LOWER ARKANSAS BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody / Assessment Unit (AU): Grouse Creek Watershed
Water Quality Threats: Total Phosphorus and Total Suspended Solids

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Kaw Lake **Counties:** Elk, Butler and Cowley

HUC8: 11060001
HUC10 (HUC12): 01 (01 and 02) and 02 (01, 02, 03, 04, 05, 06, 07 and 08)

Ecoregion: Flint Hills (28)

Drainage Area: 396 Square Miles above confluence with Otter Creek

Water Quality Limited Segments:

Main Stem	**Tributaries**	
Grouse Creek (15)	Silver Creek (17)	Pebble Cr (26)
		Snake Cr (25)
		Plum Cr (33)
Grouse Creek (16)	Crabb Creek (29)	
	Turkey Creek (27)	
	Bullington Creek (28)	
	School Creek (31)	
	Blue Branch (30)	
	Cedar Creek (32)	
	Goose Creek (34)	
	Gardners Branch (39)	
	Franklin Creek (35)	
	Ferguson Creek (38)	
	Riley Creek (37)	
	Waggoner Creek (36)	

Designated Uses: All streams and segments support Expected Aquatic Life; Grouse Creek segment 15 supports Primary Contact Recreation B; Grouse Creek segment 16, Crabb Creek, Waggoner Creek, Silver Creek and Snake Creek support Primary Contact Recreation C; all other streams support Secondary Contact Recreation b; Grouse Creek segments 15 and 16 support all other designated uses as do Silver Creek, Plum Creek, Crabb Creek, Gardners Branch, and Waggoner Creek; Pebble, Snake, School Creeks and Blue Branch support Food Procurement, Irrigation Use and Livestock Watering; Turkey Creek supports those uses as well as Groundwater Recharge; Cedar Creek supports all designated uses except Food Procurement; Goose Creek supports Irrigation Use and Livestock Watering; Bullington Creek supports those uses plus Groundwater Recharge;

Franklin Creek supports Food Procurement and Livestock Watering; Ferguson and Riley Creeks do not support any designated uses other than Secondary Contact Recreation and Expected Aquatic Life.

303(d) Listings: None for SC531 and SC761 on Grouse Creek; Dissolved Oxygen TMDL at SC706 on Silver Creek since 2000.

Impaired Use: None, protecting designated uses from threats of excessive sediment and phosphorus.

Water Quality Criteria:

Suspended Solids: Suspended solids added to surface waters by artificial sources shall not interfere with the behavior, reproduction, physical habitat, or other factors related to the survival and propagation of aquatic or semiaquatic life or terrestrial wildlife. In the application of this provision, suspended solids associated with discharges of pre-sedimentation sludge from water treatment facilities shall be deemed noninjurious to aquatic and semiaquatic life and terrestrial wildlife, if these discharges comply fully with the requirement of paragraphs (b)(6) and (8) and paragraph (c)(2)(D) of this regulation. (K.A.R. 28-16-28e(c)(2)(B)).

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

The introduction of plant nutrients into 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 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)).

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Uses under 2012 – 303(d): Fully supporting all designated uses except Expected Aquatic Life on Silver Creek (Dissolved Oxygen).

Stream Monitoring Sites and Period of Record: Active KDHE permanent routine ambient stream chemistry sampling station SC531, located on Grouse Creek ½ mile South of Silverdale; period of record is 1990-2012 (**Figure 1**). Active KDHE rotational ambient stream chemistry sampling station SC706, located on Silver Creek at US-166 Highway bridge 2 ½ miles North and 2 ½ miles East of Silverdale; period of record is 1996, 2000, 2004, 2008 and 2012. New KDHE ambient stream chemistry station SC761 on Grouse Creek, 6.3 miles North of Cambridge; period of record is 2011-2012. Biological data collected at SC531 (1994-1998, 2003, and 2005) and SC761 (2011-2012).

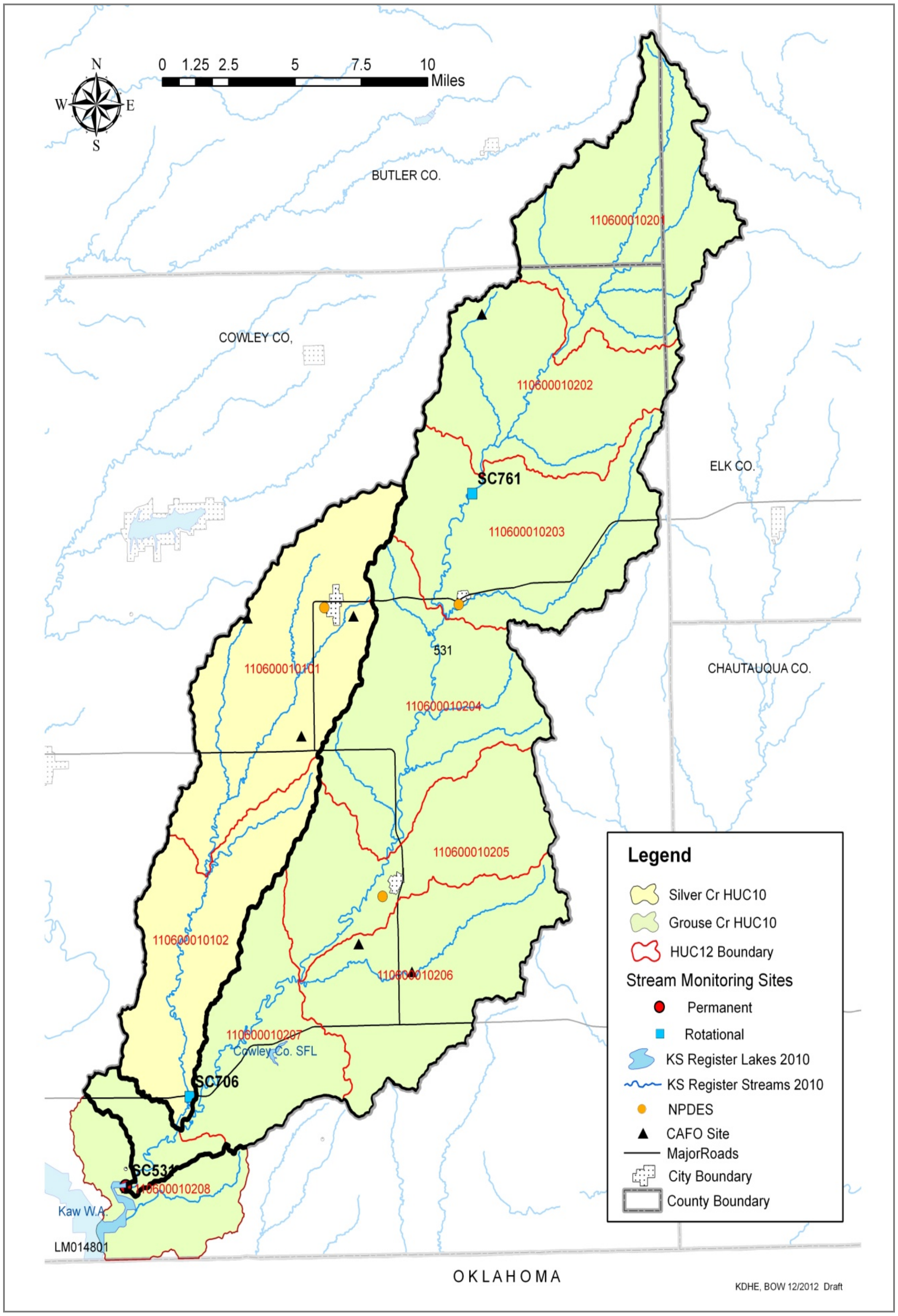

Figure 1. Grouse Creek base map with NPDES and State CAFO facilities.

Hydrology: Grouse Creek is marked by fairly strong flow under normal conditions but little baseflow once dryness is prevalent. Silver Creek is the major tributary (101 sq.mi) and contributes normal flows and runoff, but little baseflow support. The upper reaches of both Grouse Creek and Silver Creek have a propensity to go dry. Most of the tributaries to Grouse Creek are small, ranging in drainage area from 6 to 13 square miles. The exceptions are Cedar Creek (33 sq.mi) and Crabb Creek (39 sq.mi) which each contribute 11-12% of the average flow seen on the lower reach of Grouse Creek. Plum, Snake and Pebble Creeks comprise respectively 9, 19 and 15 square miles of drainage within the Silver Creek subwatershed. Since there are no flow gages on Grouse Creek or its tributaries, these flow estimates (**Table 1**) are taken from Perry, 2004. If Grouse Creek is similar to the nearby Caney River (**Figure 2**), runoff occurs sometime during the March through June time period. Flows decreased markedly during the summer and fall.

Table 1. Long term flow conditions in cfs for streams within the Grouse Creek watershed (Perry, 2004).

Stream	Drainage Area	Mean Flow (cfs)	Baseflow (75%)	Normal Flow (50%)	Runoff (10%)
Grouse Creek nr Cambridge	93.6 sq.mi	57 cfs	1 cfs	7.3 cfs	77 cfs
Grouse Creek abv Cedar Crk	113 sq.mi	66 cfs	1.8 cfs	9.1 cfs	94 cfs
Cedar Creek	34 sq.mi	22 cfs	0.2 cfs	1.8 cfs	29 cfs
Grouse Creek abv Crabb Crk	226 sq.mi	126 cfs	4.1 cfs	18 cfs	189 cfs
Crabb Crk	39 sq.mi	24 cfs	0.3 cfs	3.2 cfs	32 cfs
Grouse Creek abv Silver Crk	284 sq.mi	156 cfs	5.3 cfs	23 cfs	240 cfs
Upper Silver Creek	30 sq.mi	15 cfs	0.0 cfs	1.5 cfs	18 cfs
Snake Creek	19 sq.mi	9.1 cfs	0.0 cfs	0.7 cfs	9.5 cfs
Lower Silver Creek	101 sq.mi	49 cfs	1.2 cfs	6.3 cfs	65 cfs
Lower Grouse Creek above Otter Creek	396 sq.mi	204 cfs	7.3 cfs	31 cfs	321 cfs

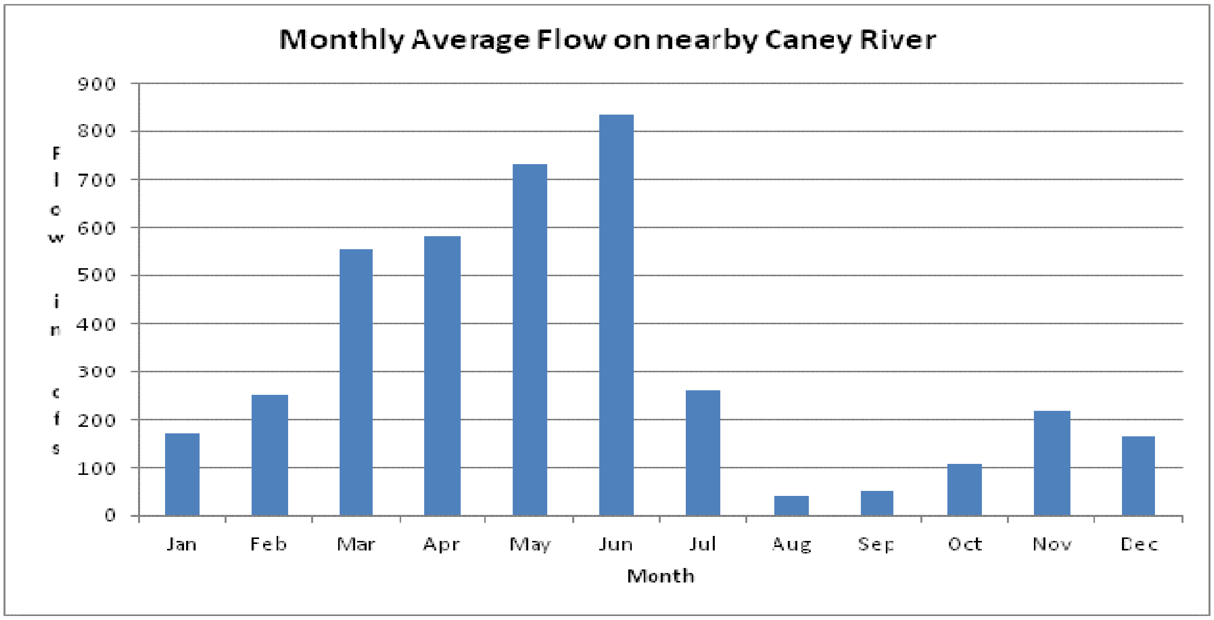

Figure 2. Average monthly flows on nearby Caney River.

