SMOKY HILL-SALINE BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: Big Creek
Water Quality Impairment: Nitrate

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); minor portion in Western High Plains, Flat to Rolling Cropland (25d)

Drainage Area: 862 square miles

Main Stem Water Quality Limited Segments: 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 nitrate in the 2008-303(d) list for the Smoky Hill – Saline Basin. Station SC541, located above the Chetolah Creek confluence was not cited for nitrate; therefore, the nitrate impairment is assigned to Segments 1 and 3. Station SC715 on the North Fork Big Creek is not cited for nitrate.

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

Water Quality Criteria: Nitrate: 10 mg/l as NO3-N (Table 1a); …, the criteria listed in table 1a, as adopted in subsection (d) of this regulation, for domestic water supply use shall not be exceeded at any point of domestic water supply diversion. (K.A.R. 28-16-28e(c)(3)(A))

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): Nitrate levels on Big Creek below Hays occasionally exceed 10 mg/l; with downstream biological transformation, elevated levels of total nitrogen 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 1990-2009 **(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 1990-2009. A rotational sampling station, SC715, on the North Fork of Big Creek is located southwest of Walker and has data from 1995, 1999 and 2003. Visits to the station in 2006 yielded no samples because of lack of flow. Additionally, probabilistic monitoring sites on Big Creek at Ogallah, Ellis and Russell 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.

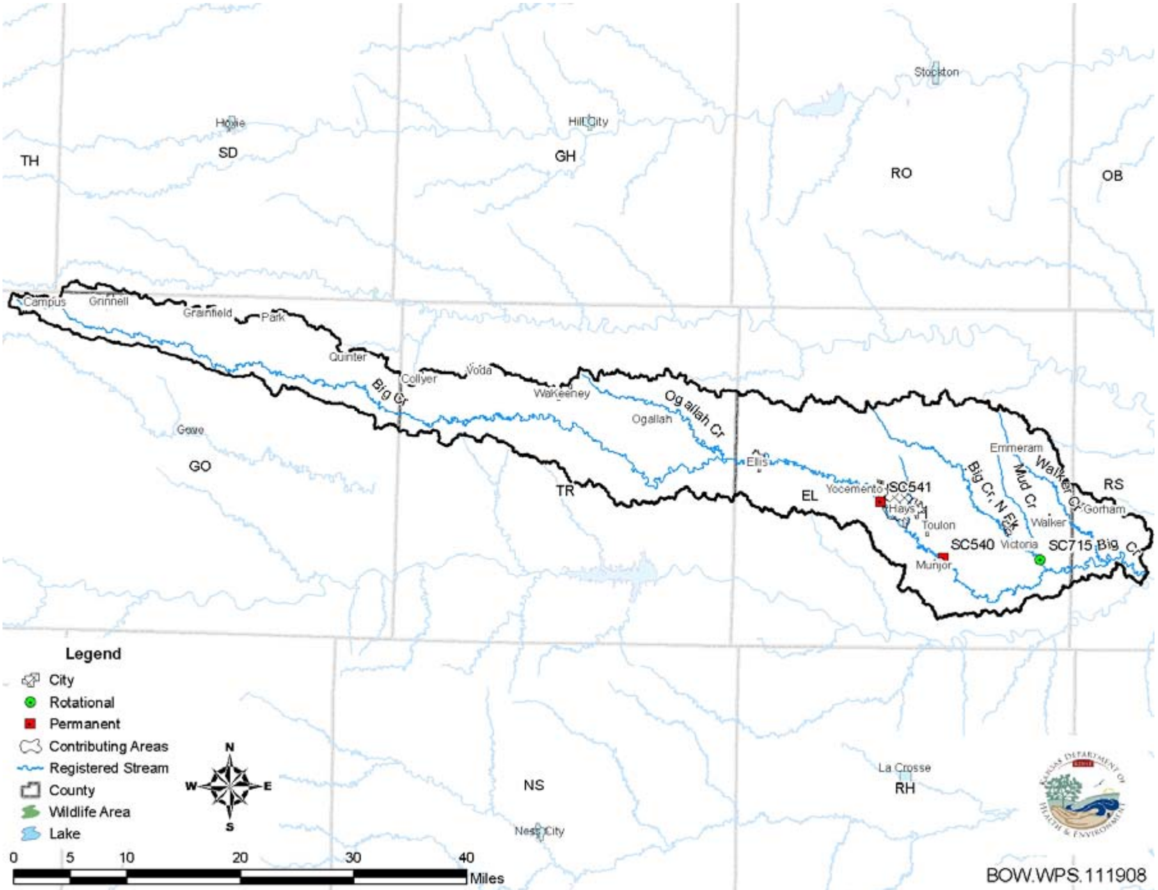

Figure 1. **Big Creek Subbasin with KDHE monitoring stations.**

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).** 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 0.34 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, 2006).**

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

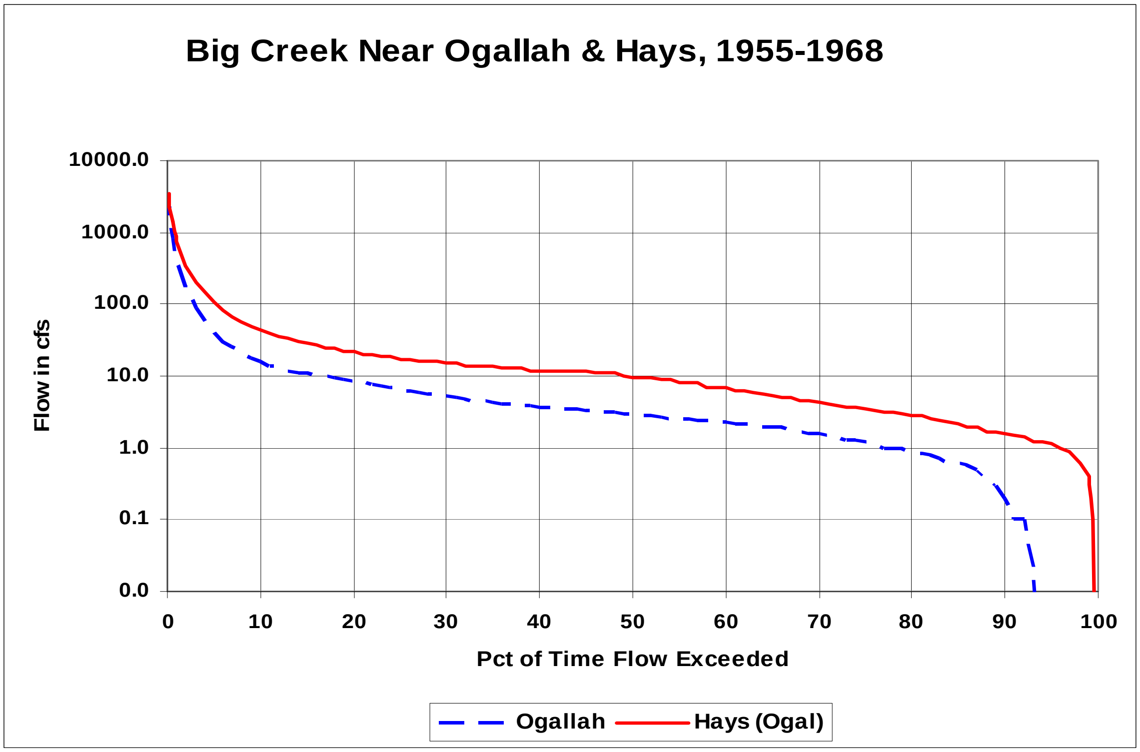

Figure 2. Flow Duration on Big Creek at Hays and Ogallah over 1955 - 1968

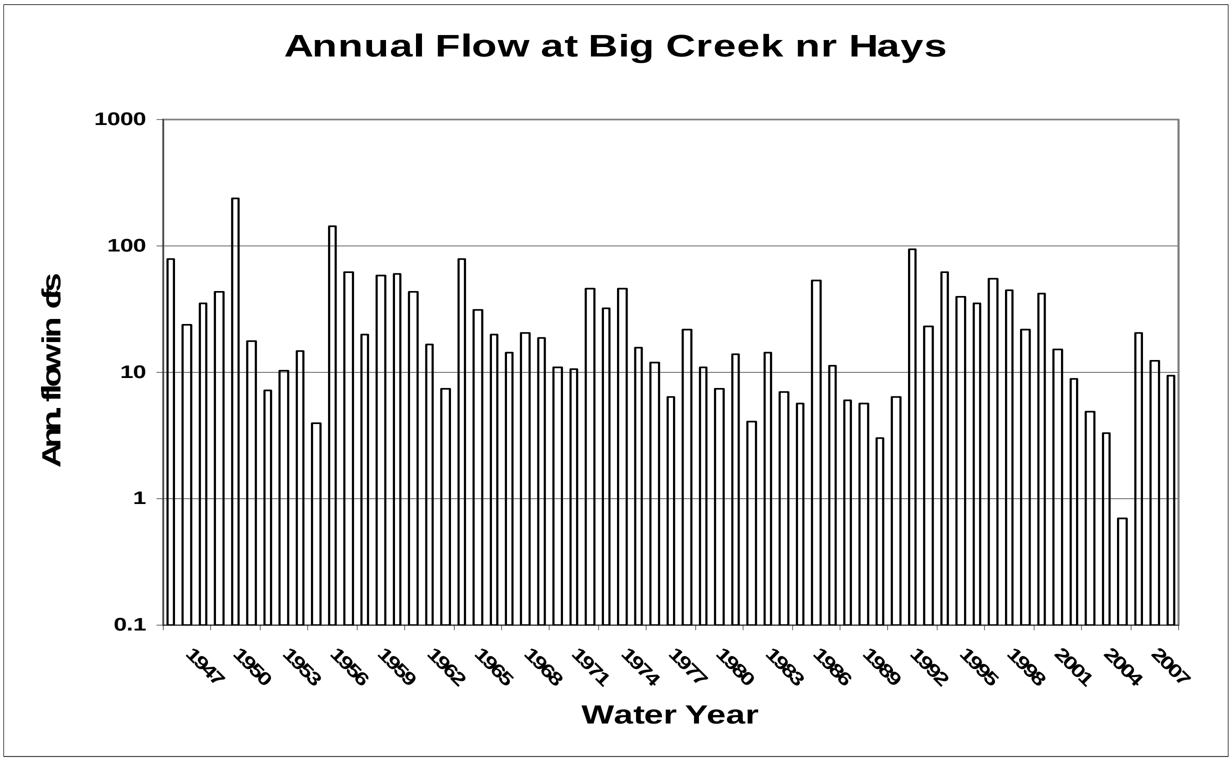

Figure 3. Average Annual Flow on Big Creek; 1947 - 2008

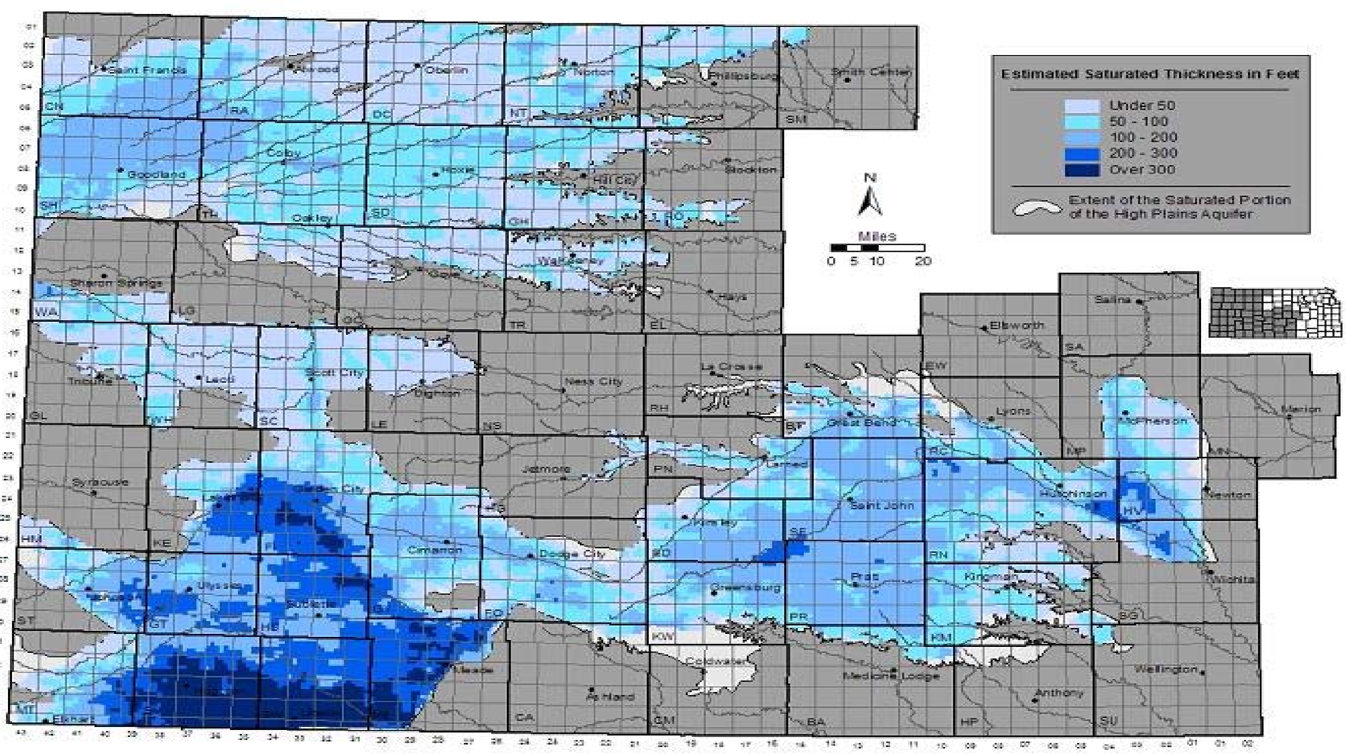

Figure 4. High Plains Aquifer Saturated Thickness

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 Hays.

Wastewater effluent from Ellis typically does not flow into the Hays area. However, flows are nearly continual below the confluence with Chetolah Creek and Hays wastewater. Since elevated nitrate is seen at the Munjor site and not at Hays, this TMDL will presume Ellis wastewater is not responsible for the exceedances seen at the downstream station. 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.

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 5).** Conversely, flows in the mid-range condition were 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.

