KANSAS-LOWER REPUBLICAN BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: Kansas River between Wamego and Willard, including Cross Creek
Water Quality Impairment: E coli Bacteria

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Middle Kansas **Counties**: Shawnee, Jackson, Pottawatomie and Wabaunsee

HUC8: **10270102**
HUC10 (HUC12): **06** (01, 02, 03, 04) – Cross Creek
05 (05, 06, 07, 08) – Main stem of Kansas River and small tribs
07 (01) – Main stem of Kansas River above Mission Creek

Ecoregion: Flint Hills (28)

Drainage Area: 177 square miles for Cross Creek
169 square miles for Kansas River main stem and minor tribs, excluding Mill Creek (588 sq.mi.) and Vermillion Creek (520 sq.mi.) watersheds

Main Stem Water Quality Limited Segments: Kansas River (Segment 11 in Shawnee County, Segments 13 and 14 in Pottawatomie and Wabaunsee Counties) and Cross Creek (Segment 12 in Shawnee, Pottawatomie and Jackson Counties).

Main Segment	**Tributaries**
Kansas River (11)	Cross Cr (12)
	Snake Cr (95)
	Coryell Cr (94)
	Salt Cr (88)
	Sullivan Cr (89)
	Illinois Cr (62)
	Little Cross Cr (61)
	Bartlett Cr (55)
Kansas River (13)	Mill Cr (27) [*unimpaired*]
Kansas River (14)	Bourbonais Cr (63)
	Turkey Cr (71)
	Doyle Cr (69)
	Riley Cr (1223)
	Deep Cr (1229)
	Lost Cr (60)
	Wells Cr (68)
	Vermillion Cr (15) [*impaired*]
Kansas River (24) [*unimpaired as monitored by Station SC260*]	

Designated Uses (per Dec.15, 2010 Kansas Surface Water Register): For Kansas River – all segments: Special Aquatic Life Support, Food Procurement, Domestic Water Supply, Industrial, Irrigation and Livestock Watering, Ground Water Recharge and Primary Contact Recreation "B".

For Cross Creek – all uses, Expected Aquatic Life Support and Primary Contact Recreation "C".

For Kansas River tributaries (excluding Mill, Cross and Vermillion Creeks) – Expected Aquatic Life Support and Primary Contact Recreation "B" and all other uses on Lost Creek (60); Expected Aquatic Life Support and Primary Contact Recreation "C" and all other uses on Deep (1229) and Doyle (69) Creeks (1229); same for Bourbonais (63) Creek except no Food Procurement; Expected Aquatic Life and Primary Contact Recreation "C", Ground Water Recharge, Livestock Watering and Irrigation Water Supply for Turkey (71) and Riley (1223) Creeks; same for Wells Creek (68), except Secondary Contact Recreation "b" and no Food Procurement.

For Cross Creek tributaries – Expected Aquatic Life Support and Secondary Contact Recreation "b" and all other uses on Snake (95), Illinois (62) and Little Cross (61) Creeks; same for Salt (88) and Bartlett (55) Creeks, except no Food Procurement; Expected Aquatic Life, Primary Contact Recreation "C" and all other uses for Sullivan Creek (89); Expected Aquatic Life Support and Secondary Contact Recreation "b", Food Procurement and Livestock Watering for Coryell Creek (94).

303(d) Listings: Kansas River segments below confluence with Vermillion Creek and above confluence with Post Creek as monitored by Station SC259 cited as impaired by E coli bacteria in the 2010-303(d) list for the Kansas – Lower Republican Basin. Kansas River Segment 24 considered non-impaired based on E coli data collected at Station SC260, located on Segment 24. Kansas River Segment 11 considered impaired between Cross and Post Creeks. Cross Creek and tributaries monitored by Station SC551 cited as impaired by E coli bacteria in the 2010 – 303(d) list for the Kansas – Lower Republican Basin.

Mill Creek Segment 27 and tributaries monitored by SC521 and other stations found to be no longer impaired by E coli bacteria in the 2010 – 303(d) list. Existing TMDL for Fecal Coliform Bacteria for Vermillion Creek terminating with Segment 15, modified in 2012 to reaffirm impairment by E coli bacteria as monitored on segments and tributaries at Stations SC520 and SC681, plus impairment on Rock Creek and its tributaries, as monitored by SC645, on the 2010 – 303(d) list for the Kansas – Lower Republican Basin.

Impaired Use: Primary Contact Recreation (Classes "B" and "C")

Water Quality Criteria: K.A.R. 28-16-28d. Surface water classification and use designation. (a) Surface water classification. Surface waters shall be classified as follows:

(1) Classified stream segments shall be those stream segments defined in K.S.A. 82a-2001(a), and amendments thereto. (K.S.A. 82a-2001(a) provided in Appendix A)

K.A.R. 28-16-28e(c)(7):
(D) Primary contact recreation for classified stream segments. At least five samples shall be collected during separate 24-hour periods within a 30-day period. A geometric mean analysis of these samples shall not exceed the criteria in table 1i, as adopted in subsection (d) of this regulation, beyond the mixing zone.

(E) Secondary contact recreation for classified stream segments. The following criteria shall be in effect from January 1 through December 31 of each year. At least five samples shall be collected during separate 24-hour periods within a 30-day period. A geometric mean analysis of these samples shall not exceed the criteria in table 1i, as adopted in subsection (d) of this regulation, beyond the mixing zone.

(F) Wastewater effluent shall be disinfected if it is determined by the department that the discharge of non-disinfected wastewater constitutes an actual or potential threat to public health. Situations that constitute an actual or potential threat to public health shall include instances in which there is a reasonable potential for the discharge to exceed the applicable criteria supporting the assigned recreational use designation or if a water body is known or likely to be used for either of the following:

(i) Primary or secondary contact recreation; or
(ii) any domestic water supply.

Table 1i. Escherichia coli Criteria For Classified Stream Segments.

USE	Colony Forming Units (CFUs)/100mL	
PRIMARY CONTACT RECREATION	Geometric Mean April 1 – Oct. 31	Geometric Mean Nov. 1 – March 31
Class A	160	2358
Class B	262	2358
Class C	427	3843
SECONDARY CONTACT RECREATION	Geometric Mean Jan. 1 – Dec. 31	
Class a	2358	
Class b	3843	

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Uses under 2010 - 303(d): Bacteria levels on the Kansas River at Willard and Cross Creek exceeded the geometric mean criteria in 2008, routine data collected at both stations over 2003 - 2010 indicated occasional digression from the criteria, during the primary recreation season (April – October).

Stream Monitoring Sites and Period of Record: KDHE permanent ambient Stream Chemistry sampling Station SC259, located on the Kansas River south of Willard and Station SC551 on Cross Creek north of Rossville have E coli data from 2003-2011 **(Figure 1)**.

Supplementing the routine KDHE sampling, intensive sampling (five samples in 30 days) was conducted four times during the primary recreation season of 2004 – 2006 and 2008 for the Kansas River near Willard; only the geometric means from samples in August and October of 2008 exceeded the criterion of 262 colony forming units per 100 ml. Intensive sampling in four periods of 2008 also occurred on Cross Creek; the October samples exceeded the criterion of 427 colony forming units per 100 ml. Those exceedances resulted in the impairment listing on the 2010 Section 303(d) list.

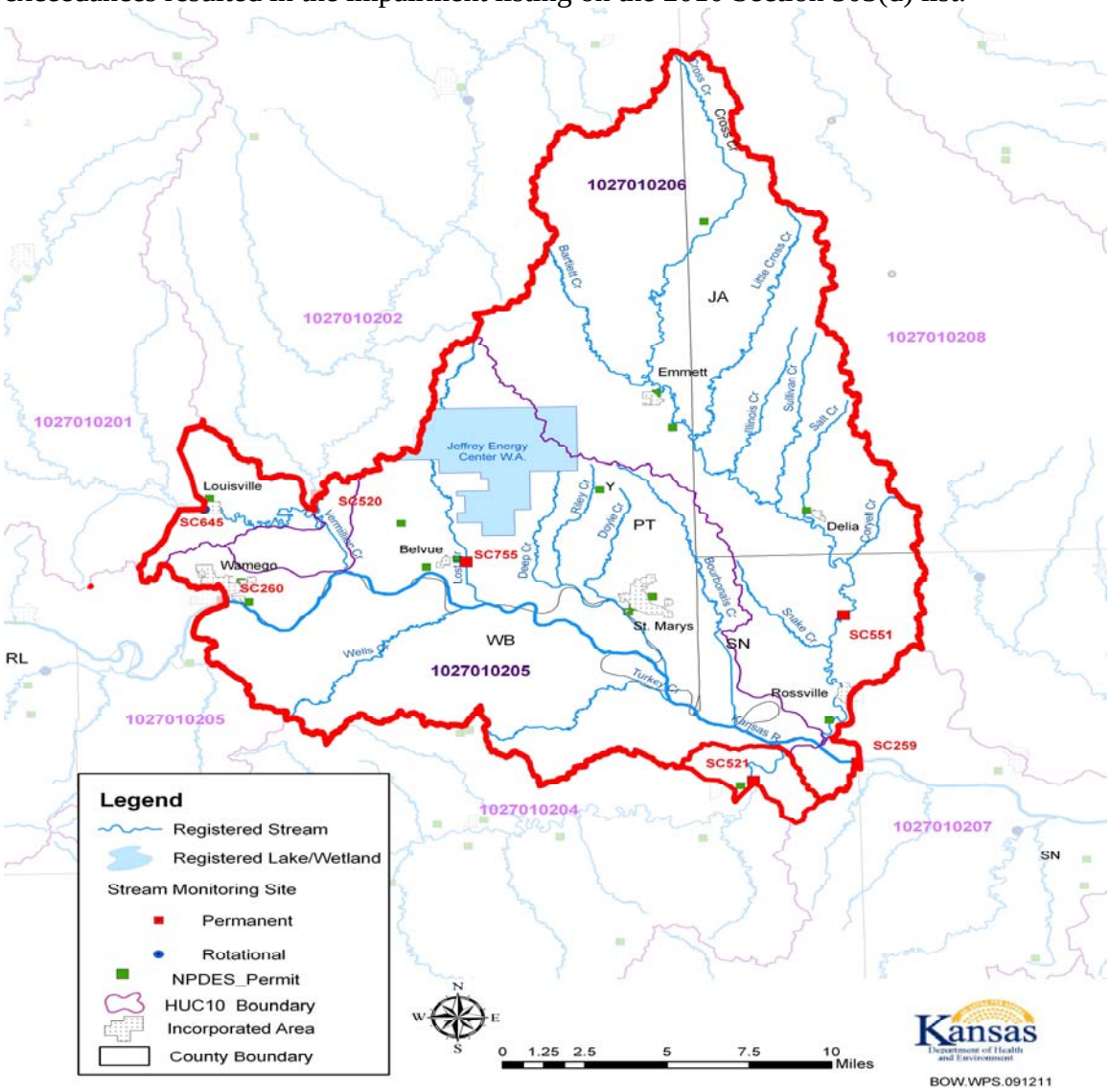


Figure 1. **Middle Kansas River and Cross Creek watersheds, including lower portions of Mill, Vermillion and Rock Creeks drainages and KDHE monitoring stations and NPDES Facilities. TMDL pertains to watershed defined by confluence of Kansas River with Vermillion Creek to Station SC259 on Kansas River, including Cross Creek, but excluding Mill Creek drainages**

Hydrology: The USGS has maintained gaging stations on the Kansas River at Wamego (06887500) since 1919; at Belvue (06888350) since 1982; and at Topeka (06889000) since 1917. Gaging stations have also operated on Vermillion Creek north of Wamego (06888000) at varying times since 1936 (1936 – 1946; 1954 – 1972; and February 2002 to present) and Mill Creek in Wabaunsee County (06888500) since 1953. **Figure 2** displays the flow duration curves for the three gaging stations on the Middle Kansas River over 1990 – 2011. The gain in drainage area between Wamego and Topeka (1440 sq.mi.) does not result in substantial gain in flow from the overall context of total streamflow coming down the river. **Table 1** displays the general flow conditions estimated at locations on the Kansas River and its tributaries between the confluence with Vermillion Creek and Willard. The two significant tributaries are Mill Creek and Vermillion Creek, with some contribution from Cross Creek.

Table 2 shows the tributary contributions to Cross Creek in Shawnee, Jackson and Pottawatomie Counties. The most significant gains in flow come from Bartlett and Little Cross Creeks. The remaining tributaries are small drainages that do not contribute much flow and the drainage is not very efficient in running off rainfall. The gain in drainage area from headwaters to mouth is 390%, but the gain in average flow is only 360%.

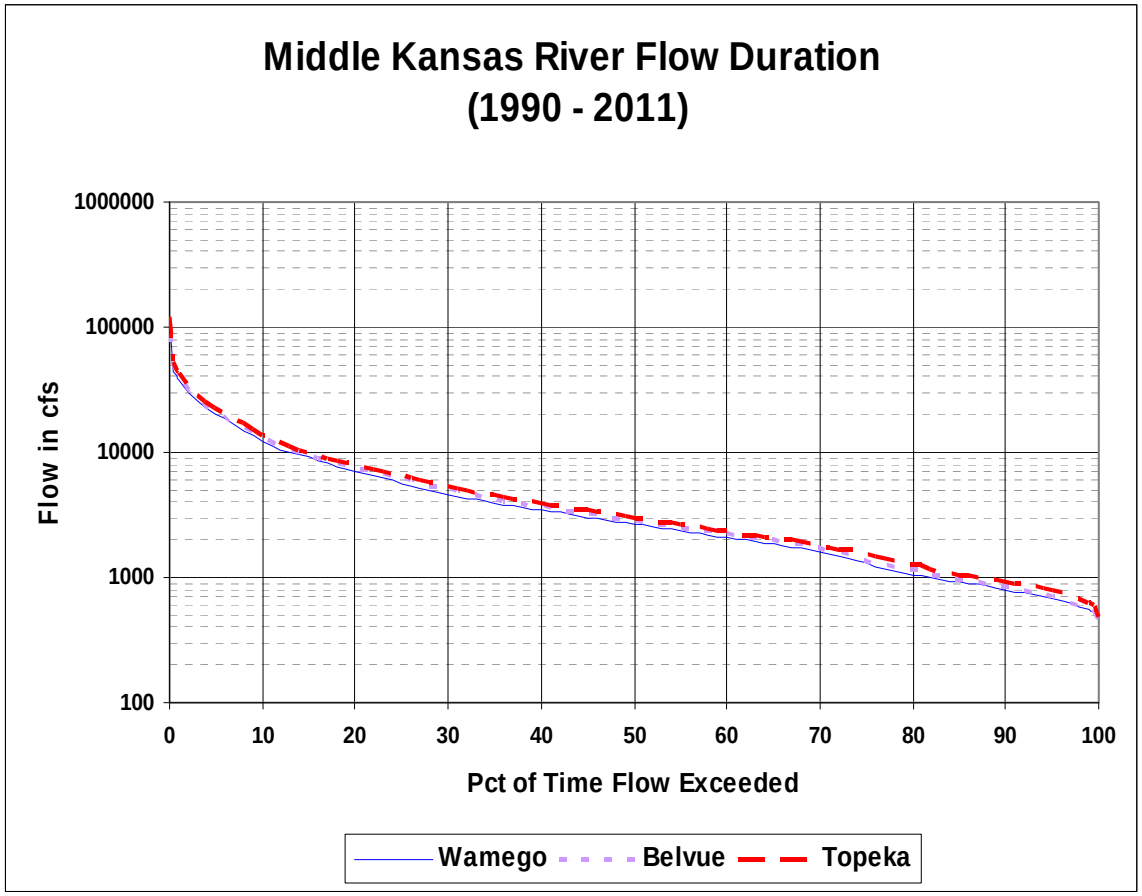


Figure 2. Flow Duration Curves for the Middle Kansas River

Table 1. **Long Term Estimated Flows on Kansas River and Tributaries between Wamego and Willard (adapted from Perry, et al. 2004).**

Location	Drainage Area	Mean Flow	90%	50%	10%	2-yr Peak
Kansas River below Wamego	53,900 sq.mi	5650 cfs	846 cfs	2700 cfs	13,600 cfs	28,600 cfs
Vermillion Creek	551 sq.mi	235 cfs	3.4 cfs	51 cfs	423 cfs	8560 cfs
Wells Creek	20 sq.mi	12.4 cfs	0.0 cfs	1.9 cfs	16 cfs	1570 cfs
Lost Creek	29 sq.mi	20 cfs	0.0 cfs	4.2 cfs	29 cfs	2010 cfs
Kansas River near Belvue	54,500 sq.mi	7180 cfs	960 cfs	3480 cfs	18,700 cfs	33,380 cfs
Doyle Creek	37 sq.mi	25 cfs	0.0 cfs	5.8 cfs	38 cfs	2980 cfs
Turkey Creek	26 sq.mi	17 cfs	0.0 cfs	2.9 cfs	22 cfs	1880 cfs
Bourbonais Creek	23 sq.mi	17 cfs	0.0 cfs	4.3 cfs	25 cfs	1800 cfs
Kansas River above Mill Creek	54,600 sq.mi	7100 cfs	960 cfs	3430 cfs	18,400 cfs	34,100 cfs
Mill Creek	400 sq.mi	241 cfs	5.5 cfs	65 cfs	426 cfs	10,700 cfs
Cross Creek	179 sq.mi	105 cfs	0.2 cfs	16 cfs	159 cfs	6000 cfs
Kansas River at Willard	55,200 sq.mi	6550 cfs	970 cfs	3100 cfs	16,300 cfs	36,000 cfs

Figure 3 shows the average daily flow occurring on the Middle Kansas River between Wamego and Topeka, as well as flows on Vermillion and Mill Creeks. It is apparent that the majority of flow on the Middle Kansas is generated from contributions upstream of Wamego, chiefly releases from Milford and Tuttle Creek Reservoirs. Because of the trapping nature of the reservoirs, when their releases comprise a majority of the flow seen in the Middle Kansas River, bacteria levels tend to remain low. Mill Creek contributes more flow than Vermillion Creek and has lower bacteria levels (moved from Category 4A to Category 2 on the 2010 Section 303(d) list). There is such little relative gain in flow from minor tributaries and the alluvium between the Belvue and Topeka gages, flows on the Kansas River at Willard can be represented as the sum of the daily flows recorded at Belvue and the gage on Mill Creek near Paxico, likely without significant error.

Table 2. Long Term Estimated Flows on Cross Creek and Tributaries (adapted from Perry, et al 2004).

