: 1986, 1989, 1992, 1996, 2000, 2003, 2007, 2011.

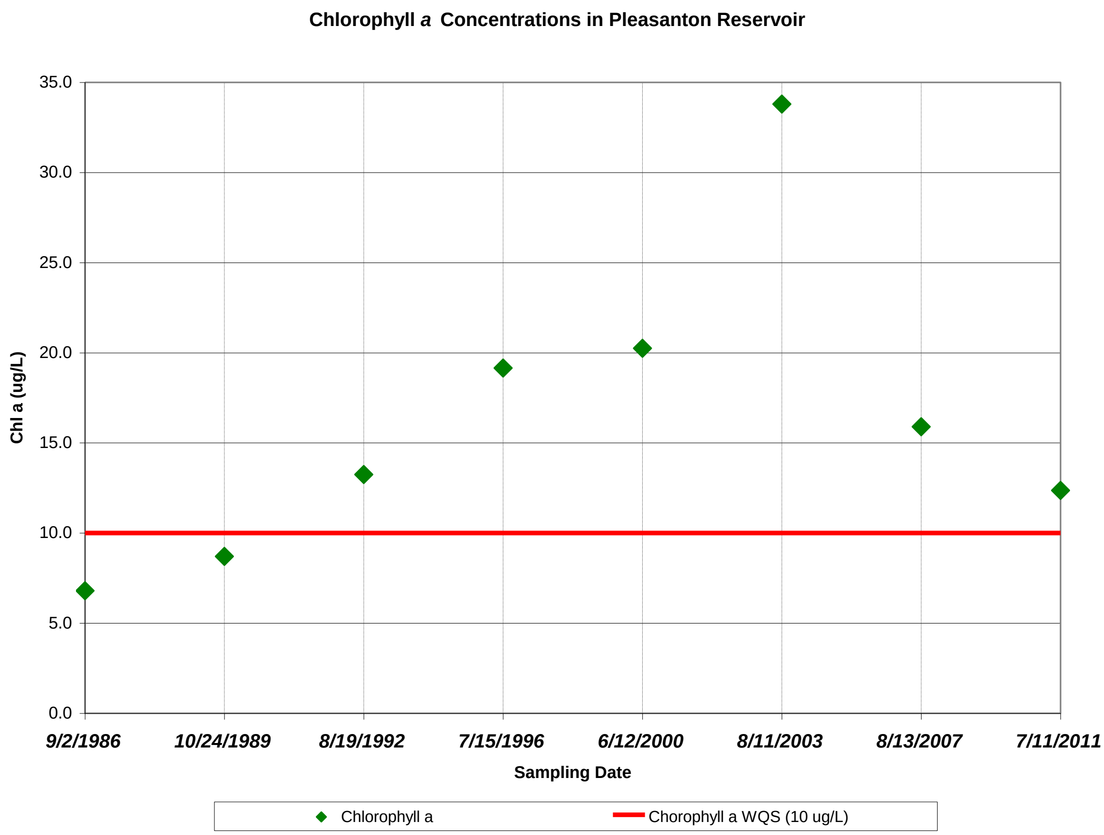
Hydrological Conditions: There are no registered streams flowing directly into Pleasanton Reservoir, however, CNET reservoir eutrophication modeling (Appendix A) estimates inflow to the lake at 1,265 acre-feet per year, based on drainage area. According to the USGS Lake Hydro calculations, the mean runoff in the watershed is 9.4 inches/year; the mean precipitation in the watershed is 39.4 inches/year; the mean loss due to evaporation for the lake is 46.3 inches/year; and the calculated mean annual outflow for the lake is 869 acre feet/year

Figure 1. Pleasanton Reservoir Watershed.



Current Conditions: Chlorophyll *a* concentrations in Pleasanton Reservoir average 16.3 µg/L giving a corresponding Trophic State Index (TSI) value of 56.9 for the period of record. Chlorophyll *a* was measured in samples taken in 1986, 1989, 1992, 1996, 2000, 2003, 2007 and 2011. As can be seen in Figure 2, the chlorophyll *a* concentration first exceeded the water quality standard of 10 µg/L in 1992 and peaked at 33.8 µg/L in 2003. There was some improvement in 2007 and 2011, however chlorophyll *a* concentrations remained above10 µg/L from 1992 onward resulting in a recent (2000-2011) average of 20.6 µg/L.

Figure 2. Chlorophyll *a* concentrations in Pleasanton Reservoir by sampling date.



The average Secchi depth in Pleasanton Reservoir for the period of record is 1.05 meters, with the poorest reading occurring in July 1996 at 0.80 meters (Figure 3). Average Secchi depth for the more recent sampling period of 2000 to 2011 was improved at 1.24 meters. Turbidity in Pleasanton Reservoir for the period of record averaged 4.55 NTU with a range of 3.0 NTU in 2000 to 7.2 NTU in 2003. Total suspended solids (TSS) ranged from <10 mg/L in 2007 to 13.0 mg/L in 2003 resulting in an average of 7.7 mg/L (Table 1).

Total phosphorus (TP) concentrations over the period of record average 31.0 µg/L and range from 10.0 µg/L in 1992 to 61.5 µg/L in 2003 (Figure 4). Average total phosphorus for the 2000 through 2011 time period was slightly higher at 39.4 mg/L. Total Nitrogen concentrations ranged from 0.125 mg/L in 1992 to 1.63 mg/L in 1996. Total nitrogen concentrations average 0.744 mg/L for the period of record and 0.787 for the 2000 to 2011 time period (Table 1).

Figure 3. Secchi Depth in Pleasanton Reservoir for the period of record.

