UPPER ARKANSAS BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody/Assessment Unit: Walnut Creek
Water Quality Impairment: Selenium

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Upper and Lower Walnut Creek

Counties: Scott, Lane, Ness, Pawnee, Rush and Barton

HUC 8: 11030007 HUC 10 (12): 01 (01, 02, 03, 04, 05, 06, 07)
02 (01, 02, 03, 04, 05, 06, 07)
03 (01, 02, 03, 04, 05, 06, 07)

HUC 8: 11030008 HUC 10 (12): 01 (01, 02, 03, 04, 05, 06, 07, 08)
02 (01, 02, 03, 04, 05, 06, 07)
03 (01, 02, 03, 04)

Ecoregions: Western High Plains, Flat to Rolling Cropland (25d)
Central Great Plains, Wellington-McPherson Lowland (27d)

Drainage Area: Approximately 1,716 square miles

Main Stem Water Quality Limited Segments:

Main Stem	Tributaries	
Walnut Creek (2)	Sand Creek (3)	
	Dry Creek (14)	
	Boot Creek (15)	
Walnut Creek (4)	Otter Creek (12)	
Walnut Creek (5)	Sandy Creek (11)	
Walnut Creek (6)	Alexander Dry Creek (7)	
Walnut Creek (8)	Bazine Dry Creek (9)	
Walnut Creek (10)	N. F. Walnut Creek (1)	Wild Horse Creek (4)
	N. F. Walnut Creek (5)	M. F. Walnut Creek (7)
	N. F. Walnut Creek (6)	
	S. F. Walnut Creek (10)	Darr Creek (12)

Designated Uses for Main Stem Walnut Creek:
Walnut Creek (2, 4): Expected Aquatic Life, Primary Contact Recreation Class C, Drinking Water Supply, Food Procurement, Groundwater Recharge, Industrial Water Use, Irrigation Use and Livestock Watering Use; Walnut Creek (5, 6): Expected Aquatic Life, Secondary Contact Recreation Class b; Drinking Water Supply, Food Procurement Use, Groundwater Recharge, Industrial Water Use, Irrigation Use and Livestock Watering Use; Walnut Creek (8, 10): Expected Aquatic Life, Secondary Contact Recreation Class b; Drinking Water Supply, Food Procurement, Groundwater Recharge, Industrial Water Use, Irrigation Use and Livestock Watering Use. Designated uses for tributaries in the Walnut Creek watershed are detailed in Table 1.

Table 1. Designated uses for the tributaries in the Walnut Creek watershed.

Tributary	Segment #	Expected Aquatic Life	Contact Recreation	Drinking Supply	Food Procurement	Ground Water Recharge	Industrial Water Use	Irrigation Use	Livestock Watering Use
HUC 8: 11030008									
Alexander Dry Cr	7	Y	b	Y	Y	Y	Y	Y	Y
Bazine Dry Cr	9	Y	b	N	N	N	N	N	N
Boot Cr	15	Y	b	N	N	Y	N	Y	Y
Dry Cr	14	Y	b	N	Y	Y	Y	Y	N
Otter Cr	12	Y	C	Y	Y	Y	Y	Y	Y
Sand Cr	3	Y	b	Y	Y	Y	Y	Y	Y
Sandy Cr	11	Y	b	Y	N	Y	Y	Y	Y
HUC 8: 11030007									
Darr Cr	12	Y	b	N	Y	N	N	N	N
M. F. Walnut Cr	7	Y	b	N	Y	Y	N	N	N
N. F. Walnut Cr	1	Y	b	Y	Y	Y	Y	Y	Y
N. F. Walnut Cr	5	Y	b	Y	Y	Y	Y	Y	Y
N. F. Walnut Cr	6	Y	b	Y	Y	Y	Y	Y	Y
S. F. Walnut Cr	10	Y	b	Y	Y	Y	Y	Y	Y
Wild Horse Cr	4	Y	b	N	Y	Y	N	N	Y

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

303(d) Listings: Station SC595, Walnut Creek near Ness City, Selenium (Se) Impairment: 2002, 2004, 2008 and 2010 Upper Arkansas River Basin Streams.

Station SC596, Walnut Creek near Alexander, Selenium (Se)

Impairment: 2002, 2004, 2008, 2010 Upper Arkansas River Basin Streams.

