UPPER REPUBLICAN BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: Prairie Dog Creek from the outfall of Norton (Sebelius) Lake to the Nebraska Stateline
Water Quality Impairment: Total Phosphorus

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Prairie Dog **Counties**: Norton, Phillips

HUC8: 10250015
HUC10 (HUC12): **02** (08)
03 (01, 02, 03, 04, 05, 06, 07, 08)

Ecoregion: Central Great Plains, Rolling Plains and Breaks (27b)

Drainage Area: 930 square miles

Main Stem Water Quality Limited Segments: Prairie Dog Creek (4) in Norton County and Prairie Dog Creek (2) in Norton and Phillips Counties.

HUC8: 10250015:
Prairie Dog Creek (2, 4) Tributaries: Buffalo Cr (21)
Horse Cr (18)
Spring Cr (15)

Designated Uses: For Prairie Dog Creek (2): Primary Contact recreation "C" (stream segment is not open to and accessible by the public under Kansas Law); Expected Aquatic Life Support; Domestic Water Supply; Food Procurement; Ground Water Recharge; Industrial Water Supply; Irrigation Use; Livestock Watering Use. Prairie Dog Creek (4) has the same designated uses with the exception of Secondary Contact recreation "a" (stream segment is by law or written permission of the landowner open to and accessible by the public).

Designated uses for Buffalo Creek (21) and Horse Creek (18): Secondary Contact recreation "b" (stream segment is not freely accessible by the public under Kansas Law); Expected Aquatic Life Support; Domestic Water Supply; and Food Procurement.

Designated uses for Spring Creek (15): Secondary Contact recreation "b", Expected Aquatic Life Support; Domestic Water Supply; Ground Water Recharge; Industrial Water Supply; Irrigation Use; and Livestock Watering Use.

303(d) Listings: Kansas Stream Segments monitored by Station SC230 cited as impaired in the 2008-303(d) list for the Upper Republican Basin.

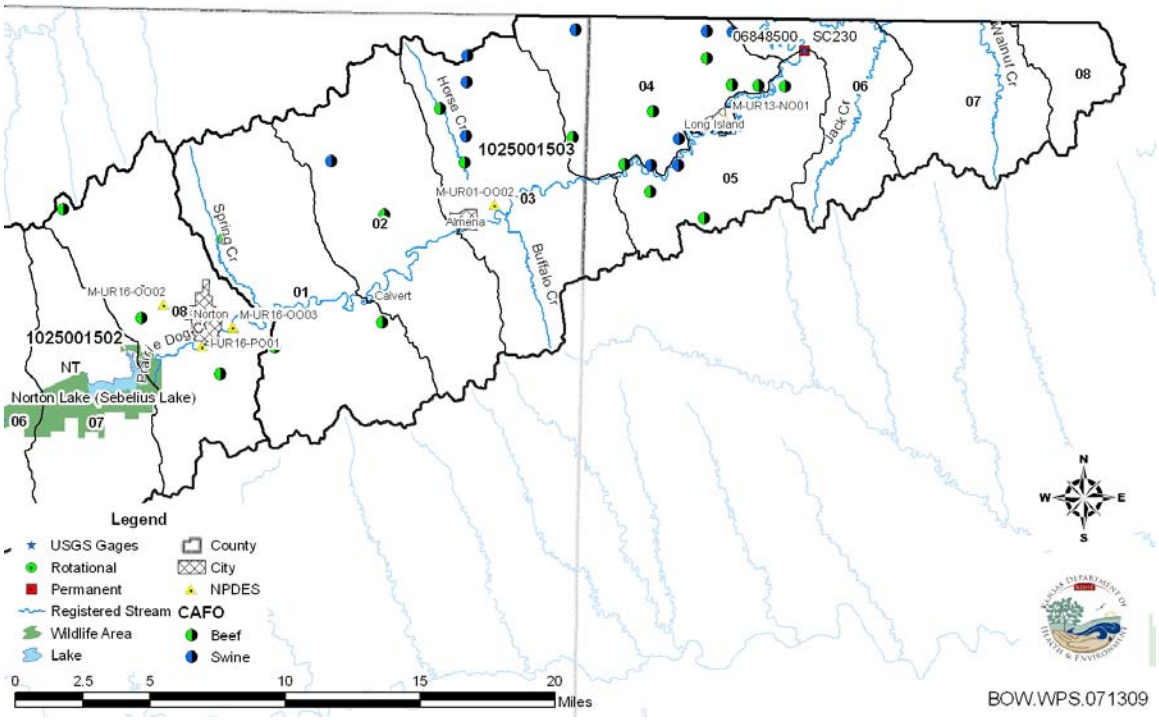
Impaired Use: Expected Aquatic Life, Domestic Water Supply, and Contact Recreation

Water Quality Criteria: Nutrients – Narratives: 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)(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 (K.A.R. 28-26-28e(c)(7)(A)).

Figure 1. Lower Prairie Dog Creek watershed, HUC 10250015.



2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Uses under 2008 – 303(d): Excessive nutrients are seen in Prairie Dog Creek and potentially impairing aquatic life; domestic water supply; as well as possibly contributing to objectionable algal blooms that impair contact recreation further downstream within Harlan County Reservoir in Nebraska.

Monitoring Site: KDHE permanent ambient Stream Chemistry sampling station SC230, located along U.S. Highway 383 two and a half miles west of Woodruff.

Period of Record Used: 1990-2008 for KDHE station SC230

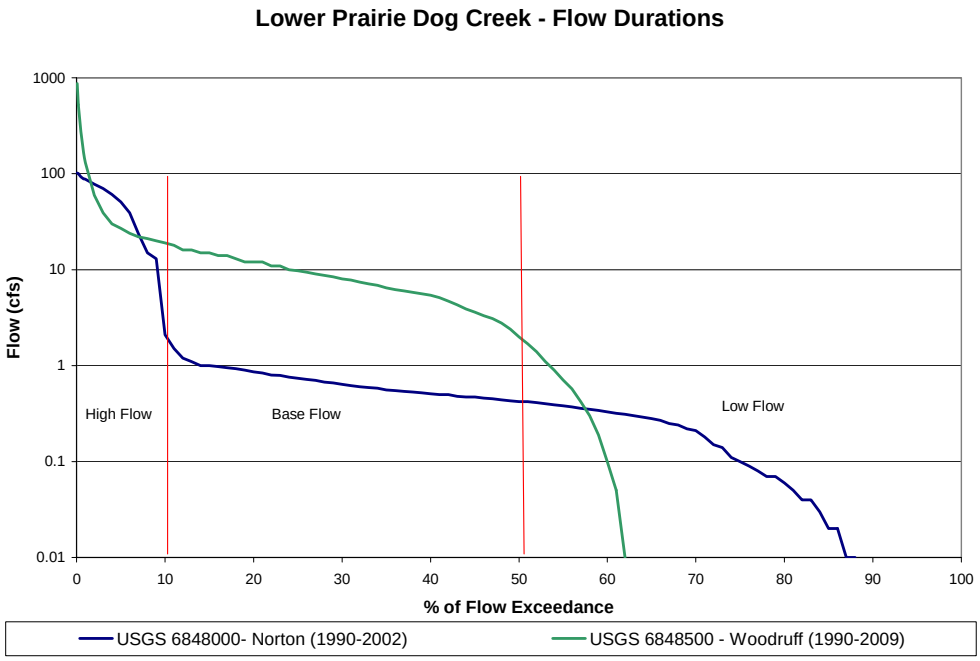
Flow Record: Prairie Dog Creek at Norton, USGS Gage 06848000 for the period of record 1990-2002. Prairie Dog Creek near Woodruff, USGS Gage 06848500 for the period of record 1990-2008.

Long Term Flow Conditions: Long term flow conditions at Norton, KS are associated with the discharge from Norton Lake. During drier conditions when minimal or no flow is being released from Norton Lake, Prairie Dog Creek is typically dry. Long-term flow conditions are illustrated in Table 1 and Figure 2 for the period of record. For purposes of this document the flow regime for Prairie Dog Creek is broken out into three flow conditions: low flow (51-100% exceedance), base flow (10-50%), and high flow (0-10%). Flow conditions along the lower portions of Prairie Dog Creek are often dry during low flow conditions, and minimal flow is sustained during base flow conditions. The USGS Gage 06848500 near Woodruff is utilized to assess flow conditions relative to water quality within Prairie Dog Creek since this station is located at the KDHE sampling station SC230.

Table 1. Actual Long Term Flow Conditions as calculated from USGS gage information for the respective periods of record. Flow Duration Values are in cubic feet per second (cfs) for the indicated percentage of time flow equaled or exceeded.

Location	Drainage Area	Mean Flow	90%	75%	50%	25%	10%
Prairie Dog Creek at Norton (USGS 06848000)	653	5.29	0	0.1	0.42	0.74	2.1
Prairie Dog Creek near Woodruff (USGS 06848500)	930	10.82	0	0	2	9.73	19

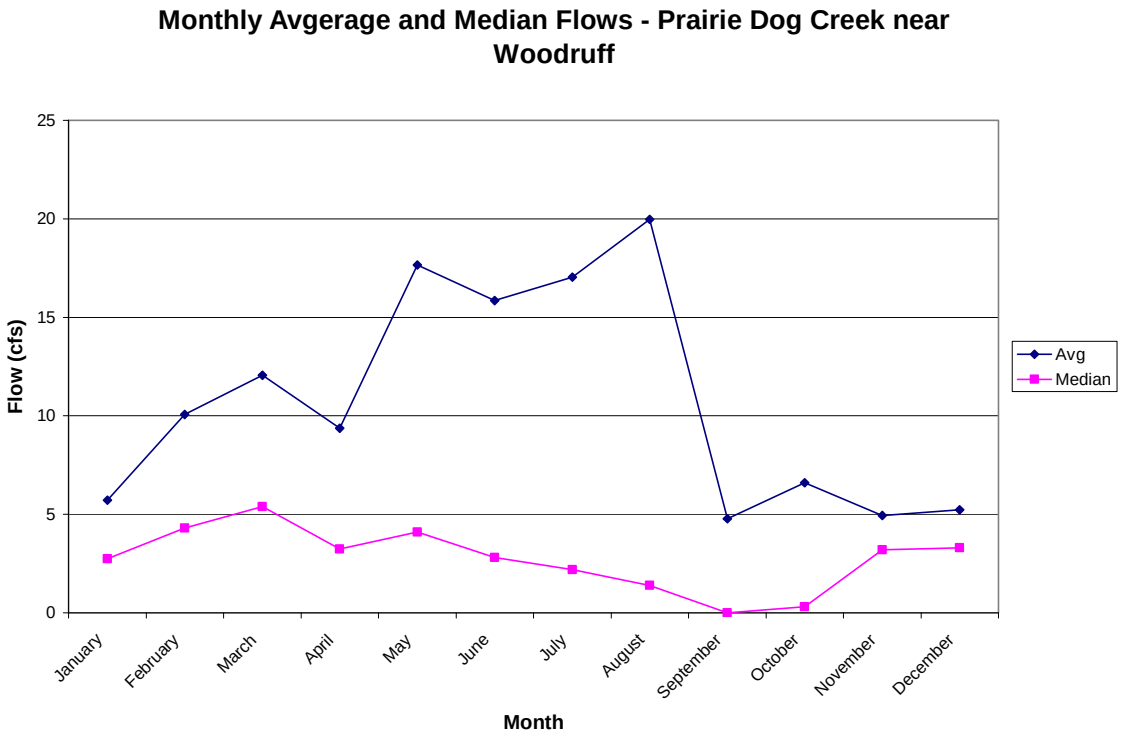
Figure 2. Flow durations for Lower Prairie Dog Creek.



The monthly average flows at USGS 06848500 over the period of record are the highest during the months of May, June, July, and August, which also coincide with the months with the highest average precipitation recorded at Norton. The months with the higher median flows over the period of record indicate the months with prolonged sustained flow as indicated in Figure 3.

The average precipitation within the watershed is 24.89 inches/year. Monthly average precipitation amounts are illustrated in Figure 5. The climate within the Prairie Dog Creek watershed is generally considered continental, with large daily and annual variations. This watershed is generally drier than many parts of the state since it lies "to the west of the flow of moisture-laden air from the Gulf of Mexico and to the east of the strong rain-shadow effects of the Rocky Mountains" (Bark, KAES). As a result, the area receives a great deal of precipitation in the form of thunderstorms, which will result in significant runoff. Consistent wind speeds are high in this area of the state, combined with drier periods significant soil loss can occur due to wind erosion. "Conservation practices are necessary to conserve moisture and prevent excessive soil loss" (Bark, KAES).

Figure 3. Monthly average and median flows for Prairie Dog Creek as USGS gage 6848500.



Based on annual average and median flows, as seen in Figure 4, it is apparent there is great variability in the annual flow conditions. Several years have median flows at 0 cfs, which indicate the stream is dry for at least half of the year. The years with higher average flows and low median flows indicate there were brief periods throughout the year that experienced high intensity precipitation and runoff events. Years with higher median flows generally indicate wet hydrologic years. The years that display similar average and median flows are the years that most likely experienced more consistent sustainable flows throughout the year.