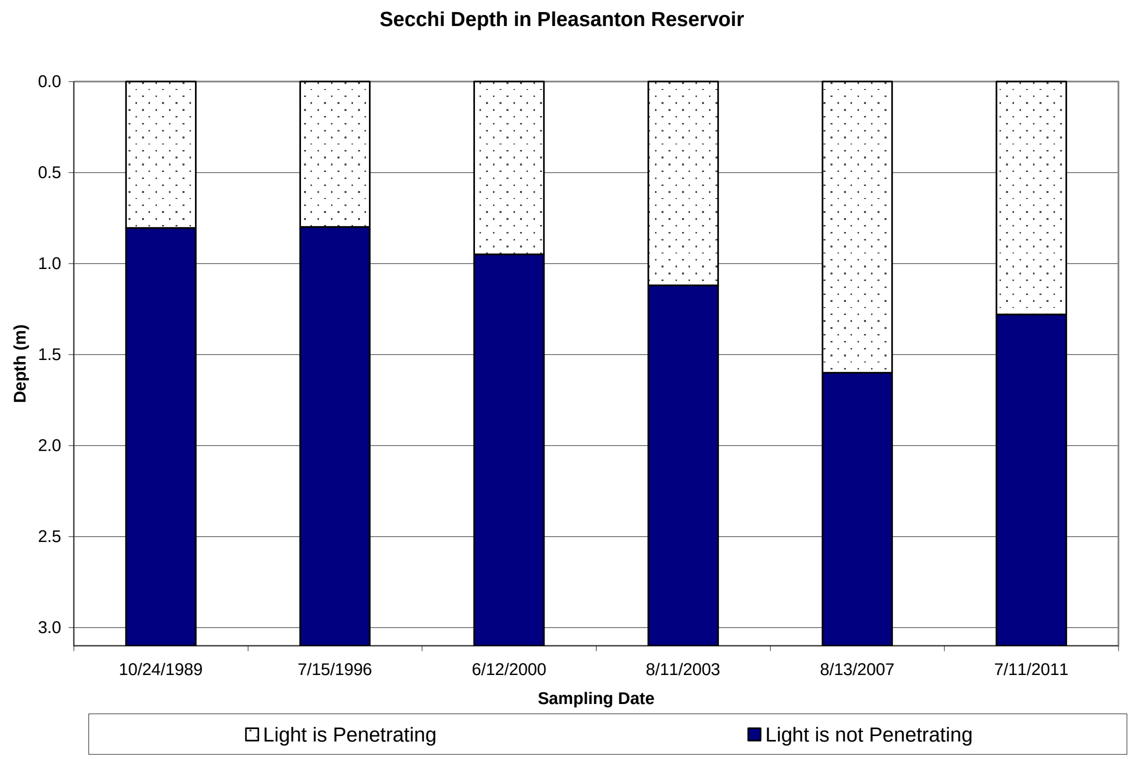
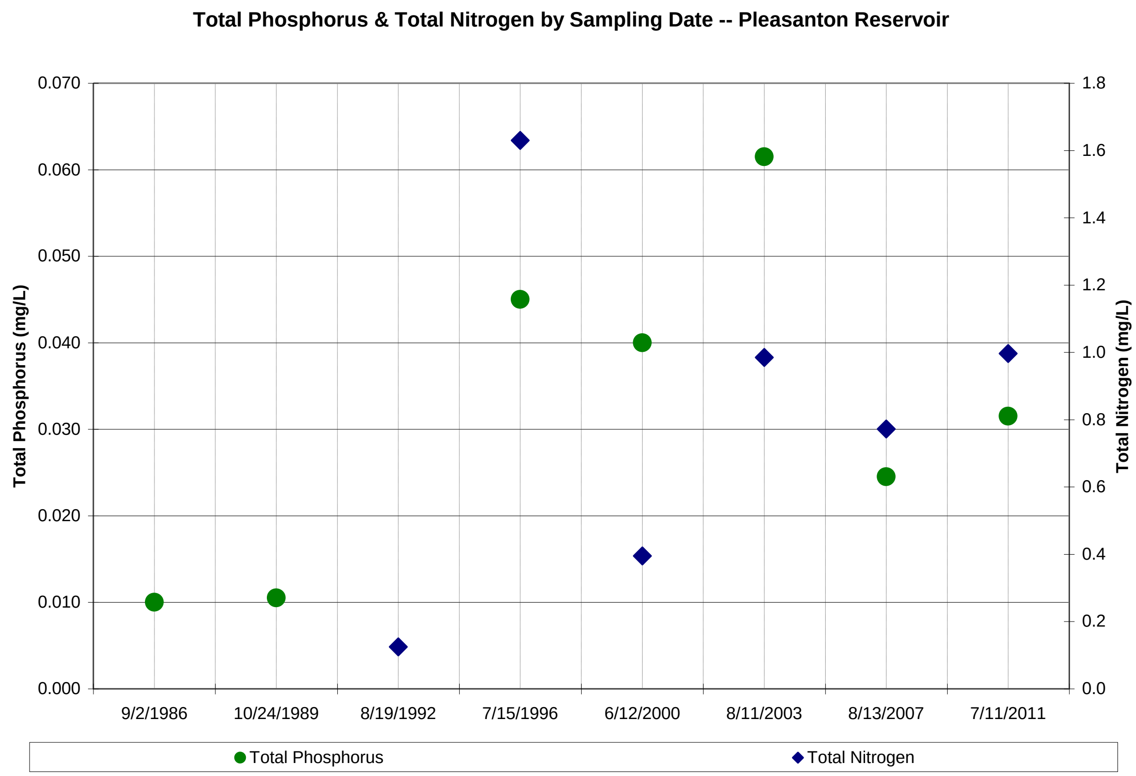
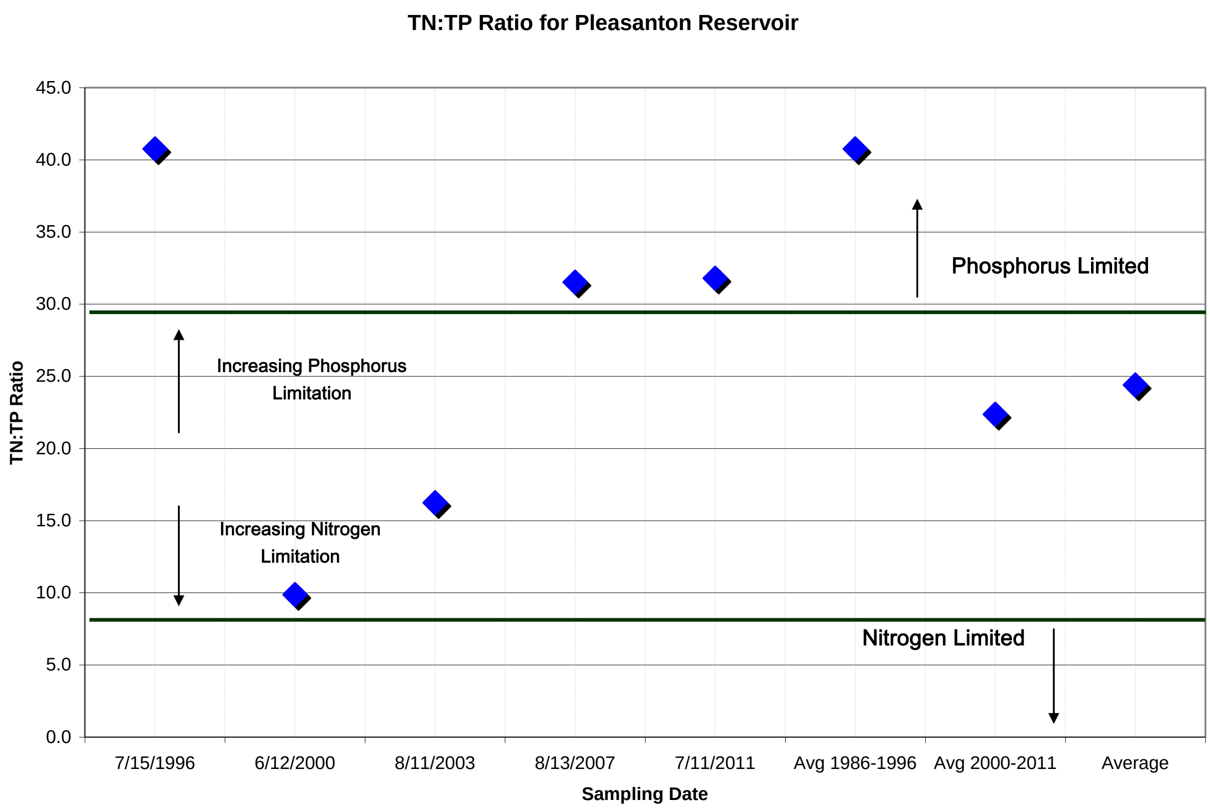


Figure 4. Average Total Phosphorus and Total Nitrogen in Pleasanton Reservoir.