Location	Drainage Area	Mean Flow	90%	50%	10%	2-yr Peak
Cross Creek Headwaters	46 sq.mi	29 cfs	0.0 cfs	3.3 cfs	38 cfs	4240 cfs
Bartlett Creek	25 sq.mi	17 cfs	0.0 cfs	2.1 cfs	22 cfs	1900 cfs
Little Cross Creek	23 sq.mi	15 cfs	0.0 cfs	1.8 cfs	19 cfs	1810 cfs
Illinois Creek	7.6 sq.mi	5.1 cfs	0.0 cfs	0.4 cfs	5.7 cfs	950 cfs
Sullivan Creek	10 sq.mi	7.2 cfs	0.0 cfs	0.9 cfs	8.8 cfs	1130 cfs
Salt Creek	10 sq.mi	7.2 cfs	0.0 cfs	0.8 cfs	8.8 cfs	1130 cfs
Cross Creek @ JA-SN County line	139 sq.mi	81 cfs	0.0 cfs	11 cfs	117 cfs	6180 cfs
Coryell Creek	7.9 sq.mi	5.8 cfs	0.0 cfs	0.6 cfs	6.9 cfs	990 cfs
Snake Creek	10 sq.mi	7.6 cfs	0.0 cfs	1.6 cfs	10.4 cfs	1130 cfs
Cross Creek at Kansas River	179 sq.mi	105 cfs	0.2 cfs	16 cfs	159 cfs	6000 cfs

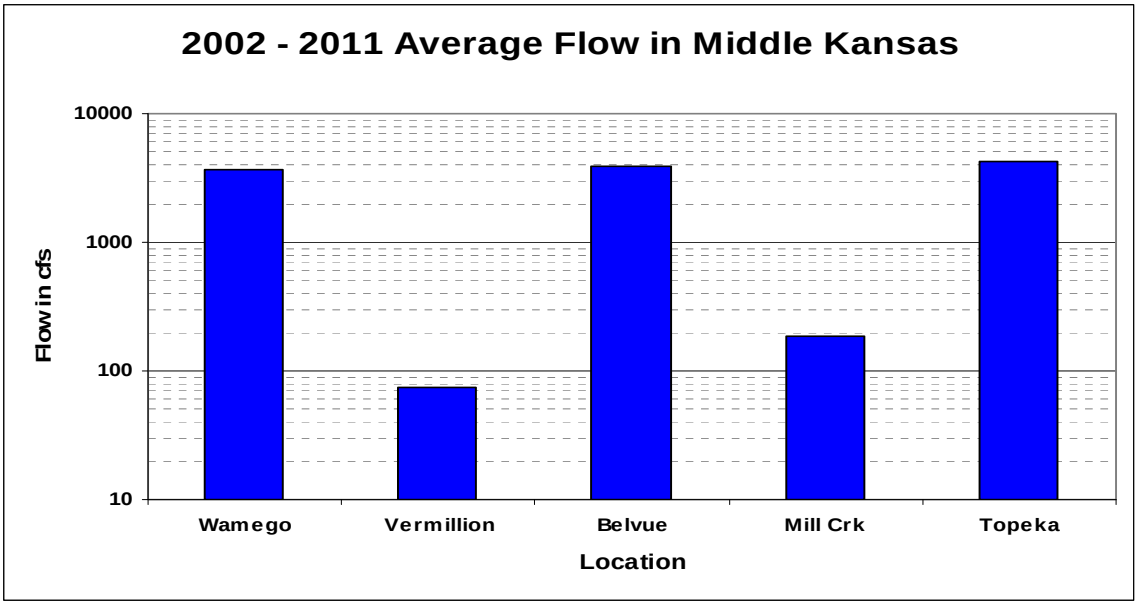


Figure 3. Average Flow on Middle Kansas River during ECB Sampling

Using those combined flows, the monthly distribution of streamflow is almost symmetrical around the peak flow month of June **(Figure 4).** Following the baseflow period of the secondary contact recreation season of November through February, a build up of flow begins in March and continues into the beginning of the primary recreation season during April through June. Following the peak flows, flows recede through the remainder of the summer and fall. Sampling for E coli bacteria has spanned the majority of flow conditions seen at Willard (**Figure 5**). Samples have been concentrated more during the lower flows over the past ten years. Daily flows at Willard over 2002 – 2011 reflect the drought conditions that dominated the sub-basin up through 2006. From 2007 – 2011, flow conditions increased notably. During this period, intensive sampling in 2008 provided evidence of impairment by E coli bacteria. **Figure 7** indicates higher bacteria levels tend to correspond to higher flow conditions seen on the Kansas River. Flows used in **Figure 7** were averaged over the day prior to, the day of and the day after intensive samplings over 2004 – 2008. Although there is scatter, the highest bacteria levels occur during flows ranging from 2000 – 10,000 cfs. There is some drop-off in bacteria levels when flows exceed 10,000 cfs, likely because of the predominance of relatively bacteria-free reservoir releases comprising those flows during flood management operations by the Kansas City Corps of Engineers**.**

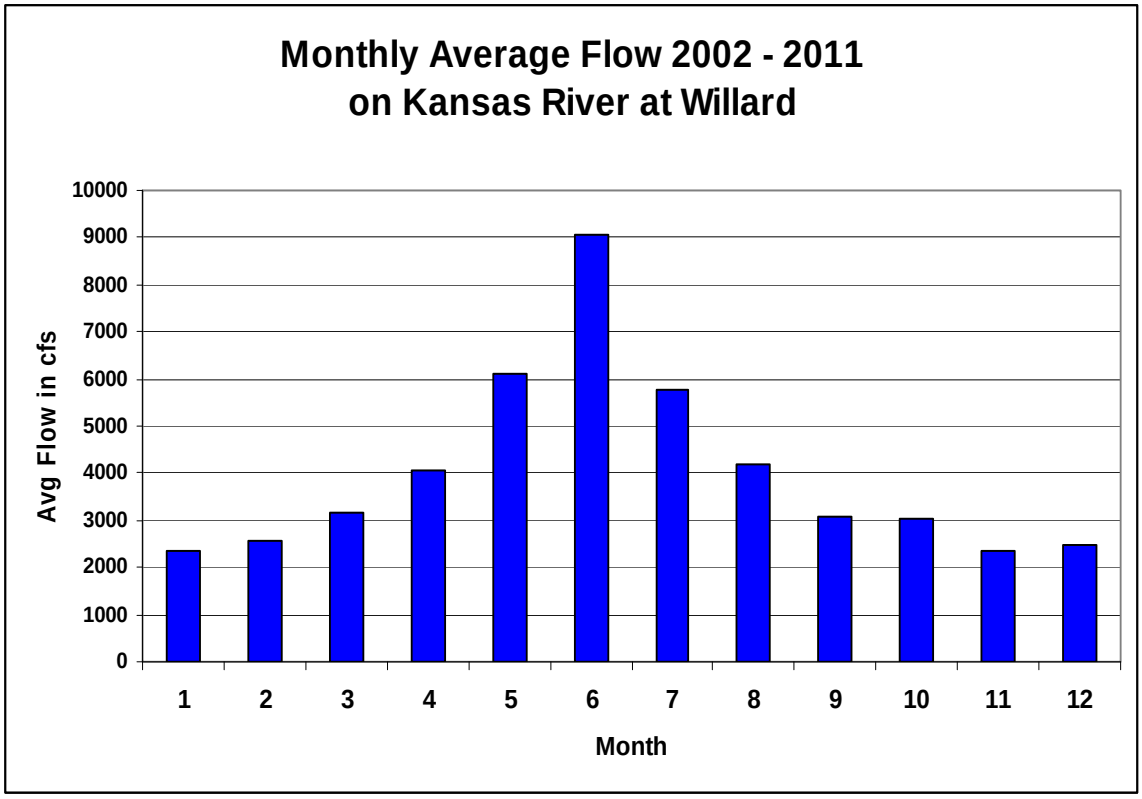


Figure 4. Monthly Average Flow on the Kansas River at Willard, 2002 – 2011

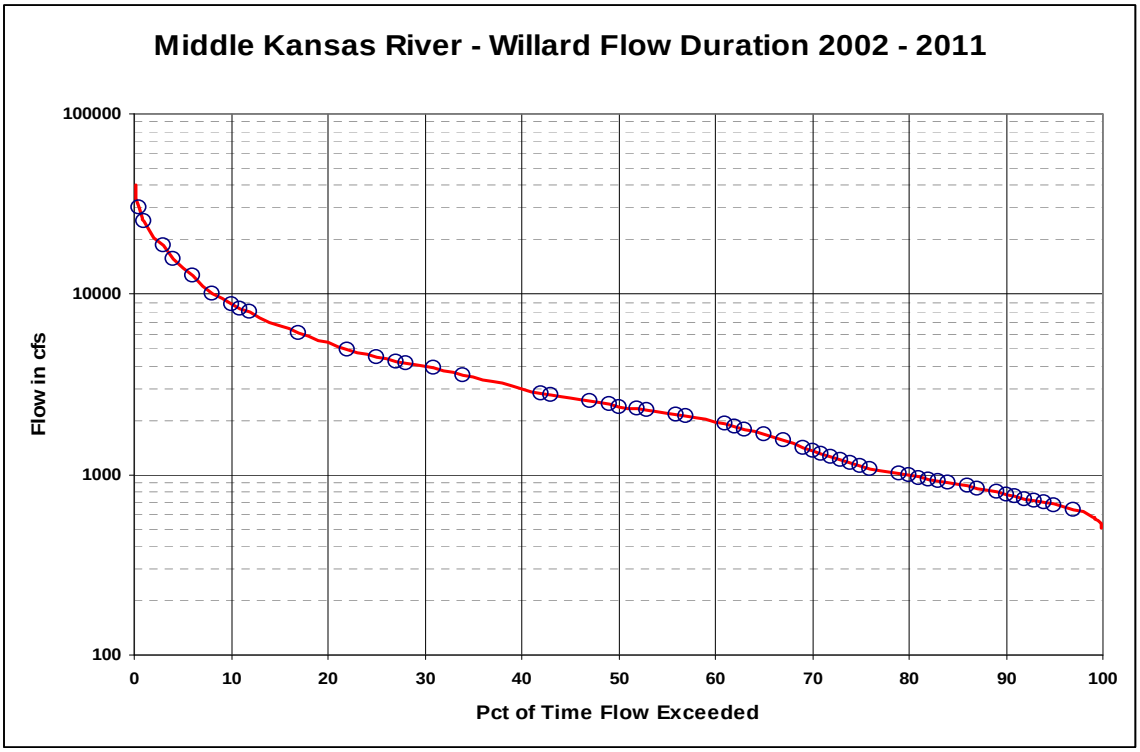


Figure 5. Flow Conditions during ECB Sampling on the Kansas River at Willard over 2002 – 2011.

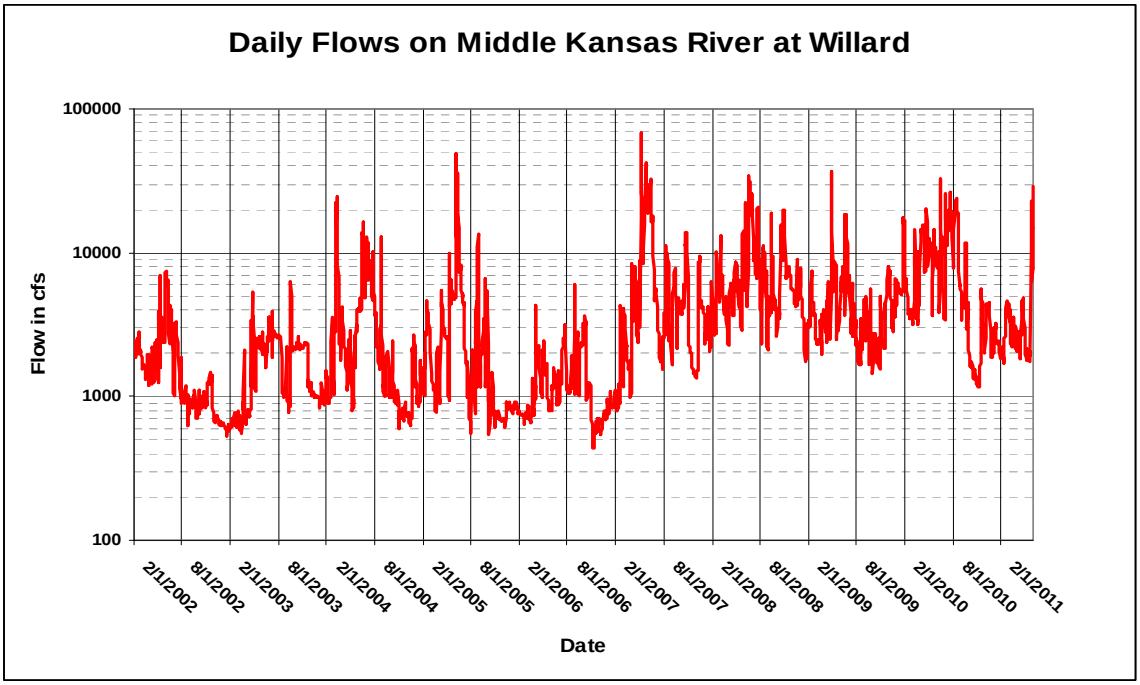


Figure 6. Daily Flows on Kansas River at Willard over 2002 - 2011

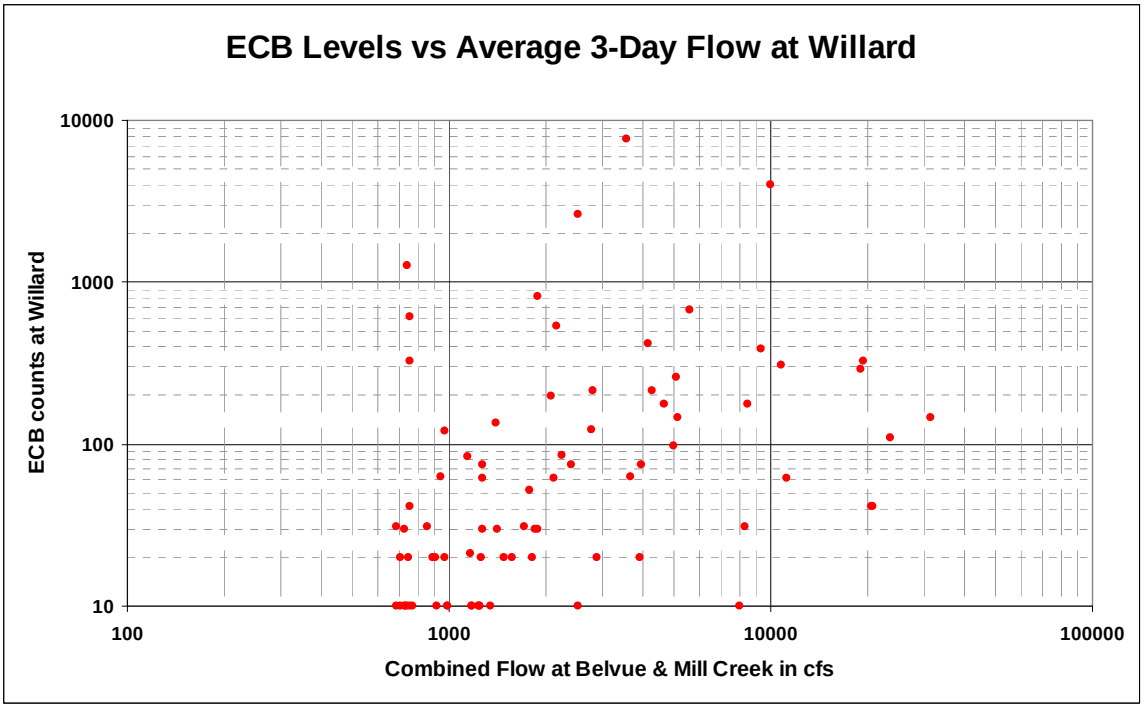


Figure 7. E coli Bacteria Levels at Average Flow Conditions on Kansas River at Willard.

Bacteria Concentrations: Fecal coliform bacteria (FCB) have been sampled on the Kansas River at Wamego and Willard since 1973 through June 2003 (**Figure 8**). Fecal coliform bacteria was sampled on Cross Creek over 1990 – 2003 (**Figure 9**). Geometric means of overall FCB data was 319 on the Kansas River at Wamego, 208 at Willard and 141 on Cross Creek. Those values rose to 467, 328 and 349, respectively, when using the data from the primary recreation season months.

Routine collection of ECB samples on the Kansas River and Cross Creek since mid-2003 resulted in overall geometric means of 54 colony forming units (CFUs)/100 ml at Wamego, 75 CFUs/100ml at Willard and 104 CFUs/100ml on Cross Creek. During primary recreation season (April – October), the ECB geometric means for the primary recreation season increased to 89 CFUs/100 ml at Wamego, 105 at Willard and 161 on Cross Creek. For the remainder of this TMDL, the term "counts" will represent CFUs/100 ml as expressed in the water quality standards or Most Probable Number (MPN)/100 ml, the measured parameter for ECB.

While there is considerable spread in bacteria values, there is little distinction among the distributions of E coli at the two stations on the Kansas River and the one on Cross Creek **(Figure 10**). For both overall data and data broken out of the primary recreation (April – October) season, there are no significant differences among the stations, particularly between Wamego and Willard. From the overall routine data, only 4 instances of sample counts exceeding the nominal value of the E coli bacteria criterion (262 counts) has been seen at Willard (**Figure 11**).

