KANSAS LOWER REPUBLICAN BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody / Assessment Unit (AU): Stranger Creek Watershed
Water Quality Impairment: Lead and Copper (Copper impairment for Upper Stranger Creek Watershed only)

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Lower Kansas **Counties:** Atchison, Jefferson, and Leavenworth

HUC8: 10270104 **HUC10(12)**: 1027010403 (01, 02, 03, 04, 05, 06, 07)
1027010404 (01, 02, 03, 04, 05, 06, 07)

Ecoregion: Western Corn Belt Plains, Loess and Glacial Drift Hills (47i)
Central Irregular Plains, Osage Cuestas (40b)

Drainage Area: 541 Square Miles

Water Quality Limited Segments:

Main Stem	***Tributaries***	
Stranger Creek (5, 6)	Tonganoxie Cr (14)	
	Ninemile Cr (15, 17)	Cow Cr (58)
Stranger Cr (7)	Hog Cr (54)	
	Little Stranger Cr (881)	Little Sandy Cr (883)
	Jarbalo Cr (51)	
	Rock Cr (902)	
	Fall Cr (52)	
	Brush Cr (49)	
Stranger Cr (8)	Walnut Cr (13)	Prairie Cr (47)
		Indian Cr (48)
		Scatter Cr (9013)
	Brush Cr, West (46)	
	Dawson Cr (45)	
	Buttermilk Cr (44)	
Stranger Cr (9)	Crooked Cr (10)	Unnamed Stream (11)
		Mooney Cr (1011)
		Howard Cr (43)
		Hulls Branch (42)
	Camp Cr (41)	
	Little Stranger Cr (959)	

Non-Water Quality Limited Segment:
Crooked Cr (12)

Designated Uses for Main Stem Stranger Creek (5,6,7,8,9): Expected Aquatic Life, Drinking Water Supply, Food Procurement, Groundwater Recharge, Industrial Water Use, Irrigation Use, and Livestock Watering Use. Contact Recreation use varies as follows: Primary Contact Recreation Class B (8); Primary Contact Recreation Class C (5, 6, 7); Secondary Contact Recreation Class b (9). Designated uses for tributaries in the Stranger Creek watershed are detailed in Table 1.

Table 1. Designated Uses for Tributaries in the Stranger Creek Watershed:

Tributary	Segment #	Expected Aquatic Life	Contact Recreation	Drinking Supply	Food Procurement	Ground Water Recharge	Industrial Water Use	Irrigation Use	Livestock Watering Use
Tonganoxie Cr	14	Y	Prim B	Y	Y	Y	Y	Y	Y
Ninemile Cr	15, 17	Y	Sec b	Y	Y	Y	Y	Y	Y
Cow Cr	58	Y	Sec b	N	N	Y	N	Y	Y
Hog Cr	54	Y	Sec b	Y	N	Y	Y	Y	Y
Little Stranger Cr	881	Y	Sec b	Y	Y	Y	Y	Y	Y
Little Sandy Cr	883	Y	Sec b	N	N	N	N	Y	Y
Jarbalo Cr	51	Y	Sec b	N	N	N	N	Y	Y
Rock Cr	902	Y	Sec b	Y	N	Y	Y	Y	Y
Fall Cr	52	Y	Sec b	N	N	N	N	Y	Y
Brush Cr	49	Y	Sec b	N	N	Y	N	Y	Y
Walnut Cr	13	Y	Sec b	Y	Y	Y	Y	Y	Y
Prairie Cr	47	Y	Sec b	Y	Y	Y	Y	Y	Y
Indian Cr	48	Y	Sec b	N	N	N	N	Y	Y
Scatter Cr	9013	Y	Sec b	N	N	N	N	Y	Y
Brush Cr, West	46	Y	Sec b	N	N	N	N	Y	Y
Dawson Cr	45	Y	Sec b	Y	N	Y	Y	Y	Y
Buttermilk Cr	44	Y	Sec b	N	N	Y	N	Y	Y
Crooked Cr	10	Y	Prim C	Y	Y	Y	Y	Y	Y
Unnamed Stream	11	Y	Sec b	N	N	N	N	Y	Y
Mooney Cr	1011	Y	Sec b	Y	Y	Y	Y	Y	Y
Howard Cr	43	Y	Sec b	N	Y	Y	N	N	Y
Hulls Branch	42	Y	Sec b	N	Y	N	N	N	N
Crooked Cr	12	Y	Prim C	Y	Y	Y	Y	Y	Y
Camp Cr	41	Y	Sec b	Y	Y	Y	Y	Y	Y
Little Stranger Cr	959	Y	Prim C	Y	Y	Y	Y	Y	Y

Y = Yes (use is designated); N = No (use is not designated)

303(d) Listings: Station SC501, Stranger Creek near Linwood, Lead (Pb) Impairment; 2002, 2008, and 2010 Kansas Lower Republican River Basin Streams.

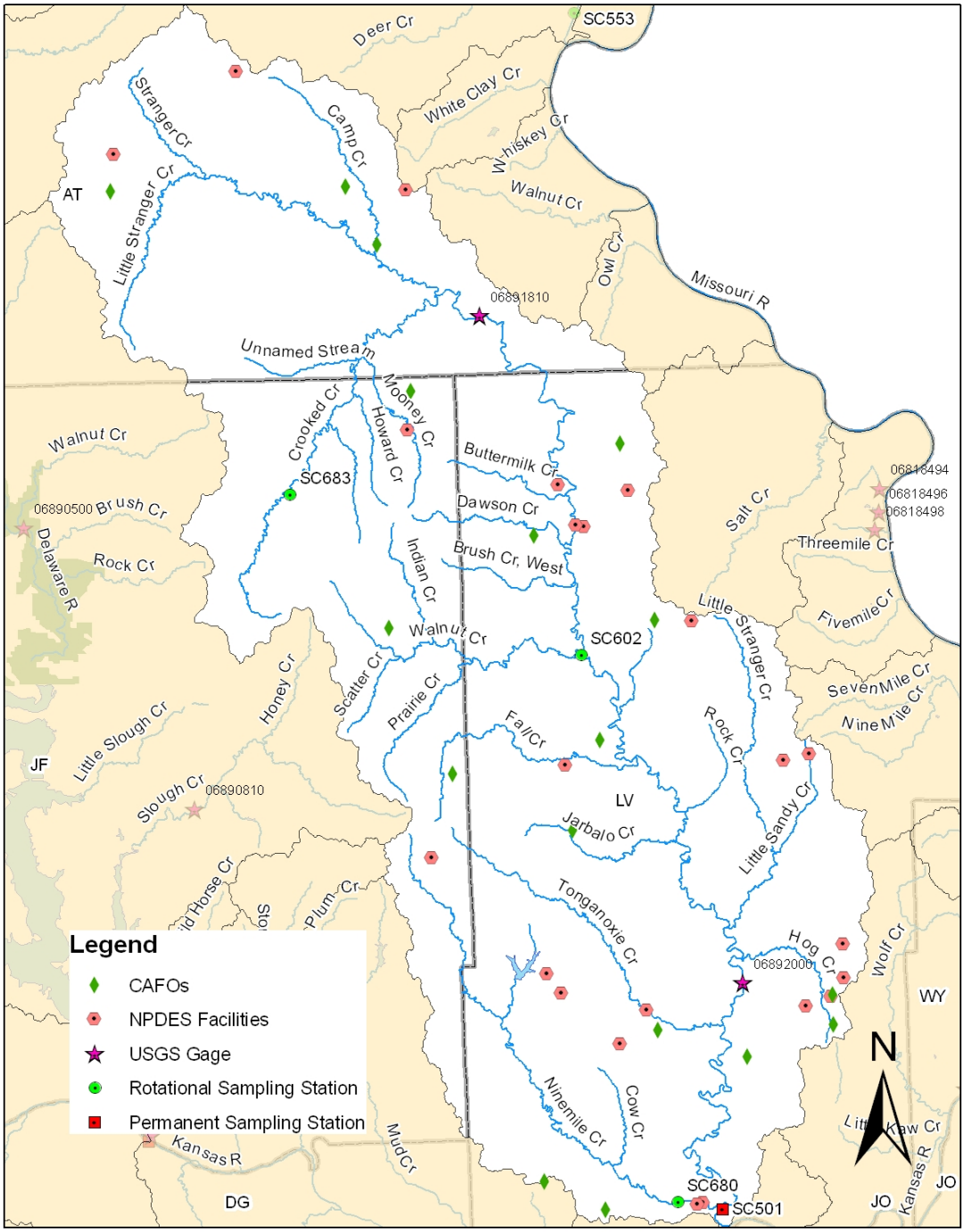
Station SC602, Stranger Creek near Easton, Lead (Pb) Impairment; 2002, 2008, and 2010 Kansas Lower Republican River Basin Streams.

Station SC602, Stranger Creek near Easton, Copper (Cu) Impairment; 2002, 2004, 2008, and 2010 Kansas Lower Republican River Basin Streams.

Station SC680, Ninemile Creek, Lead (Pb) Impairment; 2008 and 2010 Kansas Lower Republican River Basin Streams.

Impaired Use: Aquatic Life Support.

Figure 1. Stranger Creek Watershed Base Map.



Water Quality Criteria: Hardness Dependent criteria from Table 1b of the Kansas Suface Water Quality Standards (K.A.R. 28-16-28e(c)(2)(D)(ii)). Where Water Effects Ratio = WER is 1.0 and hardness is in mg/L.

Chronic AL Total Lead (µg/L) = WER[EXP[(1.273(LN(hardness)))-4.705]]*

Chronic AL Total Copper (µg/L) = WER[EXP[(0.8545(LN(hardness)))-1.702]]*

Acute AL Total Copper (µg/L) = WER[EXP[(0.9422(LN(hardness)))-1.700]]*

2.0 CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Use under 2010–303(d): Not supporting Aquatic Life

Stream Monitoring Sites: Active KDHE Permanent Stream Chemistry sampling station SC501, located on Stranger Creek on Highway K-132, 1.0 mile east of Linwood.

Active KDHE Rotational ambient Stream Chemistry sampling station SC602, located on Stranger Creek 4 ¾ miles east of Easton.

Active KDHE Rotational ambient Stream Chemistry sampling station SC680, located on Ninemile Creek ¾ of a mile west and ½ mile north of Linwood.

Non-water quality limited active KDHE Rotational ambient Stream Chemistry sampling station SC683, located on Crooked Creek is within the drainage area of this watershed.

Period of Record: SC501: 1990-2010
SC602: Sampled in 1991, 1995, 1999, 2003, and 2007.
SC680: Sampled in 1997, 2001, 2005, and 2009.

Flow Record: USGS Gage 06892000 on Stranger Creek near Tonganoxie (1980-2011) and USGS Gage 06891810 on Stranger Creek near Potter (2003-2011) were utilized to establish flow conditions in the watershed. Flow conditions for SC501 and SC680 were established based on the flow record from USGS Gage 06892000, with adjustments made based on the watershed size ratio of the respective sampling stations. Flow conditions at SC602 were established based on USGS gage 06891810, with adjustments being made based on the watershed size at the sampling station. The flow record for the earlier sampling years at SC602 when the USGS gage 06891810 was not active is based on estimates from the USGS gage 06892000.

Table 2. Long Term Flow conditions as calculated from USGS flow data for the period of record from USGS Gages 06892000 (1980-2011) and 06891810 (2003-2011) on Stranger Creek in cubic feet per second (cfs).

Stream Location	Avg. Q	10%	25%	50%	75%	90%
Stranger Cr near Potter at USGS Gage 06891810	116.7	160.9	56	23	8.33	2.4
Stranger Cr at SC602	188.4	259.7	90.4	37.13	13.44	3.87
Stranger Cr near Tonganoxie at USGS Gage 06892000	299.0	552.0	162.0	54.0	16.0	4.1
Stranger Cr at SC501	398.0	735.5	215.8	72.0	21.32	5.46
Ninemile Cr at SC680	47.9	88.4	25.9	8.65	2.56	0.66

Precipitation: The average annual rainfall in the watershed is approximately 40 inches per year.