Station SC597, Walnut Creek near Heizer, Selenium (Se) Impairment: 2010 Upper Arkansas Basin Streams.

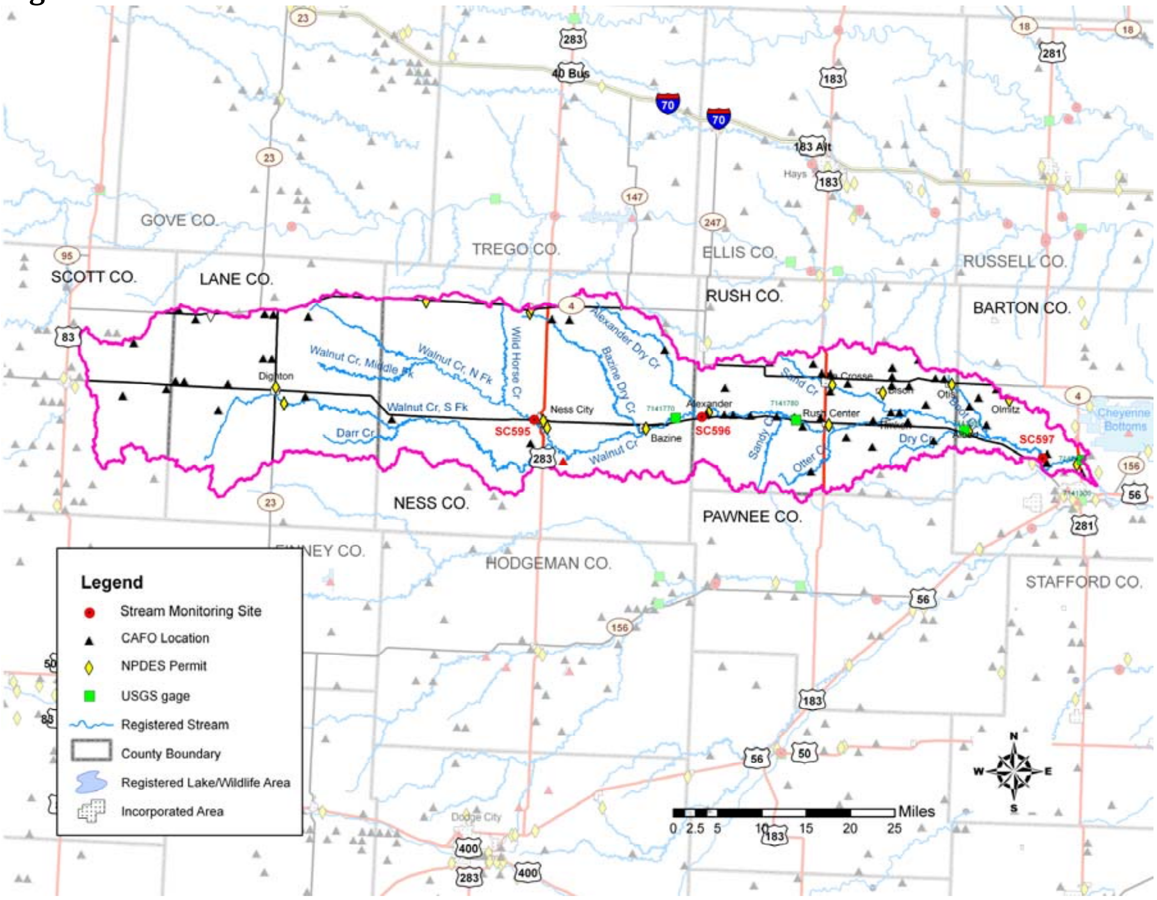
Impaired Use: Expected Aquatic Life Support, Groundwater Recharge

Water Quality Standard: 5 µg/liter for Chronic Aquatic Life

In stream segments where background concentrations of naturally occurring substances, including chlorides and sulfates, exceed the water quality criteria listed in table 1a of the "Kansas surface water quality standards: tables of numeric criteria," as adopted by reference in subsection (d) of this regulation, at ambient flow, the existing water quality shall be maintained, and the newly established numeric criteria shall be the background concentration, as defined in K.A.R. 28-16-28b(e). Background concentrations shall be established using the methods outlined in the "Kansas implementation procedures: surface water quality standards," as defined in K.A.R. 28-16-28b(gg), and available upon request from the department. (KAR 28-16-28e(b)(9)).