Figure 4. Annual average and median flows at USGS gage 6848500.

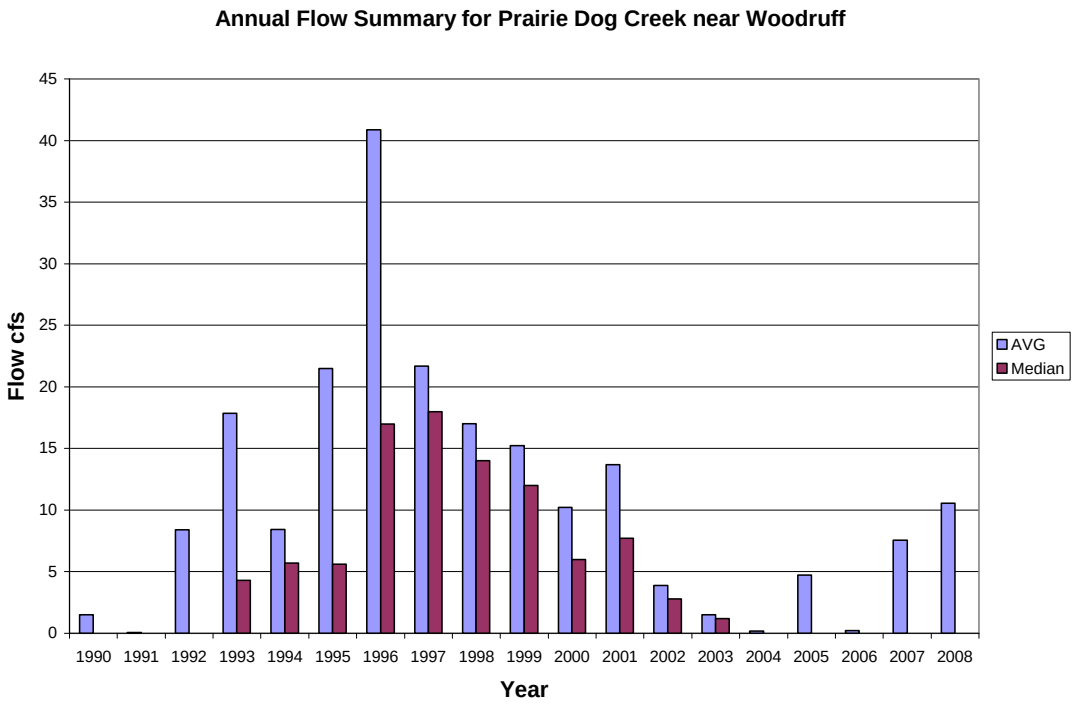
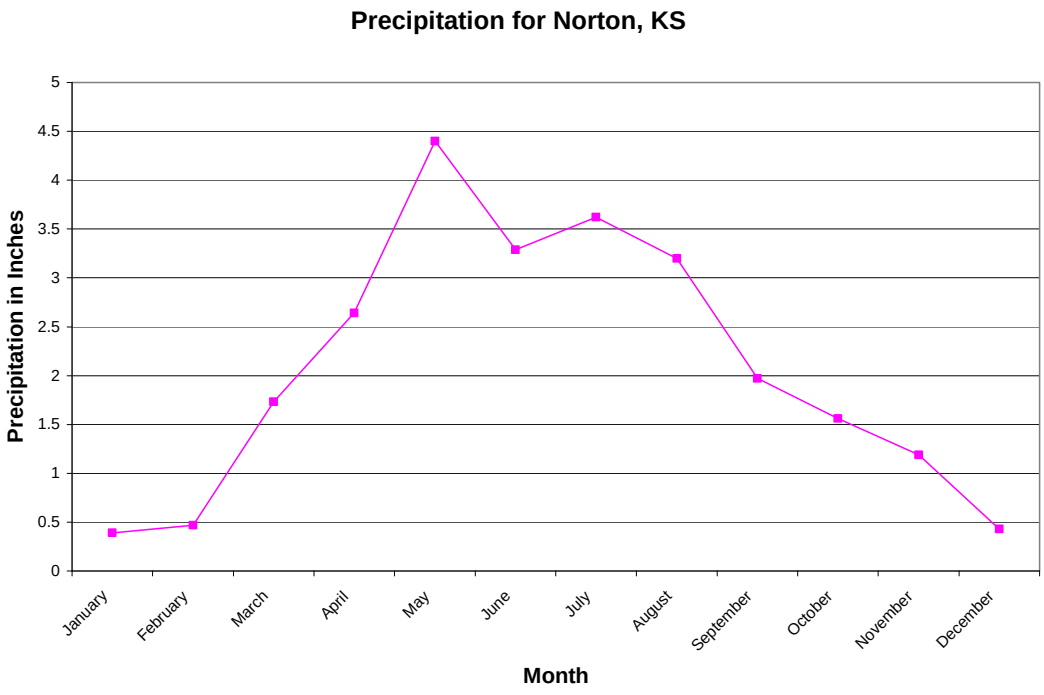


Figure 5. Monthly average precipitation for Norton, KS.



Assessment Season: Seasonal variability has been accounted for in this TMDL and seasons were defined by the average monthly temperature within Prairie Dog Creek as illustrated in Figure 6. A three season approach was utilized to include: the spring season consisting of the months of April, May and June; the Summer-Fall season consisting of the months of July, August, September, and October, and the winter season that includes January, February, March, November, and December.

Phosphorus Summary for the Upper Republican Basin: There are seven permanent KDHE stream sampling stations that are active in the Upper Republican basin. Three of these stations, SC225, SC226, and SC227 lie within ecoregion 25c: Western High Plains, Moderate Relief Rangeland. Stations and streams that lie within ecoregion 25c, have insignificant concentrations of phosphorus. However, the other four stream chemistry stations within the basin (SC228, SC229, SC230, and SC549) lie within ecoregion 27b: Central Great Plains, Rolling Plains and Breaks, are all listed as impaired on the 2008 – 303(d) list for Total Phosphorus. As seen in Table 2 and Figure 7, phosphorus concentrations observed at the KDHE stream chemistry sampling stations within the 27b ecoregion located in the Upper Republican Basin are significantly high.

Figure 6. Average Monthly in-stream temperatures and seasonal determination.

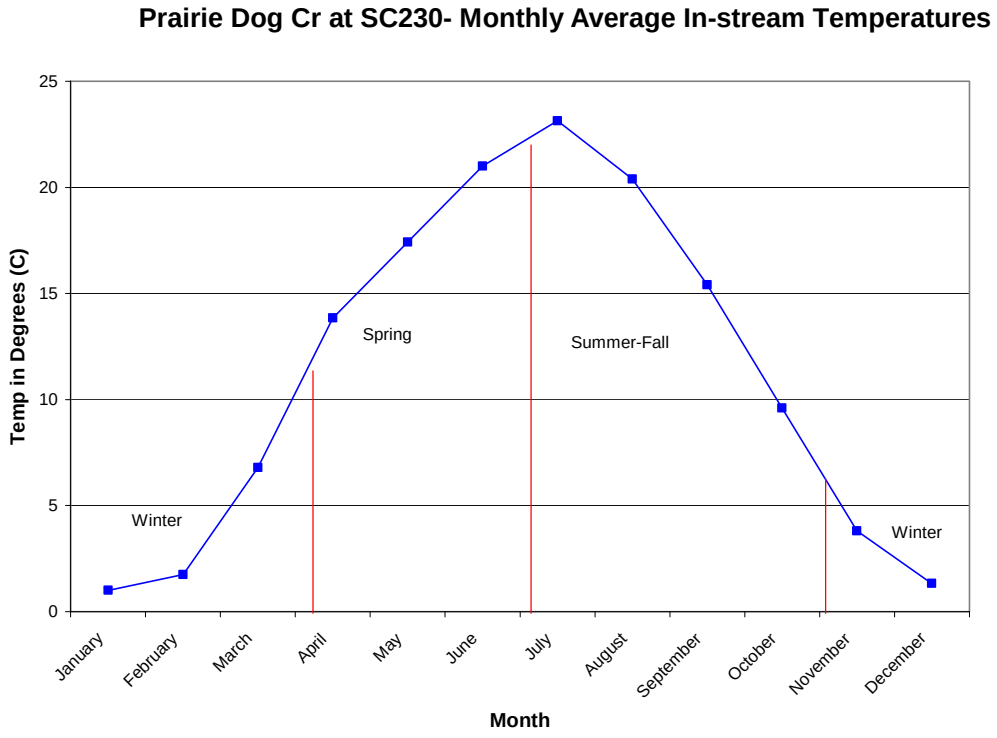


Table 2. KDHE Stream Chemistry Stations in the Upper Republican Basin with respective TP concentrations in mg/L.

Station	Location	Ecoregion	Total P Avg	Total P Median	Total P – 25% Quartile	Total P – 75% Quartile
SC225	S. Fk Republican nr St. Francis	25c	0.05	0.04	0.02	0.06
SC226	Arikaree R.	25c	0.14	0.1	0.05	0.21
SC227	S. Fk Republican nr Benkelman, NE	25c	0.07	0.05	0.04	0.10
SC228	Beaver Cr at Cedar Bluffs	27b	0.42	0.34	0.22	0.60
SC229	Sappa Cr nr Beaver City, NE	27b	0.66	0.65	0.38	0.83
SC230	**Prairie Dog Cr nr Woodruff**	**27b**	**0.86**	**0.75**	**0.58**	**1.14**
SC549	Prairie Dog Cr nr Dellvale	27b	0.42	0.31	0.17	0.55
Basin Avgs.			0.38	0.33	0.21	0.50

Figure 7. Boxplot of Phosphorus samples at KDHE Stream Chemistry sampling stations within the Upper Republican Basin with median line and mean symbol.