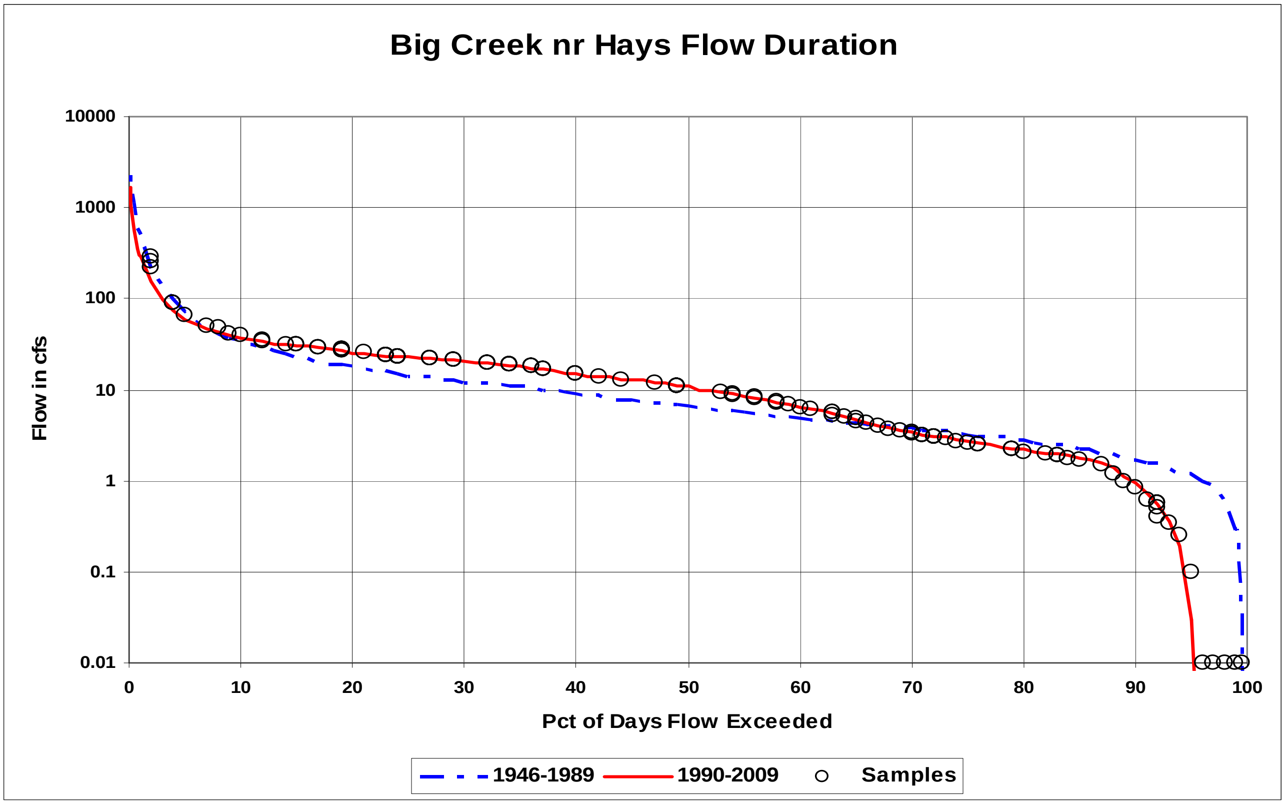

Figure 5. Big Creek Flow Duration Before and During KDHE Sampling

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 6).** Hydrograph separation of daily flows into baseflow and runoff for the two periods indicates the average annual runoff for 1946 – 1989 was 0.74 inches; while the runoff averaged 0.59 inches for 1990 – 2008. 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 7).** Some recovery of flow occurred in 2007 and 2008. Very dry conditions returned in 2009, such that average monthly flows in June through October were an order of magnitude less than the recent average flows over the sampling period of record **(Figure 6).**

According to Perry (2005), there is some gain between the current gage location south of Hays on Highway 183 and SC540. There is an eight percent increase in drainage area, but flows increase substantially more. Low flows, exceeded at least 60% of the time, increase by 25% between the two locations. Normal flows exceeded 40-60% of the time increase by 20% and high flows exceeded less than 40% of the time increase by 10%. Development of the nitrate load duration curve reflects flows adjusted by these factors.

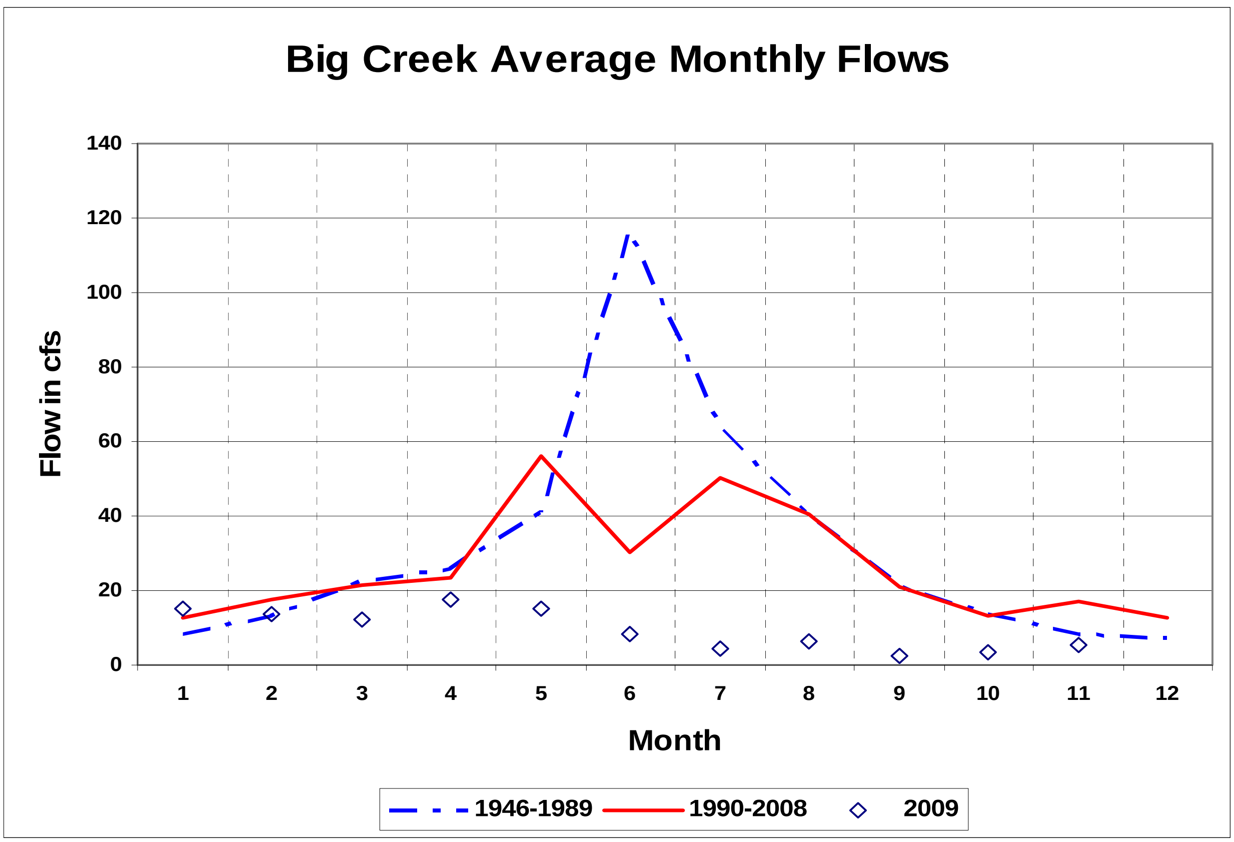

Figure 6. Average Monthly Streamflows on Big Creek Prior to and After 1990.

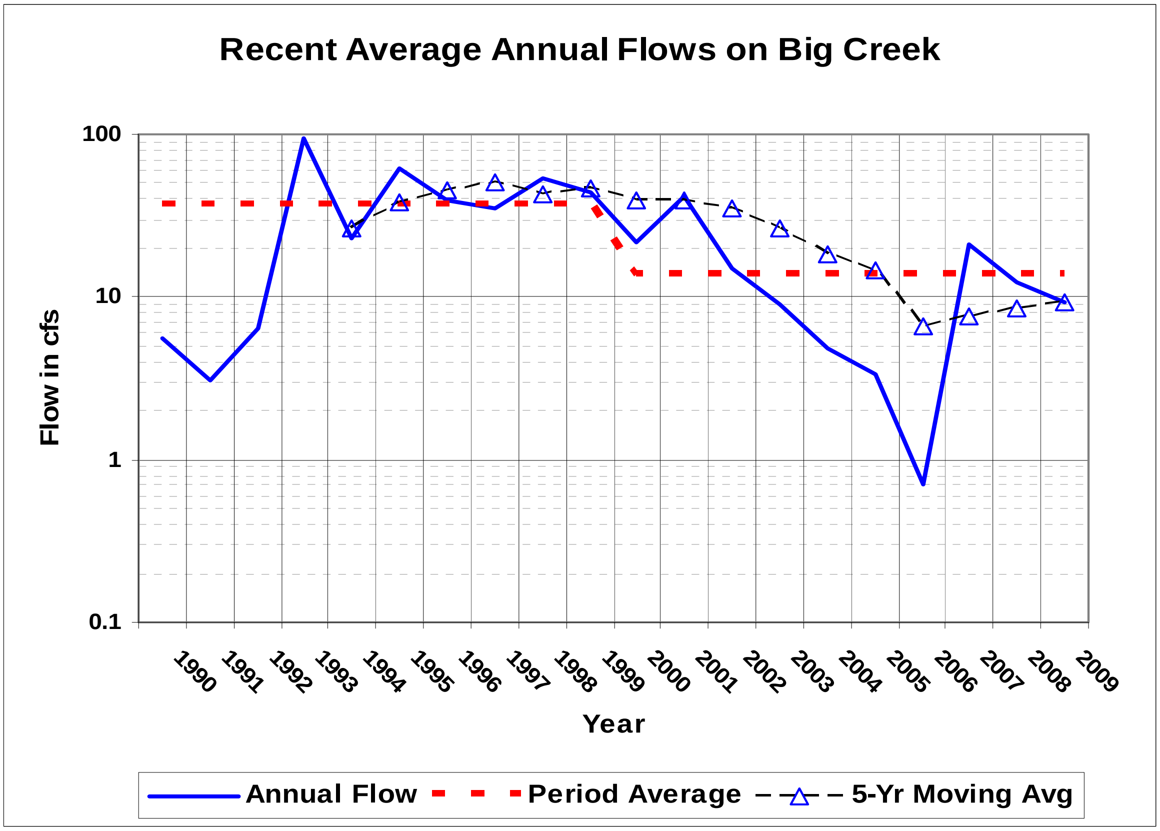

Figure 7. Average Annual Streamflows on Big Creek During KDHE Sampling Period

Nitrate Concentrations: Nitrate concentrations are significantly higher at the Munjor site (SC540) than the upstream Hays site (SC541); **(Figure 8**). Overall nitrate concentrations average 4.04 mg/l at the lower station and 0.47 mg/l at the upper station. Nitrate concentrations reflect three separate conditions seen on Big Creek over 1990-2009. The first was a relatively dry period of 1990-1993 (median flow of 3.5 cfs), terminated by the large flows of summer, 1993. This was followed by a relatively wet period from 1994 – 2003 (median flow of 20 cfs), followed by a second dry period from 2004-2009 (median flow of 3.2 cfs). Upstream nitrate concentrations averaged 0.21, 0.68 and 0.20 mg/l for the three respective periods, typical of a non-point source dominated system, while average concentrations downstream of Hays were 3.33, 2.89 and 6.50 mg/l, reflective of point source influences.

Some increase in downstream nitrate can be explained by upgrades in wastewater treatment at Hays, completed in 1993. Ammonia concentrations during the three periods averaged 1.16, 0.13 and 0.14 mg/l at the Munjor site **(Figure 9)**. Corresponding upstream averages were 0.18, 0.09 and 0.12 mg/l. Hays began to nitrify its wastewater and reduce its toxic ammonia content; the process did not include de-nitrifying, however, and high nitrate concentrations in the effluent resulted.

High nitrate levels have been seen historically based on samples taken on Big Creek near Ogallah over 1955-1968 and below Hays over 1961 – 1970 by USGS **(Figures 10 & 11)**. The USGS sampled concentrations coincided with those sampled by KDHE since 1990 under common flow conditions **(Figures 10 & 12).** Higher flows tended to increase nitrate concentrations in the upstream reaches while decreasing those in the downstream reach, effectively diluting the effluent influence and converging concentrations toward 1 mg/l.