Current Conditions: Chronic lead (Pb) excursions in the upper portions of Stranger Creek at station SC602 were observed during higher flow conditions during the Spring (April-June) and the Summer-Fall (July-October) Seasons. There were no lead violations observed during the winter (November – March) period. The Pb criterion is associated with the total hardness of each sample, and generally the hardness and the respective criterion is lower during higher flow conditions as seen in Figure 2. As Figure 2 illustrates, the lead violations at SC602 all occurred during higher flow conditions, with the magnitude of these violations increasing with higher flow. As seen in Figure 3, the violations occurred in every sampling year over the period of record with the exception of the first sampling year in 1991. Evaluating the flow condition for the 7-day period prior to the sampling date of the impaired samples, it is evident that all five violations at this station are attributed to unstable flow conditions where a runoff event has occurred within this period.

Table 3. Seasonal summary of Pb violations in relation to the respective percent exceedance flow range for Station SC602.

Number of Samples Over Lead Chronic Aquatic Life Criterion by Flow							
Station	Season	0 - 10%	11 - 25%	26 - 75%	75 - 90%	91 - 100%	Cum. Freq.
Stranger Cr near Easton – SC602	Spring	2	1	0	0	0	3/7 = 43%
	Sum-Fall	1	1	0	0	0	2/8 = 25%
	Winter	0	0	0	0	0	0/10 = 0%

Figure 2. Lead Concentrations relative to the chronic lead criterion and flow condition.

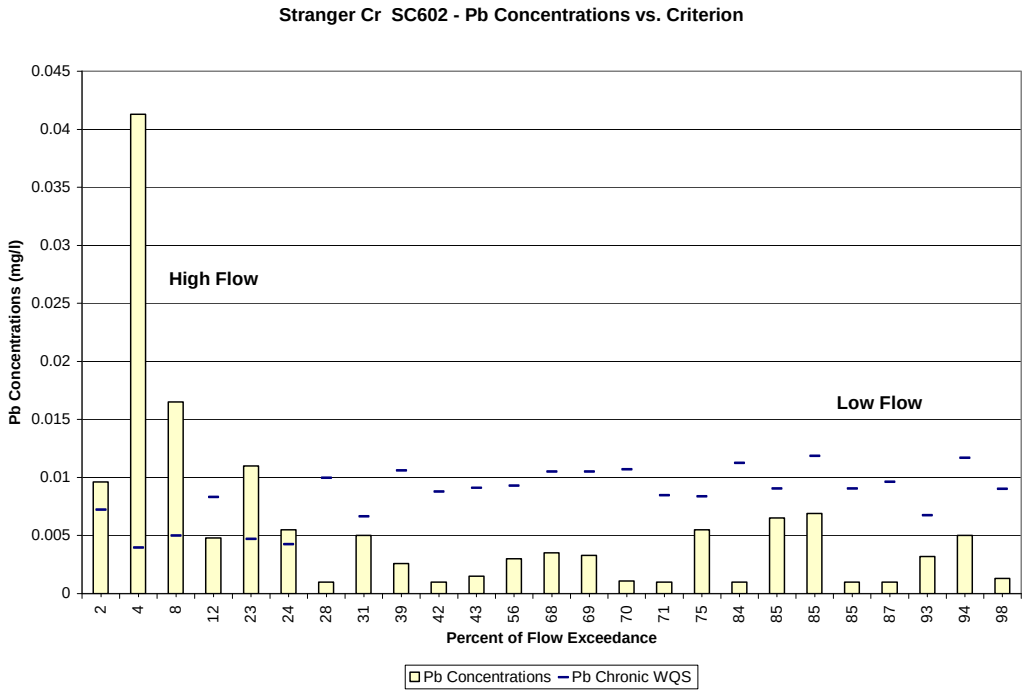
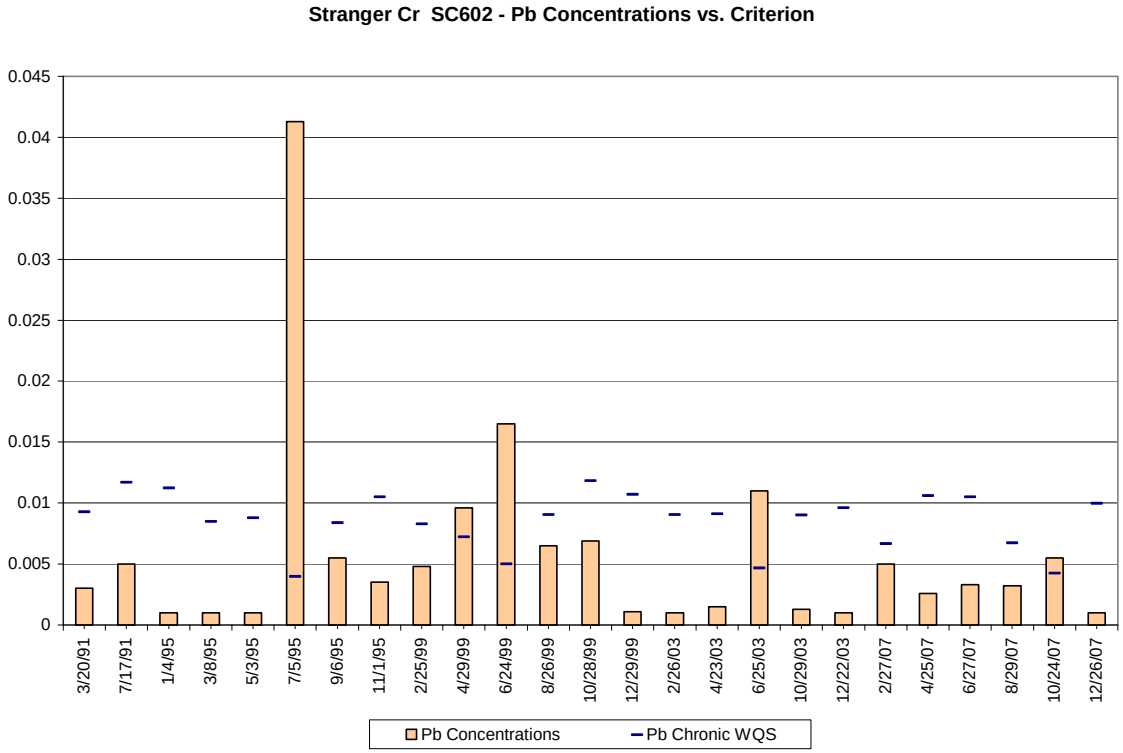


Figure 3. Lead Concentrations and chronic lead criterion (mg/L) by sampling date.



The upper portions of Stranger Creek at station SC602 are also impaired with acute and chronic copper (Cu) impairments. Typically the Cu excursions were detected during the higher flow periods during the spring and summer-fall periods, with the exception of one low flow excursion during the summer-fall season. Cu violations were detected in the sampling years of 1991, 1995, and more recently in 2003 as seen in Figure 5. During the 1990s, the KDHE Kansas Health and Environment Laboratory commonly had Cu detections in their blank samples as a result of reusing sampling vials. It is unknown whether the violations detected at SC602 during the 1990s were a result of cross contaminated sampling vials. Sampling vials are no longer re-used as of 2002. Of the four impaired copper samples, the 7-day flow period prior to the sampling date indicates that three of the four samples were influenced by unstable flow conditions and a runoff event occurred within this period. The impaired copper sample that was collected on September 13, 1991 was collected during a very low flow condition, but the flows preceding the sampling date were consistently low and stable. This sample may likely be associated with laboratory error and cross contamination, though this cannot be confirmed.

Table 4. Copper Excursions at SC602 by flow condition and season.

Number of Samples Over Copper Chronic and Acute Aquatic Life Criterion by Flow							
Station	Season	0 - 10%	11 - 25%	26 - 75%	75 - 90%	91 - 100%	Cum. Freq.
Stranger Cr near Easton – SC602	Spring - Chronic	0	2	0	0	0	2/8 = 25%
	Spring - Acute	0	1	0	0	0	1/8 = 12.5%
	Sum-Fall - Chronic	1	0	0	0	1	2/9 = 22%
	Sum-Fall Acute	1	0	0	0	1	2/9 = 22%
	Winter - Chronic	0	0	0	0	0	0/11 = 0%
	Winter - Acute	0	0	0	0	0	0/11 = 0%

Figure 4. Sample and criterion copper concentrations at SC602 relative to flow.

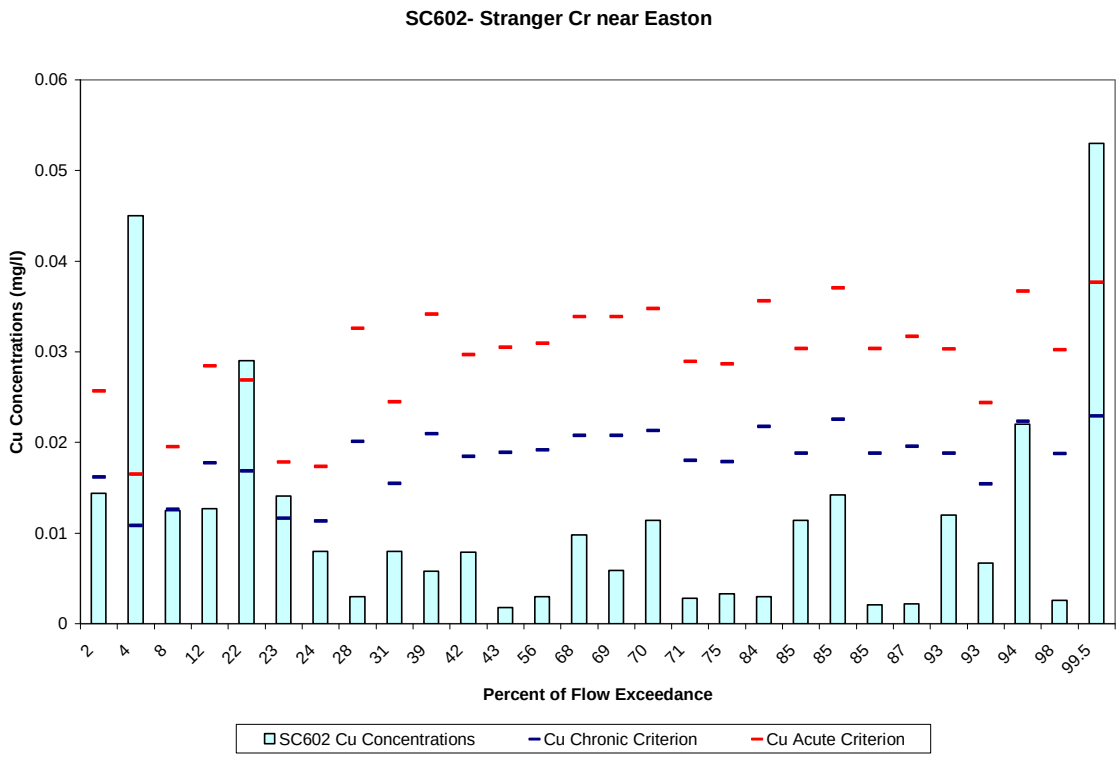
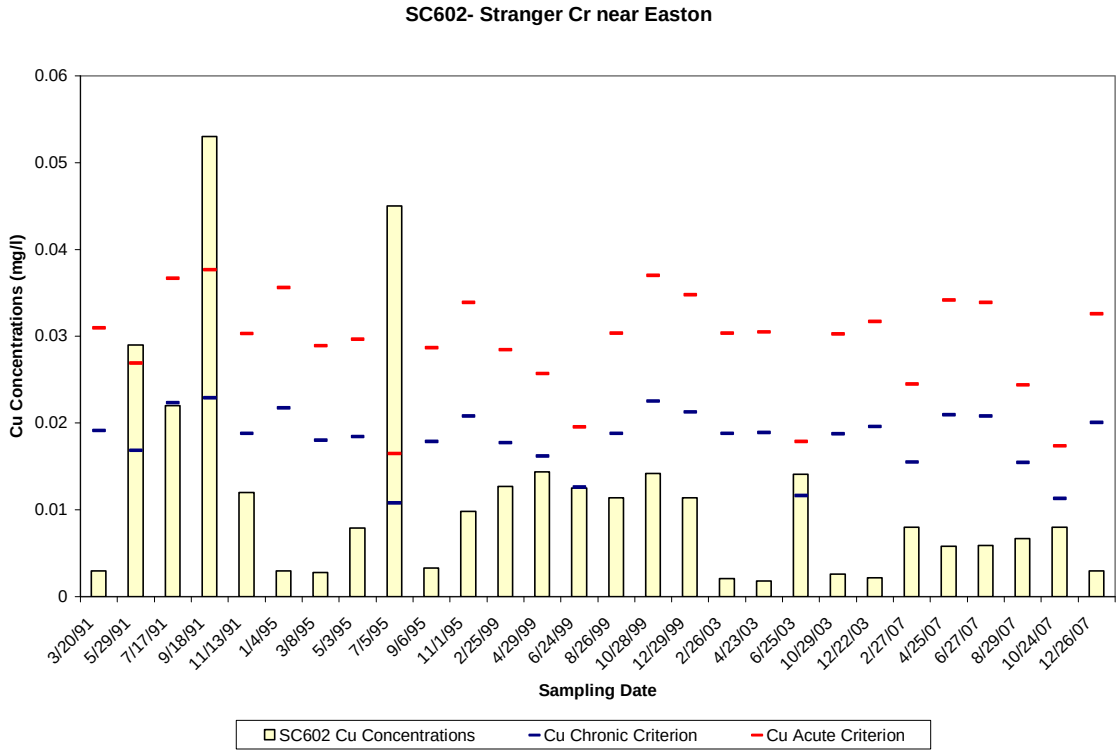


Figure 5. Sample and criterion copper concentrations at S602 relative to sampling date.