Current Condition: This TMDL intends to identify the current loads of phosphorus and total suspended solids that need to be maintained to continue the high biological integrity seen on Grouse Creek. Some reduction in loads under runoff conditions can further buttress the high quality seen at the stream monitoring sites. The three stations in the Grouse Creek watershed show overall good quality in terms of stream chemistry (**Table 2**). Average concentrations of TP and TSS may reflect influence of runoff conditions when compared to the overall median values for those two pollutants. As an indicator of high primary productivity, pH values could be well over the state criterion of 8.5. Of 161 samples taken at the three monitoring locations over 1990 – 2012, only one sample had a pH over 8.5 (8.7). Along with the low sestonic (floating) chlorophyll-a concentrations sampled on lower Grouse Creek, the stream chemistry suggests the stream system is not overburdened with phosphorus that is fueling planktonic growth in either the water column or attached to the stream substrate.

Although there are no streamflow gages on Grouse Creek, estimates of flow condition could be made by looking at flows on nearby Caney and Elk Rivers and assigning their joint average percentile of flow exceedance into three categories of runoff, normal flow and baseflow. Flows were estimated on the days of sampling and those samples were placed in the appropriate flow condition category. Over time, phosphorus concentrations under normal and baseflow conditions were similar (**Figures 3 and 4**). Runoff events tended to elevate concentrations. Similar patterns are seen for total suspended solid concentrations on lower Grouse Creek (**Figures 5 and 6**).

Table 3 indicates the average and quartile concentrations of total phosphorus and TSS on lower Grouse Creek at the three flow conditions. The few samples collected in 2011 and 2012 on upper Grouse Creek near Cambridge were taken during the severe drought and represent normal or baseflow conditions. Concentrations of phosphorus and TSS were similar to those at the lower station during non-runoff conditions (**Table 2**).

Table 2. Water Quality Statistics for Grouse Creek watershed monitoring sites.
(all values are in mg/l, except chlorophyll *a* is in µg/l)

Stream	Period	Statistic	Total P	TSS	TN	DO	#DO < 5 mg/l	Turbidity	Chlorophyll-a
Lower Grouse Creek	1990-1999	Average	0.093	58	----	9.05	1 (4.7)	20	----
		Median	.080	27	----	8.5	----	12	----
	2000-2012	Average	0.113	82	0.76	9.5	0	46	9.4
		Median	0.066	23	0.56	9.0	----	13	6.0
Silver Creek	1996, 2000, 04, 08, 12	Average	0.104	43	0.904	9.5	2 (3.9, 4.3)	24	----
		Median	0.075	16	0.885	9.15	----	9	----
Upper Grouse Creek	2011, 2012	Average	0.065	14	0.947	7.94	1 (4.21)	12	----
		Median	0.064	<10	0.609	6.8	---	9	----

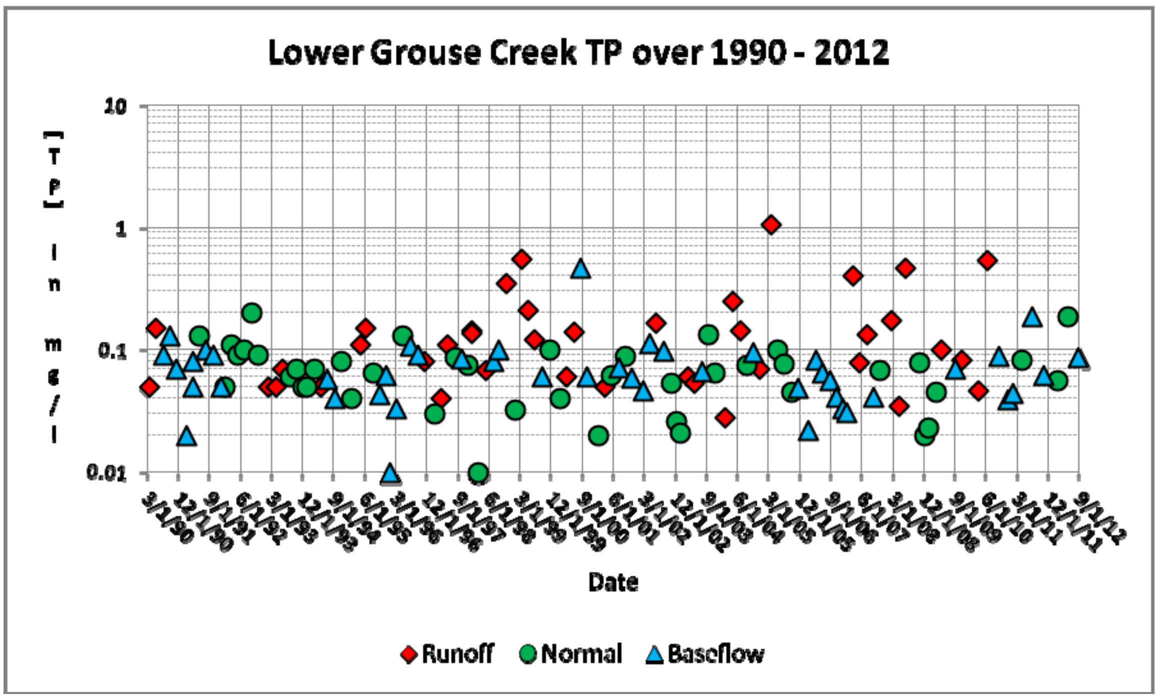

Figure 3. Total phosphorus concentrations on lower Grouse Creek (1990-2012).

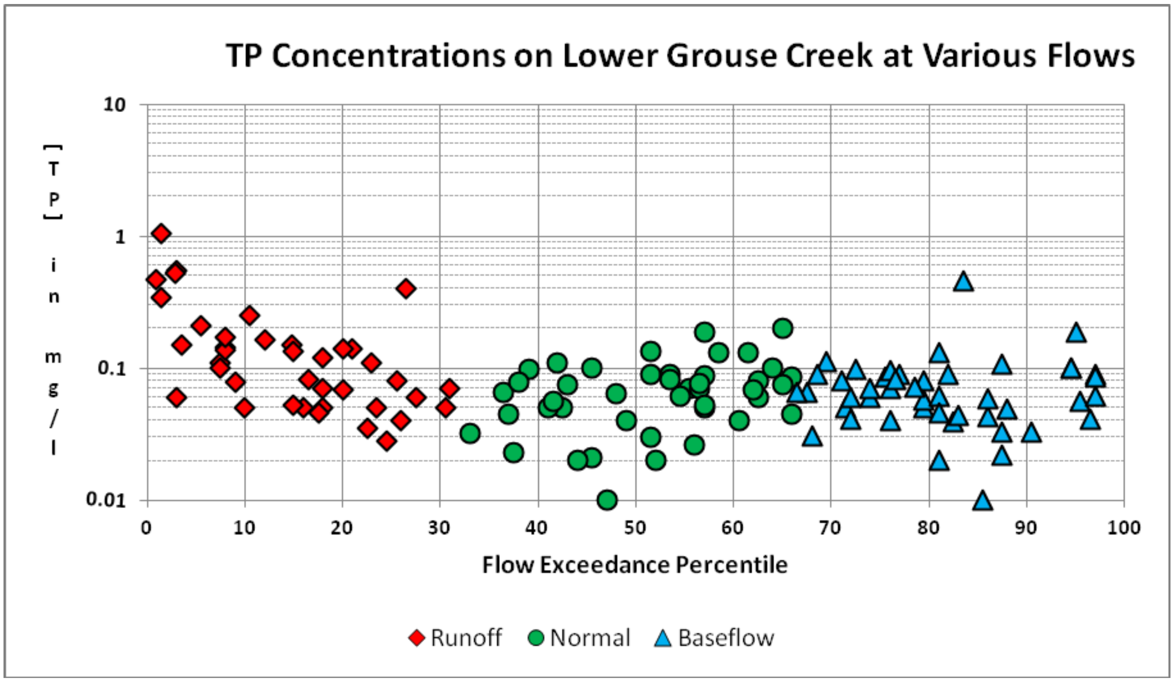

Figure 4. Lower Grouse Creek TP concentrations as function of flow condition.

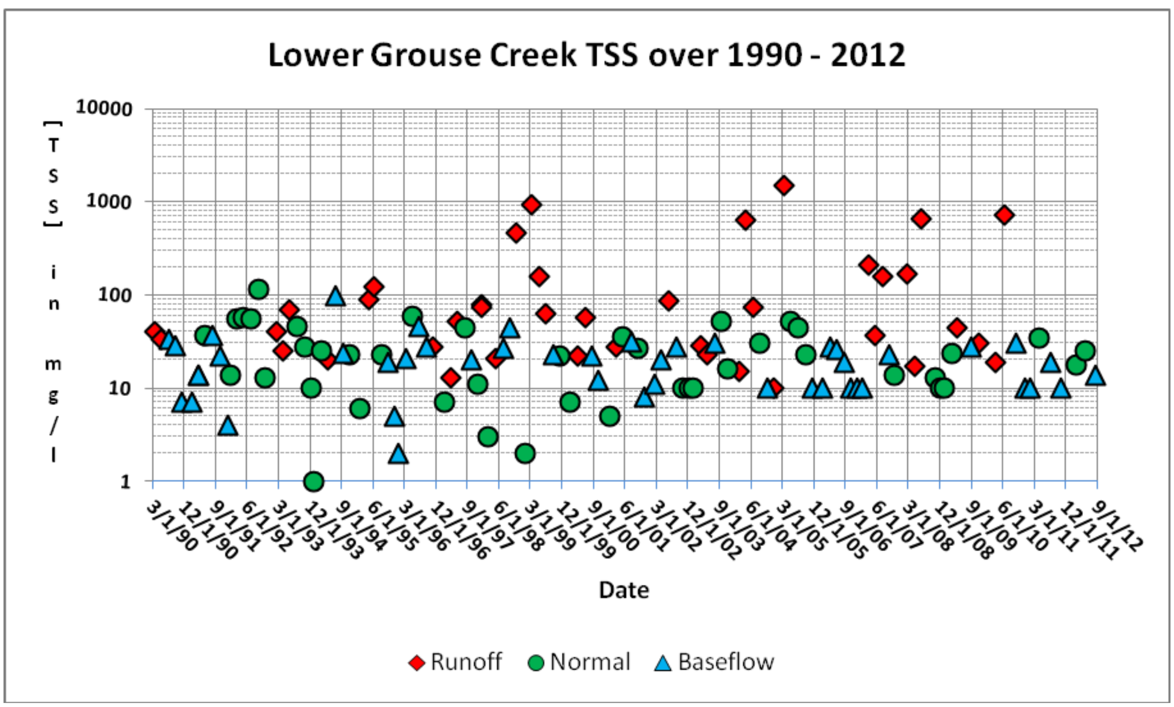

Figure 5. TSS concentrations on lower Grouse Creek (1990-2012).

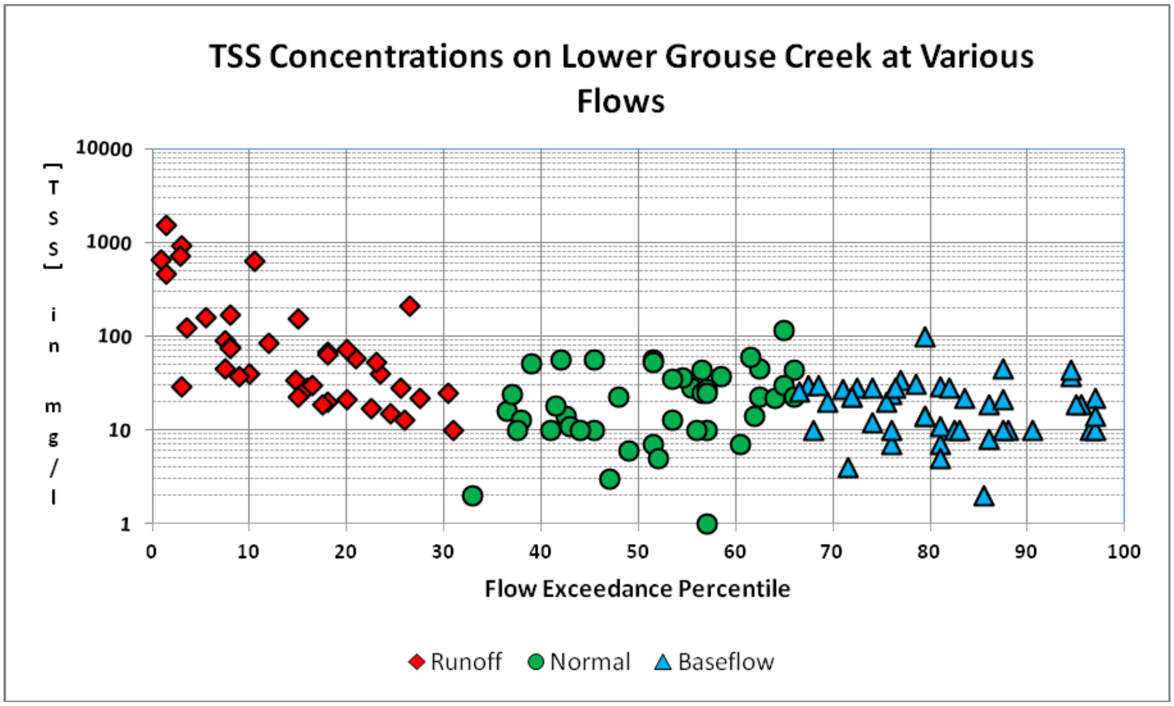

Figure 6. Lower Grouse Creek TSS concentrations as function of flow condition.