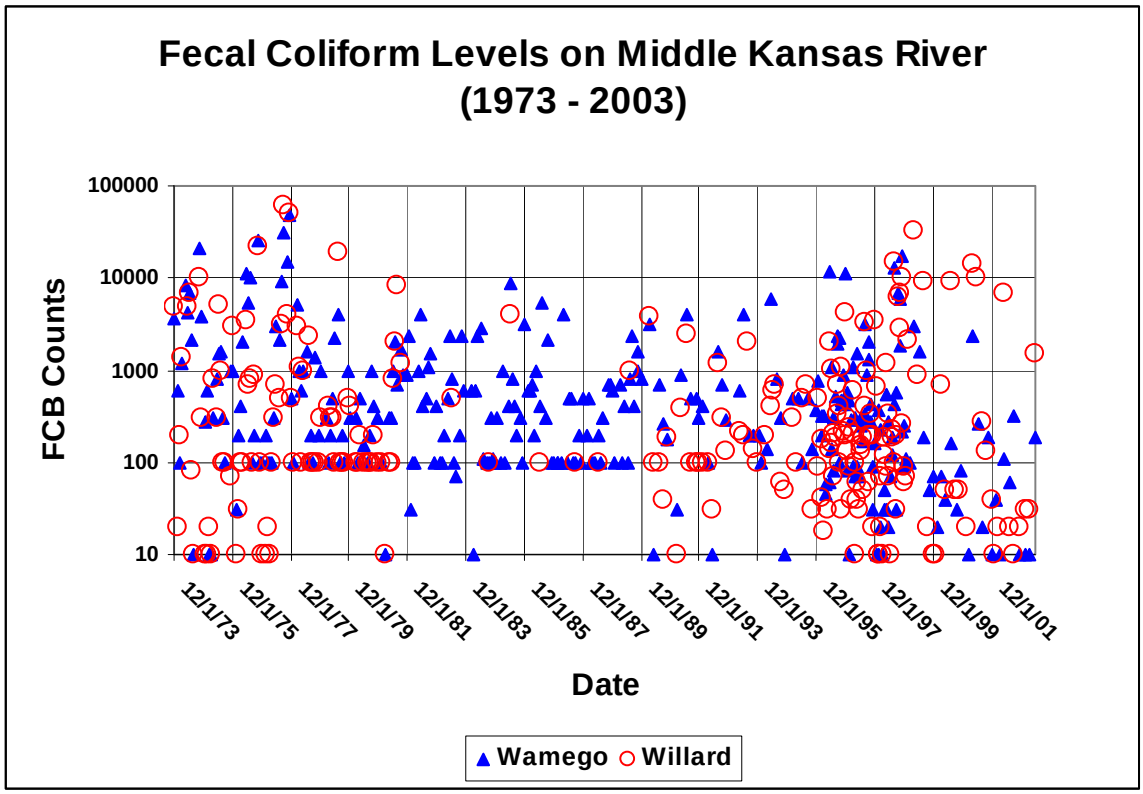


Figure 8. Fecal Coliform Bacteria on Middle Kansas River over 1973 - 2003

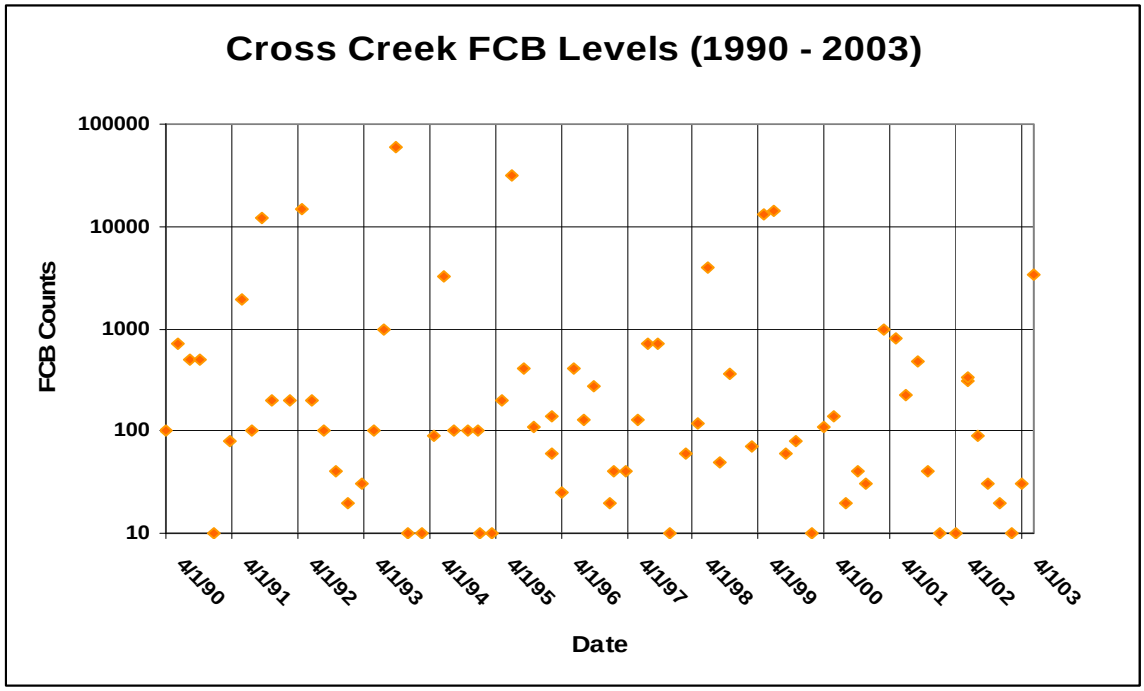


Figure 9. Fecal Coliform Bacteria on Cross Creek over 1990 - 2003

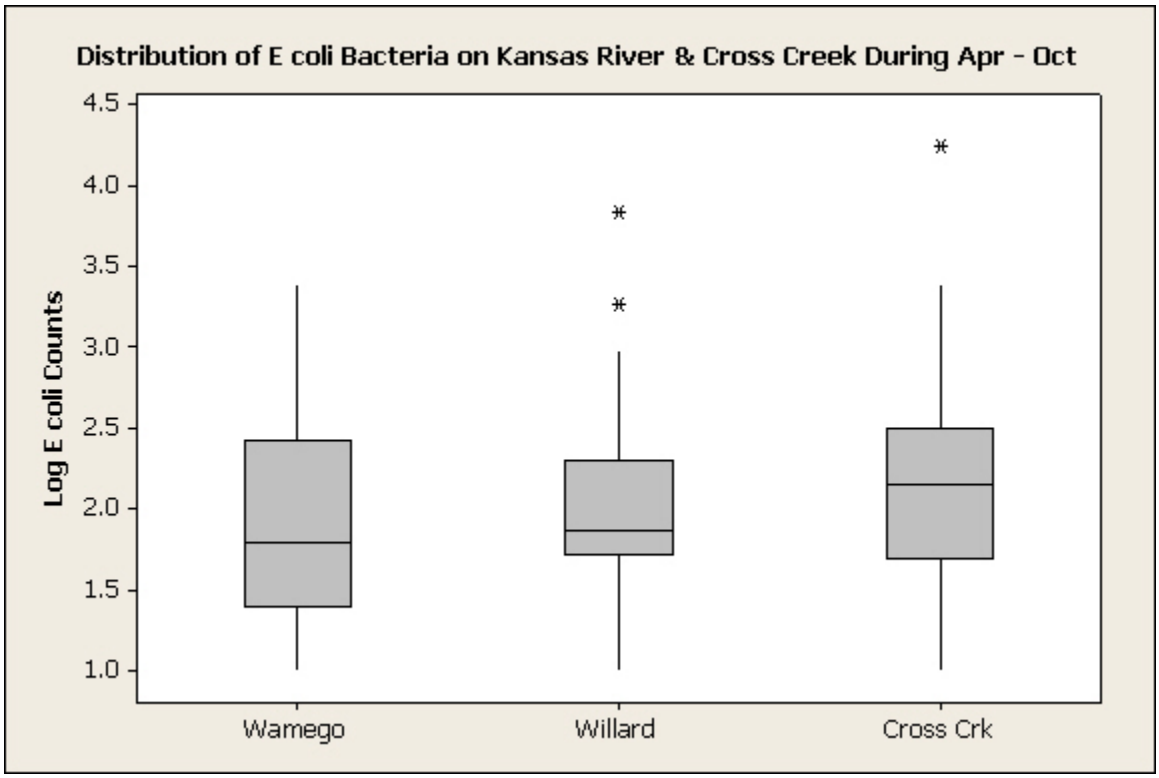


Figure 10. Distribution of ECB on Middle Kansas River & Cross Creek Over 2003 - 2011

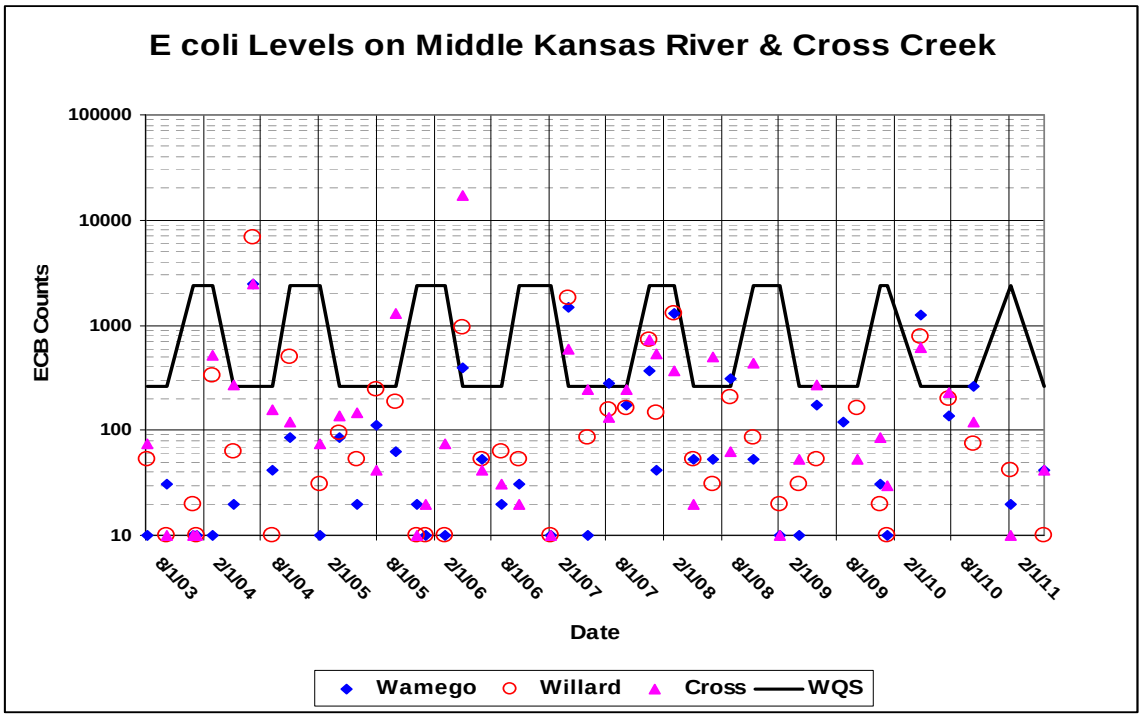


Figure 11. Routine E coli Bacteria Counts on Kansas River & Cross Creek Since 2003

In all four cases, high bacteria occurred at Wamego as well, but for three of the four high bacteria samples at Willard, the bacteria counts increased from that seen at Wamego, implicating tributary contributions (**Figure 12**). During those four events, high bacteria levels were also noted on Vermillion and Rock Creeks, high enough to elevate the downstream levels at Willard (**Figure 13**). Once, in 2006, contributions from Cross Creek may have been sufficiently high to elevate bacteria levels seen on the Kansas River at Willard.

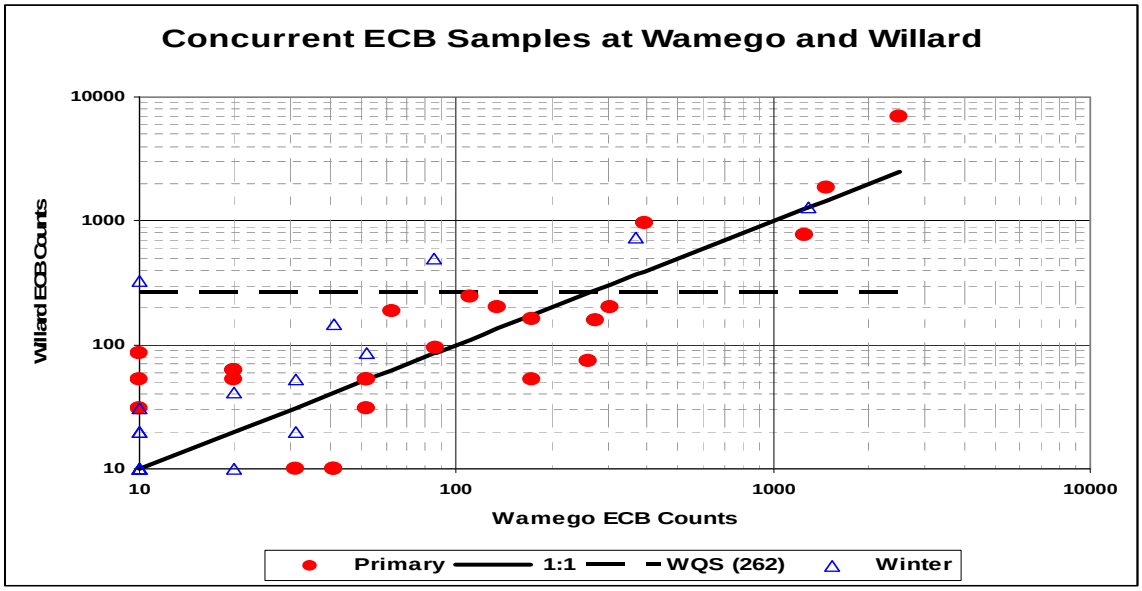


Figure 12. Concurrent ECB Samples during Routine Monitoring at Wamego & Willard

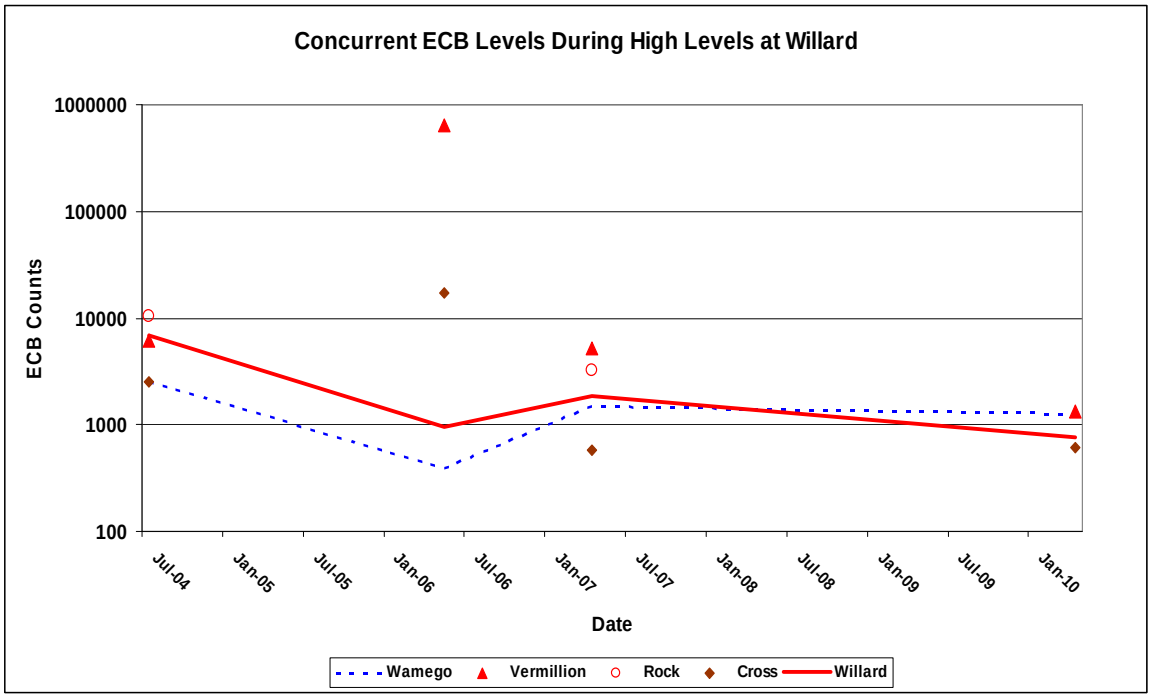


Figure 13. Concurrent Bacteria Levels during High Levels Seen at Willard

More intensive sampling (five times within 30 days) was conducted on the Kansas River at Wamego and at Willard in 2004, 2005, 2006 and 2008. Intensive sampling also occurred on the major tributaries to the Middle Kansas River in 2008. Individual samples typically were greater at Willard than at Wamego (**Figure 14**). These increases can also be seen in off-season winter months (open blue circles). The number of samples digressing from the 262 criterion value is far greater at Willard (11, with 3 more in winter) than Wamego (6).

In 2008, the geometric means over April and June were low to moderate at Wamego, Willard and the tributaries (**Figure 15**). E coli bacteria elevated substantially on Rock, Vermillion and Mill Creeks, which may be responsible for the elevated counts seen at Willard. Sampling in October saw bacteria levels moderate again except on Cross Creek which may have been enough to boost bacteria concentrations at Willard over the criterion. Even though flow conditions on the day of sampling was often stable between Wamego and Willard, some of the higher values came in the aftermath of some substantial tributary gain in flow below Wamego (**Figure 16**). Average monthly flows from Mill Creek and Vermillion Creek during this time were August: 90 and 17 cfs, respectively; September: 261 and 29 cfs; and October: 69 and 24 cfs. While Mill Creek contributed flow, the bacteria levels coming out of that watershed, while elevated above those of the Kansas River at Wamego, were not sufficient to generate the high levels seen at Willard (**Figure 17**).

On the other hand, Vermillion Creek, while having modest flows, did have very large bacteria levels that may have influenced the Willard conditions. It may be possible that the modest "loads" contributed by Vermillion Creek were "distributed" by the larger flows coming out of Mill Creek and arriving at Willard. Conditions in October were less onerous, but Cross Creek, with some assist from the other three monitored streams, looked to generate enough impact to cause Willard to elevate over criterion levels. **Table 3** displays the geometric means of E coli for the Middle Kansas stations in 2008.

Although correlations between the Kansas River station ECB counts and those of the tributaries were significant but not overwhelmingly strong (0.655 – 0.765), that likely reflects that high bacteria occurring on the river usually coincides with high tributary bacteria, but the converse was not always true. Dominance by reservoir releases could dampen tributary impact on river bacteria levels.

One way to look at the pattern of E coli presence along the Kansas River and Cross Creek is to plot the respective ECB index profiles for those stations **(Figures 18 and 19).** The index is computed for the samples taken during the primary (April – October) period as the natural log of each sample's bacteria count, divided by the natural log of the applicable criterion, in this case, 262 counts for the Kansas River and 427 counts for Cross Creek. The resulting values normalize each bacteria sample to the criterion and profiles can be derived by the cumulative frequency distribution of those index values.

Table 3. 2008 Geometric Means for Middle Kansas River Stations

Month	Wamego (B)	Rock Creek (C)	Vermillion Creek (C)	Mill Creek (C)	Cross Creek (C)	Willard (B)	Primary B Criterion	Primary C Criterion
April	107	34	14	41	31	91	262	427
June	38	239	374	210	376	69	262	427
August	179	**524**	**7454**	**339**	78	**818**	262	427
October	215	226	155	154	**536**	**283**	262	427

