SMOKY HILL-SALINE BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: Big Creek
Water Quality Impairment: Total Phosphorus

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Big **Counties**: Russell, Ellis, Trego, Gove, and Sheridan

HUC8: **10260007**
HUC10 (HUC12): **01** (01, 02, 03, 04)
02 (01, 02, 03, 04)
03 (01, 02, 03, 04, 05)
04 (01, 02, 03, 04, 05)

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

Drainage Area: 862 square miles

Main Stem Water Quality Limited Segments (Appendix A): Big Creek Segment 1 in Russell County; Segments 3 & 5 in Ellis County; Segment 7 in Trego & Gove Counties

Main Segment	**Tributaries**
Big Creek (1)	Walker Cr (2)
Big Creek (3)	North Fork Big Creek (4) Mud Cr (9)
Big Creek (5)	Chetolah Cr (8)
Big Creek (7)	Ogallah Cr (6)

Designated Uses: For Big Creek – all segments (1, 3, 5, & 7): Expected Aquatic Life Support, Food Procurement, Domestic Water Supply, Industrial, Irrigation and Livestock Watering and Ground Water Recharge. Primary Contact Recreation "C" on Segment 1; Primary Contact Recreation "B" on Segment 5; Secondary Contact Recreation "b" on Segments 3 and 7.

For tributaries – Expected Aquatic Life Support and Secondary Contact Recreation "b" on all tributaries (Secondary "a" on Chetolah Creek); Domestic Water Supply, Industrial and Irrigation Water Supply, Livestock Watering and Ground Water Recharge also on Walker Creek and North Fork Big Creek; Food Procurement also on North Fork Big Creek.

303(d) Listings: Kansas Stream segments monitored by Station SC540 cited as impaired by phosphorus in the 2008-303(d) list for the Smoky Hill – Saline Basin. Station SC541, located above the Chetolah Creek confluence was not cited for phosphorus, but its median concentration from recent data exceeds the listing threshold (201 ppb); therefore, the phosphorus impairment extends above Hays. Station SC715 on the North Fork Big Creek is not cited for phosphorus, but its median concentration of a small sample size from 1995, 1999 & 2003 was also elevated.

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

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

The introduction of plant nutrients into 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 2008- 303(d): Phosphorus levels on Big Creek below Hays are consistently high, and despite downstream biological transformations uptaking phosphorus, elevated levels of total phosphorus occur in the lower reaches, supporting undesirable quantities and types of algae in the stream.

Stream Monitoring Sites and Period of Record: KDHE permanent ambient Stream Chemistry sampling station SC540, located on Big Creek 0.5 miles east of Munjor has data from 1990-2010 **(Figure 1)**. A permanent sampling station, SC541, located on Big Creek at the U.S. 183 bypass bridge on the west edge of Hays has data from 1990-2010. A new station, SC752, south and west of Russell began sampling in 2009. A rotational sampling station, SC715, on the North Fork of Big Creek is located southwest of Walker and has data from 1995, 1999, 2003 and 2010. Visits to the station in 2006 yielded no samples because of lack of flow. Additionally, probabilistic monitoring sites on Big Creek at Ogallah and Ellis were sampled 2-4 times in 2008-09.

Supplementing the routine KDHE sampling, the Big Creek-Middle Smoky Hill Watershed Restoration and Protection Strategy (WRAPS) group has sampled throughout the basin since 2007. This sampling fills in the spatial gaps of the state network and also provides more targeted sampling of runoff events.

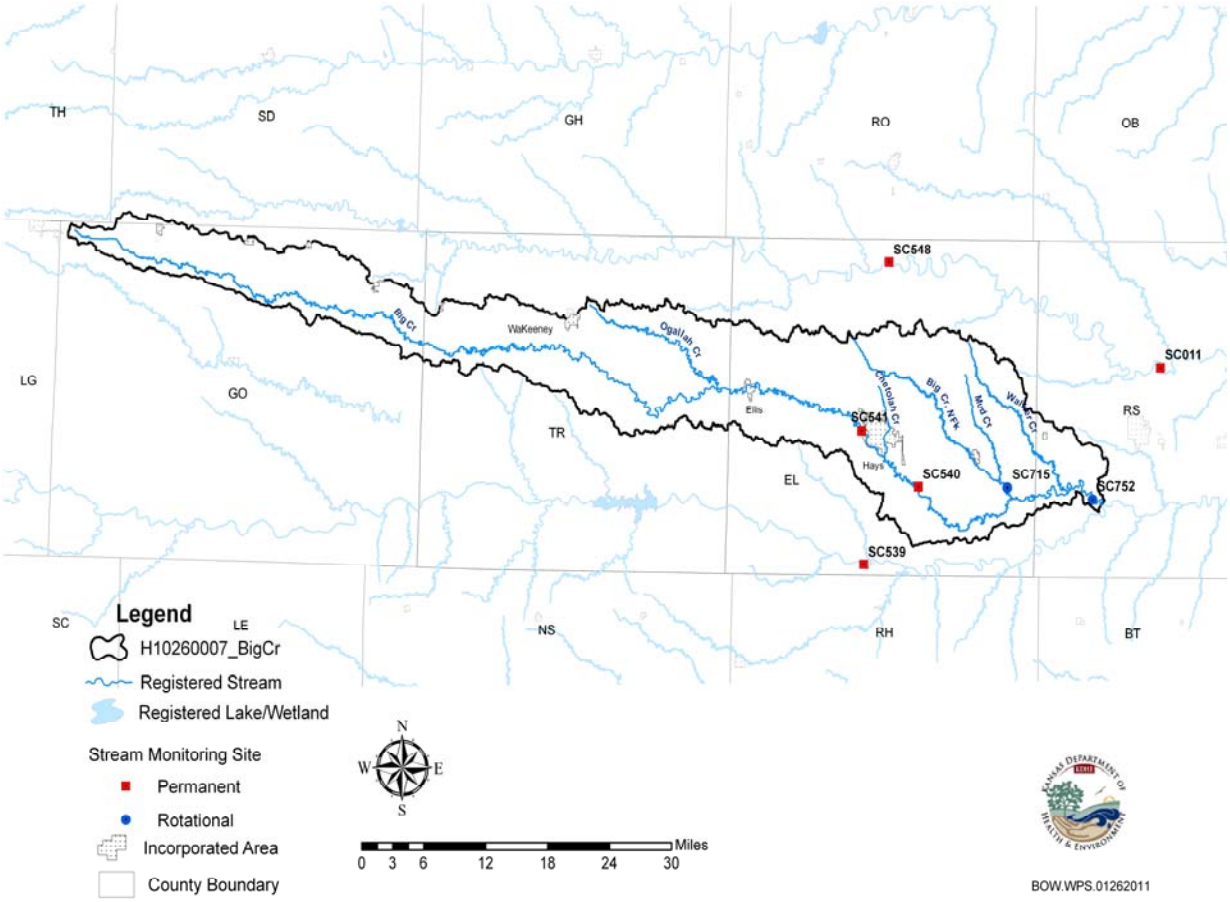


Figure 1. **Big Creek Subbasin with KDHE monitoring stations.**

Hydrology: The USGS has maintained a gaging station (06863500) on Big Creek at Highway 183 south of Hays over 1946-2009. Shorter term stations recorded flow on Big Creek at Ogallah (1955-1968) and near Russell (1962-1964). A gaging station was operated on the North Fork of Big Creek near Victoria over 1962-1987. **Table 1** displays the general flow conditions estimated at locations along Big Creek. Approximately half the flow is generated west of the Ellis-Trego county line. However, a comparison of daily flows over a 14-year period on Big Creek between Hays and Ogallah indicates substantially lower flows in Trego County than those seen at Hays **(Figure 2).** Conversely, in the brief time flow was measured at Hays and at Russell, there was consistent downstream gain in flow (**Figure 2**). The most severe drought seen on Big Creek occurred in 2006 **(Figure 3).** Between July 2005 and December 2006, only two visits out of eight on Big Creek above Hays yielded water samples. Ground water support of flow in Big Creek is nominal in Gove and Trego counties where the High Plains Aquifer underlies the stream channel; however, the saturated thickness in those areas is only roughly 50 feet with declines of 0-5 feet over 2002-2007 **(Figure 4).**

Ground water support in Ellis and Russell counties is restricted to the alluvium of Big Creek. Upstream flows tend to be retained in Ellis by the city lake (formed by damming Big Creek). Ellis wastewater discharges average 0.43 cfs over 2004-2009. Hays wastewater averages 2.94 cfs over 2003-2009.

Table 1. Long Term Estimated Flows on Big Creek at certain locations (from Perry, 2004).

Location	Drainage Area	Mean Flow	90%	50%	10%	2-yr Peak
Gove-Trego County Line	186 sq.mi	9.4 cfs	0.08 cfs	0.86 cfs	5.3 cfs	811 cfs
Above Ogallah Crk	339 sq.mi	23 cfs	0.41 cfs	3.5 cfs	18.6 cfs	1340 cfs
Trego-Ellis County Line	432 sq.mi	27 cfs	0.97 cfs	5.1 cfs	25 cfs	1340 cfs
Above Chetolah Creek	521 sq.mi	31 cfs	1.5 cfs	6.7 cfs	33 cfs	1310 cfs
Above North Fork Big Creek	620 sq.mi	35 cfs	1.9 cfs	8.3 cfs	41 cfs	1320 cfs
Ellis-Russell County Line	788 sq.mi	45 cfs	1.9 cfs	10.4 cfs	54 cfs	1610 cfs
Mouth	862 sq.mi	51 cfs	1.9 cfs	11.7 cfs	62 cfs	1760 cfs

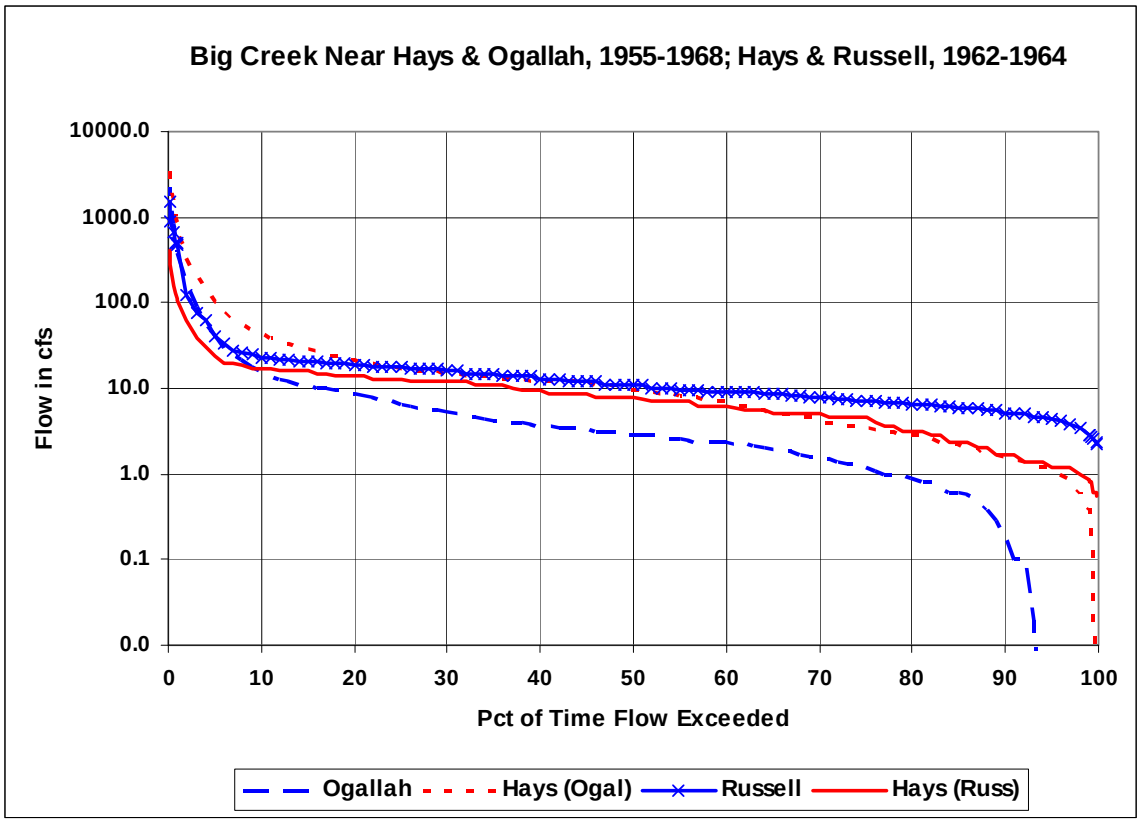


Figure 2. Flow Duration on Big Creek at Hays, Ogallah & Russell in Similar Years

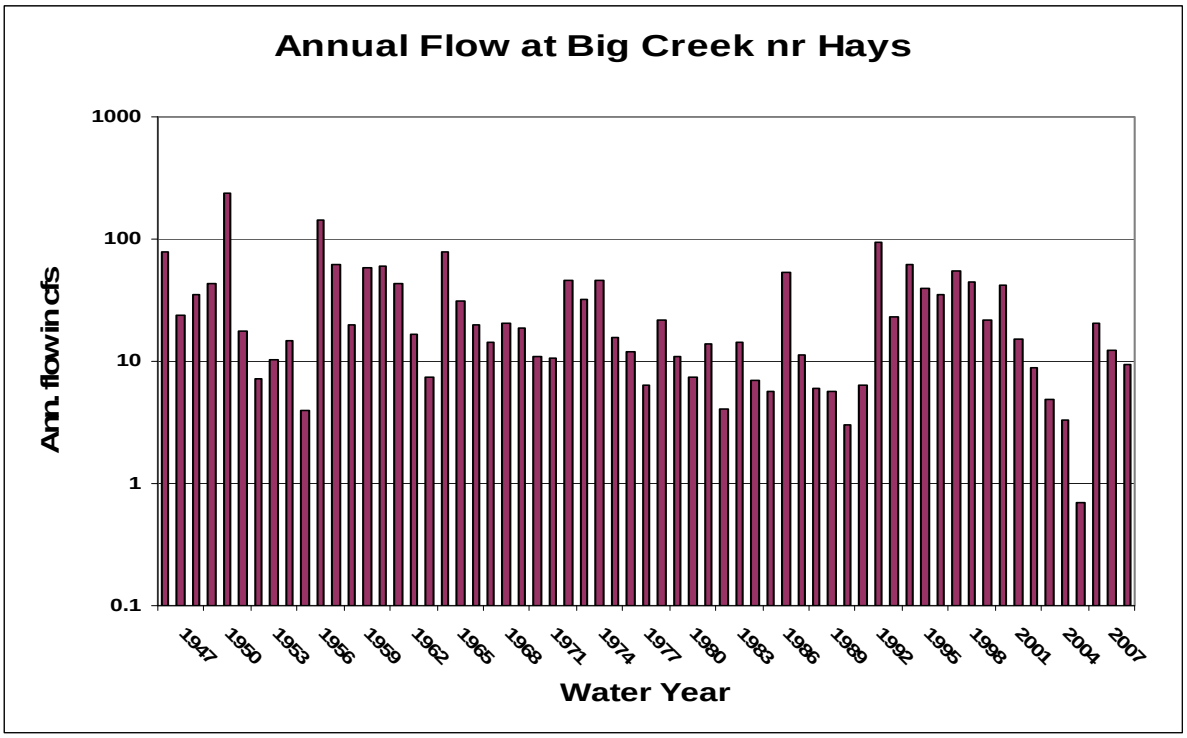


Figure 3. Average Annual Flow on Big Creek; 1947 - 2008

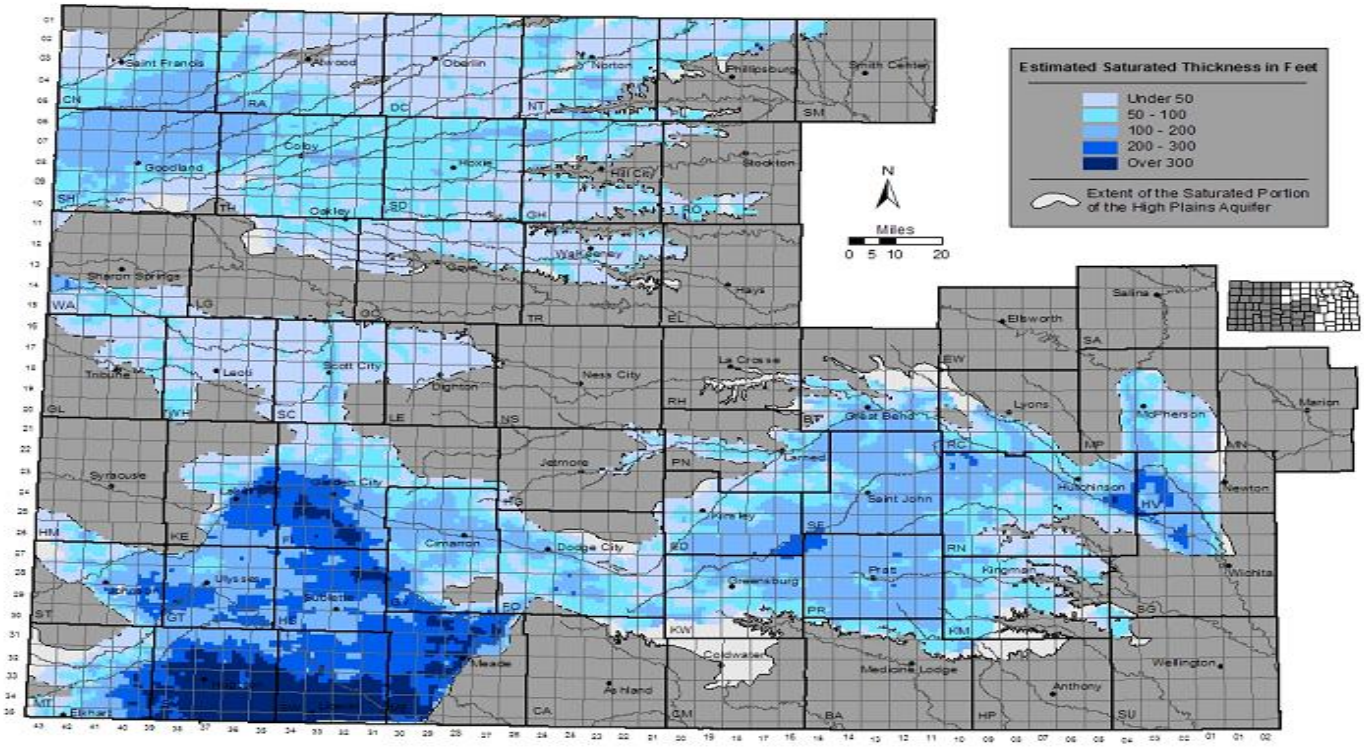


Figure 4. High Plains Aquifer Saturated Thickness

Use attainability analysis surveys conducted by KDHE staff over 2004-2008 along Big Creek and its tributaries provided a picture of steady flow along the creek in Ellis and Russell counties, but intermittent flows, channel pools and dry channel beds in Trego and Gove counties. Field observations by Division of Water Resources staff from the Stockton Field Office indicate that flow on Big Creek is very intermittent (~50% of the time) at Ellis, increases slightly toward Yocemento and then declines as the creek enters the incorporated area of west Hays.

Wastewater effluent from Ellis typically does not flow into the Hays area. However, flows are nearly constant below the confluence with Chetolah Creek transporting Hays wastewater. Since elevated phosphorus is seen at the Munjor site, but typically not above Hays during low flow, this TMDL will presume Ellis wastewater is not responsible for the high phosphorus seen in the downstream reach. Therefore, low flow conditions will be viewed as restricted to that portion of Big Creek in the vicinity of Yocemento in central Ellis County to its mouth southwest of Russell.

Peak flows, comprised of runoff from the rural watershed and urban stormwater occurs routinely on the lower portions of Big Creek. Annual peak flows seen at the USGS gaging station show peaks orders of magnitude greater than the long term daily average flow **(Figure 5**). Since 1973, peak flows have diminished in volume and frequency. This may reflect a drying of the watershed because of ground water lowering and a proliferation of watershed impoundments and conservation practices on cropland retaining rainfall (Koelliker, 1998)

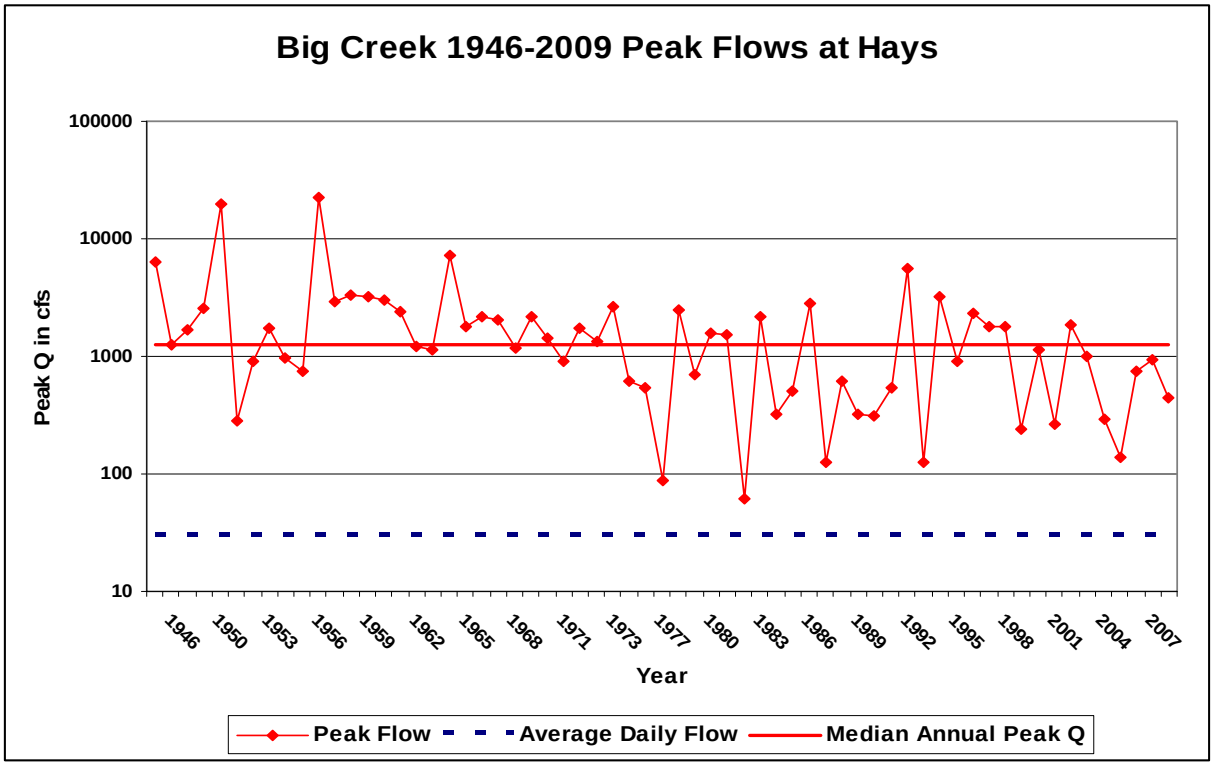


Figure 5. Annual peak flows on Big Creek at Hays

Flow duration data at the USGS gaging station at Hays indicate flows during the period of record for KDHE sampling on Big Creek (1990-present) have declined under dry conditions relative to the 45 years prior to sampling **(Figure 6).** Conversely, flows in the mid-range condition were slightly elevated compared to the past, perhaps reflecting slightly lower high flows (<5% exceedance). Sampling covers most of the flow range seen on Big Creek, with the exception of the highest flows.

The distribution of monthly average flows before and after 1990 is fairly similar with the exception of significant decline in flows during June and July, indicating reduced runoff from the upstream watershed **(Figure 7).** Hydrograph separation of daily flows into baseflow and runoff for the two periods indicates the average runoff for 1946 – 1989 was 0.78 inches; while the runoff averaged 0.45 inches for 1990 – 2010. Baseflow made up 44 percent of the flow prior to 1990 and has proportionately increased in the recent decades, comprising 59 percent of streamflow since 1990. Within the sampling period of record, the current decade is drier than the 1990's **(Figure 8).** Flow recovered over 2007 – 2010. Very dry conditions returned in late 2010, with some average monthly flows in July through December an order of magnitude less than the average flows over the sampling period of record of 1990 – 2009 **(Figure 7).**

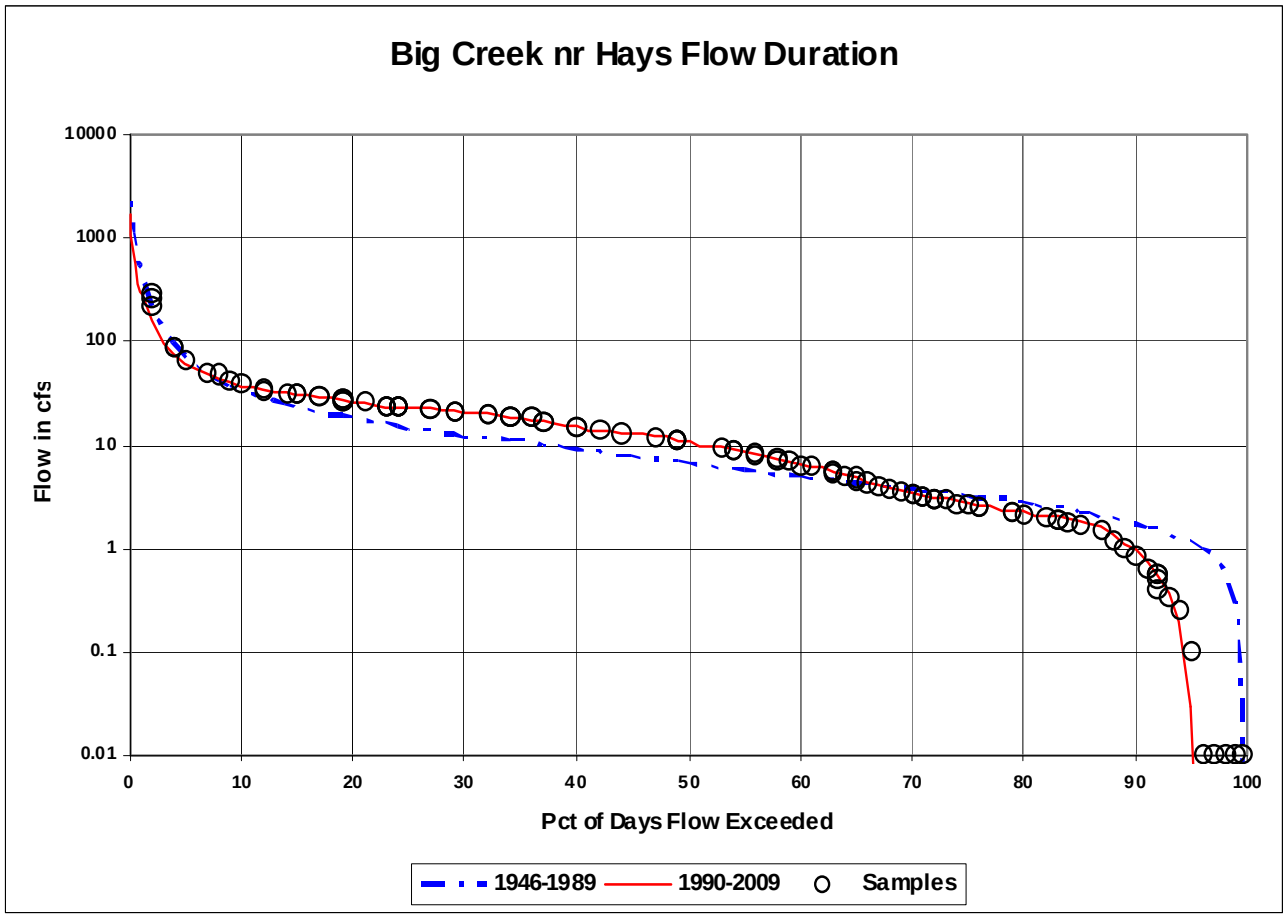


Figure 6. Big Creek Flow Duration Before and During KDHE Sampling

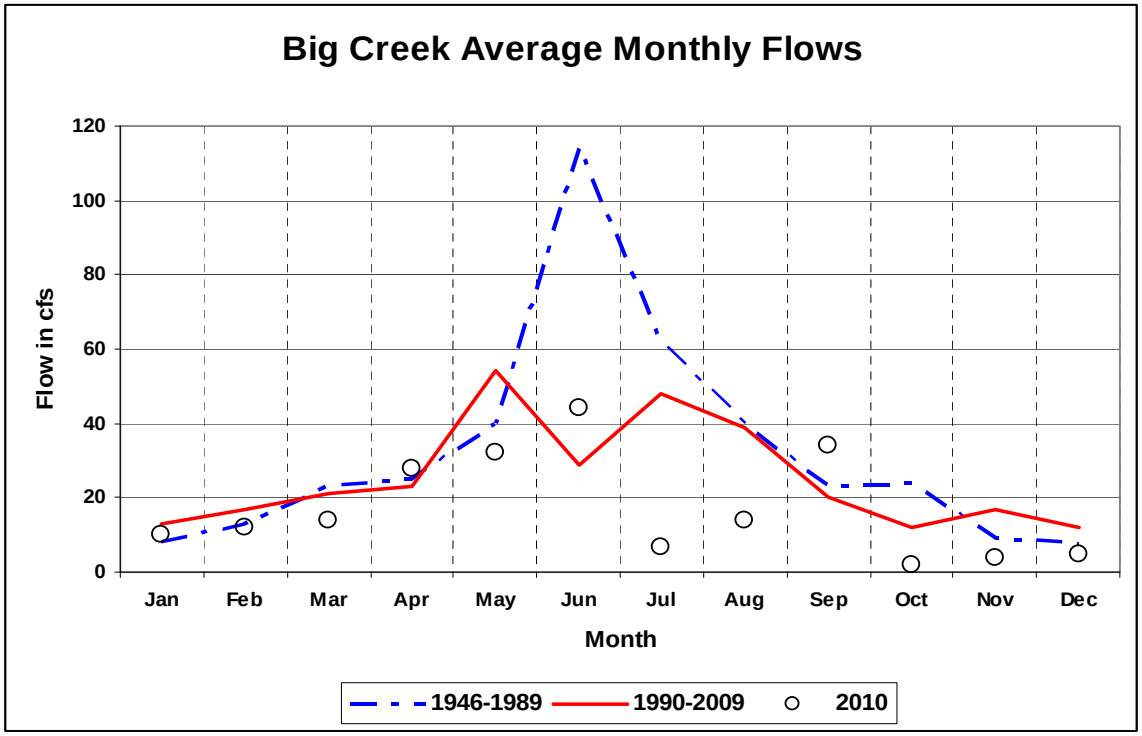


Figure 7. Average Monthly Streamflows on Big Creek Prior to and After 1990.