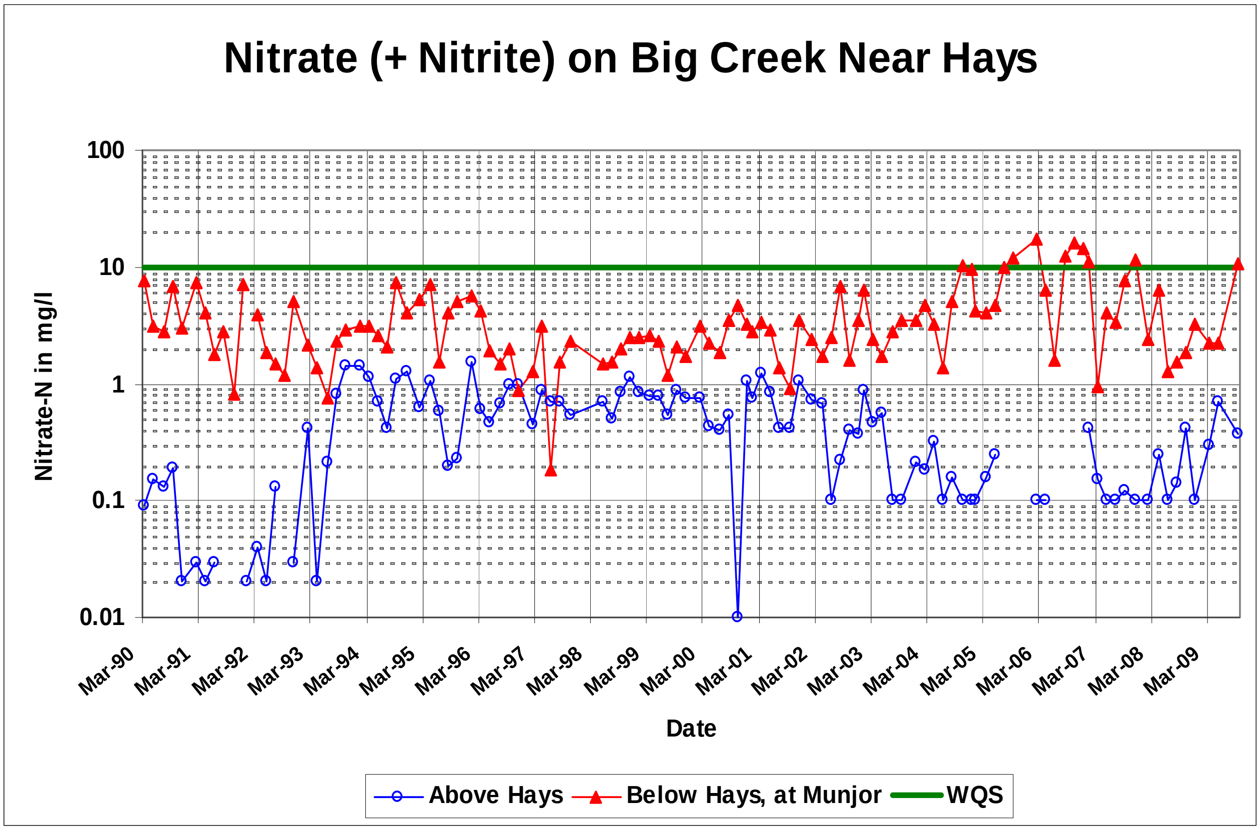

Figure 8. Nitrate Concentrations Above and Below Hays Since 1990

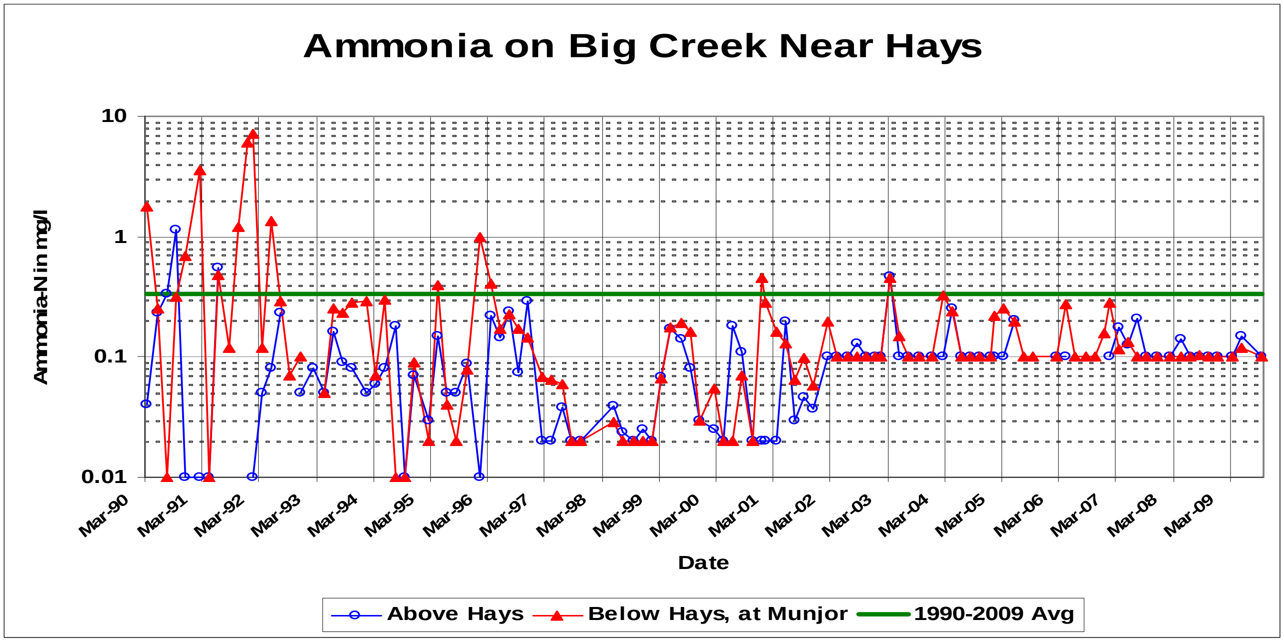

Figure 9. Ammonia Concentrations Above and Below Hays Since 1990

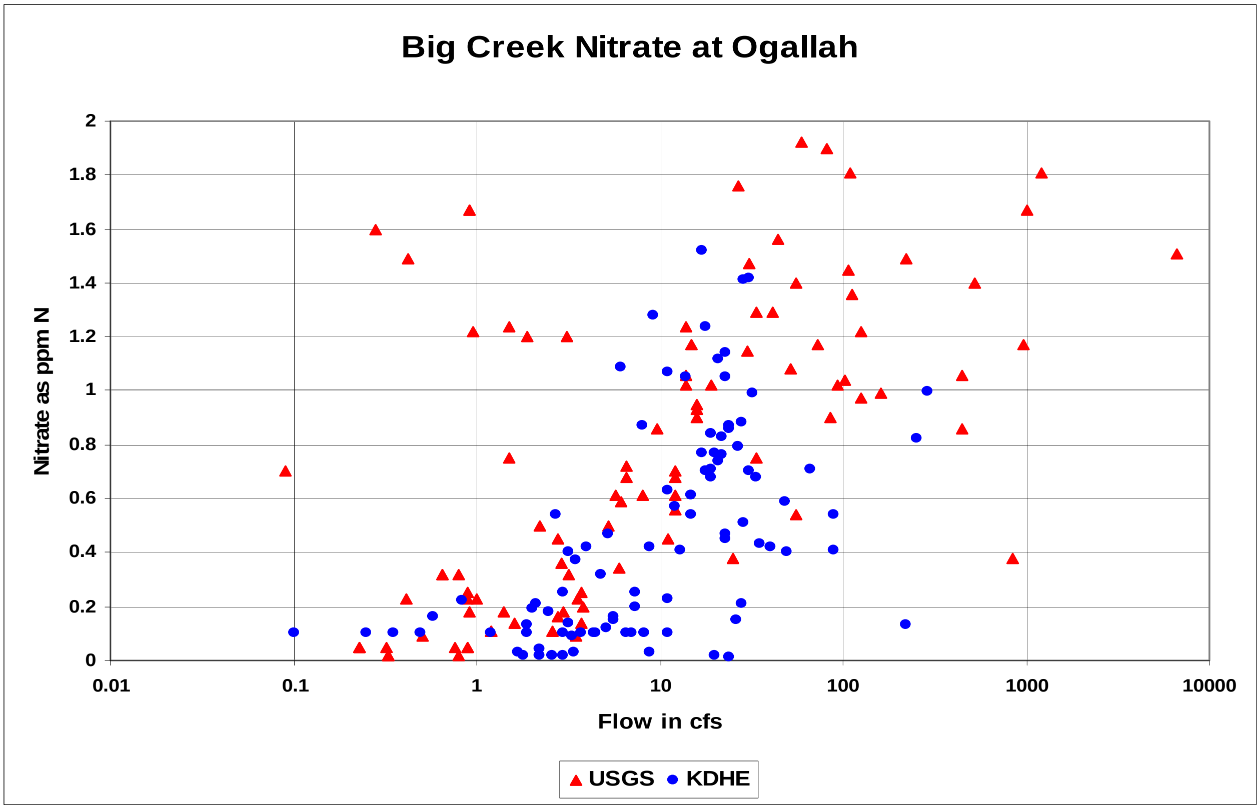

Figure 10. Nitrate Concentrations on Big Creek near Ogallah (1955-68) and above Hays (1990-2009)

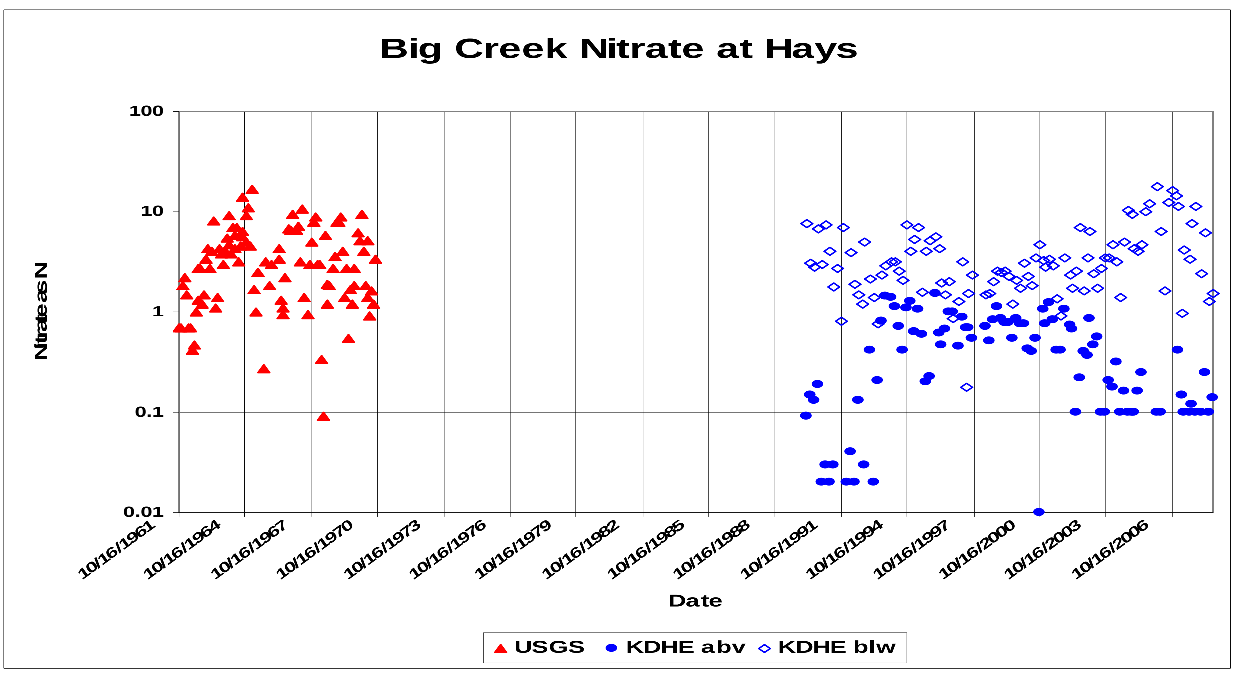

Figure 11. Historic Nitrate Concentrations on Big Creek Above and Below Hays

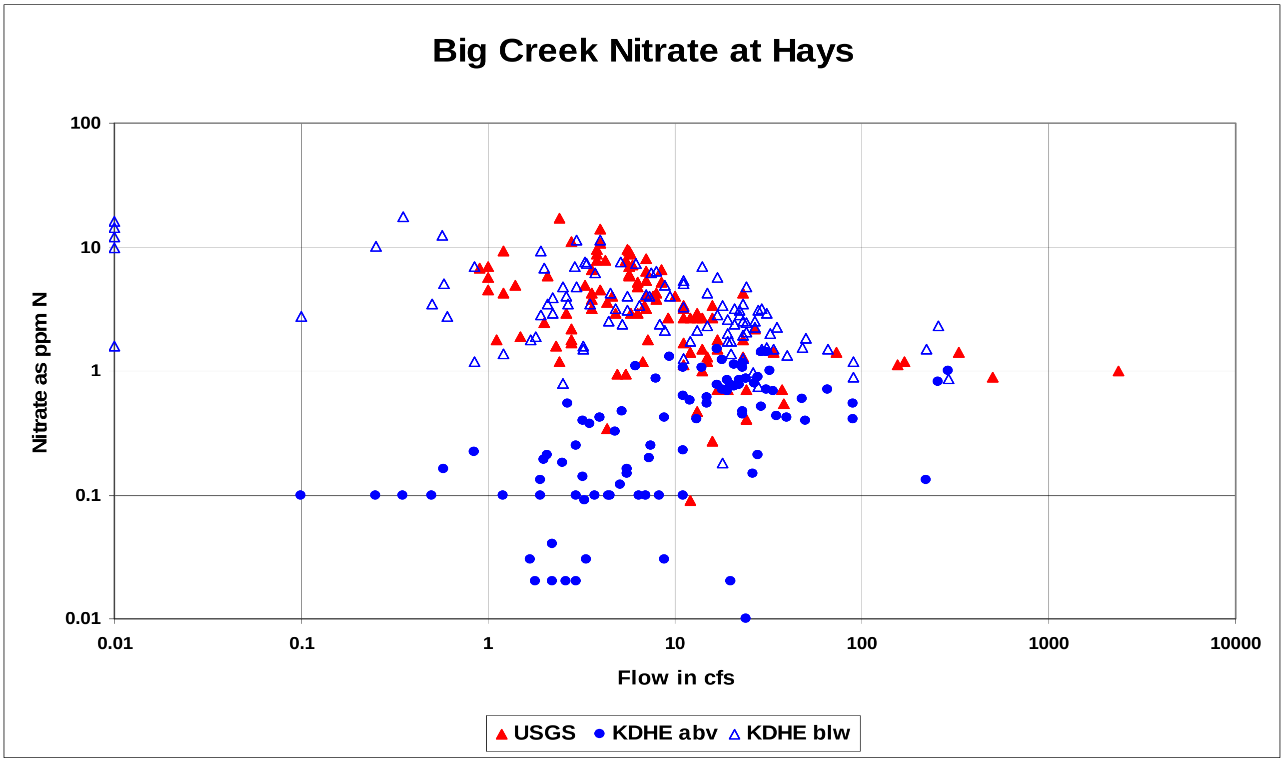

Figure 12. Historic Nitrate Concentrations on Big Creek as Function of Flow

Table 2 indicates average nitrate conditions at the stations above and below the outfall from Hays over separate temperate and flow conditions. Concentrations on the lower station are always higher than those at the upper station. Warmer water temperatures (> 15 deg C) always produce higher total Kjeldahl nitrogen and lower nitrate levels than cooler conditions, regardless of location or flow. Regardless of temperature, nitrate at the upper station tends to be higher at higher flows (> 10 cfs); the opposite is true at the lower station. Under warmer temperatures, TKN levels are slightly lower at lower flows at the lower station, but that relationship reverses at lower temperatures.

These relationships point out the influence of the Hays effluent on Big Creek nitrate levels, particularly at lower flows. Furthermore, colder conditions tend to dampen biological activity allowing more nitrate to remain in the water column. Nitrate is the dominant form of nitrogen at the lower station under cool temperatures and low flows, as well as during warm, low flow periods. During summer runoff, however, nitrate and TKN are nearly equivalent. At the upper station, TKN is the dominant form under most conditions, although nitrate will exceed TKN during high flows and cool temperatures.

Table 2. Nitrogen Concentrations on Big Creek Above and Below Hays Under Various Conditions

Flow Cond	Temp Cond	above TN	above NO23	above TKN	**below TN**	**below NO23**	**below TKN**	Flow	Excd Pct	Water Temp
Low	*Cool*	*0.842*	*0.270*	*0.580*	*9.028*	*6.464*	*1.409*	*3.638*	*73.067*	*7.533*
High	Cool	1.488	0.807	0.721	4.134	3.096	1.194	30.692	30.308	5.923
Low	*Warm*	*1.456*	*0.179*	*1.268*	*7.149*	*4.674*	*1.725*	*2.835*	*78.385*	*22.615*
High	Warm	1.721	0.545	1.304	3.832	1.799	1.831	47.071	21.179	20.536

Plotting the nitrate concentrations at the upstream and downstream locations against the long term flow duration conditions seen during each time of sampling shows excessive nitrate levels coincide with low flow conditions where Hays effluent exerts the most influence on Big Creek **(Figure 13).** Similar patterns are seen in the data collected through the probabilistic stream monitoring program during 2008 and 2009 **(Figures 14 & 15)**.