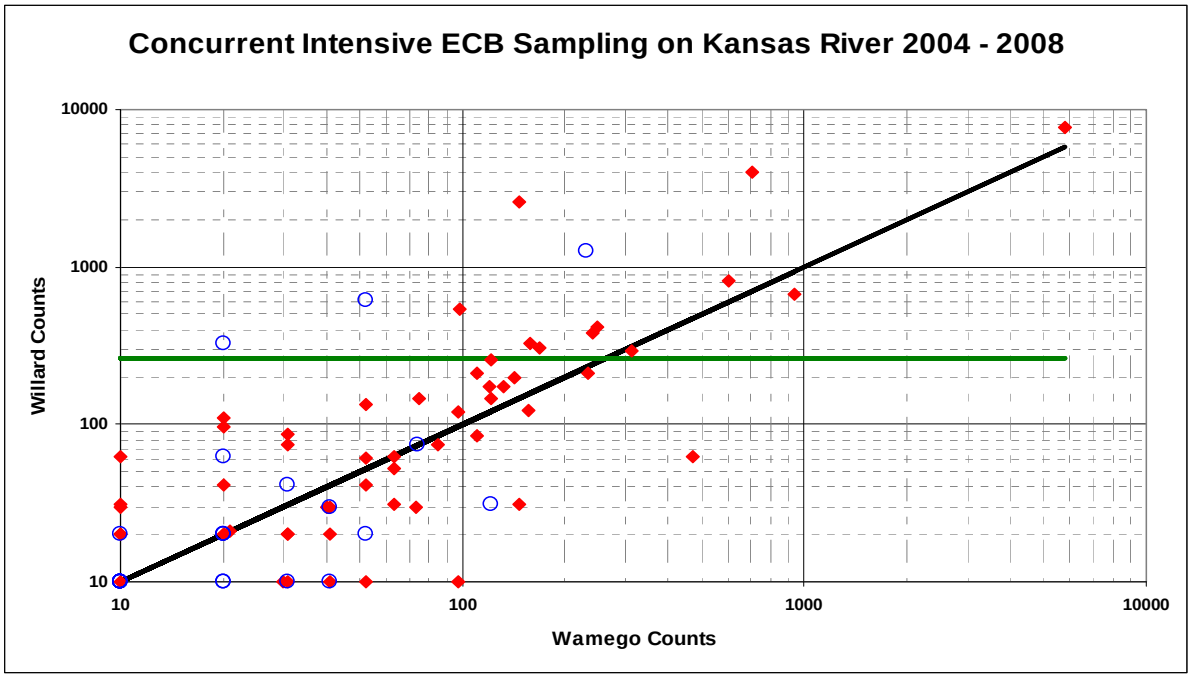


Figure 14. Concurrent Intensive ECB Sampling at Wamego and Willard

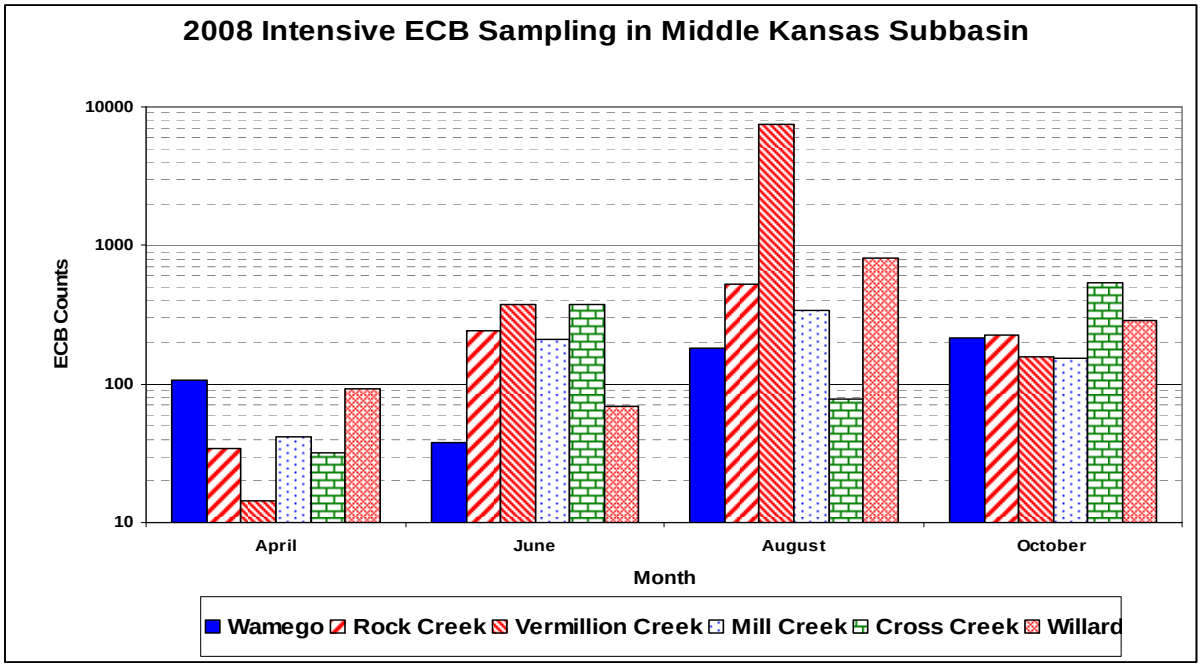


Figure 15. 2008 E coli Bacteria Geometric Means for Middle Kansas Stations

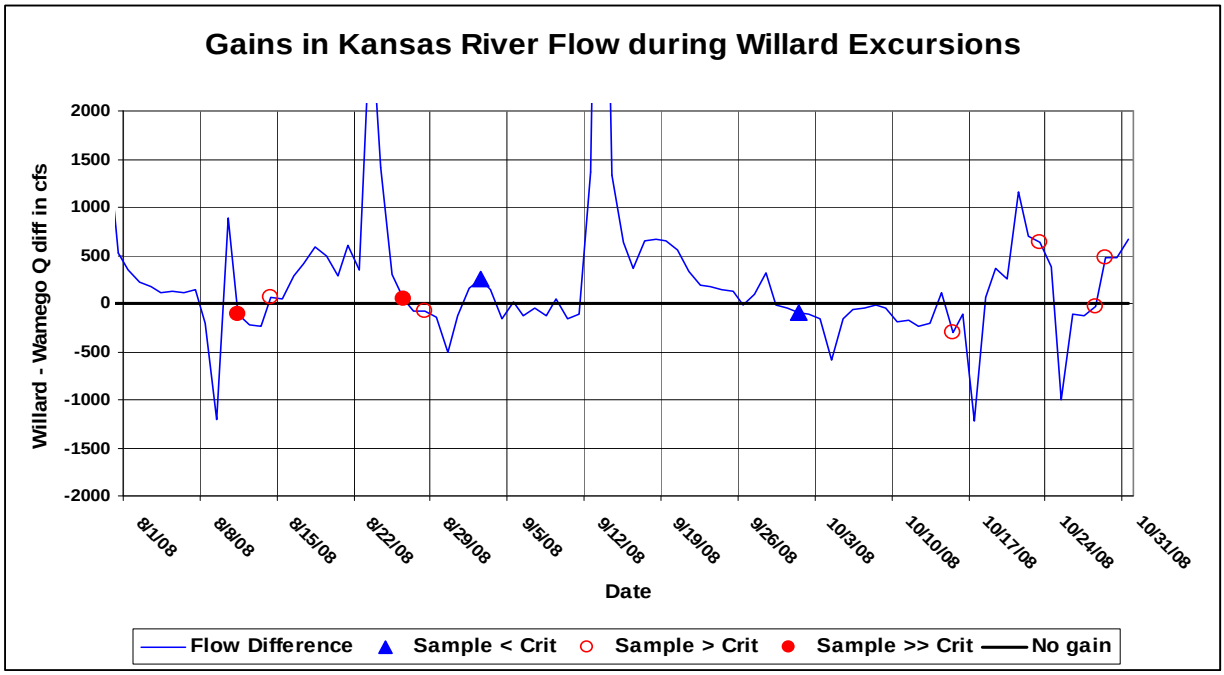


Figure 16. Gains in Flow on Kansas River between Wamego and Willard during High Bacteria Samples at Willard

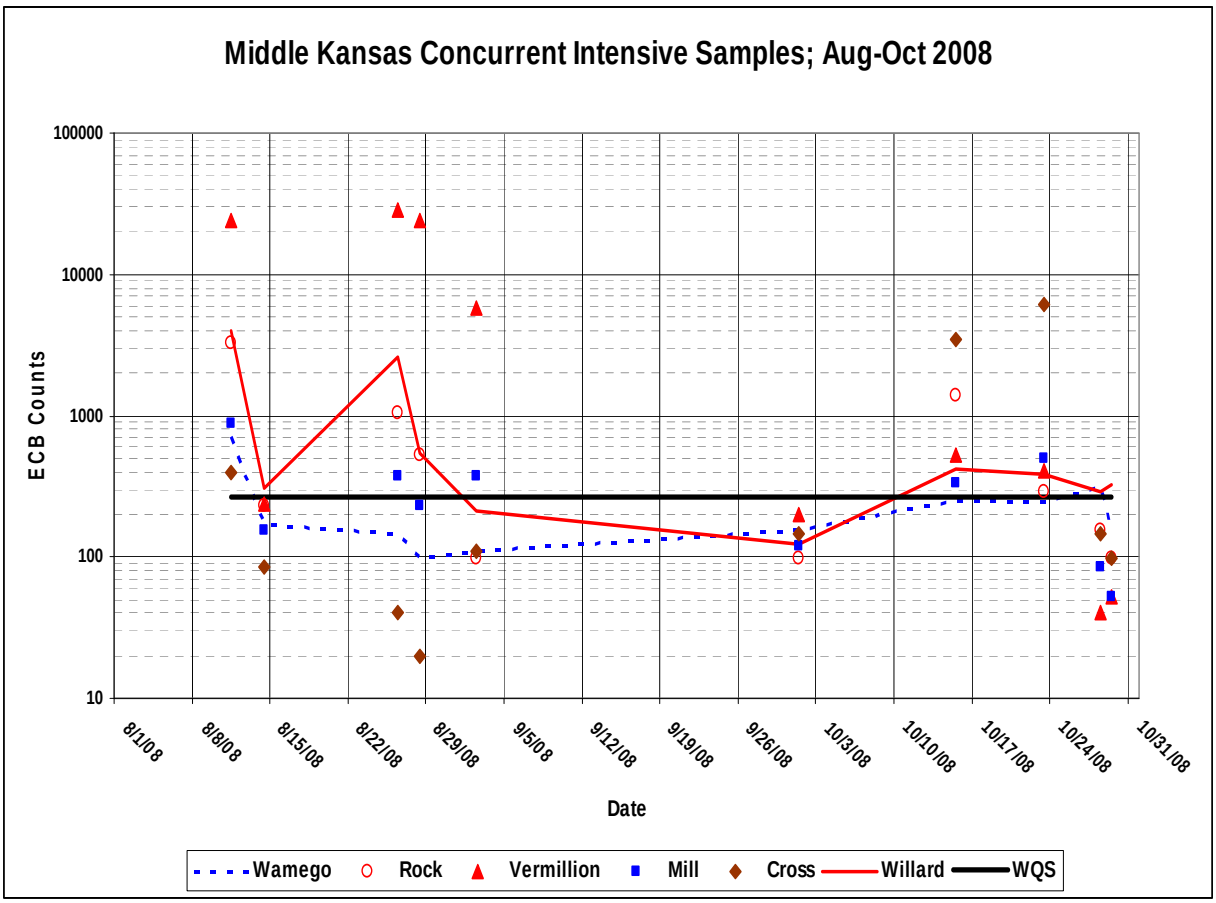


Figure 17. Individual ECB Samples for Middle Kansas Stations in Late Summer-Fall 2008

Along the river, the samples taken at Wamego are largely (85%) under the nominal criterion value (**Figure 18**). Ideally, 90% of the samples should be less than 262 counts. More important, the profile for Willard shows a tendency for higher bacteria levels more often. As an interim step toward managing the bacteria in the watershed, control measures should lower future bacteria values such that each of the profiles shift to the right and cross the unity line (index = 1: sample = 262) at the 90th percentile. Any ideal profile would be anchored at the 90th percentile value of 1 with the majority of values at or below existing profiles of values below the criterion.

Comparison of Cross Creek to Mill Creek shows the profile for the latter closely emulates the ideal profile with the vast majority of samples at or below the criterion, in this case, 427 counts (**Figure 19**). The Cross Creek profile indicates the stream is not heavily impacted by high bacteria and should not take much intervention to get it in compliance with water quality standards.

The lowering and shifting of the profiles would indicate reductions in the magnitude, duration and frequency of bacteria levels in the stream reaches. The utility of the index profile is to use routine sample data to assess bacteria conditions to indicate when use of the more intensive (five times in 30 days) sampling is warranted to assess compliance with water quality standards. The 90th percentile value is viewed as desirable since it is comparable to typical binomial assessment analysis in developing the biennial 303(d) list.

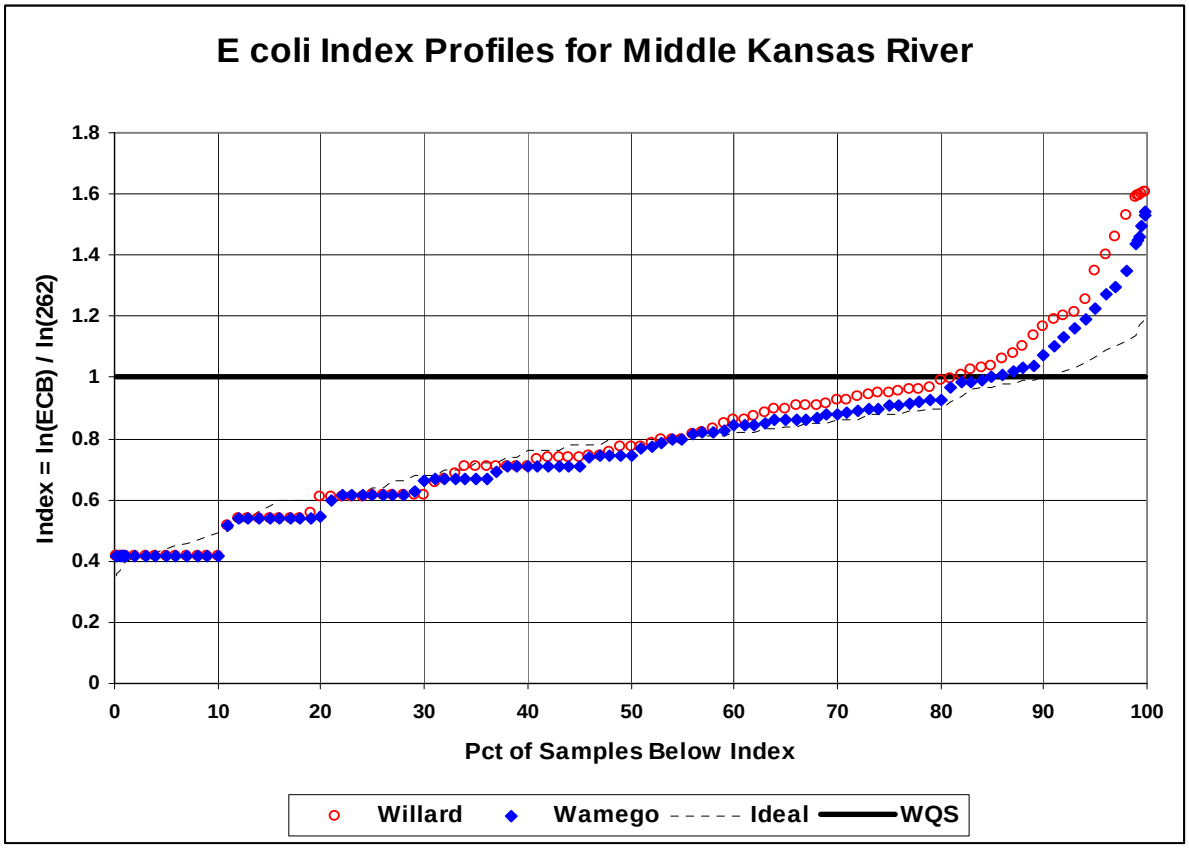


Figure 18. E coli Bacteria Index Profiles for Middle Kansas River at Wamego & Willard

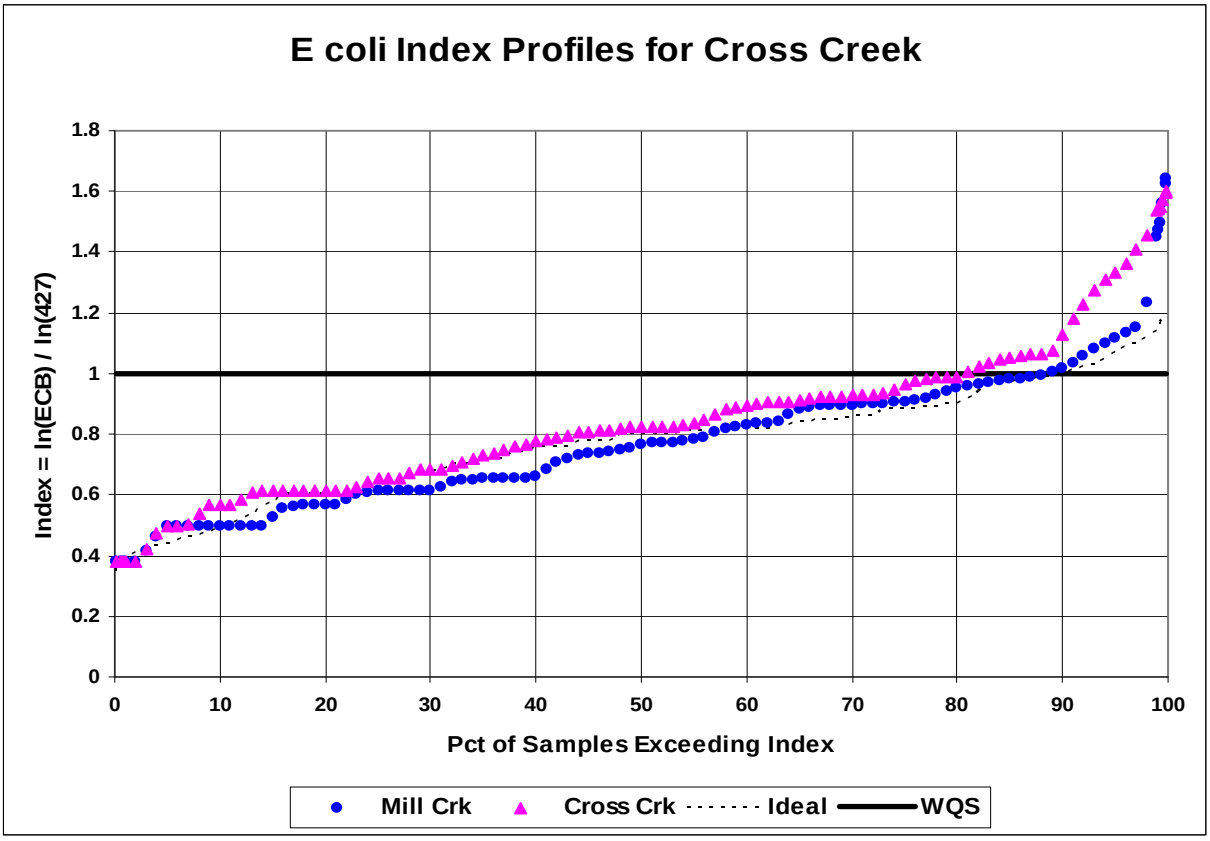


Figure 19. E coli Bacteria Index Profiles for Cross and Mill Creeks in Middle Kansas

Additionally, the Probabilistic Stream Monitoring Program collected samples on Lost Creek, a Primary B recreation tributary in Pottawatomie County in 2008 (upper reach) and 2009 (lower reach). The upper reach did not see any of the four samples taken over March to November exceed 262 counts in 2008. However, the lower reach did see some digressions from the criterion in 2009, exceeding 262 counts in June, August and October. The February sample also was greater than 262, but that was during the off-season when the operative criterion is 2358 counts. The samples taken in April and December were low (< 100 counts). Even with the high bacteria (up to 1785 counts) in the summer, the corresponding bacteria levels at Willard remained below the 262 count value. Thus, tributaries such as Lost Creek may have localized issues with bacteria, but their limited hydrology relative to the Kansas River diminish their effective impact on bacteria levels seen at Willard.

Use Attainability: Use Attainability Analyses were conducted on the Kansas River and the tributaries in the Middle Kansas Subbasin. The stream segments in the watershed are displayed in **Appendix B**. There is ample evidence that the Kansas River currently supports existing primary recreation, notably canoeing, kayaking and floating under normal flow conditions. The tributaries, such as Cross, Doyle, Turkey, Riley, Deep, Sullivan, Bourbonais and Lost Creeks, generally have adequately deep pools connected by shallow runs. Pools typically range 2 – 5 feet in depth, while runs flow at less than one foot depth. With restricted access, these streams are designated as Class C primary.

Following Stiles and Tate (2008), streamflow measurements at the USGS gage at Belvue (06888350) were used to establish a dataset of flow, depth and velocities across a wide range of flow conditions. Regression equations were used to establish hydraulic geometry relations for depth and velocity:

Velocity = 0.242 * Flow^0.262 (R2 = 81%)
Depth = 0.083 * Flow^0.439 (R2 = 86%)

These relations were used to convert the flow duration curve into duration curves for specific depths and velocities. For this TMDL, average depths over one foot are favorable to support primary recreation and average velocities over two feet per second constrain primary recreation because of safety concerns. Additionally, USGS protocols for stream wading suggest if the depth-velocity product (d x v) exceeds the wader's height, nominally, six feet, the stream is not safe to enter (J.Putnum, USGS, pers comm., 2008).

Figures 20 and 21 display the estimated depth and velocity conditions seen over time on the Kansas River at Wamego and Belvue. Even at low flow, pooled areas on the river would be adequate to support primary recreation and have some risk of immersion and intake of the river water. Depths at Belvue increase from those seen in the river at Wamego. The major constraint on in situ primary recreation on the river would be high velocities occurring during periods of high flow. Such conditions begin to develop once flows reach the 35 – 40% exceedance level. Wading during those conditions becomes problematic because of the combination of depth and velocity. As such, wading and swimming are predominant at low to moderate flows, but diminish as flows increase (**Figure 22**). However, the most prevalent recreation use is floating activities on the river and flow conditions are consistently supportive of kayaking once depths are adequate (**Figure 23**).

While no gaging station exists on Cross Creek, it likely has similar hydrology to Vermillion Creek which is gaged. The preceding analysis on the Kansas River has been made on Vermillion Creek as part of that watershed's bacteria TMDL. The implication was that low depths would limit widespread primary recreation during normal and low flow conditions, but as flows increased, there would be a window of optimal recreation support until those flows produced unsafe velocities. Therefore, the applicable potential for in-stream recreation is much narrower for Vermillion Creek than it is for the Kansas River. A similar situation is anticipated for Cross Creek.

The implication for bacteria management is to establish controls on the tributaries to minimize loading into the Kansas River during low to moderate flows when in-stream recreation is optimal. Recreation usage will diminish as flows rise beyond normal seasonal levels, because of safety concerns, but this also coincides with periods when the streamflow is chiefly composed of releases from Milford and Tuttle Creek Lakes, which are low in bacteria. The TMDL is designed to public health from elevated bacteria in the streams at all flow conditions despite the lower probability of enduring such high bacteria during the conditions most likely to be used by the public.