In surface waters designated for the groundwater recharge use, water quality shall be such that, at a minimum, degradation of ground water quality does not occur. Degradation shall include any statistically significant increase in the concentration of any chemical or radiological contaminant or infectious microorganism in ground water resulting from surface water infiltration or injection. (K.A.R. 28-16-28e(c) (5)).

Figure 1. Walnut Creek Watershed.



2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Use under 2012 303(d): Not Supporting Aquatic Life.

Stream Monitoring Sites and Periods of Record:
Station SC595: Active KDHE permanent station located on Walnut Creek ½ mile west of US 283 on K 96 highway near Ness City. Period of Record: 1990-2011.

Station SC596: Active KDHE permanent station located on Walnut Creek 1.0 mile west and ¼ mile north of Alexander on county road BR. Period of Record: 1990-2011

Station SC597: Active KDHE permanent station located 2.0 miles east of Heizer on county road BR. Period of Record: 1990-2011.

Flow Record: USGS Gage 07141780 (1990-1994) and USGS Gage 07141770 (1994-2011) on Walnut Creek were used to establish flow conditions at KDHE sampling sites SC595 and SC596. A regression calculation utilizing the common period for the gages from 1994-2011 was developed to calculate 1990-1994 flow values for USGS Gage 07141770. The ratio of the watershed area at USGS Gage 07141770 to the watershed area at each of the KDHE sampling sites SC595 and SC596 was then used to generate flow values at sites SC595 and SC596. Flow values for KDHE sampling site SC597 were estimated using the ratio of the watershed area at USGS Gage 07141900 to watershed area at SC597.

Flow Conditions: Long term flow conditions for the USGS gages used to estimated flow at KDHE sampling stations are shown in Table 2.

Table 2. Long Term Flow for Walnut Creek at USGS Gages 07141770 (1994-2011) and 07141900 (1990-2011) in units of cubic feet per second (cfs) (Perry, et al., 2004).

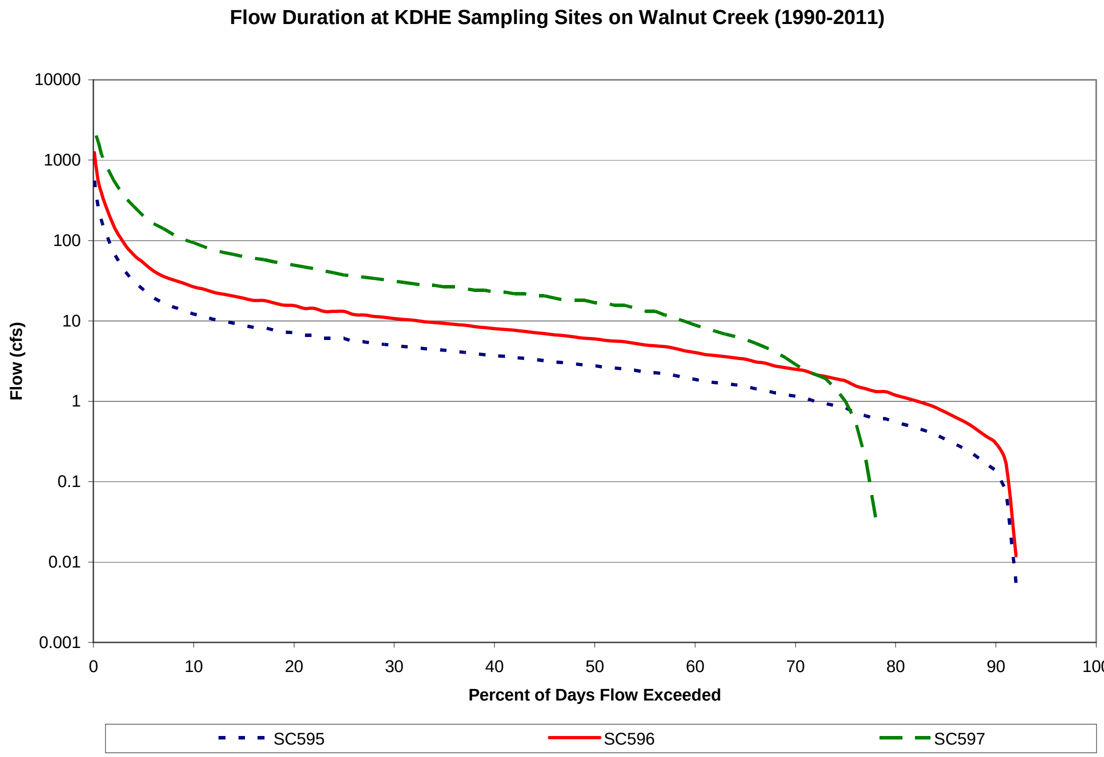
Stream Name	Drainage Area (mi^2)	Mean Flow	90%	75%	50%	25%	10%
USGS 07141770 Walnut Cr near Alexander	1,025	15.2	0.77	2.2	5.3	10.0	19.0
USGS 07141900 Walnut Cr at Albert	1,410	49.3	0	0.82	14.0	31.0	78.0