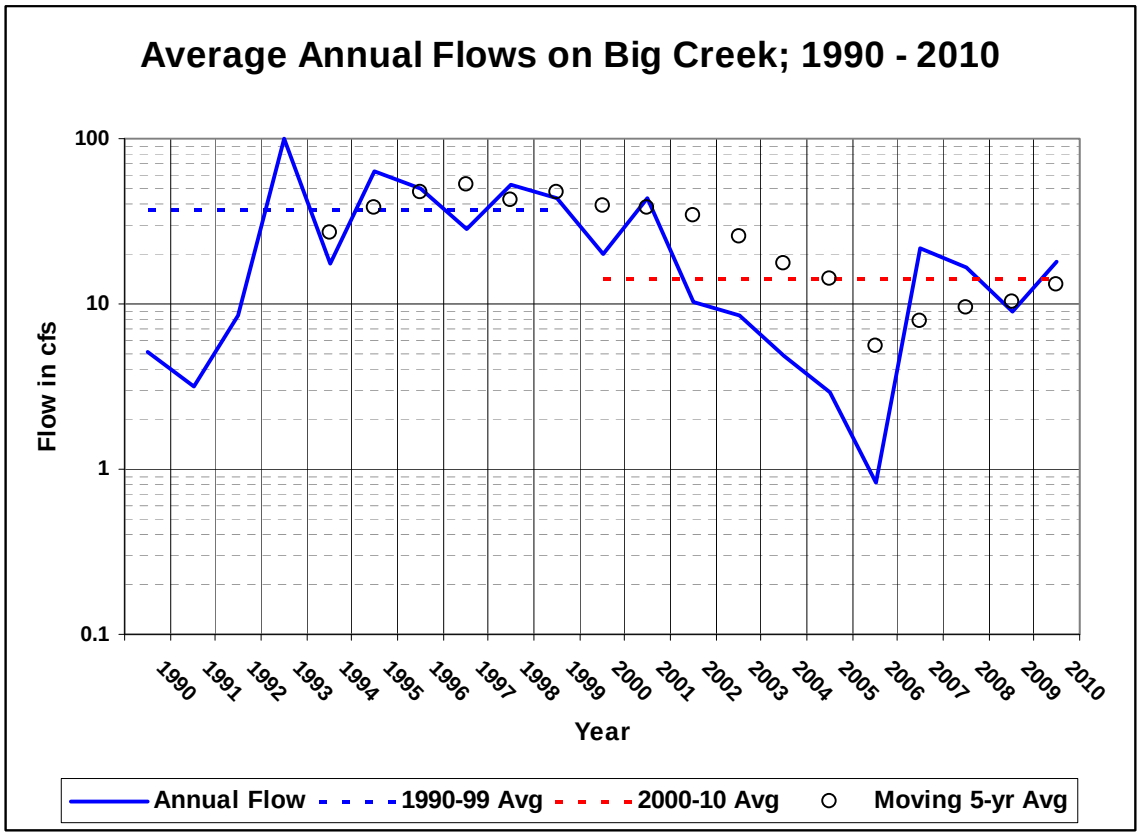


Figure 8. Average Annual Streamflows on Big Creek During KDHE Sampling Period

Phosphorus Concentrations: Phosphorus concentrations are significantly higher at the Munjor site (SC540) than the upstream Hays site (SC541); **(Figure 9**). Overall phosphorus concentrations average 1.96 mg/l at the lower station and 0.244 mg/l at the upper station. Phosphorus concentrations reflect four separate conditions seen on Big Creek over 1990-2010. The first was a relatively dry period of 1990-1992 (median flow of 2.7 cfs), terminated by the large flows of 1993. This was followed by a relatively wet period from 1993 – 2002 (median flow of 21 cfs), then a second extremely dry period from 2003-2006 (median flow of 1.6 cfs). The final period of 2007 – 2010 was moderate (median flow of 8.8 cfs). Upstream phosphorus concentrations averaged 0.317, 0.264, 0.144 and 0.224 mg/l for the four respective periods, typical of a non-point source dominated system. Meanwhile, the four respective average phosphorus concentrations downstream of Hays were 4.822, 0.981, 2.565 and 1.145 mg/l, indicative of point source influences.

Because of the large variability in ambient phosphorus concentrations, median values are appropriate for determining long term condition. Listing on the 2008 Section 303(d) list for phosphorus was determined by median concentrations exceeding 0.201 mg/l for any station. Median phosphorus concentrations on Big Creek above Hays over 1990-2009 were 0.213 mg/l; the median for the downstream station was 1.23 mg/l.

Total phosphorus levels at Munjor are significantly higher than those at the upstream Hays station (**Figure 10**). The influence of wastewater loading is indicated by the consistent increase in the dissolved form of phosphorus, ortho-phosphate (**Figure 11**) in the downstream direction. There is a seasonal pattern in phosphorus concentrations on Big Creek with the least difference in concentrations above and below Hays occurring during the runoff period of May through July (**Figure 12**).

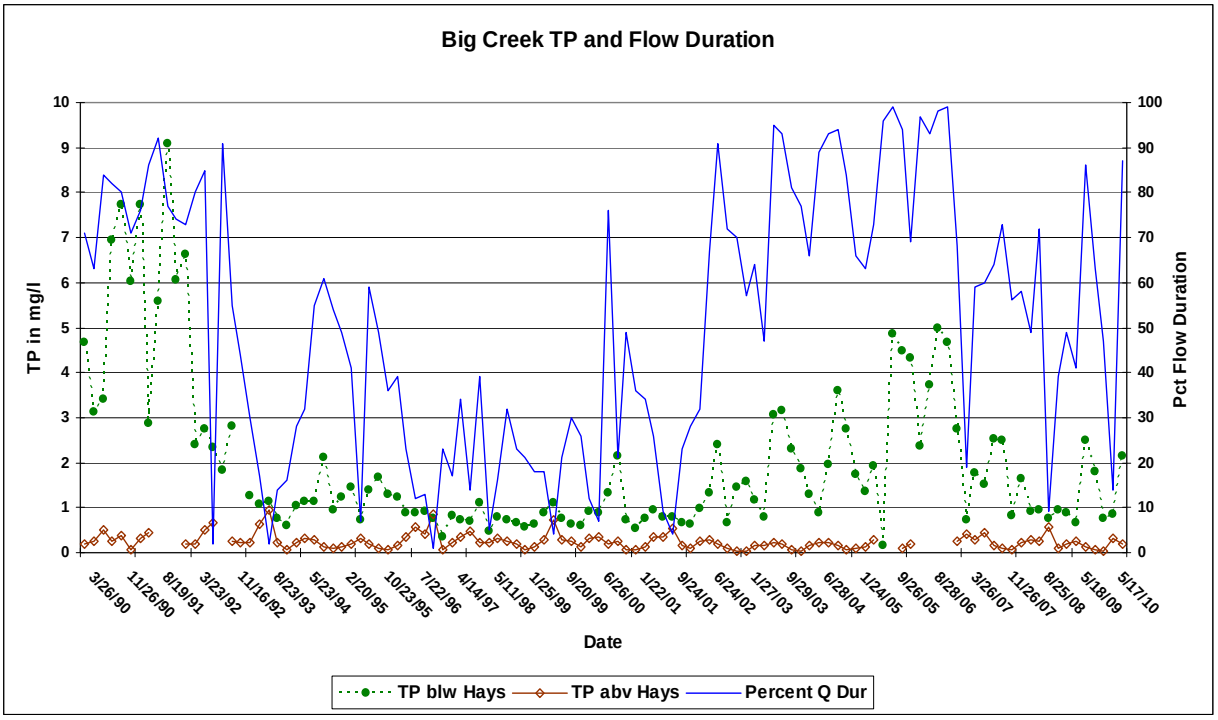


Figure 9. Phosphorus Concentrations Above and Below Hays and Flow Condition Since 1990

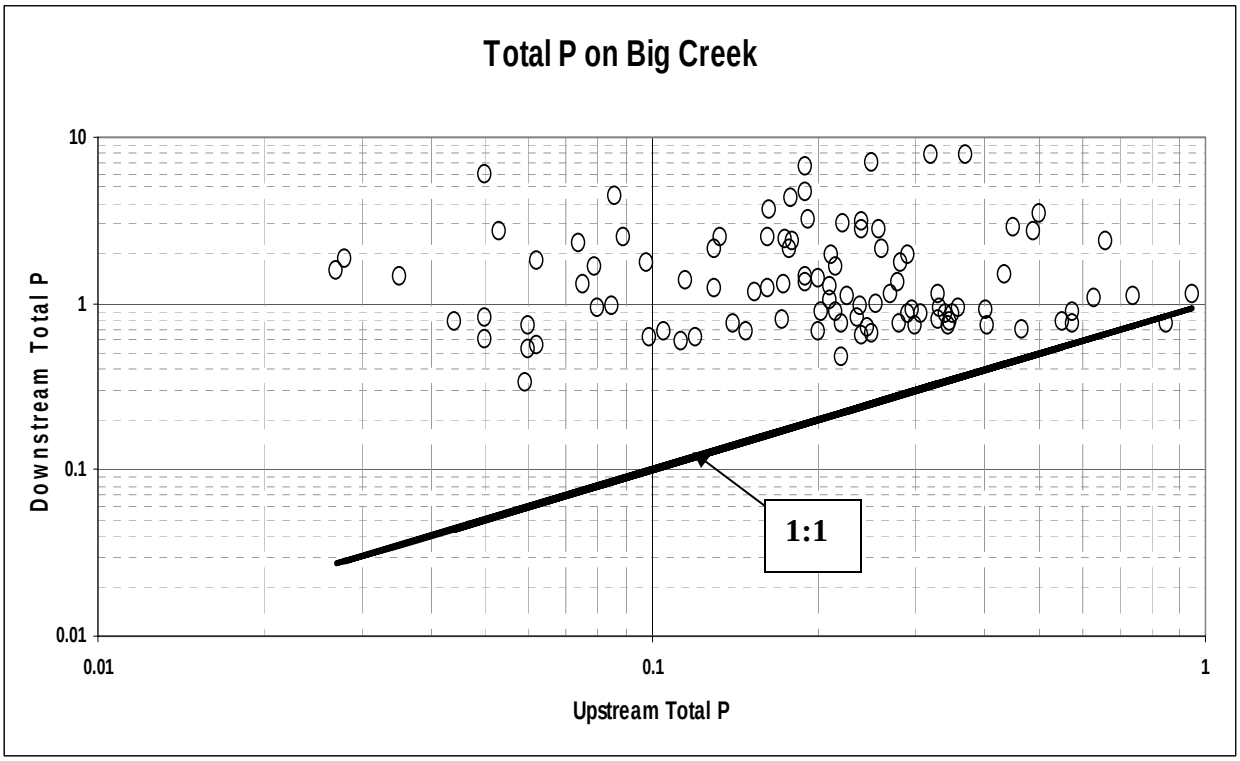


Figure 10. Concurrent Total Phosphorus Levels on Big Creek Above & Below Hays

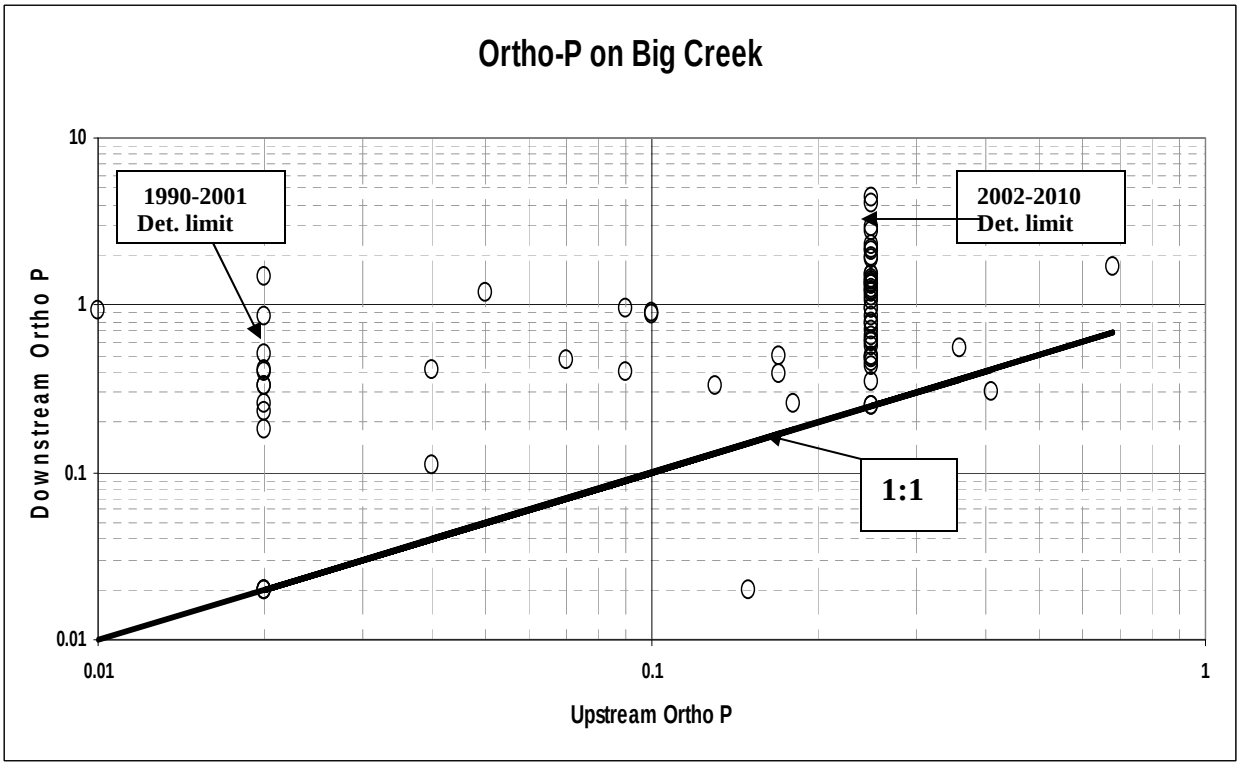


Figure 11. Concurrent Ortho-phosphate Levels on Big Creek Above & Below Hays

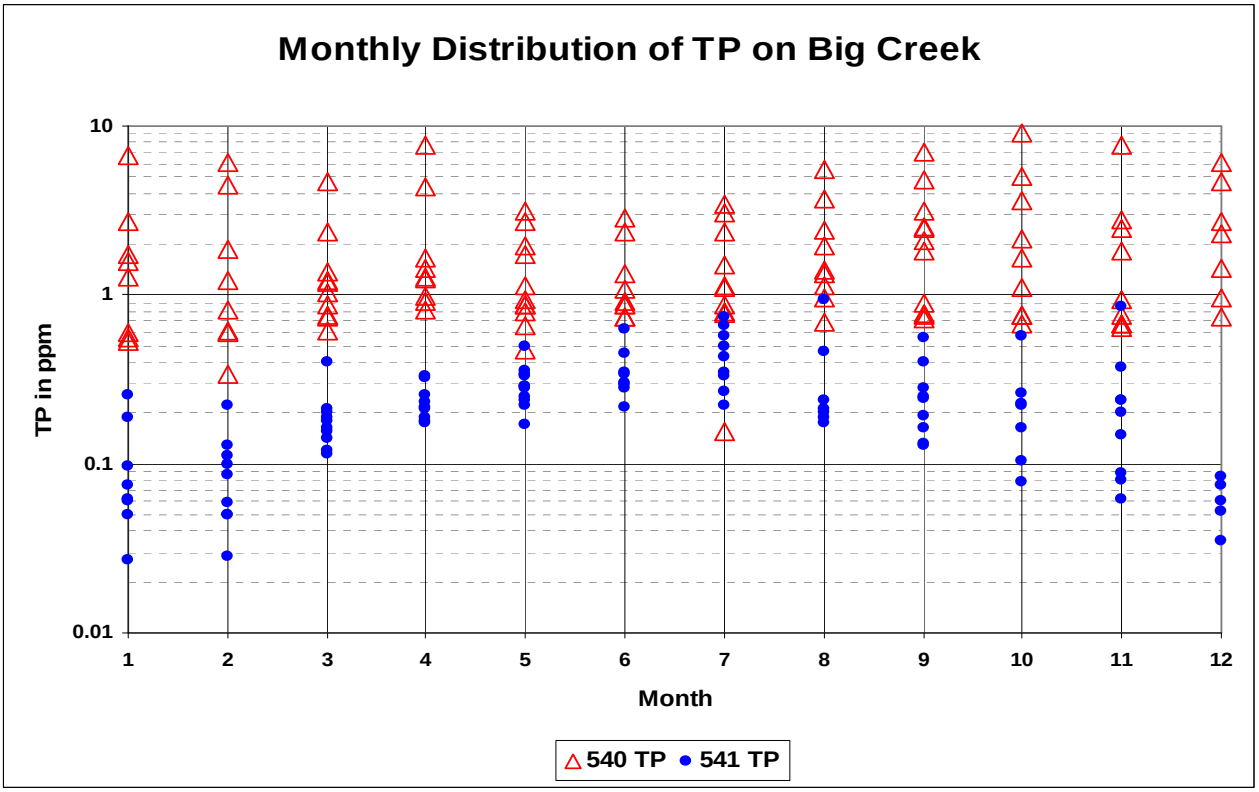


Figure 12. Monthly Distribution of Total Phosphorus on Big Creek

Seasonal (hydrologic) medians for phosphorus at the upstream station are 0.083 mg/l for winter (November – February); 0.22 mg/l for spring (March – May); 0.33 mg/l for summer (June – August); and 0.223 mg/l for fall (September & October). The associated seasonal medians for the downstream Munjor station are 1.285 mg/l; 1.13 mg/l; 1.13 mg/l & 1.97 mg/l, respectively. Seasonal concentrations are generally not significantly different at the lower station, although there is a slight, persistent difference between Spring and Fall phosphorus levels. Conversely, phosphorus concentrations are significantly different among seasons, except Spring and Fall on Big Creek above Hays. The upstream station reflects seasonal loading patterns from the watershed, while the downstream station is largely buffered from seasonal changes because of the constant wastewater input from Hays.

Although, there is always more phosphorus in the lower reaches, runoff tends to increase phosphorus at the upstream station and somewhat dilutes the wastewater effluent at the downstream Munjor site (**Figure 13**). As flows increase, phosphorus levels decline at the lower station. Meanwhile, the upper station displays the typical rural Kansas pattern of stream phosphorus, fairly constant concentrations from low flow to mean daily flow (~ upper quartile flow), followed by a marked rise with increased runoff. The concentrations of the two stations begin to merge at the highest flow conditions.

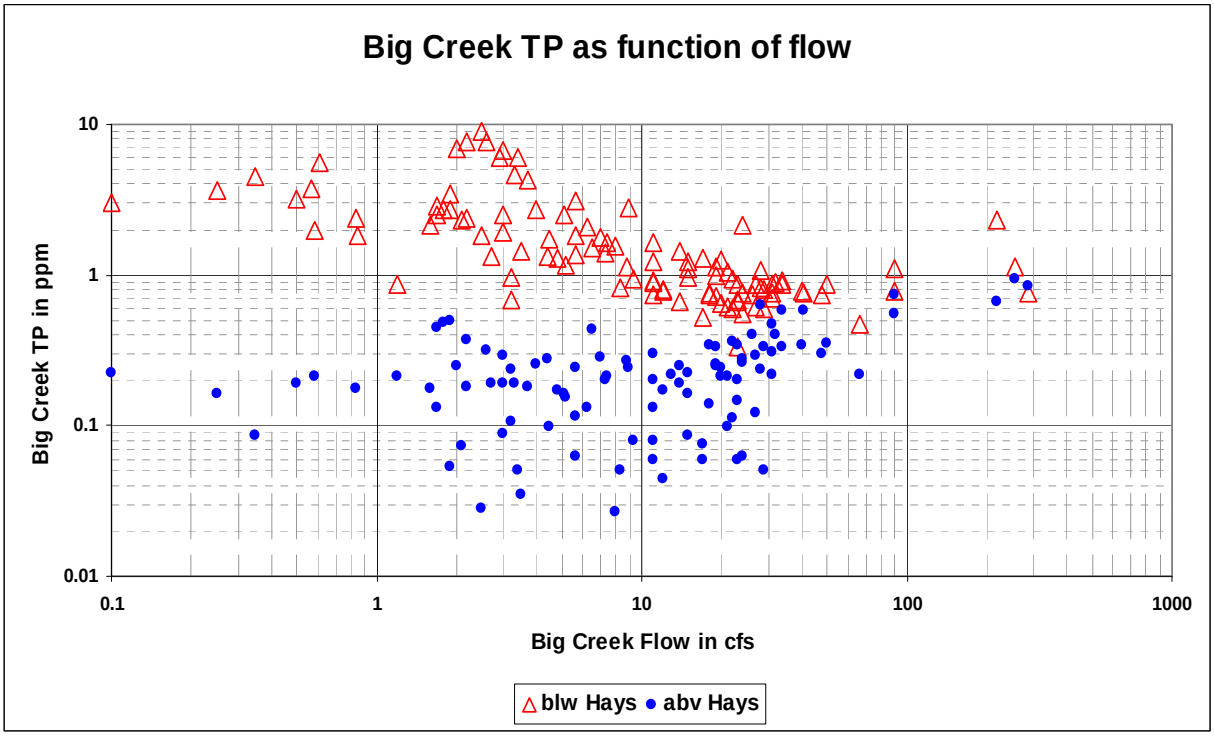


Figure 13. Total Phosphorus on Big Creek as Flow Varies

Phosphorus is typically linked to sediment or total suspended solids because of the propensity of those solids to adsorb phosphorus. TSS levels on Big Creek are only slightly distinct between upstream and downstream stations, probably due to increased contributing area downstream (**Figure 14**). Phosphorus shows a strong relationship with TSS at the upstream station, reflecting the non-point source loadings from the upper watershed (**Figure 15**). There is a notable lack of relation between TSS and phosphorus at the downstream station, indicative of the dominant influence of Hays wastewater with its elevated phosphorus and low TSS content.

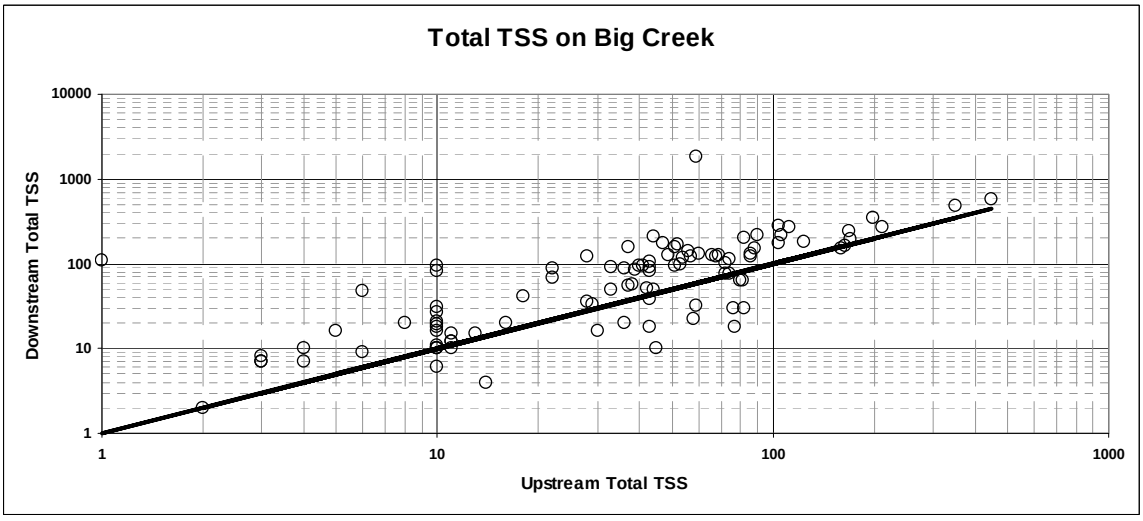


Figure 14. Total Suspended Solids Concentrations on Big Creek Above & Below Hays

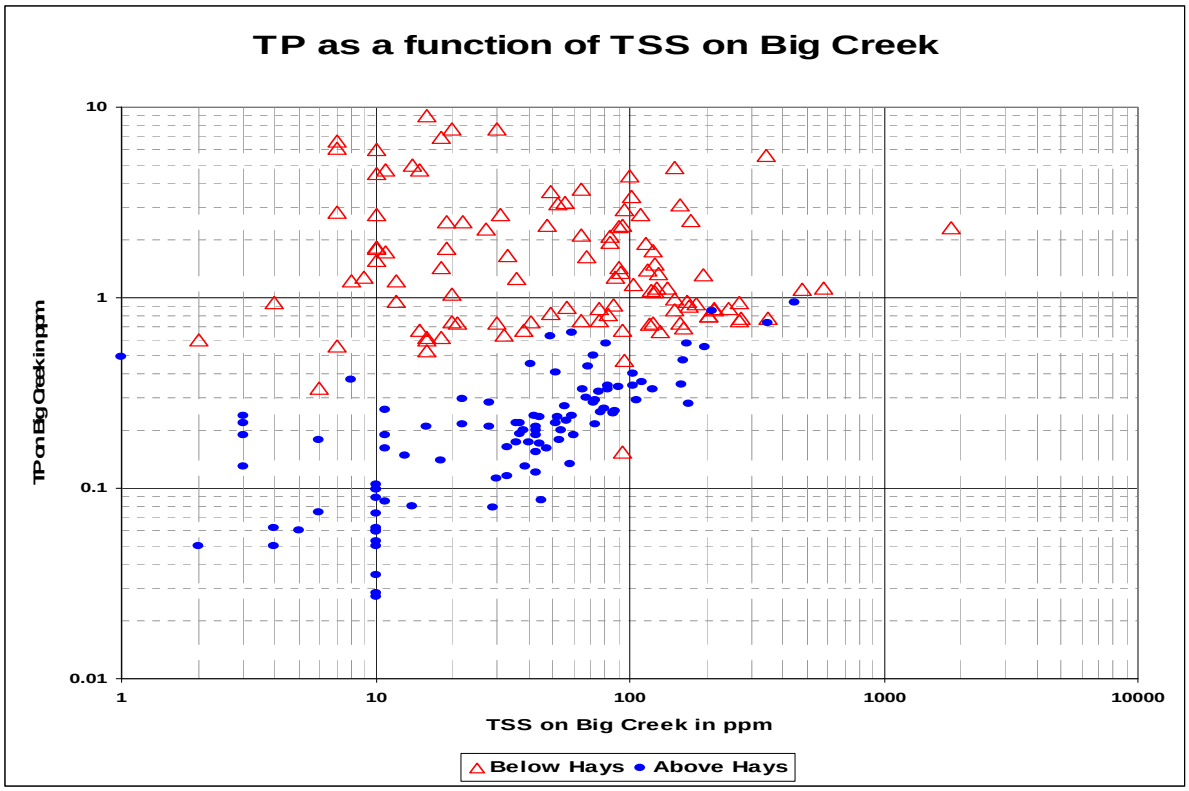


Figure 15. Phosphorus – TSS Relations on Big Creek Above & Below Hays

Therefore, there are three mechanisms in place dictating phosphorus concentrations in the lower reaches of Big Creek. The first factor is the effect of Hays' wastewater on downstream hydrology and nutrient content. The second influence is non-point sources in proximity to Big Creek that contribute direct loadings during baseflow or otherwise dry weather conditions. The final influence is wet weather sources that dominate loading during runoff events. This wet weather impact includes the impact of urban stormwater from Hays in the aftermath of rainfall; because that source is viewed as a point source, it would have to be distinguished from the rural non-point sources in the watershed.

Concurrent sampling through the stream probabilistic network and the addition of a third station on Big Creek near Russell during 2008-2010 indicated similar relationships. Upstream phosphorus levels at Ogallah and Yocemento were similar to those at the upstream Hays station (**Figure 16**). High phosphorus at Munjor exhibited the impact of Hays wastewater and, while downstream assimilation lowered those levels as Big Creek approached the Smoky Hill River near Russell, phosphorus concentrations near Russell were clearly higher than those seen above Hays. During wet weather during October 2008 and May of 2009 and 2010, runoff tended to bring in-stream concentrations closer regardless of position relative to Hays.

The Big Creek – Middle Smoky Hill River Watershed Restoration and Protection Strategy Group (WRAPS) have collected water quality data since 2007 along numerous locations of Big Creek **(Figure 17**), including total phosphorus**.** A TP profile along Big Creek over time shows variability and overlap among the stations, but the creek

concentrations above Hays (@ 110th Street, 150th Street, Highway 183 (#5) and 220th Street (#9)) are consistently among the lowest values **(Figure 18)**. Conversely, the stations below the confluence of Chetolah Creek (#6 & #7), which is the receiving stream for Hays wastewater, are consistently high in phosphorus. Dilution, biological uptake and sediment adsorption is suggested by the values seen in the lower reaches of Big Creek monitored by Station #13 and the sites on Walker, Blundon and Balta roads.