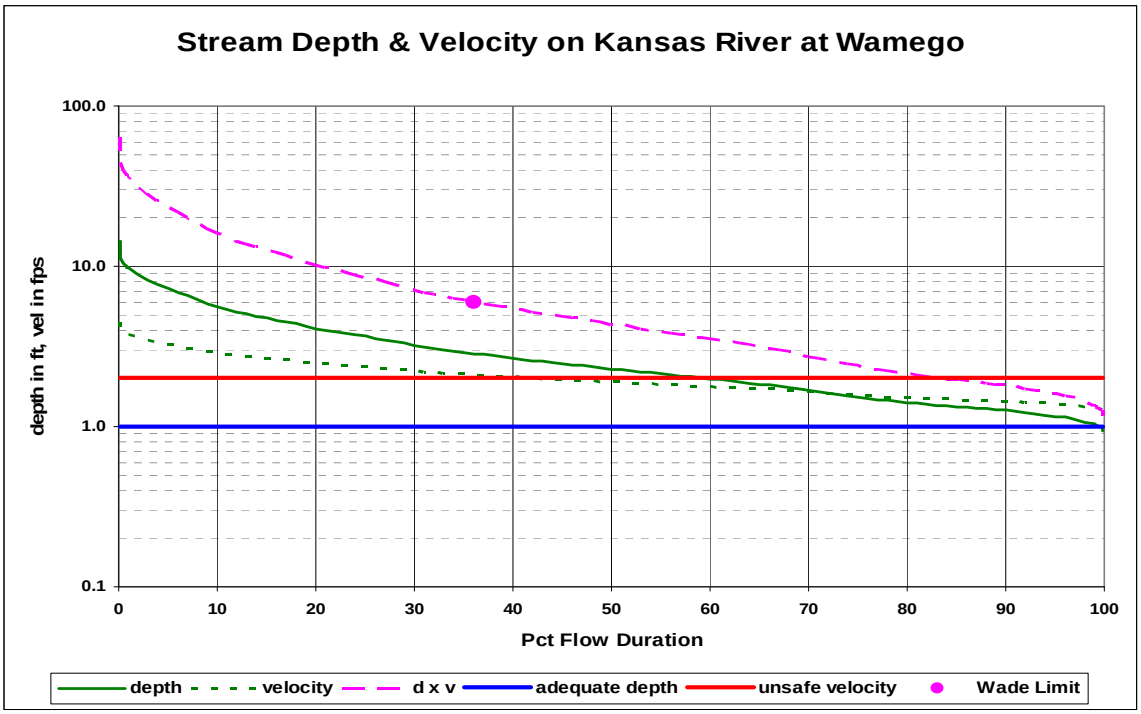


Figure 20. Depth and Velocity Conditions on the Kansas River at Wamego

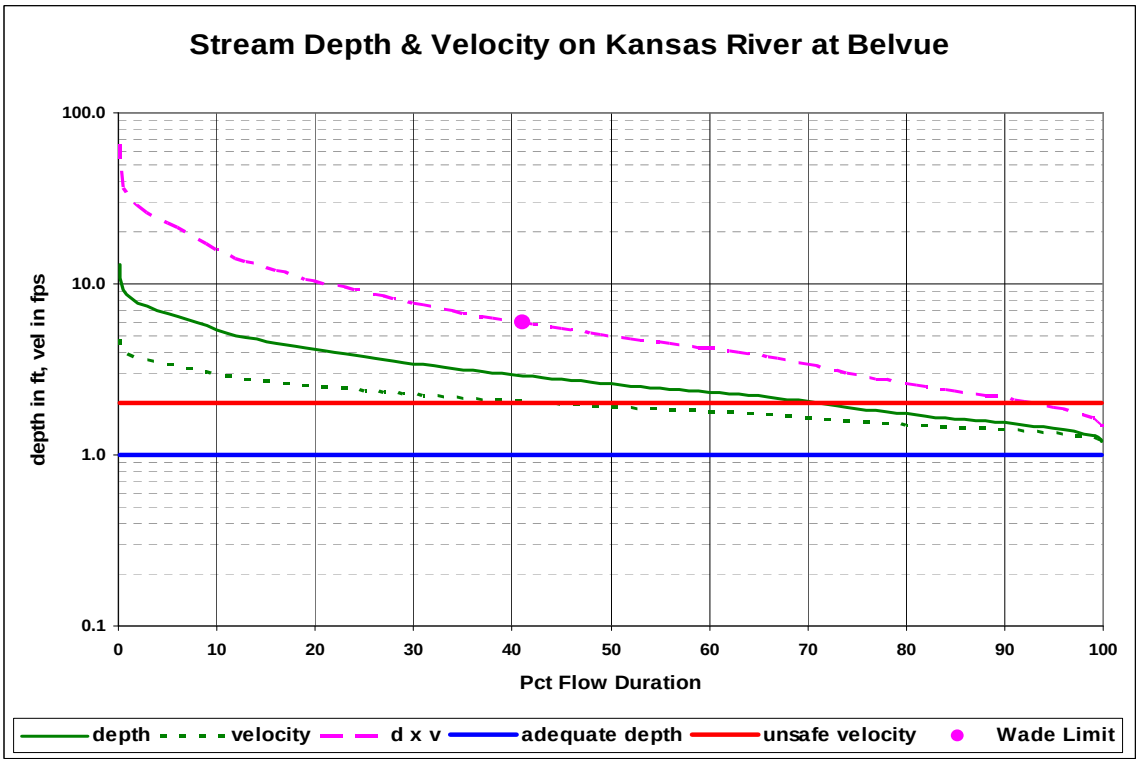


Figure 21. Depth and Velocity Conditions on the Kansas River at Belvue

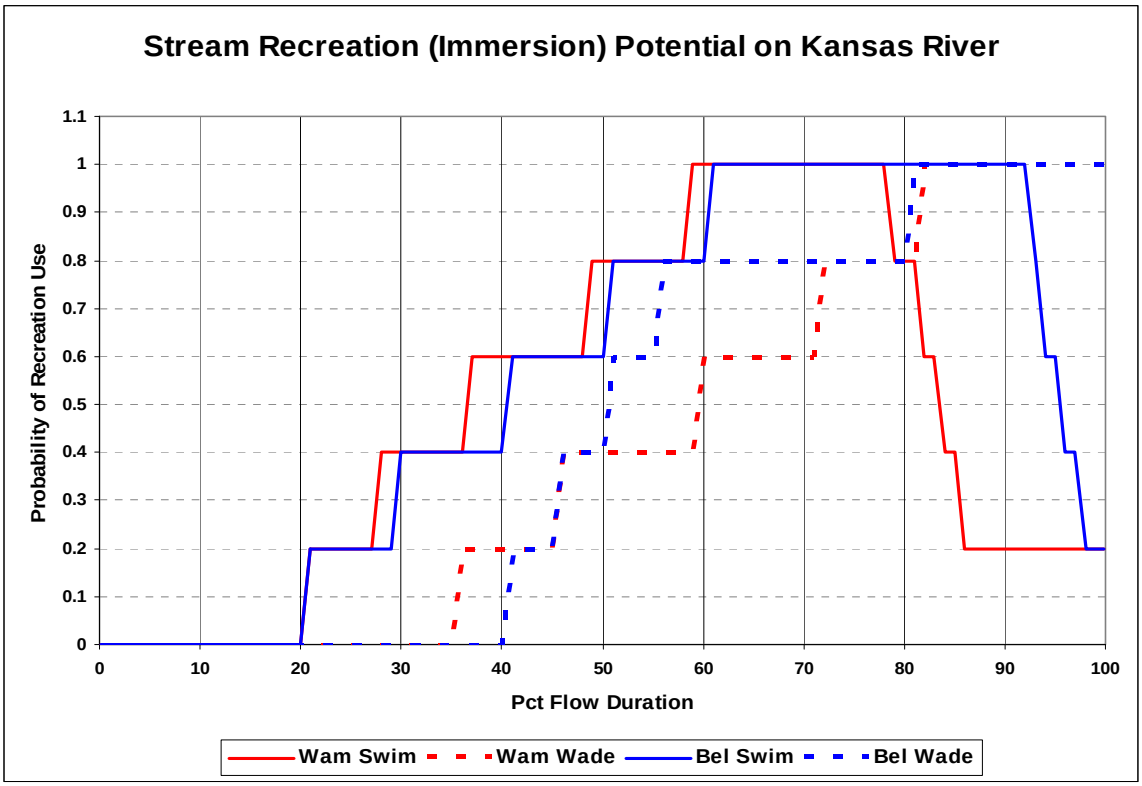


Figure 22. Recreation Potential on Middle Kansas River at Varying Flow Conditions

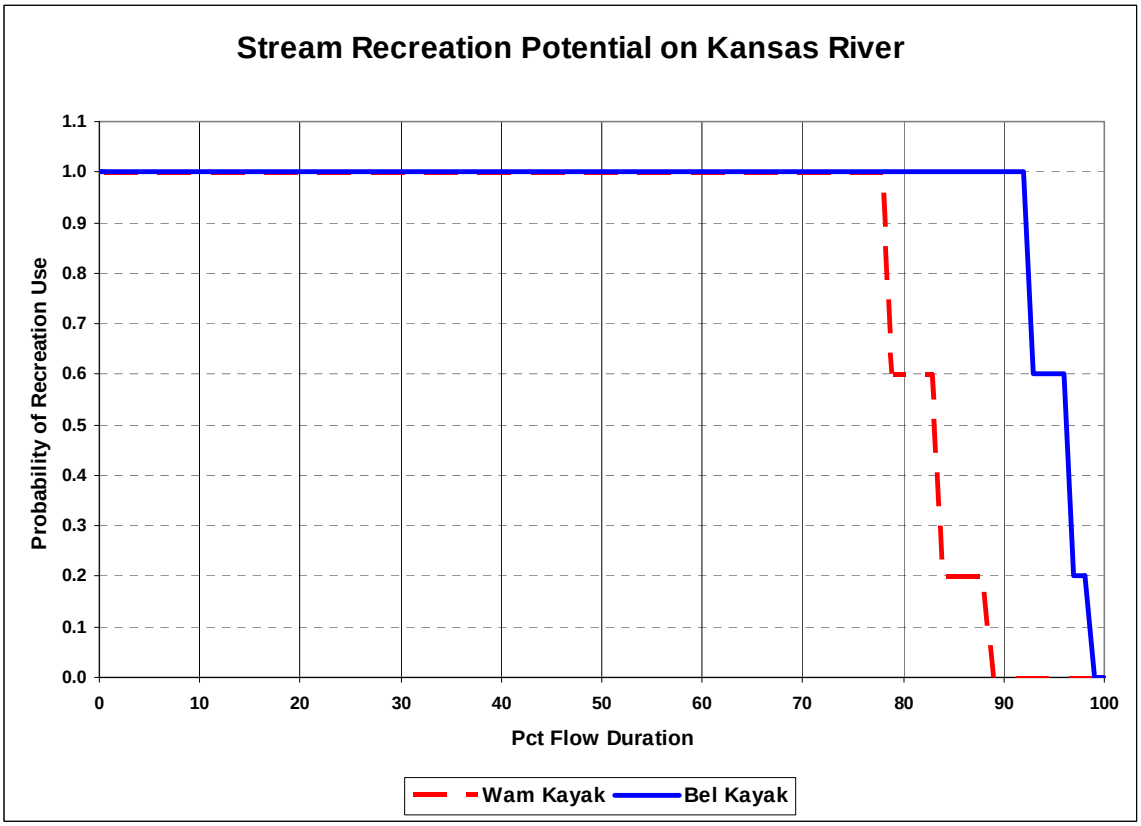


Figure 23. Potential to Support Floating Activities on Middle Kansas River

Desired Endpoint: The ultimate endpoint of this TMDL will be to achieve the Kansas Water Quality Standards and support primary recreation on the Middle Kansas River. This requires geometric means of five samples taken within a 30-day period to be below the applicable criterion of 262 counts during April to October. Reduction in bacteria loading from the tributaries of Cross, Vermillion and Rock Creeks will be conducted with the objective of reducing the ambient bacteria concentrations seen on the main stem of the Kansas River. Such reductions should work toward achieving the primary recreation criteria for the tributary streams. Therefore, a second endpoint of the TMDL is to achieve a geometric mean of 427 counts for the primary recreation season bacteria criterion on Cross Creek.

Achievement of these endpoints indicate any loads of bacteria 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 are seven NPDES permitted wastewater treatment facilities which potentially discharge bacteria to the Kansas River or to streams flowing into the river that are not monitored by KDHE **(Table 4)**. There are an additional four facilities that discharge process water that is bacteria-free. Additionally, two non-discharging facilities that should not influence the bacteria quality of streams in the watershed are located on Mill and Doyle Creeks. Based on their population, small town facilities utilize 3 and 4-cell lagoons to treat their wastewater. Wamego and St. Marys use mechanical plants equipped with ultraviolet radiation disinfection.

The City of Wamego has an aerobic sludge digestion system with UV disinfection and permit limits of 262 and 2358 counts during primary and off-seasons. The facility monitors E coli bacteria in its effluent monthly. Since July 2008, 37 samples have been taken, 13 of which were below detection limits. The overall geometric mean was 16 counts and the geometric mean for the data taken during primary recreation season was 11 counts (22 samples). The range in bacteria was 10 – 250 counts.

The City of St. Marys has an activated sludge plant with UV disinfection and permit limits of 427 and 3843 during the primary recreation and off-seasons. Effluent is monitored monthly for E coli. Thirty-seven samples taken since July 2008 had a range of 2 – 110 counts, ten of which were non-detects. The overall geometric mean was 12 counts and that for the 22 samples taken during primary recreation months was 11 counts.

The City of Maple Hill has a 3-cell lagoon with permit limits of 427 and 3843 counts and quarterly monitoring. Twelve samples taken since July 2008 ranged from 10 to 340 counts. The City of Belvue has a 4-cell lagoon, monitors quarterly but has no bacteria limits. There has not been a discharge by this facility into Lost Creek since 2004.

Similarly, the City of Delia has a 3-cell lagoon that discharges to Cross Creek. While no limits are present for E coli, there is quarterly monitoring and the facility has only

discharged twice since 2008. September 2009 saw a large bacteria release of 27,000 counts, perhaps in response to a one-half inch rain on that date. A subsequent discharge in June 2010 was only 50 counts. Also discharging to Cross Creek is the City of Emmett with its 3-cell lagoon. Quarterly monitoring but no limits are present in the permit. Discharges occurred in 2009 (20 – 2380 counts) and 2010 (31,000 in February, 1300 in July, and 4 counts in November). There has been no discharge since November 2010. The City of Rossville regularly discharges from its 3-cell lagoon into Cross Creek. It monitors quarterly but has no permit limits for E coli. Bacteria counts in its effluent has ranged 10 – 60 in 11 samples from 2008 – 2011.

Discharges from the Jeffrey Energy Center pass through a series of ponds before entering Lost Creek. While the quality of Lost Creek may be impacted by this discharge, the effluent does not contain bacteria and no permit limits are in place for E coli. Rural Water District #4 of Pottawatomie Creek discharges reject water from its reverse osmosis operation into Lost Creek without bacteria. The limestone quarry only discharges during wet weather or when dewatering its pits. A remediation project at St. Marys intercepts a plume of nitrate-laden ground water by wells and discharges into Doyle Creek. Neither activity is considered a source of bacteria.

Table 4. **NPDES facilities along the Middle Kansas River between Wamego & Willard**

Facility	NPDES#	KS Permit #	Type	Receiving Stream	Design Q (MGD)	Permit Expires
City of Belvue WWTP	KS0046370	M-KS05-OO01	4-Cell Lagoon	Lost Creek	0.0136	9/30/2015
City of Maple Hill WWTP	KS0046426	M-KS39-OO01	3-Cell Lagoon	Mill Creek	0.06	12/31/2015
City of St. Marys WWTP	KS0020974	M-KS67-OO01	Activated Sludge w/ UV	Doyle Creek	0.50	12/31/2015
City of Wamego WWTP	KS0092266	M-KS74-OO02	Aerobic Sludge Digest. w/ UV	Kansas River	0.75	4/30/2015
City of Delia WWTP	KS0046493	M-KS10-OO01	3-Cell Lagoon	Salt Creek	0.013	3/31/2015
City of Emmett WWTP	KS0046396	M-KS16-OO01	3-Cell Lagoon	Cross Creek	0.0328	12/31/2015
City of Rossville WWTP	KS0046477	M-KS64-OO01	3-Cell Lagoon	Cross Creek	0.138	9/30/2015
PT CO RWD#4 WTP	KS0095591	I-KS05-PO02	R.O. Water Treat. Plant w/ 4-Cell Lagoon	Lost Creek	0.0634	6/30/2015
Hamm-Dedonder #73	KS0087394	I-KS67-PO04	Rock Quarry	Riley Creek	Typically 0.0	6/30/2014
St. Marys Groundwater Remediation	KS0090280	I-KS67-PO05	Nitrate Plume Interceptor Well	Doyle Creek	0.324	2/28/2017
Jeffrey Energy Center – Westar	KS0080632	I-KS67-PO02	Coal-fired Power Plant	Lost Creek	2.96	5/31/2013
St. Marys College	KSJ000394	M-KS67-NO01	Non-discharging	N/A	0.0	10/31/2012
Maple Hill Truck Stop	KSJ000577	C-KS39-NO01	Non-discharging	N/A	0.0	12/31/2013

Finally, the two non-discharging facilities at St. Marys College and the Maple Hill Truck stop contain their effluent within holding lagoons which lose water to evaporation with no discharge to Doyle or Mill Creeks.

Land Use: Cropland is the predominant land use along the Kansas River corridor between Wamego and Willard as well as along Cross Creek, although it makes up only 28% of the watershed while 59 percent of the watershed land use is grassland. Grassland is the more likely source of bacteria during runoff events because of grazing possibilities. **Figure 24** indicates that cropland is interspersed with forest along stream drainages, but grassland dominates the land use of the uplands. Cropland tends to be concentrated in two bands astride the Kansas River and Cross Creek and their tributaries.

Table 5 summarizes the proportion of grassland in each of the HUC 12s (**Appendix C**) comprising the Middle Kansas corridor and Cross Creek watershed. The greatest percentage of acres in grass occurs in the upper reaches and tributaries of Cross Creek, the Lost Creek watershed and the confluence of Mill Creek with the Kansas River. The percentage grassland falls below 50 percent along lower Cross Creek, Doyle Creek, Bourbonais Creek and the lowest reaches of Vermillion Creek, where cropland use increases. The largest grass acreage is along Little Cross Creek, the smallest is in lower Cross Creek. The percentage of grass within a 100 foot riparian buffer along the streams in the drainage is proportionately less (< 30%) than for the HUC as a whole. Cropland becomes more prevalent, but the dominant land use in the riparian buffer is forest and timber. The riparian buffer makes up a very small proportion (2 – 4%) of the land area within each HUC 12.

Contributing Runoff: Soil permeability values for major tributaries within the watershed, based on NRCS STATSGO database, indicate the average soil permeability of the watershed is 0.5 – 0.6”/hour, which contributes to runoff during low rainfall intensity events. Whereas Mill Creek contributes runoff from all of its watershed under rainfall intensities of 1.5 inches per hour, the Vermillion Creek and nearby Soldier Creek watersheds contribute slightly less (95%). The proportion of watershed contributing runoff decreases with decreased rainfall. At intensities of 1.14 in/hr, 95% of Mill Creek produces runoff, while 90% of the northern watersheds contribute runoff. Those proportions drop to 90% for Mill Creek and 83% for Vermillion Creek, once intensity decreases to 0.5 – 0.6 in/hr. Soldier Creek, which may be similar to Cross Creek, only generates runoff from two-thirds of its watershed at those lower rainfall intensities. Sufficient rain over a finite amount of time will generate runoff and storm flows to carry bacteria and other non-point source pollutants.

Permeability of the soil overlying the Kansas River valley is generally greater (0.6 – 2.0 in/hr, according to county soil surveys). The valley is composed of silt loams (Paxico, Muir, and Eudora) and sandy loam (Haynie) and loamy sand (Sarpy) with some clay lens (Wabash) interspersed. The sands have very high permeability (6 – 20 in/hr) while the clays are very tight (permeability < 0.06 in/hr). Generally, it is likely that rainfall on the valley will infiltrate and increase flows in the Kansas River through increased baseflow

and interflow through the alluvial soils. These processes probably dominate runoff generation in the classic sense in the vicinity of the river.