Pb excursions on Stranger Creek at SC501 occur throughout all seasons. Approximately 22% of the total samples violate the Pb criterion at SC501. Of the impaired samples, 80% of these occurred during high flow conditions and almost 30% of the impaired samples occur during the very high flow conditions in the spring season. Pb violations have occurred less frequently than the 1990s, as seen in Figure 7, however a violation occurred as recently as 2008. The 7-day flow condition preceding each Pb impaired sample was also assessed. All of the twenty-two impaired samples had an unstable flow condition within this 7-day period prior to the sampling date and were influenced by runoff events.

Table 5. Seasonal summary of Pb violations in relation to the respective percent exceedance flow range for station SC501.

Number of Samples Over Lead Chronic Aquatic Life Criterion by Flow							
Station	Season	0 - 10%	11 - 25%	26 - 75%	75 - 90%	91 - 100%	Cum. Freq.
Stranger Cr near Linwood - SC501	Spring	6	1	0	0	0	7/25 = 28%
	Sum-Fall	3	1	4	0	0	8/38 = 21%
	Winter	4	3	0	0	0	7/38 = 18%

Figure 6. Lead sample and criterion concentrations relative to flow condition. The red up down bars note non-compliant samples and the blue up down bars illustrate compliant samples.

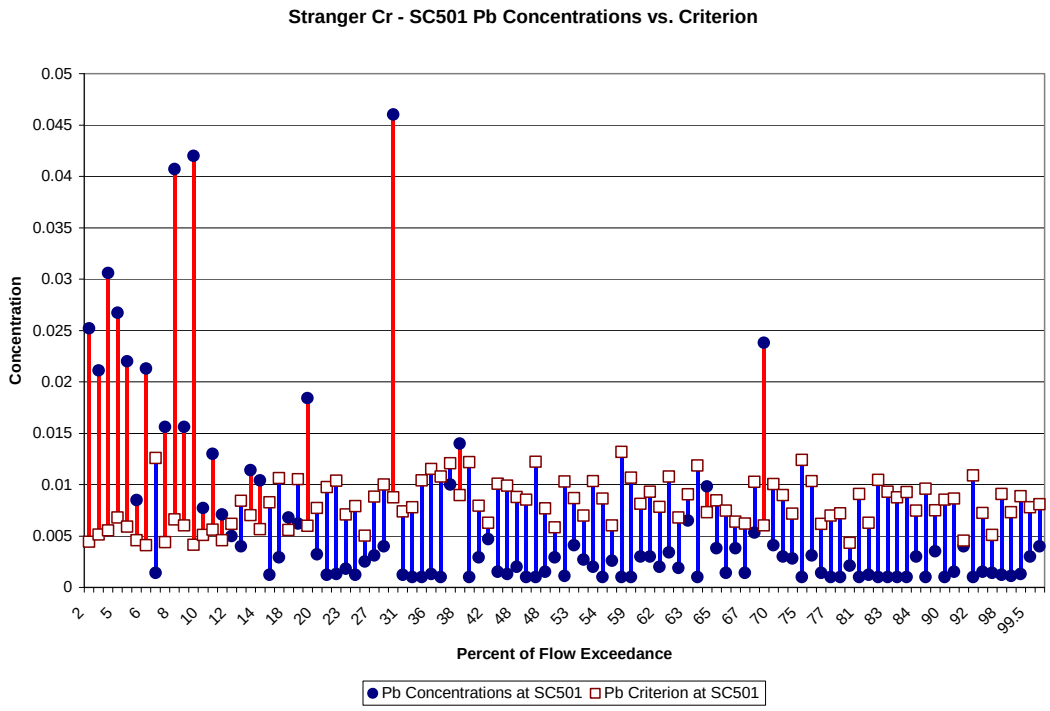
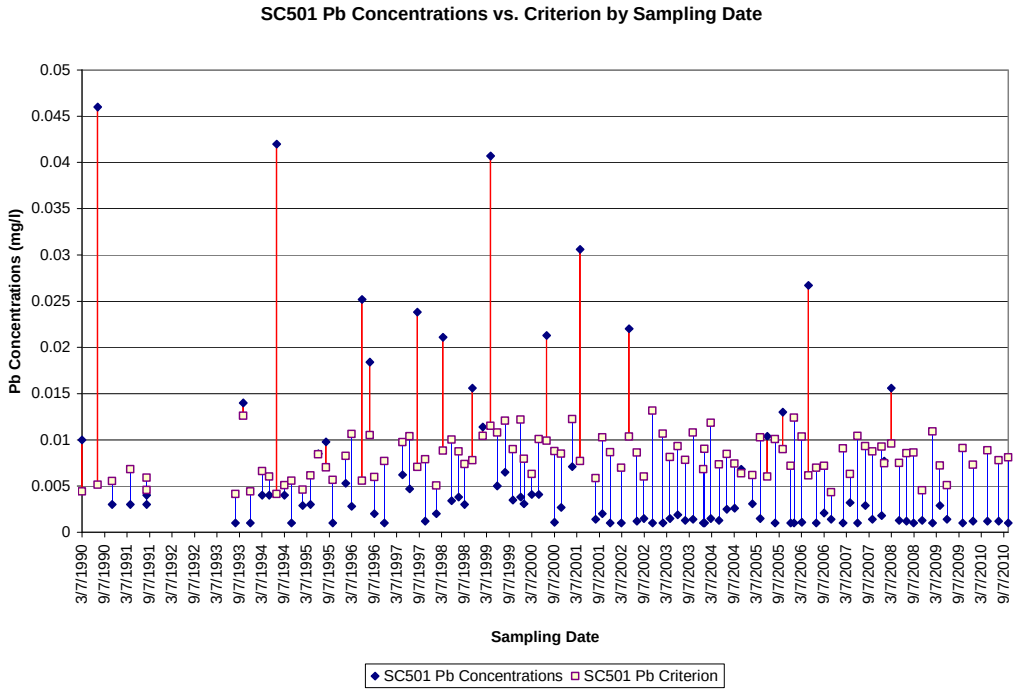


Figure 7. Sample and criterion lead concentrations relative to sampling date. Red up down bars illustrated non-compliant samples and blue up down bars illustrate compliant samples.



Station SC680 on Ninemile Creek has a total of four Pb excursions, two of which occurred during high flows during the spring and two that occurred during lower flow conditions during the summer-fall season. Since there is not a flow gage on Ninemile Creek the estimated flow condition for the specific sampling dates may not be reflective of the actual condition, which may be the case with violations that occurred during the low flow condition. There were no violations observed during the winter months at SC680. The Pb violations on Ninemile Creek were all detected during the sampling years of 1997 and 2001 as seen in Figure 9. For the sampling years of 2005 and 2009 there were no Pb violations and all but two of the samples were above the detection limit.

Table 6. Seasonal summary of Pb violations in relation to the respective percent exceedance flow range for station SC680.

Number of Samples Over Lead Chronic Aquatic Life Criterion by Flow							
Station	Season	0 - 10%	11 - 25%	26 - 75%	75 - 90%	91 - 100%	Cum. Freq.
Ninemile Cr – SC680	Spring	2	0	0	0	0	2/8 = 25%
	Sum-Fall	0	0	1	0	1	2/7 = 29%
	Winter	0	0	0	0	0	0/7 = 0%

Figure 8. Sample and criterion lead concentration relative to flow condition.

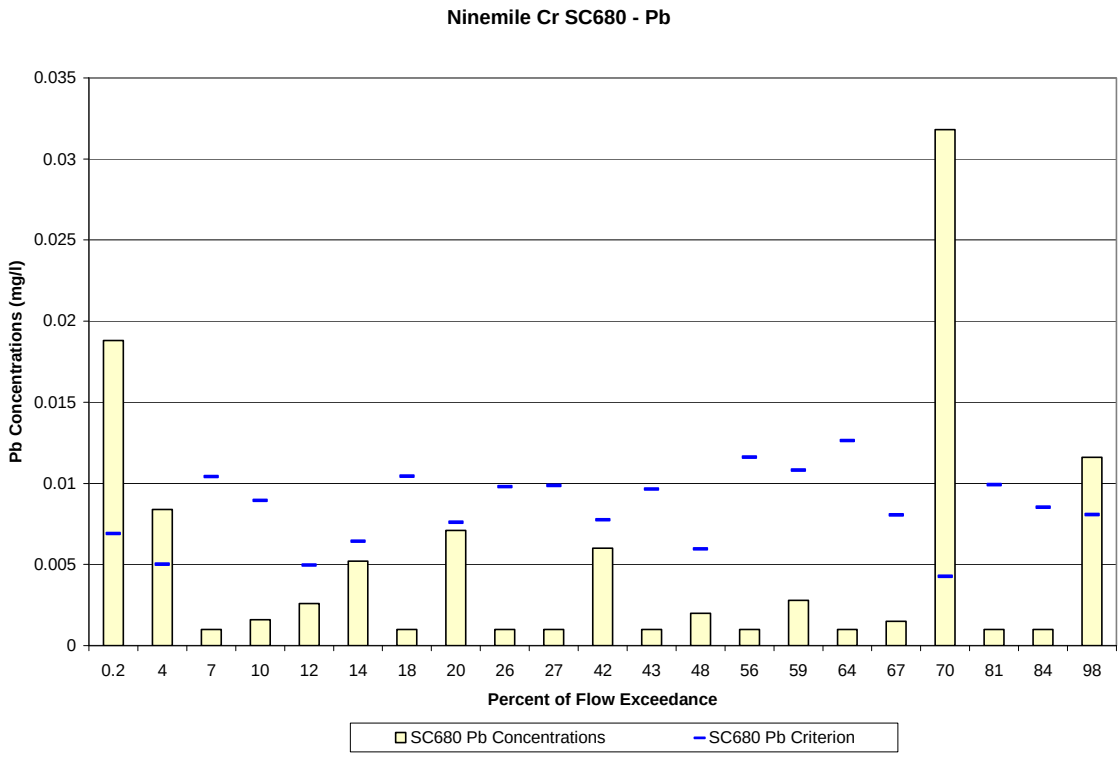
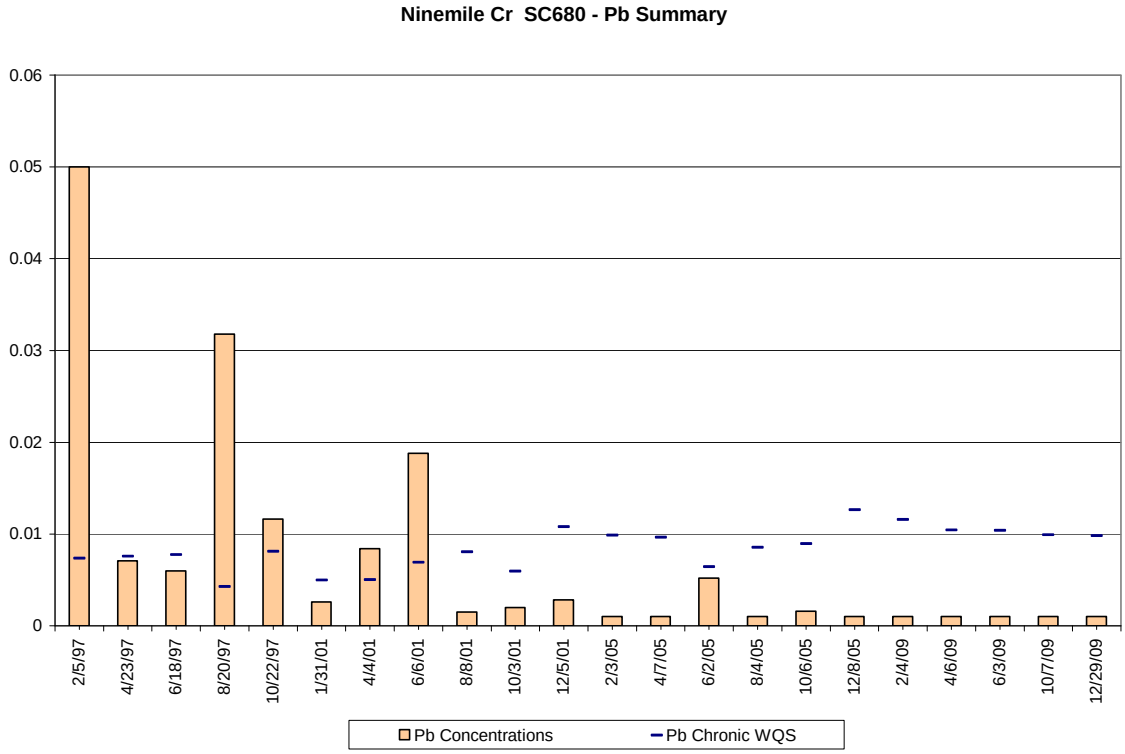