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). The TN:TP ratio in Pleasanton Reservoir indicates the lake was phosphorus limited in 1989, moved to being co-limited by phosphorus and nitrogen in 2000 and 2007 and in recent sampling years has become phosphorus limited again (Figure 5).

Figure 5. TN:TP ratio for the period of record in Pleasanton Reservoir.



A comparison of the average values for samples collected from 1986 to 1996 and 2000 to 2011 reveals deterioration in water quality over time with increases in the chlorophyll *a*, total nitrogen, total phosphorus, and total suspended solids (TSS) concentrations (Table 1). However, water clarity improved over time as turbidity and secchi depth values are slightly better for the 2000 to 2011 time frame.

Table 1. Water quality data in Pleasanton Reservoir by year.

Sample Date	Chl *a* (µg/L)	TN (mg/L)	TP (µg/L)	TN:TP Ratio	Secchi Depth (m)	Turbidity (NTU)	TSS (mg/L)
9/2/86	6.80	*	10.0	*	*	4.45	*
10/24/89	8.70	*	11.0	*	0.805	*	*
8/19/92	13.3	0.125	<50.0	*	*	4.80	6.5
7/15/96	19.2	1.63	45.0	40.8	0.800	4.90	7.0
6/12/00	20.3	0.395	40.0	9.88	0.950	3.00	6.5
8/11/03	33.8	0.985	61.5	16.2	1.12	7.20	13.0
8/13/07	15.9	0.773	24.5	31.5	1.60	3.11	<10
7/11/11	12.4	0.997	31.5	31.8	1.28	4.37	8.0
1986-1996 Average	**12.0**	**0.627**	**21.8**	**40.8**	**0.803**	**4.72**	**6.75**
2000-2011 Average	**20.6**	**0.787**	**39.4**	**22.4**	**1.24**	**4.42**	**8.13**
Period of Record Average	***16.3***	***0.744***	***31.9***	***24.4***	***1.05***	***4.55***	***7.67***

*Data not available

Table 2 lists the six metrics measuring the roles of light and nutrients in Pleasanton Reservoir. 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. Pleasanton Reservoir 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**	
1986	*	*	*	0.680	*	*	6.80
1989	0.952	2.97	7.10	0.835	3.94	5.51	8.70
1992	*	*	*	*	*	*	13.3
1996	0.750	2.34	15.3	0.428	3.90	6.09	19.2
2000	0.535	1.67	19.2	0.506	3.28	5.83	20.3
2003	0.158	0.494	37.9	0.559	2.79	6.34	33.8
2007	0.181	0.565	25.4	0.648	1.95	4.87	15.9
2011	0.400	1.25	15.8	0.394	2.44	4.92	12.4

*Data not available

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 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.

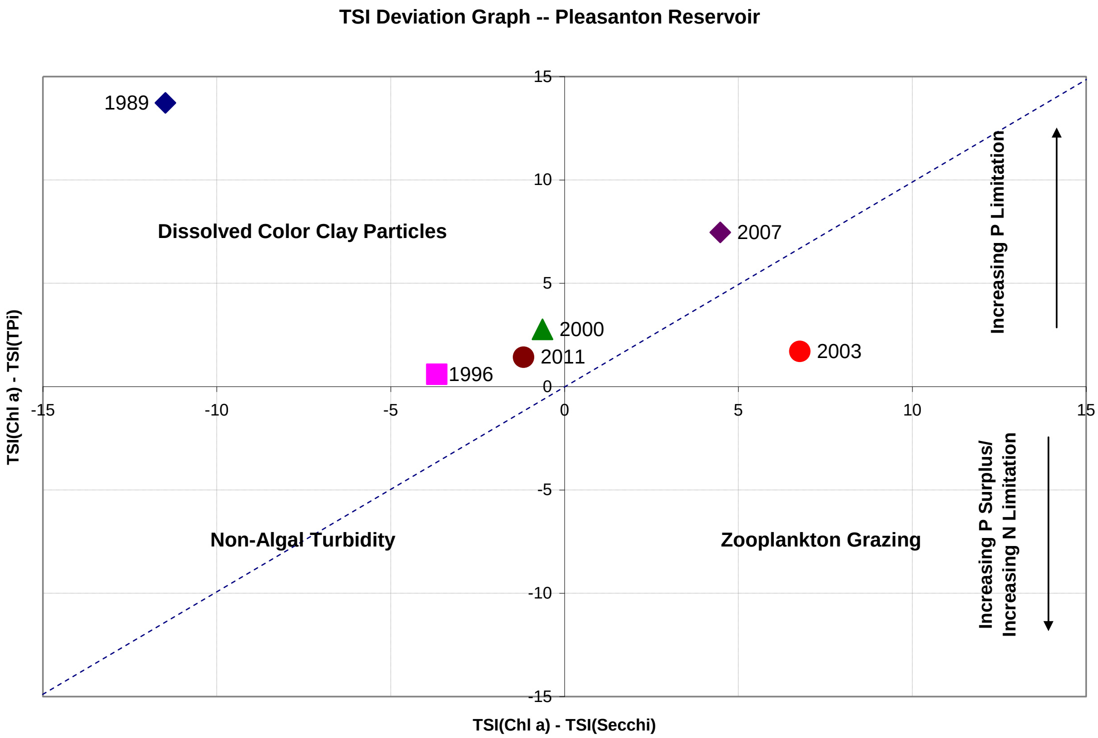
Shading values less than 16 indicate that self-shading of algae does not significantly impede productivity. This metric is most applicable to lakes with maximum depths of less than 5 meters (Carney, 2004).

The above metrics indicate there are low levels of inorganic turbidity in Pleasanton Reservoir allowing for abundant light in the mixed layer thus increasing the probability of a strong algal response to changes in nutrient levels, particularly phosphorus. Self shading of algae does not appear to be impeding productivity in Pleasanton Reservoir.

Another method for evaluating limiting factors is the TSI deviation metrics. Figure 6 (Multivariate Deviation Graph) summarizes the current trophic conditions at Pleasanton Reservoir 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.