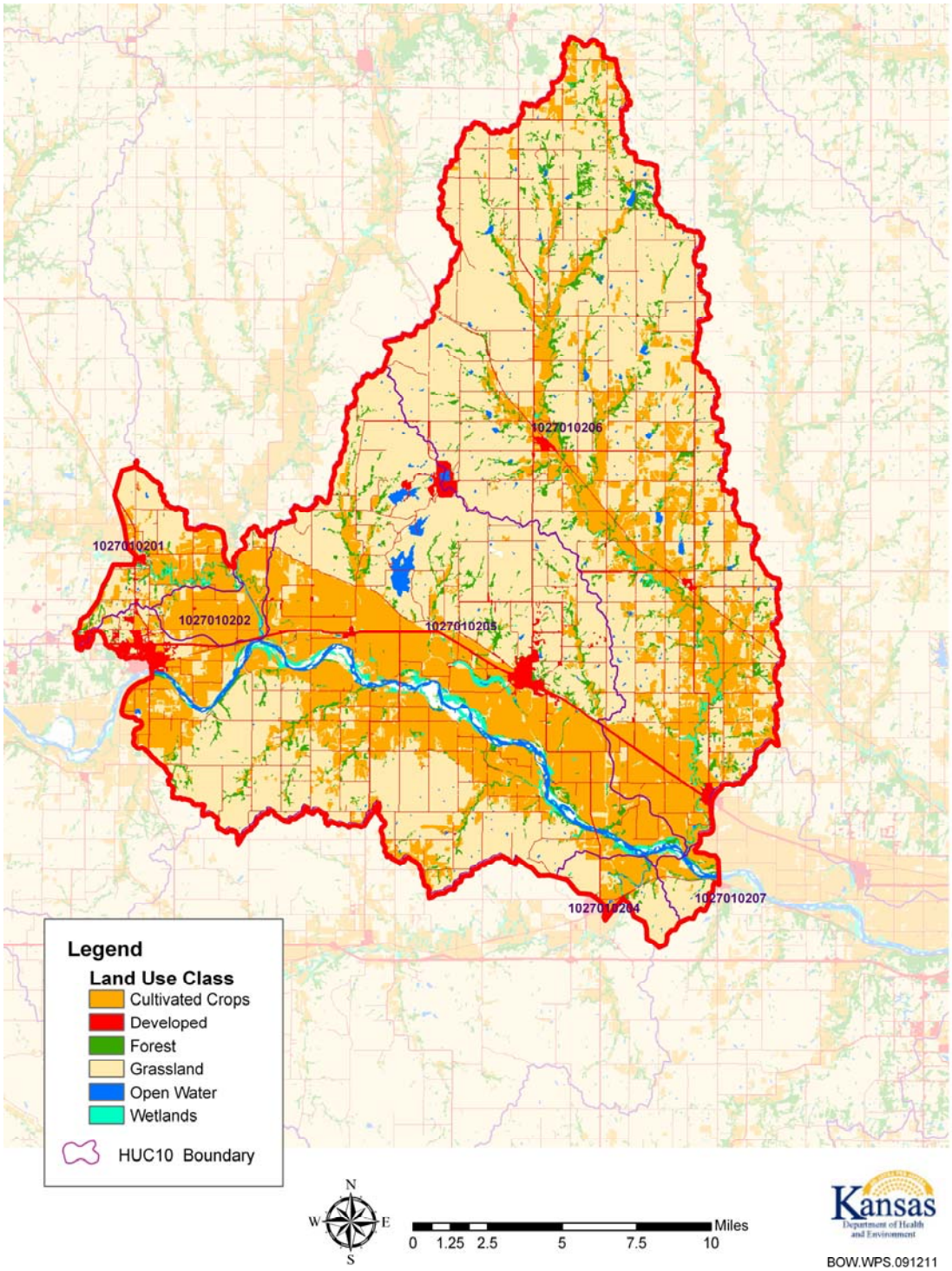


Figure 24. General Land Use along the Middle Kansas River (from 2001 NLCD)

Table 5. Grassland Acres in Middle Kansas River Corridor & Cross Creek

Watershed	HUC 12	Grass Acres	Grass%	Riparian Grass Acres	Riparian % Grass	%HUC as Riparian
Kansas R blw Cross Crk	0701	16,424	52.7%	234.0	22.9%	3.3%
Kansas R / Wells Crk	0506	13,050	47.8%	93.9	11.9%	2.9%
Lost Creek	0505	11,355	63.8%	152.8	31.1%	2.8%
Doyle Crk	0507	14,060	47.3%	356.5	30.8%	3.9%
Bourbonais Crk	0508	17,468	51.9%	302.5	26.7%	3.4%
Upper Cross Crk	0601	23,613	75.4%	151.2	22.0%	2.2%
Little Cross Crk	0602	29,720	78.0%	317.8	28.7%	2.9%
Salt Creek	0603	12,887	59.9%	256.4	25.8%	4.6%
Lower Cross Crk	0604	8,286	36.7%	154.1	18.3%	3.7%

Livestock and Waste Management Systems: There are 7 active permitted or certified animal feeding operations (AFOs) along the Kansas River between Wamego and Willard, as well as the minor tributaries to the river. Within the Cross Creek watershed, there are three certified or permitted animal facilities covered by this TMDL (**Figure 25; also see Appendix D**). Animal feeding operations exist in the lower reaches of Mill and Vermillion Creeks, and potentially may influence the quality of the Kansas River, but are currently covered under bacteria TMDLs for those two drainages. These livestock facilities have waste management systems designed to minimize runoff entering or leaving their operations, including detaining runoff emanating from their facilities. Any lagoon systems 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 8,931 animals in the watershed under permit, the actual number of animals at the feedlot operations will vary from the allowable permitted number **(Table 6).** All but one of the facilities handle beef cows with one Federally permitted facility in place along Lost Creek (NPDES KS0096865; A-KSPT-C005; 4960 cows; permit expires 1/24/2013). There is one facility in the lower Cross Creek/Snake Creek drainage that handles swine (510 animals). Specific HUC-12s are identified in **Appendix C**.

Based on Kansas Agricultural Statistics, much of the livestock are located in Pottawatomie County (**Tables 6 & 7**). Along the mainstem of the Middle Kansas River, cattle are the dominant livestock. Wabaunsee and Jackson Counties tend to have similar number of livestock, while Shawnee County has diminished numbers. Pottawatomie County also dominates the four counties in terms of number of pigs present. While

Shawnee and Jackson Counties have more farms, their average size is smaller than the average operation in Pottawatomie or Wabaunsee Counties. It would appear a majority of livestock are on open range and not in feeding facilities in the four counties.

Population Density: **Table 8** summarizes the populations for the seven main towns in the vicinity of the Middle Kansas River. Population growth is noted among the larger towns, while the small towns have lost people. Notable is the large increase at Maple Hill, coupled with the dramatic decrease at Emmett. While population levels are below the design limits for most of the wastewater facilities, the growth in population at Maple Hill has pushed beyond the design capacity of the lagoon system and possible upgrades will need to be evaluated.

Population density among the counties for 2010 indicates Wabaunsee (8.8 people per square mile (ppsm)) is rural, while Pottawatomie (23.6 ppsm) and Jackson (20.5 ppsm) are designated as densely-settled rural. Shawnee County (320 ppsm) is clearly urban but the developed areas lie east of Willard and this stretch of the Middle Kansas River. Projections for future county populations indicate significant growth (> 25%) for Pottawatomie and Jackson Counties over 2000 – 2030, moderate growth (10 – 15%) for Shawnee County and negligible growth (0.8%) in Wabaunsee County.

Table 6. Animal Feeding Operations Along the Middle Kansas River

County	HUC 12	Stream	Beef	Swine
PT	**0505**	Lost Creek	4960	
PT,WB	**0506**	Wells Creek	2417	
SN,WB	**0508**	Bourbonais Creek	359	
PT,JA	**0602**	Little Cross Creek	600	
SN	**0604**	Lower Cross Creek	85	510
Total Animals			**8,421**	**510**

Table 7. Inventory of 2007 Farms and 2010 Livestock in Counties of the Middle Kansas

County	2007 No. of Farms	2007 Ag Acreage	Avg Farm Size	2010 Cattle	2010 Pigs
Pottawatomie	**843**	**428,601 acres**	**508 acres**	**62,000**	**24,000**
Wabaunsee	**660**	**470,474 acres**	**713 acres**	**44,000**	**1,000**
Jackson	**1127**	**339,291 acres**	**301 acres**	**44,500**	**2,400**
Shawnee	**885**	**206,243 acres**	**233 acres**	**12,100**	**N/A**

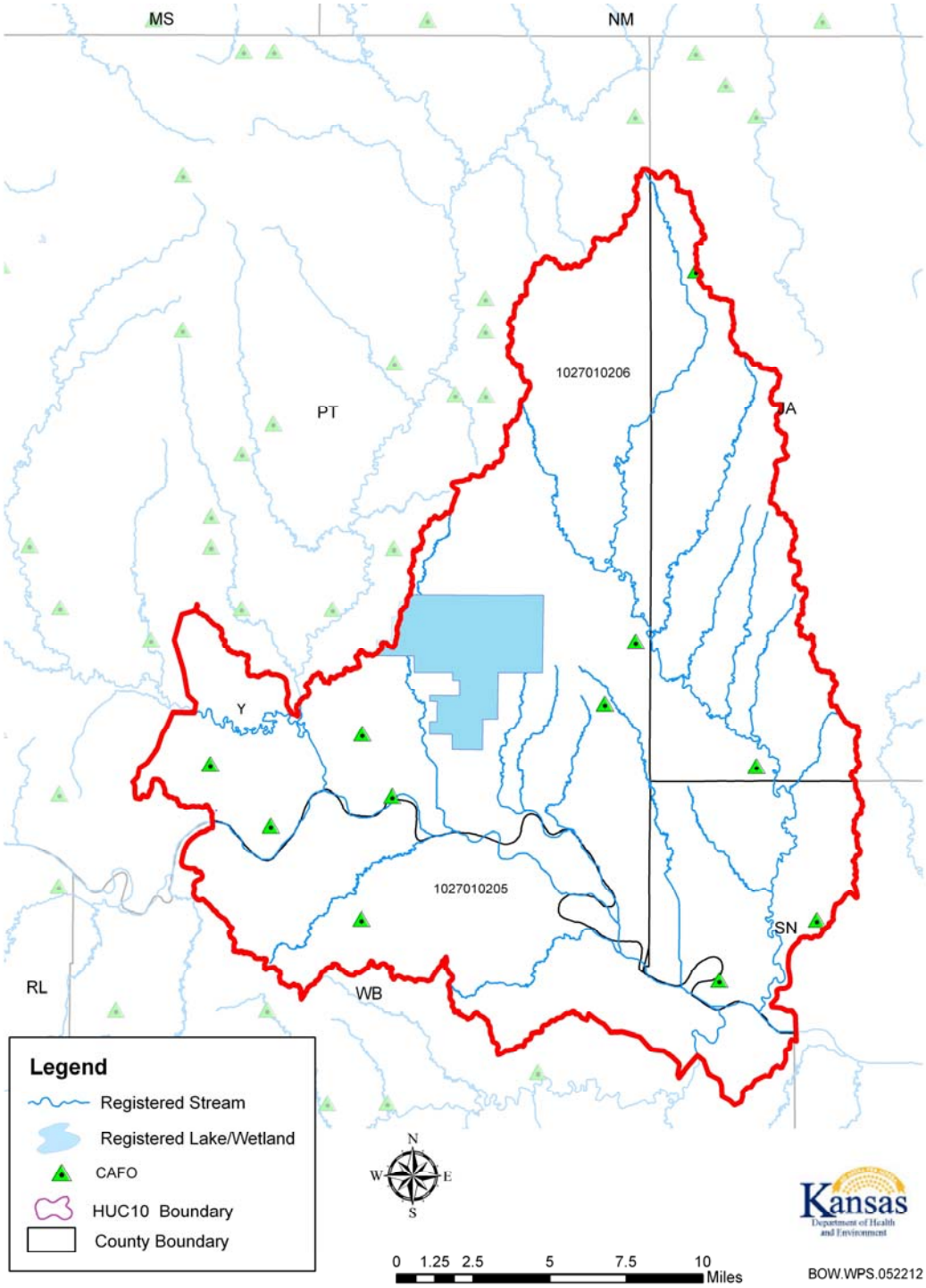


Figure 25. Animal Feeding Operations Along Middle Kansas River

Table 8. Population in Cities Along Middle Kansas River and Tributaries

County	City	2010 Population	2000 Population	WW Design Population
Pottawatomie	Wamego	4372 (+)	4246	7500
Pottawatomie	St. Marys	2627 (+)	2198	5000
Pottawatomie	Belvue	205 (-)	228	335
Pottawatomie	Emmett	191 (-)	277	328
Wabaunsee	Maple Hill	620 (+)	469	600
Jackson	Delia	169 (-)	179	200
Shawnee	Rossville	1151 (+)	1014	1720

On-Site Waste Systems: It is likely there are a number of households within the corridor of the Kansas River, as well along Cross Creek that utilize on-site systems. Because of their small flows and loads, particularly in context with flows on the Kansas River, failing on-site septic systems would be a minor, local source of bacteria loadings within the watershed and would not significantly contribute to the impairment along the Kansas River.

Background Levels: Bacteria are present from wildlife, but typically dispersed enough to not be a significant source of loading. If high densities of wildlife, particularly geese, settle in a confined area, the background levels of bacteria can be expected to increase significantly.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

For this TMDL, the attained endpoint will be the Water Quality Standard as the geometric mean of five samples taken within 30 days, therefore each geometric mean computed during the period April through October should be below 262 counts along the Kansas River. The endpoint will be established for the Kansas River between the confluences of Vermillion Creek near Wamego and Mission Creek below Willard. For the Kansas River the applicable segments lying between Stations SC260 and SC259 (Segment #'s 11, 13 & 14) are subject to this TMDL.

Additionally, Cross Creek, monitored by SC551, should meet a five-sample, 30-day geometric mean of 427 counts during the primary recreation season. Although a majority of the smaller tributaries to the Kansas River and Cross Creek are designated for Secondary Contact "b" recreation, reduction of bacteria contributions from their drainages will be reflected in improved conditions seen at the monitoring stations.

While the legal standards are the geometric means of five samples taken within 30 days, this TMDL will look to reduce the duration, frequency and magnitude of individual E coli samples taken routinely during the primary recreation season such that a majority will be below the nominal value of the criterion. **Figure 26** displays the distribution of KDHE ECB samples taken during the primary recreation months since 2003 over the range of estimated flows at the Willard site. Higher flows over 2000 cfs tend to see higher bacteria counts, but there is a drop in bacteria levels once flows exceed 10,000 cfs. This may reflect the increase in reservoir releases contributing to the flow in the river.

Figure 27 more graphically shows the distribution of bacteria values as a function of flow duration. Now it is clear that incidents of high bacteria are likely to occur at flows exceeded 10 – 60% of the time on the Kansas River.

Generally, elevated bacteria do not occur on Cross Creek until flows are greater than the 15% exceedance flow, coinciding with estimated runoff conditions. The highest bacteria coincide with runoff conditions at those two locations. While many of the samples may be over the primary recreation criterion for the Kansas River (262 counts); the lack of large hydrologic contribution likely minimizes the impact of Cross Creek on the Kansas River except at infrequent high flows. Given the relationship between bacteria levels at Willard with those at Wamego and contributions from tributaries, the emphasis will need to be placed on rural stormwater management from tributary areas abating any impact placed on the Kansas River. The principal tributaries for this emphasis will be Rock and Vermillion Creeks.

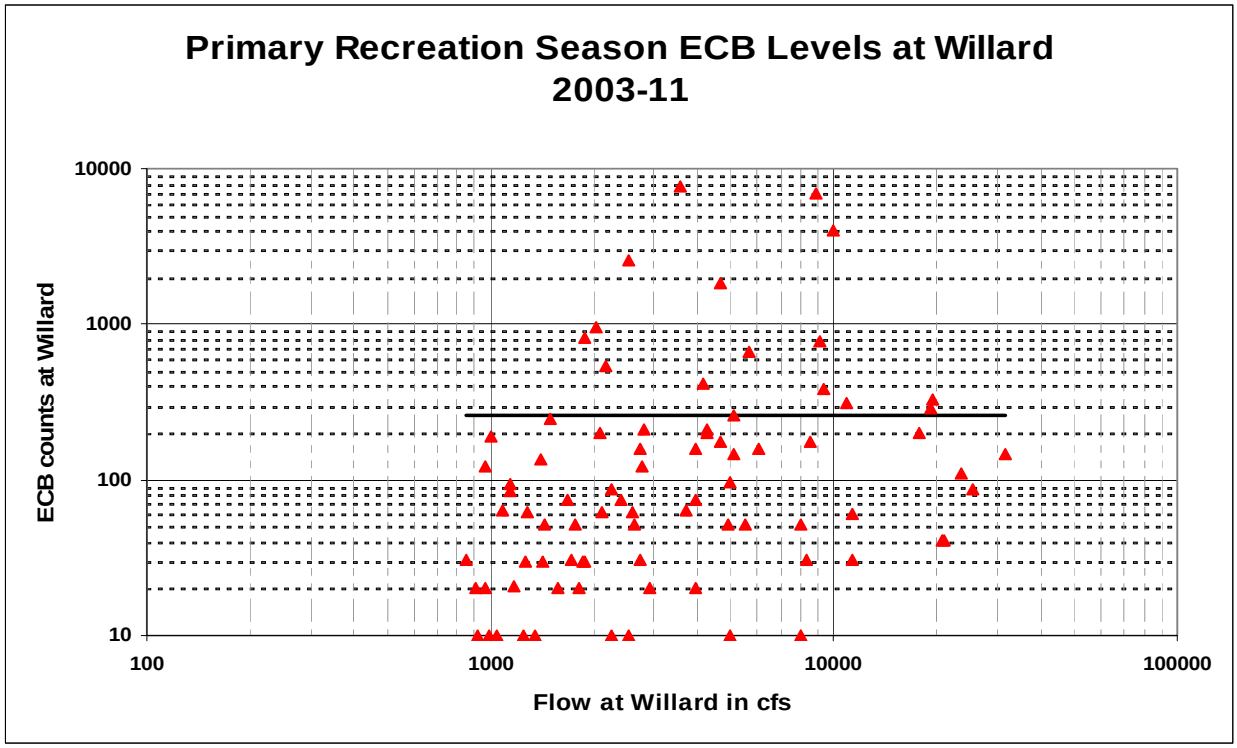


Figure 26. Distribution of E coli values at Willard under Varying Flow Conditions

Point Sources: In accordance with the Surface Water Quality Standards at K.A.R.28-16-28e(c)(7)(F), "Wastewater effluent shall be disinfected if it is determined by the department that the discharge of non-disinfected wastewater constitutes an actual or potential threat to public health". Therefore, wastewater released from the five properly operated lagoon systems should have sufficient retention time prior to discharge to ensure bacteria die-off. The two mechanical plants have ultraviolet disinfection of their wastewater to effectively eliminate any bacterial loading to the receiving waters or Kansas River.