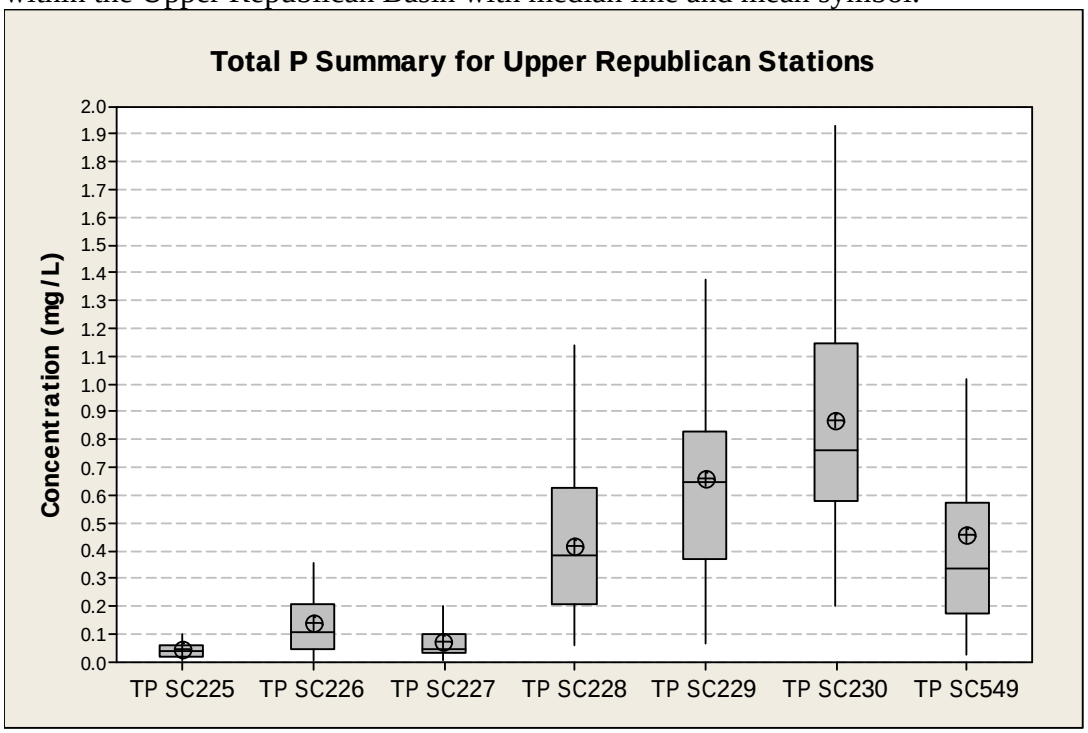


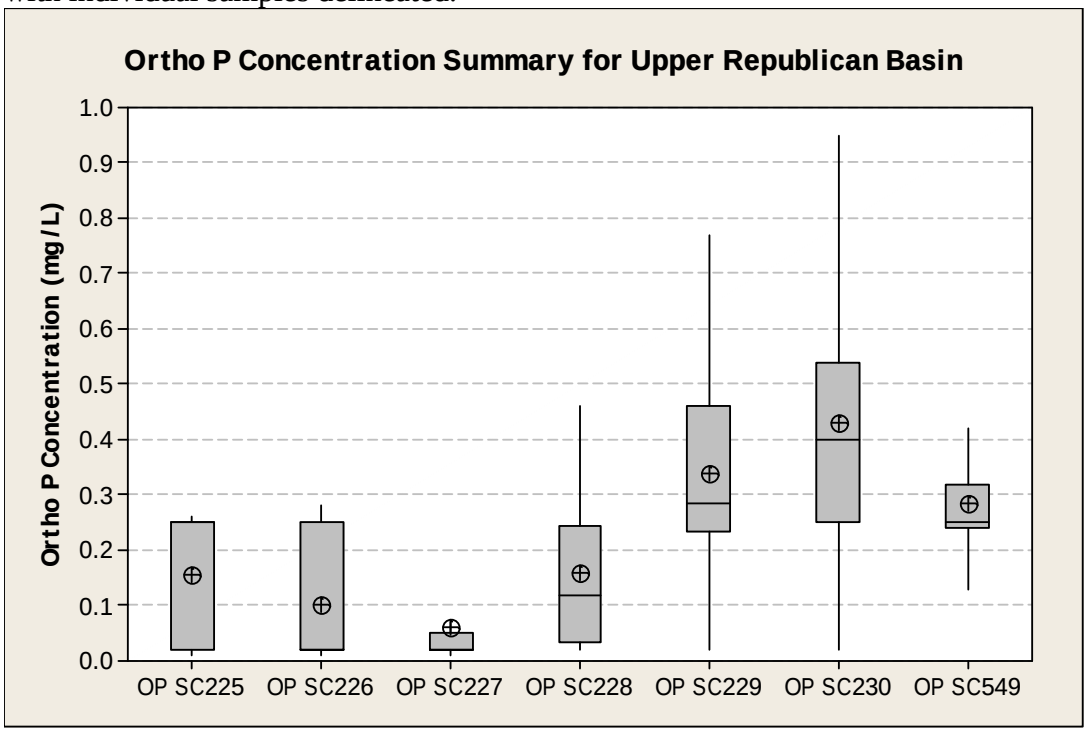
Table 3. Ortho-phosphorus data summary for the Upper Republican Basin.

Station	OP Avg	OP Median	% of OP Detections
SC225	ND	<0.25	0%
SC226	0.103	<0.02	21%
SC227	0.063	<0.02	17%
SC228	0.158	0.12	75%
SC229	0.339	0.285	68%
SC230	**0.430**	**0.40**	**87%**
SC549	0.286	0.25	56%

Note – Laboratory detection limits for Ortho Phosphorus are 0.02 from 1996-2001 and 0.25 mg/L from 2002- present.

Ortho-phosphorus (Ortho-P), which is the portion of total phosphorus that is soluble and readily available for biological uptake, is rarely detected in ecoregion 25b. However, Ortho-P is detected in 56-87% of the samples associated with the four stream stations in ecoregion 27b within the Upper Republican basin. Ortho-phosphorus concentrations within the Upper Republican Basin are summarized in Table 3 and Figure 8.

Figure 8. Boxplot of Ortho-Phosphorus samples within the Upper Republican Basin with individual samples delineated.



Phosphorus Condition for Prairie Dog Creek at Station SC230: Phosphorus concentrations within Prairie Dog Creek below Norton Lake primarily vary based on seasons. The majority of the samples were collected during baseflow conditions. As seen in Table 4, TP concentrations did not vary much based on flow conditions throughout the respective seasons as the concentrations remained relatively consistent, with the exception of the one low flow winter sample. TP concentrations are the highest during the spring season and the lowest during the winter season. As seen in Figure 9, TP concentrations are the highest during the months of May and June. The lack of flow within Prairie Dog Creek and the influence of the Norton Lake discharge may play a key role in why there is not a relationship between flow and TP concentrations as seen in Figures 10 and 11. In addition, there is no statistical significant difference between the concentrations detected at the low, base and high flow condition utilizing the Mann-Whitney test. KDHE attempted to sample station SC230 thirty-four times under dry weather conditions but only ten samples were collected with adequate flow.

Table 4. Average and median Total Phosphorus Concentrations (mg/L) based on Flow and Season for all data (period of record 1990-2008).

Stream Flow (% Exceedance)	Summer-Fall	Spring	Winter	All Seasons	All Seasons Median
High (0-10%)	0.905 (9)	1.14 (3)	0.569 (2)	0.907 (14)	0.742
Base (10-50%)	0.856 (10)	1.15 (10)	0.554 (17)	0.797 (37)	0.74
Low (51-100%)	0.905 (4)	1.01 (5)	1.51 (1)	1.02 (10)	0.865
All Flow Conditions	0.884 (23)	1.11 (18)	0.603 (20)	0.858 (61)	0.745
All Flow Median	0.850	1.07	0.547	0.745	

Figure 9. Monthly average and median concentrations at SC230.

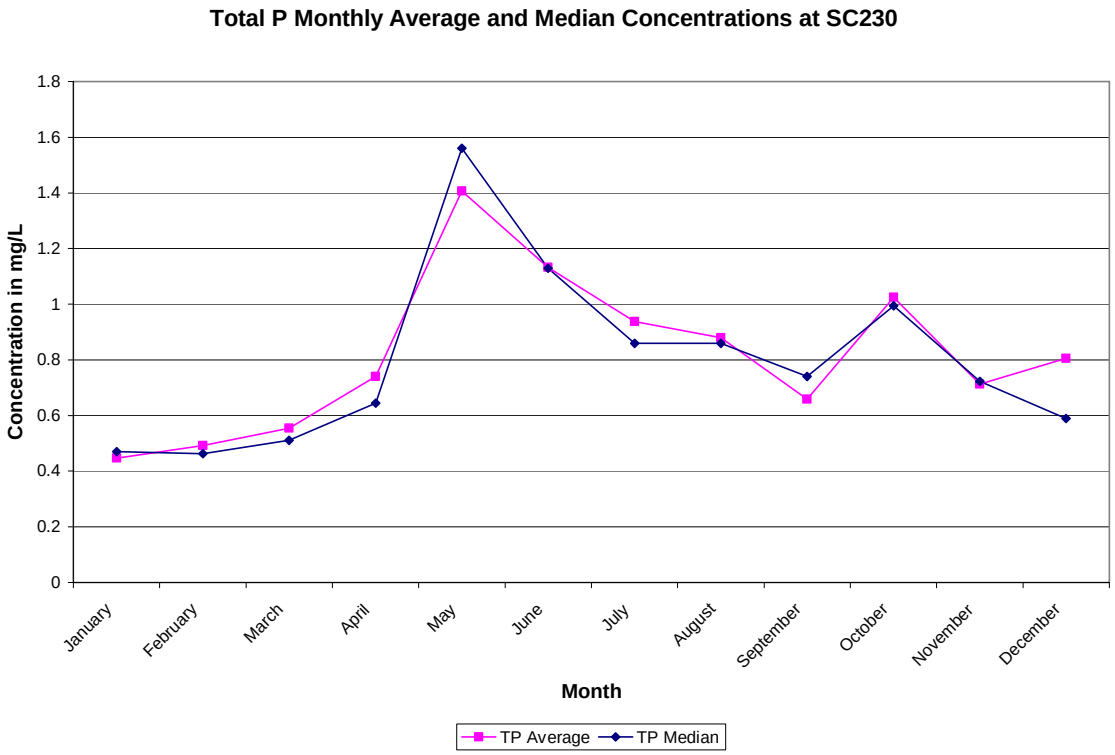


Figure 10. Seasonal Total Phosphorus concentrations based on flow condition.

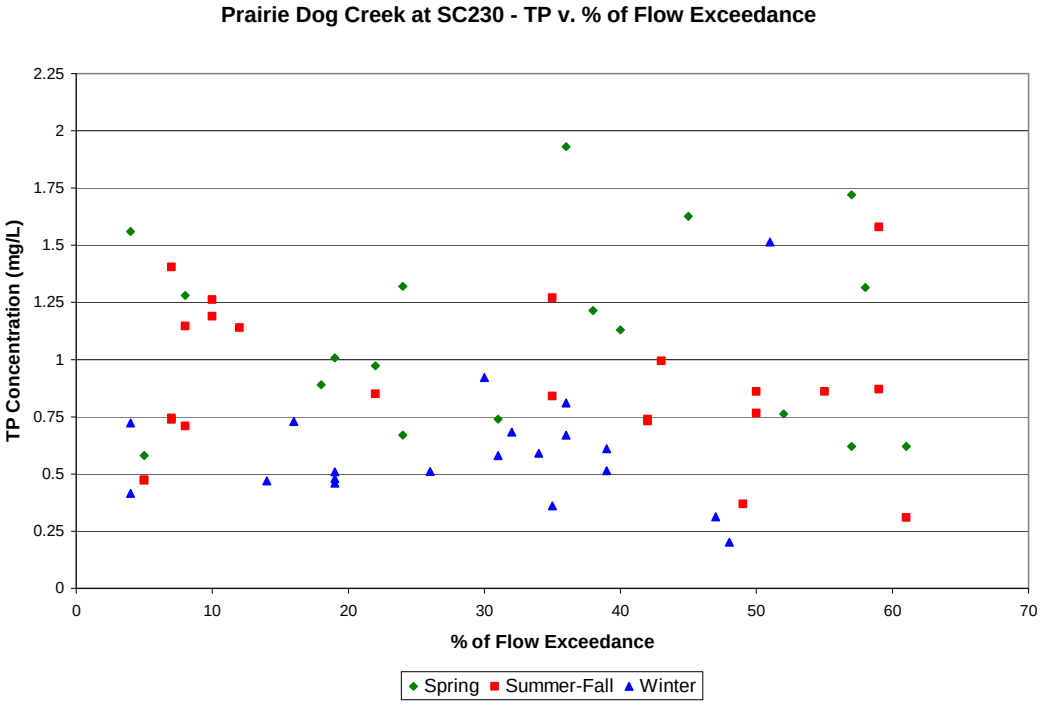
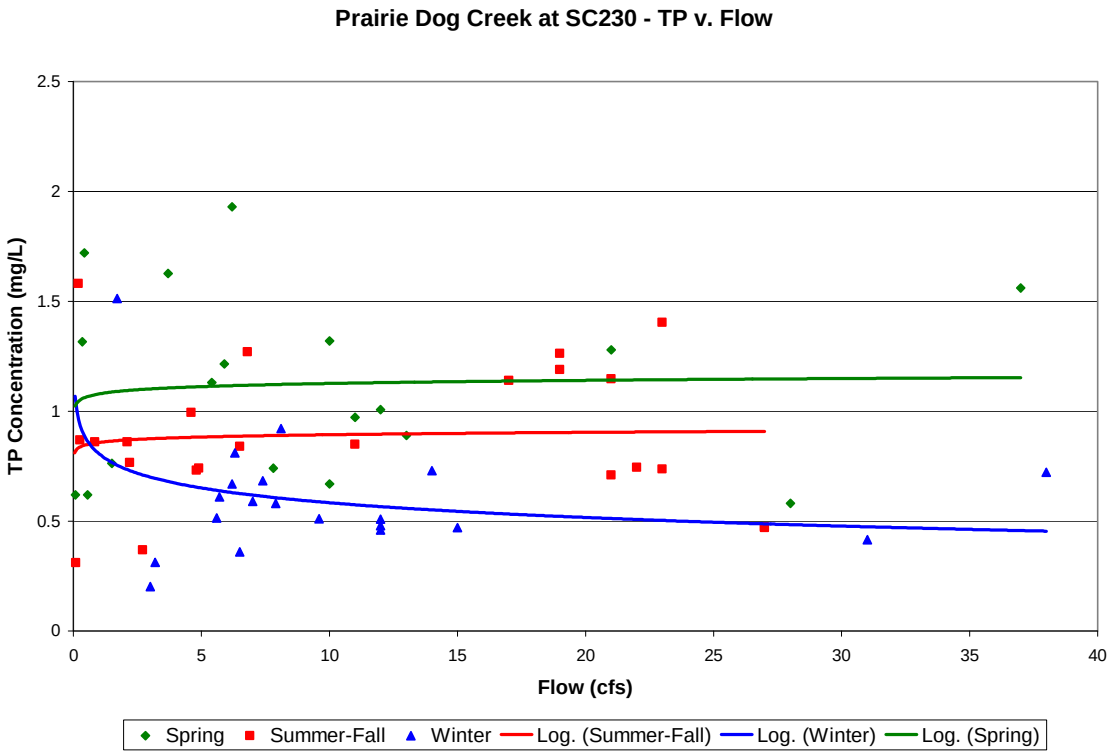


Figure 11. Seasonal TP concentrations relative to actual flow.