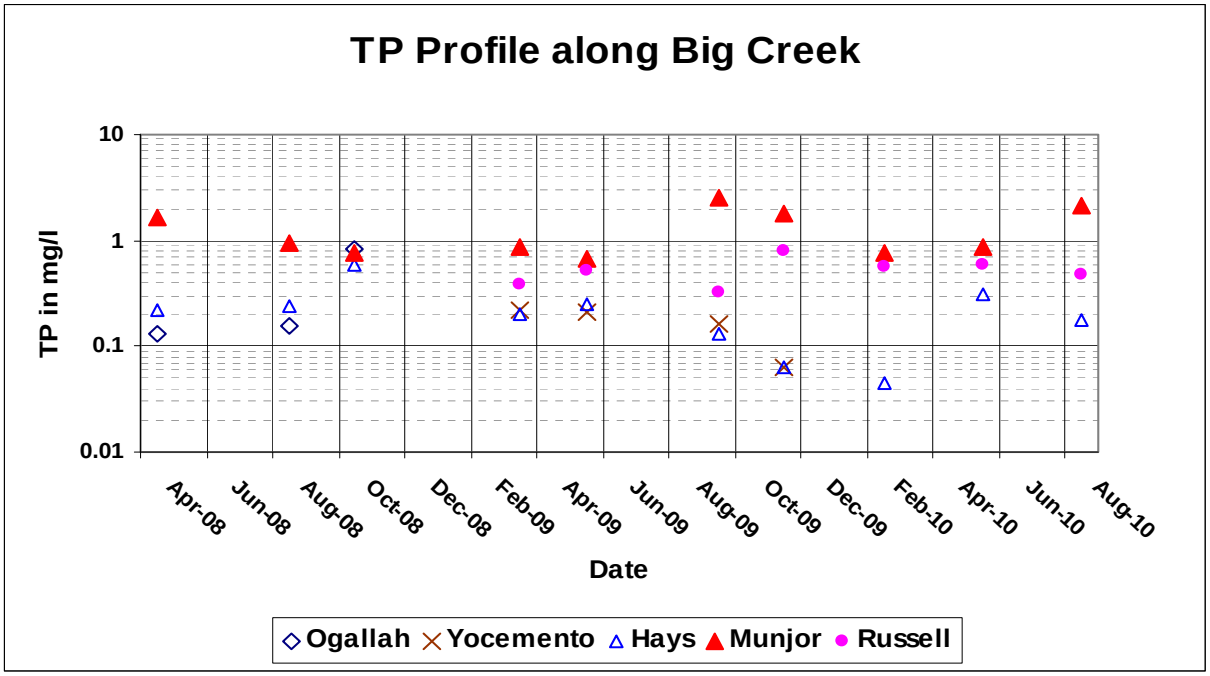


Figure 16. Probabilistic Stream Monitoring of Phosphorus on Big Creek in 2008-10

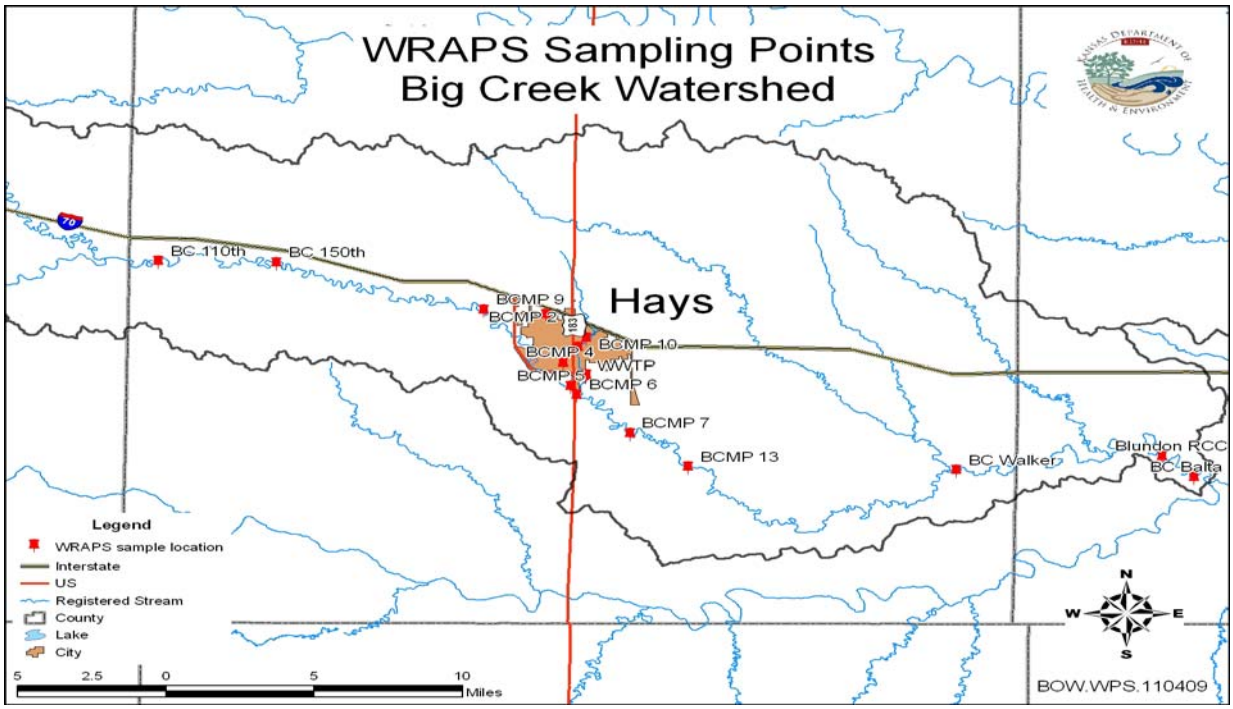


Figure 17. Locations of WRAPS Sampling Sites along Big Creek

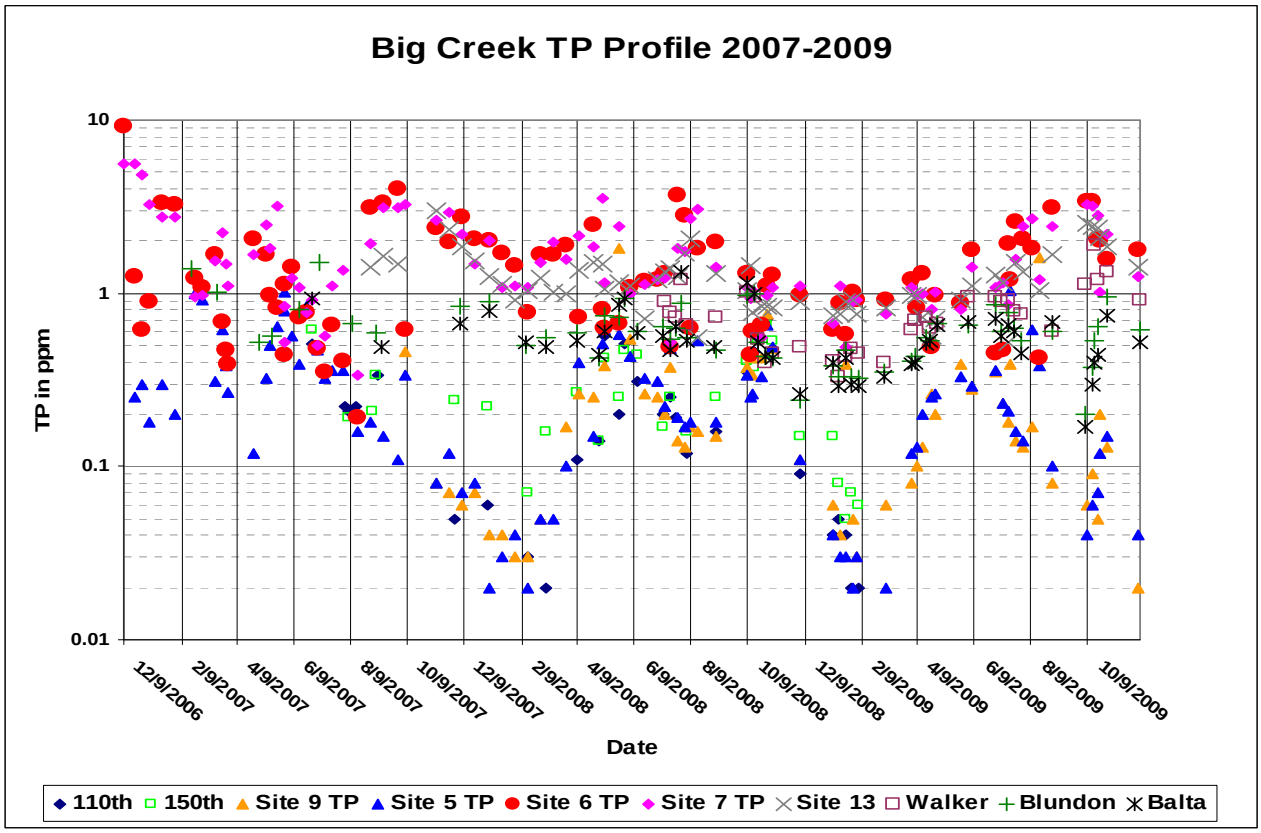


Figure 18. Profile of Phosphorus along Big Creek at WRAPS Sampling Stations

Plotting concurrent sampling at the upstream stations relative to the Big Creek station immediately below the Hays outfall (Chetolah Creek) reveals there is almost uniform increase by an order of magnitude in phosphorus below Chetolah Creek (**Figure 19**). Conversely, a concurrent plot of samples downstream from Hays shows maintenance of high phosphorus along Big Creek between Hays and Munjor, followed by decrease downstream at Site 13 (**Figure 20**). Higher concentrations can be seen at Station #7 because the WRAPS sampling is keyed to runoff events at Hays and sometimes the downstream stations are sampled before runoff appears. Therefore, certain samples at Stations #7 and #13 reflect pre-storm conditions on Big Creek and exceed the runoff-diluted concentrations seen upstream at Station #6.

Comparison between Station #6, most heavily impacted by Hays wastewater, with the farthest downstream station at Balta Road hints at significant reduction of phosphorus in Big Creek before it reaches the Smoky Hill River (**Figure 21**). The lower concentrations may reflect phosphorus being absorbed by stream biota or adsorbed by sediment within the creek or dilution by tributary flows with lower phosphorus levels as flows continue downstream toward stations #13 and Balta (near the mouth of the creek) in Russell County. The average profile of phosphorus levels along Big Creek follows the patterns described by these comparisons (**Figure 22**). Station #7 has the highest average because its samples are often not impacted by any runoff occurring at the upstream stations at the time of sampling.

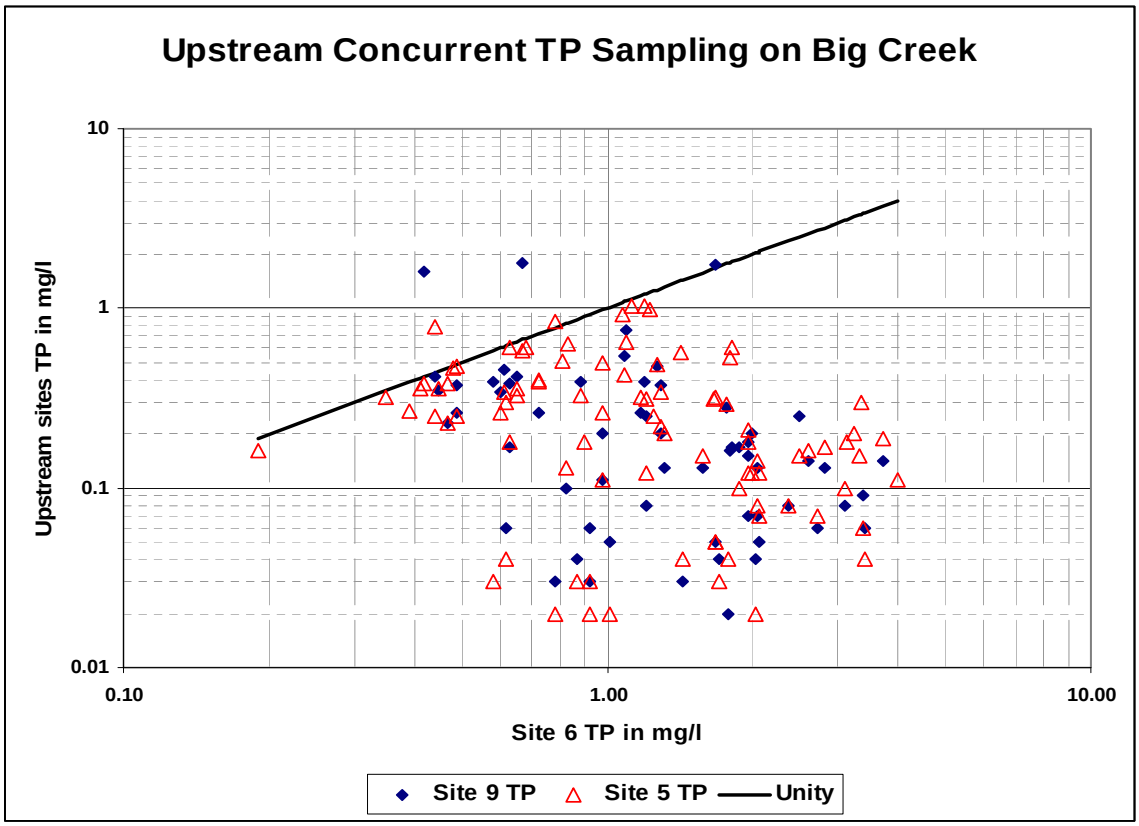


Figure 19. Concurrent Sampling on Big Creek at and above Hays

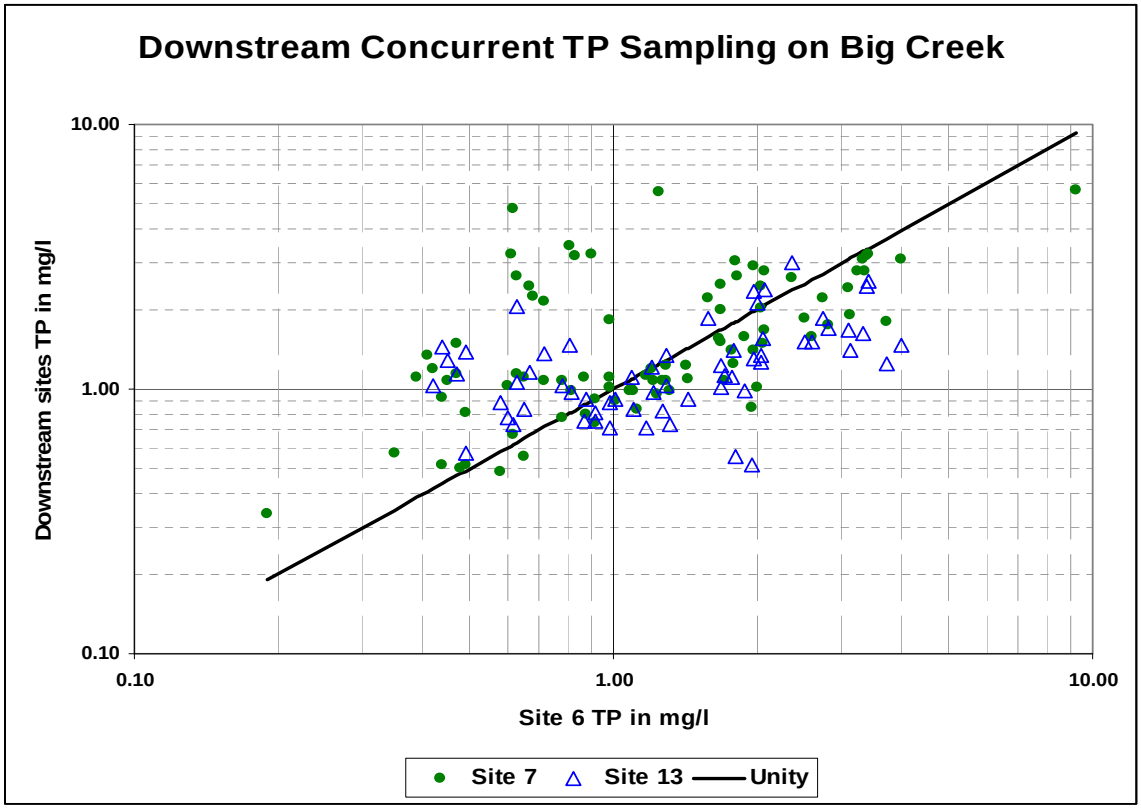


Figure 20. Concurrent Sampling on Big Creek at and below Hays

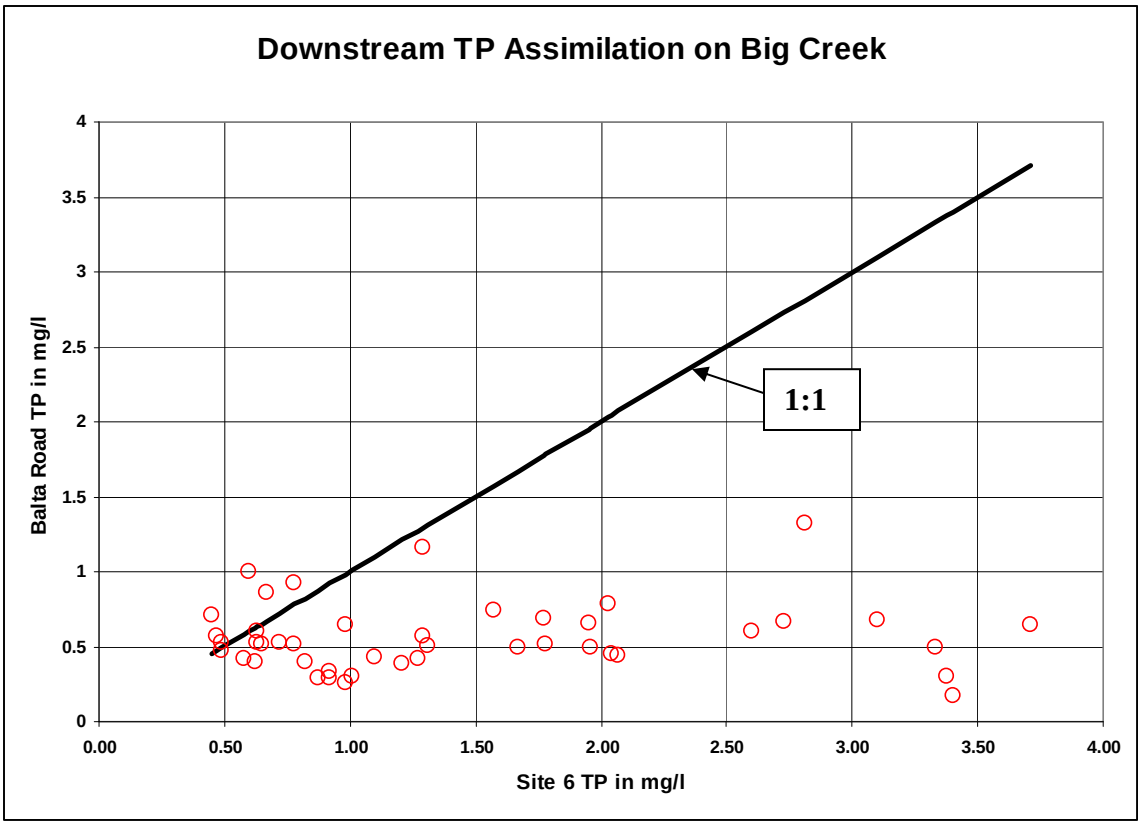


Figure 21. Assimilation of Phosphorus on Big Creek between Hays and the Smoky Hill River

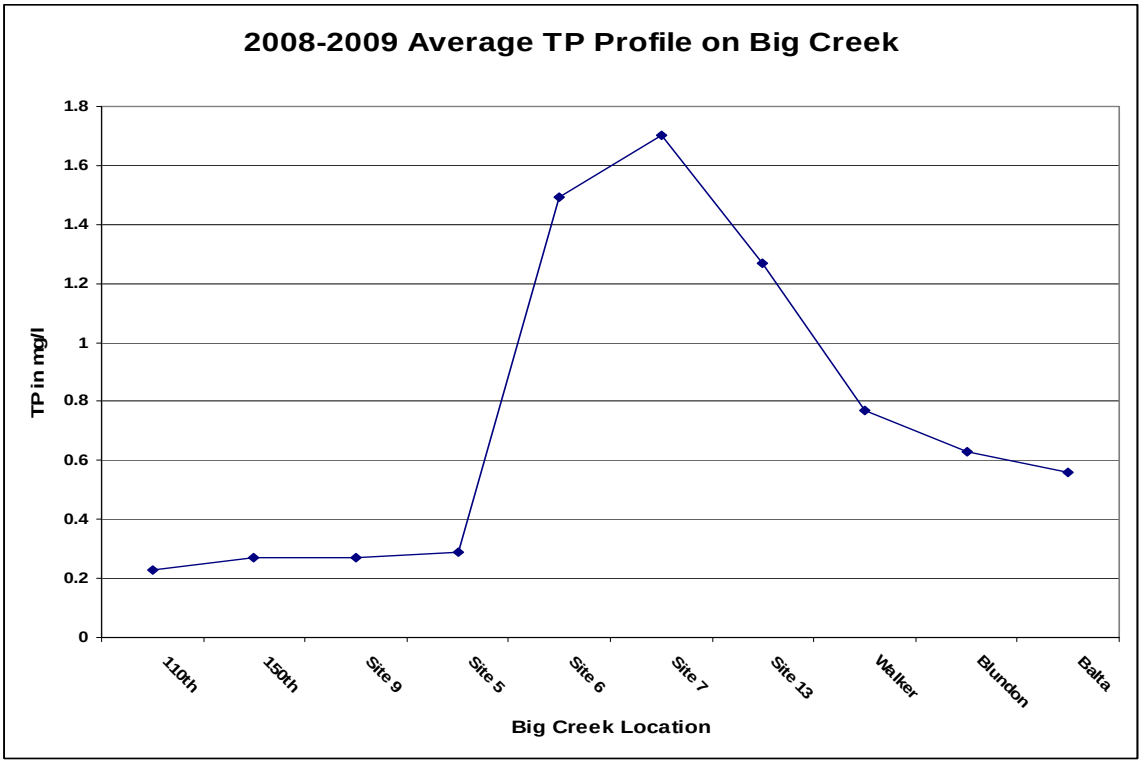


Figure 22. Profile of Average Phosphorus Concentrations along Big Creek

Relationship between Phosphorus and Biological Indicators: The narrative criteria of the Kansas Water Quality Standards are based on indications of the prevailing biological community. Excessive primary productivity may be indicated by extreme swings in dissolved oxygen or pH as the chemical reactions of photosynthesis and respiration alter the ambient levels of oxygen or acid-base balance of the stream. On Big Creek, dissolved oxygen tends to swing inversely to the ambient temperature of the stream (**Figure 23**). To discount the impacts of temperature on the solubility of oxygen in the water column, the percent of saturated dissolved oxygen was computed from the data collected at both KDHE stations on Big Creek (**Figure 24**). A seasonal pattern remained with high levels seen during cooler months and declines associated with summer. The upstream station (541) tended to exhibit more stress than the station impacted by nutrients (540). **Table 2** compares median and lower quartile values of percent dissolved oxygen saturation for the two stations on Big Creek and surrounding stream stations that are less impacted by nutrients. Percent saturation on Big Creek tends to be less than those of the less impacted streams. The upper station shows signs of more severe oxygen depletion than the lower reaches of Big Creek. The lower saturation values for Big Creek may be a result of more respiration stress in the stream or lower streamflows than the Saline or Smoky Hill Rivers.

Table 2. Percent Saturation of Dissolved Oxygen on Streams of Central Kansas

	Big Creek		Less Impacted Streams		
Statistic	**Above Hays**	**Below Hays**	**Saline R nr Russell**	**Saline R nr Hays**	**Smoky Hill R nr Schoenchen**
Median	70%	81%	95%	86%	100%
Lower Quartile	53%	67%	76%	71%	75%

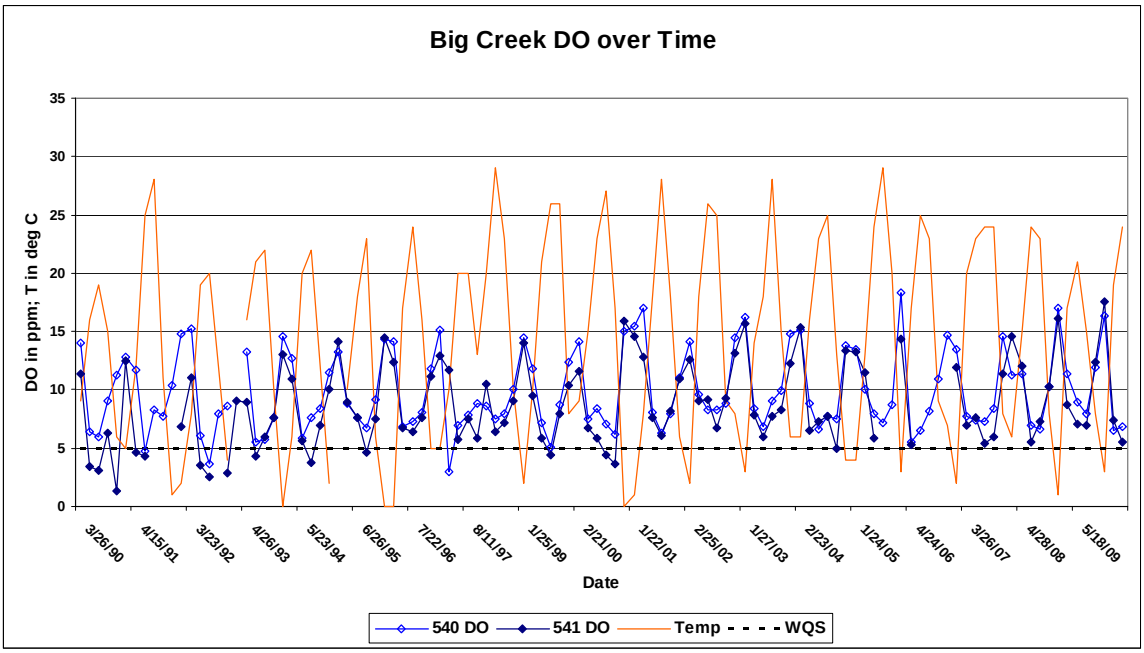


Figure 23. Dissolved Oxygen Levels on Big Creek Since 1990

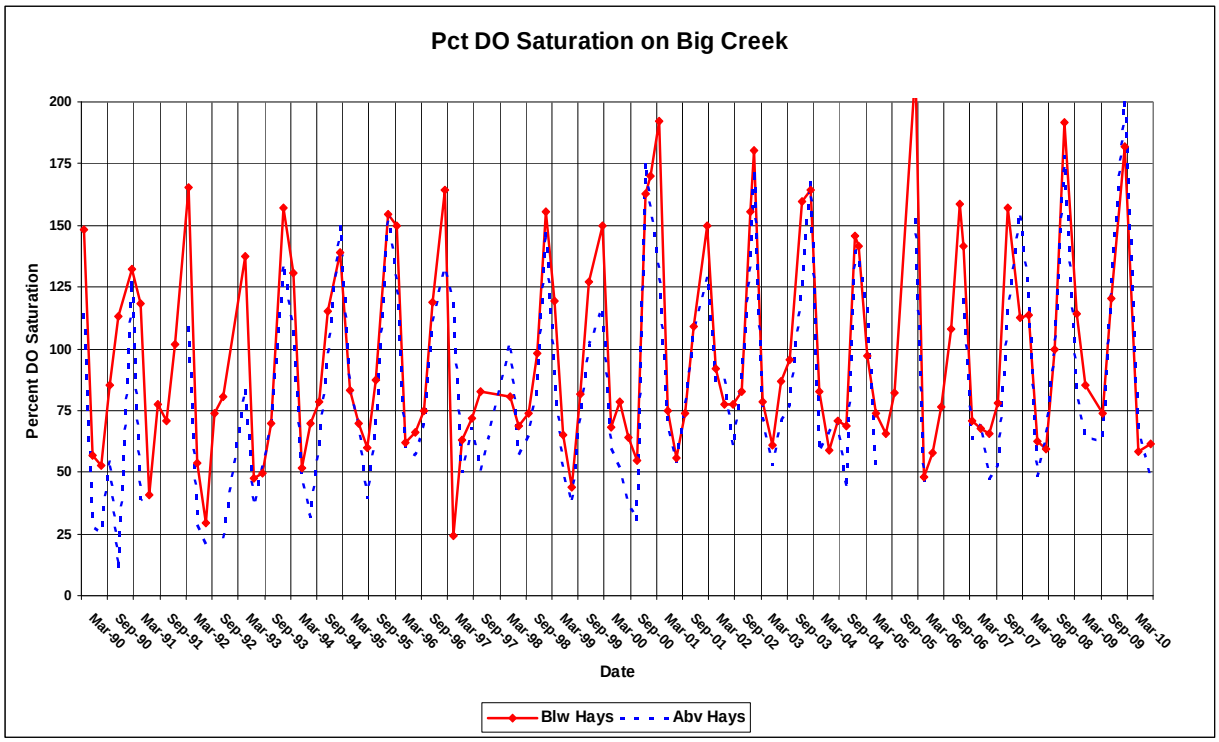


Figure 24. Percent Saturation of Dissolved Oxygen on Big Creek Since 1990

Similarly, levels of pH on Big Creek do not show many exceedances of the 8.5 criterion which can occur during strong photosynthesis periods (**Figure 25**). Only three samples from the lower (540) station exceeded pH of 8.5 since 1990. No exceedances have been recorded for the upper (541) station. Heightened primary productivity fueled by the increase availability of nutrients on the lower creek may be tempered by substrate or water depth issues on the lower reaches. Levels of pH at the lower station tend to be greater than those recorded at the upstream stations, however, so some induced primary productivity is likely occurring downstream.

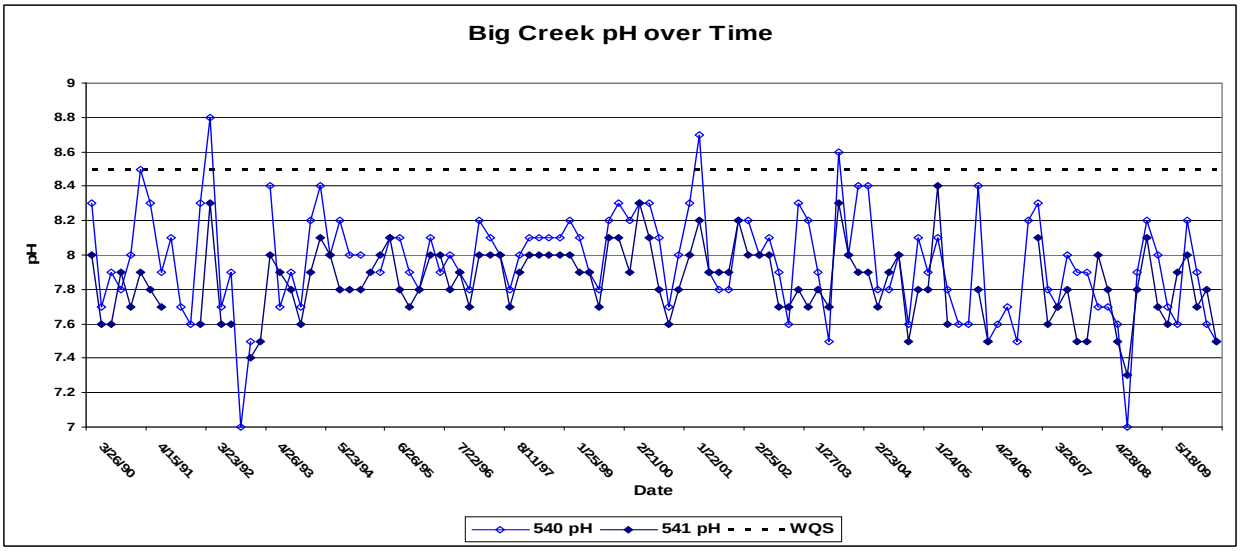


Figure 25. Big Creek pH Levels Since 1990

Current EPA philosophy is predicated on the lowest quartile of stream total phosphorus within an ecoregion as indicative of minimal impact conditions (in the absence of reference streams). This generalization is not tied to specific biological conditions, but represents water quality protection policy guiding EPA's administration of clean water programs. **Figure 26** displays the relationship between lower quartile phosphorus values and Macroinvertebrate Biotic Index (MBI) scores for streams within the four Level IV ecoregions within the Central Great Plains ecoregion of Kansas. Big Creek resides within ecoregion 27b, the Rolling Breaks and Hills area. Low MBI scores are indicative of high quality biological communities. Kansas protocol has been to delineate the boundaries between full and partial aquatic life support and between partial support and non-support as MBI scores of 4.5 and 5.4, respectively. The data of **Figure 26**, compiled by Region VII of EPA, do not show a definite relationship between the suggested EPA criteria and associated biological use. Conditions of full support span phosphorus levels of 0.070 to 0.160 mg/l. Partial support is indicated on streams with phosphorus levels of 20 – 430 ppb. Apparently, other factors impact the biological community of macroinvertebrates beyond the ambient nutrient levels present in those Central Kansas streams.

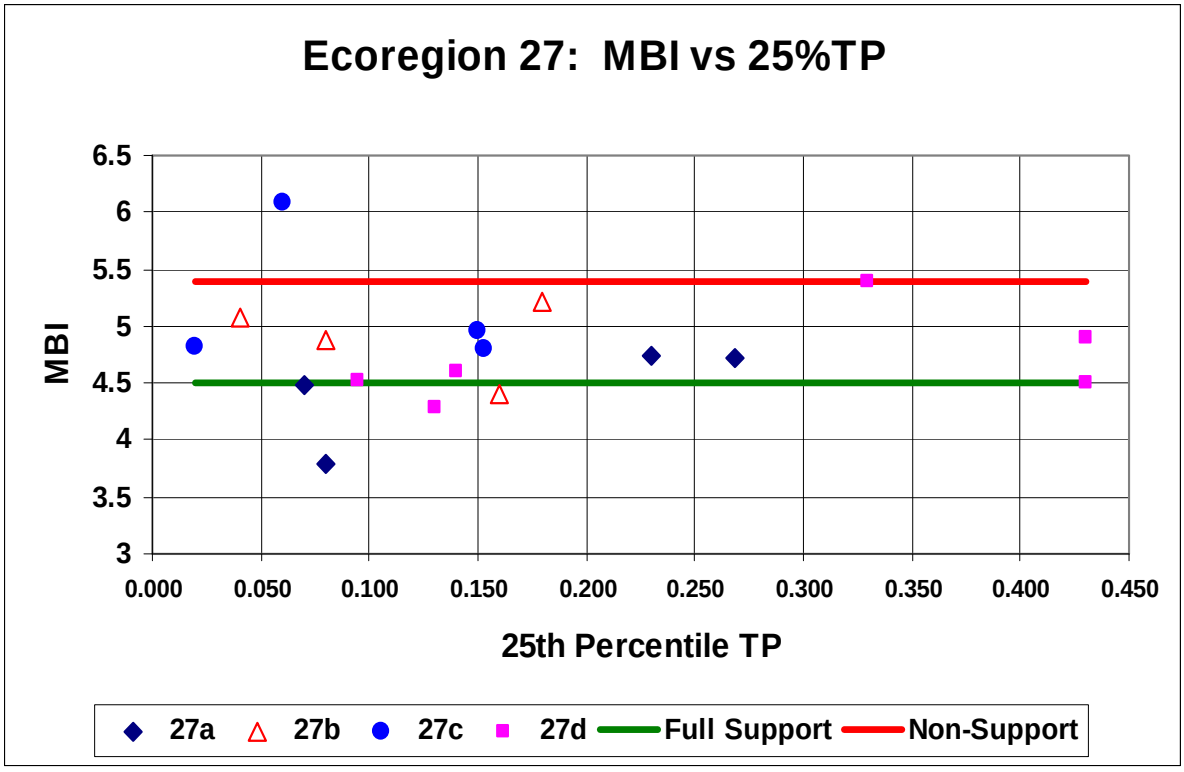


Figure 26. Lower Quartile Phosphorus Levels and MBI Scores for the Central Great Plains

A similar pattern emerges if an index of the selected families of water quality sensitive macroinvertebrates is used as the indicator of biological health. **Figure 27** shows the lower quartile phosphorus levels versus the percent of individuals comprising Ephemeroptera [mayflies], Plecoptera [stoneflies] and Trichoptera [caddisflies] (EPT). EPT percentages over 48% are viewed as signs of a fully supporting environment for

aquatic life, while percentages below 30% are deemed non-supportive. Once again, streams in the Central Great Plains show some resilience to higher phosphorus levels impacting clean water species. Identification of a specific threshold of phosphorus concentration is difficult to tie to desired biological conditions.