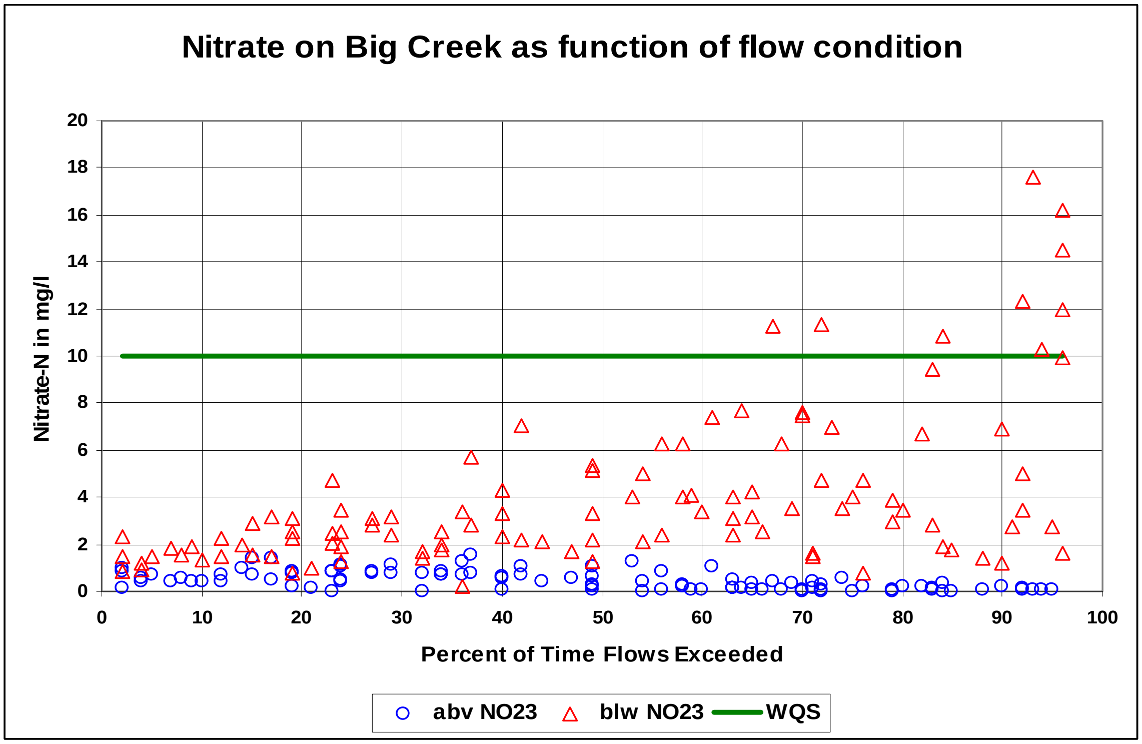

Figure 13. Nitrate Concentrations on Big Creek as a Function of Flow Duration

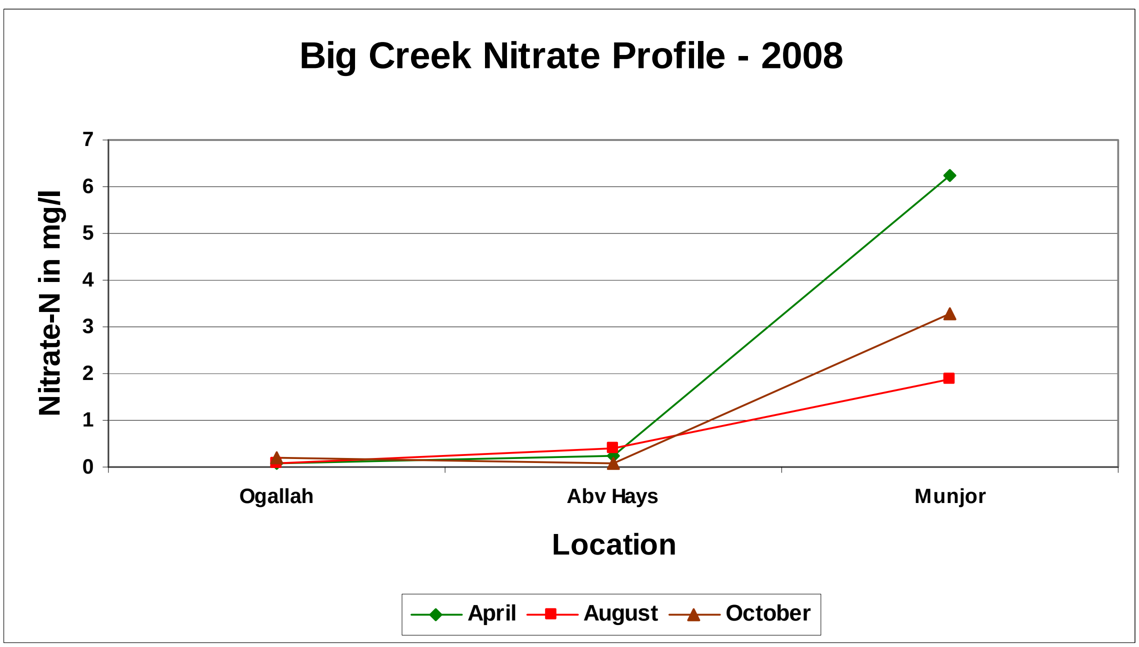

Figure 14. Probabilistic Stream Monitoring of Nitrate on Big Creek in 2008

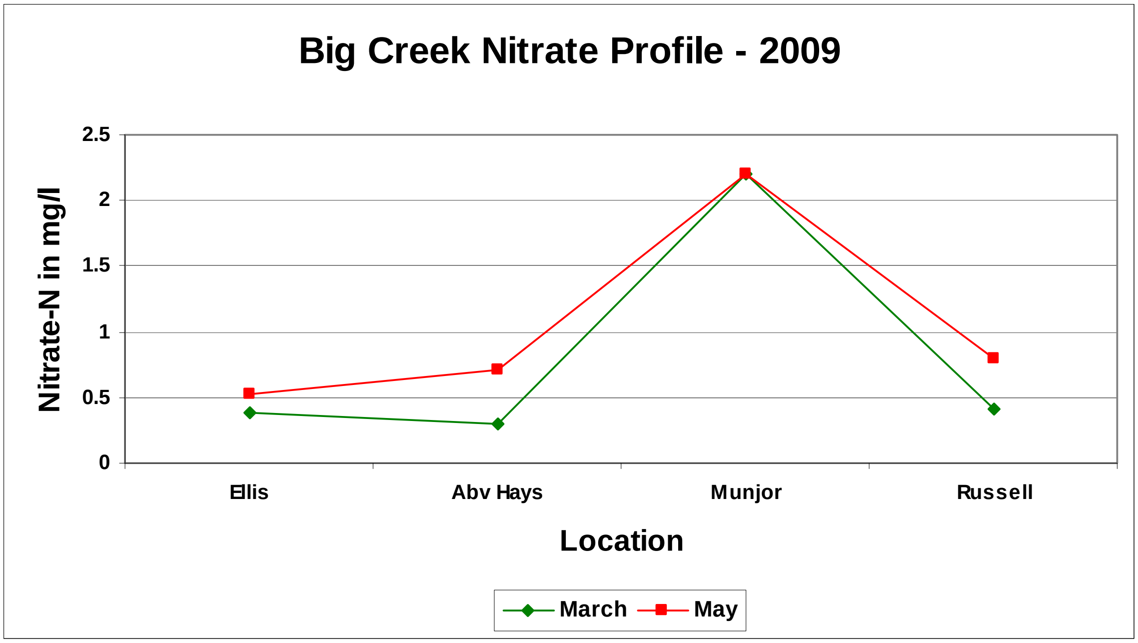

Figure 15. Probabilistic Stream Monitoring of Nitrate on Big Creek in 2009.

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 16).** Total nitrogen is sampled and reported by the WRAPS. A TN profile along Big Creek over time consistently shows modest amounts of nitrogen in the creek entering Hays (Highway 183 (#5) and 220^{th} Street (#9) with a large increase after the confluence of Chetolah Creek (#6) which is the receiving stream for Hays wastewater **(Figure 17)**. The profile sampling hints that some additional sourcing of nitrogen occurs downstream as the next station located at Commerce Parkway (#7) often has higher TN concentrations than those immediately below Chetolah Creek. Nitrogen levels decline in the creek at downstream locations below Munjor (#13).

Plotting concurrent sampling at the lower Big Creek stations reveals that at lower nitrogen levels seen at the station immediately below Chetolah Creek (#6), the increase at the next downstream station (#7) can be substantial **(Figure 18).** Much of this difference is due to the mission of the WRAPS sampling runoff events. Typically, the upstream station is sampled first when runoff is beginning to raise the creek. Then, 15 to 60 minutes later, the downstream station is sampled where runoff has yet to appear. Therefore, the samples at Station #7 reflect the pre-storm condition on Big Creek.

Nitrogen levels increase at Site 6, presumably because of wastewater influence, particularly during low flow. Levels downstream of Hays and Munjor begin to subside, initially because normal assimilation processes foster absorption by biota or adsorption by sediment, under prevalent dry flow conditions. After significant decreases in nitrogen at Walker Road, nitrogen levels decrease at a lower rate, partially because of in-stream assimilation and also through dilution by intervening, low nitrogen inflow in Russell County (**Figure 19**).

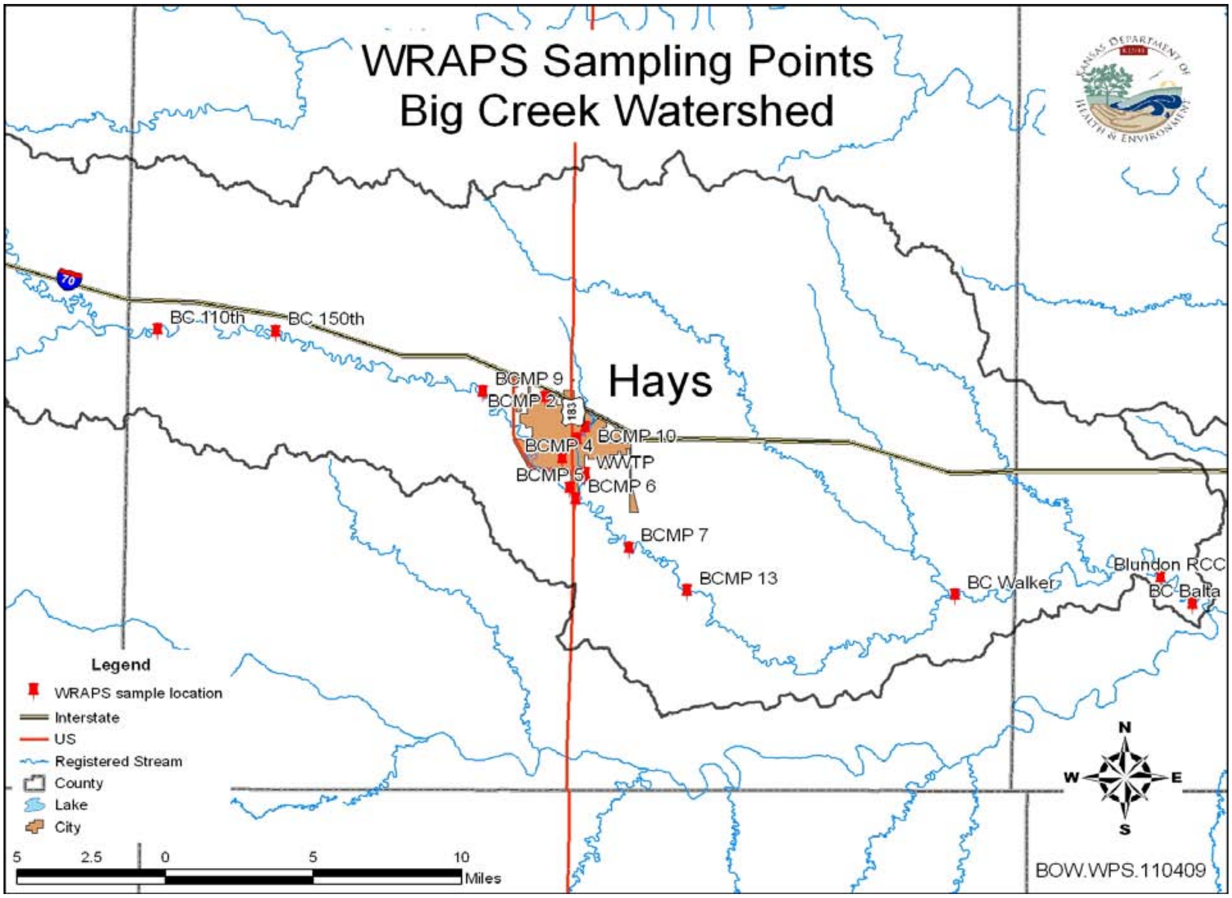

Figure 16. Locations of WRAPS Sampling Sites Along Big Creek

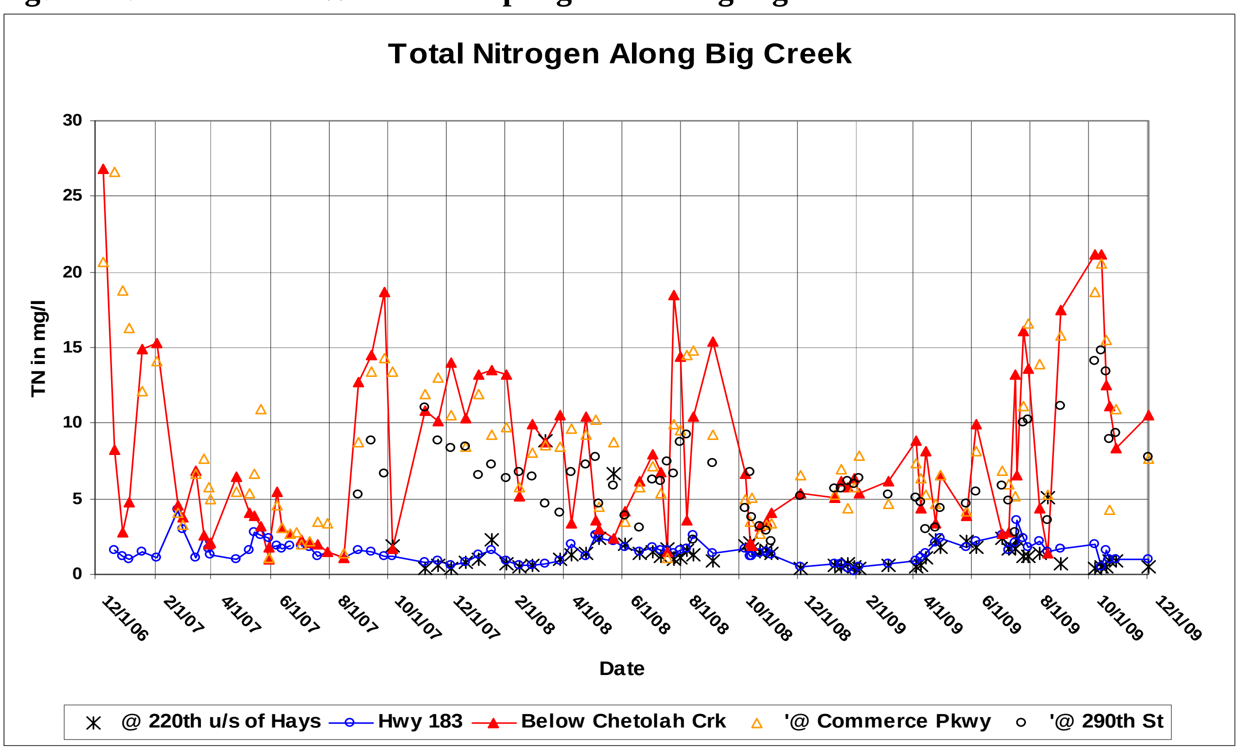

Figure 17. Total Nitrogen Profile Along Big Creek in Ellis and Russell Counties

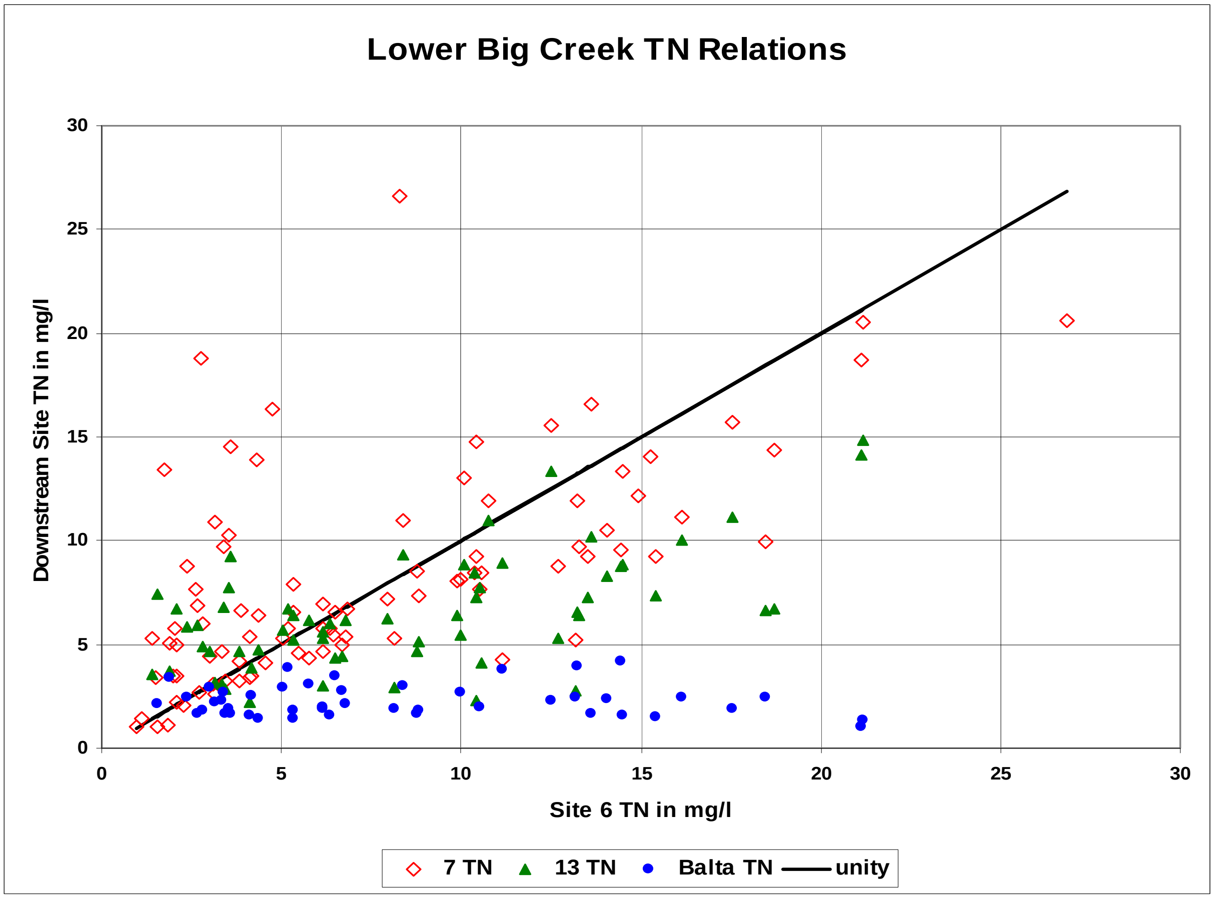

Figure 18. Concurrent Total Nitrogen Concentrations at Locations Downstream of Hays