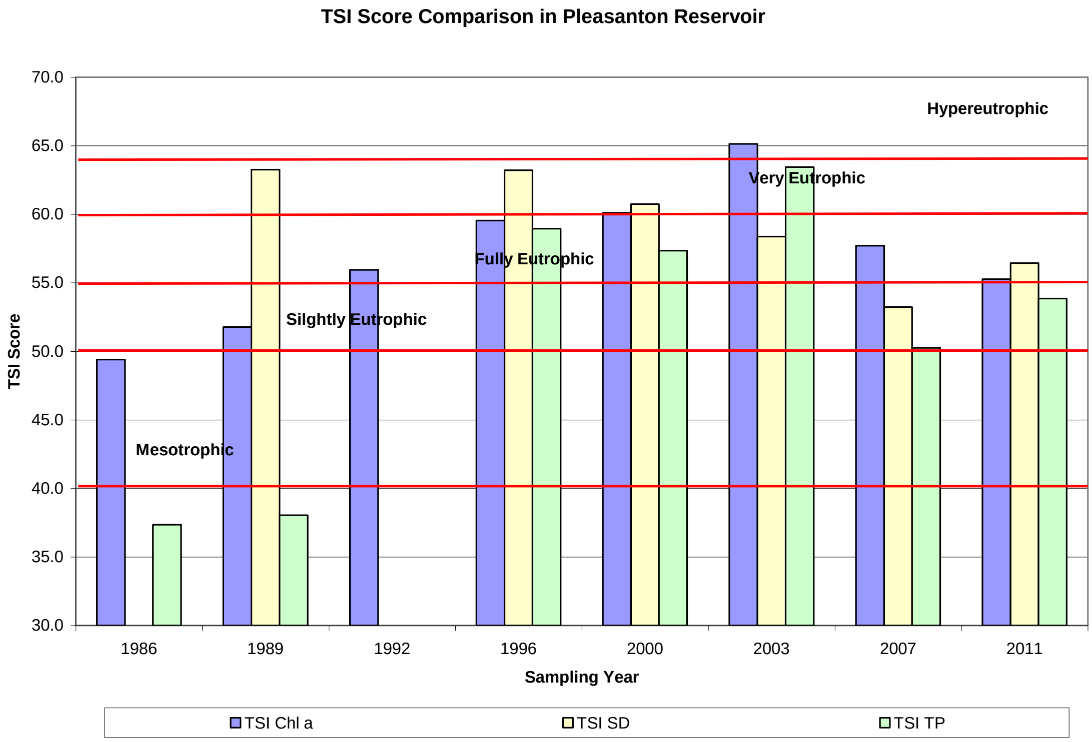
The multivariate TSI comparison chart in Figure 6 shows the chlorophyll *a* TSI is greater than the total phosphorus TSI in Pleasanton Reservoir indicating phosphorus is limiting algal response in the lake. 2000 and 2011 saw inorganic turbidity decreasing light penetration while in 1989 it dominated transparency in the lake. In 2003 and 2007 there was some zooplankton grazing in the lake and very little inorganic turbidity to limit light availability.

Figure 6. Multivariate TSI comparison chart for Pleasanton Reservoir.



The Carlson Trophic State Indices for chlorophyll *a* in Pleasanton Reservoir shown in Figure 7 reveal the lake has been in a fully eutrophic state since 1996 and reached a hypereutrophic state in 2003 when chlorophyll *a* rose to 33.8 µg/L. Improvement can be seen, however, in the 2007 and 2011 indices with the total phosphorus index nearly reaching a mesotrophic state in 2007 and the chlorophyll *a* index nearing the slightly eutrophic state in 2011.

Figure 7. Pleasanton Reservoir Trophic State Indices.



A comparison of the median trophic conditions in Pleasanton Reservoir to the benchmarks established for lakes in Kansas shows the total phosphorus concentration and Secchi depth in Pleasanton Reservoir are improved over what is seen in federal lakes in Kansas. No other benchmarks are met, however (Table 3). The statewide benchmarks and benchmarks for Kansas lakes in the central irregular plains region were derived from analysis of trophic conditions in the lakes and reservoirs in Kansas (Dodds et al., 2006). RTAG benchmarks were established by the USEPA Region 7 Regional Technical Assistance Group (RTAG) and are for lakes and reservoirs in Kansas, Iowa, Missouri and Nebraska excluding the Sand Hills ecoregion (USEPA, 2011).

Table 3. Median trophic indicator values for Pleasanton Reservoir in comparison with federal lakes in Kansas, lakes located in the central irregular plains ecoregion, draft nutrient benchmarks in Kansas and nutrient reference conditions for lakes in USEPA Region 7.

Trophic Indicator	Pleasanton Reservoir	Federal Lakes	Central Irregular Plains Lakes	Statewide Benchmark	RTAG
Secchi Depth (cm)	105	95	130	129	N/A
TN (µg/l)	879	903	362	625	700
TP (µg/l)	28	76	20	23	35
Chlorophyll *a* (µg/l)	15	12	8	8	8

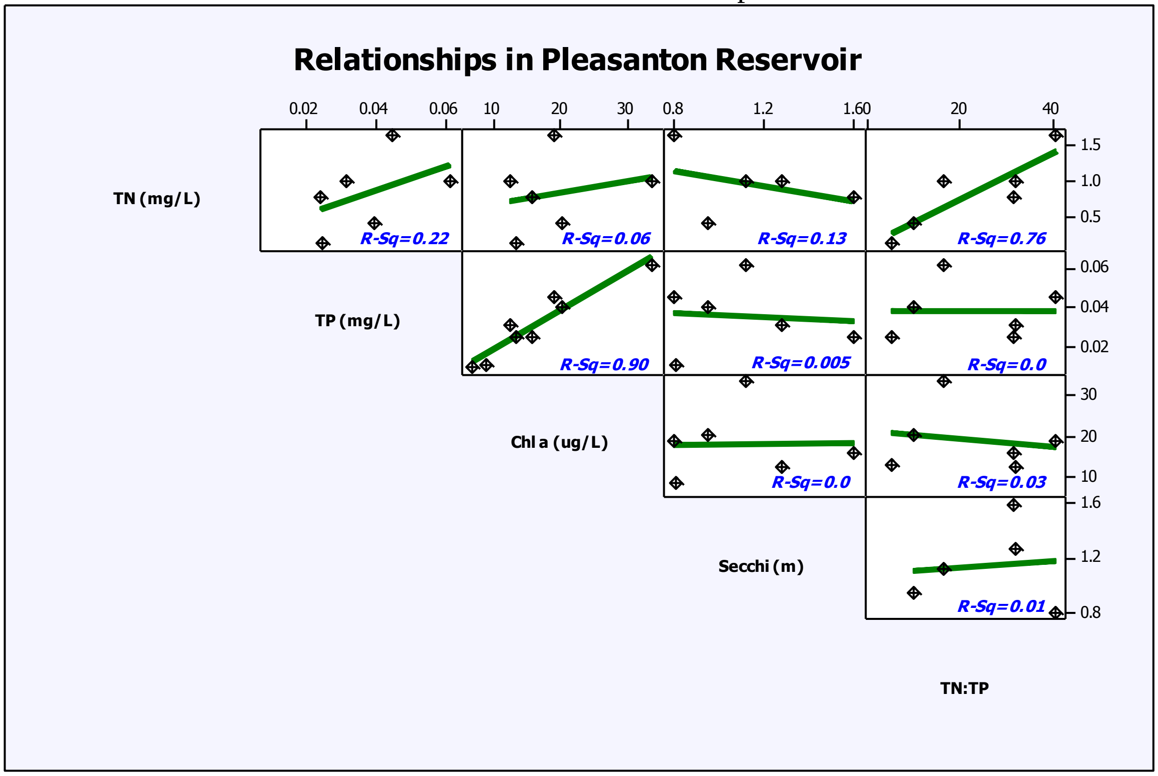
Algal Communities: As seen in Table 4, algal communities in Pleasanton Reservoir were dominated by blue-green algae, or cyanobacteria, in all years except 1992 and 2000. An increasing supply of nutrients, especially phosphorus and possibly nitrogen, will often result in higher growth of blue-green algae 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 and may influence chlorophyll *a* levels within the lake at various depths during the diel cycle.

Table 4. Algal communities observed in Pleasanton Reservoir during KDHE sampling years.