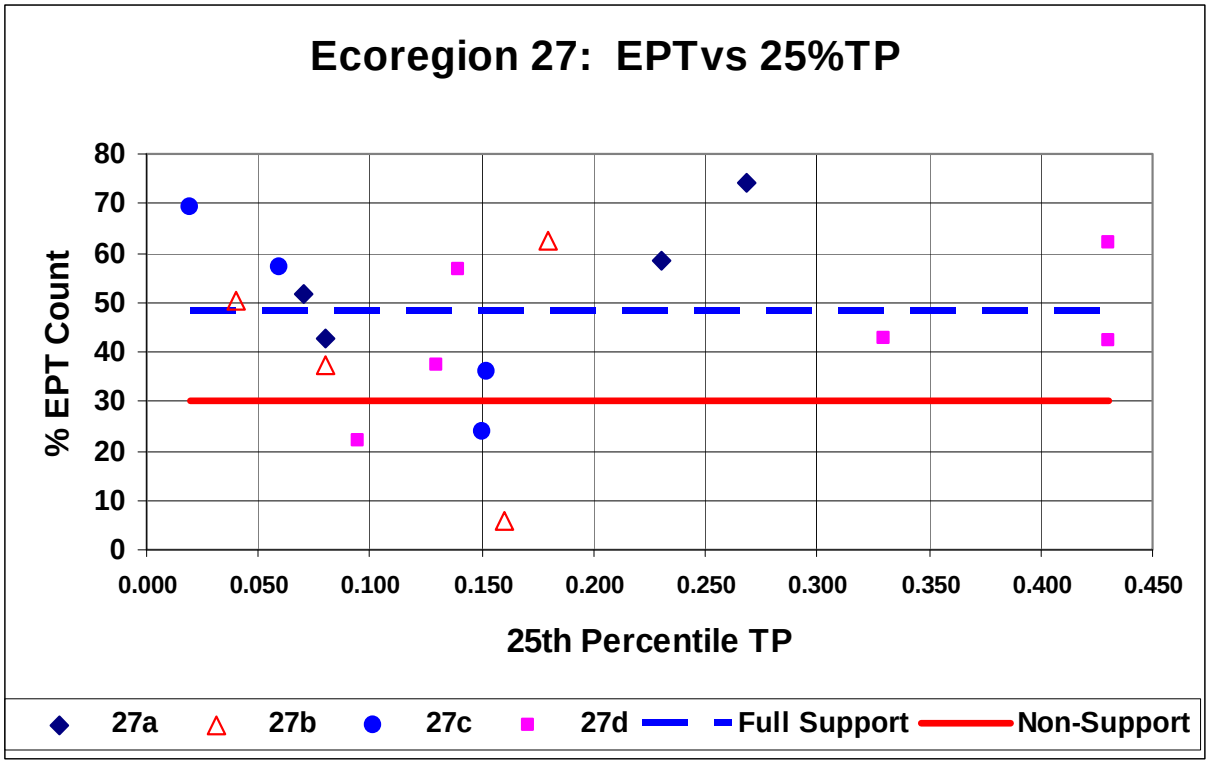


Figure 27. Phosphorus Levels and EPT Scores for Streams in the Central Great Plains

KDHE has collected sestonic chlorophyll on several streams in Central Kansas since 2003. Generally, Big Creek tends to exhibit the highest levels of chlorophyll among the four streams in the vicinity of Hays (**Figure 28**). Examining concurrent phosphorus levels at the time of sampling chlorophyll indicates the other three streams tend to have lower phosphorus, but the chlorophyll level on Paradise Creek will nonetheless rise to comparable levels seen on Big Creek (**Figure 29**). Additionally, despite the influence of Hays wastewater on downstream phosphorus levels, chlorophyll levels do not respond linearly to increases in phosphorus. This may be because of flushing of chlorophyll and nutrients downstream of the monitoring station. Sampling by KDHE's Probabilistic Monitoring Program in 2008 and 2009 along Big Creek found a downstream increase in chlorophyll, with 10 ppb measured in 2008 near Ogallah, and in 2009, 38 ppb chlorophyll a between Ellis and Hays and 119 ppb near Russell. Field notes indicate no periphyton at Ogallah but moderate amounts near Russell. EPA's guidance on nutrient criteria for streams (2000) indicated one value defining the boundary of mesotrophic and eutrophic conditions is 30 ppb sestonic chlorophyll (Table 2 of EPA (2000)). Heiskary (2008) found biological diversity suffered once total sestonic chlorophyll rose above 25 ppb in Minnesota streams.

There are no current measurements from Big Creek of benthic or attached periphyton which may predominate in fast flowing, shallow streams (EPA, 2000). Studies on streams in areas such as Montana suggest periphyton levels should remain below 150 mg/sq.m. (Suplee, et al, 2009). While there has not been a suggested concentration for sestonic chlorophyll, **Figure 30** suggests that ambient levels of phosphorus below 150 ppb may be supportive of reasonable amounts of stream algal growth.

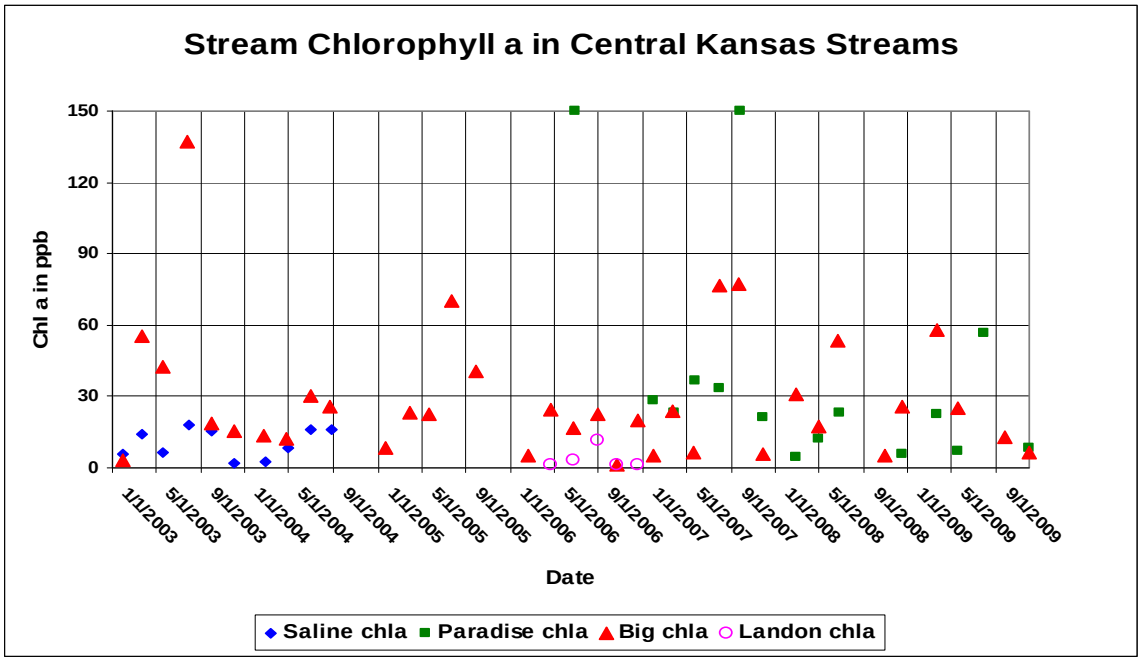


Figure 28. Sestonic Chlorophyll on Streams near Hays

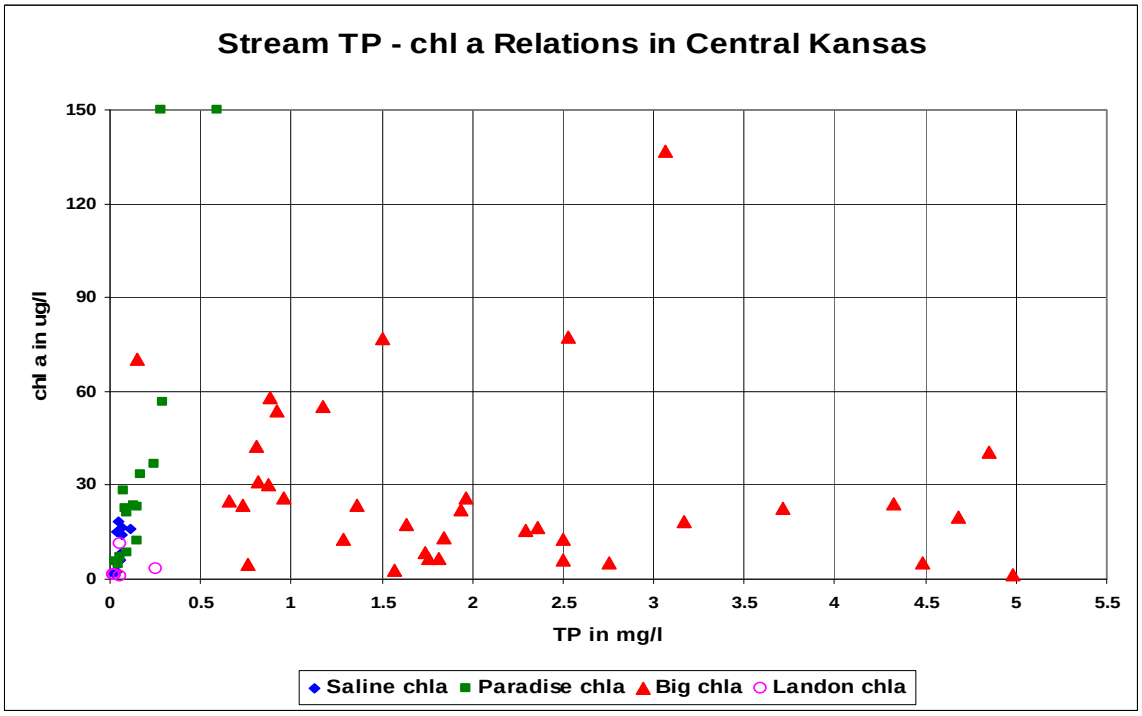


Figure 29. Sestonic Chlorophyll versus Total Phosphorus on Central Kansas Streams

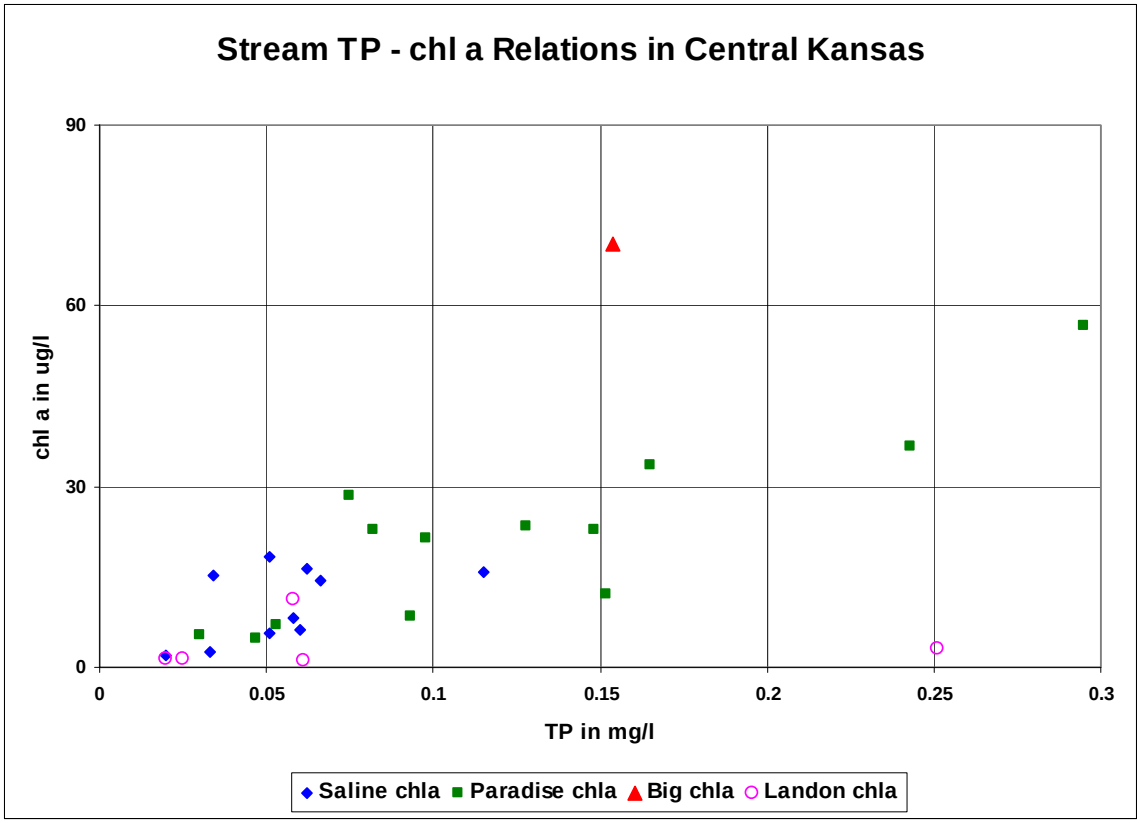


Figure 30. Low-end Phosphorus Levels versus Sestonic Chlorophyll in Central Kansas Streams

Desired Endpoint: The ultimate endpoint of this TMDL will be to achieve the Kansas Water Quality Standards by eliminating any of the impacts to aquatic life, domestic water supply or recreation associated with excessive phosphorus and objectionable amounts of algae as described in the narrative criteria pertaining to nutrients. There are no existing numeric phosphorus criteria currently in Kansas. The current EPA suggested benchmarks for stream TP in the South-Central Cultivated Great Plains ecoregion is 0.067 mg/l TP over the 10-state aggregate of Level III ecoregions. A similar TP benchmark for the Central Great Plains was 0.090 mg/l, spanning from Nebraska to Texas.

Big Creek resides in the 27b ecoregion, the Rolling Hills and Breaks. This area exhibits differences in stream-aquifer interaction, topography, land use and geology from the other three Central Great Plains ecoregions in Kansas. The differences are more striking when looking at the thickness of loess, presence of wetlands and braided streams in Central Nebraska, the Rainwater Basin and the Platte River Valley. Comparable analysis of data from 2000 – 2010 and restricted to the Kansas stations in the Central Great Plains indicates the lower quartile value of median TP from 113 stations is 0.132 mg/l TP. The value for the best 25% of medians from 33 stations in the 27b ecoregion is 0.108 mg/l. The lowest mean TP (0.065 mg/l over 2000 - 2010) in the ecoregion is monitored on the Smoky Hill River near Schoenchen, immediately to the south of the Big Creek drainage. The lower quartile and median sestonic chlorophyll a from 13 KDHE stations in the Kansas portion of the Central Great Plains is 3.7 and 12 ug/l, respectively.

The greatest complication in setting an endpoint is establishing the linkage of phosphorus levels to applicable biologic response variables. **Figures 26 – 30** show noisy relationships with phosphorus that defy establishing a solitary threshold value and support an adaptive management approach to reduce current phosphorus loads and concentrations and observe responding improvement in biological metrics, prior to further reduction.

Four such metrics will serve to establish if the biological community of Big Creek reflects recovery, renewed diversity and minimal disruption by the impacts described in the narrative criteria for nutrients on aquatic life, recreation and domestic water supply.

1. **Macroinvertebrate Biotic Index (MBI)** : A statistical measure that evaluates the effects of nutrients and oxygen demanding substances on macroinvertebrates based on the relative abundance of certain indicator taxa (orders and families); for Kansas, MBI values below 4.5 are indicative of fully supported aquatic life communities.
2. **Ephermeroptera, Plecoptera and Trichoptera (EPT)** abundance as a percentage of the total abundance of macroinvertebrates; for Kansas, EPT percentages over 48% are indicative of fully supported aquatic life communities.
3. **Periphyton density on substrate**: The concentration of attached algae (measured by chlorophyll a) over a unit surface area. Suplee (2009) and others have suggested the range of acceptable conditions lies below a value of 150 mg/sq.meter.
4. **Sestonic chlorophyll**: The concentration of planktonic algae floating in the water column of the stream. Heiskary (2008) found that <u>total</u> chlorophyll values over 25 ug/l exceeded the threshold of biological disruption to aquatic communities in Minnesota streams. EPA (2000) notes a value in its Table 2 demarcating the boundary between stream mesotrophy and eutrophy at 30 ppb. That same document also cites studies indicating sestonic chlorophyll levels over 8 – 15 ppb are problematic. For Big Creek, a target value of 20 ppb will be sought.

Therefore, the numeric endpoints for this TMDL indicating attainment of water quality standards on Big Creek will be:

1. **MBI values below 4.5**
2. **Percentage of individuals comprising the EPT families exceeds 50%**
3. **Periphyton chlorophyll concentrations below 150 mg/sq.meter**
4. **Sestonic chlorophyll concentrations below 20 ppb**

All four endpoints have to initially be maintained over **three consecutive years** to constitute full support of the designated uses of Big Creek. After standards are attained, simultaneous digression of three of these endpoints more than once every three years, on average, constitutes a resumption of impaired conditions.

These four endpoints will be evaluated periodically as phosphorus levels decline in Big Creek over time. This TMDL looks to establish management milestones for phosphorus

concentrations in Big Creek that would be the cue to examine the biological conditions of the creek. Milestones will be established by benchmarking the phosphorus distribution of nearby and regional streams with low ambient levels of phosphorus. Initially, KDHE looked at the surrounding stream stations to Big Creek for possible benchmark with median TP values below 100 ppb (**Figure 31**). Among the eleven stations on the Smoky Hill, Saline and tributaries, the lowest phosphorus levels are seen on the Saline River near Hays and Russell and the Smoky Hill River at Schoenchen (**Figure 32**). Phosphorus levels at Schoenchen are among the lowest in the Central Great Plains.

Table 3 displays the descriptive statistics for TP at the eleven stations over 1990 – 2010. The Smoky Hill River near Russell, below the confluence of Big Creek (and Fossil Creek containing Russell wastewater) is significantly higher in phosphorus than the other "big" river stations (**Figure 32**). Big Creek below Hays has the highest phosphorus levels in the two-county area, influenced by the wastewater of Hays. Big Creek above Hays also exhibits higher phosphorus than surrounding streams, as well. Flow conditions among the streams are not as divergent as their respective drainages might suggest, flows on Big Creek are less than an order of magnitude different from those on the Saline or Smoky Hill Rivers. Therefore, use of the larger rivers as comparable benchmarks is not unduly influenced by hydrologic considerations when applied to Big Creek.

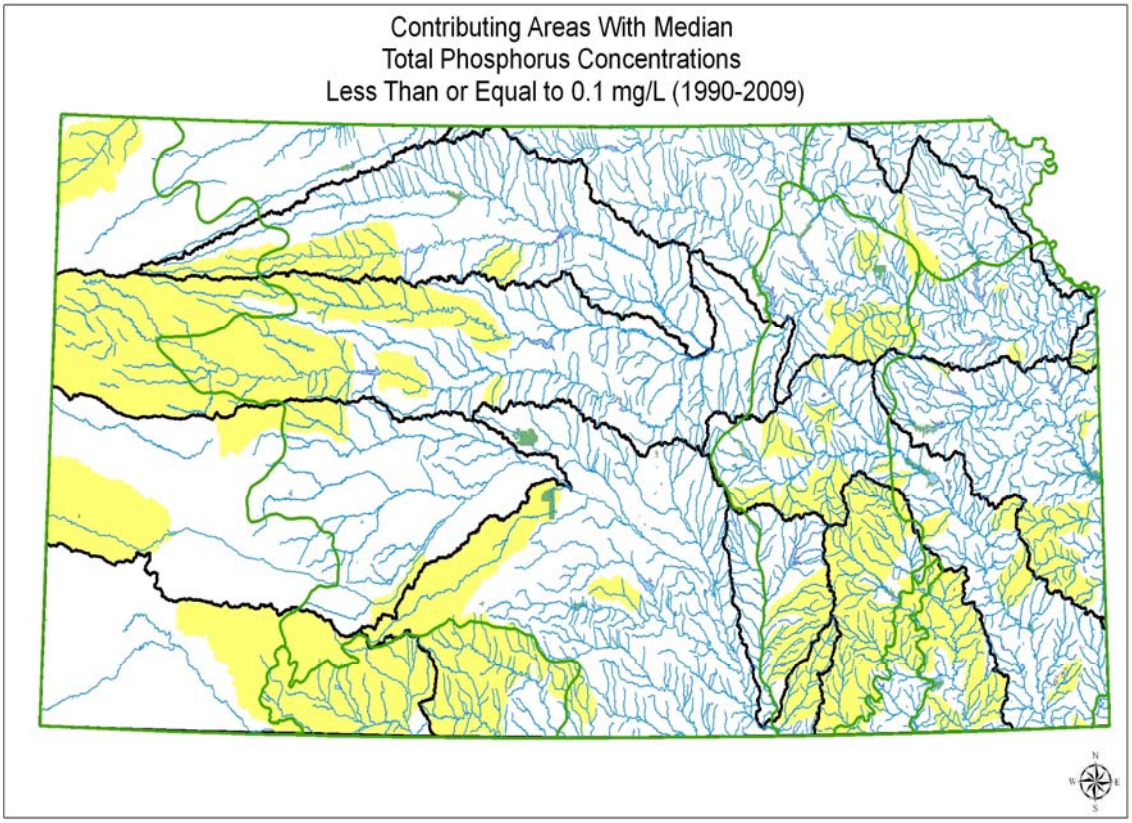


Figure 31. Statewide Watersheds with Median TP Values of 0.1 mg/l or Lower

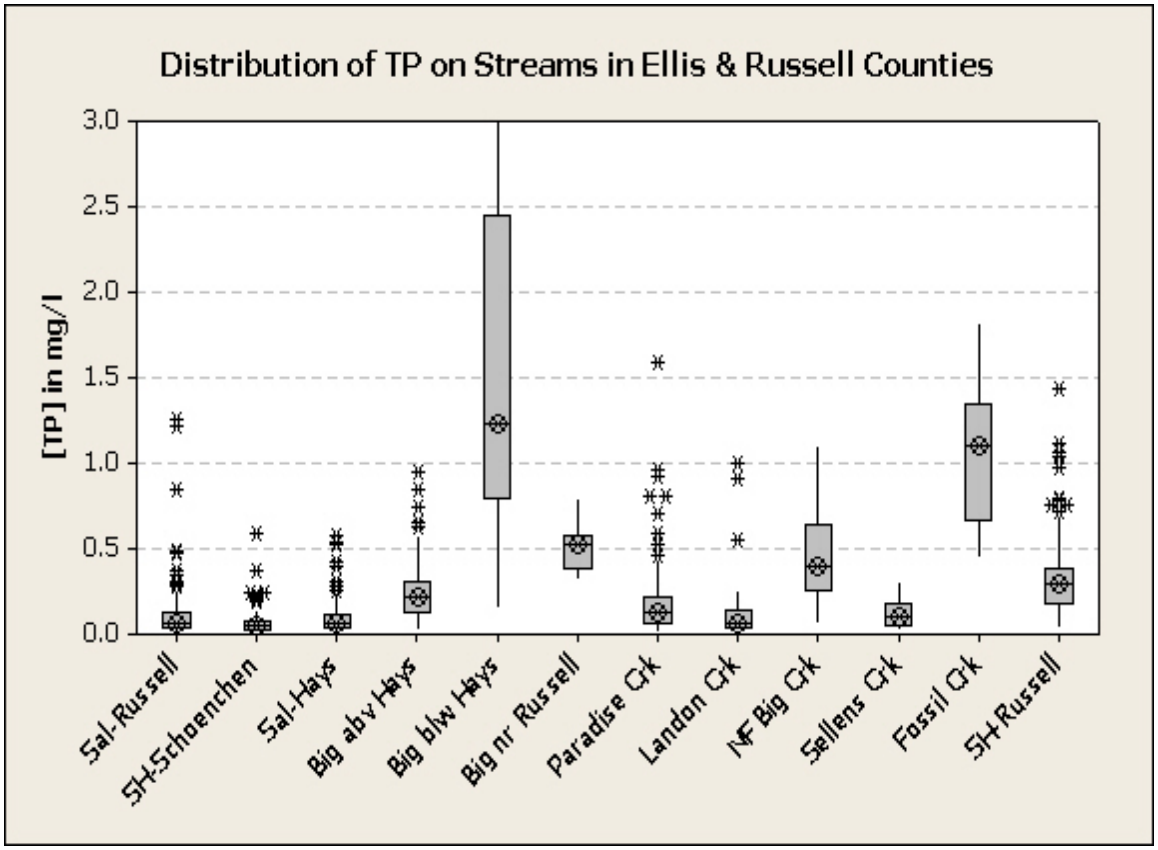


Figure 32. Phosphorus Distribution of Streams in Ellis and Russell Counties

Table 3. Statistics of Total Phosphorus (ppb) on Streams of Ellis & Russell Counties

Stream	# of Samples (1990 – 2010)	Min	Max	Mean	25%	50%	75%
Saline near Russell (SC011)	113	10	1260	130	40	66	133
Saline near Hays (SC548)	111	10	7164	166	40	64	121
Smoky Hill near Schoenchen (SC539)	102	10	590	74	32	52	80
Big Creek above Hays (SC541)	104	27	950	244	123	213	305
Big Creek below Hays (SC540)	**113**	**154**	**9070**	**1960**	**792**	**1230**	**2453**
Big Creek near Russell (SC752)	7	319	795	523	385	525	582
NF Big Creek	17	64	1098	483	257	400	635
Paradise Creek	113	10	1590	193	66	130	220
Landon Creek	31	20	996	150	41	61	140
Sellens Creek	15	30	303	130	54	103	185
Fossil Creek	20	446	3143	446	670	1100	1340
Smoky Hill near Russell	112	36	1440	341	183	293	390

The three "cleanest" locations on the Saline and Smoky Hill Rivers (**Figure 1**; blue font in **Table 3**) comprise an appropriate benchmark of the possible distribution of ambient phosphorus that likely supports biological integrity in streams of the Central Great Plains. Sestonic chlorophyll a concentrations on the Saline River near Russell average 10.5 ppb (median = 11.3 ppb; range: 2 – 18 ppb). Phosphorus levels on the Smoky Hill River near Schoenchen are the lowest in the region. Combining the three locations produces an average phosphorus concentration of 125 ppb; median concentration is 60 ppb, while the inter-quartile range spans 38 – 110 ppb.

Figure 33 compares the distribution of the three stations on Big Creek with the phosphorus distribution of the three benchmark stations. **Figure 34** combines data from the three low phosphorus stream locations into a composite benchmark for comparison. The biological endpoints will be assessed once the distribution of the Big Creek stations' total phosphorus decreases and approaches the composite benchmark distribution. The TMDL will be implemented in phases, using milestones to indicate improved conditions in-stream. Once the median of phosphorus concentrations at the downstream Munjor station (SC540) approaches the upper quartile of the upstream station in the first phase, biological assessment will be done. Subsequently, as the median TP at both Big Creek stations declines toward regional levels and ultimately, that seen in the nearby composite distribution, further assessment will be made of the biological community in Big Creek.

At the initial milestone, at least half of the future phosphorus concentrations measured at the lower Big Creek station will be within the range of values seen first upstream of Hays. Subsequently, both Big Creek stations will be within the range seen at the surrounding benchmark stations. Achievement of those milestones signifies reduction in phosphorus loading by point and non-point sources with an expectation of improved biologic support in Big Creek. Based on the initial relationship suggested between the Munjor and Russell sites on Big Creek (**Figure 34**), reductions in phosphorus at Munjor should result in a corresponding phosphorus reduction downstream at Russell with the distribution of phosphorus concentrations that approaches that seen at the benchmark stations.

There are dual mechanisms of delivery for stream phosphorus into Big Creek: wastewater discharge and stormwater via runoff. Using segmented regression (Oosterbaan, 1994) between the log value of phosphorus (in ppb) at the stations and the associated flow duration at the time of sampling, there are two breakpoints (at 55% and 25%) for the stations in the vicinity of Hays. **Figure 35** shows a typical relation between phosphorus and flow condition on the Saline River near Russell. The Y-axis is the logarithm of TP (in ppb); the X-axis is the flow percentile over 1990 – 2010, as recorded at a nearby gaging station on the sampled river. At baseflow conditions, phosphorus concentrations are essentially uniform regardless of streamflow. Once runoff conditions develop, past the 55th percentile flow, there is an upward trajectory in concentration as flows increase. The segmented regressions for the upper Saline River and Smoky Hill River near Schoenchen and composite of the three stations are provided in **Appendix D**.