The average flow in Walnut Creek increases substantially as it moves from Ness City to Heizer (Table 3) due to an increase in base flow and in the magnitude and frequency of high flow events in the creek near Heizer (Figure 2). However, flow in the creek is also subject to intermittent periods of little or no flow influenced by declining groundwater levels, regional irrigation and extended dry periods in the watershed. In order to address the declining groundwater levels in the watershed and at the same time ensure flow to the Cheyenne Bottoms Wetland in east-central Barton County, the portion of the watershed situated in Ness, Rush and Barton counties was identified as an Intensive Groundwater Use Control Area (IGUCA) by the Kansas Department of Agriculture in 1992. The establishment of the IGUCA in the watershed closed the area to further ground and surface water appropriations and limits ground water allocations to 22,700 acre-feet per year (KDA, 1992).

Table 3. Estimated flows in Walnut Creek at KDHE stream chemistry stations for the period of record.

Station	Drainage Area (mi^2)	Mean Flow	90%	75%	50%	25%	10%
SC595 Walnut Cr at Ness City	565	9.51	0.14	0.83	2.76	6.06	12.2
SC596 Walnut Cr nr Alexander	1,223	20.6	0.30	1.79	5.97	13.1	26.4
SC597 Walnut Cr nr Heizer	1,698	59.3	0	0.99	16.9	37.3	93.9

Figure 2. Flow duration on Walnut Creek at Ness City (SC595), Alexander (SC596) and Heizer (SC597) for the period of record.



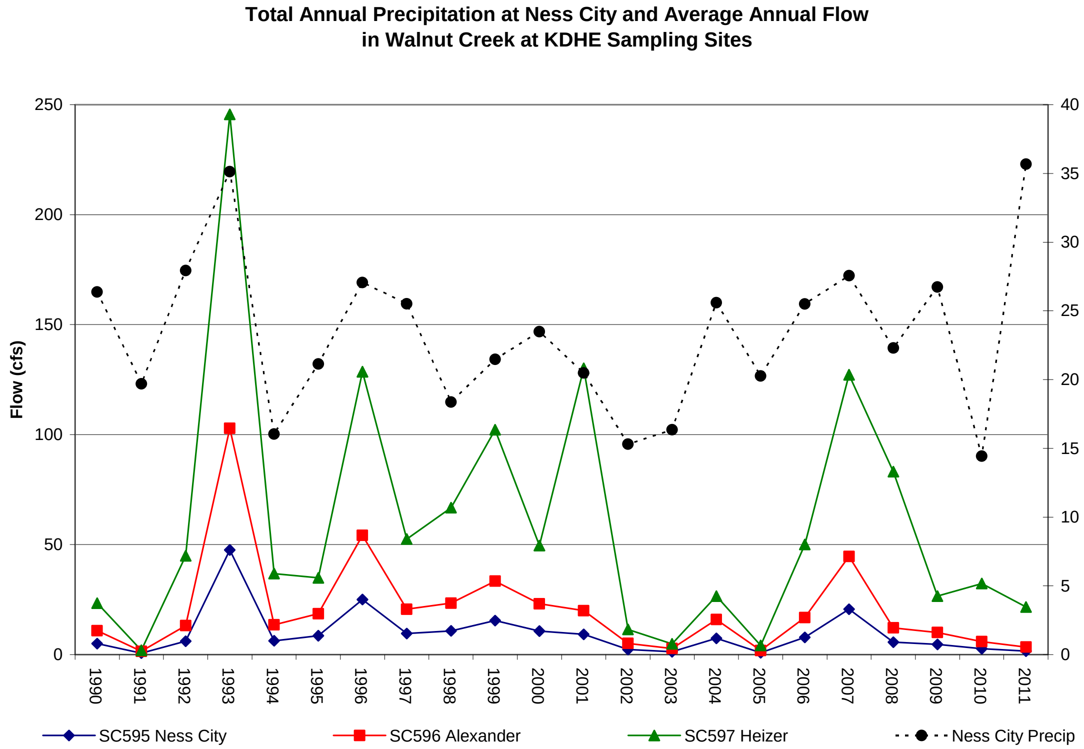
The headwaters of Walnut Creek are the North, Middle and South Forks of Walnut Creek located in Lane County. Tributaries to the creek flow less than 10% of the time while main stem Walnut Creek at the confluence of the North Fork and South Fork in Ness County is dry about 50% of the time with an average flow of 17.6 cfs (Table 4). Walnut Creek maintains flow at an average of 57.7 cfs as it reaches its confluence with the Arkansas River in Barton County.