Sampling Date	Total Cell Count cells/mL	Percent Composition				Chl-*a* µg/L
		Green	Blue Green	Diatom	Other	
1992	5,000	57	0	33	10	13.3
1996	10,521	17	72	9	2	19.2
2000	11,876	90	0	3	7	20.3
2003	58,086	27	51	21	1	33.8
2007	10,265	23	65	12	0	15.9
2011	12,159	12	77	12	20	12.4

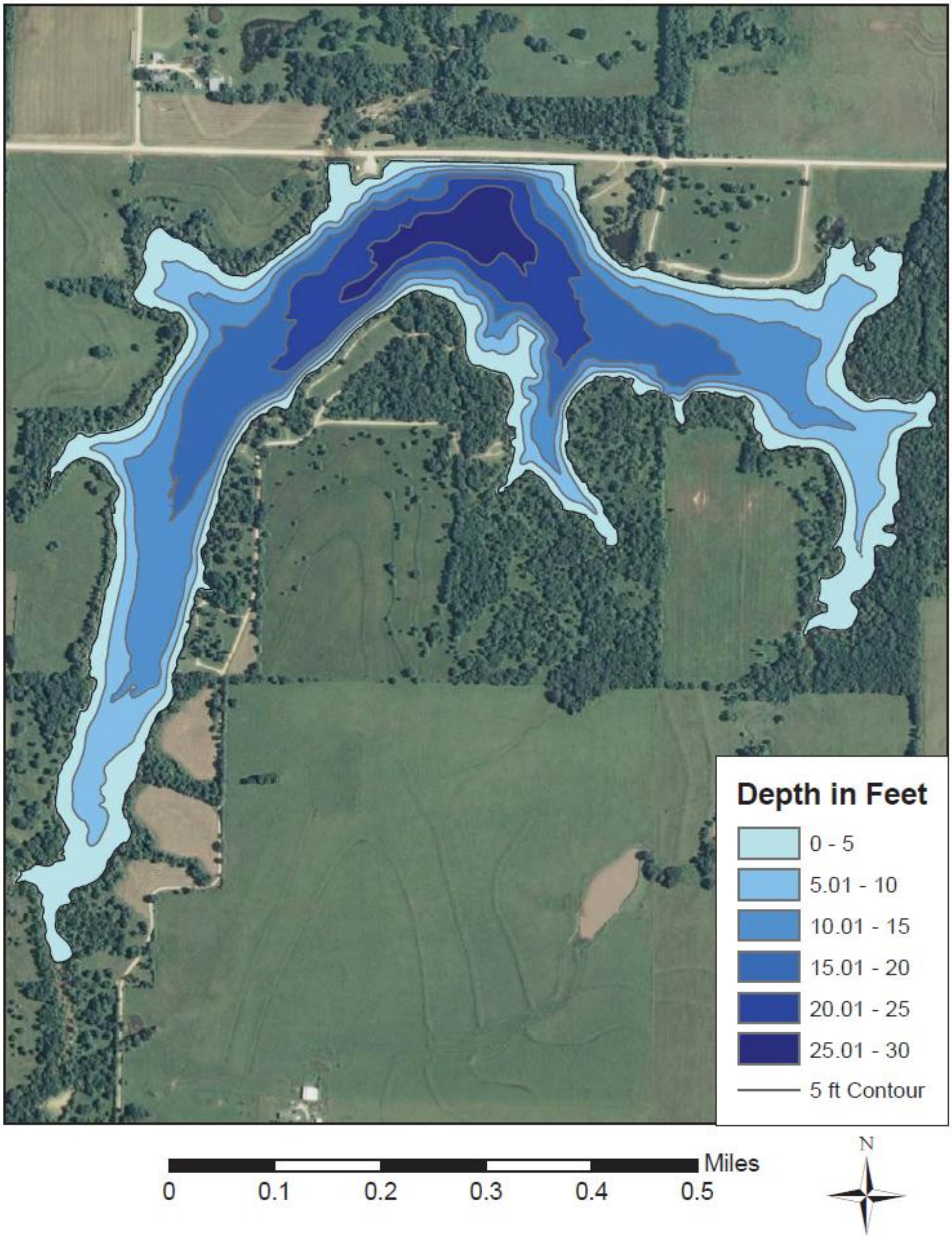
Relationships: Within Pleasanton Reservoir there is a strong relationship between total phosphorus and chlorophyll *a* and a minor relationship between total phosphorus and total nitrogen. All other relationships in Figure 8 are considered insubstantial.

Figure 8. Relationship of Chlorophyll *a*, TN, TP, TN:TP and Secchi Depth with associated coefficients of determination in Pleasanton Reservoir for the period of record.



Bathymetric Survey: A bathymetric and sediment survey performed by Kansas Biological Survey in 2010 revealed high percentages of silt and clay in the sediment of Pleasanton Reservoir. Silt and clay make up 48% and 34% of the sediment, respectively, in the southwestern arm of the lake while the eastern arm of the lake is made up of 64% silt and 36% clay. Nearer the dam the sediment is made up of 34% silt and 66% clay. Sediment and nutrient loads appear to derive from drainage channels near the southwest and east arms of the lake where the lake is shallower (Figure 9).

Figure 9. Water depth in Pleasanton Reservoir based on September 14, 2010 bathymetric survey for Pleasanton Reservoir. Depths are based on a pool elevation of 822.55 ft (KBS, 2011).



Inflow Data: No water quality data was available for the inflow to Pleasanton Reservoir.

Desired Endpoints of Water Quality (Implied Load Capacity) in Pleasanton Reservoir:

In order to improve the trophic condition of Pleasanton Reservoir from its current Fully Eutrophic status, the desired endpoint will be to maintain summer chlorophyll *a* average concentrations below 10 μg/L with the reductions focused on phosphorus entering the lake. The chlorophyll *a* endpoint of 10 μg/L is the statewide goal for lakes serving as public water supplies and will also ensure long-term protection to fully support Primary Contact Recreation within the lake. Based on CNET reservoir eutrophication model (Appendix A), the total phosphorus entering the lake must be reduced 50% in order to meet the chlorophyll *a* endpoint of 10 μg/L. Water quality data for the inflow in Pleasanton Reservoir was estimated by calibrating the stream total phosphorus concentration input in CNET to the 2000-2011 lake mean phosphorus concentration of 39.4 μg/L resulting in an estimated total phosphorus concentration at the inflow of 199 μg/L before reductions. Reduction of the total phosphorus concentration in the inflow to 100 μg/L will result in a 31% reduction in total phosphorus concentration to 27.0 μg/L and a 51% reduction in chlorophyll *a* concentration to the endpoint of 10 μg/L in 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 the TMDL since the peaks of algal growth occur in the summer months. The current average condition for Pleasanton Reservoir utilized in the model input was based on 2000-2011 data from KDHE station LM044201 (Appendix A).

Table 5. Pleasanton Reservoir Current average condition and TMDL based on CNET.