Table 3. Average and quartile concentrations of TP and TSS on lower Grouse Creek at various flow conditions.

Pollutant	Flow Condition	Average Concentration	Lower Quartile	Median	Upper Quartile
Phosphorus	**Runoff**	0.169 mg/l	0.053 mg/l	0.109 mg/l	0.164 mg/l
	Normal Q	0.072 mg/l	0.045 mg/l	0.068 mg/l	0.090 mg/l
	Baseflow	0.076 mg/l	0.044 mg/l	0.064 mg/l	0.090 mg/l
Suspended Solids	**Runoff**	177 mg/l	25 mg/l	53 mg/l	157 mg/l
	Normal Q	26 mg/l	<10 mg/l	23 mg/l	37 mg/l
	Baseflow	21 mg/l	<10 mg/l	20 mg/l	28 mg/l

From concurrent samples, there was some correlation between pollutants of TP and TSS on response variables of dissolved oxygen and turbidity but weak and not significant relations with chlorophyll a (**Table 4**). Their relationship with dissolved oxygen is inverse but not particularly strong. The relationships among turbidity, TP and TSS are fairly strong and direct, which is logical since phosphorus is typically attached to sediment which is a chief cause of turbidity.

Table 4. Correlations between TP, TSS and response variables (significance [α=0.10] in bold font).

Parameter	**Dis.O2**			
Turb	-0.080	**Turbidity**		
Log Chl-a	-0.279	0.251	**Log Chlorophyll-a**	
Log TP	**-0.471**	**0.632**	0.296	**Log TP**
LogTSS	**-0.380**	**0.673**	0.230	**0.808**

On Silver Creek, sampled only 5 years over 1996 – 2012, concentrations of TP and TSS were similar across all three flow conditions (**Figures 7 – 10**). Examination of the concentration statistics for the three flow conditions shows the lowest concentrations at normal flow while concentrations at baseflow and runoff were elevated (**Table 5**).

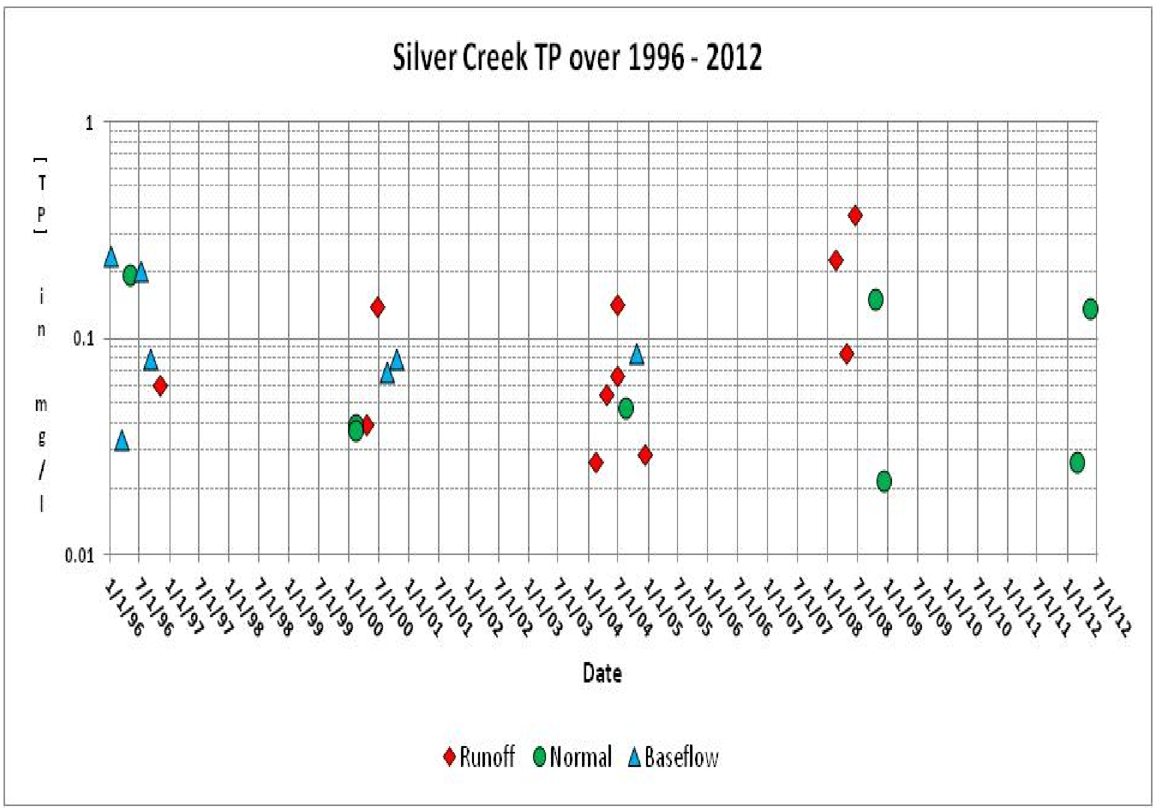

Figure 7. Total phosphorus concentrations on Silver Creek (1996-2012).

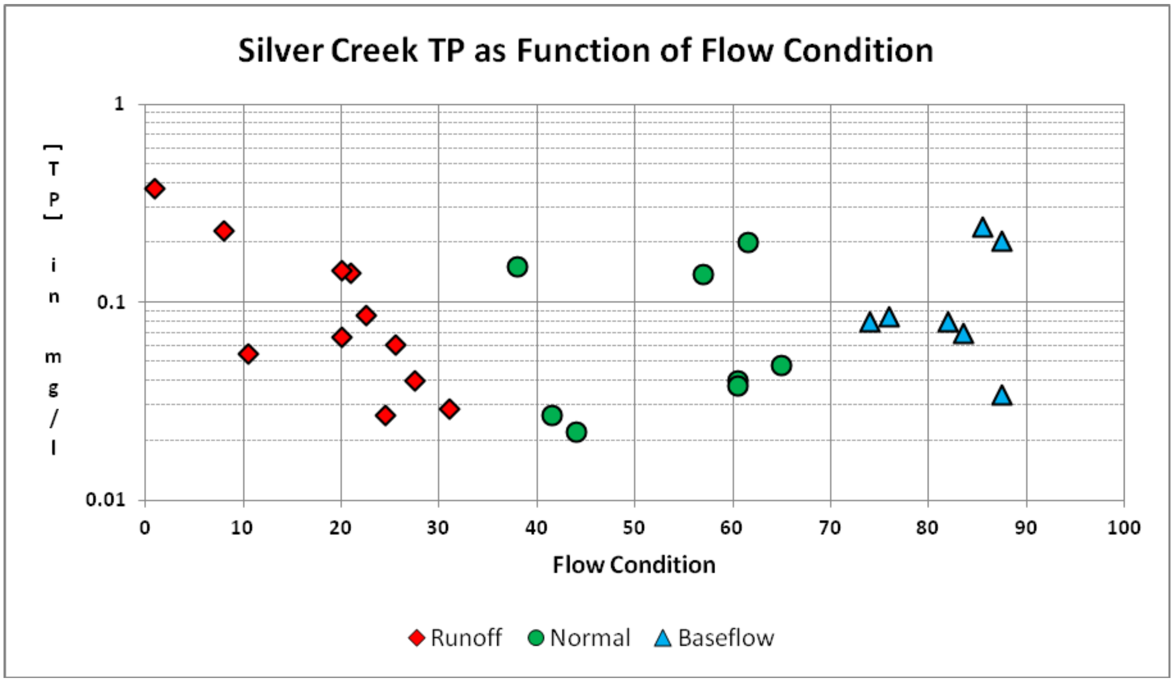

Figure 8. Silver Creek TP as a function of flow condition.

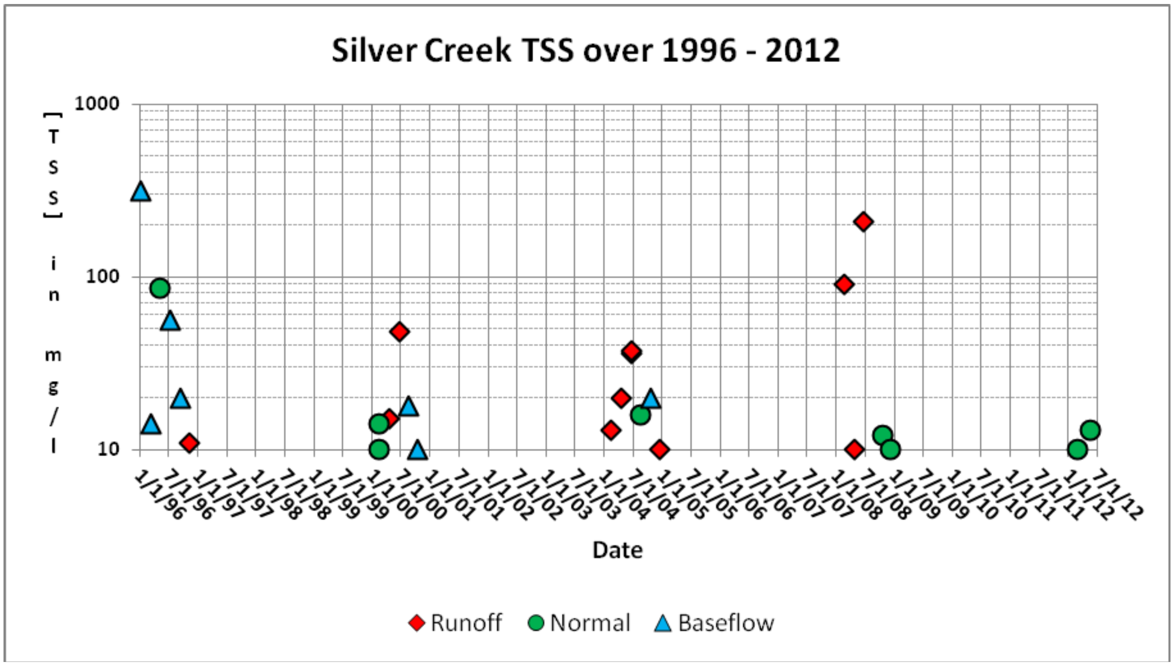

Figure 9. Silver Creek TSS concentrations (1996-2012).

Table 5. Average and quartile concentrations of TP and TSS on Silver Creek at various flow conditions.