Figure 9. Sample and criterion lead concentrations relative to sampling date.



Desired Endpoints of Water Quality (Implied Load Capacity) for the Stranger Creek Watershed: The ultimate endpoint for this TMDL will be to achieve the chronic lead Kansas Water Quality Standard fully supporting aquatic life for KDHE sampling stations SC602, SC501 and SC680. In addition, for KDHE sampling station SC602 the endpoint will be the achievement of the chronic and acute copper Kansas Water Quality Standard fully supporting aquatic life. Excursions in the Stranger Creek watershed appear to be related to flow condition, rather than seasonality. However, seasonal variation is accounted for in this TMDL since the endpoint accounts for all flow conditions throughout the year.

This endpoint will be achieved as a result of improvements in the riparian buffers within the watersheds as a result of expected, though unspecified, reductions in sediment loading from the watershed resulting from implementation of corrective actions and best management practices as directed by this TMDL. Achievement of this endpoint will provide full support of the aquatic life function within the Stranger Creek watershed and attain the respective lead and copper water quality standards

3.0 SOURCE INVENTORY AND ASSESSMENT

Land Use: The land cover in the Stranger Creek watershed includes 52% grassland, 22% cropland, 18% forest, 6% developed, and 2% openwater/wetlands. Landuse for Stranger Creek watershed is detailed in Figure 10.

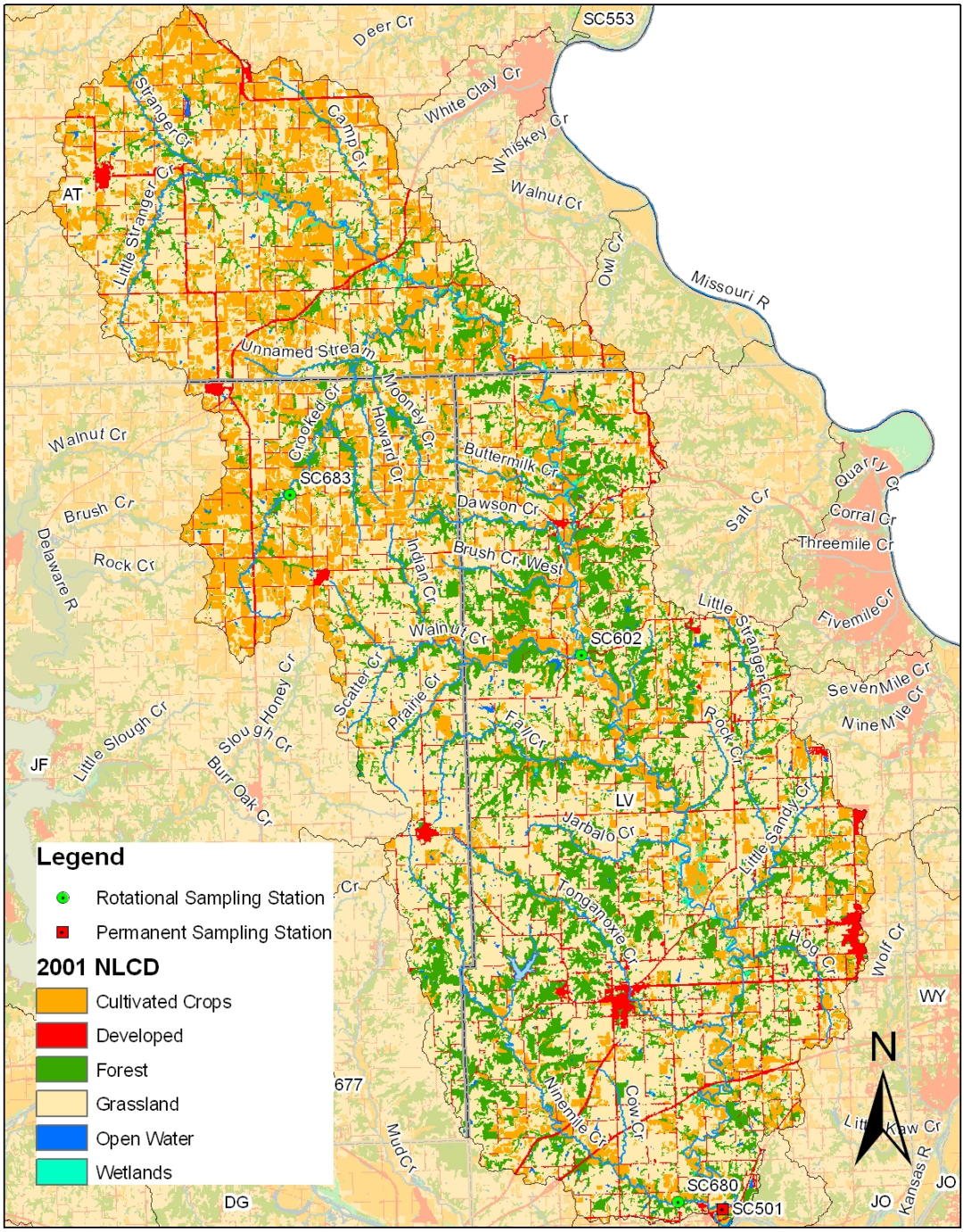
Point Sources: There are a total of 25 NPDES permitted facilities in the watershed, of which there are 11 discharging municipal wastewater dischargers. Of the other 14 facilities, there are nine non-discharging facilities and five quarry facilities that do not regularly discharge (see Appendix A). Three of the quarry facilities have no discharge on record, and two of them report a couple of discharges per year. The quarry facilities do not contribute to the copper or lead loads within the watershed. The municipal discharging facilities are detailed in Table 7.

Table 7. Discharging NPDES wastewater facilities in the Stranger Cr watershed.

Permit Number	Facility Name	Federal NPDES #	Downstream Station	Permit Expires	Receiving Stream	**Design Flow (MGD)**
M-KS04-OO03	Leavenworth Co. S.D. #5	KS0090522	SC501	12/31/2011	Hog Cr	**0.03**
M-KS04-OO04	Leavenworth Co. S.D. #1	KS0086835	SC501	1/31/2011	Little Sandy Cr	**0.026**
M-KS04-OO07	Basehor, City of	KS0094382	SC501	12/31/2011	Hog Cr	**1.12**
M-KS13-OO01	Easton, City of	KS0047261	SC602	1/31/2011	Stranger Cr	**0.0345**
M-KS15-OO01	Effingham, City of	KS0047279	SC602	12/31/2012	Unnamed Trib	**0.107**
M-KS29-OO01	Lancaster, City of	KS0024864	SC602	3/31/2011	N.Fork of Stranger Cr	**0.043**
M-KS36-OO01	Linwood, City of	KS0047481	SC501	12/15/2015	Ninemile Cr	**0.0573**
M-KS42-OO01	McLouth, City of	KS0025704	SC680	6/30/2011	Ninemile Cr	**0.184**
M-KS71-OO02	Tonganoxie, City of	KS0093092	SC501	12/31/2011	Tonganoxie Cr	**0.75**
M-KS50-OO01	Nortonville, City of	KS0047562	SC602	9/30/2011	Crooked Cr	**0.0735**
M-KS84-OO01	Winchester, City of	KS0047511	SC602	3/31/2011	Crooked Cr	**0.103**

The population in the watershed is approximately 21,450 people, according to census block information from the 2000 census. The population density in the watershed is approximately 40 people per square mile. Population projections for the municipalities in the watershed indicate slight population growth, with the exception of an estimated significant growth rate of approximately 40% population increase for the cities of McLouth and Tonganoxie by the year 2030. It appears the treatment systems in the watershed have additional capacity available to accommodate some growth. Since the majority of the excursions appear during higher flow conditions, point source impacts appear to be minimal in the watershed.

Figure 10. Stranger Creek Watershed Landuse Map (NLCD, 2001).



Livestock Waste Management Systems: There are 17 active certified or permitted confined animal feeding operations (CAFOs) within the Stranger Creek watershed (see Appendix A). 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. It is not anticipated that livestock operations contribute to the lead impairment in the watershed. However, livestock may attribute to the copper impairment in the upper Stranger Creek watershed as copper sulfate is commonly used for treatment and nutrition of livestock.

Contributing Runoff: The watershed of Stranger Creek has a mean soil permeability value of 0.5 inches/hour according to NRCS STATSGO database. According to a USGS open-file report (Juracek, 2000), the threshold soil-permeability values that represents very high, high, moderate, low, very low, and extremely low rainfall intensity, were set at 3.43, 2.86, 2.29, 1.71, 1.14, and 0.57”/hour, respectively. The lower rainfall intensities generally occur more frequently than the higher rainfall intensities. The higher soil-permeability thresholds imply a more intense storm during which areas with higher soil permeability potentially may contribute runoff. Runoff is chiefly generated as infiltration excess with rainfall intensities greater than the soil permeability. As soil profiles become saturated, excess overland flow is produced. For the Stranger Creek watershed, approximately 42% of the watershed will produce runoff with rainfall events that produce 0.57 inches/hour of rain. Over 96% of the entire watershed has a low soil permeability value and will produce runoff with rainfall events that produce 1.71 inches/hour of rain. Runoff contributes to the lead and copper impairment within the watershed.

Nonpoint Sources: The lead impairment in the Stranger Creek watershed is likely associated with nonpoint sources. The lead impairment is most likely due to erosion from cropland that is adjacent to streams within the watershed. Lead attached to soil particles from exposed land is prone to runoff during rain events that produce runoff. Common lead sources are attributed to lead based paint, leaded gasoline, and lead dust in the air. Lead will remain in the soil for prolonged periods once it is deposited and does not readily move through the soil (Rosen, 2002). Source assessments utilized to identify lead contamination sources is difficult since lead may remain in the environment for long periods of time.