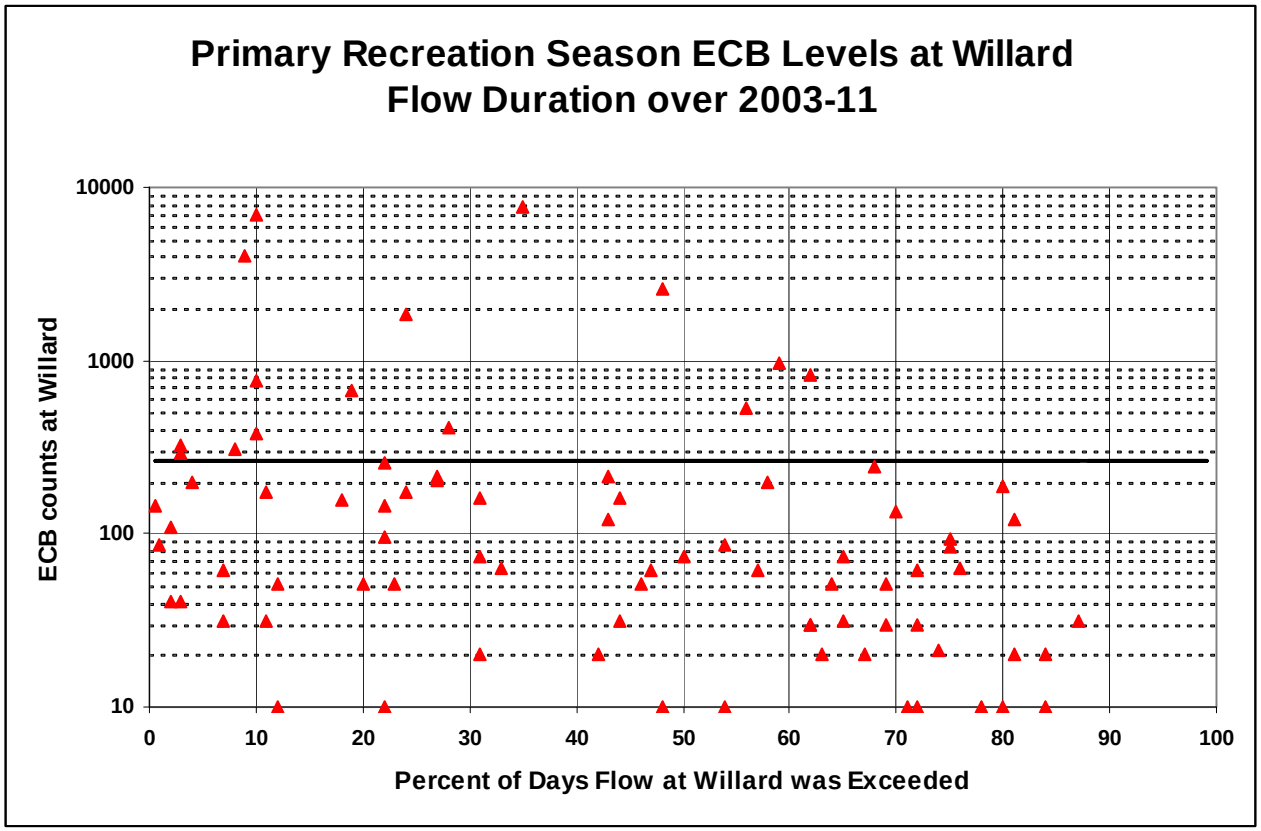


Figure 27. Bacteria Values as a Function of Flow Duration on Middle Kansas River

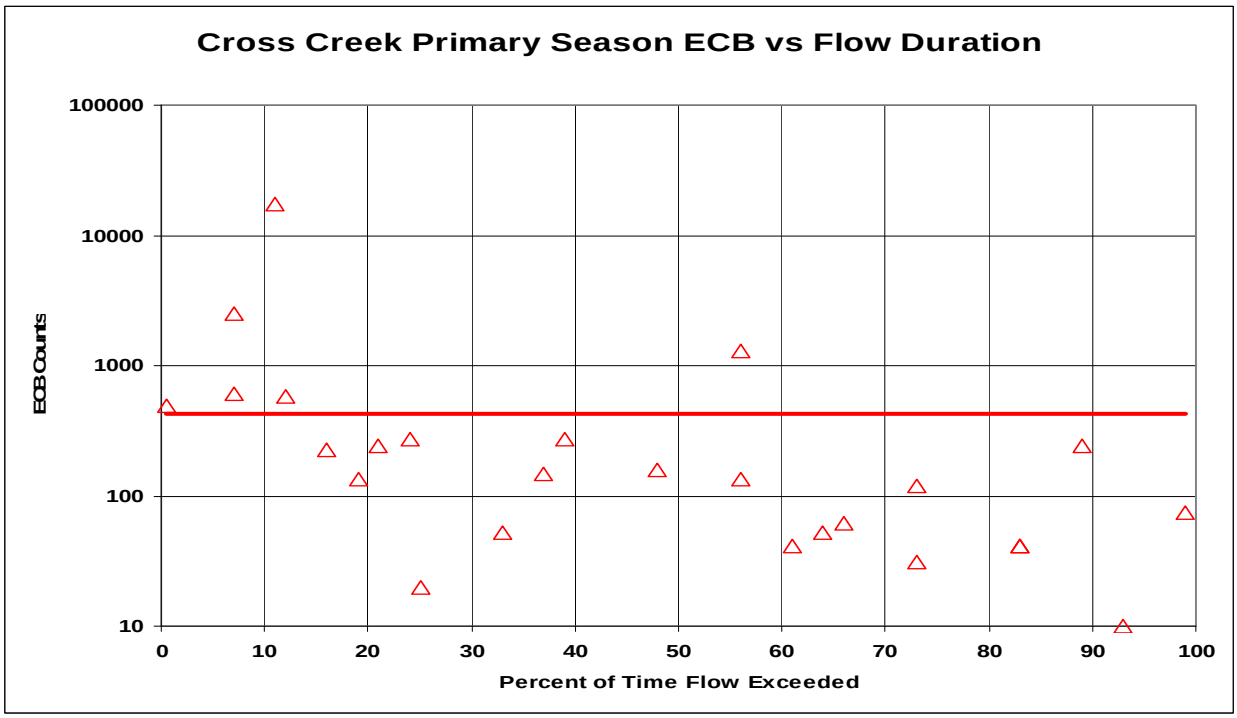


Figure 28. E coli Bacteria Counts on Cross Creek Under Estimated Flow Conditions

The Wasteload Allocations will reflect the applicable (primary) seasonal permit limits of colonies (or counts) of bacteria per 100 ml (**Table 9**). For the lagoon facilities, a limit of 427 counts per 100 ml at the end of outfall will be presumed if such a limit is not currently in place, to ensure no contributions to impairments on Cross Creek. The WLA for Belvue's lagoons is based on the 262 criterion because of the Primary Class B Recreation designation on Lost Creek. Existing limits of 427 and 262 are in the permits for the mechanical plants at St. Marys and Wamego, respectively as well as an existing limit of 427 for Maple Hill's lagoon system.

Table 9. Bacteria Wasteload Allocations for Cities in the Middle Kansas Watershed

Stream System	City	MGD	CFS	#ECB/100 ml	WLA(Bcounts/d)
Kansas River	**Wamego**	0.75	1.16	262	7.43
	St. Marys	0.50	0.77	427	8.08
	Maple Hill	0.06	0.09	427	0.97
	Belvue	0.014	0.02	262	0.13
Kansas River	**Sub-Total**	1.32	2.05	--	16.62
Cross Creek	**Rossville**	0.14	0.21	427	2.23
	Emmett	0.03	0.05	427	0.53
	Delia	0.013	0.02	427	0.21
Cross Creek	**Sub-Total**	0.18	0.28	--	2.97
Overall Total		1.51	2.33	--	19.58

The Pottawatomie County Rural Water District Water Treatment Plant does not discharge bacteria. Nor does the Hamm quarry, the St. Marys remediation project or the Jeffrey Energy Center. All four of these facilities will have a wasteload allocation of zero. The Maple Hill Truck Stop and St. Marys College have non-discharging facilities and they will also have an allocation of zero.

Animal feeding operations will have a wasteload allocation of zero as well, since they will either not discharge or their discharge will not enter the stream system. No stormwater (MS4) utilities are in the watershed, therefore, there will be no wasteload allocation for permitted stormwater.

Nonpoint Source: The Load Allocation (LA) assigns responsibility for nonpoint source contributors for the bacteria input into the Kansas River or Cross Creek from rural settings. The Load Allocations in **Figure 29** and **Appendix E** lie between the total wasteload allocations between Wamego and Willard (including those on Cross Creek) and the TMDL line for the Kansas River. **Figure 30** shows the bacteria load duration TMDL for Cross Creek with the total wasteload allocation from the three cities. Because of the low hydrologic contributions under very dry conditions, the permissible load at the lowest reach of Cross Creek coincides with the wasteload allocations present at design flows for the three cities. As mentioned before, bacteria impairment appears to be a high flow circumstance, since no excursions are noted at the lower flows for either the Kansas River or Cross Creek. As such, non-point sources are chiefly responsible for high bacteria in the streams. For the Kansas River, the primary contributor appears to be the Rock-Vermillion Creek watershed.

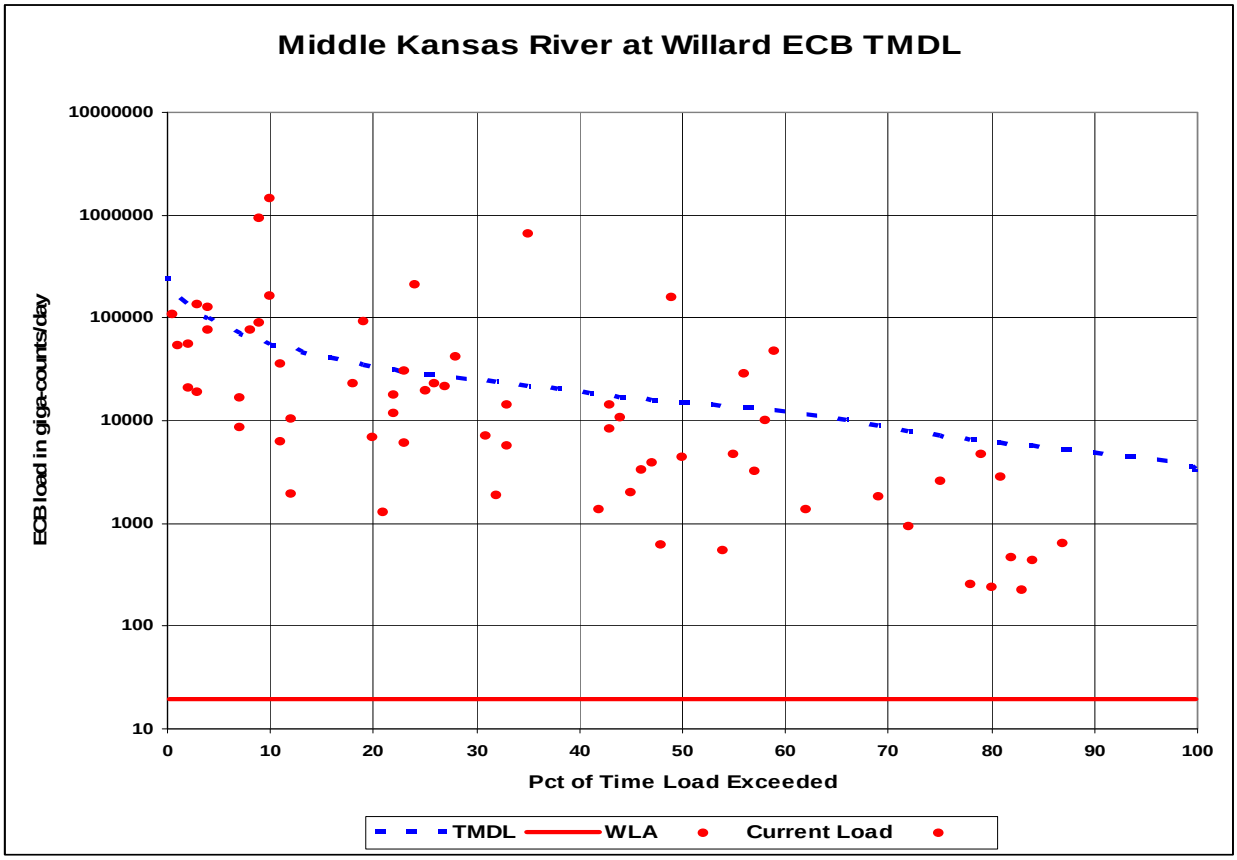


Figure 29. Bacteria TMDL Curve for Middle Kansas River at Willard

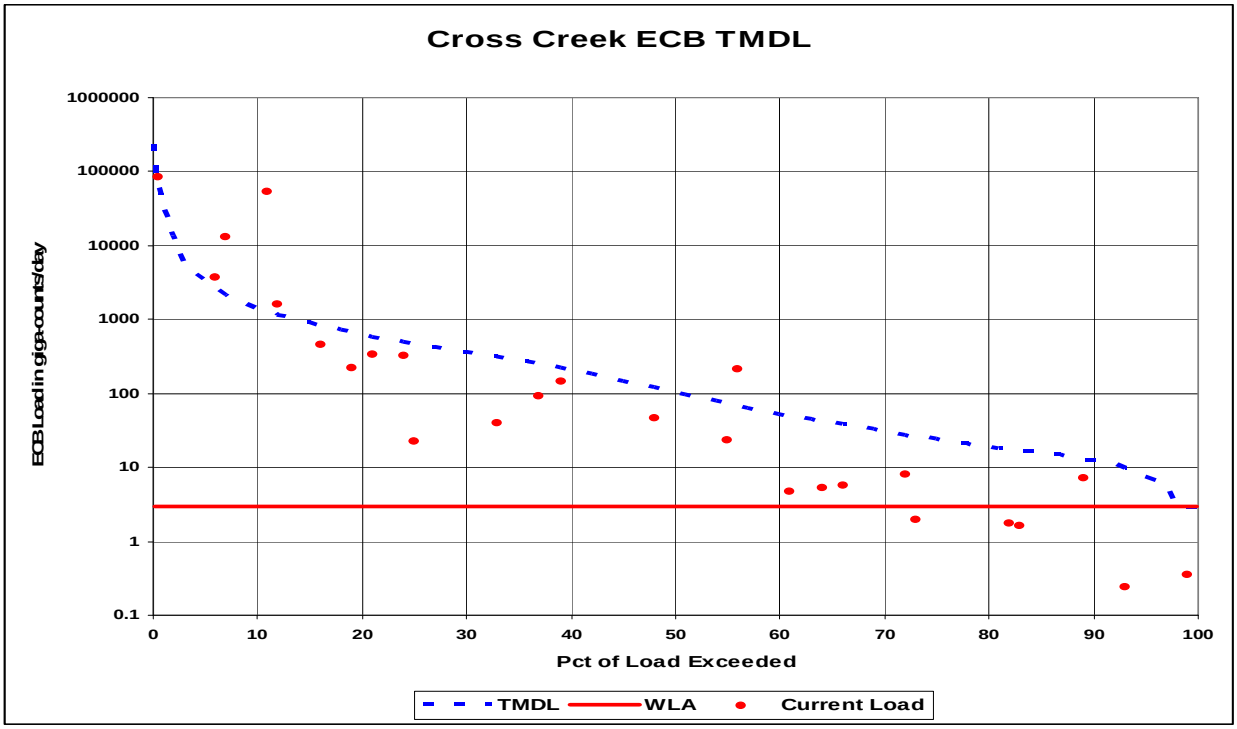


Figure 30. Bacteria TMDL Curve for Cross Creek

Defined Margin of Safety: The Margin of Safety provides an implicit hedge against the uncertainty in bacteria loading into Kansas River. Municipal wastewater sources are assigned wasteload allocations based on actual or assumed end of pipe limits directly tied to primary recreation Class B or C criteria (262 or 427 counts per 100 ml). The two mechanical plants utilize UV radiation which produces effluent with bacteria counts an order of magnitude less than limits or criteria. The wasteload allocations for lagoon systems were based on a Primary Class C criterion, even though those facilities discharge into streams that only support secondary recreation. Furthermore, all wasteload allocations are based on design flow discharges of wastewater, while actual service populations are less than assumed, and in some cases, declining.

With the emphasis of contribution from the Rock and Vermillion Creek watersheds, bacteria reductions on those streams not only have to meet their own bacteria criteria, but also those of the Kansas River. To a lesser degree, the smaller tributaries are expected to not contribute to the support of Class B primary recreation on the Kansas River. Therefore, source controls will be directed toward achieving water quality standards on the segments of the Kansas River. With die-off reductions in transit along the river, any required reductions on Rock and Vermillion Creeks will be further reduced in impact upon reaching Willard.

State Water Plan Implementation Priority: Due to the existing primary recreation activities on the Kansas River during all types of weather, this TMDL will be designated as a **High Priority** for implementation to direct non-point source management to abate such pollutant loads in the Rock – Vermillion Creek watershed. Conversely, because recreation activities on Cross Creek are limited and the episodes for elevated bacteria on the stream creating conditions of impairment are infrequent, the portion of this TMDL dealing with Cross Creek will relegated to a **Medium Priority** status.

Priority HUC12s: The principal influences on the bacteria quality seen on the Kansas River at Willard, as opposed to conditions at Wamego, are the three main tributaries within the intervening drainage (Vermillion, Mill and Cross Creeks). Of these, Vermillion Creek has the highest potential for causing impairment on the Kansas River. Occasionally, high bacteria loads from Cross Creek may create a localized impairment on the Kansas River near Willard. Therefore, the initial priority for this TMDL is to first implement the bacteria abatement practices in the Vermillion Creek watershed, per the proposed bacteria TMDL for Vermillion and Rock Creeks. Livestock management may be a principal driver of the bacteria impairment so implementation will involve both livestock access and isolation of livestock areas from runoff events. As loadings decline from Pottawatomie County, some interest should be turned toward the lower reaches of Cross Creek (HUC12s 1027010200604) to further reduce potential bacteria loading.

5. IMPLEMENTATION

Desired Implementation Activities

1. Maintain disinfection through operations under state and federal permits, inspect permitted facilities, continue monitoring requirements and evaluate compliance with permit limits.
2. Improve riparian conditions along stream systems by limiting overuse from grazing livestock along and in the stream.
3. Provide alternative water supplies for livestock to limit their use of streams as water sources.
4. Ensure land applied manure is being properly managed and is not susceptible to runoff into nearby streams.
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.

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 bacteria in wastewater discharges.
b. Maintain permit limits after 2015 and effective operation of lagoons.
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.

Nonpoint Source Pollution Technical Assistance – KDHE

a. Support Section 319 demonstration projects for reduction of bacteria loading from agricultural lands though livestock management.
b. Provide technical assistance on practices geared to the establishment of vegetative buffer strips.
c. Provide technical assistance on bacteria 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 Middle Kansas Sub-basin 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. Install livestock waste management systems for manure storage.
b. Implement manure management plans.
c. Support terracing, grass waterways and buffers along cropland
d. Repair or replace failing septic systems which are located within 100 feet of Rock or Vermillion Creeks or 500 feet of the Kansas River or their 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, initially along Rock Creek, then lower Vermillion and Adams Creeks, finally lower Cross Creek.
c. Promote wetland construction to reduce runoff and assimilate loadings in Rock and lower Vermillion Creeks.

Buffer Initiative Program – SCC

a. Install and maintain grass buffer strips initially near Rock Creek and tributary streams, then along lower Vermillion and Adams Creeks and finally Cross Creek.
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, bacteria and pasture management.
b. Educate livestock producers on livestock waste management and land applied manure applications.
c. Provide technical assistance on livestock waste management systems.
d. Provide technical assistance on buffer strip design and minimizing rural runoff.
e. Educate residents, landowners, and watershed stakeholders about homestead waste management.
f. Promote and utilize Middle Kansas WRAPS efforts at pollution prevention, runoff control and resource management.

Timeframe for Implementation: Rural runoff management should commence in 2011 in Rock Creek through WRAPS and Section 319 implementation. Implementation of abatement practices should commence in the lower Vermillion Creek HUC 12s in 2012. Implementation should continue through 2020, after which implementation in Cross Creek can be considered.

Targeted Participants: The primary participants for early implementation will be the Pottawatomie County Conservation District and the Middle Kansas WRAPS directed

toward agricultural and livestock operations immediately adjacent to the lower portions of Rock and Vermillion Creeks 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 target possible sources adjacent to Rock Creek over 2011. Non-point source implementation activities should focus on those areas with the greatest potential to impact bacteria concentrations along Rock and Vermillion Creeks.

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 and it is their primary water supply.
4. Poor riparian area and denuded riparian vegetation along the stream..

Milestone for 2015: Because bacteria daily loads are nonsensical, the preferred manner to track progress in implementing this TMDL is through alterations to the ECB index profiles for the KDHE station at Willard (**Figure 18**). As the ECB index profile declines, it will indicate reductions in duration, frequency and magnitude of future E coli bacteria samples such that a majority will be below the nominal criterion value applied at both stations. As the profiles approach the desired distribution indicated in the figures, intensive sampling during the primary recreation season can be done to ascertain whether the primary season geometric means are in compliance with the bacteria criterion.

In accordance with the TMDL development schedule for the State of Kansas, the year 2015 marks the next cycle of 303(d) activities in the Kansas – Lower Republican Basin. At that point in time, the bacteria profile from site SC259 should show decline, at least mimicking Kansas River at Wamego (SC260).

Delivery Agents: The primary deliver agents for program participation will be KDHE, the Middle Kansas WRAPS, State Extension Service, and the Pottawatomie 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 Kansas – Lower Republican River Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic 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 TMDL is located within a **High Priority** WRAPS area and should receive support for pollution abatement practices that lower the loading of bacteria and associated pollutants of sediment and nutrients to Rock and Vermillion Creeks, and ultimately, the middle Kansas River. The associated TMDL for Cross Creek should be Medium Priority after achieving the water quality standards on the Kansas River.

Effectiveness: Use of retention and buffers that isolate streams from nearby uses and potential loadings has been effective in reducing the bacteria levels in streams, including under wet weather conditions. In addition, the proper implementation of comprehensive livestock waste management plans has proven effective at reducing runoff associated with livestock facilities.