	Current Average Condition	**TMDL**	**Percent Reduction**
Total Phosphorus – Annual Load (lbs/year)	519.4	265.4	49%
Total Phosphorus – Daily Load** (lbs/day)	4.184	2.138	49%
Total Phosphorus – Lake Concentration (μg/L)	39.4	27.1	31%
Chlorophyll *a* Concentration (ug/L)	20.6	10	51%

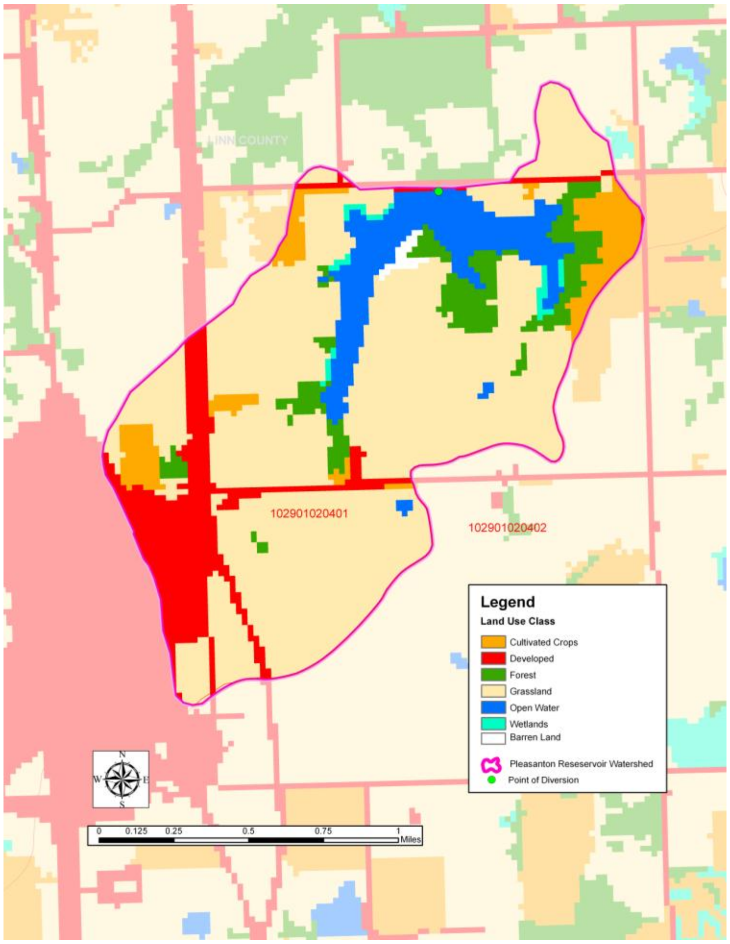
**See Appendix B for Daily Load Calculations

3. SOURCE INVENTORY AND ASSESSMENT

Point Sources: There are no NPDES permitted facilities in the Pleasanton Reservoir watershed.

Land Use: At over 64% of the watershed, the predominant land use in the Pleasanton Reservoir watershed is grassland with the remaining land area composed of developed land (11.1%), open water (9.6%), forest (6.9%) and cultivated crops (6.6%), according to the 2001 National Land Cover Data (Figure 10). Wetlands and barren land each make up less than 1% of the watershed. During precipitation runoff events, the cultivated cropland in the watershed may contribute to the nutrient load in the reservoir. Grasslands could also contribute to the nutrient load during high flow events, particularly on livestock grazing lands located in the riparian areas of the watershed.

Figure 10. Land use in the Pleasanton Reservoir watershed.



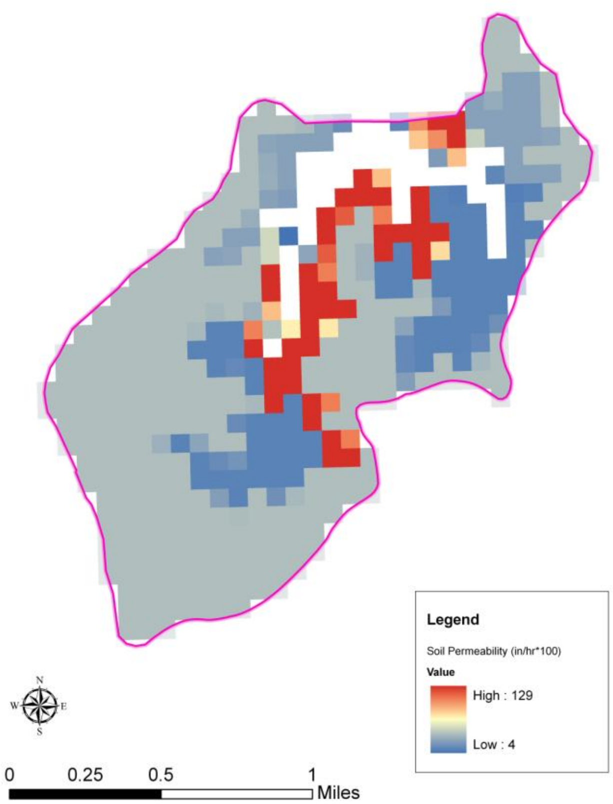
Livestock Waste Management Systems: There are no active, certified confined animal feeding operations (CAFOs) in the Pleasanton Reservoir watershed. However, according to the USDA National Agricultural Statistics Service, the cattle (including calves) inventory for Linn County was 28,000 head on January 1, 2012 and some smaller livestock facilities are likely operating in the watershed. Depending on the condition of their waste management systems and their proximity to the reservoir and its drainage channels, these operations could be contributing to the phosphorus load in Pleasanton Reservoir via runoff from feedlots and grazing lands.

On-Site Waste Systems: While the southwest section of the watershed includes a residential area of the City of Pleasanton that is connected to municipal services, much of the Pleasanton Reservoir watershed is a rural agricultural area that lies in Linn County. It can be assumed that rural residences in the watershed are not connected to public sewer systems and according to the 1990 U.S. Census there are 2,248 septic systems in Linn County. Failing on-site septic systems may contribute to nutrient loading in the watershed.

Population: According to the 2010 U.S. Census, the population of the Pleasanton Reservoir is 188 people (~ 100 people per square mile); however, 181 of 188 people living in the watershed reside within the City of Pleasanton. The population in the City of Pleasanton was 1,216 in 2010, down 12.3% from 2000.

Contributing Runoff: The watershed of Pleasanton Reservoir has a low mean soil permeability value of 0.36 inches/hour. Permeability ranges from 0.04 inches/hour to 1.29 inches/hour according to NRCS STATSGO database with nearly 50% of the watershed having a permeability value less than 0.32 inches/hour, which contributes to runoff during extremely low rainfall intensity events. 27% of the Pleasanton Reservoir watershed has a permeability value of 1.29 inches/hour, generating runoff during very low to low rainfall intensities (Figure 11). 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 with rainfall intensities greater than soil permeability. As the watershed's soil profiles become saturated, excess overland flow is produced.

Figure 11. Soil permeability in the Pleasanton Reservoir watershed.



Background and Natural Sources: Undissolved nutrients bound to suspended solids in the inflow of Pleasanton Reservoir are potentially significant sources of nutrients that may endure in the sediment layer until they are removed by dredging. These internal nutrient loads can undergo remineralization and resuspension and may be a continuing source of nutrients in Pleasanton Reservoir. In addition, geological formations (i.e. soil and bedrock) may also contribute to nutrient loads and, with deciduous forest making up nearly 7% of the land cover in the watershed, leaf litter and wastes derived from natural wildlife in the area are also likely to add to the nutrient load in Pleasanton Reservoir. Further nutrient loading is also occurring through the atmospheric deposition of nitrogen and phosphorus compounds to Pleasanton Reservoir and its watershed.