The TP concentrations for the 25th percent quartile and 75th percent quartile are very similar for the spring and summer-fall seasons as seen in Table 5. The winter concentrations are noticeably lower, as the 75th percent quartile for the winter samples is similar to the 25th percent quartile for the spring and summer-fall seasons. There is no significant difference (Mann-Whitney Test) between concentrations observed during the summer-fall and spring seasons, however there is a significant difference between the winter season samples and those of both the spring and summer-fall.

Table 5. Lower Prairie Dog Creek at SC230 TP summary based on season in mg/L.

Season	Avg.	Q25	Median	Q75	Max	Min
Spring	1.11	0.746	1.07	1.32	1.93	0.58
Sum-Fall	0.884	0.735	0.85	1.14	1.58	0.31
Spr, Sum-F Combined	0.983	0.738	0.87	1.26	1.93	0.31
Winter	0.603	0.468	0.547	0.694	1.513	0.202

Figure 12. Boxplot of SC230 TP data, summer-fall and spring data was combined as there was no significant difference amongst the data from these seasons.

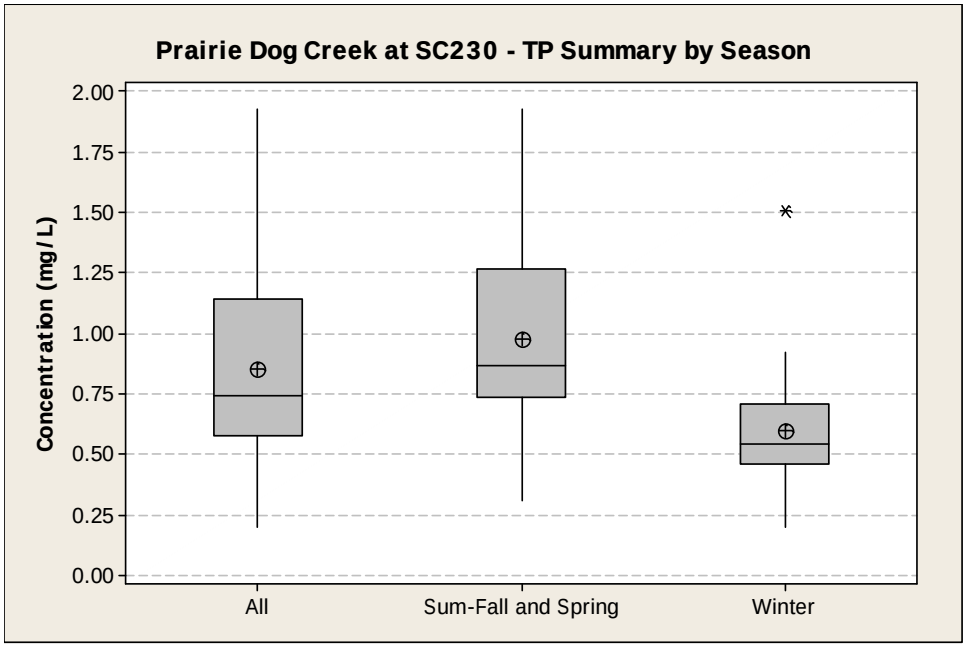
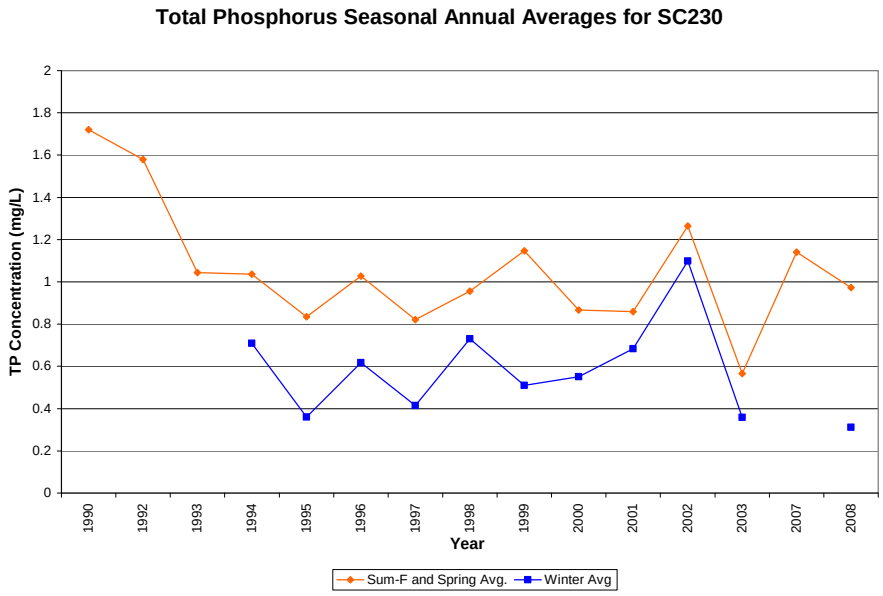


Figure 13 illustrates the TP average for each sampling year based on the season. The summer-fall and spring averages were combined and compared against the winter averages. Due to dry conditions the years of 1991, 2004, 2005, and 2006 were not sampled. Over the years TP concentrations have remained generally stable. The years of 1990, 1992, and 2007 had only one sample, where most other years had 3-6 samples taken each year.

Figure 13. Seasonal TP Concentrations based on sampling year.

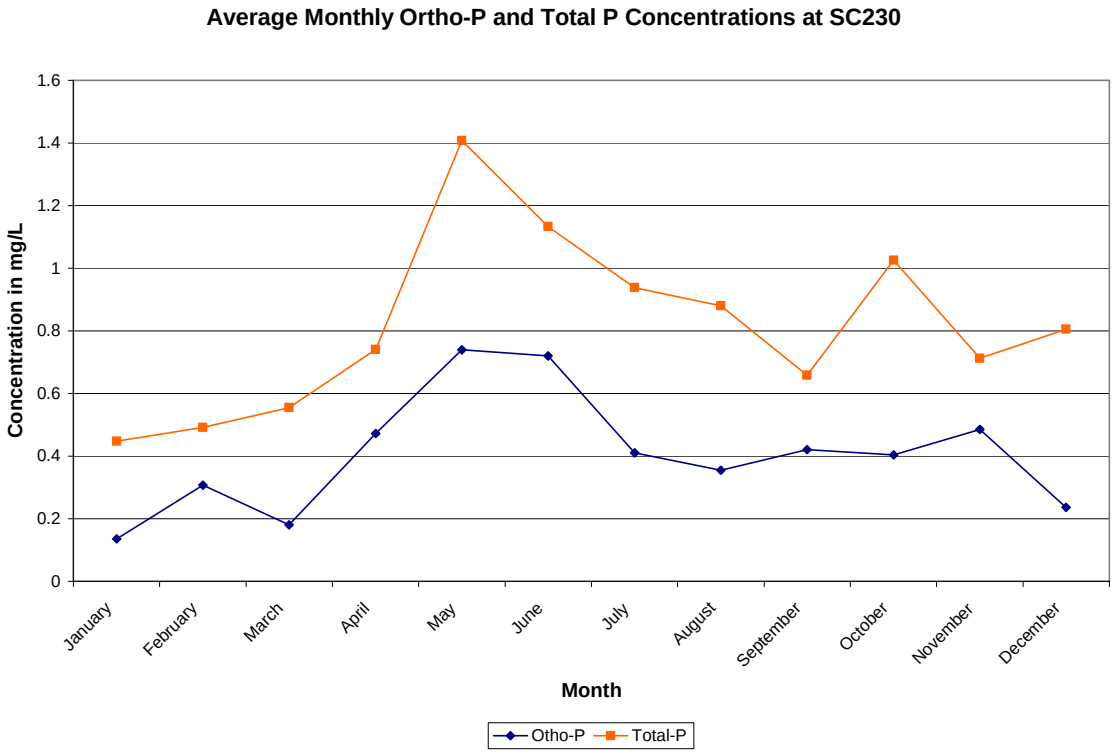


Ortho-Phosphorus (Ortho-P) within the lower portion of Prairie Dog Creek was detected in all of the spring samples and all but one of the summer-fall season samples. As seen in Table 6, the Ortho-P average is the highest during the spring season. During the winter season Ortho-P was detected in 64% of the samples. Ortho-P concentration averages were very similar under all flow conditions. The ratio between Ortho-P and TP (OP:TP) demonstrates the percentage of the TP that is attributed to Ortho-P. The current detection limit for Ortho-P is high at 0.25 mg/L. Ortho-P accounts for around 50-63% of the TP concentration at SC230 based on the OP:TP ratio.

Table 6. Ortho-P detection and concentration summary for SC230.

Condition	% of Ortho-P Samples above Detection Limit	Ortho P Avg. (mg/L)	OP:TP Ratio Avg.	Ortho P Median (mg/L)
Spring	13/13 = 100%	0.629	0.622	0.52
Summer-Fall	12/13 = 92%	0.393	0.509	0.33
Winter	9/14 = 64%	0.266	0.528	0.25
High Q	9/9 = 100%	0.394	0.578	0.33
Base Q	20/25 = 80%	0.431	0.555	0.4
Low Q	5/6 = 83%	0.447	0.503	0.375
All Data	34/40 = 85%	0.425	0.552	0.375

Figure 14. Actual average TP and Ortho-P monthly concentration averages within Prairie Dog Creek at SC230 near Woodruff.



A regression equation is displayed in Figure 15, which illustrates a strong relationship between Ortho-P and TP concentrations within Prairie Dog Creek. The regression formula was derived from the observed Ortho-P and TP for the thirty-four sampling events that had detected Ortho-P at station SC230. The regression formula was then applied to all samples with detected TP, since Ortho-P was not analyzed for the entire sampling set. Once each sample was assigned a calculated Ortho-P concentration based on the regression equation, the calculated Ortho-P portion of the TP was subtracted out to prove a net result of TP if Ortho-P loading was removed. A summary of the expected TP average and median concentrations based on flow and season when Ortho-P is removed is illustrated in Table 7.

Figure 15. Ortho-P regression based on common samples with Ortho-P and TP data.