The copper impairment in the upper portions of Stranger Creek is likely associated with nonpoint sources. Copper may originate from roads and highways, urban areas, livestock facilities and agriculture lands. Some automobile brake pads are a source of copper as are some building products such as plumbing, wiring, and paints (Boulanger and Nikolaidis, 2003). Copper may be associated with the use of copper sulfate, which is used for treatment and nutrition of livestock, at livestock facilities. Copper is also widely used in fertilizers, particularly for the application to soybean crops to correct copper deficiencies, and copper-based pesticides are widely used in the United States (Avery, 2001). Thus, agricultural and livestock applications could contribute to the primary source of the copper impairment in the upper portions of Stranger Creek.

Background: Background levels of lead and copper are derived from geological sources and detectable concentrations are naturally present in the soil. Lead or copper attached to silt becomes suspended during high flow events as soil bank erosion occurs.

4.0 ALLOCATION OF POLLUTION REDUCTION RESPONSIBLITY

The cubic regression between the chronic aquatic life criterion load for the observed samples at the respective stations and the flow exceedance establishes the TMDL for lead in the Stranger Creek watershed (see Appendix B). In addition, this same approach was utilized to establish the copper TMDL for SC602 in the upper Stranger Creek watershed. As seen in Figures 11a, 12a, and 14a, the total hardness values within the watershed generally are lower during higher flow conditions and tend to rise during lower flow conditions. Therefore, the lead and copper water quality criterions tend to be more restrictive and decrease as streamflows increase.

Point Sources: Since the lead violations in the Stranger Creek watershed are generally not associated with the low flow conditions, it is conceivable that point sources are not contributing to the lead impairment. Regardless, a Wasteload Allocation (WLA) of 0.134 lbs/day of lead has been established at SC501 for discharging point sources in the watershed. The Wasteload Allocation for lead was conservatively established by setting the chronic lead criteria for the point source discharges based on the total hardness value of 208 mg/l. This total hardness value is conservatively based on the median total hardness value at the 75-99.9% flow exceedance condition since point sources are not expected to contribute to the lead impairment. The respective lead WLA for SC602 and SC680 are detailed in Tables 9 and 11.

Upper Stranger Creek has a WLA of 0.057 lbs/day of copper at station SC602. The copper WLA was established by setting the chronic copper criteria for the point source discharges above station SC602 based on the total hardness value of 227 mg/l. Similarly, this total hardness value is based on the median total hardness value at the 75-99.9% flow exceedance condition at SC602. Establishing the WLA based on the chronic criteria calculation establishes a lower and more conservative WLA than if the acute criteria calculation was utilized. Therefore, the more conservative WLA applies to both the established chronic and acute TMDL.

The WLA for each of the CAFO and NPDES facilities is detailed in Appendix A. All non-discharging facilities and CAFOs have a WLA of 0 lbs/day.

Nonpoint Sources: The TMDL assigned to the watersheds for the impaired stations within the Stranger Creek watershed are illustrated in Figures 11b, 12b, 13 and 14b. The TMDL load duration curve for each sampling station has been developed with a cubic regression based on the log transgression of the observed sample criterion load for each data set collected at the respective stations. The specific Load Allocations for various flow conditions at each sampling station is detailed in Tables 8, 9, 10 and 11.

Figure 11a. Stranger Cr SC501 Total Hardness and Flow relationship.

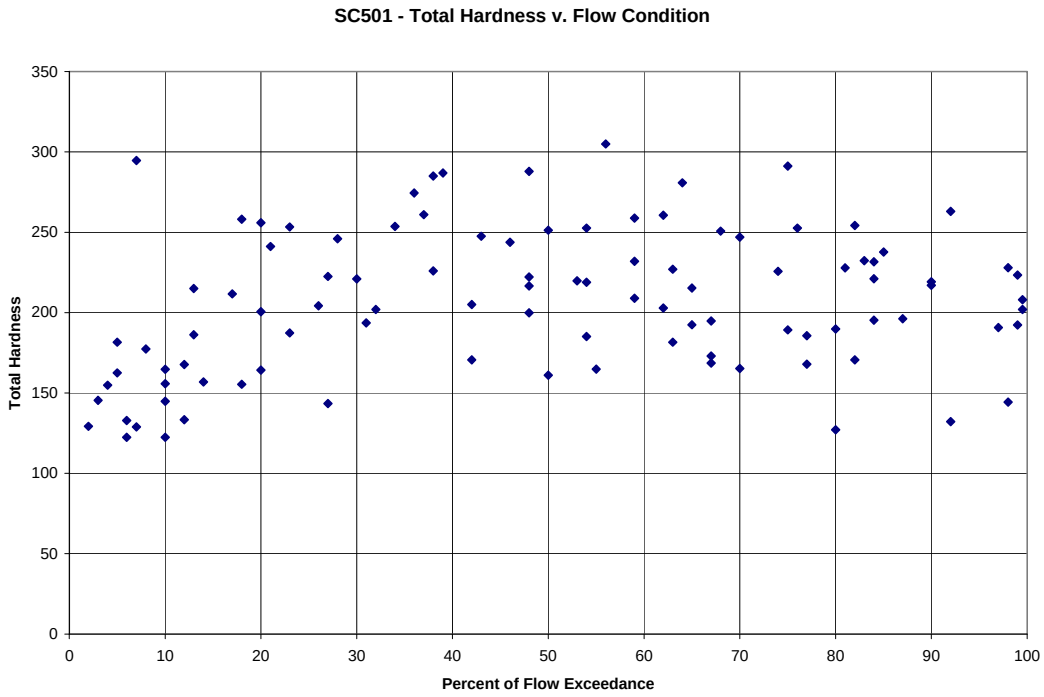


Figure 11b. Stranger Creek SC501 Pb TMDL.

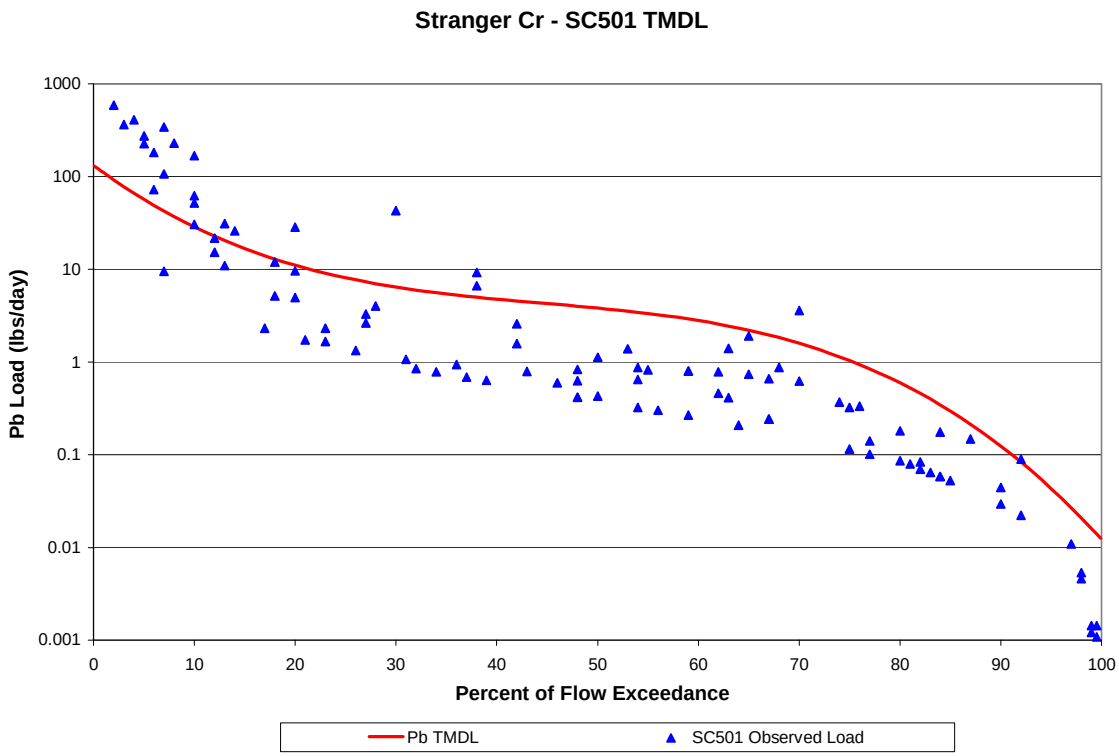


Table 8. Lead TMDL for Station SC501 on Stranger Creek near Linwood.

% Flow Exceedance	Flow (cfs)	Load Allocation (lbs/day)	MOS (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)
10%	735.5	25.615	2.861	0.134	28.61
25%	215.8	7.129	0.807	0.134	8.07
50%	72.0	3.295	0.381	0.134	3.81
75%	21.3	0.802	0.104	0.134	1.04
Average Flow	398.0	14.086	1.58	0.134	15.8

Figure 12a. Total Hardness concentrations relative to Flow condition at SC602

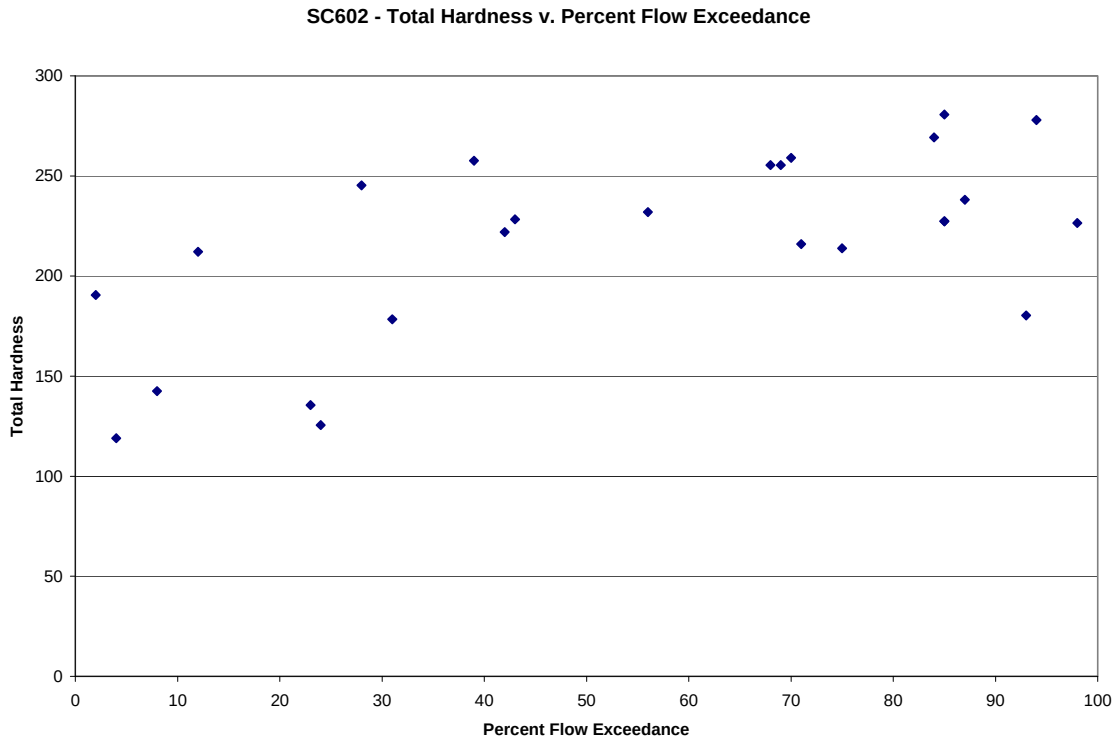


Figure 12b. Stranger Cr SC602 Lead TMDL.