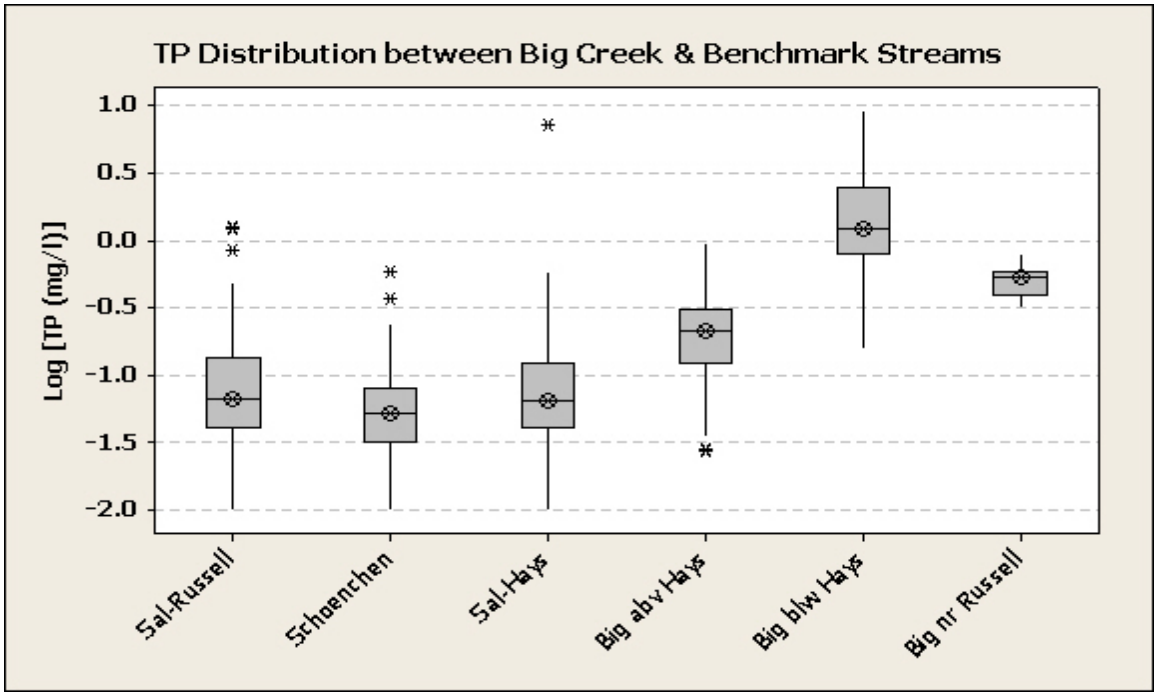


Figure 33. Comparison of Phosphorus Distribution on Big Creek & Benchmark Stations

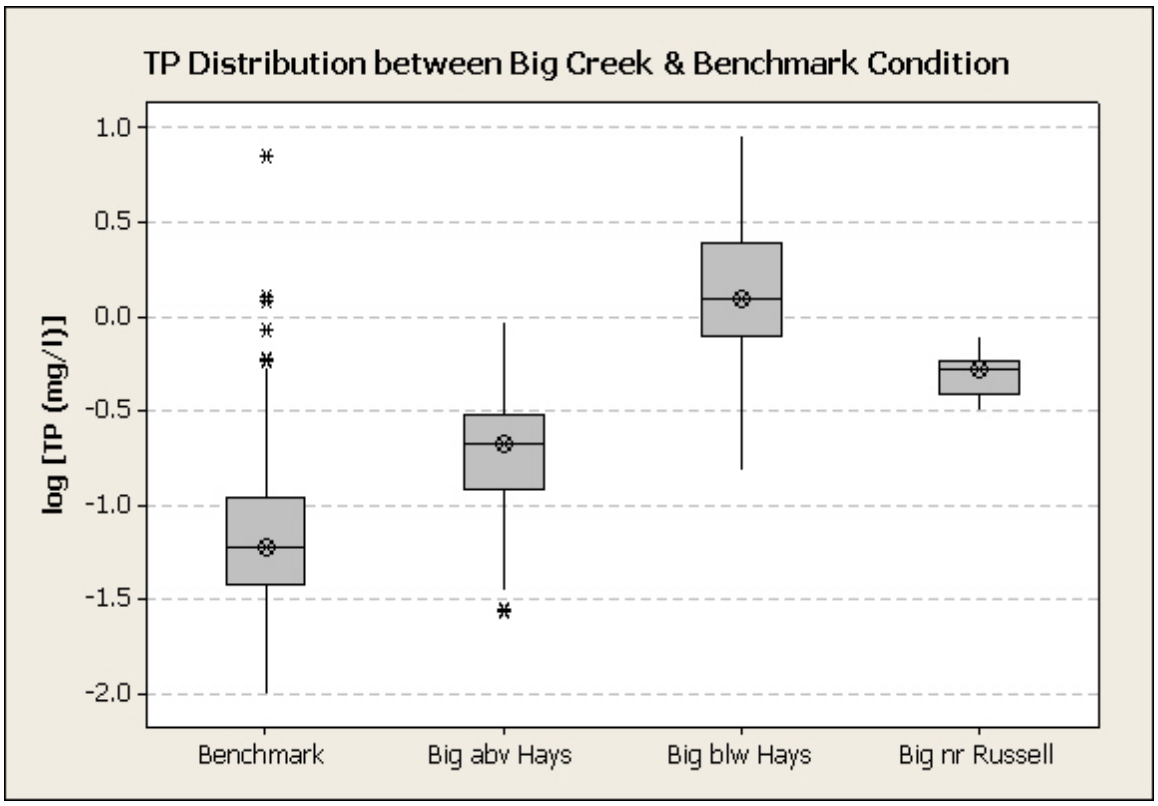


Figure 34. Comparison of Benchmark TP Distribution and Big Creek Stations

A similar pattern occurs on Big Creek above Hays (**Figure 36**), but the breakpoint is near the lower quartile (25%) flow. However, the pattern for Big Creek below Hays is quite different (**Figure 37**), with declining phosphorus with increased flow under baseflow conditions, up to the 55% breakpoint, followed by near constant concentrations during wet weather. This situation likely reflects the dominance of wastewater at low flow and subsequent blending of wastewater and stormwater on the lower creek reaches. At higher flows, Hays wastewater is essentially diluted by the lower phosphorus carried by runoff.

Because both wastewater and runoff contribute to elevated phosphorus, at each Phase of this TMDL, implementation will be staged to meet hydrologic specific milestones, based on the current distribution of phosphorus values seen on less impacted streams (**Figures 38 -40**). Under the first Phase, the median phosphorus value of the lower Munjor (SC540; currently 2400 ppb at baseflow, 930 ppb at normal flow) site will be reduced in time to match the upper quartile (75%) value of the upstream Hays site(250 ppb, overall). Initially, the focus of remedial implementation will be reduced phosphorus loading by Hays wastewater at Stage One that reduce baseflow (55 – 99%) phosphorus to levels that are commensurate with concentrations seen on Big Creek above Chetolah Creek (**Figure 38**). Stage Two will involve reduced loading by adjacent non-point sources at moderate flows (25 – 55%), through livestock management and riparian grass buffers that should insulate Big Creek from surrounding land use.

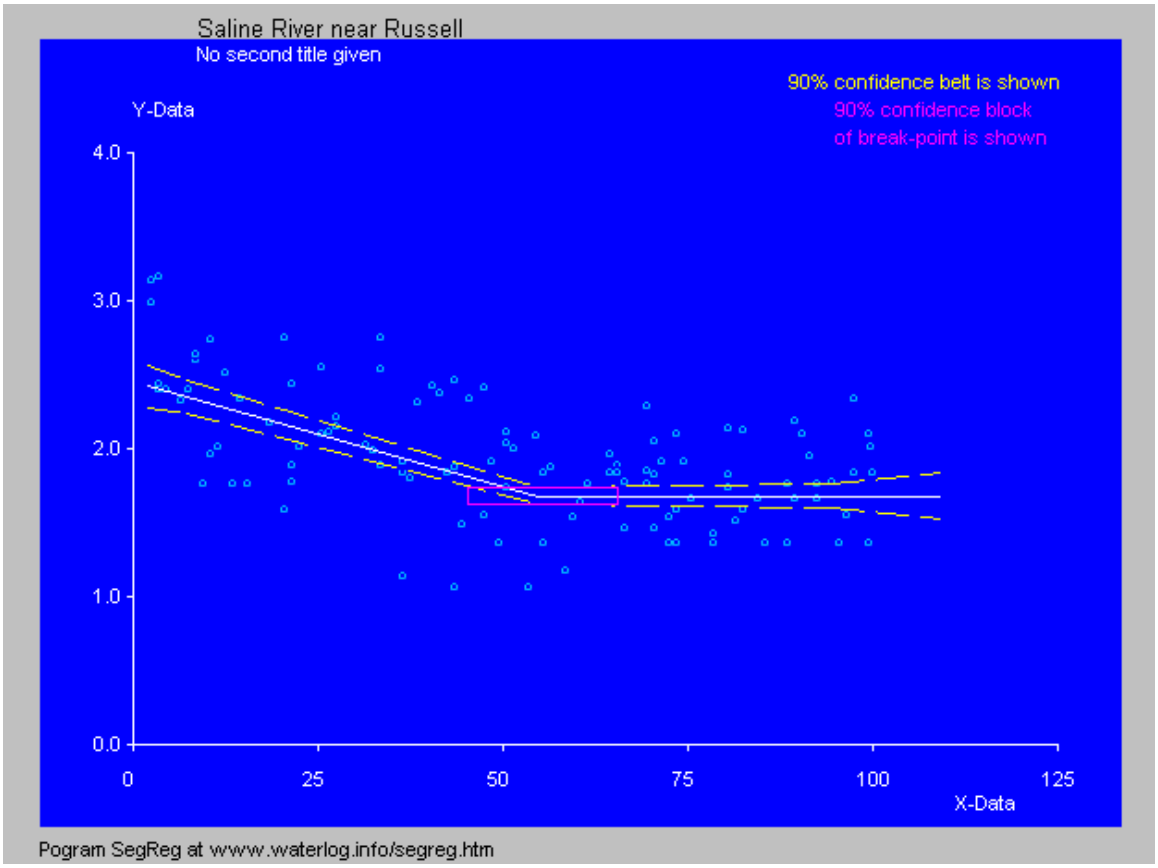


Figure 35. Segmented Regression of Phosphorus & Flow Duration on the Saline River (X = flow percentile; Y = log (TP as ppb)

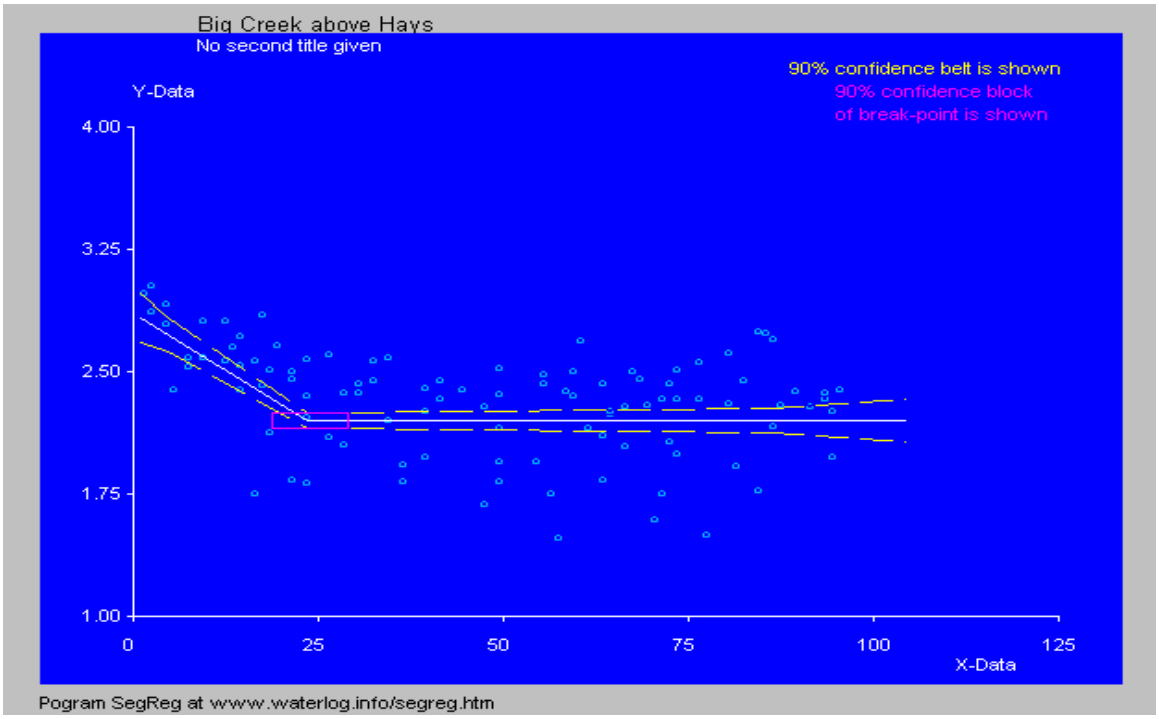


Figure 36. Segmented Regression of Phosphorus and Flow Duration on Big Creek above Hays

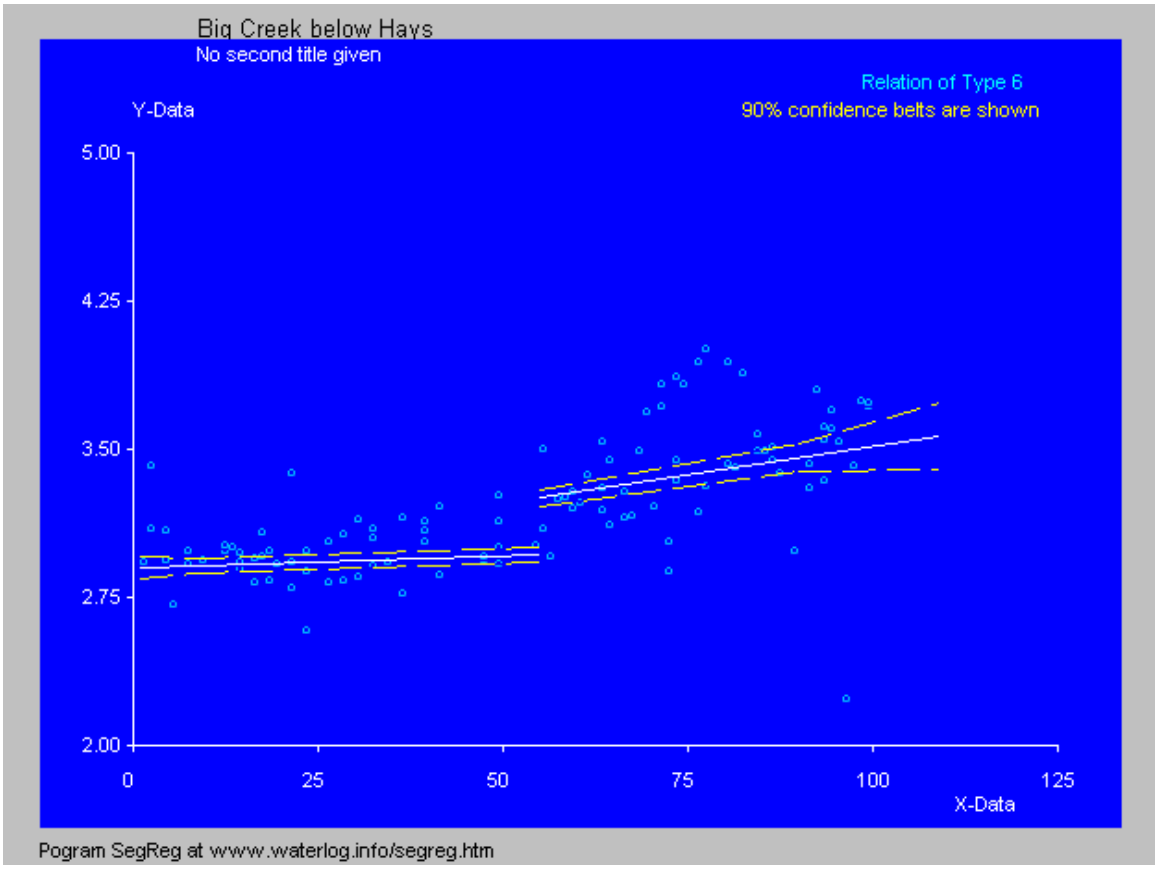


Figure 37. Segmented Regression of Phosphorus and Flow Duration on Big Creek below Hays

Presuming the first Phase of reducing phosphorus levels on lower Big Creek to levels seen above Hays improves water quality but does not attain all four of the biological indicators, a second Phase of implementation will commence (**Figure 39**). Stage One will direct further reductions in wastewater phosphorus by Hays, while Stage Two installs treatment and practices on the tributaries to Big Creek from Ellis to Russell. In time, median phosphorus concentrations on Big Creek (now at ~ 250 ppb below, 190 ppb above) should approach the lower quartile value of the stations within ecoregion 27b (110 ppb) at baseflow and the lower quartile value of the stations within all of ecoregion 27 (130 ppb) at normal flows. At this milestone, another evaluation of the biological indicators should be made, and if all four are indicative of fully supporting the biological integrity of Big Creek, the new ambient phosphorus concentrations should be locked in as numeric criteria to protect the improved conditions from backsliding.

If conditions still appear to be less than fully supportive of the designated uses, then a third Phase will direct further treatment of Hays wastewater to the limits of technology to commence, along with directed installation of best management practices throughout the Big Creek watershed to abate loads occurring under high flows. Under this Phase, expected ambient phosphorus levels in Big Creek would approach 75 ppb at baseflow, 110 ppb at normal flows and 240 ppb at high flows, comparable to the upper quartile values for the composite of the three nearby benchmark stations. (**Figure 40**).

Achievement of all four of the biological endpoints indicates any loads of phosphorus are within the loading capacity of the stream, water quality standards are attained and full support of the designated uses of the stream has been restored. Additionally, achievement of lower phosphorus loading on Big Creek will contribute to achieving the TMDL for eutrophication in Kanopolis Lake, approved in August 2003. The load capacity computed for Kanopolis Lake is 73,920 pounds TP per year, 50,331 pounds of which comprise the annual wasteload allocation for discharging point sources in the Middle Smoky Hill and Big Creek Subbasins. Wasteloads from Hays make up about 60 – 68% of the desired and current phosphorus loads to Kanopolis Lake. Therefore, reduction in phosphorus wasteload from Hays will benefit Big Creek and ultimately, Kanopolis Lake.

3. SOURCE INVENTORY AND ASSESSMENT

Point Sources: There will be six NPDES permitted facilities potentially discharging to Big Creek **(Table 4)**. There are an additional eight non-discharging facilities that do not influence the quality of Big Creek. By design or through circumstance, only the City of Hays consistently discharges into Big Creek and impacts its water quality. The City of Wakeeney now operates a three-cell lagoon wastewater system in place of its old mechanical plant. The effluent from Wakeeney does not appear to flow consistently down channel toward Ellis. Observations made during use attainability analysis found the channel of Big Creek to be dry in Trego County. The City of Ellis operates a low volume activated sludge treatment plant, whose effluent typically does not reach Hays according to observations by Division of Water Resources field personnel. Gorham updated its non-discharging system to discharge into Walker Creek in late 2010.

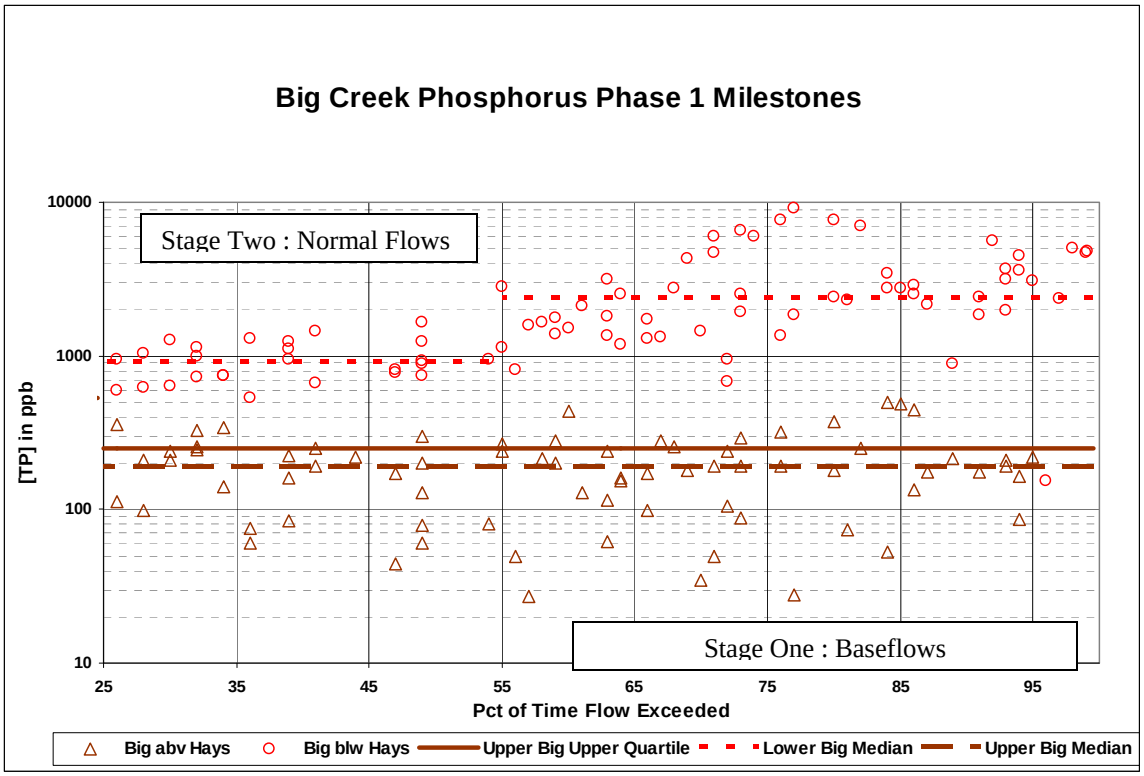


Figure 38. Staged Milestones for Phase 1 Phosphorus Reduction on Big Creek

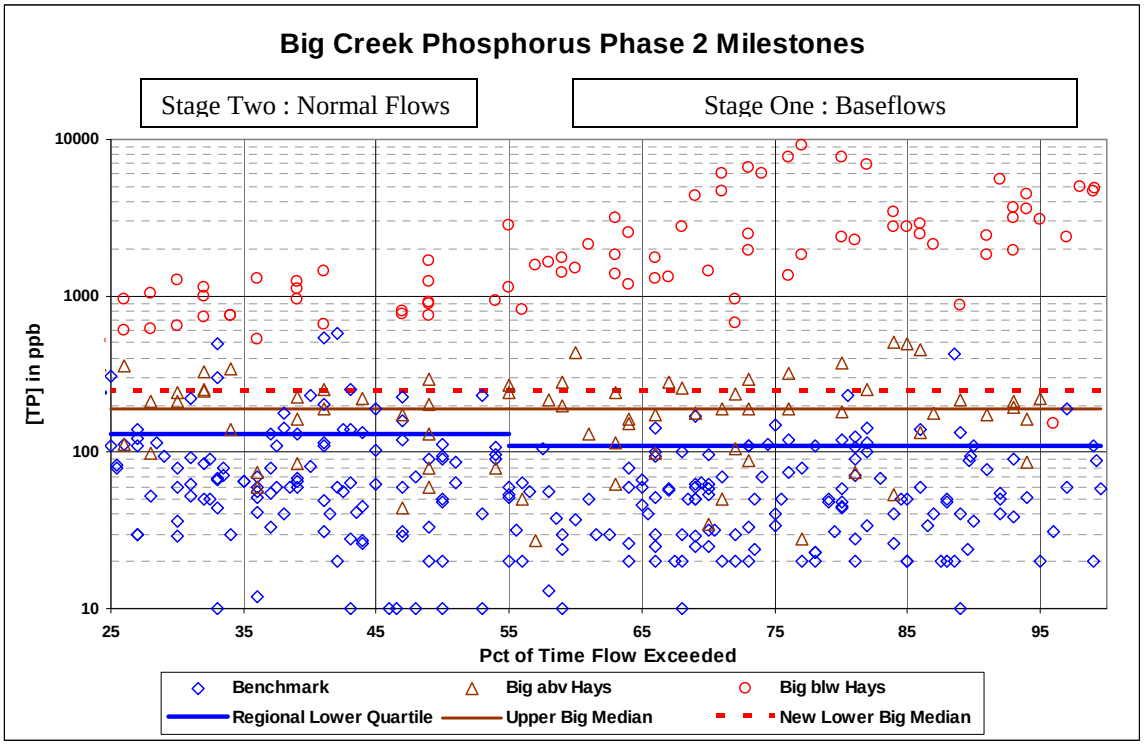


Figure 39. Staged Milestones for Phase 2 Phosphorus Reduction on Big Creek

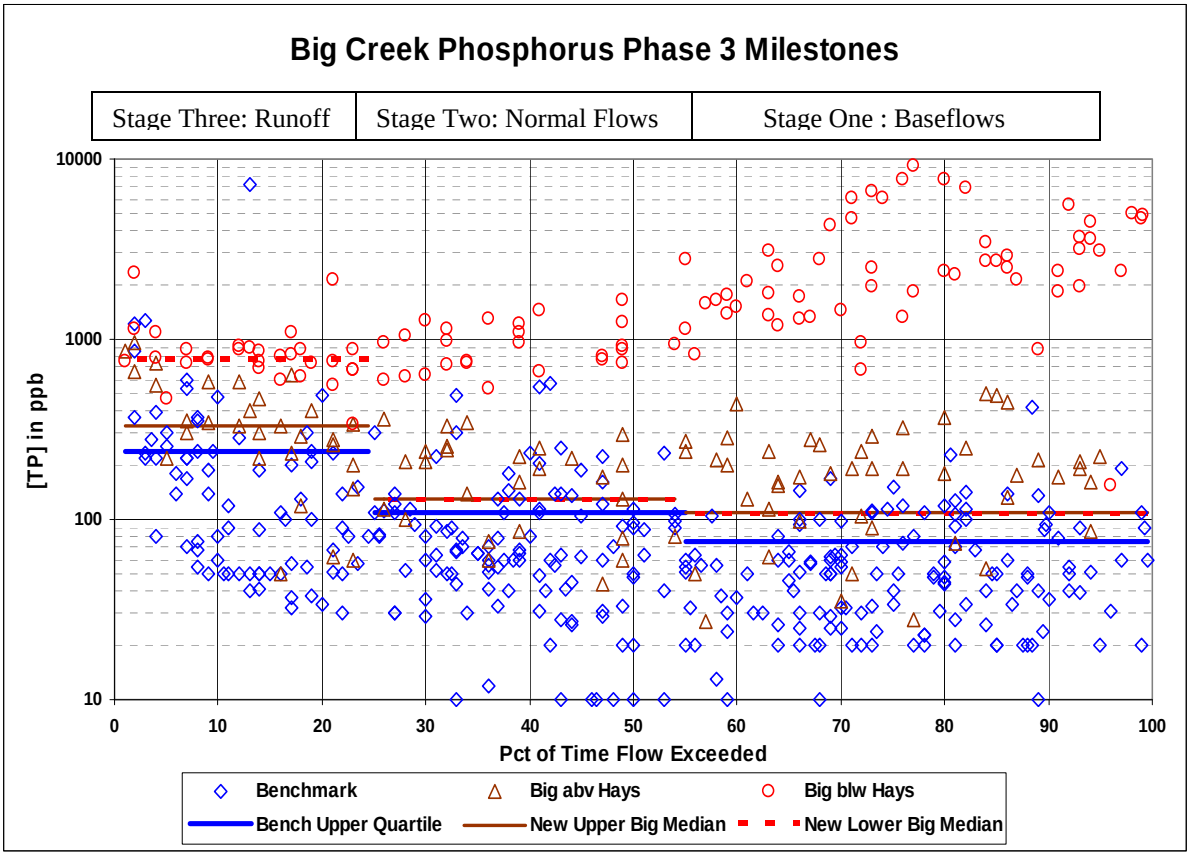


Figure 40. Staged Milestones for Phase 3 Phosphorus Reduction on Big Creek

Two dry batch, ready mix concrete plants are permitted to discharge, but their operations collect any wash water for subsequent re-use or dust suppression. Domestic wastewater at both plants is directed toward the City of Hays wastewater collection and treatment system. Neither has discharged over the period 2003 – 2009.

Wakeeney is not required to monitor for phosphorus in its effluent. Because of the 120-day retention time in the lagoons, most phosphorus is retained by organic matter in the three cells prior to discharging. A study on lagoon wastewater quality by KDHE indicated an average of 2 mg/l of phosphorus is typical for lagoon effluent. That value may rise and fall over winter and summer as a function of biological activity occurring in the lagoon cells. Regardless, the pervasive dry conditions in Trego County limit the transport of any effluent discharge from Wakeeney's outfall down Big Creek.

Similarly, Gorham's three cell lagoon system was upgraded to discharge in August 2010. Wastewater will flow, up to 0.0478 MGD, down an unnamed tributary to Walker Creek and then, lower Big Creek. Effluent can be used to irrigate adjacent cropland, but as a lagoon system, Gorham will not be required to monitor for phosphorus.

Table 4. **NPDES facilities along Big Creek**

Facility	NPDES#	KS Permit #	Type	Rec Stream	Design Q (MGD)	Permit Expires
City of Hays WWTP	KS0036684	M-SH16-OO02	Activated Sludge	Chetolah Creek	2.8	2/28/2014
City of Ellis WWTP	KS0094145	M-SH06-OO02	Aeromod Activated Sludge	Big Creek	0.3	3/31/2014
City of Wakeeney WWTF	KS0099309	M-SH38-OO02	3-Cell Lagoon	Unnamed Trib to Big Creek	0.25	12/31/2014
Ellis County Concrete	KSG110186	I-SH16-PR02	Ready Mix Plant with retention basin	Unnamed Trib to Big Creek	0.0	9/30/2012
APAC-KS-Shears (Hays Plant #601)	KSG110018	I-SH16-PR01	Ready Mix Plant with retention basin	Big Creek	0.0	9/30/2012
City of Gorham*	~~KSJ000327~~ KS0096610	~~M-SH10-NO01~~ M-SH10-OO01	~~Non-Q;~~ 3-Cell Lagoon	Unnamed Trib to Walker Creek	~~0.0~~*; 0.0478	~~7/31/2010~~ 12/31/2014
City of Victoria	KSJ000118	M-SH37-NO01	Non-Overflowing	NA	0.0	5/31/2010
Munjor Improvement District	KSJ000316	M-SH50-NO01	Non-Overflowing	NA	0.0	2/28/2015
APAC-KS-Shears (Hays Plant #921)	KSJ000116	I-SH16-NP05	Non-Overflowing	NA	0.0	1/31/2010
KDOT – Trego Co Rest Area	KSJ000311	M-SH38-NR02	Non-Overflowing	NA	0.0	3/31/2015
KDOT – Gove Co Rest Area	KSJ000331	M-SH12-NR02	Non-Overflowing	NA	0.0	1/31/2015
City of Grinnell	KSJ000332	M-SH14-NO01	Non-Overflowing	NA	0.0	1/31/2015
City of Grainfield	KSJ000329	M-SH12-NO01	Non-Overflowing	NA	0.0	1/31/2015
USD#292 Grainfield-Wheatland School	KSJ000330	M-SH12-NO02	Non-Overflowing	NA	0.0	2/28/2015

- * Gorham converted to discharging 3-Cell Lagoon in late 2010

The City of Ellis Wastewater Treatment Plant discharges to Big Creek and is required to monitor phosphorus on a monthly basis, and measure flows during the week. Effluent can be diverted to the municipal golf course for irrigation purposes. Ellis averages 2.29 mg/l of phosphorus over 2004-2010 (**Figure 41**). With an average discharge of 0.220 MGD, the average phosphorus load is 4.2# per day from Ellis' wastewater treatment.

The city of Hays discharges to Chetolah Creek which enters Big Creek south of town. The wastewater treatment plant underwent an upgrade in 1993, but has not emphasized

phosphorus removal as part of its treatment process. Hays monitors phosphorus on a monthly basis but has no permit limits. The plant has averaged 1.9 MGD in discharge over 2003-2010. Like Ellis, effluent can be diverted to irrigate several golf courses and ball fields. Hays has averaged 5.82 mg/l of phosphorus in its wastewater with a typical daily wasteload of 93# per day (**Figure 41**). During the summer of 2008, Hays began to test applying ferrous sulfate to its wastewater to precipitate phosphorus. Phosphorus concentrations averaged 5.33 mg/l since July 2008. Hays has begun to increase its ferrous additions to further reduce its phosphorus loading.

By March, 2011, Hays will complete studies indicating the cost and feasibility of upgrading for nutrient removal and meeting effluent goals for total phosphorus of 1.5, 0.5 and 0.3 mg/l, associated with Biological Nutrient Removal (BNR), Enhanced Nutrient Removal (ENR), and Limits of Technology (LOT). The studies include operational and capital costs for making operational changes, adding biological treatment and physical and chemical treatment additions. Additionally, Hays has begun to sample the phosphorus content of its influent entering the wastewater treatment plant. Five samples taken in 2010 average 7.0 mg/l TP, which is above typical sewage levels. Ellis and Russell influent phosphorus averages 4.8 – 4.9 mg/l over 2009 – 2010.