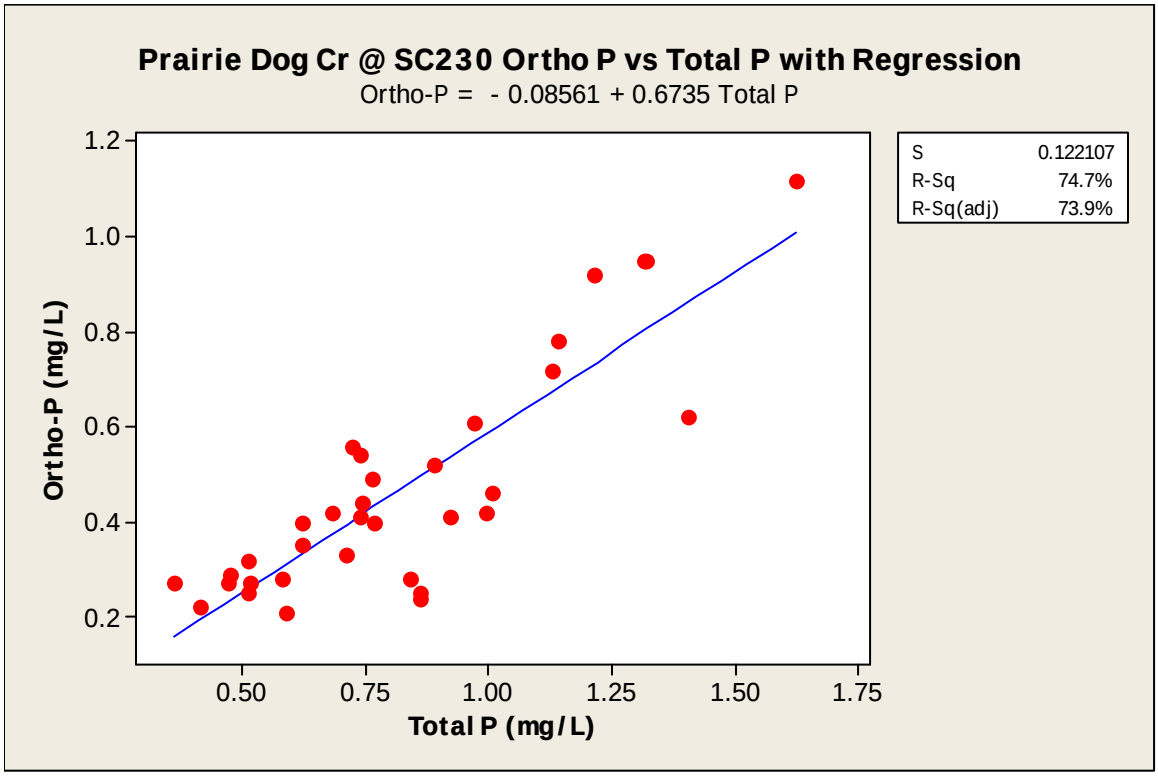


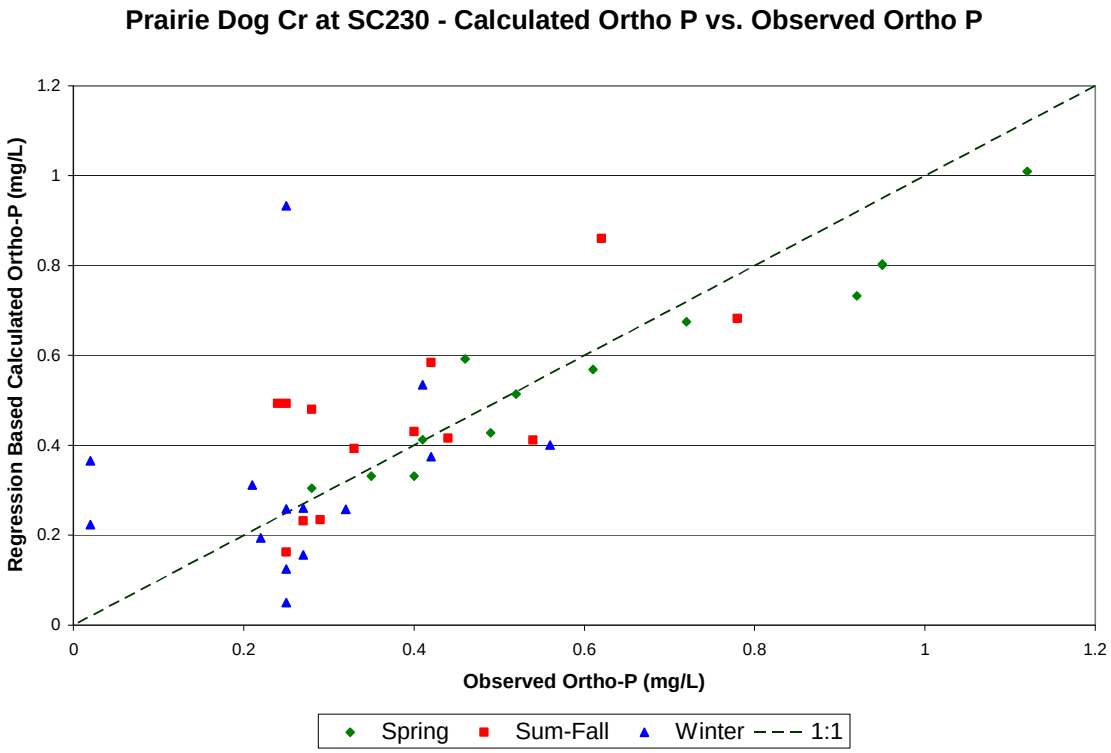
Table 7. Total P condition if the calculated Ortho-P concentration is removed (TP-OP).

TP-OP condition	Spring (mg/L)	Summer-Fall (mg/L)	Winter (mg/L)	Spring/Summer-Fall Combined (mg/L)	All Seasons
Average	0.448	0.374	0.283	0.406	0.366
High Q Avg.	0.458	0.333	0.271	0.400	0.382
Base Q Avg	0.461	0.365	0.266	0.413	0.346
Low Q Avg	0.415	0.366	0.58	0.4	0.418
Median	0.434	0.363	0.264	0.370	0.328

As Figure 16 indicates, the actual Ortho-P concentrations were compared against the regression based calculated Ortho-P concentrations for sampling events that had Ortho-P

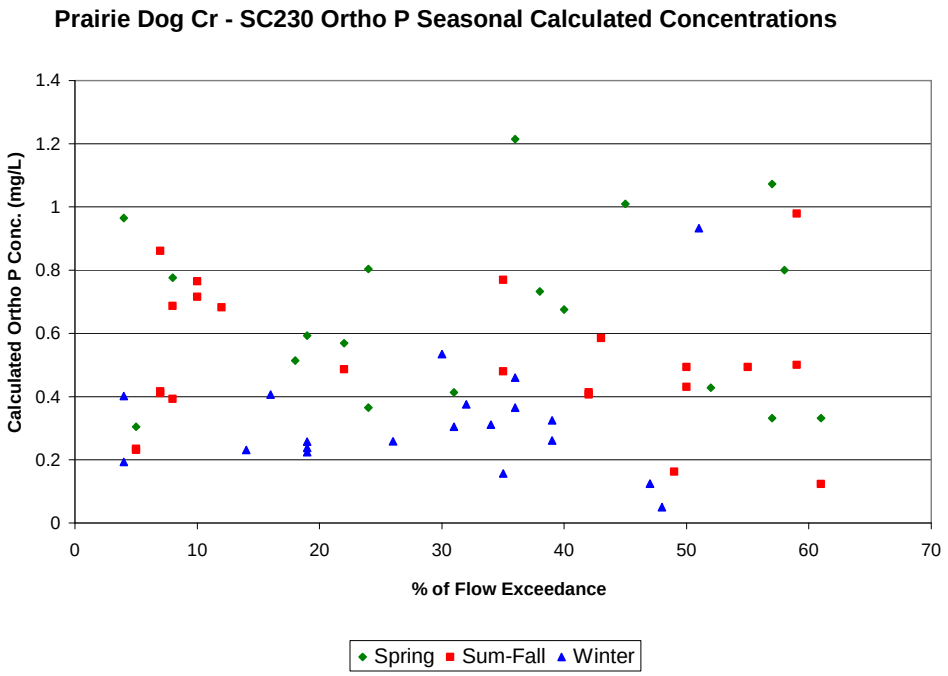
analyzed. Samples obtained during the spring and summer-fall seasons have strong correlations. Samples for the winter season do not appear to correlate as well since the detection limit is high and the majority of the non-detects were observed in this season. The regression based calculated Ortho-P concentrations prove to be a better estimate for the winter time Ortho-P concentrations and provide reasonable estimates for the Ortho-P concentrations for the sampling events that were either non-detect or did not have Ortho-P analyzed since KDHE did not consistently sample Ortho-P prior to the sampling year of 2000.

Figure 16. Calculated Ortho-P and observed Ortho-P concentrations for common samples in Prairie Dog Creek at station SC230.



Ortho-P concentrations generally are not influenced by the flow condition in Prairie Dog Creek, however as seen with the TP concentrations at SC230, there is no significant difference between the summer-fall and spring seasons. There is a significant difference between the Ortho-P concentrations between winter and both the summer-fall and spring seasons (Mann-Whitney Test). The relationship between the calculated Ortho-P concentrations and the percent of flow exceedance are displayed in Figure 17.

Figure 17. Regression based calculated OP concentrations relative to % of flow exceedance for all samples.



Other Relationships: Concentrations of Total Suspended Solids (TSS) are low in the winter and very high in the spring and summer-fall seasons within the lower portions of Prairie Dog Creek. In general, there is a positive relationship between TP and TSS during the spring and summer-fall seasons. This relationship is expected as phosphorus is typically bound to sediment particles. There is a negative relationship between TP and dissolved oxygen (DO) as seen in Figure 19. During the winter months, DO concentrations are higher as TP concentrations are lower. The lowest DO concentrations occur during the summer-fall season, when higher stream temperatures and lower stream flows are prevalent. There is a negative relationship between TP and pH and a positive relationship between DO and pH as seen in Figures 20 and 21.

Figure 18. Comparison of TP and TSS relationship based on season.

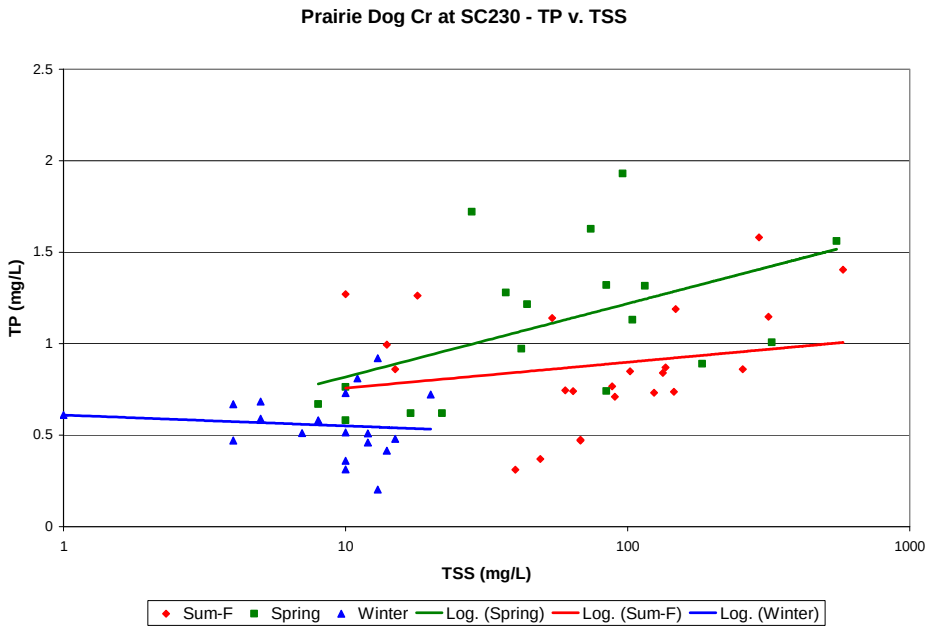


Figure 19. Comparison between TP and DO relationship based on seasons.

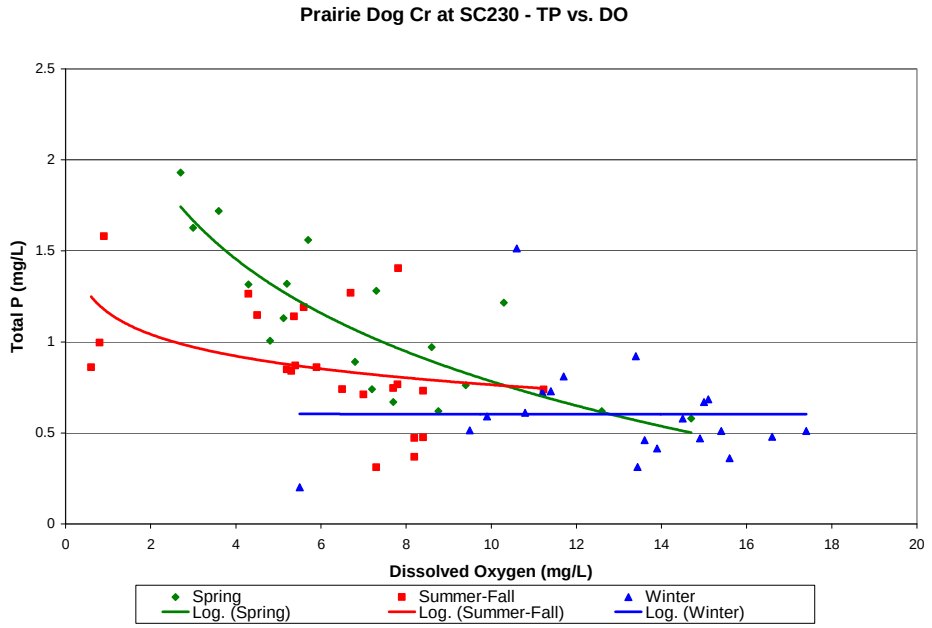


Figure 20. Comparison of TP and pH relationship based on seasons.