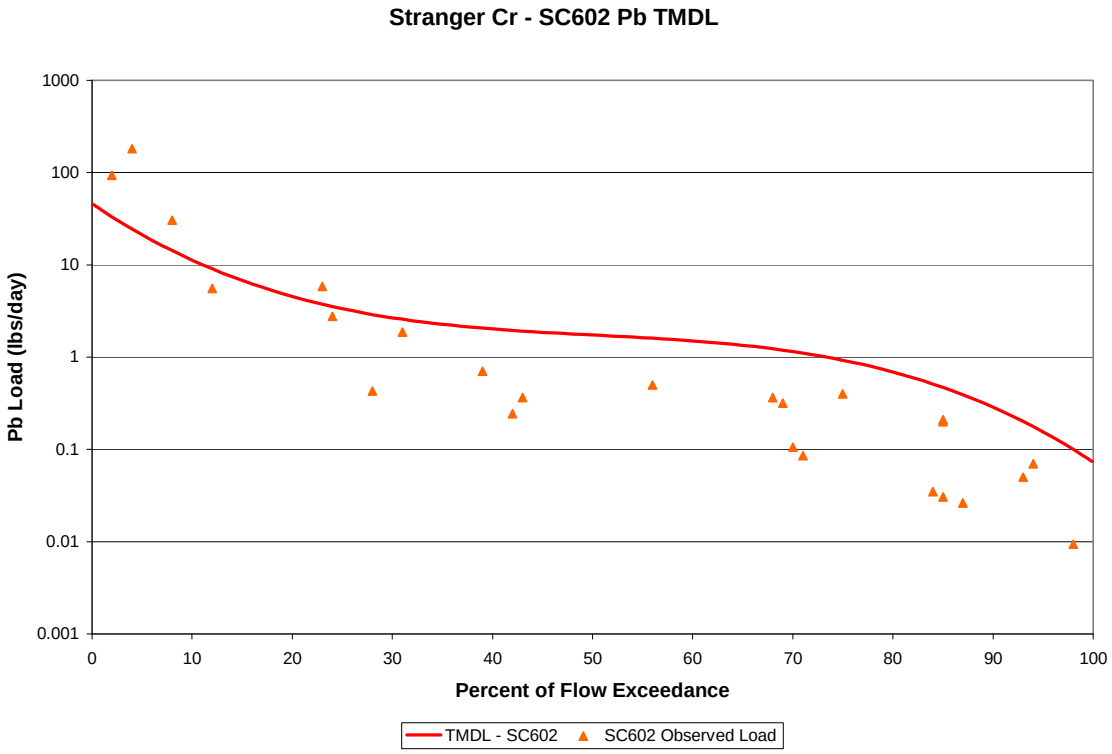


Table 9. Lead TMDL for Station SC602 on Stranger Creek near Easton

% Flow Exceedance	Flow (cfs)	Load Allocation (lbs/day)	MOS (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)
10%	259.71	10.106	1.13	0.0244	11.26
25%	90.39	2.986	0.34	0.0244	3.35
50%	37.13	1.546	0.17	0.0244	1.74
75%	13.44	0.816	0.09	0.0244	0.93
90%	3.87	0.236	0.03	0.0244	0.29
Average Flow	188.4	7.356	0.82	0.0244	8.20

Figure 13. Copper TMDL for Stranger Creek at SC602.

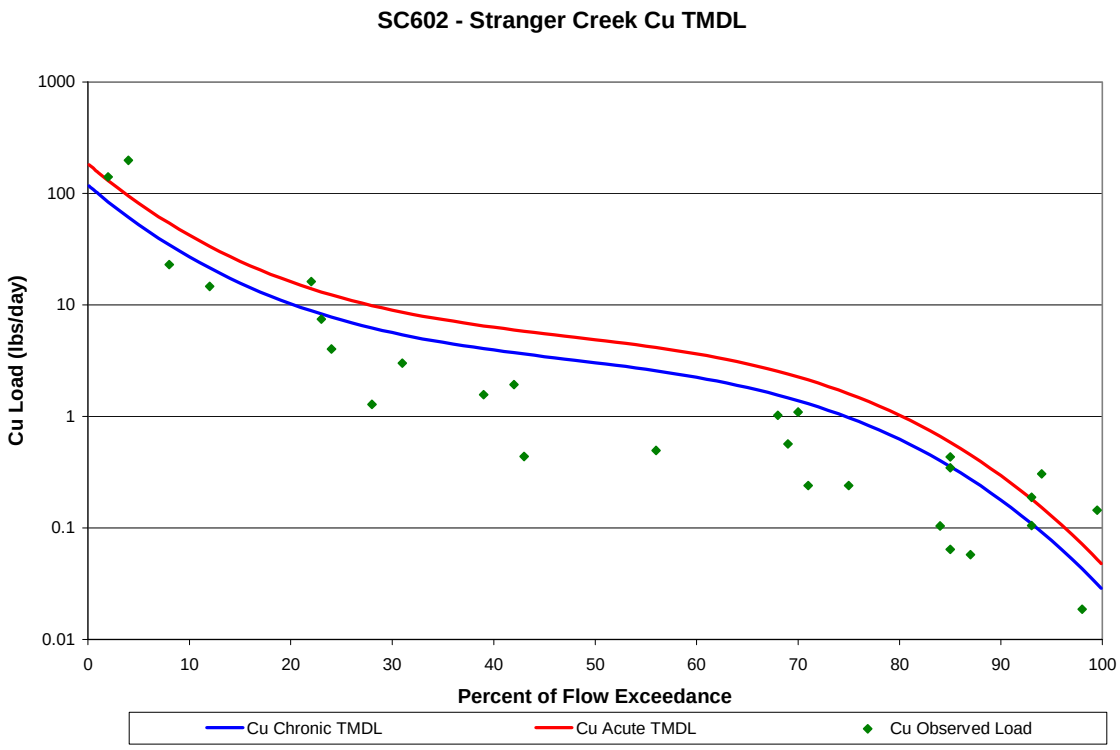


Table 10. Copper TMDL for Station SC602 on Stranger Cr near Easton.

% Flow Exceedance	Flow (cfs)	Load Allocation (lbs/day)		MOS (lbs/day)		WLA (lbs/day)	TMDL (lbs/day)	
		Chronic	Acute	Chronic	Acute		Chronic	Acute
10%	259.71	24.263	37.953	2.70	4.22	0.057	27.02	42.23
25%	90.39	6.543	10.383	0.73	1.16	0.057	7.33	11.60
50%	37.13	2.683	4.353	0.30	0.49	0.057	3.04	4.90
75%	13.44	0.823	1.383	0.10	0.16	0.057	0.98	1.60
90%	3.87	0.103	0.203	0.02	0.03	0.057	0.18	0.29
Average Flow	188.4	17.313	27.123	1.93	3.02	0.057	19.3	30.2

Figure 14a. Total Hardness values relative to flow condition at SC680.

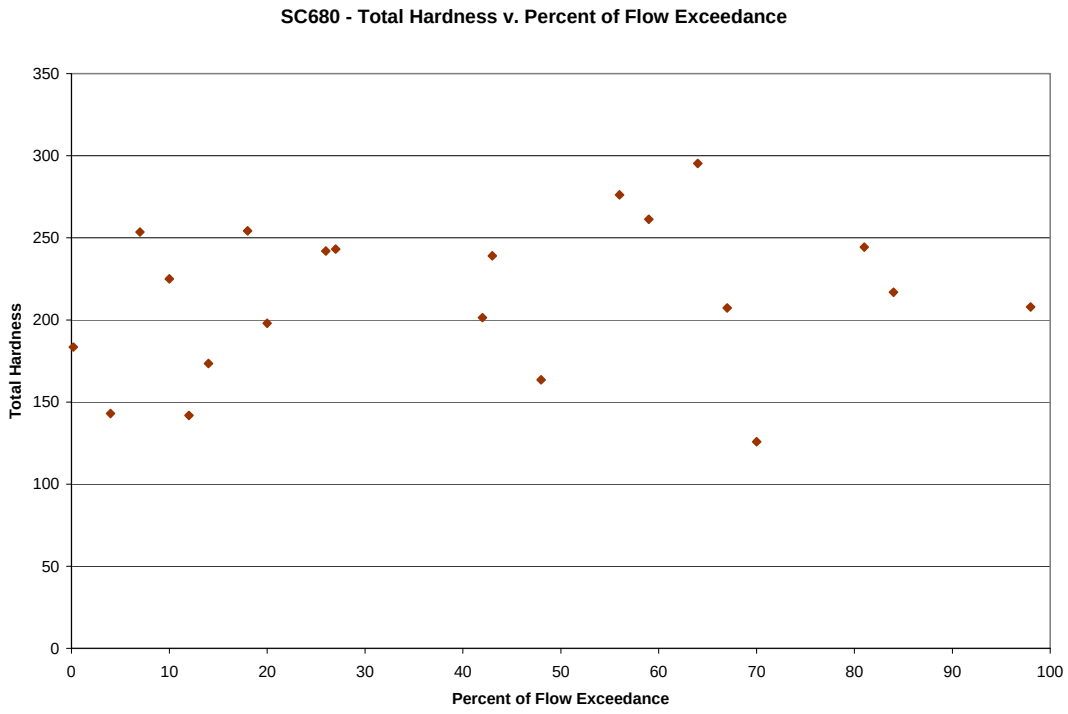


Figure 14b. Lead TMDL at SC680 on Ninemile Creek.

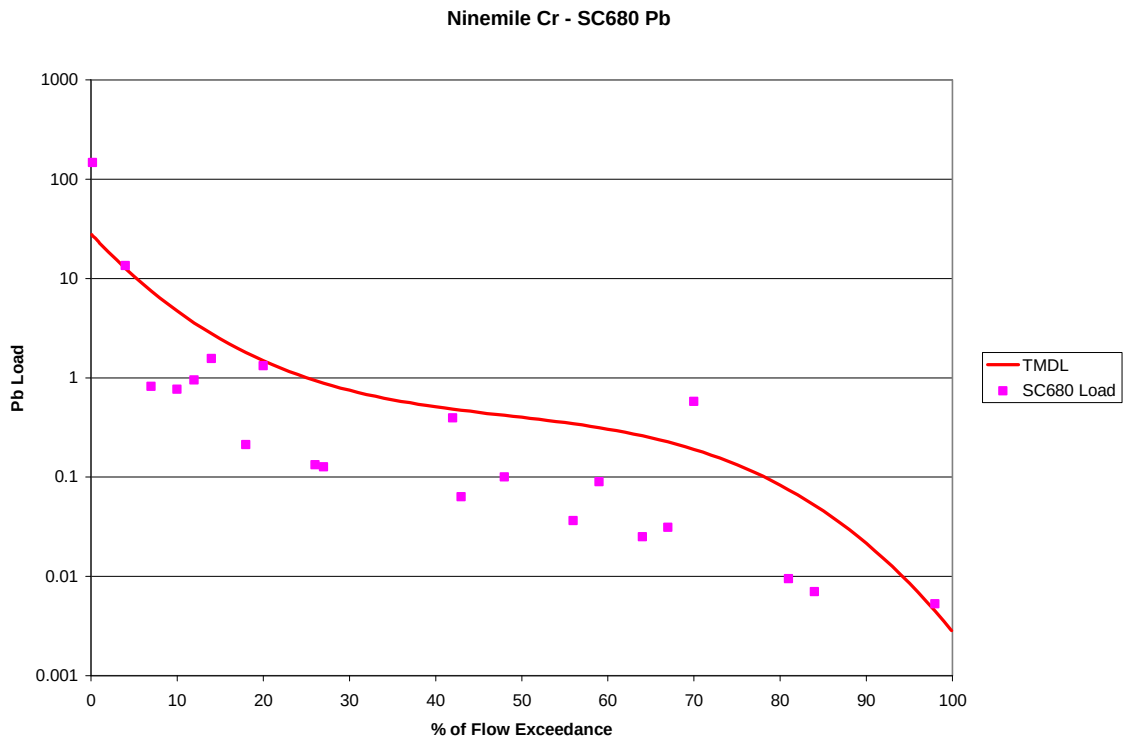


Table 11. Lead TMDL for SC680 on Ninemile Creek.