Pollutant	Flow Condition	Average Concentration	Lower Quartile	Median	Upper Quartile
Phosphorus	**Runoff**	0.114 mg/l	0.040 mg/l	0.067 mg/l	0.144 mg/l
	Normal Q	0.083 mg/l	0.030 mg/l	0.044 mg/l	0.149 mg/l
	Baseflow	0.113 mg/l	0.070 mg/l	0.080 mg/l	0.205 mg/l
Suspended Solids	**Runoff**	49 mg/l	12 mg/l	28 mg/l	77 mg/l
	Normal Q	12 mg/l	<10 mg/l	12 mg/l	14 mg/l
	Baseflow	65 mg/l	14 mg/l	20 mg/l	56 mg/l

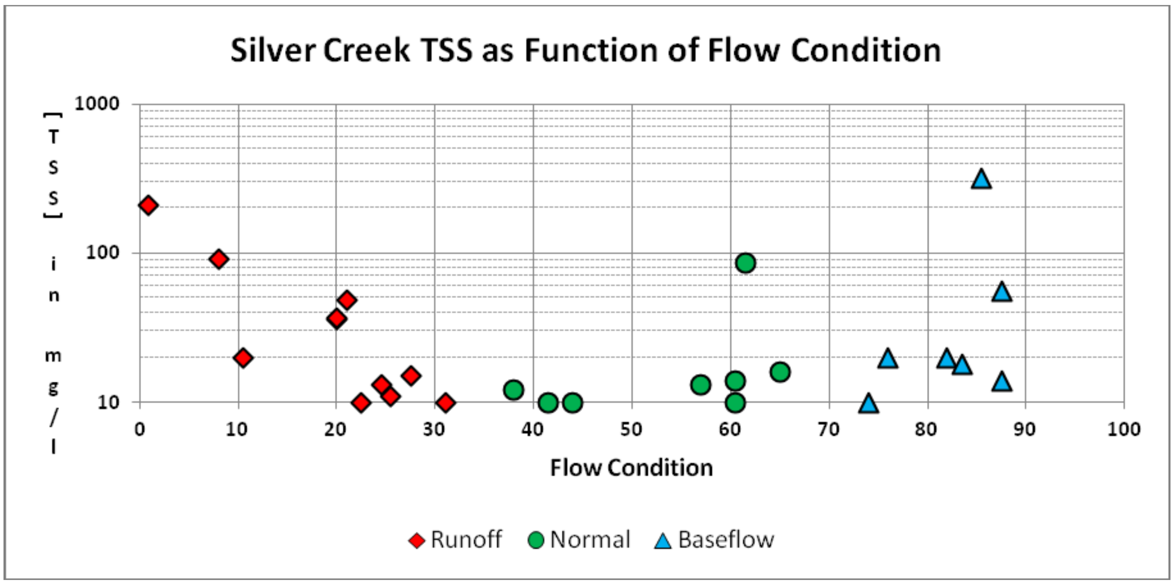

Figure 10. Silver Creek TSS as function of flow condition.

Biology: Macroinvertebrate sampling has occurred on lower Grouse Creek in seven years over 1994 – 2005 and three times on upper Grouse Creek in 2011 and 2012. Recently, KDHE updated its aquatic life use support (ALUS) multimetric index. The new scoring criteria were based on candidate reference stream and stream probabilistic network site data from 1990-2010 (N=1172). Five metrics were selected to provide measures of community richness, composition, dominance, and tolerance to oxygen demanding pollutants.

Following EPA's Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (Barbour et al., 1999), metric percentiles were quadrisected and a scoring scale of 1 to 4 was assigned to the quadrisects, with 4 representing the highest or best quality score (**Table 6**). The ALUS score was then derived by averaging the scores of the five metrics. Any average score near 4.0 was considered a high quality biological community. Any score near 1.0 was considered a severely degraded biological community. A score greater than or equal to 2.51 was considered supporting of aquatic life while lower scores were considered non-supporting.

Table 6. ALUS multi-metric index scoring criteria based on SBMP candidate reference stream and network site data (1990-2010). MBI = Macroinvertebrate Biotic Index (Davenport and Kelly, 1983); KBI-N = Kansas Biotic Index for nutrients and oxygen demanding substances (Huggins and Moffett, 1988); EPT = number of Ephemeroptera, Plecoptera, Trichoptera taxa; EPT % ABUND = percent sample relative abundance of EPT; SHAN EVN = Shannon's Evenness Index.

Score	**MBI**	**KBI**	**EPT**	**EPT%**	**SHAN EVN**
4	< 4.19	< 2.53	>15	> 63	> 0.846
3	4.19-4.44	2.53-2.68	13-15	54-63	0.815-0.846
2	4.45-4.80	2.69-2.83	11-12	41-53	0.773-0.814
1	> 4.80	> 2.83	< 11	< 41	< 0.773

Average multimetric scores for Grouse Creek near Silverdale ranged from 2.4 to 3.6; six of the seven years of sampling yielded scores greater than 3.2. Only 2005 had a low score of 2.4, mostly because of a lower count of mayflies, stoneflies and caddisflies in the macroinvertebrate population, as well as the sampling occurring in November. The upper portion of Grouse Creek near Cambridge was sampled in 2011 and 2012 and had poor scores (1-2.2). The sampling time for the upper reaches coincided with severe drought and the stream habitat was severely dewatered, diminishing the diversity and presence of macroinvertebrates associated with good water quality. **Figures 11 and 12** show the pattern of Macroinvertebrate Biotic Index scores and the percentage of sampled counts that were pollution intolerant orders of Ephemeroptera, Plecoptera and Trichoptera. The lower reaches of Grouse Creek likely benefited by a more robust hydrology supporting habitat conditions in the stream channel whereas the upper site suffered from severely diminished flow.

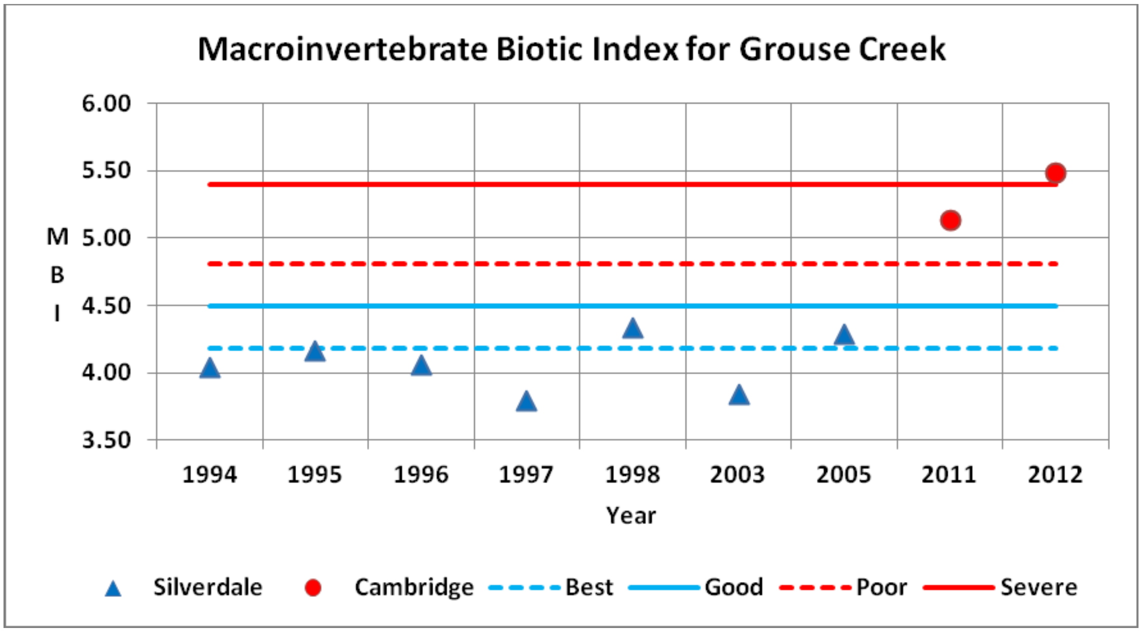

Figure 11. MBI scores for Grouse Creek (1994-2012).

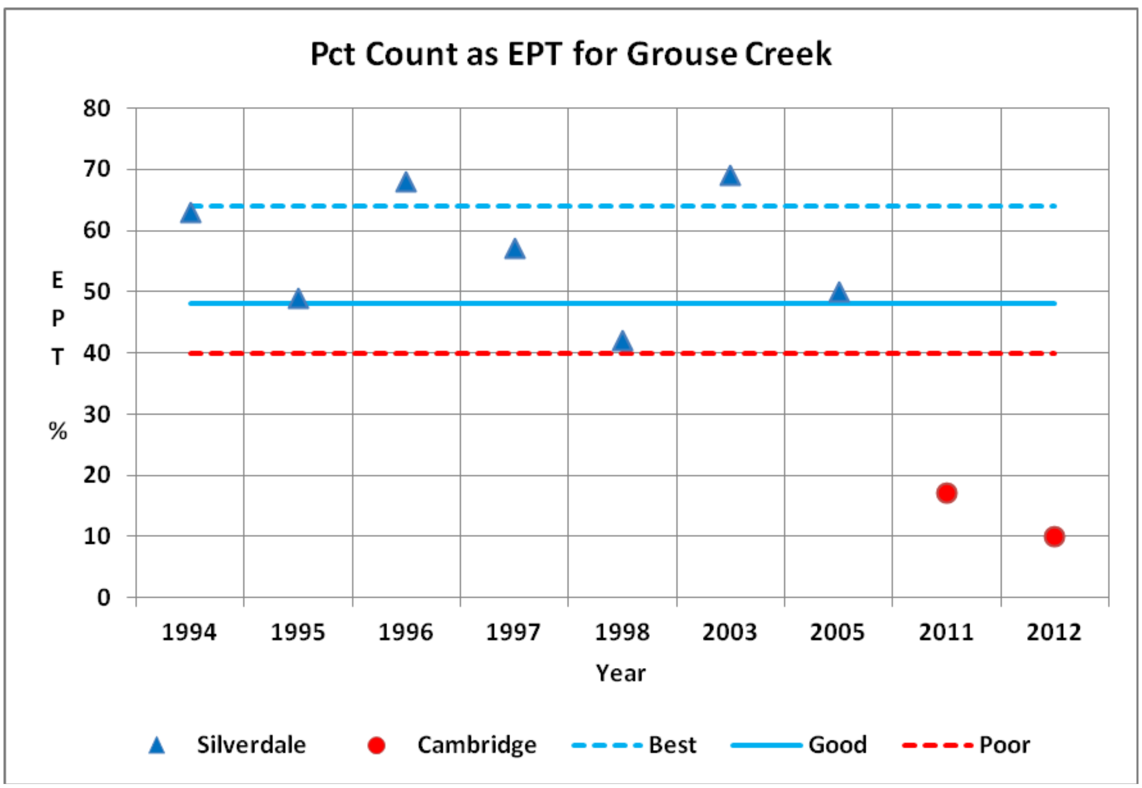

Figure 12. Percentage of sample counts comprising Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) on Grouse Creek.

Because biological sampling occurs typically once a year and not in conjunction with stream chemistry sampling, correlations are harder to derive. Individual metric values for MBI and the percent count of EPT were correlated with the median sample values of certain parameters for each specific year of biological sampling (**Table 7**). When viewed from an annual basis, any relationship between dissolved oxygen and TP and TSS is essentially absent, while the pollutants' remain significantly correlated with turbidity. Chlorophyll-a in the stream is not related to any of the variables as before. The biological metrics are related to one another and MBI has a strong relationship with TSS with worsening scores occurring with higher TSS levels. No such relationship exists with the EPT metric and TSS or TP.

Table 7. Correlation of biological metrics with annual median values of other parameters (significance [α=0.10] in bold font).

Parameter	**Dis. O2**					
Turbidity	0.106	**Turbidity**				
Log Chl-a	-0.481	0.280	**Log Chl-a**			
MBI	-0.224	0.592	------	**MBI**		
% EPT	-0.133	-0.346	------	**-0.719**	**% EPT**	
Log TP	-0.148	**0.356**	0.034	0.368	-0.445	**Log TP**
Log TSS	0.017	**0.362**	-0.433	**0.801**	-0.419	**0.385**

Desired Endpoints of Water Quality (Implied Load Capacity for TP and TSS) in Grouse and Silver Creeks:

The ultimate endpoint for this TMDL will be to maintain the Kansas Water Quality Standards fully supporting chronic aquatic life support from the impacts of excessive phosphorus or total suspended solids. The current ambient conditions that coincide with evidence of a strongly supported aquatic community will be maintained. Since the only stress of excessive loads occurs under runoff conditions, any restoration efforts will be directed at reducing the concentration of TP and TSS under those conditions which will serve as a margin of safety.

The following endpoints will define maintenance of the water quality standards pertaining to aquatic life support and will be determined at the biological monitoring site located on Grouse Creek near Silverdale.

1. **The upper quartile of the MBI biological metric will remain below 4.2.**
2. **The lower quartile of the EPT Count Percent will remain above 50%.**
3. **Median sestonic chlorophyll-a concentrations will remain below 6 µg/l.**

The following milestones will assess the baseline of current acceptable water quality conditions in the watershed.