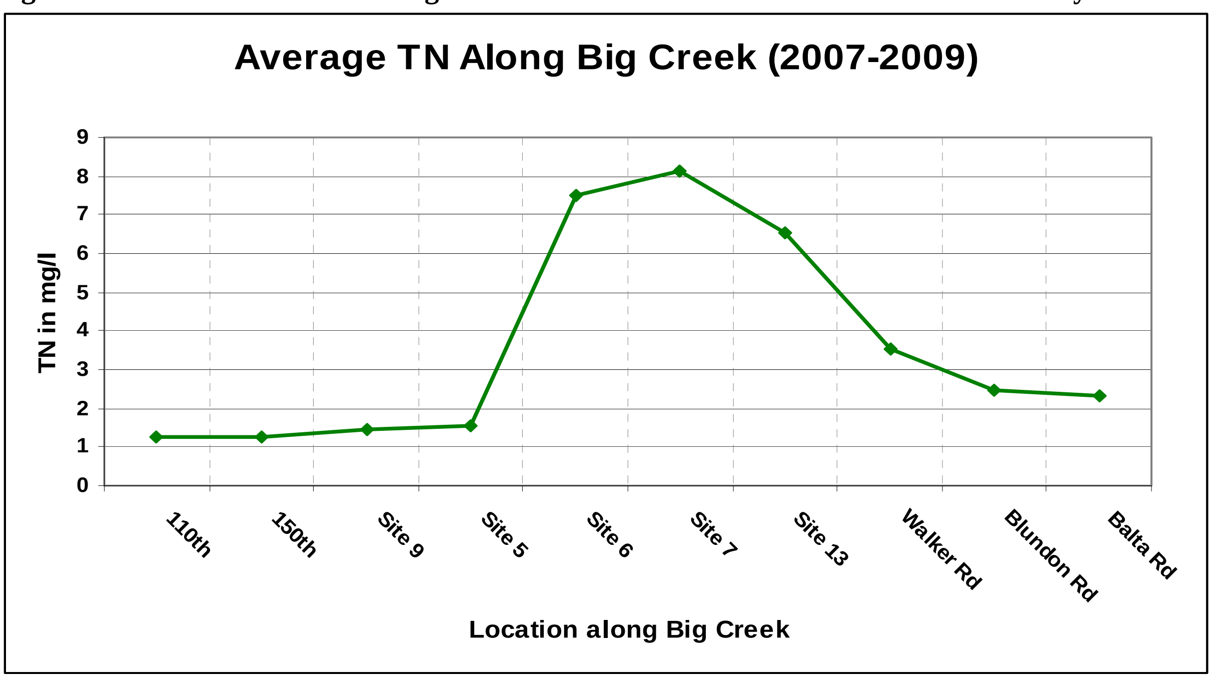

Figure 19. Total N Averages Along Big Creek (2007 – 2009)

Desired Endpoint: The ultimate endpoint of this TMDL will be to achieve the Kansas Water Quality Standards by reducing nitrate levels to protect full support of aquatic life, domestic water supply use, and to prevent objectionable concentrations of algae. The current criterion is 10 mg/l as N which will serve as the numeric endpoint. Therefore, the short term endpoint will be to reduce ambient nitrate concentrations at SC540, Big Creek near Munjor, always below 10 mg/l. Visual assessment will be made along Big Creek to ascertain if the detrimental conditions described in the narrative criterion remain once nitrate levels have been reduced on the lower creek.

Achievement of this endpoint indicates any loads of nitrate 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.

3. SOURCE INVENTORY AND ASSESSMENT

Point Sources: There will be six NPDES permitted facilities potentially discharging to Big Creek **(Table 3)**. 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 has a non-discharging system that is being updated to discharge to Walker Creek in late 2010.

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 required to monitor for ammonia on a quarterly basis, but not nitrate. Because of the 120-day retention time in the lagoons, most nitrogen leaving the lagoon cells is likely organic in nature after nitrifying and uptake processes reduced the ammonia in the wastewater. Over six quarters in 2008 – 2010, ammonia levels ranged from 0.11 – 13.1 mg/l, with the high value occurring in February, 2010. Otherwise the average is 1.46 mg/l.

The City of Ellis Wastewater Treatment Plant discharges to Big Creek and is required to monitor monthly BOD, TSS, pH, Ammonia, E. Coli, Total Phosphorus, Total Kjeldahl Nitrogen, Nitrate and Nitrite, calculate Total Nitrogen, and measure flows during the week. Effluent can be diverted to the municipal golf course for irrigation purposes. Ellis has permit limits for BOD and TSS (45 mg/L weekly and 30mg/L monthly average) and ammonia (daily maximum of 10.2 mg/l as N; monthly average of 3.5 – 10.2 mg/l as N). Ellis has had elevated nitrate (average = 7.5 mg/l; TN = 9.5 mg/l) prior to 2007, but has

Table 3. 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 converting to discharging 3-Cell Lagoon in late 2010

reduced its effluent concentrations over 2007 – 2009 (average = 5.0 mg/l, TN = 5.7 mg/l) **(Figure 20).** Nitrate comprises the majority (~ 80%) of total nitrogen present in the Ellis wastewater. Nitrate from Ellis averages 4.4 mg/l in the wet spring, 5.5 mg/l during the dry summer and fall and 8.5 mg/l during the cold weather months. Average flow was 0.218 MGD.

Gorham has a 3-cell non-discharging lagoon system that will be upgraded to a discharging system, basically by August, 2010. Wastewater will flow, up to 0.0478 MGD, down an unnamed tributary to Walker Creek and then, the lower Big Creek. BOD, TSS, pH, ammonia, chloride, sulfate and E coli bacteria will be sampled quarterly from the treated wastewater. Effluent can be used to irrigate adjacent cropland. Gorham will not affect the water quality of Big Creek at Station SC540.

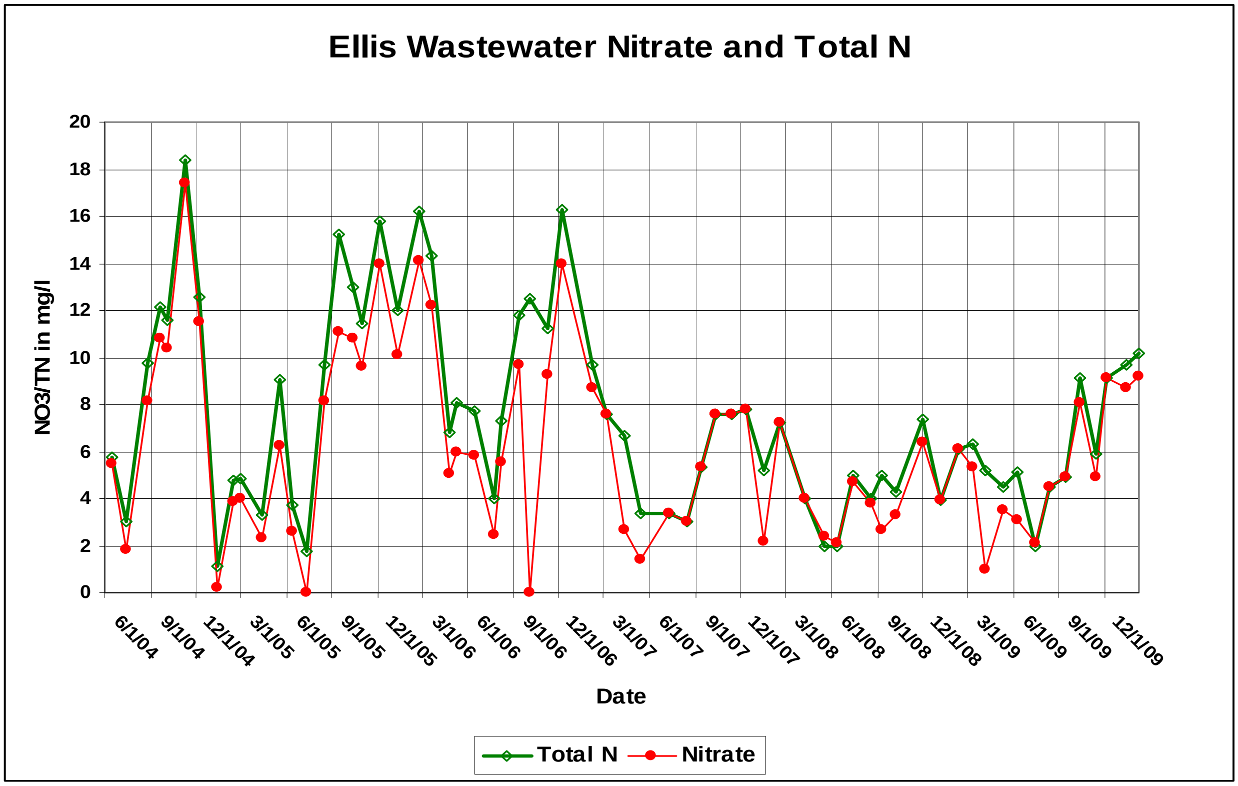

Figure 20. Wastewater Nitrate and Total N at Ellis

The city of Hays discharges to Chetolah Creek which enters Big Creek south of town. The wastewater treatment plant underwent an upgrade in 1993 that introduced nitrification into its treatment train and reduced its effluent ammonia content. Like Ellis, Hays has permit limits (weekly/monthly averages) for TSS (45/30 mg/l) and BOD (40/25 winter; 30/20 summer) and ammonia (monthly average of 4.1 – 12.6 mg/l). Nutrients are sampled once monthly and effluent can be diverted to irrigate several golf courses and ball fields.

By March, 2011, Hays will complete studies indicating the cost and feasibility of upgrading for nutrient removal and meeting effluent goals for total nitrogen of 3, 5 and 8 mg/l. Upgrades under consideration to achieve the varying goals include making operational changes to the existing biological treatment, physical changes to the treatment facility, addition of filters and chemical feeds.

There has been an increasing trend in nitrate concentration in the Hays effluent **(Figure 21)**. Average wastewater nitrate over 2003-2006 was 18.1 mg/l (23.7 mg/l TN); while the more recent average over 2007-2009 was 28.6 mg/l (31.1 mg/l TN). Nitrate comprises 85% of the total nitrogen in Hays effluent. Current operations induce aeration to nitrify wastewater, but there is an inadequate anoxic zone to de-nitrify. The recent increased trend may reflect ineffective use of aeration and altered staffing schedules. Downstream episodes of elevated nitrate at the Munjor monitoring site can be linked to loading from Hays **(Figure 22).** Elevated nitrate usually occurs with lower flows and colder temperatures where the downstream flow is chiefly composed of Hays effluent and the cooler climates impede the biological activity supporting assimilation and denitrification. However, some assimilation or transformation consistently occurs between Hays and Munjor, with lower concentrations seen downstream.

An additional way to view the relative impact of Hays wastewater is looking at the change in Total Nitrogen concentrations seen on Big Creek above and below Chetolah Creek **(Figure 23).** Clearly, below 15 cfs, Hays has marked influence on the change in Total Nitrogen seen downstream. That impact decreases as runoff builds and beyond 20 cfs, there is little difference in TN on the upper and lower reaches of the creek. Differences under cooler temperatures tend to be greater than those occurring over 10 degrees C.

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, excessive nitrate is associated with wastewater discharges at low flow. Runoff loads from either urban or rural lands tend to dilute nitrate concentrations in Big Creek. Although this TMDL begins to address nitrate, such loads are relative to wastewater discharges and no attempt has been made to establish a nitrate wasteload allocation for stormwater in Big Creek.

Land Use: Cropland is the predominant land use within Big Creek Subbasin, comprising 62% of the acreage. **Figure 24** 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 25).** 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 nitrogen to the surface water via overland flow or ground water discharge. While some nitrate may be discharged, it is easily taken up by in-stream biota and does not present a cause for highly elevated nitrates seen below Hays.

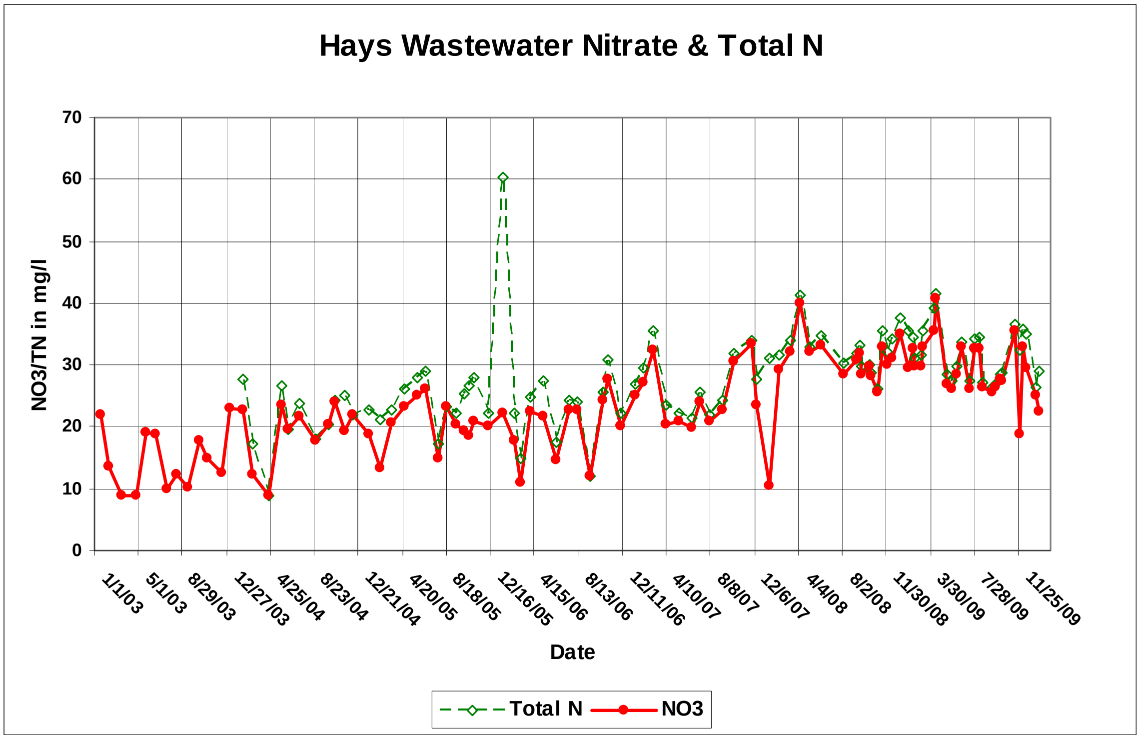

Figure 21. Nitrate and Total N Content of Hays Wastewater

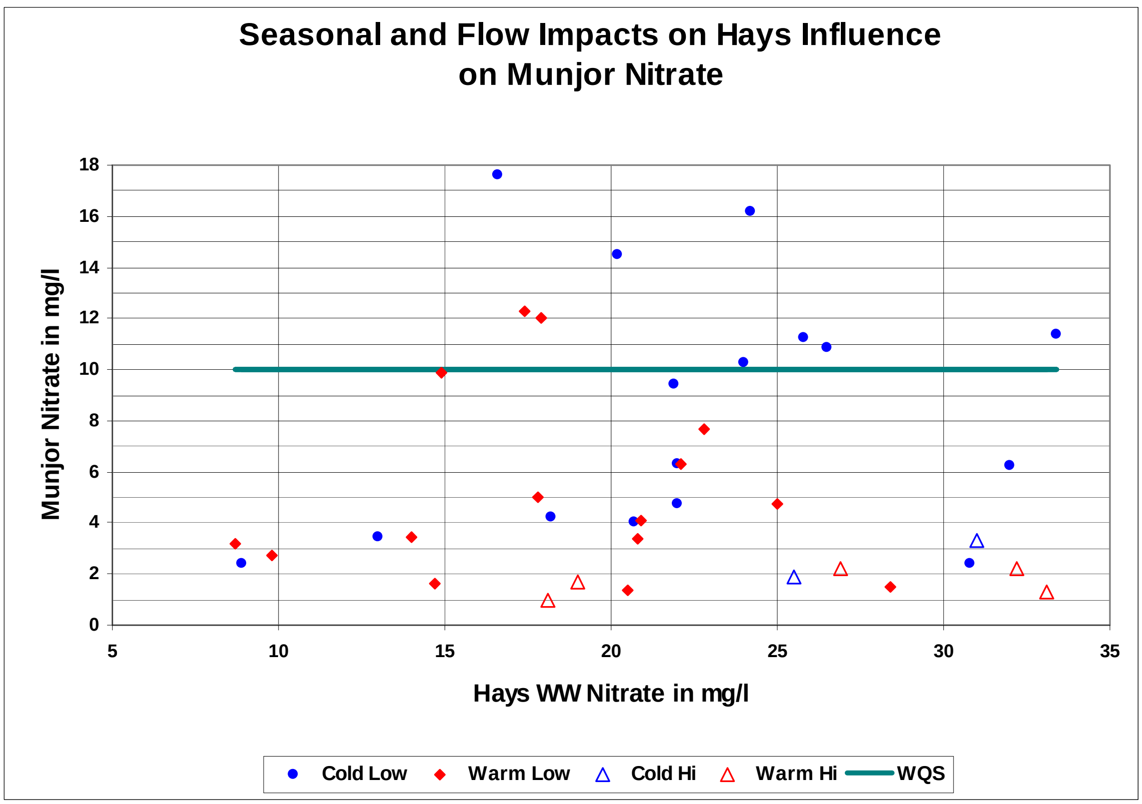

Figure 22. Relationship between Hays Wastewater and Downstream Nitrate under Various Conditions