% Flow Exceedance	Flow (cfs)	Load Allocation (lbs/day)	MOS (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)
10%	88.37	4.227	0.471	0.0124	4.71
25%	25.94	0.897	0.101	0.0124	1.01
50%	8.65	0.348	0.04	0.0124	0.40
75%	2.56	0.105	0.013	0.0124	0.13
90%	0.66	0.006	0.002	0.0124	0.02
Average Flow	47.9	2.058	0.23	0.0124	2.30

Defined Margin of Safety: The margin of safety is explicit and provides some hedge against the uncertainty of daily allocated loading. The margin of safety will be 10% of the load capacity under all flow conditions for lead in the Stranger Creek watershed (SC602, SC680 & SC501) and for copper in the upper Stranger Creek watershed (SC602).

State Water Plan Implementation Priority: Because of the relevant low frequency and magnitude of any recent lead or copper excursions seen in the Stranger Creek watershed, this TMDL will be a Low Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Lower Kansas Subbasin (HUC8: 10270104) with a priority ranking of 1 (Highest Priority for restoration work).

Priority HUC12s and Stream Segments: Because of the lack of certainty regarding potential sources and naturally occurring background concentration in the watershed, no priority subwatershed or stream segment will be identified.

5.0 IMPLEMENTATION

Desired Implementation Activities

1. Identify sources of copper and lead in the watershed and in stormwater runoff.
2. Install grass buffer strips where needed along streams.
3. Educate land owners of copper-containing chemicals that may pose a concern.

Implementation Programs Guidance

Nonpoint Source Pollution Technical Assistance-KDHE

a. Support Section 319 demonstration projects for reduction from streambank erosion, sediment runoff, and livestock operations.

b. Provide technical assistance on practices geared to the establishment of vegetative buffer strips.
c. Coordinate and support the Lower Kansas WRAPS group to incorporate a long-term plan to comprehensively reduce the loading and delivery of sediment in the Stranger Creek watershed.

Riparian Protection Program – SCC

a. Establish or re-establish natural riparian systems, including vegetative filter strips along small tributaries.

Buffer Initiative Program – SCC

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

Timeframe for Implementation: Continued monitoring over the years from 2012 to 2020.

Milestone for 2015: 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 to review data from the Stranger Creek watershed to assess continued incidence of high lead and copper.

Delivery Agents: The primary delivery agents for program participation will be the Kansas Department of Health and Environment and the Lower Kansas WRAPS teams. Implementation decisions and scheduling will be guided by planning documents prepared through the Lower Kansas WRAPS.

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

1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

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

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

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

6. The *Kansas Water Plan* and the Kansas-Lower Republican Basin Plan provide guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant reduction activities in the state through the Kansas Water Plan. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund programs supporting water quality protection through the WRAPS program. This watershed and its TMDL are a Low Priority consideration.

Effectiveness: Buffer strips are publicized as a means to filter sediment before it reaches a stream and riparian restoration project have been acclaimed as a significant means of stream bank stabilization. The key to effectiveness is participation within a targeted area to direct resources to the activities influencing water quality.

6.0 MONTITORING

KDHE will continue to collect samples through 2020 at the permanent station SC501 on a quarterly or bimonthly basis every year. Samples for the rotational stations, SC680 and SC602, will continue to be sampled bimonthly every fourth year. The next scheduled sampling year for SC602 is tentatively scheduled in 2011 and SC680 is projected to be sampled in 2013.

7.0 FEEDBACK

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

Public Hearing: A Public Hearing on the Kansas Lower Republican TMDLs was held on August 31, 2011 in Topeka to receive comments on this TMDL. No comments were received by KDHE regarding this TMDL.

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, June 16, 2011 in Lawrence, and September 29, 2011 in Topeka.

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

Milestone Evaluation: In 2015, evaluation will be made as to the degree of impairment continuing to occur 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 2015 with consultation from local stakeholders and WRAPS teams.

Consideration for 303(d) Delisting: Stranger Creek will be evaluated for delisting under section 303(d), based on the monitoring data over 2011-2020. 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 2012, which will emphasize implementation of WRAPS activities. At that time, incorporation of this TMDL will be made into the WRAPS. Recommendation of this TMDL will be considered in the Kansas Water Plan implementation decisions under the State Water Planning Process for Fiscal Years 2011-2020.

Revised April 13, 2012

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Appendix A. Confined Animal Feeding Operations NPDES Facilities in the Stranger Creek watershed.

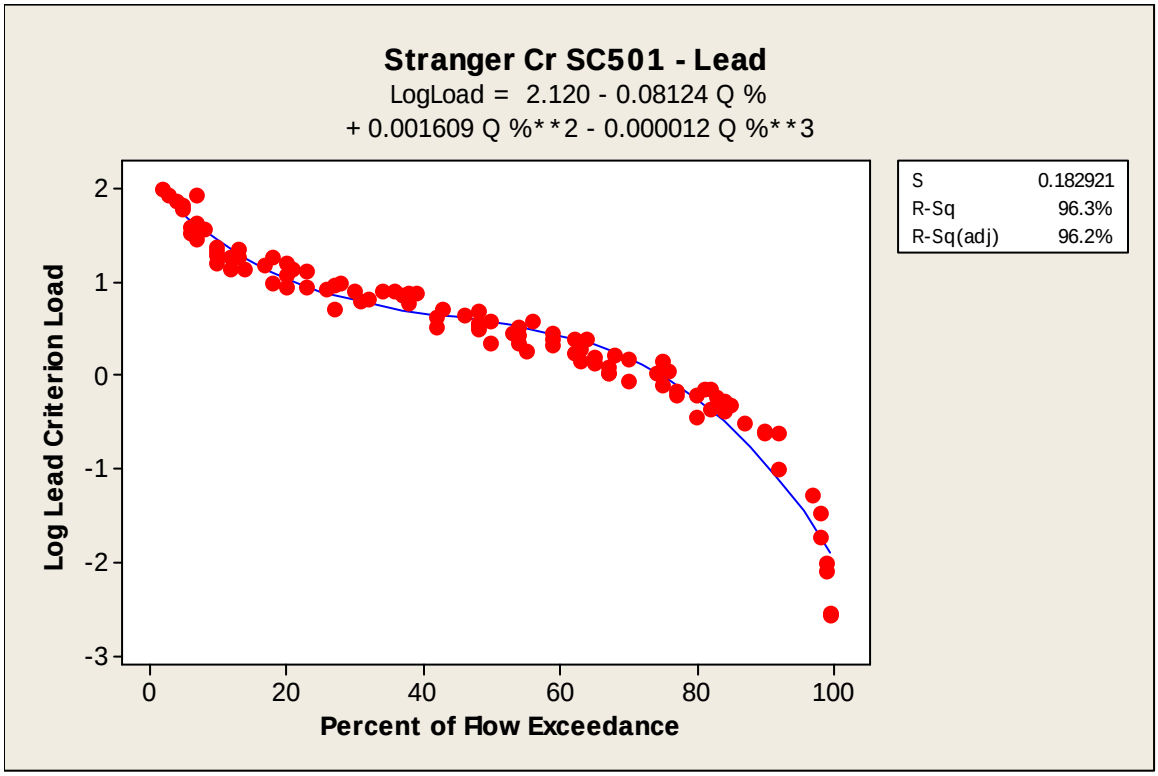
Confined Animal Feeding Operations in the Stranger Cr watershed.

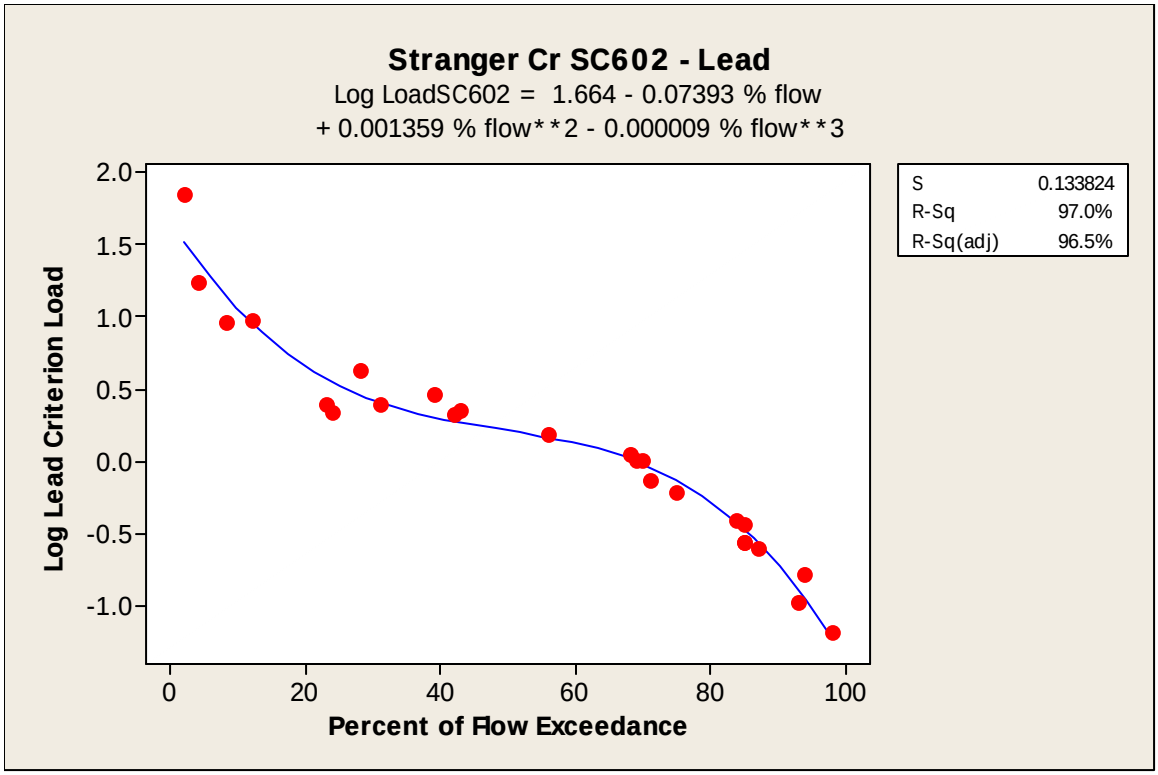
Permit Number	County	Animal Total	Type	Pb WLA (lbs/day)	Cu WLA (lbs/day)
A-KSAT-MA12	Atchison	50	Dairy	0	0
A-KSJF-SA02	Jefferson	350	Swine	0	0
A-KSJF-MA01	Jefferson	70	Dairy	0	0
A-KSLV-M005	Leavenworth	280	Dairy	0	0
A-KSLV-M001	Leavenworth	490	Dairy	0	0
A-KSLV-SA01	Leavenworth	200	Swine	0	0
A-KSLV-S013	Leavenworth	700	Swine	0	0
A-KSLV-MA06	Leavenworth	45	Dairy	0	0
A-KSLV-S017	Leavenworth	266	Swine,Beef	0	0
A-KSJF-S020	Jefferson	340	Swine	0	0
A-KSLV-M003	Leavenworth	166	Dairy	0	0
A-KSLV-MA13	Leavenworth	30	Dairy	0	0
A-KSLV-M007	Leavenworth	256	Dairy	0	0
A-KSLV-MA14	Leavenworth	80	Dairy	0	0
A-KSLV-M004	Leavenworth	650	Dairy	0	0
A-KSAT-BA01	Atchison	150	Beef	0	0
A-KSAT-SA02	Atchison	572	Swine	0	0