The lack of influence of Ellis wastewater on downstream Big Creek phosphorus can be seen in **Figure 42**. An order of magnitude decline is seen between the effluent concentration and that seen at Station SC541 above Hays. Hays wastewater causes a major rise in phosphorus levels between SC541 and downstream SC540. However, there is also dilution and in-stream assimilation between Hays and Munjor, resulting in lower concentrations downstream than those seen in Hays effluent. The same relationships appear with the WRAPS data with finer spatial and temporal resolution relative to

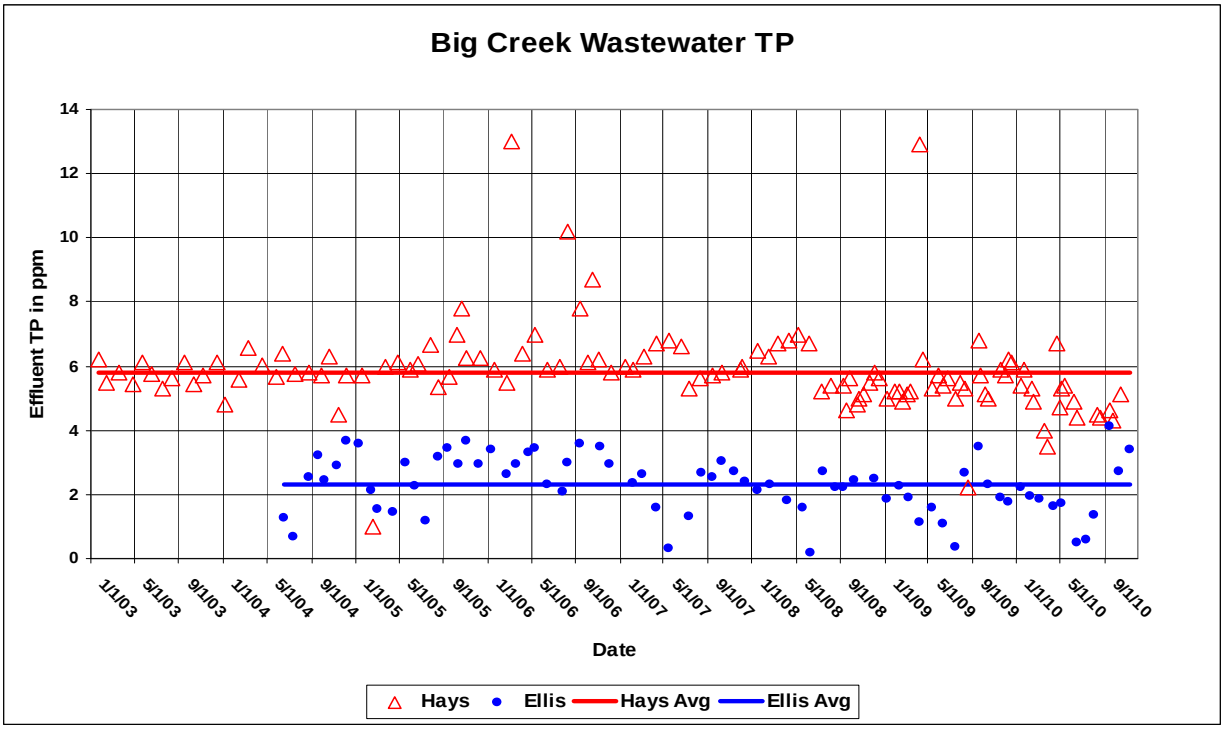


Figure 41. Wastewater Phosphorus at Hays and Ellis

wastewater sampling (**Figure 43**). Even though WRAPS sampling tended to focus on runoff conditions with diminished effect from wastewater, the synoptic sampling along Big Creek indicated the same relationships among monitoring stations above and below Hays.

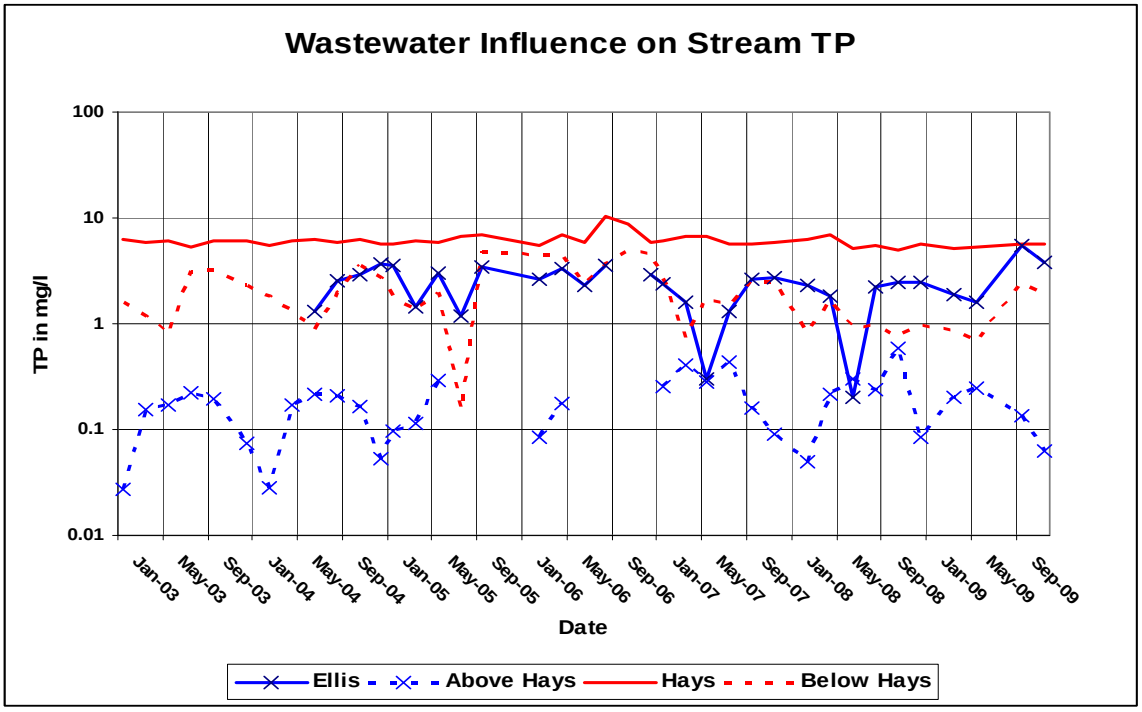


Figure 42. Relation between Wastewater and Big Creek Phosphorus Levels

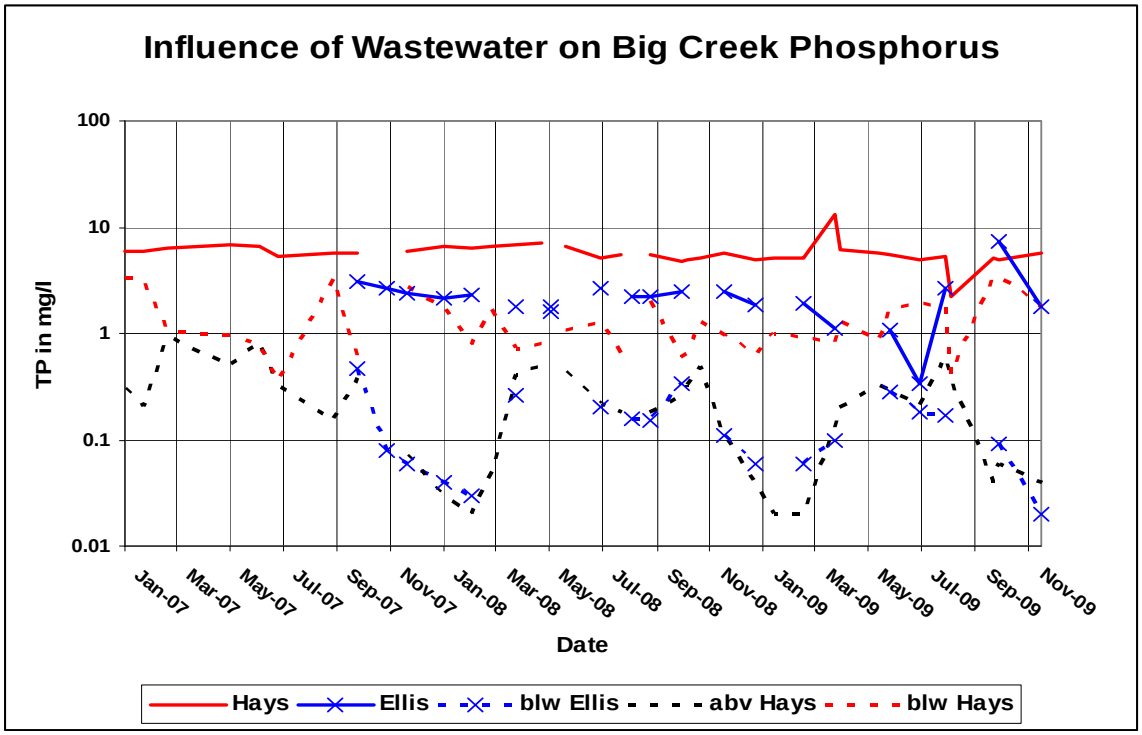


Figure 43. Relationship between Wastewater and Big Creek Phosphorus from WRAPS data

An additional way to view the relative impact of Hays wastewater is looking at the change in total phosphorus concentrations seen on Big Creek above and below Chetolah Creek **(Figure 44).** Clearly, below 10 cfs, Hays has marked influence on the change in phosphorus seen downstream. That impact decreases as runoff builds and beyond 20 cfs, there is little difference in TP on the upper and lower reaches of the creek.

Hays also has a MS4 NPDES stormwater permit, (M-SH16-SN01; KSR044008) currently in renewal (Expired September 30, 2009). The permit follows a general permit format, requiring the six minimum controls to be implemented throughout the corporate limits of Hays. Part III of the permit lists required best management practices to attenuate specific pollutants loading to specific waterbodies, with a minimum of one BMP for each listed parameter to be implemented within two years of permit renewal. In the case of this TMDL, phosphorus concentrations decrease on the lower reaches of Big Creek receiving urban stormwater during wet weather, while rural runoff increases the phosphorus levels from the remainder of the watershed.

Land Use: Cropland is the predominant land use within Big Creek Subbasin, comprising 62% of the acreage. **Figure 45** indicates that cropland is interspersed with grasslands throughout the drainage, but dominates the land use in Gove County, where ground water irrigation from the High Plains Aquifer supports row crop production, along Ogallah Creek and in the eastern half of Ellis County. Cropland tends to be concentrated on the uplands where flatter slopes support expansive cultivation **(Figure 46).** As Big Creek enters Russell County, it courses through a series of breaks that do not lend themselves to extensive agriculture. Row crop production in the vicinity of Big Creek can contribute phosphorus to the surface water via overland flow. Phosphorus increases with runoff from the rural portions of the watershed. Irrigation diversions in 2007 totaled 17,100 acre-ft in Gove County, 5820 ac-ft in Trego County, 950 ac-ft in Ellis County and 105 ac-ft in Russell County (KWO, 2008).

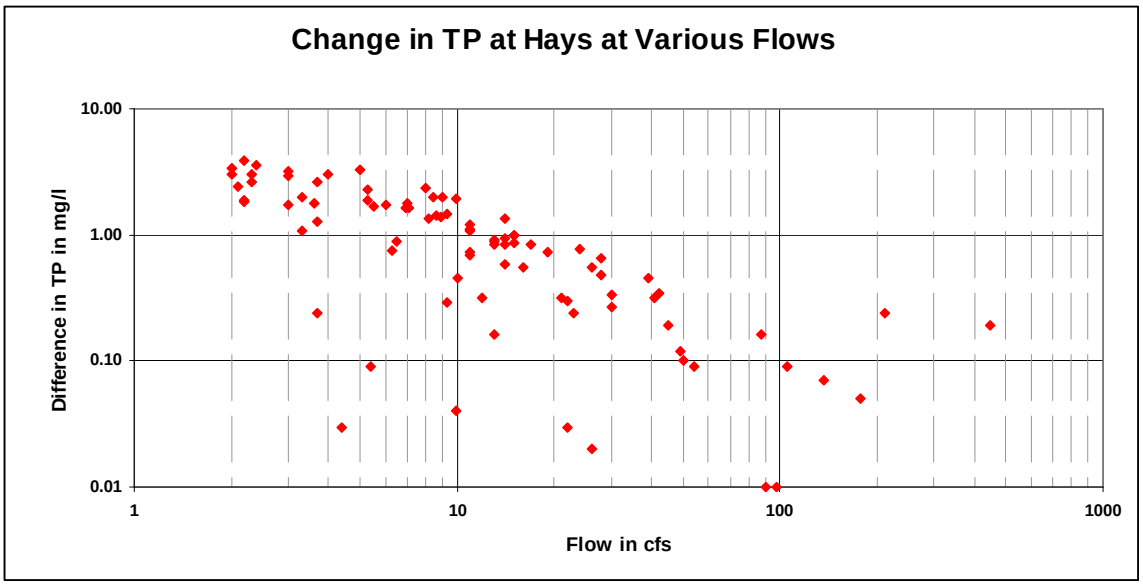


Figure 44. Difference between upstream and downstream TP concentrations at Hays.

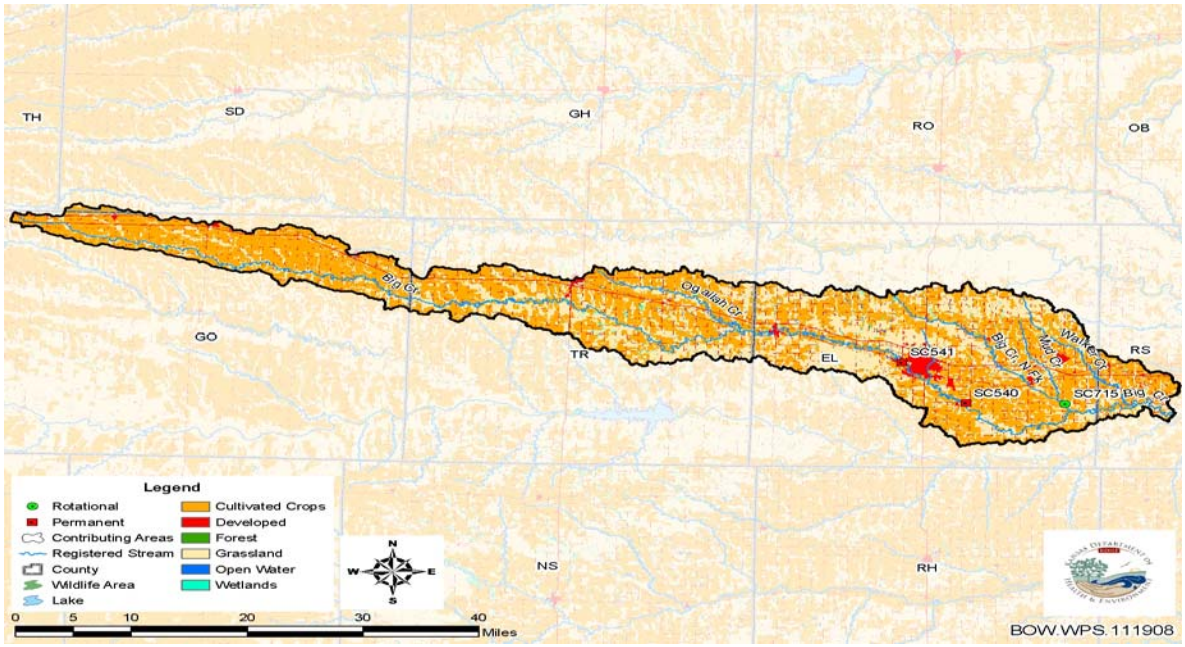


Figure 45. General Land Use in Big Creek Watershed (from 2001 NLCD)

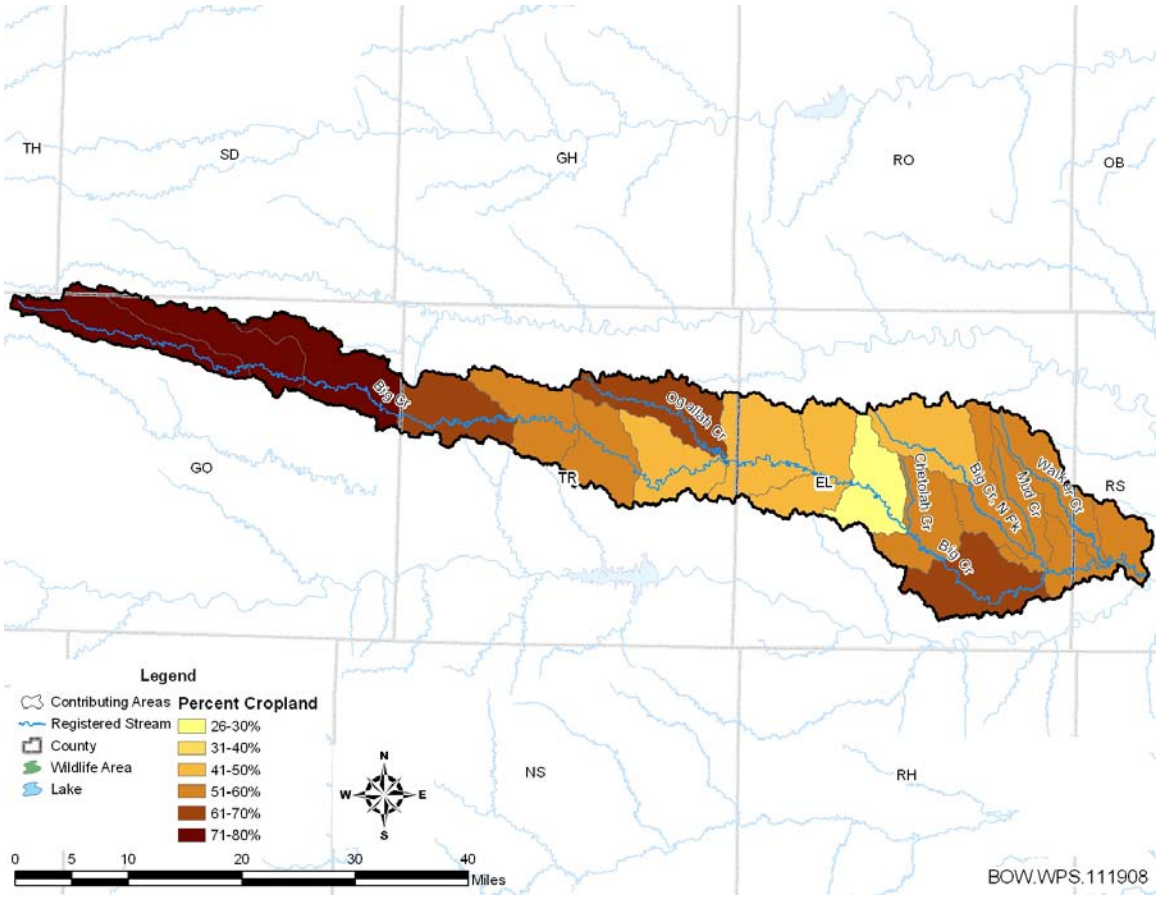


Figure 46. Cropland Distribution Across Big Creek Watershed

Table 5 summarizes the most recent crop year plantings for the four counties in the Big Creek drainage. Wheat is the predominant crop over the winter and spring and sorghum dominates the summer – fall period. Corn is prevalent in Gove and Trego counties where irrigation from the High Plains Aquifer is an option. Soybeans have a small niche within all four counties. The acres of corn for silage in Gove County are unusually high likely because of salvaging after the 2006 drought, typical silage averages 4400 acres.

Table 5. Planted Crop Acres in Counties of Big Creek Drainage

	Big Creek Counties			
Year & Crop	**Ellis**	**Russell**	**Trego**	**Gove**
2009 Wheat	113,000 ac	77,000 ac	89,000 ac	104,000 ac
2008-9 Corn	4500 ac	----------	15,500 ac	74,500 ac
2009 Sorghum	51,000 ac	51,000 ac	61,000 ac	48,000 ac
2006-8 Soybeans	1800 ac	2500 ac	900 ac	2200 ac
2006 Corn Silage*	----------	----------	2100 ac	19200 ac
2007 Sorghum Silage*	3300 ac	----------	600 ac	1400 ac

- * Silage represents acres harvested or salvaged for fermentation

Contributing Runoff: Soil permeability values across the watershed, based on NRCS STATSGO database, indicate the average soil permeability of the watershed is less than 1.2”/hour, which contributes to runoff during low rainfall intensity events (Juracek, 2000). Whereas over 95% of the watershed would contribute runoff under rainfall intensities of 1.5 inches per hour, that proportion drops to 50% at 1.14”/hr, 21% at 0.9”/hr and 6% at 0.5”/hr.(Juracek, 1999,2000). Soil-permeability probably dictates the production of runoff along Big Creek. Relatively small slopes **(Figure 47)** throughout the watershed would allow for landscape saturation provided there was enough rainfall to overcome the strong evapo-transpiration processes present along the warm, windy plains.

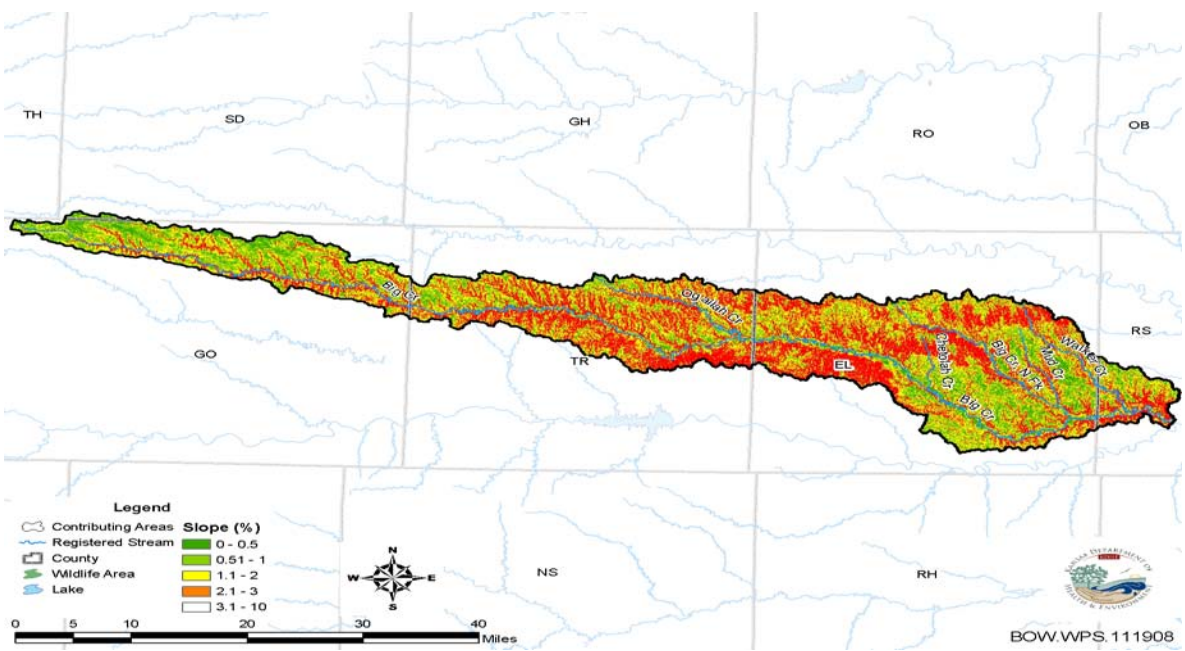


Figure 47. Land slope Across the Big Creek Watershed

Livestock and Waste Management Systems: There are 44 certified, permitted or registered animal feeding operations (AFOs) within the Big Creek Subbasin covered by this TMDL (see **Appendix B**). All of these livestock facilities have waste management systems designed to minimize runoff entering their operations 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 47,600 animal units in the watershed, the actual number of animals at the feedlot operations is typically less than the allowable permitted number **(Table 6).** Most of the facilities handle cattle, with one facility in Ellis County exceeding the Federal threshold (1000 AU), requiring a NPDES permit (KS0037630; A-SHEL-CO02; 30,000 animal units of cattle, permit expiring in 3/15/2014). Cattle comprise 93% of the animal units under KDHE review and dairy represents another 4.4%. Swine and Sheep make up the balance and there is a game bird operation (exotic) that is not counted toward Federal Animal Units.

Based on Kansas Agricultural Statistics, most cattle are located in Gove and Ellis Counties as are the cattle in confined feeding operations **(Tables 6 & 7).** There are livestock present in Russell County but no regulated facilities in the Big Creek drainage portion of the county **(Figure 48).**

Table 6. Animal Units Associated with Feeding Operations in the Big Creek Subbasin

County	HUC 12	Beef	Dairy	Swine	Sheep	Game Birds
Gove	**0101**	2310				
	0103	5290	1241		999.9	
Trego	**0201**	1052		171.2		
	0203	943	140	5.6		
	0204	800				
Ellis	**0302**	450	56			
	0303	31099	323			
	0304	150				
	0305		150			
	0401	1233				
	0402		84			
	0403		105			5000*
	0404	700				
	0405	300				
Total	**Animal Units**	**44327**	**2099**	**176.8**	**999.9**	**5000***

*** Exotic animal units not counted toward Federal permit thresholds**

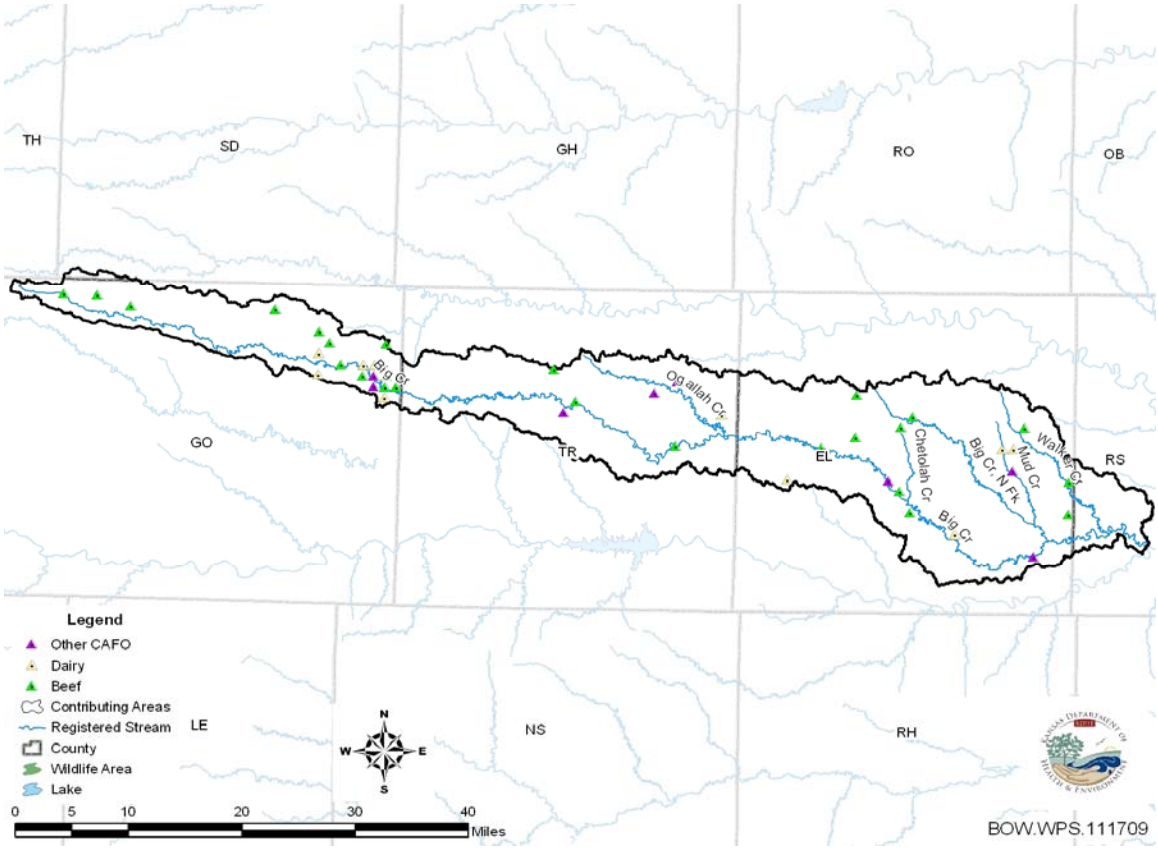


Figure 48. Animal Feeding Operations in Big Creek Watershed

Population Density: **Table 7** summarizes the populations for the four counties overlying the Big Creek Sub-Basin. The population trends for all of these counties, except Ellis (+ 1.1%) indicate the population bases are declining (– 9.9% to – 16.9%). The population density is greatest in Ellis County (30.6 people/sq.mi.), because of Hays; and least in Gove County (2.9 people/sq.mi.). The population residing in cities and towns in each county ranges from 56-58% in Gove and Trego counties to 69-84% in Russell and Ellis counties. Farms are smaller and more numerous in Ellis County than Gove County. The percentage of farmland in each county ranges from 76% in Trego County to 91% in Ellis County.

Table 7. Selected Facts for Counties that have Big Creek Drainage

County	2009 Population*	2000 Census Population	County Size Sq.Miles	2007 # of Farms**	2007 Farm Acreage	2009 Cattle Head***
Ellis	27,739	27,507	900	687	526,202	52,800
Russell	6,596	7,370	885	522	442,550	30,900
Trego	2,920	3,319	888	380	429,588	30,800
Gove	2,480	3,068	1,071	413	593,622	76,000

* - U.S. Census Bureau Estimates ** 2007 Ag Census & Kansas Agricultural Statistics
*** Figures represent total cattle in county, not just Big Creek drainage

On-Site Waste Systems: Based on the 1990 census data, about 13% of the households in Ellis County, 39% of the households in Trego County, 37% of the households in Gove County and 19% of the households in Russell County utilize septic or other on-site systems. Current model estimates indicate a 10 – 15% failure rate for on-site wastewater treatment systems. Because of their small flows and loads, failing on-site septic systems would be a minor source of nutrient loadings within the watershed and would not significantly contribute to the phosphorus impairment along lower reaches of Big Creek.

Background Levels: Phosphorus is present over the landscape, in the soil profile as well as terrestrial and aquatic biota. Wildlife can contribute phosphorus loadings, particularly if they congregate to a density that exceeds the assimilative capacity of the land or water. However, background concentrations of phosphorus should be below 100 ppb.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

This TMDL will be established in Phases and Stages to progressively reduce phosphorus loadings and ambient concentrations with periodic assessment of the biological endpoints on the lower reaches of Big Creek. **Figure 49** displays the desired phosphorus loads above Hays, at Munjor and near Russell during **Phase One**. This phase will entail dramatic reductions in phosphorus levels of Hays wastewater that should translate to median concentrations approaching the levels seen upstream of Hays under baseflow conditions (**Stage One**). Additionally, riparian management and livestock management in the vicinity of Big Creek should reduce non-point source loads under conditions of moderate flows (25-55 percentile flows) as part of **Stage Two**. Once the concentrations at Stations 540 and 752 approach those of Station 541, intensive assessment of macroinvertebrate diversity and composition and planktonic abundance in the water column and attached to stream substrates will be made to determine compliance with the narrative nutrient criteria.