1. **Maintain the median TP concentrations on Grouse Creek at or below 0.065 mg/l (Figure 13).**
2. **Maintain the median TSS concentrations on Grouse Creek at or below 20 mg/l (Figure 14).**
3. **Reduce the median TP concentrations on Silver Creek to 0.065 mg/l (Figure 15).**
4. **Reduce the upper quartile TSS concentration on Silver Creek to a comparable level of the upper quartile TSS concentration on Grouse Creek – 30 mg/l (Figure 16).**

The following goals are established for load reduction under runoff conditions to further assure the achievement of the primary normal flow milestones for Grouse Creek.

1. **Reduce the median TP concentration on Grouse Creek under runoff conditions to the normal flow upper quartile TP value – 0.090 mg/l (Figure 13).**
2. **Reduce the median TSS concentration on Grouse Creek under runoff conditions to the normal flow upper quartile TSS value – 30 mg/l (Figure 14).**

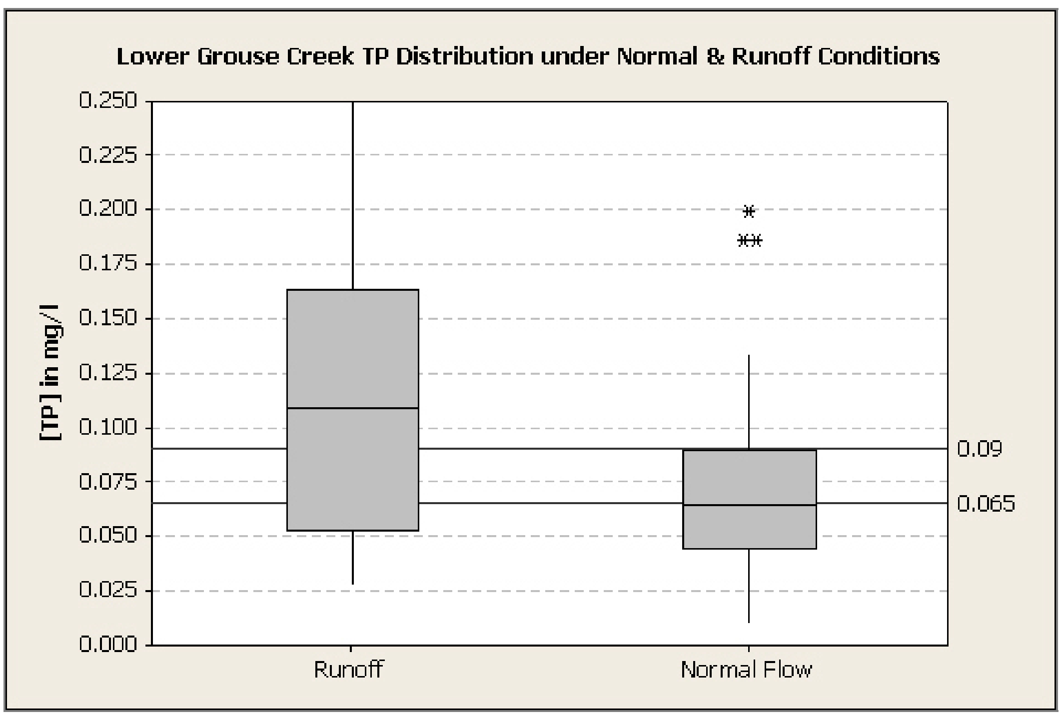

Figure 13. Distribution of TP on Grouse Creek under normal flow and runoff.

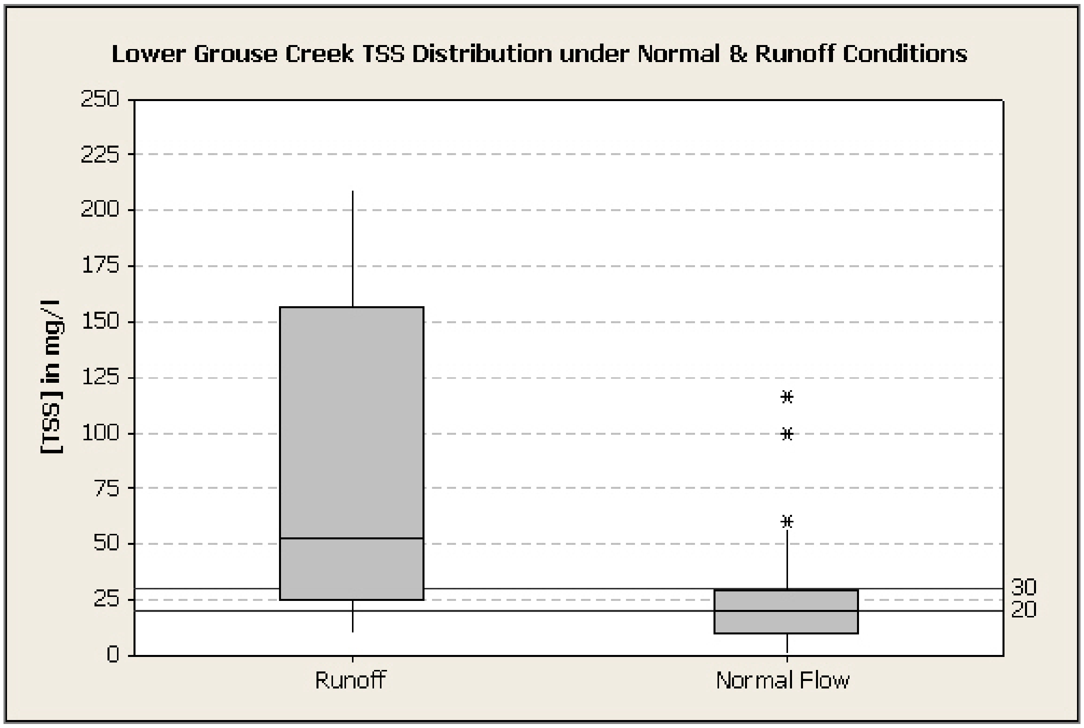

Figure 14. Distribution of TSS on Grouse Creek under normal flow and runoff.

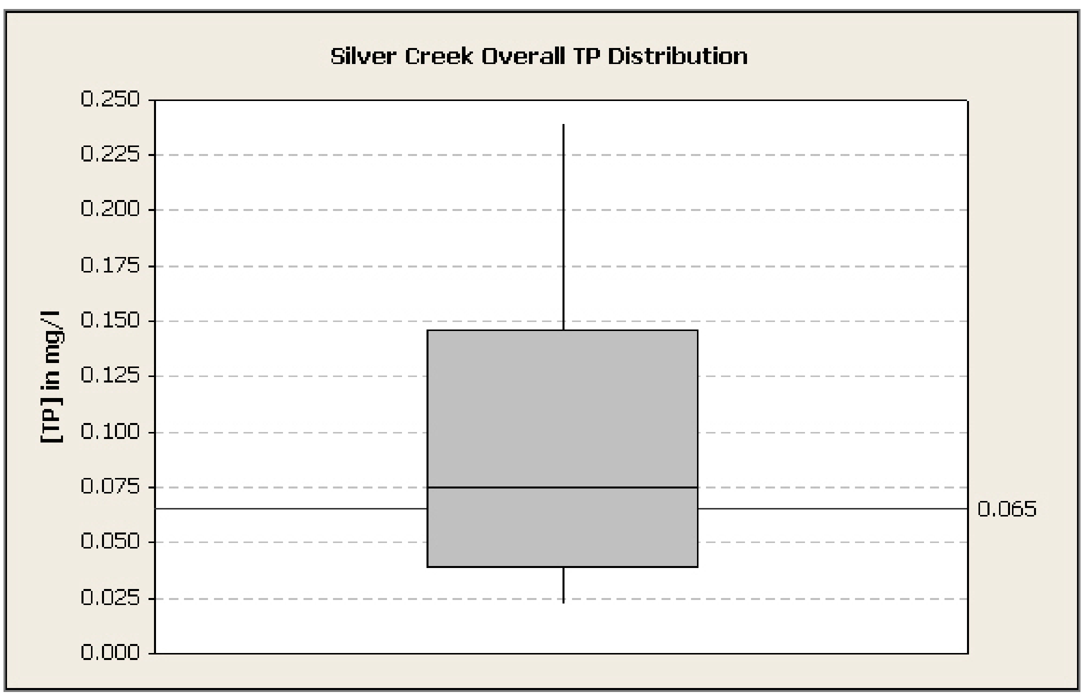

Figure 15. Overall distribution of TP on Silver Creek.

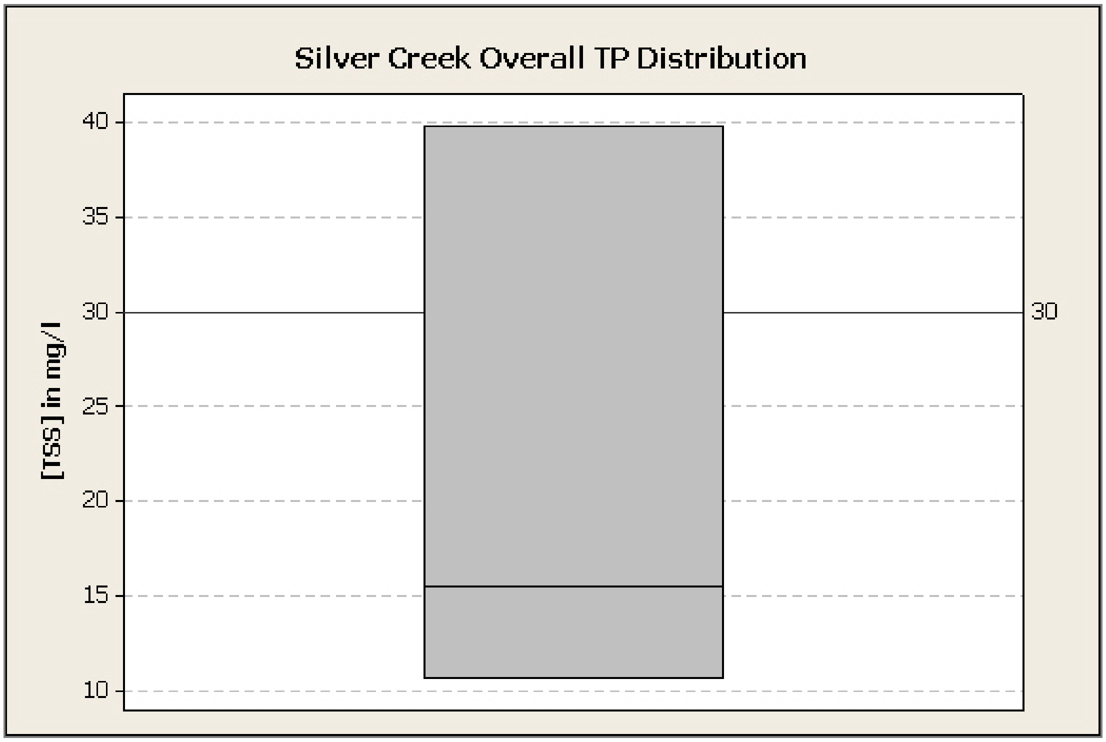

Figure 16. Overall distribution of TSS on Silver Creek.

3. SOURCE INVENTORY AND ASSESSMENT

Land Use: Grouse Creek's watershed is located in the Bluestem Hills land use area, often referred to as the Flint Hills tall grass prairie. Ten HUC 12 subwatersheds comprise the Grouse watershed; 8 along Grouse Creek and two on Silver Creek (**Figure 1**). The watershed is chiefly range and pasture which is primarily native grasses (**Table 8**). Approximately 11% of the land area is cropland of which wheat, corn, soybeans, alfalfa and sorghum are the major crops. Proportionately, most of the cropland is along Silver Creek, whereas Grouse Creek's watershed is overwhelmingly grass- and woodland with cropland concentrated along riparian areas (**Figure 17**). Agricultural production is the primary industry in the watershed.

The Grouse Creek watershed above the confluence of Otter Creek, below which is the headwater area of Kaw Lake in Oklahoma, covers 396 square miles and includes about 216 linear miles of riparian area on Silver Creek and 489 linear miles on Grouse Creek.

KDHE evaluation of disturbance among the small subwatersheds comprising Grouse Creek shows extensive areas of little disturbance (**Figures 18 and 19**). The headwaters of Silver Creek is really the only area with 'widespread' areas of disturbance. There is a high proportion of cultivated land in that area, while Grouse Creek shows just the opposite pattern (**Figure 17**). The watershed has six floodwater detention dams on tributaries to Grouse and Silver Creek that controlling 31.8 square miles of drainage. These dams were constructed under the management of the Grouse-Silver Creek

Watershed District #92 general plan and funded by state and county sources. Based on the KDHE analysis, these impoundments seem to have only localized impacts.