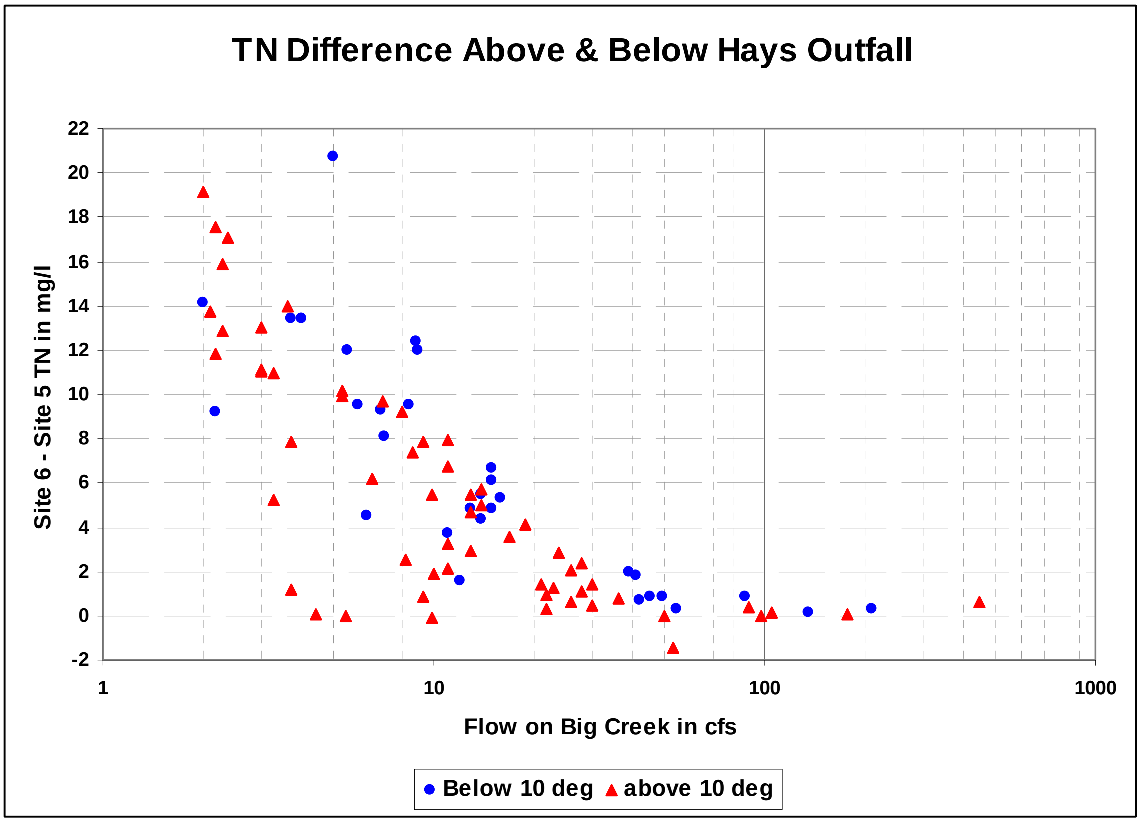

Figure 23. Difference between upstream and downstream TN concentrations at Hays.

Table 4 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. 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).

Table 4. Planted Crop Acres in 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 the 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 26)** 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.

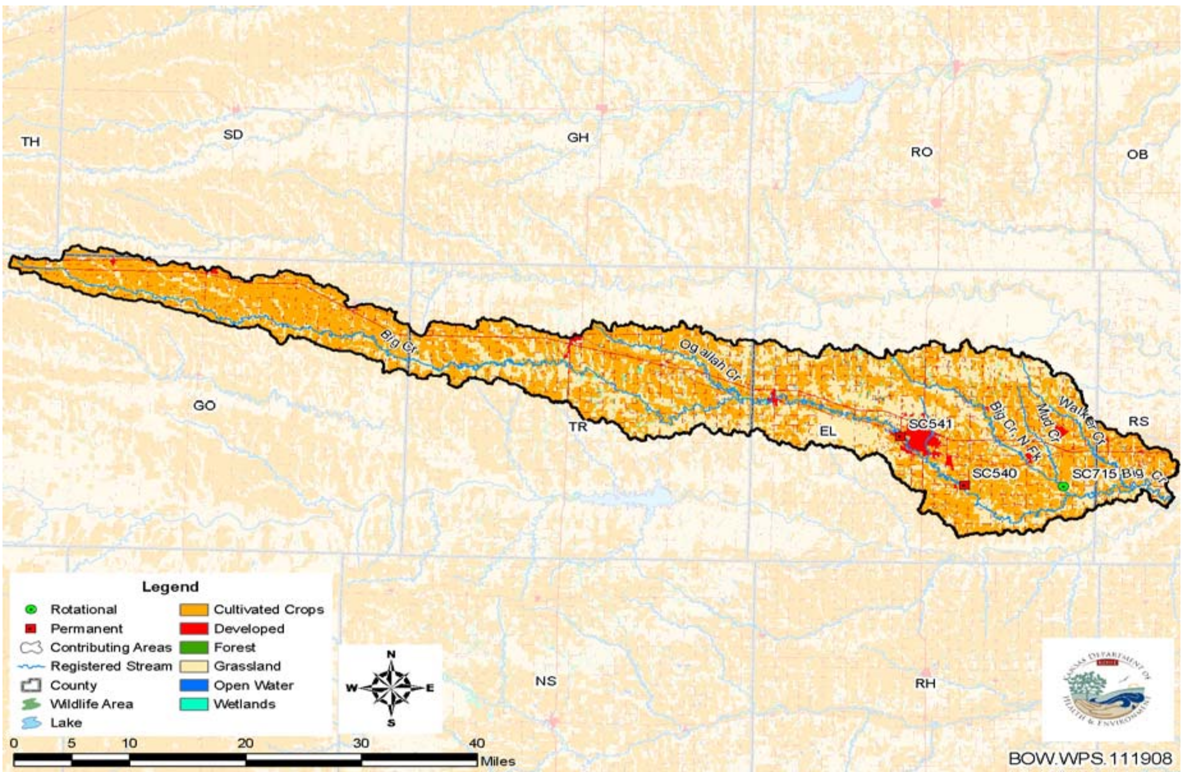

Figure 24. General Land Use in Big Creek Watershed (from 2001 NLCD)

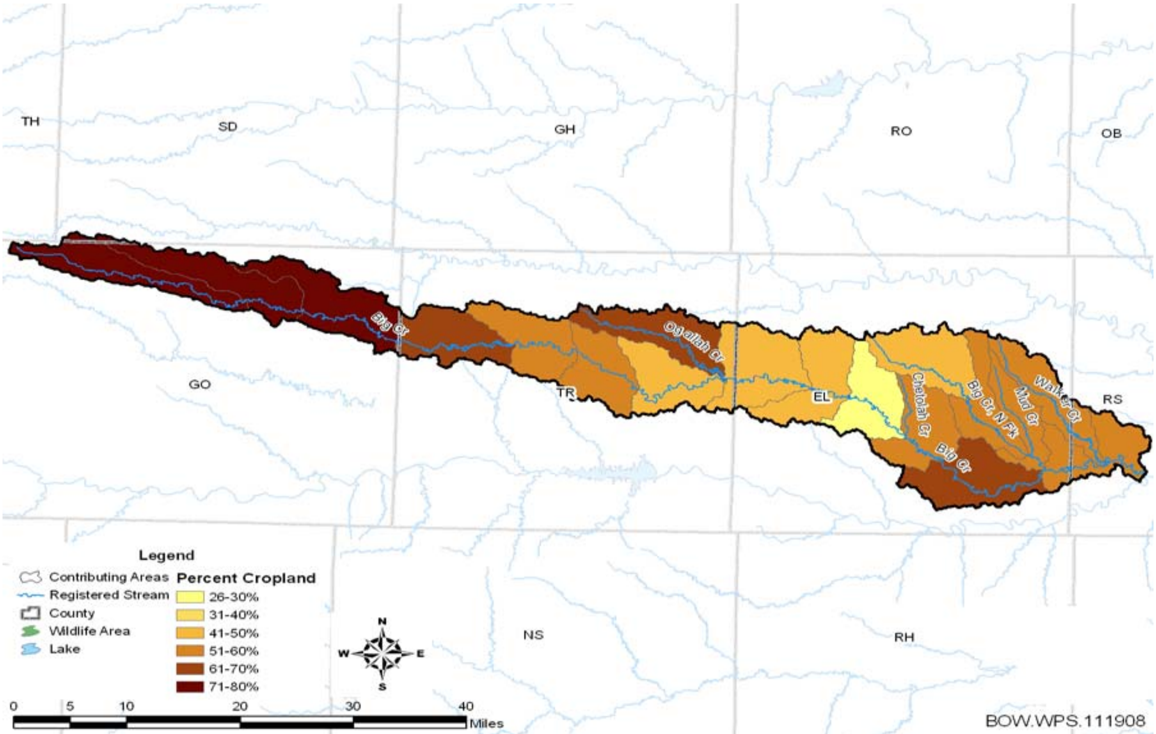

Figure 25. Cropland Distribution Across Big Creek Watershed

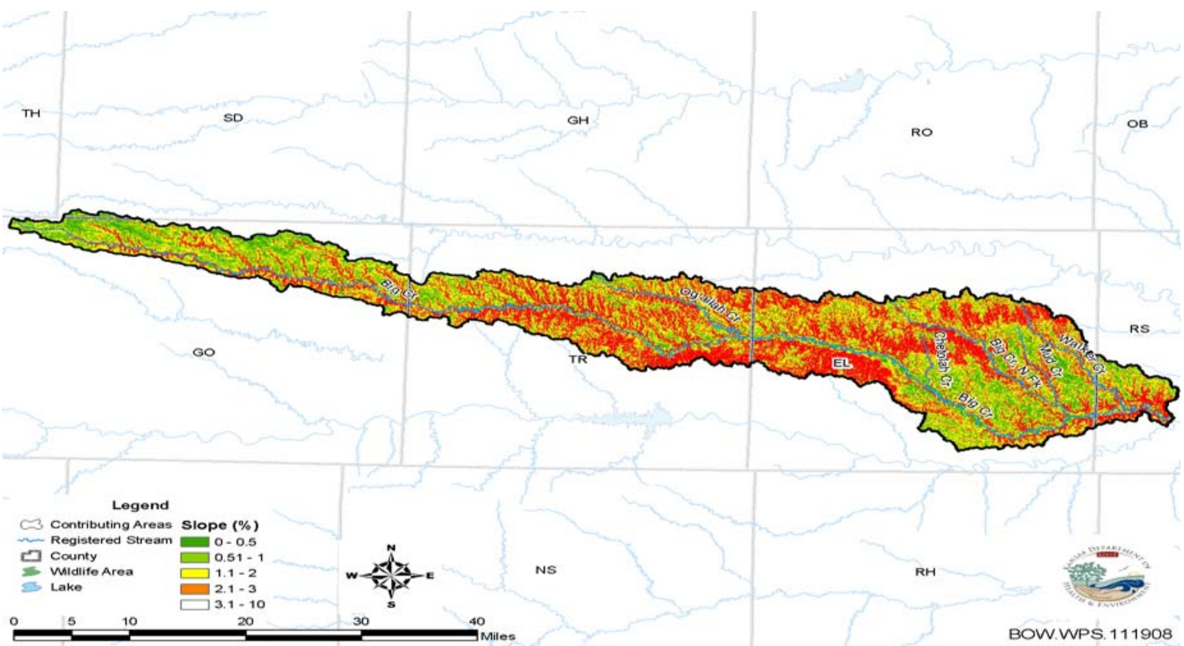

Figure 26. Land slope Across the Big Creek Watershed

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 A**). 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 5).** 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 5 & 6).** There are livestock present in Russell County but no regulated facilities in the Big Creek drainage portion of the county **(Figure 27).**

Table 5. Animal 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**

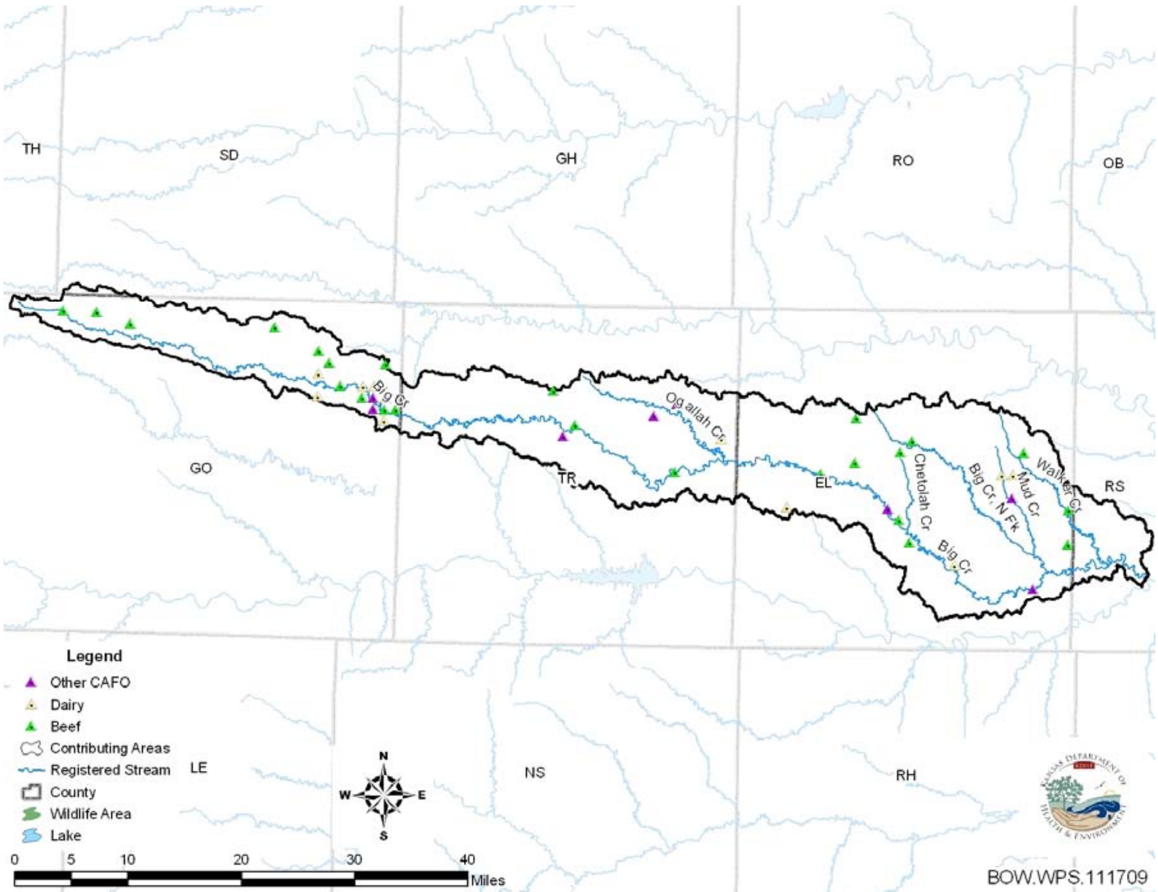

Figure 27. Animal Feeding Operations (AFO & CAFO) in Big Creek Watershed

Population Density: **Table 6** summarizes the populations for the four counties within 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 6. Selected Big Creek County information.