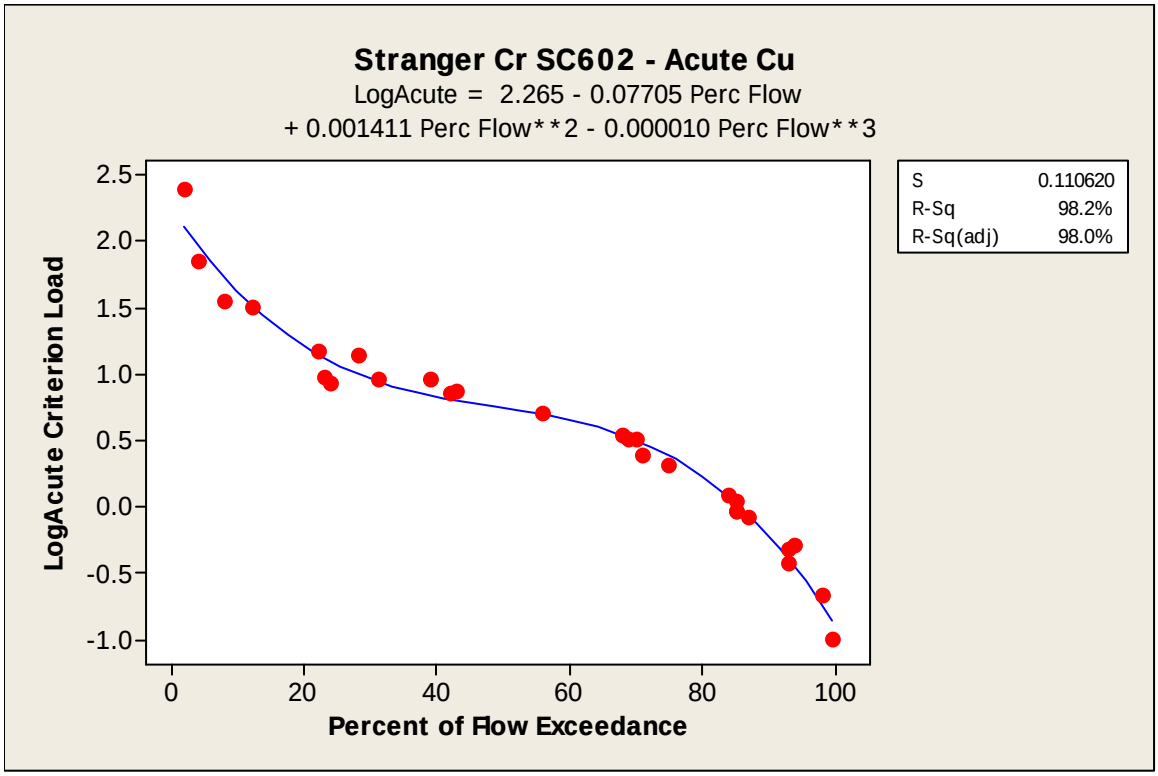
NPDES Permitted Facilities in the Stranger Creek Watershed.

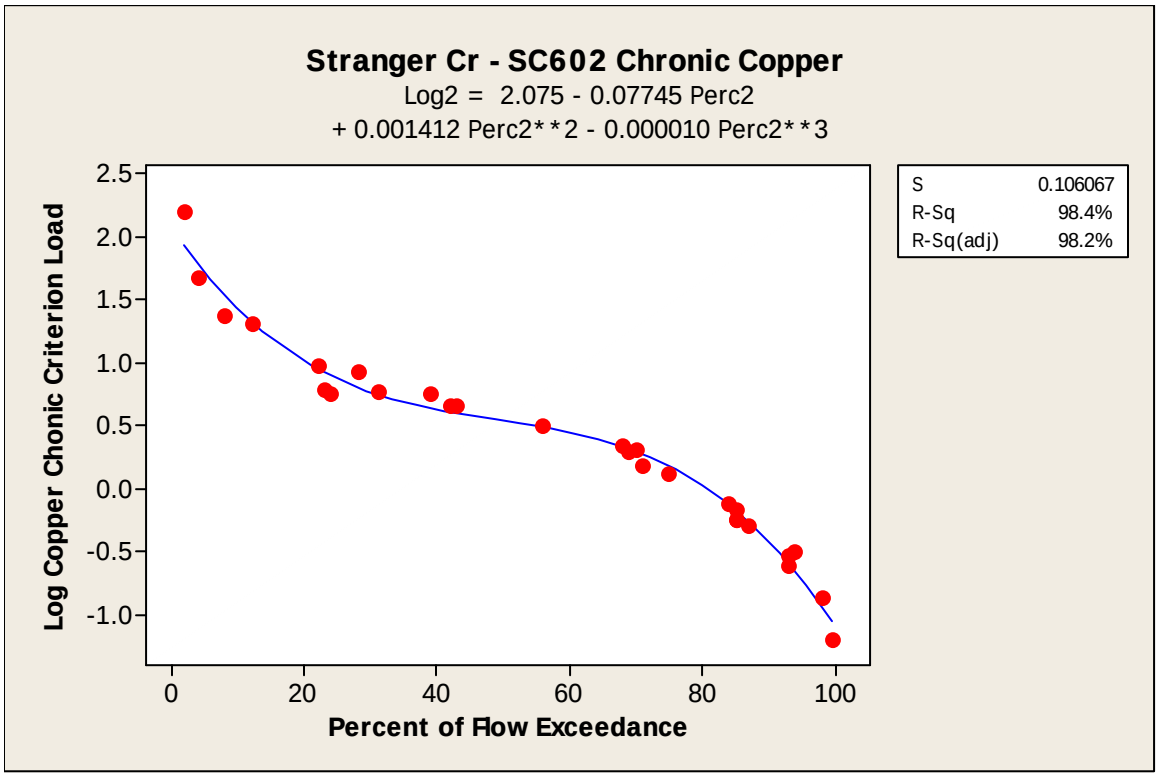
Permit Number	Facility Name	Federal NPDES #	Type	**Design Flow (MGD)**	Pb WLA (lbs/day)	Cu WLA (lbs/day)
M-KS04-OO03	Leavenworth Co. S.D. #5	KS0090522	Lagoon	**0.03**	0.002	NA
M-KS04-OO04	Leavenworth Co. S.D. #1	KS0086835	Lagoon	**0.026**	0.0018	NA
M-KS04-OO07	Basehor, City of	KS0094382	Mechanical	**1.12**	0.0756	NA
M-KS36-OO01	Linwood, City of	KS0047481	Lagoon	**0.0573**	0.0039	NA
M-KS71-OO02	Tonganoxie, City of	KS0093092	Mechanical	**0.75**	0.0506	NA
M-KS13-OO01	Easton, City of	KS0047261	Lagoon	**0.0345**	0.0023	0.0054
M-KS15-OO01	Effingham, City of	KS0047279	Lagoon	**0.107**	0.0072	0.0168
M-KS29-OO01	Lancaster, City of	KS0024864	Lagoon	**0.043**	0.0029	0.0068
M-KS50-OO01	Nortonville, City of	KS0047562	Lagoon	**0.0735**	0.0050	0.0115
M-KS84-OO01	Winchester, City of	KS0047511	Lagoon	**0.103**	0.0070	0.0162
M-KS42-OO01	McLouth, City of	KS0025704	Lagoon	**0.184**	0.0124	NA
C-KS04-NO04	HOLY-FIELD VINEYARD & WINERY	KSJ000125	Non-discharging	NA	0	0
C-KS04-NO05	TRINITY LUTHERAN CHURCH	KSJ000630	Non-discharging	NA	0	0
C-KS13-NO03	HILLTOP MARKET	KSJ000623	Non-discharging	NA	0	0
C-KS36-NO02	ALEX R. MASSON, INC.	KSJ000171	Non-discharging	NA	0	0
C-KS71-NO01	PARADISE MOBILE HOME PARK	KSJ000571	Non-discharging	NA	0	0
C-KS71-NO02	CAMP MOUNT HERMON	KSJ000195	Non-discharging	NA	0	0
C-KS71-NO03	EARTH RISING/GAEA RETREAT CENTER	KSJ000169	Non-discharging	NA	0	0
C-KS96-NO01	SUNCATCHER LAKE & RV RESORT	KSJ000105	Non-discharging	NA	0	0
I-KS13-PO02	HAMM - PENNINGTON #66	KS0118486	Treated Washwater / Stormwater	NA	0	0
I-KS13-PO04	LARKIN EXCAVATIN - EASTON QUARRY	KS0099538	Stormwater Runoff	NA	0	0
I-KS50-PO01	HAMM - MOONEY CREEK #83	KS0081604	Pit Watering / Stormwater Runoff	NA	0	0
I-KS71-PO03	HAMM - TONGANOXIE QRY #15	KS0088439	Pit Watering / Stormwater Runoff	NA	0	0
I-KS96-PO01	HAMM - LEAVENWORTH #17	KS0117358	Treated Washwater / Stormwater	NA	0	0

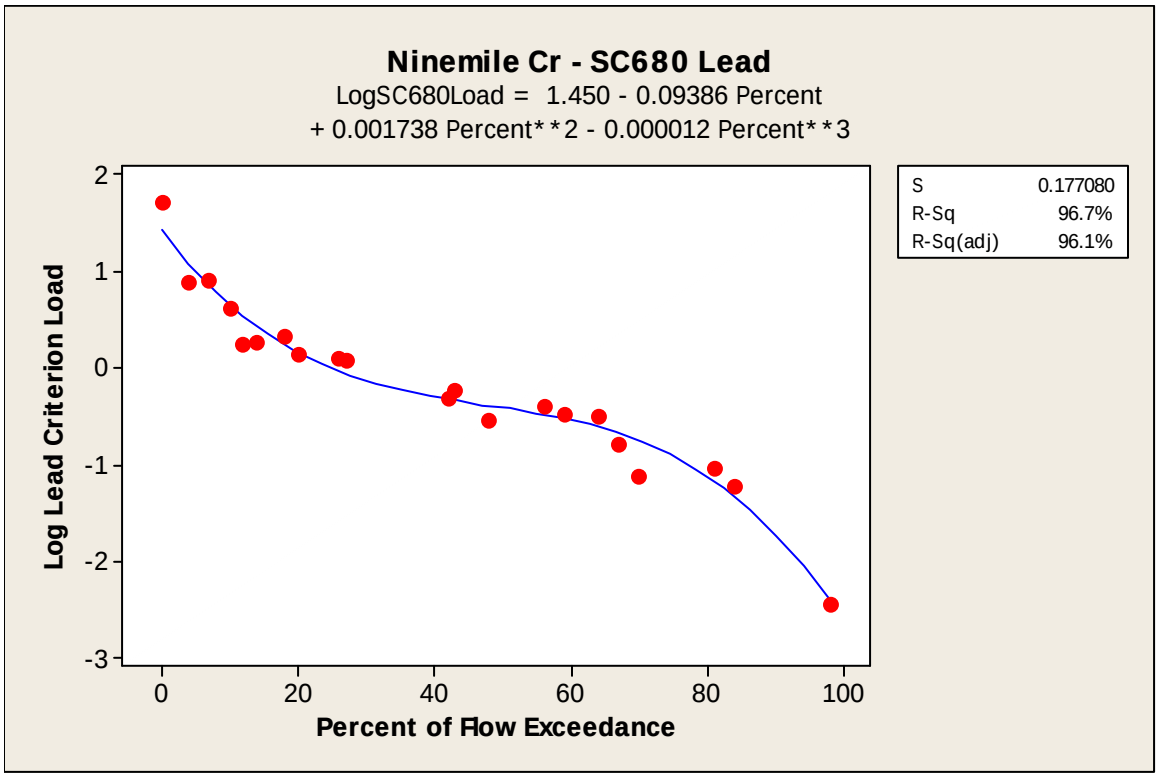
Appendix B. TMDL Cubic Regression Figures.






Stranger Cr SC602 - Acute Cu
LogAcute = 2.265 - 0.07705 Perc Flow
+ 0.001411 Perc Flow**2 - 0.000010 Perc Flow**3
S 0.110620
R-Sq 98.2%
R-Sq(adj) 98.0%
LogAcute Criterion Load
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
0
20
40
60
80
100
Percent of Flow Exceedance


Stranger Cr - SC602 Chronic Copper
Log2 = 2.075 - 0.07745 Perc2
+ 0.001412 Perc2**2 - 0.000010 Perc2**3
S 0.106067
R-Sq 98.4%
R-Sq(adj) 98.2%
Log Copper Chonic Criterion Load
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
0
20
40
60
80
100
Percent of Flow Exceedance


Ninemile Cr - SC680 Lead
LogSC680Load = 1.450 - 0.09386 Percent
+ 0.001738 Percent**2 - 0.000012 Percent**3
S 0.177080
R-Sq 96.7%
R-Sq(adj) 96.1%
Log Lead Criterion Load
Percent of Flow Exceedance
2
1
0
-1
-2
-3
0
20
40
60
80
100