Internal Loading: Due to inadequate data for Pleasanton Reservoir on the potential for internal nutrient loading, no estimates of internal loading were made outside those inherently contained within the CNET modeling of the lake. Internal loading is a complex function of hydrologic conditions, lake morphometry and lake sediment nutrient availability. Because Pleasanton Reservoir stratifies during the summer growing season and has a small watershed to lake area ratio, internal loading of nutrients could play an important role in the eutrophic state of the lake.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

Data for the recent period of record (2000-2011) indicate total phosphorus is limiting the production of algal growth in Pleasanton Reservoir; 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 operations.

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 runoff conditions from pasture used for grazing and fertilized farm ground, exacerbated by very low soil permeability in the watershed, is contributing to the fully eutrophic state of lake. Load reductions should be focused on nonpoint source runoff contributions attributed to livestock operations, cultivated crop land and pasture land within the watershed. Using the CNET reservoir eutrophication modeling spreadsheet (Appendix A), a TMDL of 265.4 lbs/year of total phosphorus entering the lake, accounting for a 49% reduction, was found to be necessary to reach the chlorophyll *a* endpoint (Table 6).

Table 6. Pleasanton Reservoir TMDL

Description	Allocations (lbs/year)	Allocations (lbs/day)*
Total Phosphorus Atmospheric Load	8.8	0.0709
Total Phosphorus Wasteload Allocation	0	0
Total Phosphorus Nonpoint Source Load Allocation	230.1	1.853
Total Phosphorus Margin of Safety	26.5	0.2138

Total Phosphorus TMDL	265.4	2.138

*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 and the chlorophyll *a* endpoint. Therefore, the margin of safety is explicitly set at 10% of the total loading capacity for total phosphorus, which compensates for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality. The margin of safety for total phosphorus is 0.2138 lbs/day, as indicated in Table 6.

State Water Plan Implementation Priority: Because the City of Pleasanton utilizes Pleasanton Reservoir as a drinking water source this TMDL will be a **High** Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Lower Marais des Cygnes Basin (HUC 8: 10290102) with a priority ranking of 12 (High Priority for restoration work).

Priority HUC 12: The entire watershed is within HUC 12: 102901020401.

5. IMPLEMENTATION

Desired Implementation Activities: There is potential that urban and agricultural best management practices will improve the condition of Pleasanton Reservoir.

Some of the recommended urban practices are as follows:

1. Educate watershed residents on appropriate lawn fertilizer application.
2. Install grass buffer strips along drainage channels in the watershed.
3. Promote proper management of construction sites to minimize sediment and nutrient runoff.
4. Investigate feasibility of installing storm water wetlands and ponds in the watershed to remove nutrients prior to entering the lake.
5. Promote installation of porous and concrete grid pavement in the watershed.

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.
8. Promote and adopt livestock grazing practices that will minimize erosion and protect the integrity of riparian areas in the watershed.

Implementation Program Guidance:

Watershed Management Program – KDHE

a. Support selected Section 319 project activities for Pleasanton Reservoir, 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 in rural portion of county.
b. Leverage Conservation Reserve 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 2013-2021. Additional implementation may be required over 2022-2030 to achieve the endpoints of this TMDL.

Targeted Participants: Primary participants for implementation will be agricultural producers and stakeholders and new and existing development sites within the Pleasanton Reservoir watershed. A detailed assessment of sources conducted over 2013-2014 should include local assessments by conservation district personnel and county public works 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.
5. Construction sites.
6. New residential development.
7. Existing residential development.

Milestone for 2017: In accordance with the TMDL development schedule for the State of Kansas, the year 2017 marks the next cycle of 303(d) activities in the Marais des Cygnes River Basin. At that point in time, data from 2014 and 2017 at site LM044201 at Pleasanton Reservoir will be reexamined to assess improved conditions in the lake.

Delivery Agents: The primary delivery agents for program participation will be the Kansas Department of Health and Environment, the Kansas Department of Agriculture Division of Conservation, the Natural Resources Conservation Service, the Kansas State University Extension Service, the City of Pleasanton and the Linn 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 Kansas Department of Agriculture – Division of Conservation 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 Kansas Department of Agriculture – Division of Conservation 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. The Kansas Water Plan and the Marais des Cygnes 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 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. Additionally, $2 million has been allocated between the State Water Plan Fund and EPA 319 funds to support implementation of Watershed Restoration and Protection Strategies. This watershed and its TMDL are a High priority consideration for funding.

Effectiveness: Nutrient control has been proven effective through the implementation of urban best management practices (BMPs) including biofilters, bioretention units, detention basins, permeable pavement, retention ponds and wetlands. In addition, the use of proper fertilizer rates on urban lawns with appropriate disposal of pet waste has proven effective at reducing nutrient loading associated with stormwater runoff. Conservation tillage, contour farming, use of grass waterways and buffer strips and the proper implementation of comprehensive livestock waste management plans has proven effective at reducing nutrient runoff associated with farming operations. The key to success of this TMDL will be widespread utilization of conservation farming and proper livestock waste management combined with urban best management practices for those residing in the City of Pleasanton.

6. MONITORING

KDHE will continue its 3-year sampling schedule in order to assess the trophic state of Pleasanton Reservoir. Based on the sampling results, the 303(d) listing will be evaluated in 2022. Should impairment status continue, the desired endpoints under this TMDL may be refined and sampling conducted over the period 2022-2026 to assess progress in this implementation.

7. FEEDBACK

Public Notice: Draft TMDLs for the Marais des Cygnes River Basin were made available through the active Internet Website at www.kdhe.gov/tmdl on May 1, 2013.

Public Hearing: A Public Hearing was held May 23, 2013 in Ottawa to receive comment on this TMDL. Public comments for this TMDL were held open from May 4 through June 7, 2013. No comments were received for this TMDL.

Basin Advisory Committee: The Marais des Cygnes River Basin Advisory Committee met to discuss these TMDLs on September 14, 2012 in Fort Scott.

Milestone Evaluation: In accordance with the TMDL development schedule for the State of Kansas, the year 2017 marks a future cycle of 303(d) activities in the Marais des Cygnes Basin. At that pint in time, sample data from Pleasanton Reservoir will be reexamined to assess improved conditions in the lake. Should the impairment remain, adjustments to source assessment, allocation and implementation activities may occur.

Consideration for 303(d) Delisting: Pleasanton Reservoir will be evaluated for delisting under Section 303(d), based on the monitoring data over 2012-2021. Therefore, the decision for delisting will come about in the preparation of the 2022 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 2014, 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 2013-2021.

Developed 8/12/13

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Appendix A. CNET Eutrophication Model for Pleasanton Reservoir.