County	2008 Population*	2000 Census Population	County Size Sq.Miles	2007 # of Farms**	2007 Farm Acreage	2009 Cattle Head
Ellis	27,801	27,507	900	687	526,202	52,800
Russell	6,641	7,370	885	522	442,550	30,900
Trego	2,882	3,319	888	380	429,588	30,800
Gove	2,548	3,068	1,071	413	593,622	76,000

* - U.S. Census Bureau Estimates ** 2007 Ag Census & Kansas Agricultural Statistics

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. 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 nitrate impairment along lower reaches of Big Creek.

Background Levels: Nitrate is present in streamflow as biological processes transform nitrogen through nitrification of ammonia produced from organic material. Uptake and de-nitrification processes control nitrate levels typically under 0.5 mg/l. Atmospheric deposition of nitrogen and ground water discharge of nitrate will contribute loadings to Big Creek, but once in the ambient surface water, the biological processes will transform most of that nitrate into forms best suited to support the life functions of the micro- and macro- biota of the stream.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

This TMDL will be established to meet the target of the existing nitrate criterion (10 mg/l) at SC540 **(Figure 28)** but its implementation sets out to achieve a longer term goal of reducing total nitrogen**.** After the nitrate criterion has been achieved, if detrimental conditions remain in Big Creek, this TMDL may be revised to address reductions in total nitrogen in Big Creek from both point and non-point sources. Initial analysis of endpoints and allocations of total nitrogen is provided in **Appendix B**.

Point Sources: Even though the nitrogen loads from Wakeeney and Ellis typically do not travel down Big Creek and arrive at Hays, this TMDL will assign a wasteload allocation to those facilities to manage any local effects below their respective outfalls. There will be no wasteload allocation assigned to the pending new lagoon facility at Gorham because it discharges to Walker Creek which enters Big Creek below SC540.. The main attention for this TMDL will be the wastewater discharge of Hays.

Table 7 lists the three Wasteload Allocations to Wakeeney, Ellis, and Hays. The nitrate WLAs are based on the current design flows of the respective wastewater treatment facilities and a nitrate concentration of 8 mg/l. Although the current nitrate criterion is 10 mg/l, this TMDL will use the long term total nitrogen goal of 8 mg/l as the limit, in accord with the Kansas Surface Water Nutrient Reduction Plan. Using this value, presumes that all nitrogen leaving the wastewater facilities will be nitrate, which is very conservative and not likely to occur. Therefore, after upgrade of facility operations and treatment processes at Hays, there should not be any excursions from the nitrate criterion at SC540. After that point in time, this TMDL may be revisited and revised to address excessive levels of total nitrogen in Big Creek.

There will be Wasteload Allocations of zero assigned to the concrete batch plants, the non-discharging wastewater facilities and the animal feeding operations because all of these facilities should have no discharge to Big Creek. Because the nitrate impairment is a low flow condition, there will also be a wasteload allocation of zero for Hays MS4 stormwater. Since this impairment is low flow oriented, urban stormwater management is not warranted. However, when the nitrate criterion is re-attained on Big Creek below Hays and this TMDL is modified to address total nitrogen, the MS4 stormwater allocation will be revised to reflect expected loadings of nitrogen (all forms) to Big Creek during wet weather.

Table 7. Nitrate Wasteload Allocations for Big Creek Dischargers

Facility	Design Q	Expected [NO3]	Nitrate WLA
Hays	2.8 MGD (4.33 cfs)	8.0 mg/l	187.1 #/d
Ellis	0.3 MGD (0.46 cfs)	8.0 mg/l	20.2 #/d
Wakeeney	0.25 MGD (0.39 cfs)	8.0 mg/l	16.7 #/d
Total	3.35 MGD (5.18 cfs)	8.0 mg/l	224.0 #/d

Figure 28 shows several historic loads, associated with nitrate concentrations greater than 10 mg/l, plotting below the intended TMDL curve. The plotted loads reflect smaller wastewater discharges from the point sources historically occurring during low flow conditions, whereas the TMDL curve is adjusted by the anticipated change in hydrology resulting from design flows from the point sources arriving at SC540. Because wastewater dominates the hydrology of low flows, future plots of nitrate loads should fall below the designated Wasteload Allocation lines.

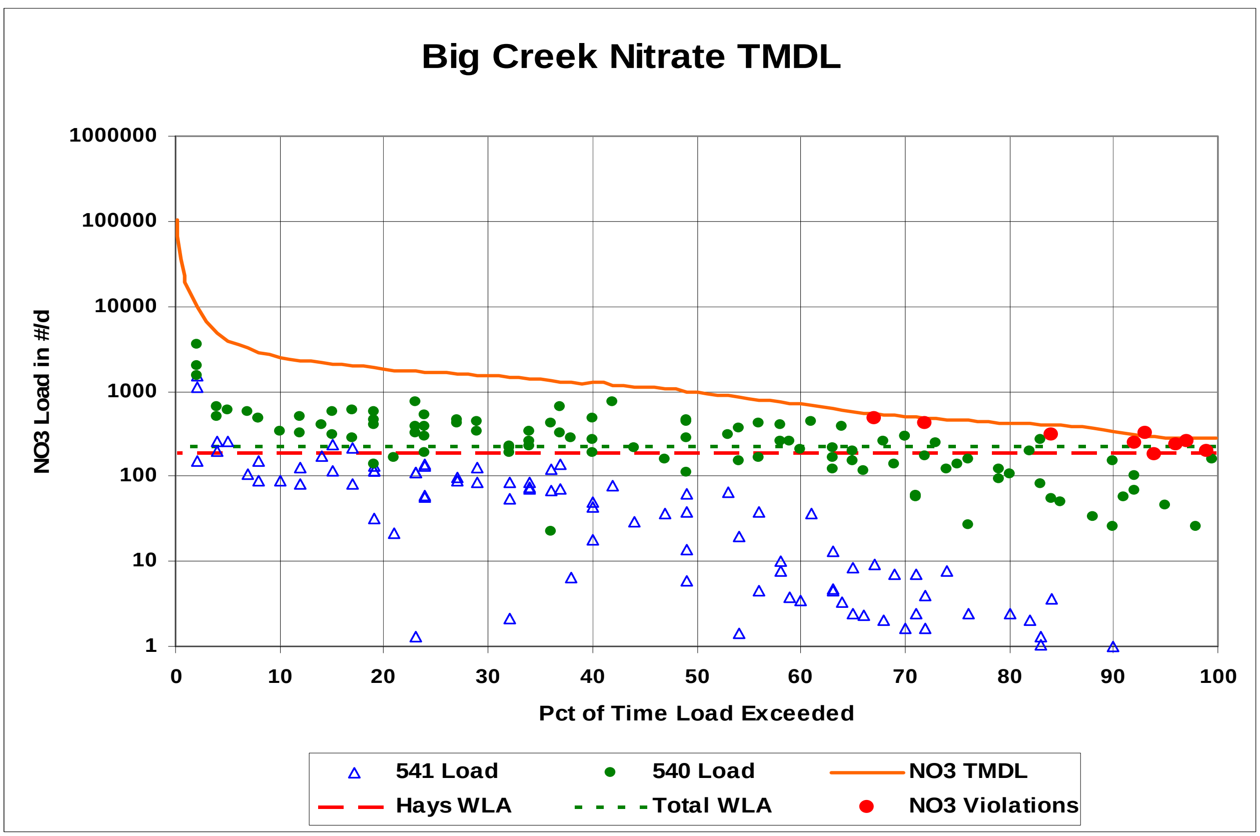

Figure 28. Nitrate TMDL for Big Creek

Nonpoint Source: The Load Allocation (LA) assigns responsibility for nonpoint source contributors for the nitrate input into Big Creek. Since nitrate concentrations do not exceed the criterion value of 10 mg/l during wet weather, the LA will simply be the area under the TMDL curve that lies above the total WLA **(Figure 28)**. Under those conditions, non-point sources will not cause ambient concentrations of nitrate to exceed the endpoint of 10 mg/l. After the nitrate impairment is addressed and there is cause to address reductions in total nitrogen throughout Big Creek, the Load Allocation will be re-calculated to reflect the greater expectations placed on abating non-point source nitrogen loadings to the creek at higher flows.

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty in nitrate 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 exceedances in the nitrate criterion. First, design flows are used for the three point source dischargers to set wasteload allocations, although demographic trends indicate Wakeeney is just as likely to decline in current population. Second, the wasteloads from Ellis and Wakeeney are assumed to travel the course of Big Creek and arrive at Hays. Third, implementation of this TMDL will cause the point sources to discharge less than 8 mg/l of total nitrogen in their wastewater, resulting in nitrate levels to fall below the 10 mg/l criterion. Finally, nitrate is assumed to comprise all of the nitrogen in the wastewater.

Once the TMDL transitions to address total nitrogen, the assumptions regarding the arrival of upstream wasteloads, assimilation of nitrogen between outfall and monitoring station and the proportion of design flow actually discharges will be revisited.

State Water Plan Implementation Priority: Due to the prevalence of high nitrate concentrations on Big Creek below Hays, priority should be given to wastewater treatment upgrades at Hays to effectively eliminate the exceedance of the nitrate criterion. 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 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 the streams in the watershed. Because the hydrology of the watershed is meager to the west of Hays, those sub watersheds will be relegated to a deferred status for implementation actions. The HUC 12s surrounding Hays (102600070303 & 04) have the largest percentage of developed land within them among the 18 sub watershed comprising the Big Creek watershed.

Because the initial efforts will focus on point source implementation, those two HUC 12s will be the priority. Once the nitrate impairment is eliminated, and the focus shifts to reduction in total nitrogen, those two HUC 12s will remain a priority because of the need to address urban stormwater loads. 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. Upstream HUC's 102600070301 & 02 will be assessed for the capability to load Big Creek during wet weather.

5. IMPLEMENTATION

Desired Implementation Activities

Short Term Nitrate Reduction

1. Install and operate enhanced wastewater treatment at Hays to induce denitrification and lower nitrate content of effluent.
2. Facilitate wastewater reuse for treated municipal wastewater
3. Renew state and federal permits, inspect permitted facilities, continue monitoring requirements and evaluate nutrient reduction study for Hays.

Long Term Nitrogen Reduction

4. Revise this TMDL to reflect necessary reductions and allocations of total nitrogen among sources within the Big Creek watershed.
5. Incorporate, or for no-till farms, subsurface apply nitrogen fertilizers, particularly prior to first runoff.
6. Improve riparian conditions along stream systems by installing grass and/or forest buffer strips along the stream and drainage channels in the watershed.
7. Perform extensive soil testing to ensure excess nitrogen is not unnecessarily being applied.
8. Ensure land applied manure is being properly managed and is not susceptible to runoff by implementing nutrient management plans, incorporation or subsurface injection.
9. Install pasture management practices, including proper stock density to reduce soil erosion and storm runoff.
10. Ensure proper on-site waste system operations in proximity to the main stream segments.
11. Ensure that labeled application rates of chemical fertilizers are being followed and implement runoff control measures.

Implementation Programs Guidance

NPDES and State Permits - KDHE

a. Monitor effluent from the discharging permitted wastewater treatment facilities, continue to encourage wastewater reuse and ensure compliance and proper operation to control nitrate and total nitrogen levels in wastewater discharges.
b. Establish permit limits 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. 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 nitrogen loading from agricultural lands though 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 toward small livestock operations which minimize impacts to stream resources.
d. Support Watershed Restoration and Protection Strategy (WRAPS) efforts for the Big Creek – Middle Smoky Hill Sub-basins 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. Support conservation farming practices and/or erosion control, including no-till farming
b. Encourage residue management to reduce nitrogen loss to volatization or runoff transport from croplands in the watershed.
c. Install livestock waste management systems for manure storage.
d. Implement manure management plans.
e. Support soil testing prior to fertilizer or manure applications
f. Support terracing, grass waterways and buffers along cropland
g. Repair or replace failing septic systems which are located within 100 feet of Big Creek or its tributaries.

Riparian Protection Program – SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and stream bank vegetation.
b. Develop riparian restoration projects along targeted stream segments, below Hays.
c. Promote wetland construction to reduce runoff and assimilate nitrogen loadings.

Buffer Initiative Program – SCC

a. Install grass buffer strips near Big Creek and tributary streams.

b. Mitigate removal of riparian lands from Conservation Reserve Program to hold streamside 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 nitrogen.
f. Educate residents, landowners, and watershed stakeholders about homestead fertilizer management.
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. Implementation of nitrogen abatement practices should commence in the three priority HUC 12s after 2011. Implementation should continue through 2019.

Targeted Participants: The primary participants for implementation will be the City of Hays wastewater and stormwater programs, initially. In time, agricultural and livestock operations immediately adjacent to the lower portions of Big Creek and tributaries within the priority sub watersheds 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 2010 - 2011. Non-point source implementation activities should focus on those areas with the greatest potential to impact nitrogen concentrations along Big Creek.

Targeted activities to focus attention toward include:

1. Unbuffered cropland adjacent to the stream.
2. Sites where drainage runs through or adjacent to livestock areas.
3. Sites where livestock have full access to the stream and it is their primary water supply.
4. Opportunities for no till or residue management on cropland near Big Creek.
5. Acreage of poor rangeland or overstocked pasture.
6. Poor riparian area and denuded riparian vegetation along the stream.

Eventually, residents of Hays should be informed on fertilizer management in conjunction with the Hays Stormwater Management Program to reduce loadings to Big Creek from urban runoff.

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, nitrate data from sites SC540 and SC541 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 denitrify its wastewater and begin to decrease its nitrogen content.

Delivery Agents: The primary deliver agents for program participation will be 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.

Effectiveness: Use of Biological Nutrient Removal technology has been well established to reduce nutrient levels in wastewater, including nitrate and total nitrogen. 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 in every year at Stations SC540 and SC541. Based on the sampling data, the priority status of the 303(d) listing will be evaluated in 2014. If the impairment status of Big Creek changes, the desired endpoints under this TMDL may be refined to reflect necessary reductions in total nitrogen. In order to assess the support of aquatic life, biological monitoring should commence on the lower reaches of Big Creek in 2012. The stream will be evaluated for possible delisting in 2020 based on the biological condition found in Big Creek in Ellis and Russell counties.

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 in Hays and October 1, 2009 in Hays and again on March 3, 2010 in Hays.

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

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 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 2010, 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 2010-2019.

Revised June 22, 2010

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Appendix A: 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 B. Implementation Logic and Calculation of Total Nitrogen Load Capacity and Allocations to Sources

1. Current load is calculated as the product of the representative flow for the five flow categories, plus the average wastewater discharge from Hays (1.9 MGD) and Ellis (0.218 MGD) and the average TN seen at Station SC540 within those flow ranges and the 5.4 conversion factor:

Flow Category	Flow Percentile Range	Representative Flow	Flow	Average TN	Current Load
Dry	**80 – 99%**	Upper Decile (90%)	1 cfs	7.03 mg/l	162.37 lbs/day
Low	**60 – 79%**	Upper Quartile (75%)	2.7 cfs	5.08 mg/l	163.96 lbs/day
Normal	**40 – 59%**	Median (50%)	11 cfs	3.79 mg/l	292.20 lbs/day
High	**20 – 39%**	Lower Quartile (25%)	23 cfs	2.53 mg/l	367.51 lbs/day
Wet	**1 – 19%**	Lower Decile (10%)	37 cfs	1.75 mg/l	380.62 lbs/day

2. Current Wasteload is calculated as the product of the average wastewater discharge in cfs and average TN content from Hays and Ellis (Wakeeney and Gorham did not discharge); the Wasteload in the stream is adjusted by a reduction (or assimilation) factor, F, determined at dry flow…F = Current Load / Current Wasteload.
   For Big Creek TN, F = 0.322. Thus, 68% of the wasteload is assimilated between the outfall and the monitoring station.