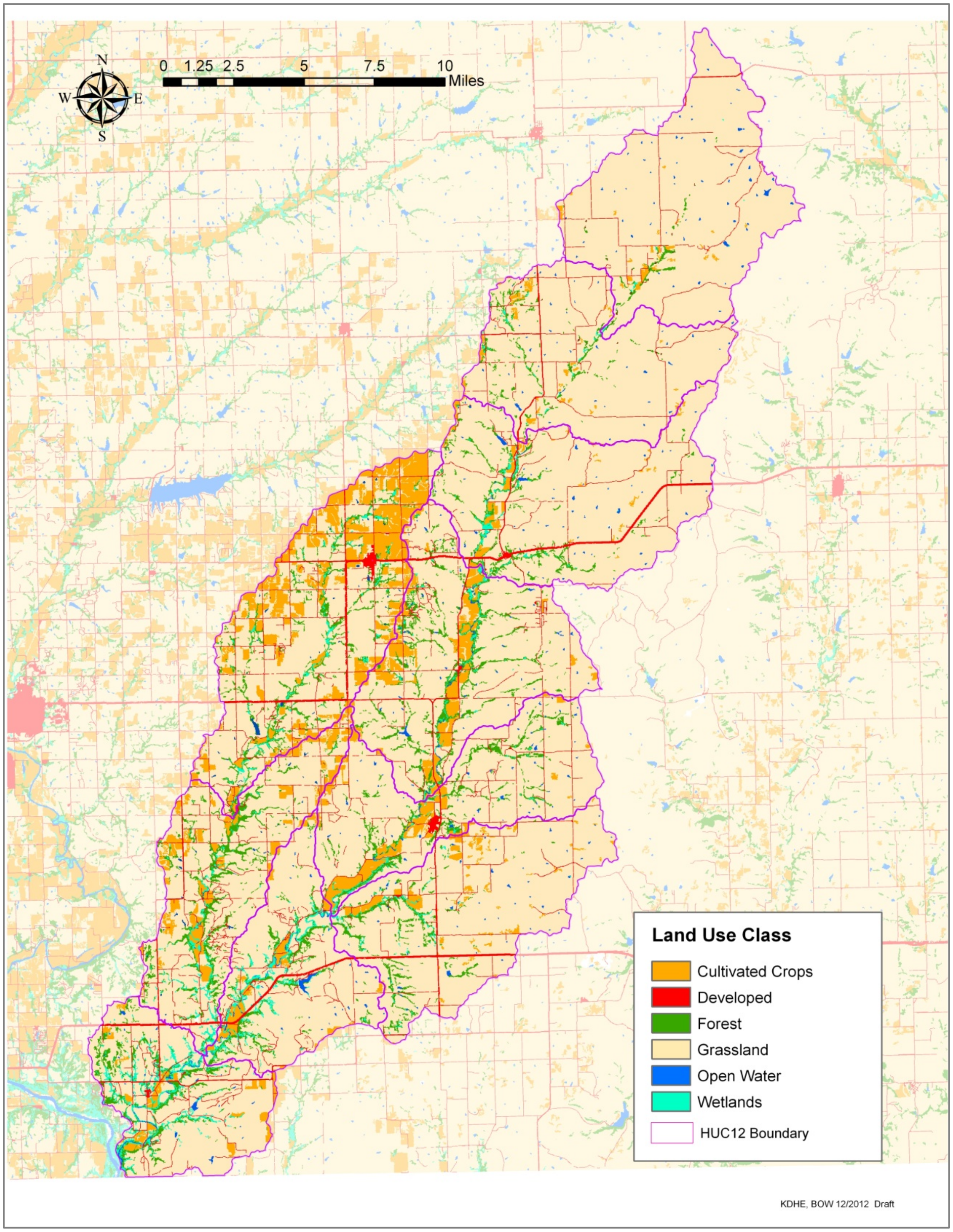

Figure 17. Land use in Grouse Creek watershed.

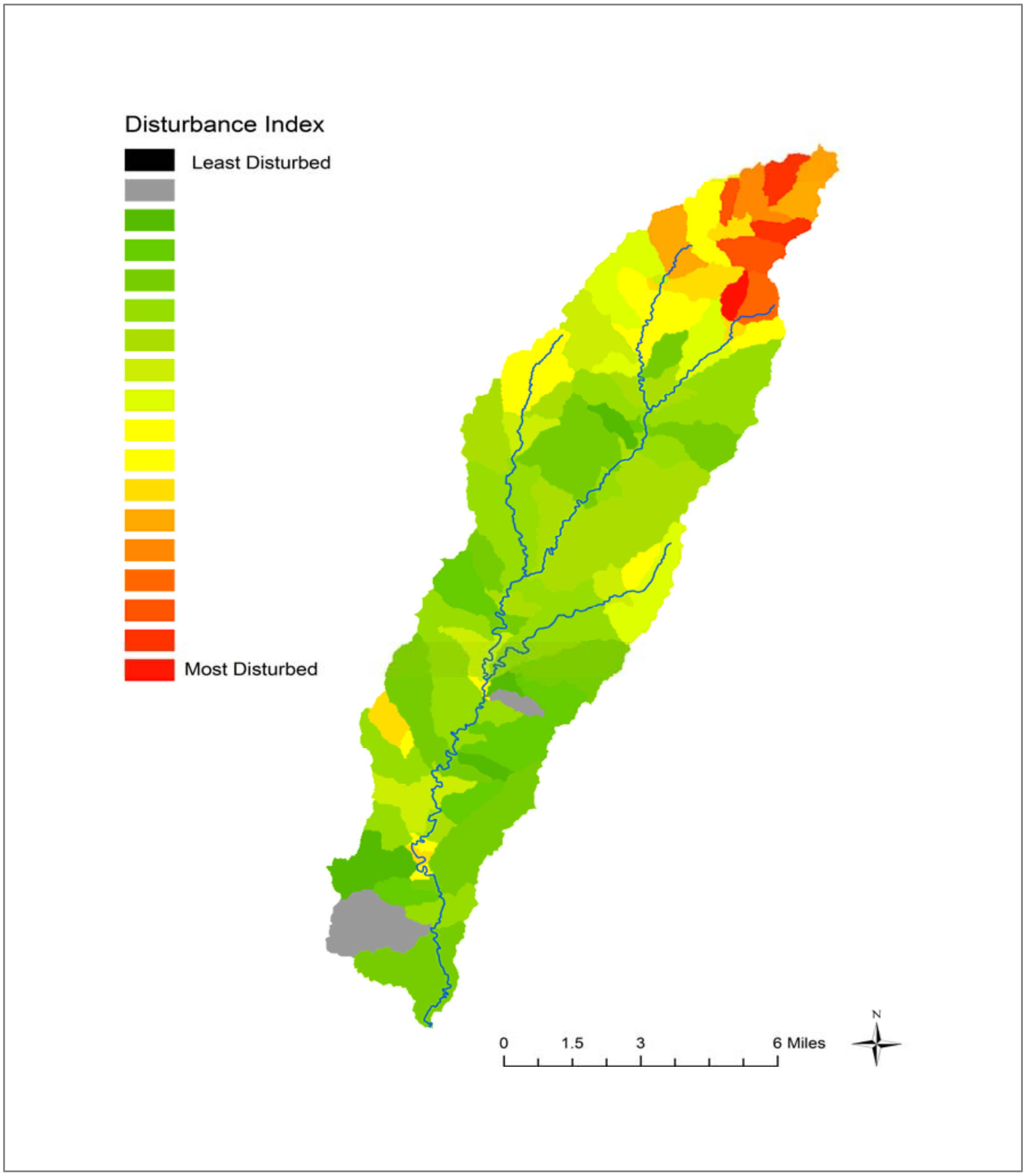

Figure 18. KDHE disturbance analysis of Grouse Creek subwatershed.

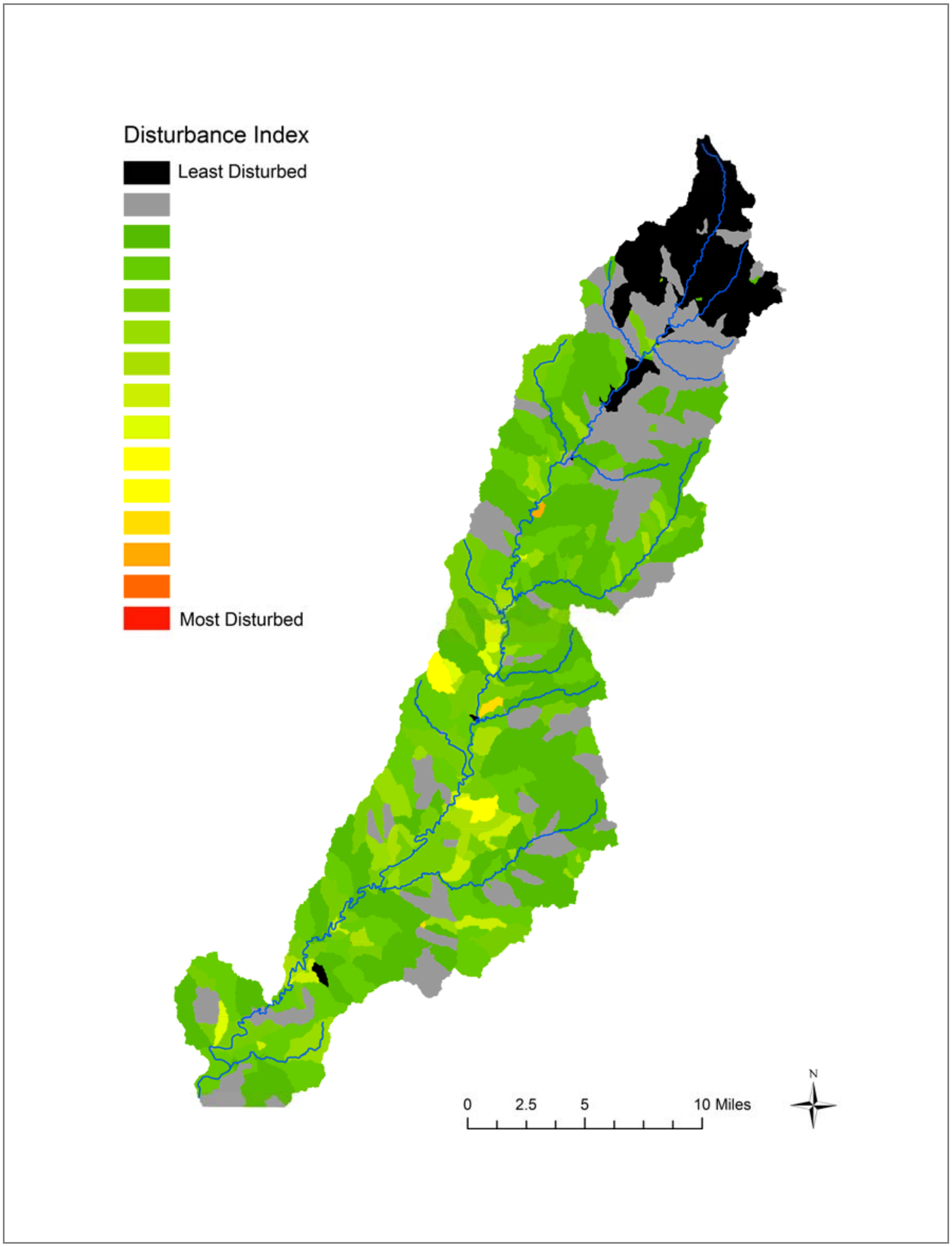

Figure 19. KDHE disturbance analysis of Silver Creek subwatershed.

Table 8. Proportion of land use in Grouse Creek watershed (11060001).

Watershed HUC10/12	% Grassland	% Cropland	% Woodland	%Development
		Silver Creek		
0101	45%	31%	16%	8%
0102	54%	20%	19%	7%
		Grouse Creek		
0201	92%	3%	2%	3%
0202	85%	4%	6%	5%
0203	80%	5%	9%	6%
0204	63%	13%	18%	6%
0205	66%	12%	16%	6%
0206	81%	5%	9%	5%
0207	69%	9%	16%	7%
0208	65%	8%	20%	7%
Overall	**70%**	**11%**	**13%**	**6%**

Livestock Waste Management Systems: Grasslands in the area support the largest cow herds of any Kansas county and are the destination of thousands of stockers each year. Approximately 52,000 head of cattle graze the prairie annually. There are four state-permitted confined animal feeding operations and two certified operations in the watershed with another certified operation under construction (**Figure 1**). **Table 9** provides the attributes of the seven facilities. All of these livestock facilities have

Table 9. State permitted animal feeding operations in Grouse Creek watershed.