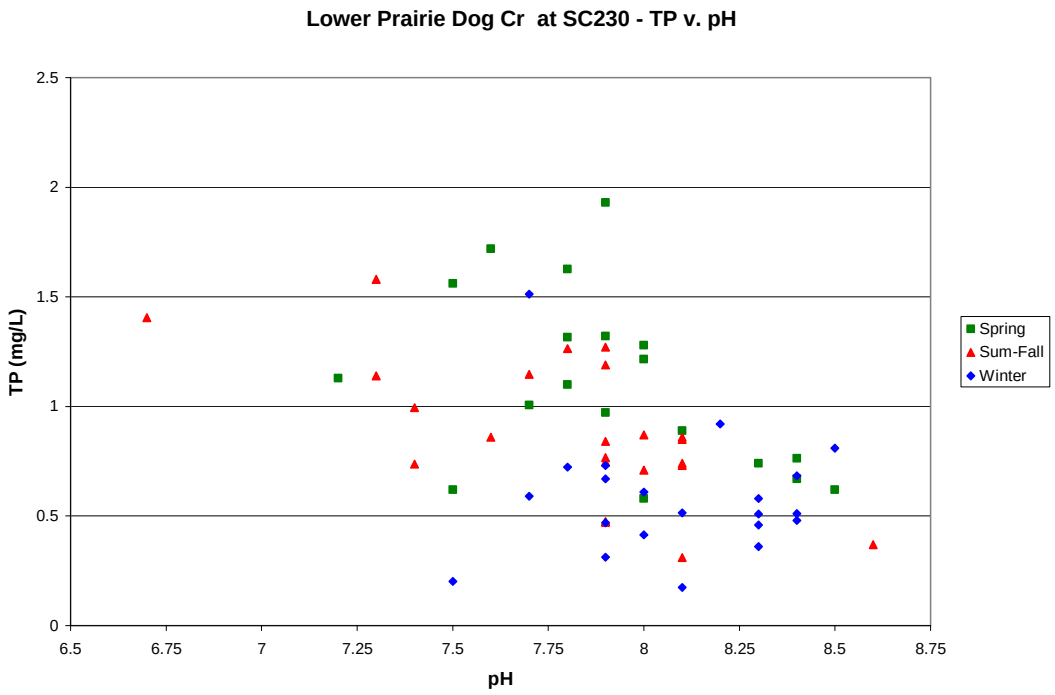


Figure 21. Comparison of DO and pH relationship based on seasons

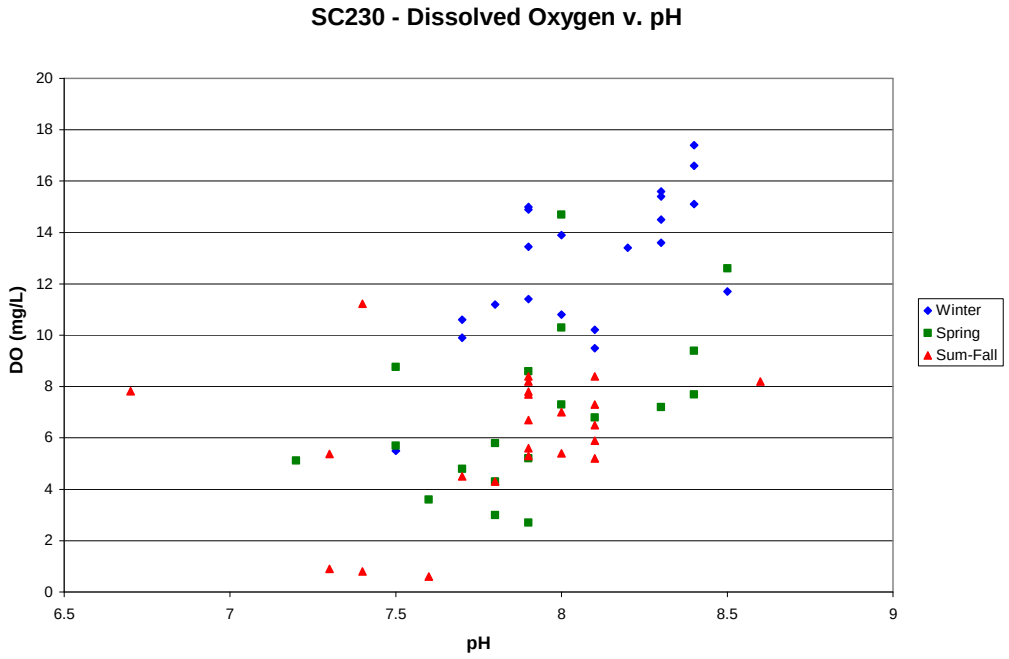


Figure 22. Average monthly DO and Temperature concentrations in Prairie Dog Cr.

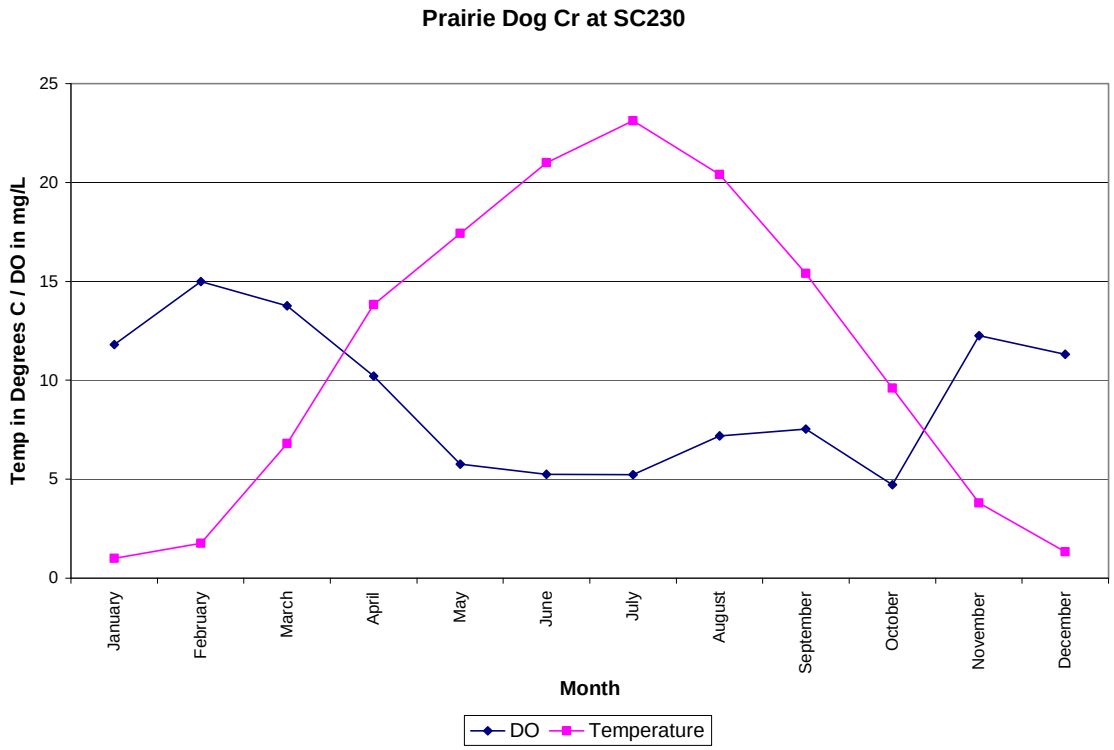
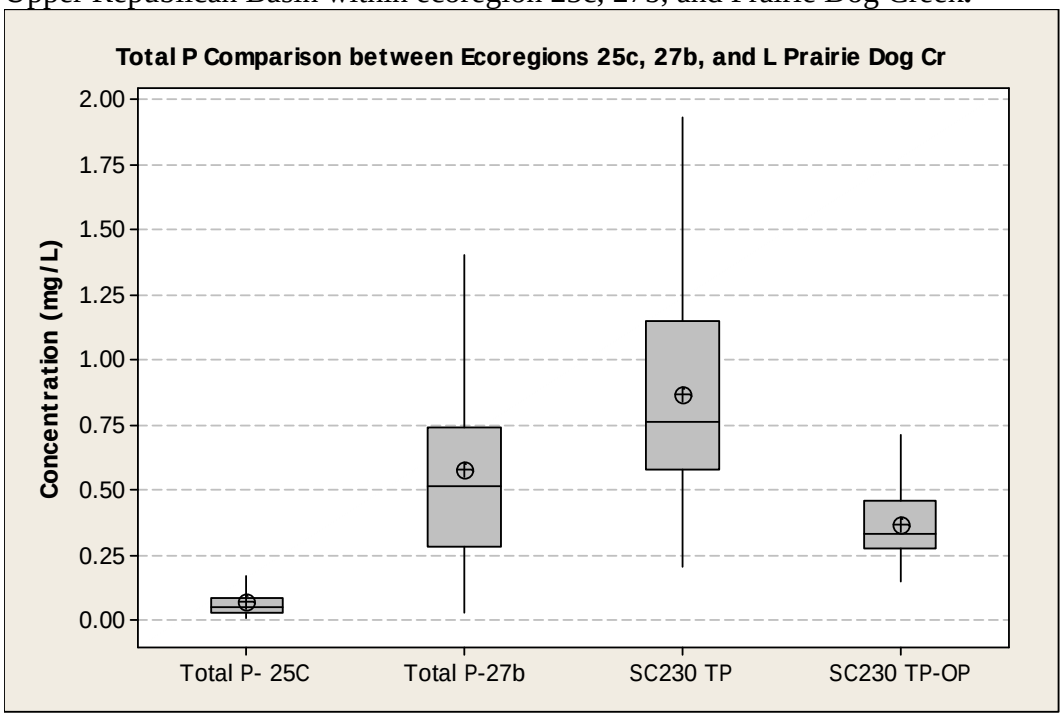


Figure 23. Total Phosphorus concentration boxplots for KDHE sampling stations in the Upper Republican Basin within ecoregion 25c, 27b, and Prairie Dog Creek**.**



Desired Endpoint: The ultimate endpoint of this TMDL will be to achieve the Kansas Water Quality Standards by controlling Total Phosphorus to prevent the impact described in the standards relative to aquatic life, domestic water supply use, and recreation, primarily by preventing objectionable concentrations of algae. There are no set numeric criteria associated with the current narrative water quality standard. This TMDL establishes a numeric TP goal, based on season and flow condition that will increase the likelihood of attaining the narrative criteria pending a numeric Water Quality Standard for TP.

The initial endpoint for Prairie Dog Creek is to control TP loads so readily available dissolved ortho-phosphate is not loading into the stream leading to overall reduced seasonal TP loads. Therefore, the TP goal for this TMDL to attain the narrative nutrient criteria is expressed as a median TP concentration over all season's equivalent to the upper quartile concentration seen in the three streams of the Western High Plains during the Spring and Summer-Fall seasons. The current median TP concentration at Station SC230 is 0.745 mg/L. The upper quartile TP concentration for the three "benchmark" stations in the western portions of the Upper Republican Basins during the spring and Summer-Fall seasons is 0.130 mg/L.

3. SOURCE INVENTORY AND ASSESSMENT

Point Sources: There are five NPDES permitted facilities within the lower Prairie Dog Creek watershed below Norton Lake. The City of Norton has a newer wastewater treatment facility that has been in operation since late 2007. The average discharge from this facility is 0.25 MGD. The permit identifies the facility as having the capability for nutrient removal and assigns a nutrient goal for their discharge of $\leq$ 1.5 mg/L TP as an annual average, which is noted as a supplemental condition within the permit. The City of Norton is required to monitor Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), pH, Ammonia, E. Coli, Dissolved Oxygen, Total Phosphorus, Total Kjeldahl Nitrogen, Nitrate, Nitrite, and Flow. Permit limitations are in place for BOD (*45 mg/L weekly average and 30 mg/L monthly average*), TSS (*45 mg/L weekly average and 30 mg/L monthly average*), pH (6.0-9.0), Ammonia (*daily maximum not to exceed 9.6 mg/L and; monthly average ranging from 2.9-9.4 mg/L*), E. coli (*monthly geometric average of 160 colonies/100 mL for April – October and 2358 colonies/ 100 mL for November-March*). This facility has averaged 2.92 mg/L of TP within the discharge based on monitoring reports submitted by the facility for monthly samples from November 2007 through February 2009.

The Norton Correctional Facility wastewater treatment facility permit requires monthly monitoring of BOD, TSS, pH, Ammonia, and E.Coli. Permit limits are in place for BOD (45mg/L weekly average and 30 mg/L monthly average) and TSS (120 mg/L weekly average and 80 mg/L monthly average). This facility does not monitor flow, however they do report when the facility is not discharging. This plant did not discharge in 2007 and it typically does not discharge all months out of the year based on previous discharge monitoring reports.

The permit for the City of Almena's Wastewater Treatment Facility requires monthly monitoring of BOD, TSS, pH, Ammonia, and E.Coli. Permit limits are in place for BOD (45mg/L weekly average and 30 mg/L monthly average) and TSS (120 mg/L weekly average and 80 mg/L monthly average). This facility does not monitor flow, however they do report when the facility is not discharging. This facility has only discharged a couple months out of the year based on the discharge monitoring reports.

The Norton Water Treatment Plant is permitted to discharge the plant's wastewater from a two-cell lagoon treatment system. This is wastewater generated from the water treatment process. The City of Norton is required to monitor TSS, pH, and Total Residual Chlorine on a monthly basis and measure sludge levels in the lagoon on an annual basis. There are limits for TSS (100 mg/L monthly average) and pH (6.0-9.0). The plant has reported that there has not been any discharge since the current permit was issued in 2007.

The City of Long Island's Wastewater Treatment Facility is a non-overflowing permitted facility that is prohibited from discharging and would only contribute a nutrient load under extreme precipitation or flooding events. Such events would not occur at a frequency or for duration sufficient to cause impairment in the watershed.

Table 8. NPDES permitted facilities within the Lower Prairie Dog Creek watershed.

Facility	NPDES#	KS Permit #	Type	Rec Stream	Design Q (MGD)	Permit Expires
City of Norton WTF (new)	KS0097730	M-UR16-OO03	Activated Sludge, Digesters, UV	Prairie Dog Cr	0.45 MGD	12/31/2010
Norton Correctional Facility WTF	KS0095834	M-UR-OO02	Six-Cell Lagoon	Prairie Dog Creek via Robinson Cr	0.109 MGD	06/30/2012
Norton Water Treatment Plant	KS0098931	I-UR16-POO01	Lagoon Wastewater Overflow	Prairie Dog Cr	0.06 MGD	01/31/2012
City of Almena WTF	KS0096768	M-UR-01-OO02	Three-Cell Lagoon	Prairie Dog Cr	0.043	09/30/2012
City of Long Island WTF	KSJ000251	M-UR13-NO01	Four-Cell Lagoon	Non-Overflowing	0	09/30/2013

Livestock and Waste Management Systems: There are thirty-eight certified or permitted confined animal feeding operations (CAFOs) within the lower Prairie Dog Creek watershed. All of these livestock facilities have waste management systems designed to minimize runoff entering their operation and detain runoff emanating from their facilities. These facilities 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. Though the total potential number of animals is approximately 217,650 head in the watershed, the actual number of animals at the feedlot operations is typically less than the allowable permitted number. According to the National Agricultural Statistics Service, there are 40,800 head of cattle in Norton County and 55,600 head of cattle in Phillips

County, with a grazing density of 46.5 head/square mile and 63 head/square mile respectively.