Presuming one or more of the biologic endpoints are not met at the end of **Phase One**, **Phase Two** will commence. Additional reductions in loads and phosphorus concentrations will be accomplished through enhanced implementation of controls on point and non-point sources (**Figure 50**). The desired target levels are comparable to the concentrations seen on the best streams in ecoregion 27 and sub-ecoregion 27b. Hays wastewater will undergo enhanced nutrient removal and management of riparian activities will be extended to the upper reaches of Big Creek between Hays and Ellis, as well as along tributaries and to urban stormwater contributing flow and loads to Big Creek. Once again, two stages will be established to lower phosphorus levels at baseflow and normal flows. A second intensive biological assessment will be made once phosphorus levels approach that seen at the regional benchmarks.

Should the biological endpoints still not be met, a **third Phase (Figure 51)** will be initiated that begins to address watershed-wide phosphorus loading during high flows (exceeded less than 25% of the time). Benchmarks will be established using the Saline and Smoky Hill Rivers in the vicinity of Hays. Treatment of the Big Creek watershed throughout Ellis County will occur to attempt to abate runoff contributions under very

wet weather. Furthermore, Hays wastewater may need to be treated to the Limits of Technology so that the overall median phosphorus concentrations on Big Creek are near the composite benchmark upper quartile value from the Smoky Hill and Saline Rivers (at or below 75 ppb). **Table 8** summarizes the Phases and Stages of this TMDL to bring about compliance with the narrative nutrient criterion (lack of impacts to designated uses) once phosphorus loadings decrease.

Table 8. Big Creek TP TMDL Phases, Stages, Milestones and Action

TMDL Phase	TMDL Stage	Applicable Flows	TP Milestone	Anticipated Action
I	**I – 1**	Baseflows: 55 – 99%	250 ppb*	Hays WW BNR and Disposal by Irrigation
I	**I – 2**	Normal: 25 – 55%	250 ppb*	Lower Big Creek Riparian & Livestock Management
II	**II – 1**	Baseflows: 55 – 99%	110 ppb	Hays WW ENR and Irrigation
II	**II – 2**	Normal: 25 – 55%	130 ppb	Hays MS4; Big Creek above Hays & Trib Riparian Management
III	**III – 1**	Baseflows: 1 – 25%	75 ppb	Hays WW LOT, Re-use and Disposal by Irrigation
III	**III – 2**	Normal: 25 – 55%	110 ppb	Riparian Management in Eastern Trego County; Hays MS4
III	**III – 3**	High: 1 – 25%	240 ppb	Full Watershed Treatment of NPS via Runoff Control

* applicable at SC540 only, otherwise applicable at both SC540 & SC541

Point Sources: The Wasteload Allocation (WLA) is associated with the wastewater treatment facilities for the City of Wakeeney, City of Ellis and City of Hays and the new facility at the City of Gorham. Even though the phosphorus loads from Wakeeney and Ellis typically do not pass through downstream and arrive at Hays and discharges from Gorham will not be prevalent, this TMDL will assign a wasteload allocation to those facilities to manage any local effects below their respective outfalls. The main focus for this TMDL, however, will be the wastewater discharge of Hays.

Table 9 lists the four phased Wasteload Allocations to Wakeeney, Ellis, Gorham and Hays. These WLAs are based on the current design flows of the respective wastewater treatment facilities and an initial wastewater phosphorus concentration of 1.5 mg/l for the mechanical plants and 2 mg/l for the two lagoon systems (annual averages). No modification to treatment or removal process are anticipated for the two lagoon systems, but the likelihood of discharges impacting Big Creek from Wakeeney and Gorham is small, given the arid flow regime of their receiving streams and their declining population base. The 1.5 mg/l values reflect imposition of Biological Nutrient Removal or ferrous additions at Hays and Ellis. Additional treatment may be necessary if the TMDL moves to Phases Two or Three. In all cases, the resulting Wasteload Allocations for the four cities are less than those prescribed by the 2003 eutrophication TMDL for Kanopolis Lake.

Use of wastewater for irrigation, efficient operation of the treatment processes at Hays and Ellis and lower volumes of Wakeeney and Gorham wastewater reaching the lower portion of Big Creek will assist lowering phosphorus loading and concentrations seen below Hays. Prior to initiating efforts for Enhanced Nutrient Removal, growth in current wasteloads among the four facilities, the probability of discharge and transport of wastewater from the three smaller facilities to lower reaches of Big Creek, consideration of assimilation rates of wastewater phosphorus, wasteload trading opportunities among cities, opportunities to further irrigate with wastewater and actual efficiency in phosphorus removal by the mechanical and lagoon systems should be evaluated, along with resulting downstream (SC540) total phosphorus levels. Pending the outcome of its cost study, Hays may choose to invest in ENR initially and forego BNR treatment.

Phase 2 would commence if biological information indicated the impacts identified in the narrative criterion for nutrients were still occurring after **Phase 1** was complete. Should the **Stage II – 1** milestone become the new goal, the wasteload allocation for Hays and Ellis will be reduced to reflect a typical annual average concentration of 0.5 mg/l from Enhanced Nutrient Removal. This would be done in concert with corresponding reductions in wasteload volumes from Wakeeney and Gorham. Given the dependence of downstream phosphorus concentrations on wasteloads emanating from Hays, significant reduction in ambient concentrations of phosphorus should be realized with the further reductions by Hays in its wastewater. Under normal flow conditions, urban Best Management Practices would be installed to reduce loads delivered to Big Creek by stormwater generated within the jurisdictional limits of Hays.

Phase 3 reductions would be required if biological assessments indicated that full support of the designated uses for aquatic life, recreation and drinking water supply was lagging. Wastewater treatment at Hays and Ellis would approach the Limits of Technology (~0.3 mg/l). Discharge reduction would be encouraged at all four municipalities through re-use and irrigation of wastewater. Extensive runoff retention and infiltration practices would be installed in Hays, pursuant to its urban stormwater management program, designed to handle the flow volumes from larger design storms.

Actual wasteloads attributed to ambient concentrations seen downstream under normal conditions are anticipated to be much less (~36%) than the allocations of **Table 9** because of adsorption to sediments and absorption by biota. **Table 10** outlines the expected impact of these Wasteload Allocations at the three monitoring locations along Big Creek. Under the driest flow conditions (90%), wasteloads will be largely reduced through, efficient treatment, transit losses along the channel and alternative disposal such as irrigation, so that they match up with the overall Load Capacity. In-stream wasteloads in the three segments are chiefly defined by the lesser of the Load Capacity at the low flow (75%) condition or the anticipated reduced (36%) wasteload allocations, and applied to all wet conditions. These arriving wasteloads are expected to decline with each Phase of the TMDL and associated upgrade in wastewater treatment.

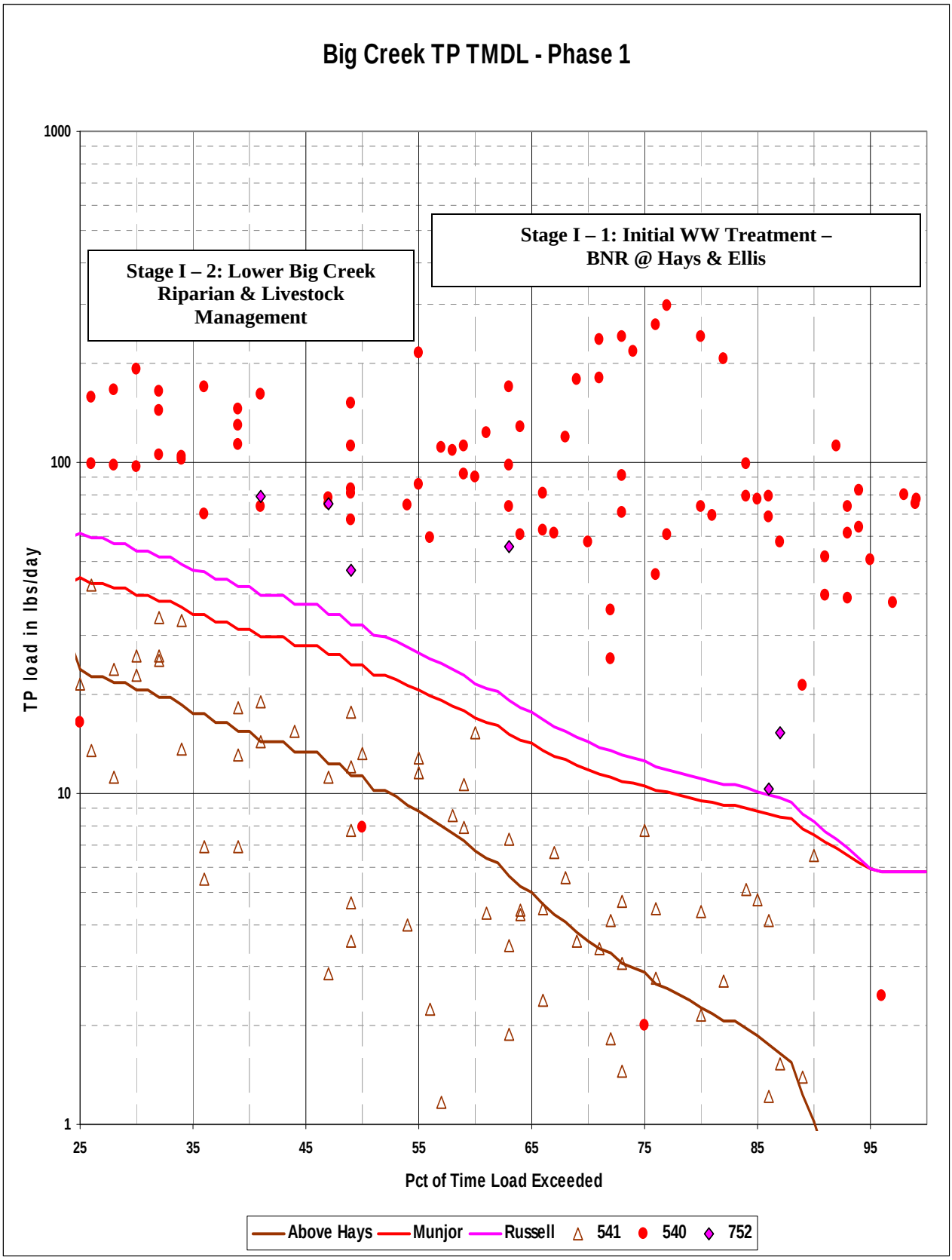


Figure 49. Phase One TP TMDL Load Capacities for Big Creek at Three Locations

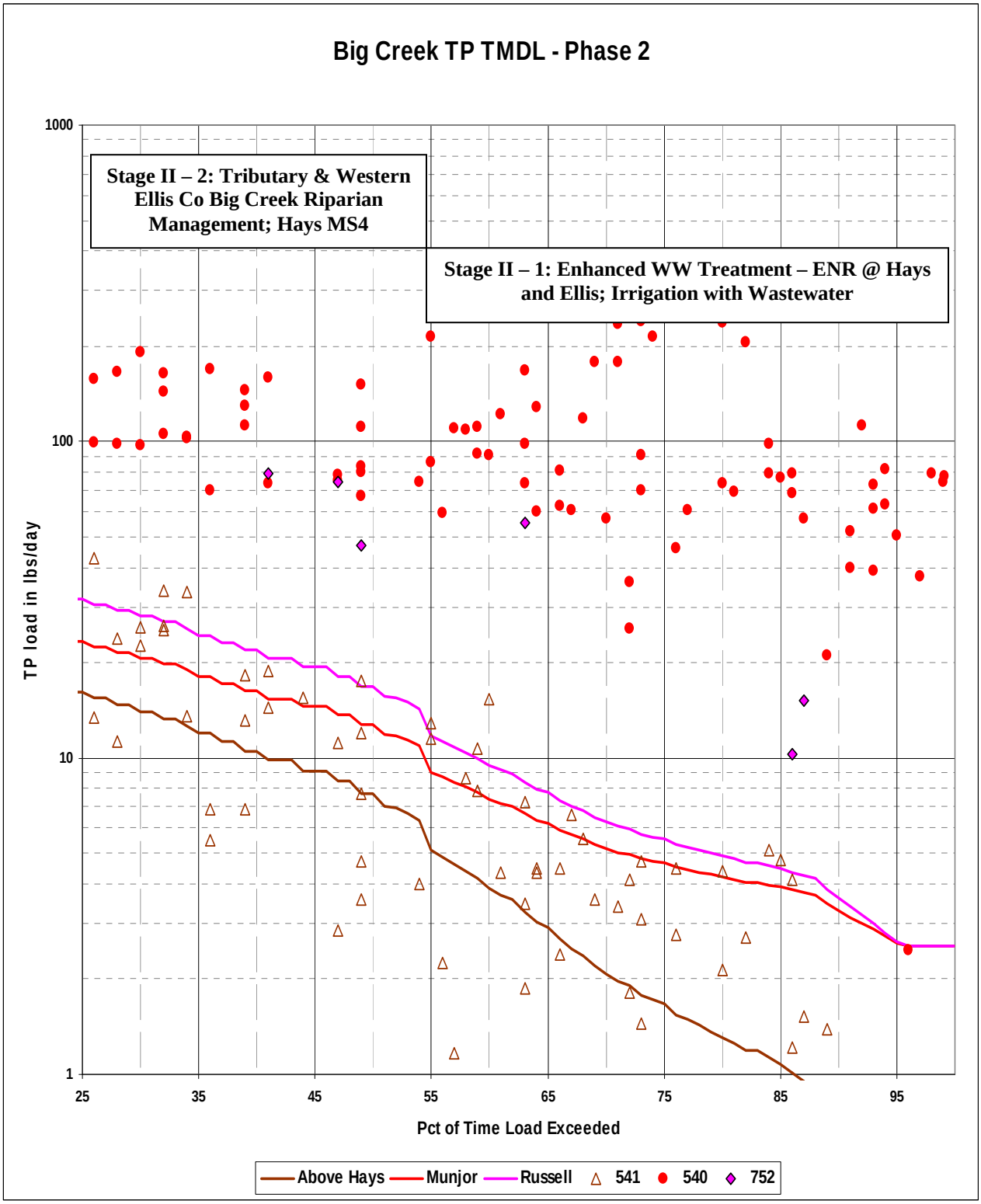


Figure 50. Phase Two TP TMDL Load Capacities for Big Creek at Three Locations

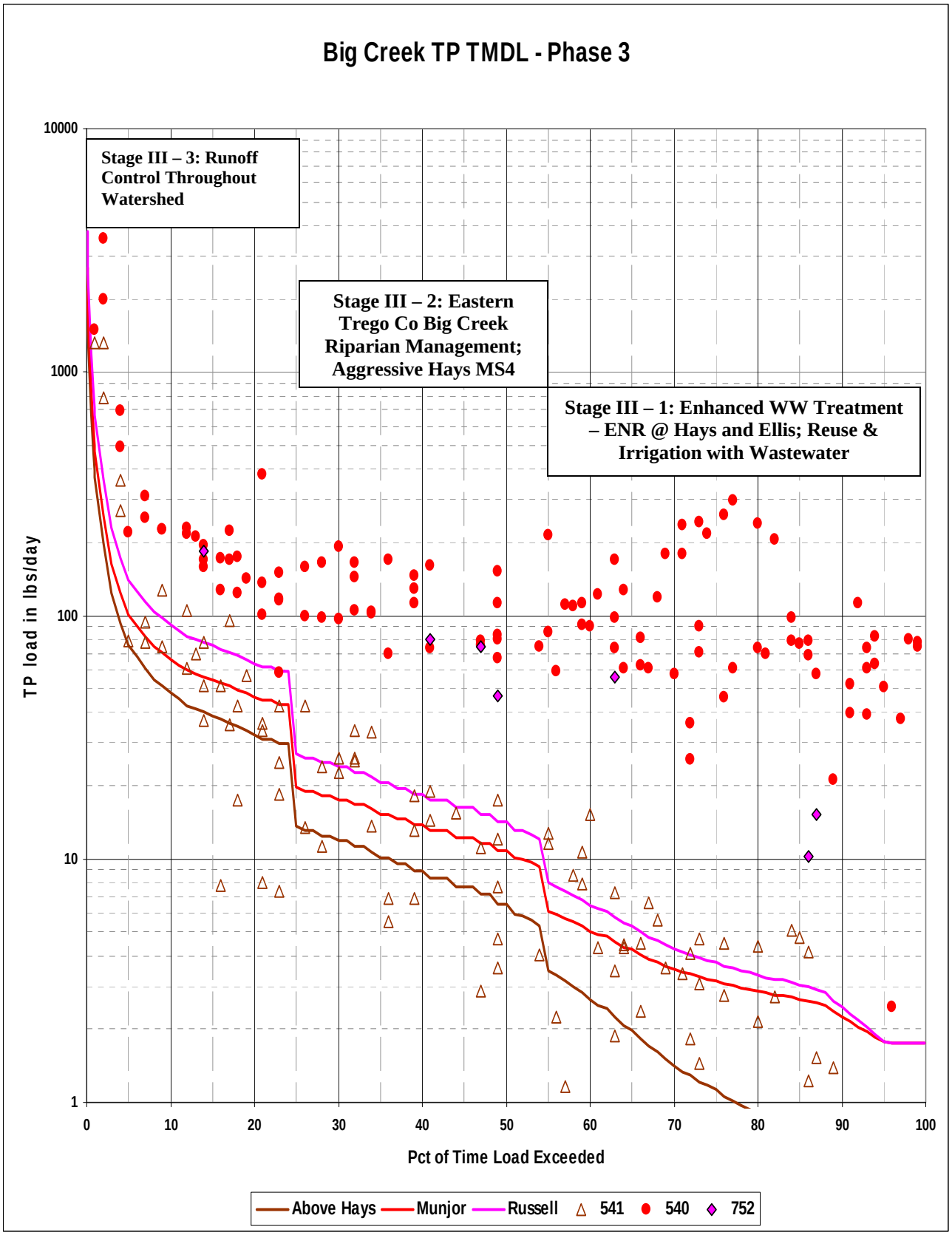


Figure 51. Phase Three TP TMDL Load Capacities for Big Creek at Three Locations

Table 9. Current and Projected Wasteload Allocations for Dischargers to Big Creek

					Phase I	Phase II	Phase III	
City	**Current WW flow**	**Current TP**	**Current load**	**Design Flow**	**BNR load @ 1.5 ppm**	**ENR load @ 0.5 ppm**	**LOT load @ 0.3 ppm**	**WLA from Kanopolis Lake TMDL**
Hays	1.9 MGD	5.82 mg/l	92.4 #/d	2.8 MGD	35.1 #/d	11.7 #/d	7.0 #/d	81.83 #/d
Ellis	0.22 MGD	2.29 mg/l	4.2 #/d	0.3 MGD	3.8 #/d	1.3 #/d	0.8 #/d	8.77 #/d
Wakeeney	~0.20 MGD	~ 2.0 mg/l	3.3 #/d	0.25 MGD	4.2 #/d	4.2 #/d	4.2 #/d	12.6 #/d
Gorham	0 MGD	0 mg/l	0 #/d	0.0478 MGD	0.8 #/d	0.8 #/d	0.8 #/d	1.05 #/d
Total Daily Load			**99.9 #/d**		**43.8 #/d**	**17.9 #/d**	**12.7 #/d**	**104.25 #/d**
Total Annual Load			**36,500 #/yr**		**16,000 #/yr**	**6500 #/yr**	**4650 #/yr**	**38051 #/yr**

There will be Wasteload Allocations of zero assigned to the concrete batch plants, the non-discharging wastewater facilities and the confined animal feeding operations because these facilities should not discharge to Big Creek.

MS4 Stormwater: A Wasteload Allocation for Hays MS4 is provided by proportioning the remaining load capacity, after accounting for the assimilated NPDES WLA, between MS4 and NPS loads **(Table 10).** No stormwater occurs on Segment 3 until normal-to-wet flow conditions (exceeded less than 60% of the time). Under normal flow conditions (50% exceedance), load contributions were assumed to arise from the HUC 12's surrounding Hays (**Appendix C**). The MS4 WLA was proportioned by the amount of developed land in HUCs 102600070303 & 04 ~ **11%** (6200 acres out of 57,650 acres). Under wet conditions (flows exceeded 1 – 40% of the time), additional load contributions are assumed to arise from western Ellis County and the proportion of developed land dwindles to **6%** (7900 acres (including Ellis) divided by 127,730 acres in HUC 12's 01, 02, 03 & 04).

NPS Load Allocation: The load allocation for non-point sources is the remaining load capacity after assimilated wasteloads for NPDES wastewater and MS4 stormwater have been accounted **(Table 10).** Non-point sources are assumed to be non-existent at times that Big Creek is composed strictly of Hays wastewater. The load allocation grows proportionately as normal conditions occur, comprising 89% of non-wastewater load during normal flow conditions and generally restricted to central and eastern Ellis County. The allocation and contributing areas grows as wet weather ensues. At least 94% of the runoff-driven loads are by non-point sources and emanate throughout Ellis County up to the Trego County line. Sources in Trego and Gove counties are assumed to arrive at Hays only under prolonged wet conditions, once stream depletions from irrigation withdrawals and conservation practices are overcome.

Table 10. Load Capacities and Allocations (lbs/day) Along Big Creek Under the Three TMDL Phases

Phase I		Segment 5 Loads			Segment 3 Incremental Load				Segment 1 Incremental Load			Total Loads			
Pct Flow	Flow	LC	WLA	LA	LC	WLA	MS4	LA	LC	WLA	LA	LC	WLA	MS4	LA
90%	1 cfs	1.03	1.03	0.00	6.48	6.48	0.00	0.00	0.71	0.71	0.00	8.22	8.22	0.00	0.00
75%	2.8 cfs	2.87	2.87	0.00	7.70	7.70	0.00	0.00	2.00	0.80	1.20	12.57	11.37	0.00	1.20
50%	11 cfs	11.29	2.87	8.42	13.23	7.70	0.61	4.92	7.85	0.80	7.05	32.37	11.37	0.61	20.39
25%	23 cfs	27.60	2.87	24.73	17.33	7.70	0.61	9.02	16.43	0.80	15.63	61.36	11.37	0.61	49.38

Phase II		Segment 5 Loads			Segment 3 Incremental Load				Segment 1 Incremental Load			Total Loads			
Pct Flow	Flow	LC	WLA	LA	LC	WLA	MS4	LA	LC	WLA	LA	LC	WLA	MS4	LA
90%	1 cfs	0.59	0.59	0.00	2.71	2.71	0.00	0.00	0.32	0.32	0.00	3.62	3.62	0.00	0.00
75%	2.8 cfs	1.66	1.66	0.00	2.99	2.99	0.00	0.00	0.88	0.80	0.08	5.53	5.45	0.00	0.08
50%	11 cfs	7.72	1.66	6.06	5.03	2.99	0.22	1.82	4.08	0.80	3.28	16.83	5.45	0.22	11.16
25%	23 cfs	16.15	1.66	14.49	7.21	2.99	0.25	3.97	8.55	0.80	7.75	31.91	5.45	0.25	26.21

Phase III		Segment 5 Loads			Segment 3 Incremental Load				Segment 1 Incremental Load			Total Loads			
Pct Flow	Flow	LC	WLA	LA	LC	WLA	MS4	LA	LC	WLA	LA	LC	WLA	MS4	LA
90%	1 cfs	0.41	0.41	0.00	1.84	1.84	0.00	0.00	0.22	0.22	0.00	2.47	2.47	0.00	0.00
75%	2.8 cfs	1.13	1.13	0.00	2.04	2.04	0.00	0.00	0.60	0.60	0.00	3.77	3.77	0.00	0.00
50%	11 cfs	6.53	1.13	5.40	4.26	2.46	0.20	1.60	3.45	0.60	2.85	14.24	4.19	0.20	9.85
25%	23 cfs	13.66	1.13	12.53	6.11	2.46	0.22	3.43	7.23	0.60	6.63	27.00	4.19	0.22	22.59
10%	37 cfs	47.95	1.13	46.82	18.04	2.46	0.93	14.65	25.38	0.60	24.78	91.37	4.19	0.93	86.25

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty in phosphorus loading into Big Creek, predominantly from the point source dischargers in the watershed. This TMDL uses an implicit margin of safety, relying on conservative assumptions to be assured that future wasteload allocations will not cause further excursions from the nutrient criteria. First, design flows are used for the four point source dischargers to set wasteload allocations, although demographic trends indicate Gorham and Wakeeney are just as likely to decline in population. Second, the wasteloads from Ellis and Wakeeney are assumed to travel through Big Creek and arrive at Hays. Third, four biological endpoints are used to assess the narrative criteria and have to be maintained for three consecutive years before attainment of water quality

standards can be claimed. Finally, because there is often a synergistic effect of phosphorus and nitrogen on in-stream biological activity, concurrent efforts by Hays to reduce nitrogen content of its wastewater should complement the effect of phosphorus load reduction in improving the biological condition of Big Creek.

State Water Plan Implementation Priority: Due to the prevalence of high phosphorus in the lower portions of Big Creek below Hays, **Phase One** priority is focused on wastewater treatment upgrades at Hays and riparian management along the lower reaches to effectively reduce the phosphorus loading to the creek. **Phase Two** priorities will expand non-point source abatement along Big Creek on either side of Hays and along the tributaries contributing flows and loads to Big Creek. Additionally, further reduction in wastewater phosphorus loads at Ellis and Hays will occur. Finally, **Phase Three** expands watershed treatment to upland areas throughout Ellis, Russell and eastern Trego counties in an effort to reduce loads at high flows. If necessary, further wasteload reduction may be made at Hays. In conjunction with the need to reduce nutrient loading into the drainage leading to Kanopolis Lake, this TMDL will be **High Priority** for implementation.

Priority HUC12s: Although, this TMDL is initially driven by implementation of point source treatment improvements, priority HUC12s within the watershed can be identified based on the land use seen among the sub-watersheds and within 100 foot buffers along Big Creek. Because the hydrology of the watershed is meager to the west of Hays, those sub-watersheds will be relegated to **Phase Two and Three** implementation. The HUC 12s surrounding Hays (102600070303 & 04) have the largest percentage of developed land within them among the 18 sub-watersheds comprising the Big Creek watershed (**Appendix C**). Additionally, HUC 102600070305 with the highest proportion of cropland in its sub-watershed (66%) would be targeted as high priority for non-point source abatement along the lower portions of Big Creek. These three HUC 12s will be the initial **Phase One** priority. In their Section 319 9-Element Watershed Plan, the Big Creek – Middle Smoky Hill River WRAPS has identified these HUC 12s as two of their five priority areas (**Appendix E**). As progress is made on these priority areas, and as biological assessments warrant, the two upstream HUC 12s (01 & 02) in Ellis County should receive attention to abate non-point source loadings during **Phase Two**. **Phase Three** watersheds comprise the HUC 12s in Ellis and Russell counties and 102600070203 (Ogallah Creek) and 04 in western Trego County.

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. Make operational changes in wastewater treatment at Hays and alternative disposal such as irrigation and, if necessary, install enhanced nutrient reduction technology to reduce wasteloads.
9. Renew state and federal permits and inspect permitted facilities for permit compliance.
10. Facilitate urban stormwater management in Hays to abate pollutant loads.

NPDES and State Permits - KDHE

a. Monitor influent into and effluent from the discharging permitted wastewater treatment facilities, continue to encourage wastewater reuse and irrigation disposal and ensure compliance and proper operation to control phosphorus levels in wastewater discharges.
b. Establish applicable permit limits and conditions after 2014 and implementation of the recommended nutrient reduction option from the 2011 study.
c. Inspect permitted livestock facilities to ensure compliance.
d. New Livestock permitted facilities will be inspected for integrity of applied pollution prevention technologies.
e. New Registered livestock facilities with less than 300 animal units will apply pollution prevention technologies.
f. Manure management plans will be implemented, to include proper land application rates and practices that will prevent runoff of applied manure.
g. Reduce runoff on Lincoln and Chetolah Draws in Hays through stormwater management program and MS4 permit.
h. Establish nutrient reduction practices among urban homeowners to manage application on lawns and gardens, through the Hays stormwater management program.

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 the implementation efforts of the Big Creek – Middle Smoky Hill River Watershed Restoration and Protection Strategy (WRAPS) and incorporate long term objectives of this TMDL into their 9-element watershed plan.

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.

g. Promote and utilize Big Creek – Middle Smoky Hill WRAPS efforts at pollution prevention, runoff control and resource management.

Timeframe for Implementation: Reduction strategies for Hays wastewater should be evaluated by mid-2011 with subsequent planning, design and construction of any necessary enhanced treatment completed within the next permit cycle after 2014. Urban stormwater and rural runoff management should commence in 2011 in Hays and the eastern reaches of Big Creek. Implementation of abatement practices should commence in the three priority HUC 12s in 2011. Implementation should continue through 2019. Implementation of Enhanced Nutrient Removal at Hays will await evaluation of the biological endpoints at Munjor and Russell, affected by **Phase One** abatement efforts at Hays and concomitant load reductions by non-point sources. If biological conditions warrant, **Phase Two** will begin in 2020 and continue through 2030. **Phase Three** activities commence after 2030 if biological conditions still indicate less than full support of designated uses on Big Creek.

Targeted Participants: The primary participants for implementation will be the City of Hays wastewater and stormwater programs, and agricultural and livestock operations immediately adjacent to the lower portions of Big Creek and tributaries within the priority sub watersheds. All will be encouraged to implement appropriate practices. Watershed coordinators and technical staff of the WRAPS, along with Conservation District personnel and county extension agents should assess possible sources adjacent to Big Creek below Hays over 2011. Non-point source implementation activities should focus on those areas with the greatest potential to impact nutrient concentrations along Big Creek.

Targeted activities to focus attention toward include:

1. Overused grazing land 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 as a primary water supply.
4. Poor riparian area and denuded riparian vegetation along the stream.
5. Unbuffered cropland adjacent to the stream.
6. Conservation compliance on highly erodible areas.
7. High density urban and residential development in proximity to streams and tributary areas to Big Creek.
8. Residents of Hays should be informed on fertilizer and waste management through the Hays Stormwater Management Program to reduce urban runoff loads to Big Creek.

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 Smoky Hill-Saline Basin. At that point in time, phosphorus data from sites SC540 should show indications of declining concentrations relative to the pre-2010 data, particularly at baseflow conditions. By this date, the City of Hays should be well underway in implementing the appropriate treatment upgrades to decrease the phosphorus content of its wastewater.

Delivery Agents: The primary deliver agents for program participation will be the City of Hays, KDHE, the Big Creek – Middle Smoky Hill WRAPS, Kansas State University Agricultural Experiment Station – Hays, State Extension Service, and the Ellis County Conservation District for programs of the State Conservation Commission.

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 Smoky Hill-Saline River Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting

water quality and to target those programs to geographic area of the state for high priority in implementation.

Funding: The State Water Plan 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 located within a **High Priority** WRAPS area and should receive support for pollution abatement practices that lower the loading of sediment and nutrients to Kanopolis Lake. The Middle Smoky Hill – Big Creek (Kanopolis Lake) WRAPS is among the top ten in the state to receive priority 319 funding.

Effectiveness: Use of Biological Nutrient Removal technology has been well established to reduce nutrient levels in wastewater, including phosphorus. Additionally, 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.

6. MONITORING

KDHE will continue to collect quarterly to bimonthly samples over 2011 - 2020 at Stations SC540, SC541 and SC752. This monitoring will include continuation of sestonic chlorophyll collections at SC541 and SC752. Commencing in 2013, macroinvertebrate and periphyton sampling will occur at accessible locations on lower Big Creek. The stream will be evaluated for possible delisting, after **Phase One** implementation in 2020. If the four biological endpoints are achieved over 2017 – 2019, the conditions described by the narrative nutrient criteria will be viewed as attained and Big Creek will be moved to Category 2 on the 2020 303(d) list. If they are not, **Phase Two** of this TMDL begins in 2020.