Permit No.	Permit Type	Facility Type	Federal Animal Units	HUC12 Location
A-ARCL-SA04	Certification	Swine	90	110600010101 (Up. Silver Crk)
A-ARCL-B001	Permit	Beef	700	110600010101 (Up. Silver Crk)
A-ARCL-BA10	Certification (planned)	Beef	998	110600010101 (Up. Silver Crk)
A-ARCL-M001	Permit	Dairy	450	110600010202 (Goose Crk)
A-ARCL-S010	Permit	Swine	990	110600010206 (Crabb Crk)
A-ARCL-BA03	Certification	Beef	600	110600010206 (Crabb Crk)
A-ARCL-B002	Permit	Beef	980	110600010208 (Lo Grouse Crk)

waste management systems designed to minimize runoff entering their operation and detain runoff emanating from their facilities. Typically, these facilities are designed to manage a 25-year, 24-hour rainfall/runoff event in addition to two weeks of normal wastewater from their operations. Such an event is associated with streamflows that occur less than 1-5% of the time. It is unlikely TP or TSS loading is attributable to properly operated permitted facilities, especially given the low concentrations of those pollutants seen on stream in the Grouse Creek watershed, even during runoff periods.

Population Density and On-Site Waste Systems: Cowley County has a 2010 population of 36,311. Population in cities with centralized sanitary sewer systems in the county (Arkansas City, Winfield, Dexter, Burden, Cambridge, Atlanta, Geuda Springs, and Udall) comprises 74% of the county population (26,737). That leaves approximately 9574 people served by on-site waste systems. While the population density of Cowley County is 32.3 people per square mile; most of that population is located within the incorporated cities. The "rural" population density, considering Cowley is the 7th largest county in the state, is only 9.4 people per square mile. Such a light density does not present much stress on the stream systems in the county and, again, because of the lack of degraded water quality seen in Grouse Creek, is not likely to be of significant impact to the streams of the watershed.

Point Sources: There are three permitted NPDES waste treatment facilities located within the Grouse Creek watershed (**Figure 1**). **Table 10** displays the characteristics of those three facilities. All three are detention/retention lagoon systems; Cambridge is designed not to discharge, the other two will discharge low flows. All three towns served by these systems have seen population decline in the past decade: Burden (-5%), Dexter (-24%) and Cambridge (-20%). Burden peaked in population in 1960; it currently has 92% of that peak number. Cambridge peaked in 1930 (now at 30% of peak) and Dexter peaked in 1910 (now with 54% of peak). Therefore, the current facilities are likely to manage any wasteloads from current and future populations. For the discharging lagoon systems, total suspended solids are limited (80 mg/l monthly average/120 mg/l weekly average) as is Biochemical Oxygen Demand (30 mg/l /45 mg/l). Dexter averages 22 mg/l BOD and 66 mg/l TSS while Burden averages 21 mg/l and 53 mg/l, respectively (**Table 11**). Phosphorus is neither limited or monitored in Kansas lagoon systems.

Table 10. NPDES point sources in Grouse Creek watershed.

Facility	KS Permit #	NPDES #	Type	Design Flow	Receiving Stream	Permit Expires
City of Burden	M-AR14-OO02	KS0088455	3-cell lagoon	0.0612 MGD	Silver Creek	3/31/17
City of Dexter	M-AR30-OO01	KS0022667	3-cell lagoon	0.058 MGD	Grouse Creek	6/30/17
City of Cambridge	M-AR18-NO01	KSJ000462	Non-discharging lagoon	0.0 MGD	Cedar Creek	12/31/13

Table 11. Burden and Dexter wastewater statistics (2004-2012),

City	Pollutant	Average	Maximum	Number of Samples	Number > weekly average	Number > monthly average
Dexter	BOD	22 mg/l	52 mg/l	30	2	7
Dexter	TSS	66 mg/l	127 mg/l	36	4	11
Burden	BOD	21 mg/l	40 mg/l	33	0	4
Burden	TSS	53 mg/l	114 mg/l	32	0	7

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

Since this TMDL is oriented toward protecting the condition of Grouse Creek and its tributaries from excessive loading of TSS and TP, maintenance of current loads of those two pollutants will be the focus of its implementation. Current loads will be expressed as loads resulting from application of the desired median endpoints of TSS and TP to baseflows and normal flows, given that those current conditions have yielded a high quality, diverse aquatic community.

Point Sources: Both discharging facilities (the cities of Dexter and Burden) operate three-cell lagoons for their wastewater treatment. By design, these systems effectively remove most of the suspended material entering their treatment works. They generally contribute only a small portion of the TSS load into the streams and report TSS monitoring data that frequently fall well below their permit limits. Even with limits of 80 mg/l, the cumulative wastewater discharge would have to be well over 0.1 MGD to exert a significant impact to the stream. Estimated current discharges from the two cities are about 0.08 MGD and the two waste streams must traverse two separate stream reaches before potentially comingling in the lower Grouse Creek reach.

Additionally, the TSS generated by lagoon systems is usually biological in nature, e.g., algae masses, etc. The TSS addressed by the TMDL is dominated by sediment and its scour and depositional impacts to the stream channel habitat and biota. Therefore, lagoon wastewater treatment systems will be given broad latitude to continue to operate under current permit expectations unless it is demonstrated that these lagoon discharges are impairing Grouse Creek.

Waste load allocations are determined by multiplying design flow times the permit limit, and as design flows are singular values assigned in the permit, the waste load allocation remains constant over all flows. **Table 12** presents the applicable wasteload allocations for TP and TSS for Burden and Dexter. Under baseflow conditions, the full wasteload allocations will exceed the load capacity of Grouse and Silver Creek. Under those situations, there will be some in-stream assimilation of TP in the unnamed tributaries before reaching the classified streams, lower discharge rates because of evaporation off the lagoons lowering the hydraulic loading, and settling of any TSS entering the unnamed tributaries. Therefore, the applicable baseflow wasteloads are expected to match up with the load capacity of the receiving stream reach. Once normal flows occur, the full wasteload allocations may be allowed. Any future wasteloads would have to be offset by equivalent reductions in load allocations from non-point sources.

All other facilities, such as Cambridge or the animal feeding operations in the watershed, will have wasteload allocations of zero because they are not expected to discharge these pollutants to the stream system.

Table 12. TP and TSS loads and wasteload allocations for Burden and Dexter.

City	Design Flow	Est. Current Flow	Expected [TP]	TSS Limit	Current TP Load	TP WLA	Current TSS Load	TSS WLA
Burden	0.0612 MGD	0.0535 MGD	2 mg/l	80 mg/l	0.89 #//d	1.02 #/d	255.9 #/d	441.8 #/d
Dexter	0.580 MGD	0.0278 MGD	2 mg/l	80 mg/l	0.46 #/d	0.97 #/d	165.6 #/d	418.7 #/d

Non-point Sources: A majority of the loading into the Grouse Creek stream system is generated from non-point sources in the watershed. Since the chemical and biological integrity of Grouse Creek is high during baseflow and normal flow conditions, the gross load allocations assigned to non-point sources are established to maintain current loading patterns and desired water quality. **Tables 13 and 14** show the load allocations and load capacities for total phosphorus and total suspended solids to be maintained along various reaches of Grouse Creek and Silver Creek. Non-point source loads within each incremental reach can be distributed to activities along Grouse Creek or the tributaries that enter Grouse Creek within that reach. Baseflow is defined by the estimated lower quartile (75%) flow in each of those reaches, while normal flow is established as median flow.

Defined Margin of Safety: The margin of safety is both implicit with the assumption that the WLAs from Burden and Dexter will occur despite low population and that they would arrive undiminished to the receiving streams. But, because this TMDL is protection oriented, there will be an explicit expression of the margin of safety that applies to establishing load capacities under runoff conditions. Any occasional excursions from the desired endpoints for TSS or TP occur during seasonal runoff. Since current loadings during high flow are apparently not sufficiently impactful to cause a diminishment in the biological integrity of Grouse Creek nor excessively high concentrations of TSS or TP once the runoff event ends, any efforts to reduce pollutant loadings during runoff will work to further bolster the maintenance of the normal flow milestones and biological conditions. Runoff will be represented as the upper decile flow found on the reaches of Grouse and Silver Creeks. **Table 15** shows the applicable load allocations and capacities for TP and TSS during runoff. A seasonal load capacity will be expressed as 90 days of the desired daily loads. Any targeted reduction efforts during the runoff season will further increase the probability of maintaining water quality standards on Grouse Creek.

Table 13. TP load allocations and capacities at baseflow and normal flow on Grouse Creek.

Stream Location	Med. [TP] mg/l	Baseflow				Normal Flow			
		Flow (cfs)	WLA (#/d)	LA (#/d)	LC (#/d)	Flow (cfs)	WLA (#/d)	LA (#/d)	LC (#/d)
@ Cambridge	0.065	1.0	0.0	0.4	0.4	7.3	0.0	2.6	2.6
abv Cedar NPS				0.2				0.6	
Above Cedar Crk	0.065	1.8	0.0	0.6	0.6	9.1	0.0	3.2	3.2
Dexter WLA		0.09	0.8			0.1	1.0		
abv Crabb NPS		4.0		0.0		17.9		2.1	
Above Crabb Crk	0.065	4.1	0.8	0.6	1.4	18.0	1.0	5.3	6.3
abv Silver NPS				0.5				1.8	
Above Silver Crk	0.065	5.3	0.8	1.1	1.9	23.0	1.0	7.1	8.1
Burden WLA		0.10	0.4			0.1	1.0		
Silver Crk NPS		1.1		0.0		6.2		1.2	
Silver Creek	0.065	1.2	0.4	0.0	0.4	6.3	1.0	1.2	2.2
Lower Grouse NPS				0.3				0.6	
Lower Grouse Creek	0.065	7.3	1.2	1.4	2.6	31.0	2.0	8.9	10.9

Table 14. TSS load allocations and capacities at baseflow and normal flow on Grouse Creek.

Stream Location	Med. [TSS] mg/l	Baseflow				Normal Flow			
		Flow (cfs)	WLA (#/d)	LA (#/d)	LC (#/d)	Flow (cfs)	WLA (#/d)	LA (#/d)	LC (#/d)
@ Cambridge	20	1.0	0.0	108.0	108.0	7.3	0.0	788.4	788.4
abv Cedar NPS				86.4				194.4	
Above Cedar Crk	20	1.8	0.0	194.4	194.4	9.1	0.0	982.8	982.8
Dexter WLA		0.09	248.4			0.1	418.7		
abv Crabb NPS		4.0		0.0		17.9		542.5	
Above Crabb Crk	20	4.1	248.4	194.4	442.8	18.0	418.7	1525	1944
abv Silver NPS				129.6				540.0	
Above Silver Crk	20	5.3	248.4	324.0	572.4	23.0	418.7	2065	2484
Burden WLA		0.10	129.6			0.1	441.8		
Silver Crk NPS		1.1		0.0		6.2		238.6	
Silver Creek	20	1.2	129.6	0.0	129.6	6.3	441.8	238.6	680.4
Lower Grouse NPS				86.4				183.6	
Lower Grouse Creek	20	7.3	378.0	410.4	788.4	31.0	860.5	2488	3348

Table 15. TP and TSS load allocations and capacities during runoff on Grouse Creek**.**

Stream Location	Runoff Flow (cfs)	Desired [TP] mg/l	TP			Desired [TSS] mg/l	TSS		
			WLA #/d	LA #/d	Load Capacity		WLA #/d	LA #/d	Load Capacity
@ Cambridge	77	0.090	0.0	37.4	37.4	30	0.0	12474	12474
abv Cedar NPS				8.3				2754	
Above Cedar Crk	94	0.090	0.0	45.7	45.7	30	0.0	15228	15228
Dexter WLA	.09		1.0				418.7		
abv Crabb NPS	188.9			46.2				14971	
Above Crabb Crk	189	0.090	1.0	90.9	91.9	30	418.7	30199	30618
abv Silver NPS				24.8				8262	
Above Silver Crk	240	0.090		115.7	116.6	30	418.7	38461	38880
Burden WLA	0.10		1.0				441.8		
Silver Crk NPS	64.9			30.6				10088	
Silver Creek	65	0.090	1.0	30.6	31.6	30	441.8	10088	10530
Lower Grouse NPS				7.8				2592	
Lower Grouse Creek	321	0.090	2.0	154	156	30	860.5	51142	52002

State Water Plan Implementation Priority: Protection TMDLs are the exception to the norm in Kansas. Nonetheless, there is a current Watershed Restoration and Protection Strategy group housed within the Grouse-Silver Creek Watershed District #92 that is ready, willing and able to implement protective practices along the creeks in the watershed. There is currently a High Priority Dissolved Oxygen TMDL for Silver Creek that can concurrently be aided by implementation of this TMDL. This TMDL will be **High Priority** for implementation.