Inputs:

Parameter	Input Value (Current)
Drainage Area (km^2)	4.88
Precipitation (m/yr)	1.00
Evaporation (m/yr)	1.17
Unit Runoff (m/yr)	0.239
Stream Total P (ppb)	199
Surface Area (km^2)	0.400
Max Depth (m)	8.6
Mean Depth (m)	3.1
Current Lake Phosphorus (ppb)	39.4
Current Lake Chlorophyll *a (*ppb)	20.6
Current Lake Secchi Depth (m)	0.75
Total P Model Number	3
Chl *a* Model Number	5

Outputs:

Parameter	Predicted Values
Stream Total P (ppb)	100
Total Inflow (hm^3/yr)	1.57
Total Outflow (hm^3/yr)	1.10
Predicted Lake Phosphorus (ppb)	27.1
Predicted Lake Chlorophyll *a (*ppb)	10.0
Predicted Lake Secchi Depth (m)	0.83
Current Total Phosphorus Load (lbs/yr)	519.4
Load Capacity (lbs/yr)	265.4

CNET Model:

RESERVOIR EUTROPHICATION MODELING WORKSHEET TITLE -> **Pleasanton**

VARIABLE	UNITS	Current	LC
WATERSHED CHARACTERISTICS...	drop down select unit - conversion is automatic	Latitude	38.2
Drainage Area	km2	4.88	4.88
Precipitation	m/yr	1.00	1
Evaporation	m/yr	1.17	1.17
Unit Runoff	m/yr	0.239	0.239
Stream Total P Conc.	ppb	199	100
Stream Ortho P Conc.	ppb	39.8	20
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	km2	0.400	0.4
Max Depth	m	8.6	8.6
Mean Depth	m	3.1	3.1
Non-Algal Turbidity (1/m)	Dzialowski	0.64	0.37
Mean Depth of Mixed Layer	m	3.1	3.1
Mean Depth of Hypolimnion	m	1.18	1.18
Observed Phosphorus	ppb	39.4	24.9
Observed Chl-a	ppb	20.6	10.0
Observed Secchi	m	0.75	1.20
MODEL PARAMETERS...			
BATHTUB Total P Model Number	(1-8)	3	3
BATHTUB Total P Model Name		2ND ORDER	
BATHTUB Chl-a Model Number	(2, 4, 5)	5	5
BATHTUB Chl-a Model Name		JONES	
Beta = 1/S vs. C Slope (m2/mg)	Default	0.0647	0.0833
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	0.40	0.40
NonPoint Flow	hm3/yr	1.17	1.17
Point Flow	hm3/yr	0.00	0.00
Total Inflow	hm3/yr	1.57	1.57
Evaporation	hm3/yr	0.47	0.47
Outflow	hm3/yr	1.10	1.10

VARIABLE	UNITS	Current	LC
AVAILABLE P BALANCE...			
Precipitation Load	kg/yr	4.00	4.00
NonPoint Load	kg/yr	232.10	116.63
Point Load	kg/yr	0.00	0.00
Total Load	b	236.10	120.63
Sedimentation	kg/yr	192.79	90.90
Outflow	kg/yr	43.31	29.74
PREDICTION SUMMARY...			
P Retention Coefficient	-	0.817	0.753
Mean Phosphorus	ppb	39.4	27.1
Mean Chlorophyll-a	ppb	17.3	10.0
Algal Nuisance Frequency	%	80.9	24.3
Mean Secchi Depth	meters	0.57	0.83
Hypol. Oxygen Depletion A	mg/m2-d	998.6	759.0
Hypol. Oxygen Depletion V	mg/m3-d	846.3	643.2
Organic Nitrogen	ppb	600.0	412.9
Non Ortho Phosphorus	ppb	41.9	22.5
Chl-a x Secchi	mg/m2	9.8	8.3
Principal Component 1	-	2.83	2.43
Principal Component 2	-	0.77	0.74
	Observed	Pred	Target
Carlson TSI P	57.2	57.2	51.8
Carlson TSI Chl-a	60.3	58.6	53.2
Carlson TSI Secchi	64.1	68.2	62.7
OBSERVED / PREDICTED RATIOS...			
Phosphorus		1.00	0.92
Chlorophyll-a		1.19	1.00
Secchi		1.32	1.44
OBSERVED / PREDICTED T-STATISTICS...			
Phosphorus		0.00	-0.31
Chlorophyll-a		0.64	0.00
Secchi		1.02	1.35
ORTHO P LOADS...			
Precipitation	kg/yr	0.00	0.00
NonPoint	kg/yr	46.42	23.33
Point	kg/yr	0.00	0.00
Total	kg/yr	46.42	23.33
Total	lbs/yr	102.12	51.32

Based on CNET.WK1 VERSION 1.0

VARIABLE	UNITS	Current	LC
RESPONSE CALCULATIONS...			
Reservoir Volume	hm3	1.24	1.24
Residence Time	yrs	1.1290	1.1290
Overflow Rate	m/yr	2.7	2.7
Total P Availability Factor		1.00	1
Ortho P Availability Factor		0	0
Inflow Ortho P/Total P		0.197	0.193
Inflow P Conc	ppb	215.0	109.8
P Reaction Rate - Mods 1 & 8		7.1	3.6
P Reaction Rate - Model 2		11.8	6.1
P Reaction Rate - Model 3		24.3	12.4
1-Rp Model 1 - Avail P		0.312	0.406
1-Rp Model 2 - Decay Rate		0.252	0.330
1-Rp Model 3 - 2nd Order Fixe		0.183	0.247
1-Rp Model 4 - Canfield & Bach		0.267	0.351
1-Rp Model 5 - Vollenweider 19		0.485	0.485
1-Rp Model 6 - First Order Dec		0.470	0.470
1-Rp Model 7 - First Order Set		0.733	0.733
1-Rp Model 8 - 2nd Order Tp Or		0.312	0.406
1-Rp - Used		0.183	0.247
Reservoir P Conc	ppb	39.4	27.1
Gp		0.601	0.601
Bp	ppb	31.5	18.8
Chla vs. P, Turb, Flus	2	10.2	7.9
Chla vs. P Linear	4	11.0	7.6
Chla vs. P 1.46	5	17.3	10.0
Chla Used	ppb	17.3	10.0
m1 - Nuisance Freq Calc.		2.8	2.2
z		-0.872	0.696
v		0.273	0.313
w		0.775	0.812
x		0.191	0.243

TOTAL P LOADS...

BAF Override (KS) (see below)	OrP %	Current	LC
0	0%	4.00	4.00
0	20%	232.10	116.63
0	0%	0.00	0.00
		236.1	120.6
		519.4	265.4

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 $\sigma^2 = \ln(CV^2 + 1)$

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 lbs/year	CV	$e^{[Z\sigma - 0.5\sigma^2]}$	MDL lbs/day	Atm LA lbs/day	LA lbs/day	WLA lbs/day	MOS (10%) lbs/day
TP	265.4	0.56	2.94	2.138	0.0709	1.853	0	0.2138

Maximum Daily Load Calculation

Annual TP Load = 265.4 lbs/yr

Maximum Daily TP Load = [(265.4 lbs/yr)/(365 days/yr)]*$e^{[2.326*(0.522) - 0.5*(0.522)^2]}$
= 2.138 lbs/day

Margin of Safety (MOS) for Daily Load

Annual TP MOS = 26.5 lbs/yr

Daily TP MOS = [(26.5 lbs/yr)/(365 days/yr)]*$e^{[2.326*(0.522) - 0.5*(0.522)^2]}$
= 0.2138 lbs/day

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