Land Use: As illustrated in Figure 24 and Table 9 the predominant land use in the Lower Prairie Dog Creek watershed is grassland and cultivated cropland, which accounts for 48.5% and 43.5% of the watershed respectively according to the 2001 National Land Cover Data set. Together these account for 92% of the total land in the watershed.

Figure 24. Lower Prairie Dog Creek watershed Landuse map.

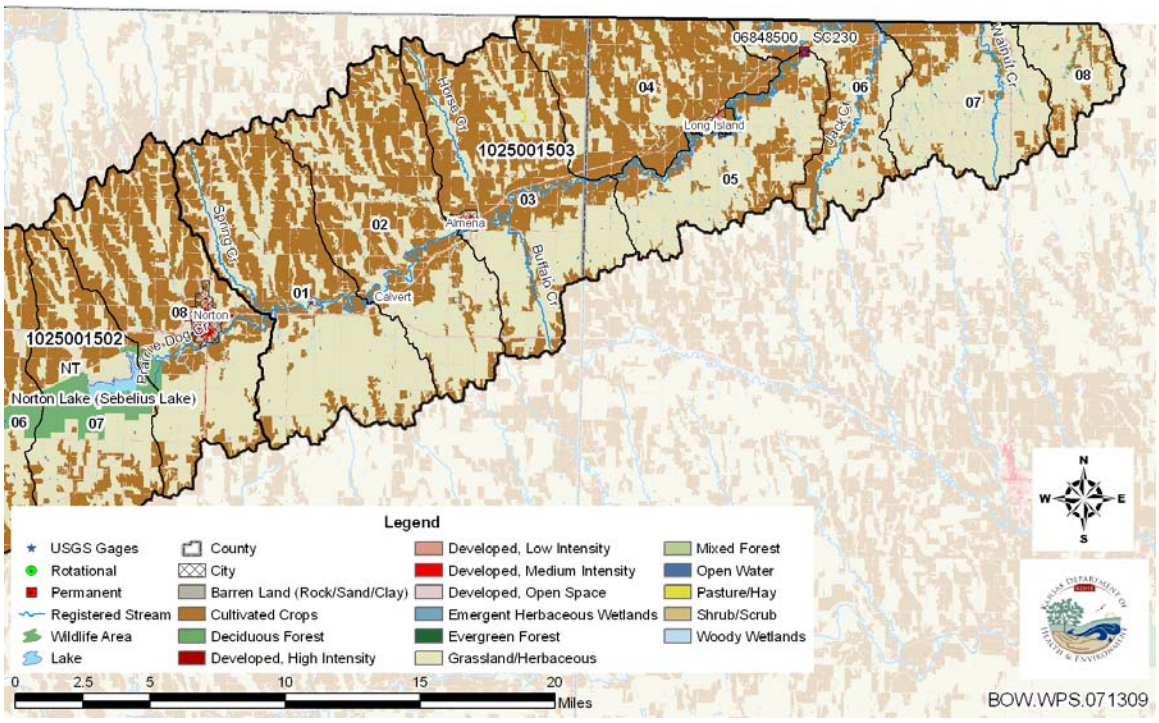


Table 9. General Land Use acres in the lower Prairie Dog Creek watershed.

General Land Use Class	Area (acres)	Percent of Watershed
Grassland	128,525	48.5%
Cultivated Cropland	115,180	43.5%
Roads/Developed	12,059	4.6%
Wetlands	5338	2.0%
Open Water	2908	1.1%
Forest	698	0.3%

Population Density: According to the 2000 census data from the U.S. Census Bureau, the population of the entire watershed is approximately 5,521 people, and therefore the population density for the watershed is approximately 5.94 people/square mile. Urban areas within the watershed include the Cities of Norton, Long Island, and Almena, which have respective populations of 3012; 155; and 469. The City of Norton accounts for 55% of the population within the watershed. According to the Kansas Water Office, population projections for the City of Norton indicate a slight increase and the Cities of Long Island and Almena are projected for slight declines by 2020. Outside of these three urban areas, there are only 1,885 people residing in the rural area (2.02 people/square mile) of the watershed.

On-Site Waste Systems: Based on the 1990 census data, about 29% of the households in Norton County utilize septic systems. The households within the watershed that are not served by the sewer systems associated with the cities of Norton, Almena, and Long Island are presumably on septic systems. Though they are not likely to contribute significantly to the TP impairment within Prairie Dog Creek, failing on-site septic systems can contribute significant nutrient loadings locally within the watershed.

Contributing Runoff: Soil permeability values across the watershed, based on NRCS STATSGO database indicate over 98% of the watershed has a soil permeability of 1.29”/hour, which contributes to runoff during low rainfall intensity events. According to a USGS open-file report (Juracek, 2000), the threshold soil-permeability values that represent very high, high, moderate, low, very low, and extremely low intensity are set at 3.43, 2.86, 2.29, 1.71, 1.14, and 0.57 inches/hour, respectively. Runoff is primarily generated as infiltration excess with rainfall intensities greater than soil permeability. Excess overland flow is produced as the watersheds’ soil profiles become saturated.

Background Levels: Phosphorus is naturally found in rocks, soil and organic material and is essential for the growth of aquatic and terrestrial vegetation, to include agricultural crops. The natural erosion of soil contributes to the amount of background phosphorus within the watershed that becomes available as nutrients to the ecosystem. However, erosion that may be facilitated by human activities and practices may cause excess runoff and streambank erosion, which contributes to an excess of readily available inorganic phosphorus (ortho-phosphorus) and high levels of suspended phosphorus-bound streambed sediment during runoff events. Land use changes such as the removal of riparian forest and wetlands, streambank erosion, urbanization, and agricultural activities, to include manure application to cropland, may significantly affect the levels of total phosphorus in aquatic systems. The typical levels of phosphorus within some streams have been significantly increased due to human activities and land use changes and practices within Kansas, and therefore it is difficult to determine what the actual background phosphorus concentrations within the watershed are expected to be.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

Point Sources: The current Wasteload Allocation (WLA) is associated with the wastewater treatment facilities for the City of Norton, the Norton Correctional Facility,

and the City of Almena. The City of Norton's facility is new and is discharging a higher TP concentration than the goal of ≤1.5 mg/L as stated in the permit, however the facility also is not discharging at design flow. The WLA assigned to the City of Norton is based on discharging 1.5 mg/L of TP at design flow.

The Norton Correction Facility does not discharge very often and is therefore being assigned a WLA based on a discharge concentration of 2.0 mg/L of TP at design flow for a 180 day period throughout the year.

The City of Almena typically has only discharged a few months throughout the year and this facility is being assigned a WLA based on a discharge concentration of 2.0 mg/L of TP at design flow for a 180 day period throughout the year. The TP discharge concentration for lagoon systems in Kansas is expected to be around 2.0 mg/L based on performance assumptions for new lagoon facilities within the state.

Table 10. Lower Prairie Dog Creek Wasteload Allocations.

Facility	Flow (MGD)	TP Discharge Conc (mg/L)	Annual TP WLA (lbs/year)	Daily TP WLA (lbs/day)
City of Norton WTF (new)	0.45	1.5	2055	5.63
Norton Correctional Facility WTF	0.109	2.0	328*	1.82
Norton Water Treatment Plant	0.06	0	0	0
City of Almena WTF	0.043	2.0	130*	0.72
City of Long Island WTF	0	0	0	0
Total	0.602 (0.931 cfs)		2349	8.17

*- Annual load based on 180 days of discharge per year

Note: These wasteload allocations may be adjusted and revised in subsequent versions of this TMDL, after evaluating performance in load reduction by point and nonpoint sources in the watershed.

The resulting instream load attributed to the WLA at the sampling station SC230 near the Stateline is dependent upon flow conditions and the assimilation capacity of the stream. Since the City of Norton is over 40 stream miles from the KDHE sampling station, a conservative assumption is that the entire WLA reaches the sampling station at high flows (0-10% flow exceedance), all of the City of Norton's WLA reaches the sampling station at higher base flows (11-20%), 50% of the City of Norton's WLA reaches the sampling station at moderate base flows (21-30%), 25% of the City of Norton's WLA reaches the sampling station at base flows (31-40%) and 10% of the City of Norton's WLA reaches the sampling station near median flows (41-50%). There is no WLA reaching the sampling station at flows less than the median flow condition (>50% flow exceedance) since at this point the streamflow is negligible. This assumption presumes the WLA for the City of Almena and the Norton Correctional facility will be assimilated under typical flow conditions and based on historical monitoring reports the facilities will likely have limited discharge during these conditions.

The two other NPDES permitted facilities and the numerous CAFOs within the watershed have been assigned a Wasteload Allocation of zero since these facilities should not discharge to receiving streams within the watershed during typical hydrologic conditions. Ongoing inspections and monitoring of these facilities should be made to ensure that a 25-year, 24-hour precipitation event does not result in significant pollutant loadings.

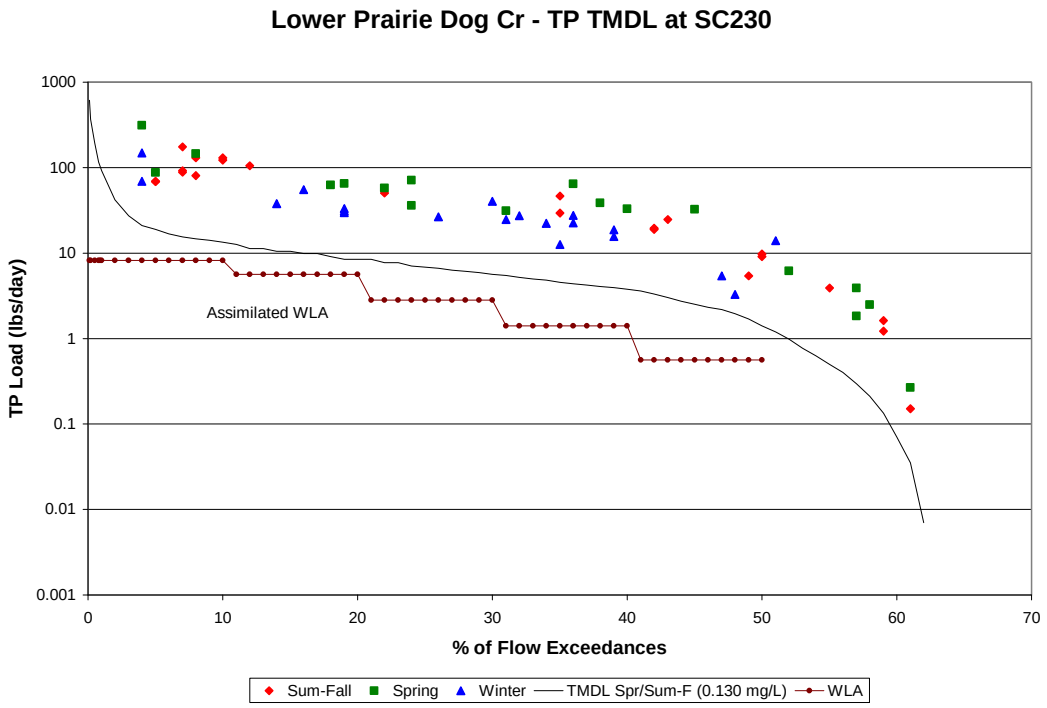
Nonpoint Source: The Load Allocation (LA) assigns responsibility for nonpoint source contributors for the TP input into the lower Prairie Dog Creek watershed. It is likely that runoff transporting TP loads associated with animal wastes and cultivated crops where fertilizer has been applied, to include pasture and hay, contribute to the TP impairment within Prairie Dog Creek. The TMDL is based on an instream concentration of 0.130 mg/L at the KDHE stream sampling station SC230. The resulting Load Allocation is dependant upon flow conditions as well. The associated TP Load Allocations estimated at site SC230 are indicated in Table 11.

Table 11. Lower Prairie Dog Creek TMDL for various flow conditions.

Flow Condition	Load Allocation (lbs/day)	Assimilated Waste Load Allocation @ SC230 (lbs/day)	Margin of Safety	TP TMDL (lbs/day)
Mean Flow (10.82 cfs)	4.30	2.815	0.478	7.60
10% (19 cfs)	4.65	8.17	0.517	13.34
25% (9.73 cfs)	3.61	2.815	0.402	6.83
50% (2 cfs)	0.757	0.563	0.084	1.40
75% (0 cfs)	0	0	0	0
90% (0 cfs)	0	0	0	0

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty of variable total phosphorus loads and the endpoints of the TMDL. The margin of safety is explicitly set at 10% of the calculated total phosphorus load allocations, 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 11.