6. MONITORING

KDHE will continue to collect quarterly to bimonthly samples in every year at Stations SC259, SC260 and SC551 in the watershed. Additionally, a provisional monitoring site will be located on East Fork of Rock Creek to provide a baseline for subsequent evaluation of implementation by the Middle Kansas WRAPS. The streams in the watershed will be evaluated for possible delisting during the development of the 2020 303(d) list. Once bacteria index profiles (**Figures 18 and 19**) decline sufficiently, a series of intensive (5-in-30 day) samplings will commence to evaluate if impairment remains.

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 Kansas – Lower Republican Basin.

Public Hearing: A Public Hearing on this TMDL was held on August 30, 2011 in Westmoreland to receive comments on this TMDL. None were received throughout the August 11 – September 14, 2011 public comment period.

Basin Advisory Committee: The Kansas – Lower Republican Basin Advisory Committee met to discuss the TMDLs in the basin on September 30, 2010 in Lawrence, March 17, 2011 in Manhattan and June 16, 2011 in Lawrence.

Watershed Restoration and Protection Strategy Group: This TMDL has been reviewed in August 2011 by the Middle Kansas Subbasin WRAPS group.

Milestone Evaluation: In 2016, evaluation will be made as the degree and impact 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 2016 with consultation from local stakeholders and WRAPS members.

Consideration for 303(d) Delisting: The Kansas River at Willard will be evaluated for delisting under section 303(d), based on the monitoring data over 2011-2019. 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. Cross Creek will be evaluated sometime after 2020.

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 2012, 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 June 25, 2012

References

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 Surface Water Quality Standards and Supporting Materials found at: http://www.kdheks.gov/water/download/kwqs_plus_supporting.pdf

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.

Stiles, T.C. & M.B.Tate, 2008. Managing bacteria TMDLs by overlaying water quality, hydrology and corrective measures on stream recreation. Water Practice 2: 1-13.

Appendix A. K.S.A. 82a-2001, et seq: Classified stream segments defined; other definitions. As used in this act:

(7) (A) "Recreational use" means:

(i) Primary contact recreational use is use of a classified stream segment for recreation during the period from April 1 through October 31 of each year, provided such classified stream segment is capable of supporting the recreational activities of swimming, skin diving, water skiing, wind surfing, kayaking or mussel harvesting where the body is intended to be immersed in surface water to the extent that some inadvertent ingestion of water is probable.

(a) Primary contact recreational use-Class A: Use of a classified stream segment for recreation during the period from April 1 through October 31 of each year, and the classified stream segment is a designated public swimming area. Water quality criterion for bacterial indicator organisms applied to Class A waters shall be set at an illness rate of eight or more per 1000 swimmers. The classified stream segment shall only be considered impaired for primary contact recreational use-Class A if the calculated geometric mean of at least five samples collected in separate 24-hour periods within a 30-day period exceeds the corresponding water quality criterion. The water quality criterion for primary contact recreational use-Class A waters during the period November 1 through March 31 of each year shall be equal to the criterion applied to secondary contact recreational use-Class A waters.

(b) Primary contact recreational use-Class B: Use of a classified stream segment for recreation, where moderate full body contact recreation is expected, during the period from April 1 through October 31 of each year, and the classified stream segment is by law or written permission of the landowner open to and accessible by the public. Water quality criterion for bacterial indicator organisms applied to Class B waters shall be set at an illness rate of 10 or more per 1000 swimmers. The classified stream segment shall only be considered impaired for primary contact recreational use-Class B if the calculated geometric mean of at least five samples collected in separate 24-hour periods within a 30-day period exceeds the corresponding water quality criterion. The water quality criterion for primary contact recreational use-Class B waters during the period November 1 through March 31 of each year shall be equal to the criterion applied to secondary contact recreational use-Class A waters.

(c) Primary contact recreational use-Class C: Use of a classified stream segment for recreation, where full body contact recreation is infrequent during the period from April 1 through October 31 of each year, and is not open to and accessible by the public under Kansas law and is capable of supporting the recreational activities of swimming, skin diving, water-skiing, wind surfing, boating, mussel harvesting, wading or fishing. Water quality criterion for bacterial indicator organisms applied to Class C waters shall be set at an illness rate of 12 or more per 1000 swimmers. The classified stream segment shall only be considered impaired for primary contact recreational use-Class C if the calculated geometric mean of at least five samples collected in separate 24-hour periods within a 30-day period exceeds the corresponding water quality criterion. The water quality criterion for primary contact recreational use-Class C waters during the period November 1 through March 31 of each year shall be equal to the criterion applied to secondary contact recreational use-Class B waters.

(ii) Secondary contact recreational use is use of a classified stream segment for recreation, provided such classified stream segment is capable of supporting the recreational activities of wading, fishing, canoeing, motor boating, rafting or other types of boating where the body is not intended to be immersed and where ingestion of surface water is not probable.

(a) Secondary contact recreational use-Class A: Use of a classified stream segment for recreation capable of supporting the recreational activities of wading or fishing and the classified stream segment is by law or written permission of the landowner open to and accessible by the public. Water quality criterion for bacterial indicator organisms applied to secondary contact recreational use-Class A waters shall be nine times the criterion applied to primary contact recreational use-Class B waters. The classified stream segment shall only be considered impaired for secondary contact recreational use-Class A if the calculated geometric mean of at least five samples collected in separate 24-hour periods within a 30-day period exceeds the corresponding water quality criterion.

(b) Secondary contact recreational use-Class B: Use of a classified stream segment for recreation capable of supporting the recreational activities of wading or fishing and the classified stream segment is not open to and accessible by the public under Kansas law. Water quality criterion for bacterial indicator organisms applied to secondary contact recreational use- Class B waters shall be nine times the criterion applied to primary contact recreational-Class C use waters. The classified stream segment shall only be considered impaired for secondary contact recreational use-Class B if the calculated geometric mean of at least five samples collected in separate 24-hour periods within a 30-day period exceeds the corresponding water quality criterion.

(B) If opposite sides of a classified stream segment would have different designated recreational uses due to differences in public access, the designated use of the entire classified stream segment may be the higher attainable use, notwithstanding that such designation does not grant the public access to both sides of such segment.

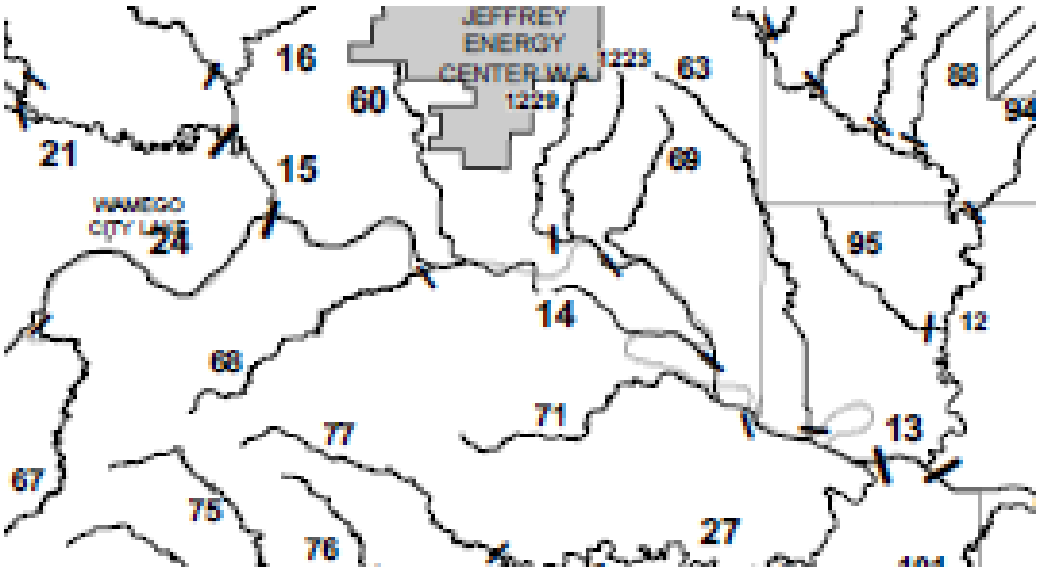
(C) Recreational use designations shall not apply to stream segments where the natural, ephemeral, intermittent or low flow conditions or water levels prevent recreational activities.

(d) "Ephemeral stream" means streams that flow only in response to precipitation and whose channel is at all times above the water table.

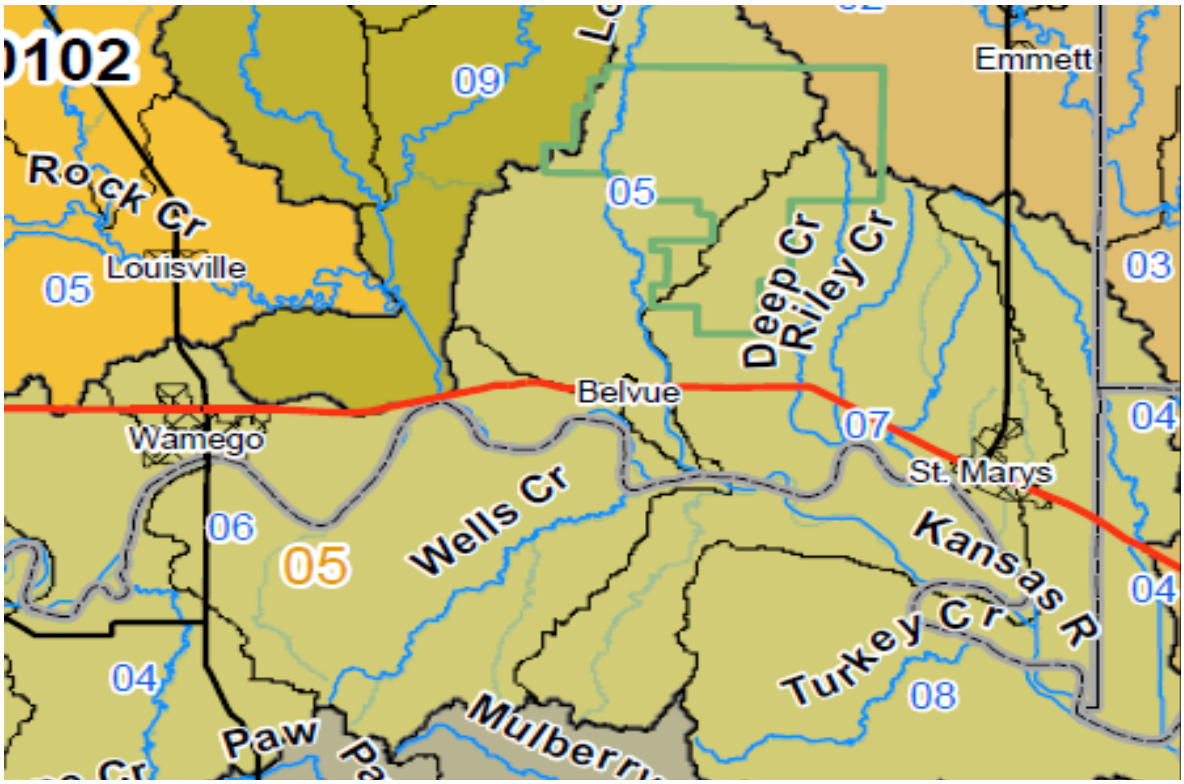
(e) "Secretary" means the secretary of health and environment.

History: L. 2001, ch. 100, § 1; L. 2003, ch. 105, § 1; May 1.

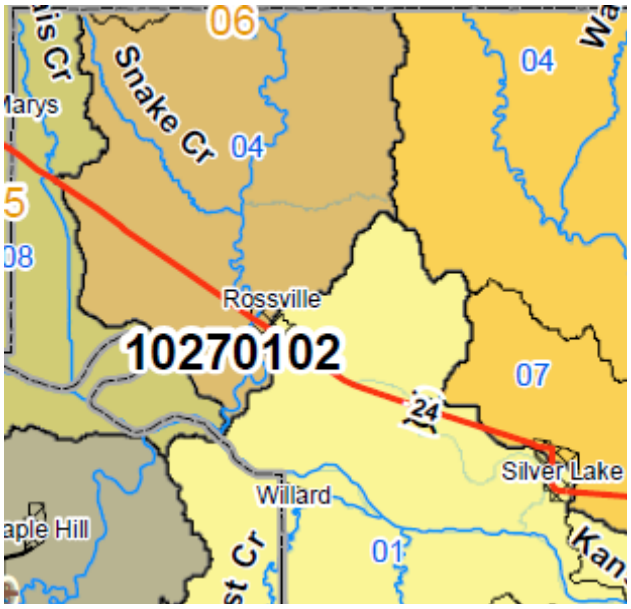
Appendix B. Classified Streams of the Middle Kansas Subbasin Between Wamego and Willard.



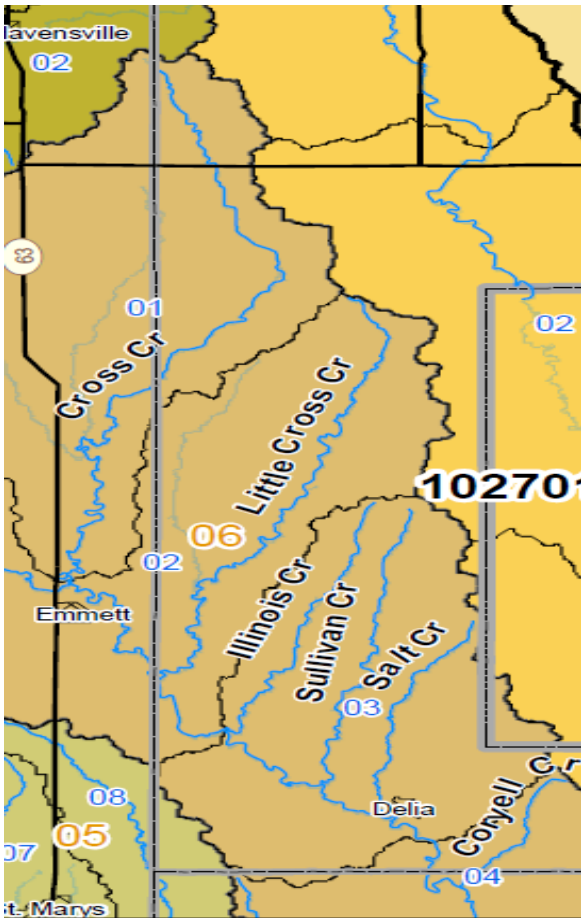
Appendix C: HUC 12 Subwatersheds Along the Main Stem of the Middle Kansas River Between Wamego and Willard



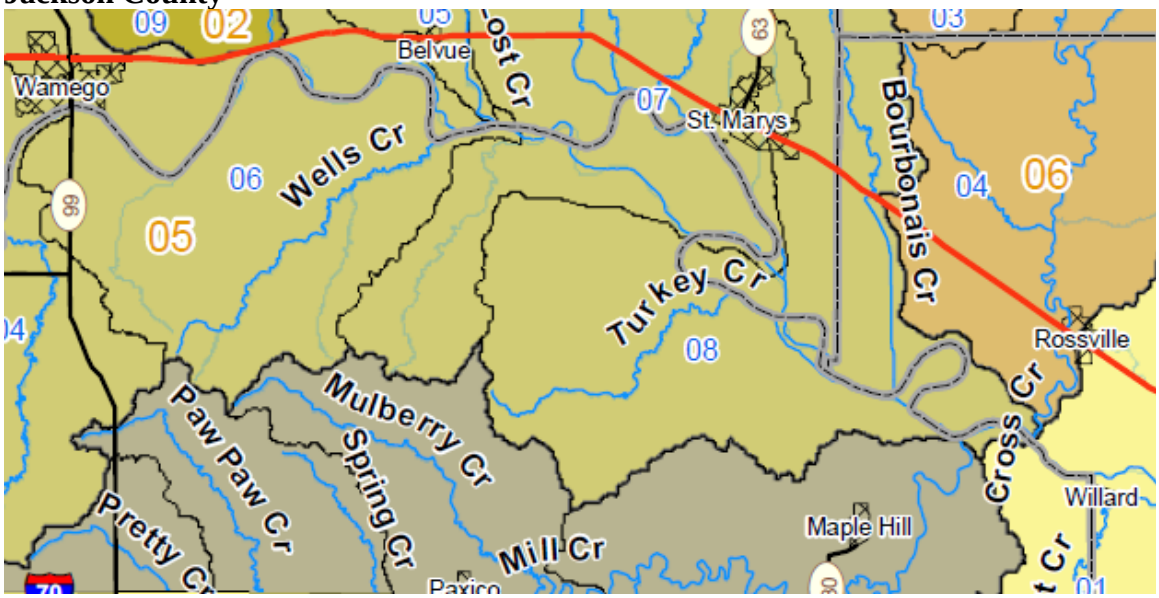
Pottawatomie County



Shawnee County



Jackson County



Wabaunsee County

Appendix D: Registered and Permitted Animal Feeding Operations Along Main Stem Middle Kansas River Between Wamego and Willard and Adjacent Tributaries

County	HUC 10/12	KS Permit #	Permit Type	# of Head	Type
Lost Creek					
Pottawatomie	***0505***	**A-KSPT-C005**	**NPDES Permit***	**4960**	**Cattle**
Middle Kansas River Main Stem					
Pottawatomie	***0506***	**A-KSWB-BA02**	Certificate	120	Beef
& Wabaunsee		**A-KSPT-B001**	Permit Renewal	998	Beef
		A-KSPT-B002	Permit Renewal	999	Beef
		A-KSPT-BA02	Certificate	300	Beef
Shawnee &	***0508***	**A-KSSN-BA10**	Certificate	299	Beef
Pottawatomie		**A-KSPT-BA04**	Certificate	60	Beef
Cross Creek					
Pottawatomie	***0602***	**A-KSPT-BA05**	Certification	600	Beef
Jackson	***0604***	**A-KSJA-S021**	Permit	510	Swine
& Shawnee		**A-KSSN-BA01**	Certificate	85	Beef

***KS0096865**

Livestock operating facilities receive a Wasteload Allocation of 0, with the expectation that they will not discharge bacteria into the Kansas River or Cross Creek.

Livestock operations in Vermillion or Mill Creek watersheds are covered under the bacteria TMDLs for those two drainages.

Appendix E. Wasteload Allocations for NPDES Wastewater and Load Allocations for NPS (Loads in Giga-counts/day)

	Percent	Wamego	Vermillion	Lost Creek			Doyle Creek			Mill Creek			Cross Creek			Willard		
Condition	**Flows**	**LC**	**LC**	**WLA**	**LA**	**LC**	**WLA**	**LA**	**LC**	**WLA**	**LA**	**LC**	**WLA**	**LA**	**LC**	**WLA**	**LA**	**LC**
Drought	**99**	3511	17	0.1	0.9	1.0	6.4	0.0	6.4	1.0	47.0	48.0	3.0	0.0	3.0	19.6	3677	3697
Dry	**90**	4670	60	0.1	5.7	5.8	8.1	8.3	16.4	1.0	155.6	156.6	3.0	9.7	12.7	19.6	4923	4943
Low Flow	**75**	6727	144	0.1	9.3	9.4	8.1	15.9	24.0	1.0	239.1	240.1	3.0	21.7	24.7	19.6	7179	7199
Normal	**50**	14158	369	0.1	25.8	25.9	8.1	50.5	58.6	1.0	615.0	616.0	3.0	104.6	107.6	19.6	15278	15298
High Flow	**25**	26093	1044	0.1	69.1	69.2	8.1	141.6	149.7	1.0	1606.9	1607.9	3.0	477.5	480.5	19.6	28725	28745
Wet	**10**	49642	2885	0.1	141.3	141.4	8.1	293.2	301.3	1.0	3256.5	3257.5	3.0	1442.5	1445.5	19.6	55815	55835
Flood	**1**	155671	20199	0.1	1208.3	1208.4	8.1	2534.6	2542.7	1.0	27645.9	27646.9	3.0	40629.6	40632.6	19.6	161877	161897

Note: Accumulation of Bacteria Loads from Wamego to Cross Creek lies within 5% of Load Capacity at Willard except under flood flows, exceeded 1% or less of the time; coincidental time of peak flows typically does not occur (see Perry, et al, 2004 and **Table 1**); if it did, the load capacity at Willard would essentially double. Sustained wet weather and high flows would be expected at Willard (and associated bacteria loads) as each tributary's peak flow and load would transit downstream along the Kansas River