Nutrient Reduction Framework Priority Ranking: The Grouse Creek watershed lies within the Kaw Lake Subbasin (HUC8: 11060001) which is outside the top 16 HUC 8s targeted for State action on nutrient reduction.

Priority Stream Subwatersheds: The long-range priority focus for maintaining the chemical and biological quality of Grouse Creek is on four subwatersheds: 0102 (Lower

Silver Creek), 0205 (Plum-Grouse Creek), 0206 (Crabb Creek) and 0207 (Panther-Grouse Creek). Additionally, attention is drawn to the two upper subwatersheds: 0201 (Waggoner Creek) and 0202 (Gardners Branch). The allocations and load capacities determined for Silver Creek should be used to guide implementation in lower Silver Creek. The allocations and capacities for the location on Grouse Creek above Silver Creek (including Crabb Creek) should guide implementation in the 0206 and 0207 subwatersheds. The allocations and capacities for Grouse Creek above Crabb Creek but below Cedar Creek can guide implementation in subwatershed 0205. Finally, the allocations and capacities for Grouse Creek at Cambridge will guide implementation in the upper two subwatersheds of Grouse Creek.

Implementation should be keyed to load reductions necessary to achieve the capacities under runoff conditions. The WRAPS may plan and schedule load reductions over time for smaller areas within the applicable subwatersheds analyzed by this TMDL. Therefore, planned load reductions may not align tightly with the margin of safety capacities and allocations of this TMDL, but, given the dynamics of storm flow pollutant loading in this watershed, any designed reduction during runoff will serve to maintain the endpoints and milestones of this TMDL. After a five-year period of implementation, both the plan and TMDL may be revisited for adjustments to planning and implementing load reductions.

5. IMPLEMENTATION

Desired Implementation Activities: Standard nutrient and sediment management and erosion control to abate loads during runoff events will be the primary implementation activities for this TMDL. Such activities will center on application of no-till farming, grassed waterways, vegetative buffers, terraces, cover crops and nutrient management plans on cropland areas. Livestock impacts will be managed by feeding site relocations, development of off-stream watering systems and grazing management. Some streambank stabilization may be applied in spots, as will treatment wetlands and on-site wastewater treatment system upgrades.

Implementation Programs Guidance:

NPDES and State Permits – KDHE:

a. Monitor effluent from the discharging lagoon systems to confirm low wasteload contributions of TP and TSS to Grouse and Silver Creeks.
b. Inspect permitted livestock facilities to ensure compliance.
c. Ensure pollution prevention practices are employed by animal feeding operations and ensure manure is managed, including proper land application rates that will prevent runoff of applied manure.

Nonpoint Source Pollution Technical Assistance – KDHE

a. Support implementation projects for reduction of runoff loads of TP and TSS from cropland, including erosion and sediment control practices.
b. Provide technical assistance on practices geared to the establishment of vegetative buffer strips.
c. Guide federal programs, such as the Environmental Quality Improvement Program and Conservation Security Program, to support installation of cropland and grazing Best Management Practices in Grouse Creek watershed.
d. Coordinate and support the Grouse Creek WRAPS group to incorporate a long-term plan to comprehensively reduce the loading and delivery of runoff-borne TSS and TP in the Grouse Creek watershed.
e. Encourage the review and revision of the WRAPS watershed plan in 2017 to incorporate information from implementation and monitoring efforts.

Water Resource Cost Share and Nonpoint Source Pollution Control Programs – KDA-DOC:

a. Apply conservation farming practices, including terraces and waterways, sediment control basins, and constructed wetlands in cropland.
b. Provide sediment control practices to minimize erosion and sediment and nutrient transport from cropland and grassland in the watershed.
c. Support installation of livestock management practices.

Riparian Protection Program – KDA – DOC:

a. Establish or re-establish natural riparian systems, including vegetative filter strips along small tributaries.
b. Develop riparian restoration projects in cropland and grazed areas.

Buffer Initiative Program – KDA-DOC:

a. Install buffer strips along small streams.
b. Work in conjunction with federal Conservation Reserve Enhancement Program and Conservation Security Program to hold marginal riparian land out of production.

Extension Outreach and Technical Assistance – Kansas State University:

a. Educate agriculture producers on cropland and livestock management and effective BMPs that reduce nutrient and sediment runoff.
b. Provide technical assistance on buffer strip design, techniques to minimize cropland runoff and construction of livestock feed and watering sites.
c. Provide planning assistance to local interests to support WRAPS activities in the Grouse Creek watershed.

Time Frame for Implementation: Pollutant reduction strategies and pollutant source assessment should be initiated within the Grouse Creek watershed in 2013 through the 9-element watershed plan for the Grouse-Silver Creek WRAPS. Pollutant reduction practices and implementation activities within the watershed should be initiated by 2013 and continue through 2020.

Targeted Participants: The primary participants for implementation will be agricultural operations immediately adjacent to streams within the watershed. Watershed District and Conservation district personnel and county extension agents should conduct a detailed assessment of sources adjacent to streams within the watershed over 2013 in conjunction with the 9-element watershed plan of the WRAPS. Implementation activities should target those areas that are located within a half mile of the streams within the watershed.

Milestone for 2017: In accordance with the long-range TMDL development schedule for the State of Kansas and the WRAPS watershed plan, the year 2017 marks the next cycle of 303(d) and 319 review of implementation data, stream chemistry and biological data for the Grouse Creek watershed. Runoff concentrations should show some reduction and median TP and TSS values during normal flow should be at or below current concentrations on Grouse Creek.

Delivery Agents: The primary deliver agents for program participation will be the Cowley County Conservation District, the Kansas State University Extension Service and the Grouse-Silver Creek WRAPS team (Grouse-Silver Creeks Watershed District #92). Implementation decisions and scheduling will be guided by planning documents prepared through the Grouse-Silver Creek WRAPS.

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

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's Division of Conservation (formerly State Conservation Commission) to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

3. K.S.A. 75-5657 empowers the Division of Conservation to provide financial assistance for local project work plans developed to control nonpoint source pollution.

4. K.S.A. 82a-901, et. seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan*, including selected Watershed Restoration and Protection Strategies.

6. The *Kansas Water Plan* and the Lower Arkansas and Walnut Basin Plans 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 programs supporting water quality protection through the WRAPS program. This watershed and its TMDL are High Priority consideration for funding.

Effectiveness: Nutrient and sediment control has been proven effective through conservation tillage, including no-till, contour farming, and use of grass waterways and buffer strips and filters. Proper implementation of comprehensive livestock and waste management plans and practices has been effective in reducing nutrient runoff associated with livestock and secured streambanks and channels from livestock trampling.

6. MONITORING

KDHE will continue to collect chemical and biological samples from Grouse and Silver Creeks at the permanent station on lower Grouse Creek and the rotational sites on Silver and upper Grouse Creek. The next scheduled visits to the rotational sites will be in 2014. Macroinvertebrate sampling and sestonic (floating) chlorophyll-a samples will be collected at both the lower and upper Grouse Creek sites. Additional sampling, such as ongoing efforts by Southwestern College, may be sponsored by the Grouse-Silver Creek WRAPS within the watershed to assess improvement in possible contributing areas.

7. FEEDBACK

Public Notice: An active internet website was established at http://www.kdheks.gov/tmdl/index.htm to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Lower Arkansas Basin.

Public Hearing: Since this is a protection TMDL, no approval from EPA is necessary and a Public Hearing on the TMDL was foregone.

Basin Advisory Committee: The Walnut Basin Advisory Committee met to discuss this TMDL on March, 2013. (Under planning protocols of the Kansas Water Office, the

Grouse Creek Watershed falls under the Walnut Basin Advisory Committee for planning purposes.

Watershed Restoration and Protection Strategy Group: This TMDL has been reviewed in 2013 by the Grouse-Silver Creek WRAPS group.

Milestone Evaluation: In 2017, evaluation will be made as to the degree of implementation which has occurred within the watershed pursuant to the Grouse-Silver Creek WRAPS 9-element plan. 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 watershed in 2017 with consultation from local stakeholders and WRAPS teams.

Developed January 25, 2013

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Appendix A. Classified Streams in Grouse Creek watershed.

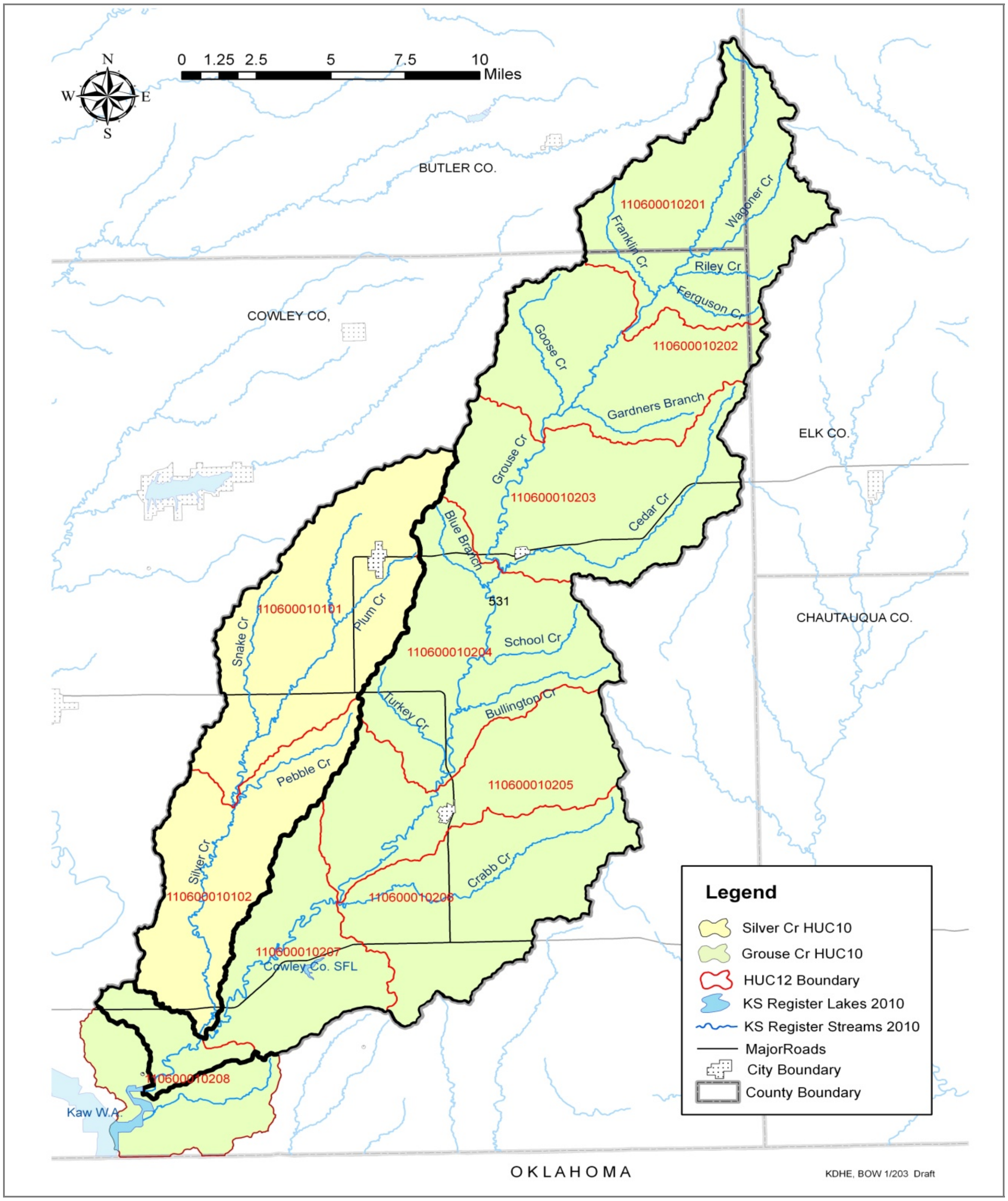

Figure A.1. Classified streams in Grouse Creek watershed.