Figure 25. Lower Prairie Dog Creek Total Phosphorus TMDL at Station SC230.



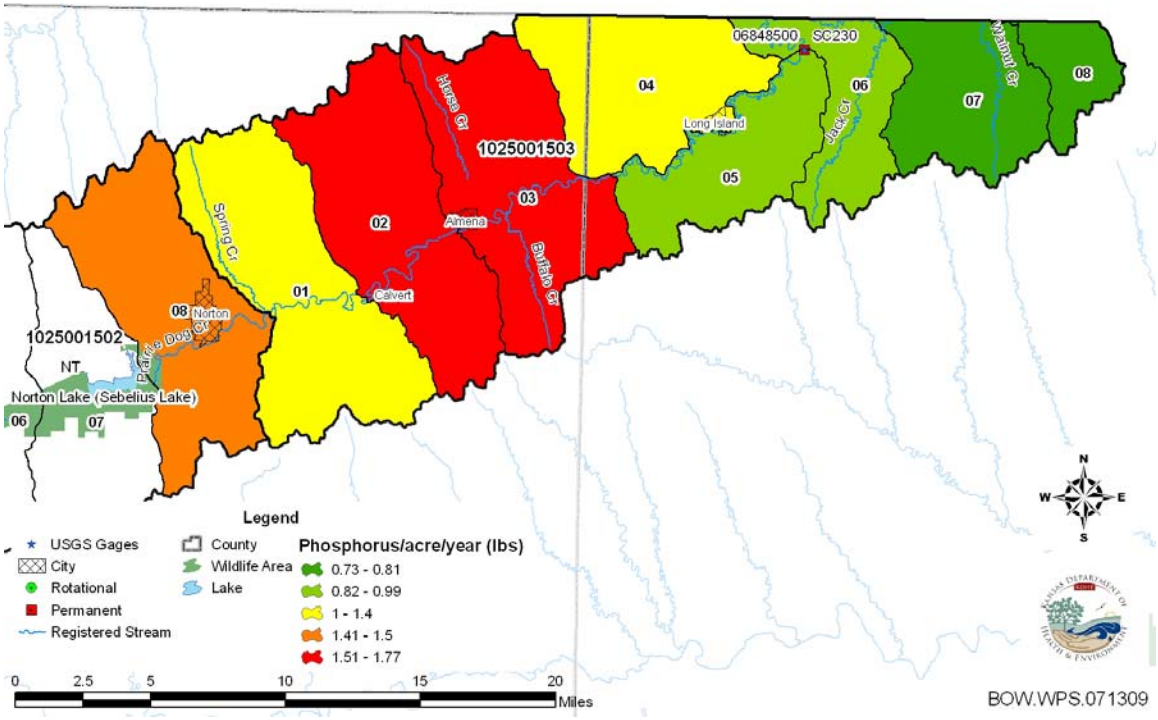
State Water Plan Implementation Priority: Due to the high magnitude and frequency of excessive total phosphorus concentrations within Prairie Dog Creek and the fact that the Prairie Dog Creek watershed contributes to the water quality within Harlan County Reservoir in Nebraska, which is currently listed for Eutrophication on the 2008-303(d) list for the State of Nebraska, this watershed will be a **High** Priority for implementation.

Priority HUC12s: The Spreadsheet Tool for Estimating Pollutant Load (STEPL) was utilized to identify priority HUC12s within the watershed. STEPL is a simple watershed model that provides both agricultural and urban annual average sediment and nutrient simulations as well as implementation evaluation of best management practices. STEPL results for phosphorus are illustrated in Table 12, which includes the HUC12s below Norton Lake. Based on these results, initial priorities should focus on the top three HUC12 subwatersheds as prioritized by the modeling results of TP lbs/acre/year within the Lower Prairie Dog Creek subbasin.

Table 12. Priority HUC 12 subwatersheds as identified through STEPL.

HUC12	Acres	TP Load (lbs/year)	TP lbs/acre/year	Preliminary Implementation Priority Rank
102500150303	34,657	61,341	1.77	1
102500150302	33,537	55,862	1.67	2
102500150208	32,779	49,161	1.50	3
102500150301	36,218	50,585	1.39	4
102500150304	33,544	46,097	1.37	5
102500150306	30,436	30,031	0.99	6
102500150305	18,861	16,675	0.88	7
102500150307	27,993	22,767	0.81	8
102500150308	14,198	10,306	0.73	9

Figure 26. STEPL modeling results for the Lower Prairie Dog Creek for Phosphorus.



5. IMPLEMENTATION

Desired Implementation Activities

1. Implement and maintain conservation farming, including conservation tiling, contour farming, and no-till farming to reduce runoff and cropland erosion.
2. Improve riparian conditions along stream systems by installing grass and/or forest buffer strips along the stream and drainage channels in the watershed.
3. Perform extensive soil testing to ensure excess phosphorus is not unnecessarily being applied.
4. Ensure land applied manure is being properly managed and is not susceptible to runoff by implementing nutrient management plans.
5. Install pasture management practices, including proper stock density to reduce soil erosion and storm runoff.
6. Ensure proper on-site waste system operations in proximity to the main stream segments.
7. Ensure that labeled application rates of chemical fertilizers are being followed and implement runoff control measures.
8. Renew state and federal permits and inspect permitted facilities for permit compliance.

Implementation Programs Guidance

NPDES and State Permits – KDHE

a. Monitor effluent from the discharging permitted wastewater treatment facilities, establish permit limits, and ensure compliance to determine their total phosphorus contribution to Prairie Dog Creek.
b. Inspect permitted livestock facilities to ensure compliance.
c. New Livestock permitted facilities will be inspected for integrity of applied pollution prevention technologies.
d. New Registered livestock facilities with less than 300 animal units will apply pollution prevention technologies.
e. Manure management plans will be implemented, to include proper land application rates and practices that will prevent runoff of applied manure.

Nonpoint Source Pollution Technical Assistance – KDHE

a. Support Section 319 demonstration projects for reduction of phosphorus 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 and practices geared towards small livestock operations which minimize impacts to stream resources.

d. Support Watershed Restoration and Protection Strategy (WRAPS) efforts for Prairie Dog Creek.

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

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 transport from cropland and grassland in the watershed.
c. Install livestock waste management systems for manure storage.
d. Implement manure management plans.

Riparian Protection Program – SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.
b. Develop riparian restoration projects along targeted stream segments, especially those areas with baseflow.
c. Promote wetland construction to reduce runoff and assimilate sediment loadings.
d. Coordinate riparian management within the watershed and develop riparian restoration projects.

Buffer Initiative Program – SCC

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

Extension Outreach and Technical Assistance – Kansas State University

a. Educate agricultural producers on sediment, nutrient, and pasture management.
b. Educate livestock producers on livestock waste management, land applied 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. Educate residents, landowners, and watershed stakeholders about nonpoint source pollution.

Timeframe for Implementation: Pollutant reduction strategies and pollutant source assessments should be initiated within the priority HUC12 subwatersheds in 2010. Pollutant reduction practices and implementation activities within the priority HUC12 subwatersheds should be initiated by 2011 and continue through 2019.

Targeted Participants: The primary participants for implementation will be agricultural and livestock operations immediately adjacent to the streams within the priority subwatersheds. Conservation district personnel and county extension agents should conduct a detailed assessment of sources adjacent to streams within the watershed over 2010. Implementation activities should target those areas with the greatest potential to impact total phosphorus concentrations within Prairie Dog Creek and should be targeted for:

1. Unbuffered cropland adjacent to the stream.
2. Sites where drainage runs through or adjacent to livestock areas.
3. Sites where livestock have full access to the stream and it is their primary water supply.
4. Conservation compliance on highly erodible areas.
5. Acreage of poor rangeland or overstocked pasture.
6. Poor riparian area and denuded riparian vegetation along the stream.

Milestone for 2014: In accordance with the TMDL development schedule for the State of Kansas, the year 2014 marks the next cycle of 303(d) activities in the Upper Republican Basin. At that point in time, data from site SC230 should indicate evidence of improved total phosphorus levels at base flow conditions.

Delivery Agents: The primary delivery agents for program participation will be KDHE and the Kansas State University Extension Service.

Reasonable Assurances:
Authorities: The following authorities may be used to direct activities in the watershed to reduce pollution:

1. K.S.A. 65-164 and 165 empowers the Secretary of KDHE to regulate the discharge of sewage into the waters of the state.

2. 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.

3. K.S.A. 2002 Supp. 82a-2001 identifies the classes of recreation use and defines impairment for streams.

4. K.A.R. 28-16-69 through 071 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.

5. 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.

6. 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.

7. 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.

8. 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.

9. The *Kansas Water Plan* and the Upper Republican 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. This watershed and its TMDL are High Priority consideration and should not receive funding at this time.

Effectiveness: Nutrient control has been proven effective through conservation tillage, contour farming and use of grass waterways and buffer strips. In addition, the proper implementation of comprehensive livestock waste management plans has proven effective at reducing nutrient runoff associated with livestock facilities. The key to success will be widespread utilization of conservation farming and proper livestock waste management within the watershed cited in this TMDL.

6. MONITORING

KDHE will continue to collect bimonthly samples, including Total and Ortho-Phosphorus measurements, in each of the three defined seasons every year at Station SC230. Based on the sampling data, the priority status of the 303(d) listing will be evaluated in 2014. If the impairment status continues, the desired endpoints under this TMDL may be refined. The stream will be evaluated for possible delisting in 2020.

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 Republican Basin.

Public Hearing: A Public Hearing on the Upper Republican TMDLs was held in Phillipsburg, KS on February 10, 2010.

Basin Advisory Committee: The Upper Republican Basin Advisory Committee met to discuss these TMDLs on March 3, 2010 in Atwood, KS.

Milestone Evaluation: In 2014, evaluation will be made as to the degree of implementation which has 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 at the next TMDL cycle for this basin in 2014 with consultation from local stakeholders and WRAPS teams.

Consideration for 303(d) Delisting: Prairie Dog Creek will be evaluated for delisting under section 303(d), based on the monitoring data over 2009-2019. Therefore, the decision for delisting will come about in the preparation of the 2020-303(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 might 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 2009, which will emphasize implementation of WRAPS activities. At that time, incorporation of this TMDL will be made into the WRAPS. Recommendations of this TDML will be considered in the Kansas Water Plan implementation decisions under the State Water Planning Process for Fiscal Years 2010-2019.

Developed January 26, 2010

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Appendix A

Permit #	Type	County	Animal Units	Wasteload Allocation (lbs/day)
A-URNT-P001	Turkey, Ducks, Chicken	Norton	82000	0
A-URNT-BA02	Beef	Norton	250	0
A-URNT-MA03	Dairy	Norton	40	0
A-URNT-BA05	Beef	Norton	600	0
A-URNT-B006	Beef	Norton	400	0
A-URNT-BA06	Beef	Norton	200	0
A-URNT-BA07	Beef	Norton	150	0
A-URNT-B003	Beef	Norton	600	0
A-URNT-MA05	Dairy	Norton	40	0
A-URNT-B001	Beef	Norton	999	0
A-URNT-B007	Beef	Norton	400	0
A-URNT-H005	Swine	Norton	7680	0
A-URNT-B009	Beef	Norton	999	0
A-URNT-H003	Swine	Norton	16000	0
A-URNT-H004	Swine	Norton	7680	0
A-URNT-H007	Swine	Norton	7680	0
A-URPL-C001	Beef, Swine	Phillips	17799	0
A-URPL-S012	Swine	Phillips	3000	0
A-URNT-C002	Beef	Norton	5000	0
A-URPL-H005	Swine	Phillips	4836	0
A-URPL-S010	Swine	Phillips	3340	0
A-URPL-B002	Beef	Phillips	870	0
A-URPL-B004	Beef	Phillips	990	0
A-URPL-B003	Beef	Phillips	990	0
A-URPL-S007	Swine	Phillips	1600	0
A-URPL-BA01	Beef	Phillips	300	0
A-URNT-H001	Swine	Norton	15688	0
A-URPL-H006	Swine	Phillips	7200	0
A-URPL-S009	Swine	Phillips	3340	0
A-SOPL-B007	Beef	Phillips	230	0
A-URPL-M001	Dairy	Phillips	50	0
A-URPL-C002	Beef	Phillips	1600	0
A-URPL-MA01	Dairy	Phillips	45	0
A-URPL-B001	Beef	Phillips	980	0
A-URPL-H003	Swine	Phillips	8238	0
A-URPL-H007	Swine	Phillips	15496	0
A-URPL-MA02	Dairy	Phillips	40	0
A-URPL-B005	Beef	Phillips	300	0