3. Stage 1 Load Capacity is computed from the representative flow plus the design flows of the three facilities (5.18 cfs) multiplied by the Stage 1 endpoint (1.78 mg/l) and the 5.4 conversion factor.

4. Stage 1 Wasteload Allocation is the sum of the individual WLA for the three facilities, determined by their design flow and expected average TN in their wastewater with BNR treatment (8 mg/l); the Wasteload Allocation is adjusted to the Stage 1 Load Capacity by applying the F factor and then, if need be, reducing the expected average TN until the instream WLA is comparable to the LC (no allocations for stormwater or non-point sources are set under the Dry flow condition. The adjusted Wasteload Allocation is then fixed for the other flow conditions.

5. Stage 2 Load Capacity and Wasteload Allocations are calculated the same as for Stage 1, but uses the Stage 2 endpoint of 1.13 mg/l TN for the Load Capacity and expected TN average values from ENR treatment (5 mg/l).

6. Individual Wasteload Allocations are determined by adjusting the expected average TN of each facility's wastewater downward until the sum of the three WLAs equates to the Wasteload Allocation and its instream adjustment computed from the Load Capacity and summed design flows.

7. The Wasteload Allocation for Hays MS4 is determined by proportioning the remaining load capacity after accounting for wastewater WLA by the proportion of developed land lying within the two HUC 12s where Hays resides (11%). This proportion to the normal and low flow conditions. Once high and wet conditions prevail, there is an assumption that the flows seen in the vicinity of SC540 are also generated by the HUC 12s of western Ellis County, therefore, the MS4 WLA proportion diminishes to reflect the addition of more rural land (6%).

8. The Load Allocation is calculated as the remaining load capacity.
   Load Allocation(nps) = Load Capacity – WLA(ww) – WLA(MS4)

Implementation Planning for Total Nitrogen

Total nitrogen imparts an eutrophication impact on streams and the long term goal of this TMDL will be to reduce nitrogen loadings from all sources such that total nitrogen concentrations resemble those found in relatively un-impacted streams. The current EPA suggested benchmark for stream TN in the South-Central Cultivated Great Plains ecoregion is 0.88 mg/l TN over the 10-state aggregate of Level III ecoregions. A similar TN benchmark for the Central Great Plains was 0.84 mg/l, spanning Nebraska to Texas (U.S.EPA, 2001).

For this TMDL, the initial effort will focus on reducing the total nitrogen concentration of Big Creek below Hays toward levels seen on the creek above Hays. In the long term, should evidence persist in showing stream eutrophication impacts as described in the current narrative criterion for nutrients, Big Creek concentrations should begin to approach those on the Saline River north of Hays and the Smoky Hill River at Schoenchen. **Figure A** displays the distribution of total nitrogen among the four KDHE stations and those sampled by the Big Creek WRAPS. There is no significant difference between the total nitrogen values recorded at the KDHE station at Munjor (SC540) and those sampled on the lower creek by the WRAPS at Sites 6, 7 and 13. Similarly, there is no significant difference between KDHE station SC541 and Sites 5 and 9, although they are different than the stations below Hays. All stations on Big Creek are significantly different than the two long term reference stations on the Saline River (SC548) and the Smoky Hill River (SC539).

The initial long term endpoint is to reduce the median of total nitrogen at lower Big Creek stations (SC540, Sites 6 to Balta Road) [6.15 mg/l] to a level in the vicinity of the upper quartile of the upstream stations on Big Creek (SC541, Sites 5 & 9) [1.78 mg/l; **Figure B**]. If detrimental conditions and impacts are still occurring, further nitrogen reduction should occur along Big Creek, such that median TN levels reflect similar conditions on the Saline and Smoky Hill Rivers bracketing Hays north-to-south [new median ~ upper quartile of SC539 & SC548 (1.13 mg/l). Nitrogen levels in this range will begin to approach the values suggested by the initial work of EPA on ecoregion benchmarks for total nitrogen.

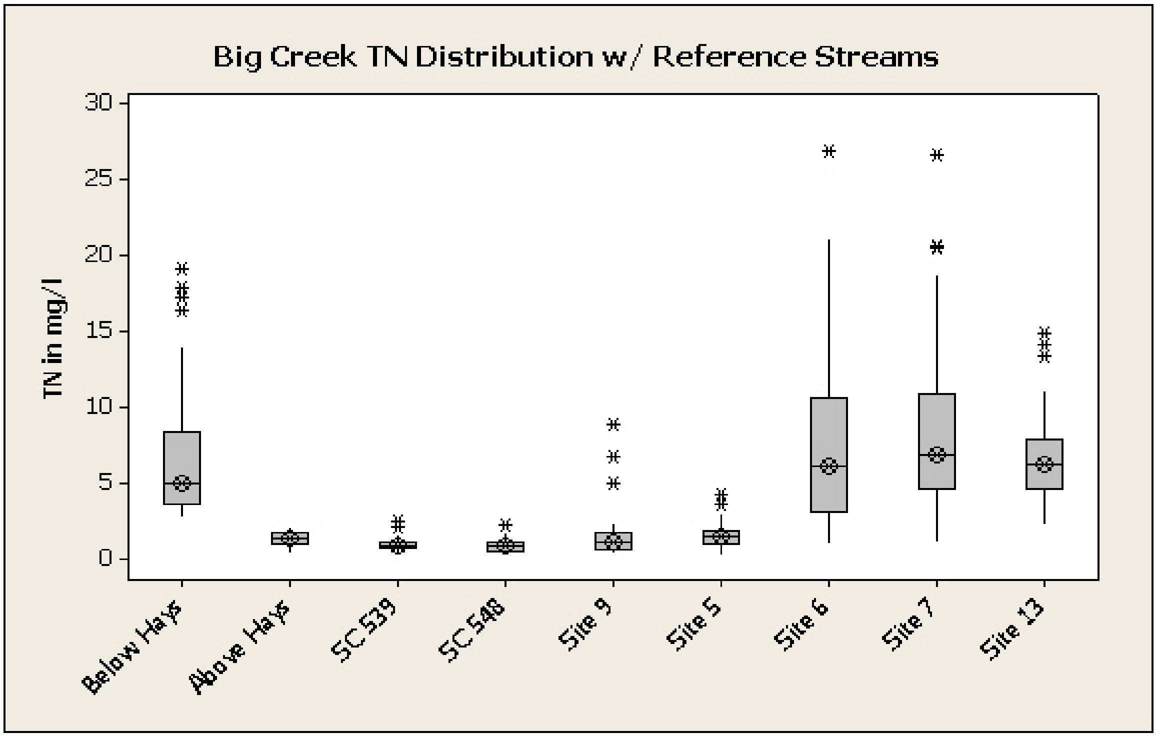

Figure A. Distribution of Total Nitrogen along Big Creek, Saline and Smoky Hill Rivers in Ellis County.

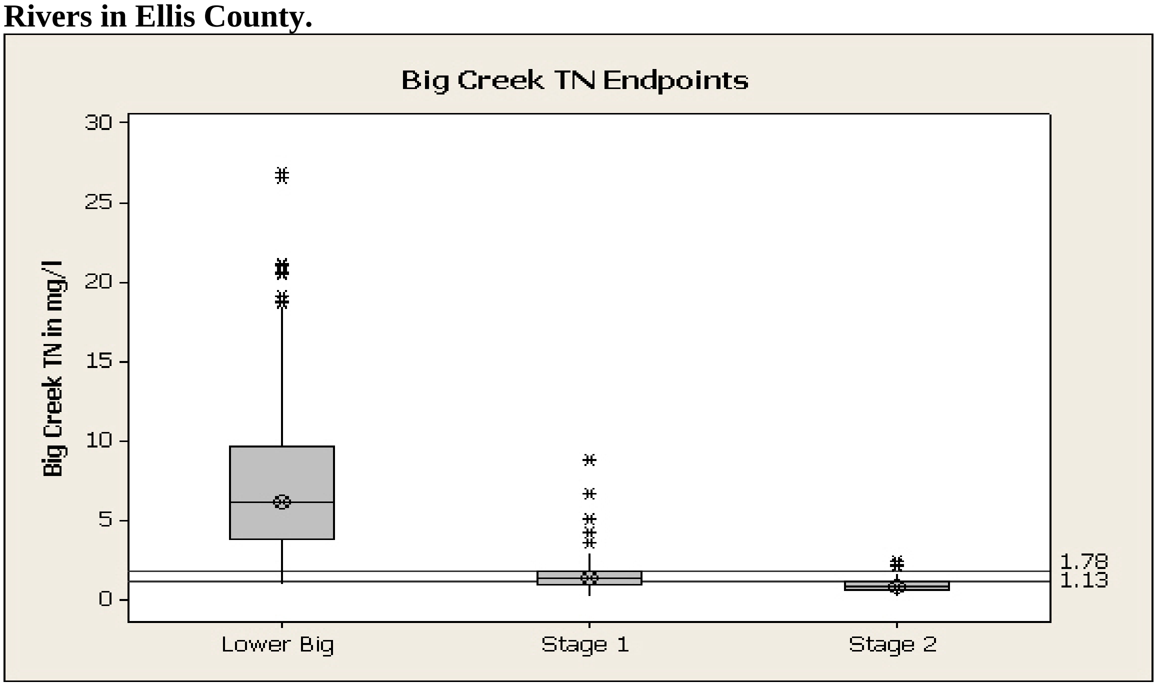

Figure B. Total Nitrogen Endpoints for Big Creek

Transition to Total Nitrogen: The long term (Stage 1) goal for point source dischargers is to reduce annual average total nitrogen in their wastewater below 8 mg/l, through Biological Nutrient Removal (BNR). Accounting for current estimates of proportional loss and assimilation, BNR wasteloads should support the long term TN goal for lower

Big Creek at SC540 as a median of 1.78 mg/l. If stream biological community needs dictate further lowering of loads and endpoints (median of 1.13 mg/l TN), Enhanced Nutrient Removal (ENR) will be employed by the point source discharges, along with non-point source load reductions.

After attaining the nitrate criterion of 10 mg/l or lower on the lower reaches of Big Creek, this TMDL will transition to address lowering total nitrogen loads into Big Creek from wastewater, urban stormwater and rural non-point sources above SC540. **Table A** indicates the applicable Load Capacity (TMDL), Wasteload Allocations for wastewater and urban stormwater and non-point source Load Allocations for two stages of nitrogen load reduction at various flow conditions. Stage 1 occurs after Hays has reduced the nitrate content of its wastewater and looks to lower loads such that a median nitrogen level of 1.78 mg/l occurs at Site 540. This would make the nitrogen levels of the lower reaches of Big Creek comparable to those seen above Hays. Once this stage has been achieved, visual assessment will be made of Big Creek in Russell and Ellis counties to ascertain if impacts to the biological community in the stream are still present. If so, Stage 2 commences with more reductions of total nitrogen loading from wastewater (through ENR), urban stormwater in Hays and non-point source abatement throughout Ellis County, resulting in a median nitrogen level of 1.13 mg/l at SC540 and SC541. Logic for the TN allocation calculations is described above.

Pct	Flow	Current Load	Current Wasteload	Stage 1 LC	WLA 1*	MS4-1	LA1	Stage 2 LC	WLA 2*	MS4-2	LA2
80-99%	1.0 cfs	162.3#/d	162.3#/d	**59.4**#/d	**59.4**#/d	**0.0**#/d	**0.0**#/d	**37.7**#/d	**37.7**#/d	**0.0**#/d	**0.0**#/d
60-79%	2.7 cfs	164.0#/d	162.3#/d	**75.7**#/d	**59.4**#/d	**1.8**#/d	**14.5**#/d	**48.1**#/d	**37.7**#/d	**1.1**#/d	**9.3**#/d
40-59%	11 cfs	292.2#/d	162.3#/d	**155.5**#/d	**59.4**#/d	**10.6**#/d	**85.5**#/d	**98.7**#/d	**37.7**#/d	**6.6**#/d	**54.4**#/d
20-39%	23 cfs	367.5#/d	162.3#/d	**270.9**#/d	**59.4**#/d	**12.7**#/d	**198.8**#/d	**172.0**#/d	**37.7**#/d	**8.0**#/d	**126.3**#/d
1-19%	37 cfs	380.6#/d	162.3#/d	**405.4**#/d	**59.4**#/d	**20.8**#/d	**325.2**#/d	**257.4**#/d	**37.7**#/d	**13.1**#/d	**206.6**#/d

- *** assumes that 32% of the wasteloads reach the downstream monitoring station**

Table A. Anticipated Total Nitrogen TMDL and Allocations for Big Creek

Wastewater: Stage 1 Wasteload Allocations are based on the anticipated annual average TN content of wastewater falling below 8 mg/l, predominantly by Biological Nutrient Removal at Hays and Ellis (**Table B**). Assuming similar (~68%) assimilation of wastewater nitrogen occurs between Hays and Munjor, the TN levels at Station SC540 should be substantially lower. Because the metric of Stage 1 is a median concentration of 1.78, WLAs may need to be adjusted downward (~6.6 mg/l) in order to achieve the endpoint. Increased use of wastewater for irrigation, efficient operation of treatment processes at Hays and Ellis and less volume of Wakeeney wastewater reaching the lower portion of Big Creek will lower nitrogen loading and concentrations seen at SC540.

Similarly, Stage 2 Wasteload Allocations are based on further reductions of nitrogen content (~ 4.2 – 5 mg/l) through Enhanced Nutrient Removal at Hays and Ellis and further reduced discharge volume at Wakeeney. Achievement of these WLAs, along with in-stream assimilation should allow Big Creek to achieve a median concentration of

1.13 mg/l at both Stations SC540 and SC541. Stage 2 would commence only if biological information indicated the impacts identified in the narrative criterion for nutrients were occurring after Stage 1 was complete.

Facility	Current Wasteload	Stage 1 WLA	Adj Stage 1 WLA	Stage 2 WLA	Adj Stage 2 WLA
Hays	493.7 #/d	187.2 #/d	154.3 #/d	116.9 #/d	98.2 #/d
Ellis	10.4 #/d	20.1 #/d	16.4 #/d	12.4 #/d	10.4 #/d
Wakeeney	0.0 #/d	16.7 #/d	13.9 #/d	10.5 #/d	8.9 #/d
Total WLA	504.1 #/d	224.0 #/d	184.6 #/d	141.8 #/d	117.5 #/d

Table B. Anticipated Wasteload Allocations for Discharging Wastewater to Big Creek

MS4 Stormwater: A Wasteload Allocation for Hays MS4 is provided by proportioning the remaining load capacity after accounting for the NPDES WLA between MS4 and NPS loads (**Table A**). This was done by assuming that there would be no stormwater under dry, low flow conditions (exceeded at least 80% of the time). Under normal flow conditions (40 – 80% exceedance), load contributions were assumed to arise from the HUC 12's surrounding Hays). Thus the MS4 WLA was based on the proportion of developed land in HUCs 102600070303 & 04 ~ 11% (6200 acres out of 57,650 acres) and was similarly apportioned. Under wet conditions (flow exceeded 1 – 40% of the time), load contributions are assumed to arise from western Ellis County as well and the developed land WLA proportion 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 Wasteload Allocations for NPDES wastewater and MS4 stormwater have been accounted **(Table A).** 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 non-point source in nature 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, particularly as stream depletions from irrigation withdrawals and conservation practices have taken hold.