Once the water quality standards are attained, the adjusted ambient phosphorus concentrations on Big Creek will be the basis for establishing numeric phosphorus criteria through the triennial water quality standards process to protect the restored biological and chemical integrity of Big Creek.

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 Smoky Hill-Saline Basin.

Public Hearing: A Public Hearing on this TMDL was held on February 10, 2010 in Hays to receive comments on this TMDL.

Basin Advisory Committee: The Smoky Hill – Saline River Basin Advisory Committee met to discuss the TMDLs in the basin on July 7, 2009 and October 1, 2009 in Hays, and on this specific TMDL on March 3, 2010 and September 22, 2010 in Hays and again on March 16, 2011 in Hays.

Watershed Restoration and Protection Strategy Group: This TMDL has been reviewed in February 2010 and again in March 2011 by the Big Creek – Middle Smoky Hill Subbasin WRAPS group. The data collected by the WRAPS were used in the development of this TMDL.

City of Hays: The strategy of this TMDL was discussed with the City of Hays on December 15, 2010.

Milestone Evaluation: In 2014, evaluation will be made as 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: Big Creek will be evaluated for delisting under section 303(d), based on the biological monitoring data over 2010-2019. 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 2011, which will emphasize implementation of WRAPS activities. At that time, incorporation of this TMDL will be made into the WRAPS. Recommendations of this TMDL will be considered in the Kansas Water Plan implementation decisions under the State Water Planning Process for Fiscal Years 2012-2020.

Revised April 18, 2011

References

Devlin, Daniel L., K. Dhuyvetter, K. McVay, T. Kastens, C. Rice, K. Janssen and G. Pierzynski; February 2003; Water Quality Best Management Practices, Effectiveness and Cost for Reducing Losses from Cropland. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF-2572

Heartland Regional Water Coordination Initiative, 2005. Agricultural PhosphorusManagement and Water Quality Protection in the Midwest; University of Nebraska-Lincoln Extension Research Paper 187; 24 pp.

Heiskary, S., 2008, Relation of Nutrient Concentrations and Biological Responses in Minnesota Streams: Applications for River Criteria Development, March 2008, Minnesota Pollution Control Agency, 66 p.

Juracek, K.E., 1999, Estimation of Potential Runoff-Contributing Areas in Kansas Using Topographic and Soil Information, U.S.G.S. Water-Resources Investigations Report 99-4242, 29 pp.

Juracek, K.E., 2000, Estimation and Comparison of Potential Runoff-Contributing Areas in Kansas Using Topographic, Soil and Land-Use Information, U.S.G.S. Water-Resources Investigations Report 00-4177, 55 pp.

Kansas Water Office, 2008. Kansas Irrigation Water Use – 2007, 38 pp.

Koelliker, J.K., 1998, Chapter 7 – Effects of Agriculture on Water Yield in Kansas; in *Perspectives on Sustainable Development of Water Resources in Kansas*, Kansas Geological Survey Bulletin 239, 239 pp.

Middle Smoky Hill and Big Creek Watershed Restoration and Protection Strategy Report; 2006; 62 pp.

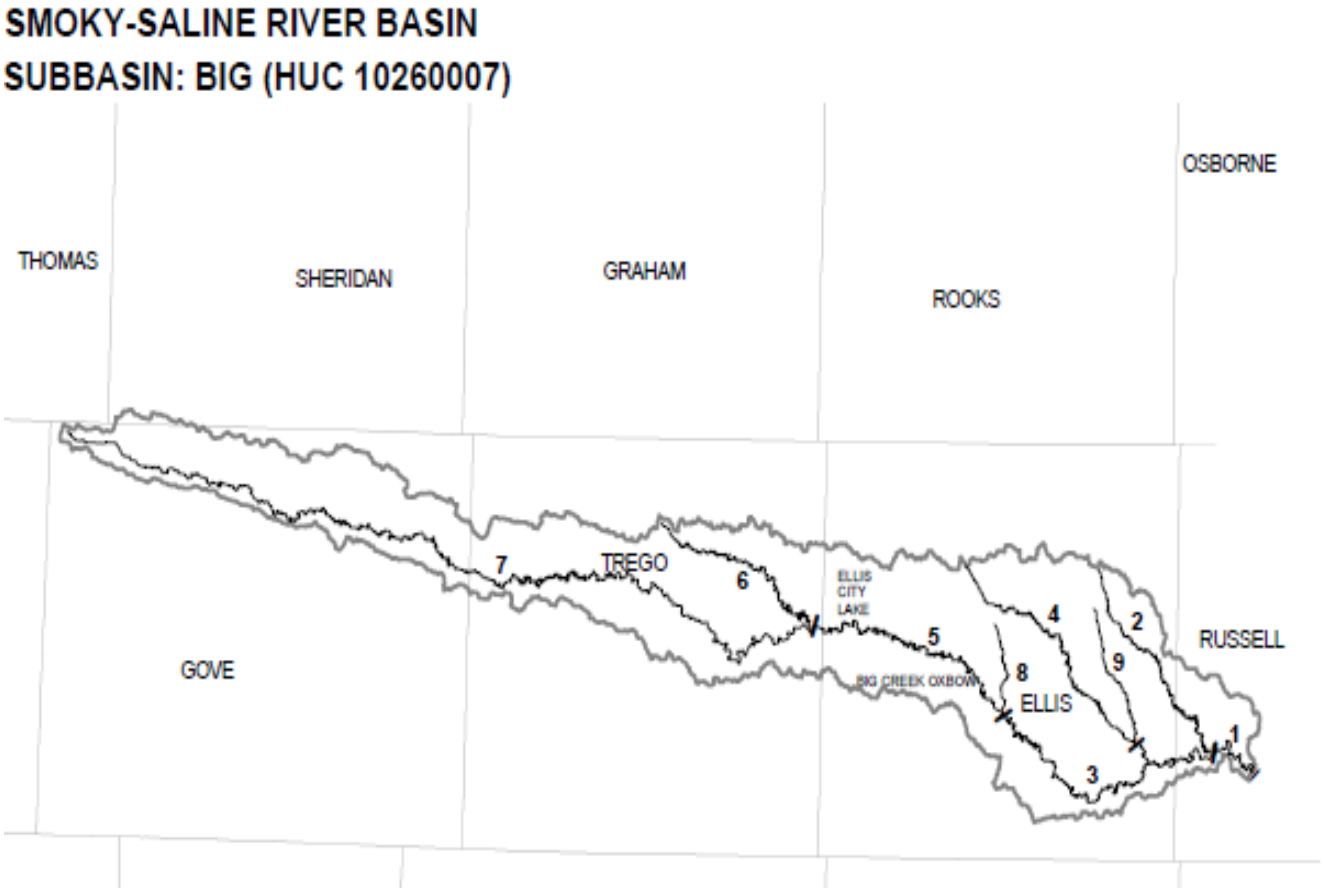
Oosterbaan, R.J., 1994, *FREQUENCY AND REGRESSION ANALYSIS OF HYDROLOGIC DATA*, Chapter 6 of H.P.Ritzema (Ed.), Drainage Principles and Applications, Publication 16, second revised edition, 1994, International Institute for Land Reclamation and Improvement (ILRI), Wageningen, The Netherlands. ISBN 90 70754 3 39. Found at ***www.waterlog.info/segreg.htm***

Perry, C.A., D.M. Wolock and J.C. Artman, 2004. Estimates of Flow Duration, Mean Flow and Peak-Discharge Frequency Values for Kansas Stream Locations, USGS Scientific Investigation Report 2004-5033.

Suplee, M.W., V. Watson, M. Teply and H. McKee, 2009, *How Green is Too Green? Public Opinion of What Constitutes Undesirable Algae Levels in Streams*, Journal of the American Water Resources Association, 45(1): p. 123 – 140.

U.S. EPA. 2000. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. U.S.Environmental Protection Agency, Washington, DC. EPA-822-B00-002.

Appendix A. Classified Streams of the Big Creek Sub basin.

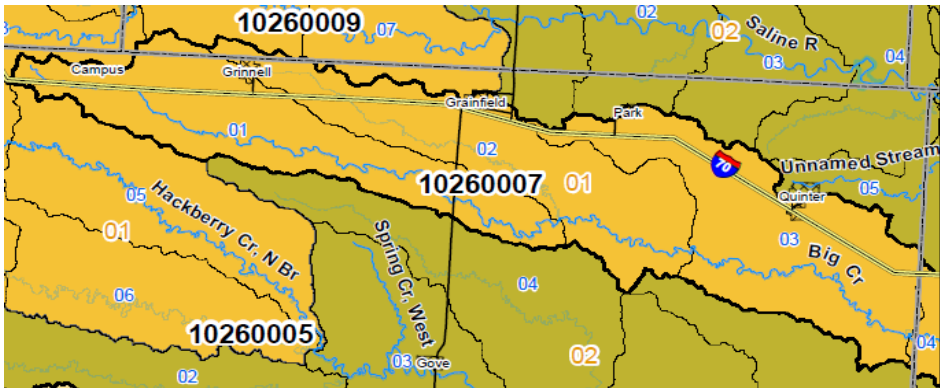


Appendix B: Registered and Permitted Animal Feeding Operations in 10260007

County	HUC 10/12	KS Permit #	Permit Type	Fed AU	Type
Gove	***0101***	***A-SHGO-BO02***	***Permit***	***350***	***Beef***
		A-SHGO-BO18	Permit	980	Beef
		A-SHGO-BO15	Permit	590	Beef
	0103	***A-SHGO-BA02***	***Certificate***	***540***	***Beef***
		A-SHGO-BA03	Certificate	400	Beef
		A-SHGO-BA12	Certificate	600	Beef
		A-SHGO-BA08	Certificate	300	Beef
		A-SHGO-BO21	Permit	980	Beef
		A-SHGO-BO16	Permit	980	Beef
		A-SHGO-BO01	Permit	990	Beef
		A-SHGO-BO10	Permit	500	Beef
		A-SHGO-MA04	Certificate	63	Dairy
		A-SHGO-MA05	Certificate	112	Dairy
		A-SHGO-MA07	Certificate	42	Dairy
		A-SHGO-MA03	Certificate	168	Dairy
		A-SHGO-MO04	Permit	272	Dairy
		A-SHGO-MO03	Permit	482	Dairy
		A-SHGO-MO01	Permit Renewal	102	Dairy, Horses
		A-SHGO-LA01	Certificate	999.9	Sheep
Trego	***0201***	***A-SATR-BO02***	***Permit Renewal***	***252***	***Beef***
		A-SHTR-BO01	Permit Renewal	800	Beef
		A-SHTR-SO04	Permit	171.2	Swine
	0203	***A-SHTR-BO04***	***Permit***	***943***	***Beef, Swine***
		A-SHTR-MO05	Permit	140	Dairy
		822	Complaint	5.6	Swine
	0204	***A-SHTR-BO03***	***Permit Renewal***	***800***	***Beef***
Ellis	***0302***	***A-SHEL-BO06***	***Permit***	***450***	***Beef***
		A-SHEL-MA15	Certificate	56	Dairy
	0303	***A-SHEL-CO02***	***NPDES Permit****	***30000***	***Beef***
		A-SHEL-BO01	Permit	999	Beef
		A-SHEL-BA07	Registration	100	Beef
		A-SHEL-MO01	Permit	323	Dairy,Swine,Sheep
	0304	***A-SHEL-BO08***	***Permit***	***150***	***Beef***
	0305	***A-SHEL-MA16***	***Certificate***	***70***	***Dairy***
		A-SHEL-MO04	Permit	80	Dairy, Beef
	0401	***A-SHEL-BO07***	***Permit***	***473***	***Beef***
		A-SHEL-BO04	Permit	760	Beef
	0402	***A-SHEL-MA19***	***Certificate***	***84***	***Dairy***
	0403	***A-SHEL-MA05***	***Certificate***	***49***	***Dairy***
		A-SHEL-MO07	Permit	56	Dairy
		A-SHEL-EA01	Certificate	0**	Exotic (Game Birds)
	0404	***A-SHEL-BA05***	***Certificate***	***300***	***Beef***
		A-SHEL-BA06	Certificate	400	Beef
		A-SHEL-BO10	Permit Application	300	Beef

***KS0037630 **5000 Game Birds**

Appendix C: HUC 12 Subwatersheds of the Big Creek Watershed by County



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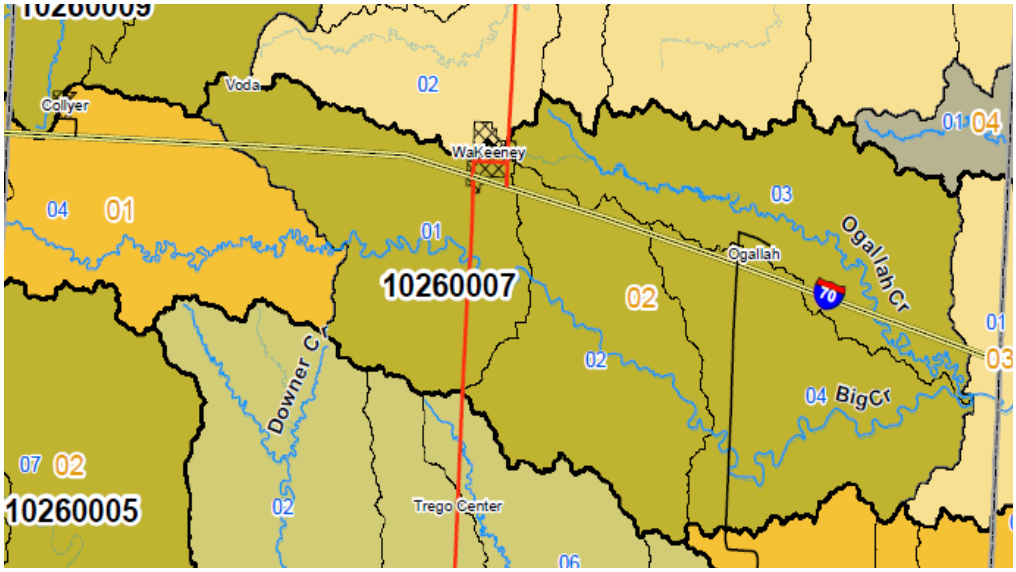
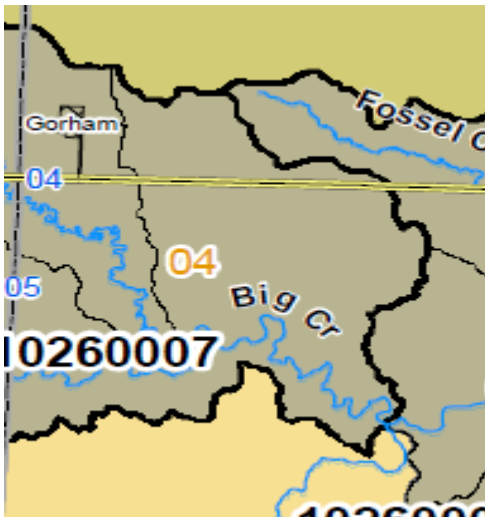
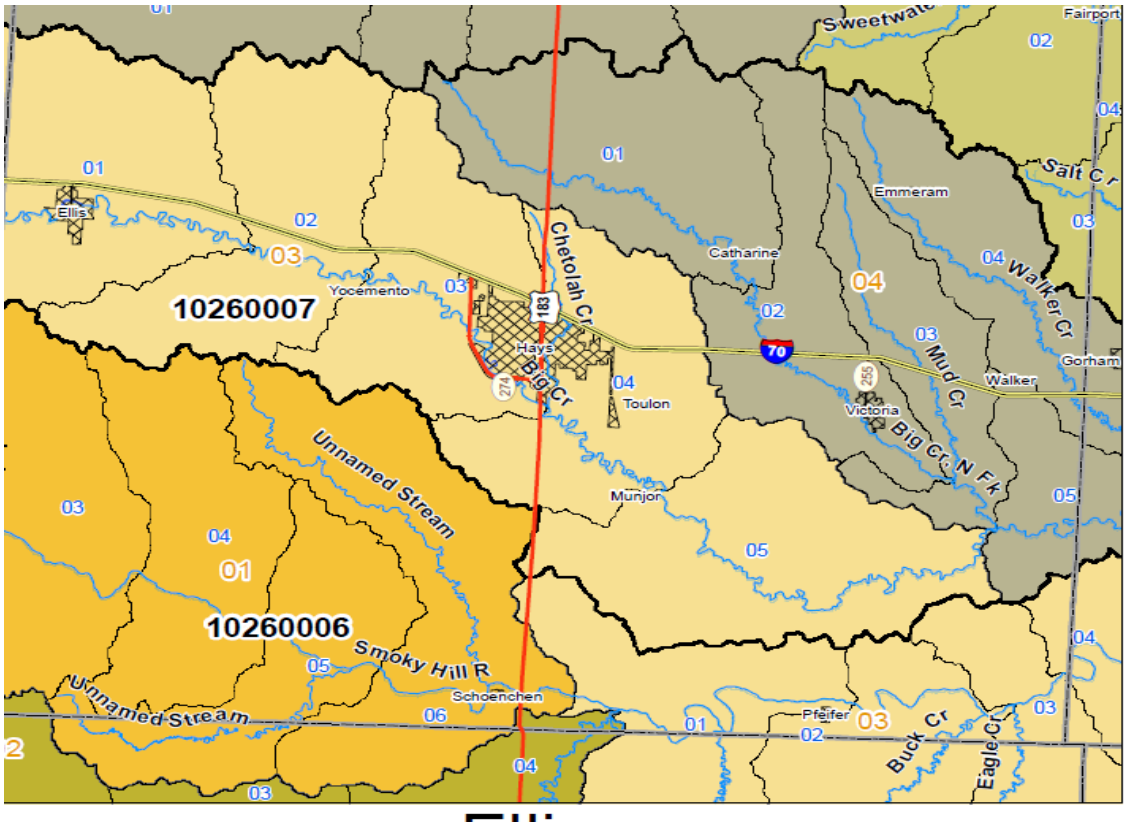


Trego County

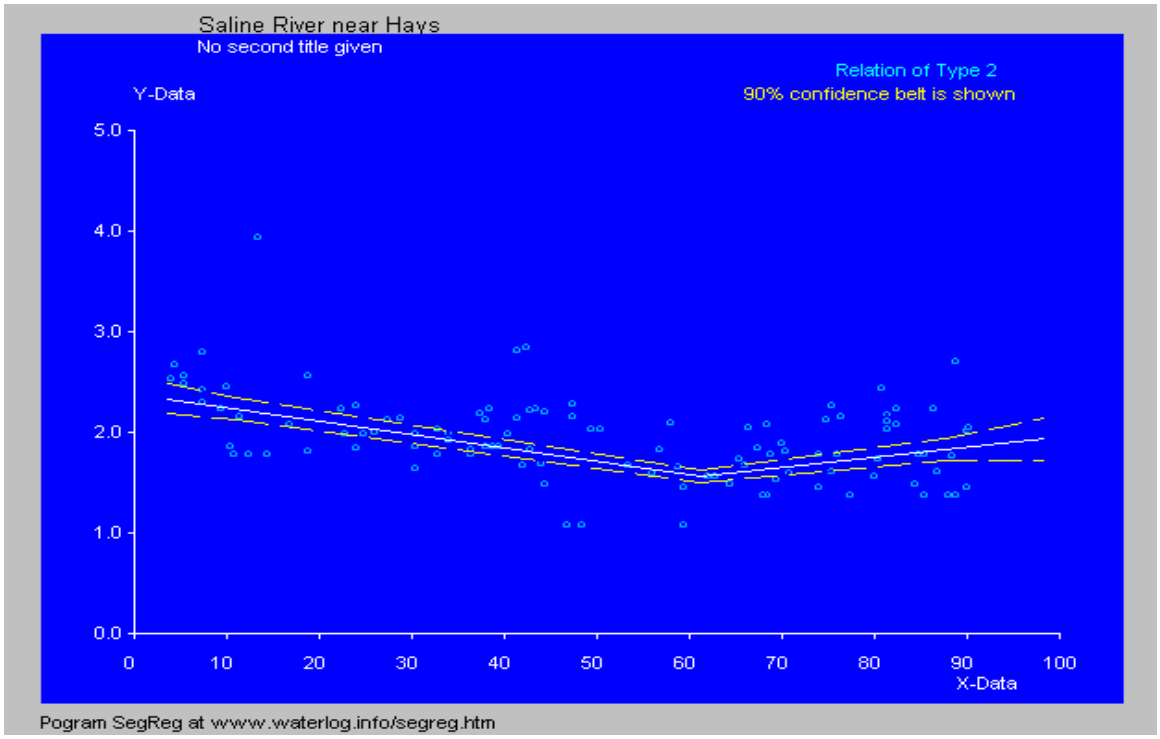


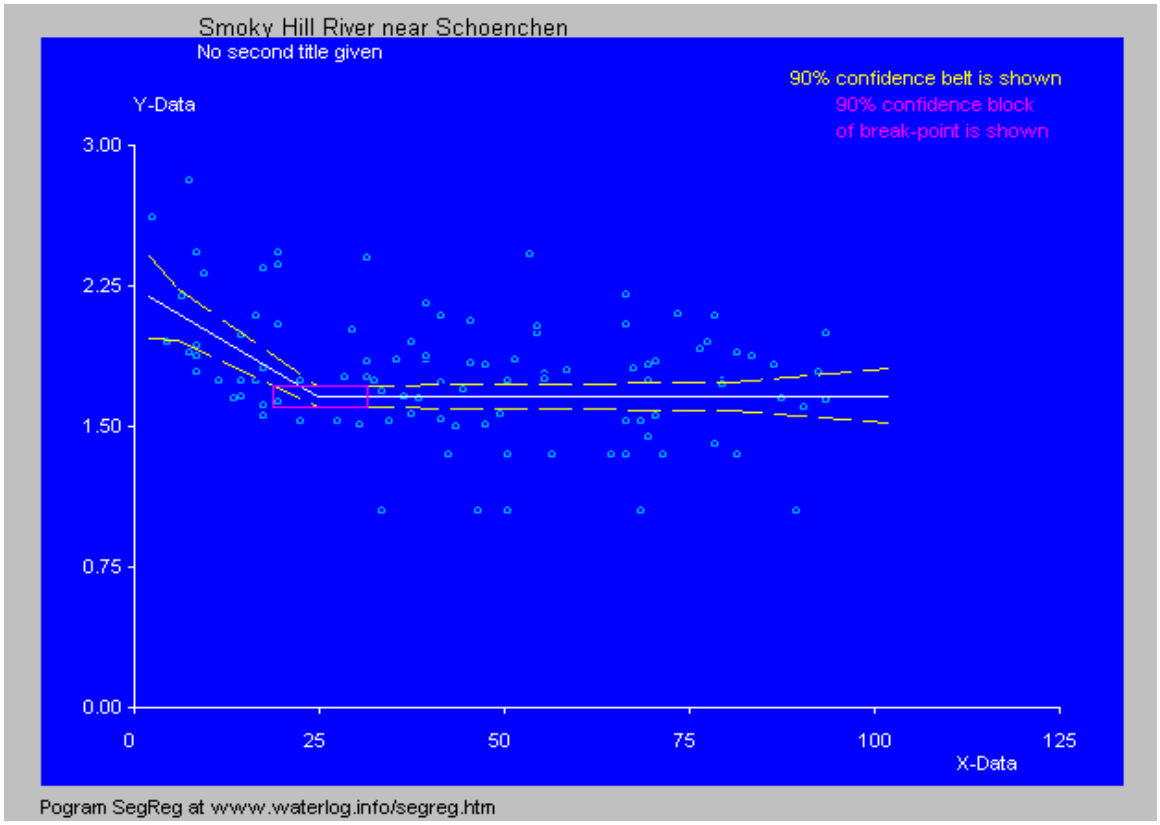
Russell County

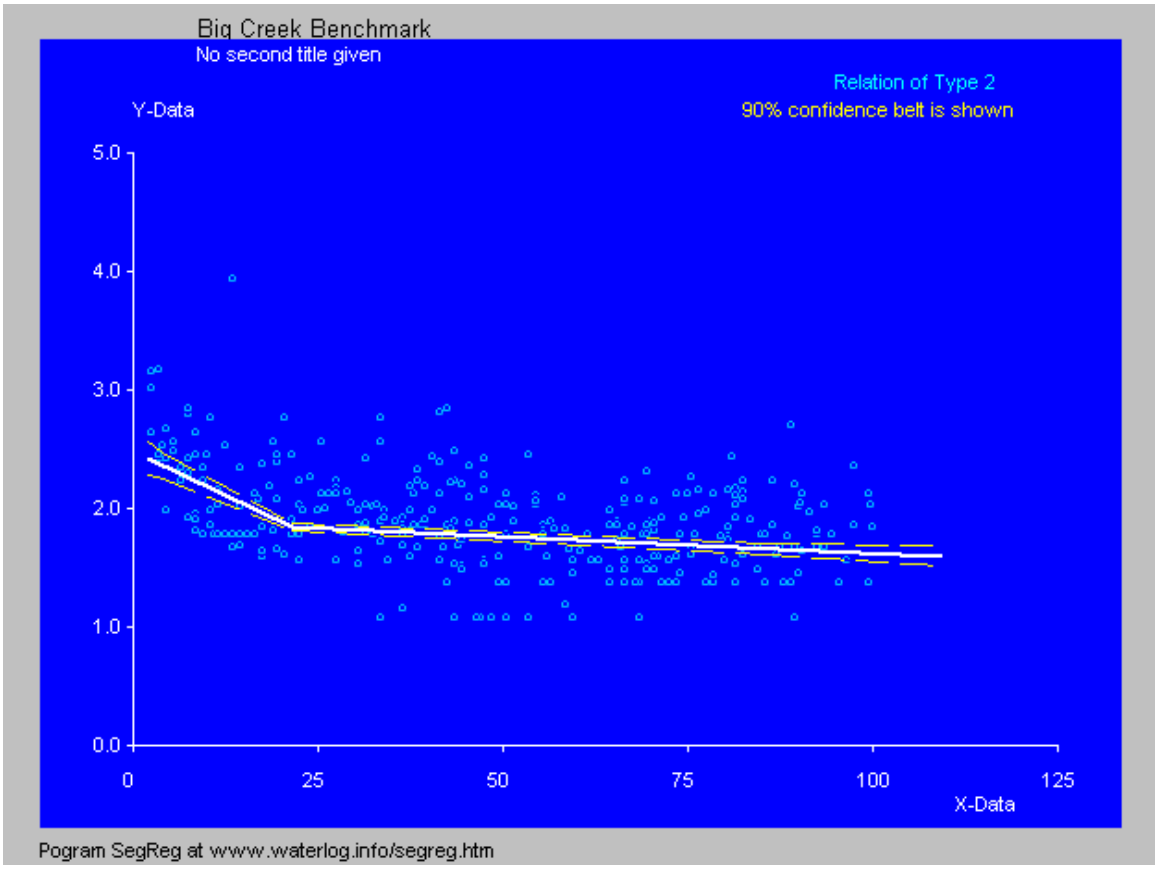
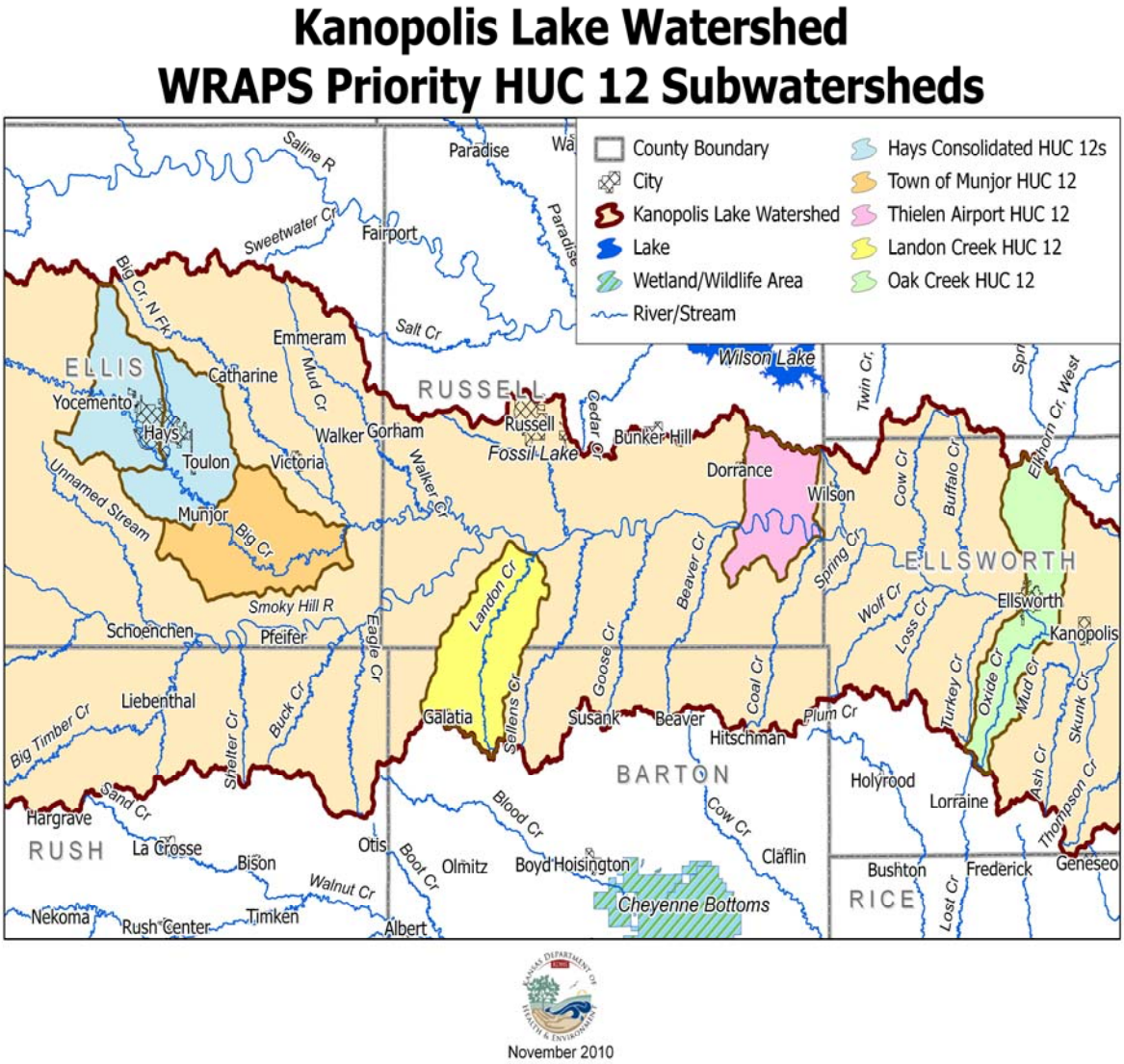


Ellis County

Appendix D: Segmented Regression of Saline and Smoky Hill Rivers near Hays




Smoky Hill River near Schoenchen
No second title given
90% confidence belt is shown
90% confidence block
of break-point is shown
Y-Data
3.00
2.25
1.50
0.75
0.00
0
25
50
75
100
125
X-Data
Pogram SegReg at www.waterlog.info/segreg.htm


Big Creek Benchmark
No second title given
Relation of Type 2
90% confidence belt is shown
Y-Data
5.0
4.0
3.0
2.0
1.0
0.0
0
25
50
75
100
125
X-Data
Pogram SegReg at www.waterlog.info/segreg.htm

Appendix E. Priority Sub-Watersheds for Non-Point Source Control under the Big Creek – Middle Smoky Hill River (Kanopolis Lake) WRAPS 9-Element Watershed Plan