Table 4. Long term estimated flows for Walnut Creek and its tributaries (Lane, Ness, Rush & Barton Counties, Perry et al., 2004).

Stream (USGS Site ID #)	County	Drainage Area (mi^2)	Flow (cfs)						
			Mean	90%	75%	50%	25%	10%	2-year Peak
N.F. of M.F. Walnut Creek (2667)	Lane	73.3	0.34	0	0	0	0	0	348
M.F. Walnut Creek (2736)	Lane/Ness	224	3.70	0	0	0	0	0.42	569
S.F. Walnut Creek (2865)	Lane/Ness	272	3.81	0	0	0	0	0.45	653
Darr Creek (2900)	Lane/Ness	55.8	0.41	0	0	0	0	0	362
M.F. Walnut Creek (2735)	Ness	241	4.41	0	0	0	0	1.21	603
Wild Horse Creek (2785)	Ness	52.9	0.64	0	0	0	0	0	304
N.F. Walnut Creek (2908)	Ness	531	12.4	0	0	0.48	3.67	10.5	679
S.F. Walnut Creek (2976)	Ness	461	8.65	0	0	0	1.71	5.73	856
Walnut Creek (2936)	Ness	1,000	17.6	0	0	0.50	7.00	17.3	909
Bazine Creek (2876)	Ness	91.7	1.94	0	0	0	0	0	426
Alexander Dry Creek (2818)	Ness/Rush	84.7	2.22	0	0	0	0	0	462
Walnut Creek (2836)	Ness/Rush	1,340	22.5	0	0	0.73	10.9	25.6	993
Sandy Creek (2983)	Rush	75.9	2.59	0	0	0	0	0.10	550
Otter Creek (2982)	Rush	38.5	1.44	0	0	0	0	0	394
Sand Creek (2820)	Rush	82.3	3.82	0	0	0	0	1.41	520
Dry Creek (2939)	Rush/Barton	44.9	2.65	0	0	0	0	0.57	543
Walnut Creek (2868)	Rush/Barton	1,640	42.9	0	0	1.88	20.4	53.4	1,230
Boot Creek (2885)	Barton	34.2	1.70	0	0	0	0	0	404
Walnut Creek (2929)	Barton	1,760	53.5	0.30	0.55	3.39	25.6	68.2	1,360
Walnut Creek (3061)	Barton	1,810	57.7	0.62	1.12	4.51	28.1	74.5	1,330

Average annual flow in Walnut Creek reveals a period of low flow from 2002 through 2006 that coincides with a period of lower than average annual precipitation for the same time period (Figure 3). According to the National Climatic Data Center, the average annual precipitation (1990-2011) at Ness City is 23.3 inches, at Alexander it is 26.1 inches and at Bison, located near Sand Creek in Rush County, is 26.6 inches per year.

Figure 3. Yearly average precipitation at Ness City and flow for Walnut Creek



Figures 4, 5, and 6 display the flow duration curves for the period of record at each of the KDHE sampling stations in the watershed. Flow in Walnut Creek increases as it moves towards its confluence with the Arkansas River and similar patterns for the dry period that occurred from 2002-2006 and the relatively wet period of 1990-2001 can be seen in the flow curves for each of the sampling stations.

Figure 4. Estimated flow duration curve for Walnut Creek at Ness City based on USGS Gage 07141770.

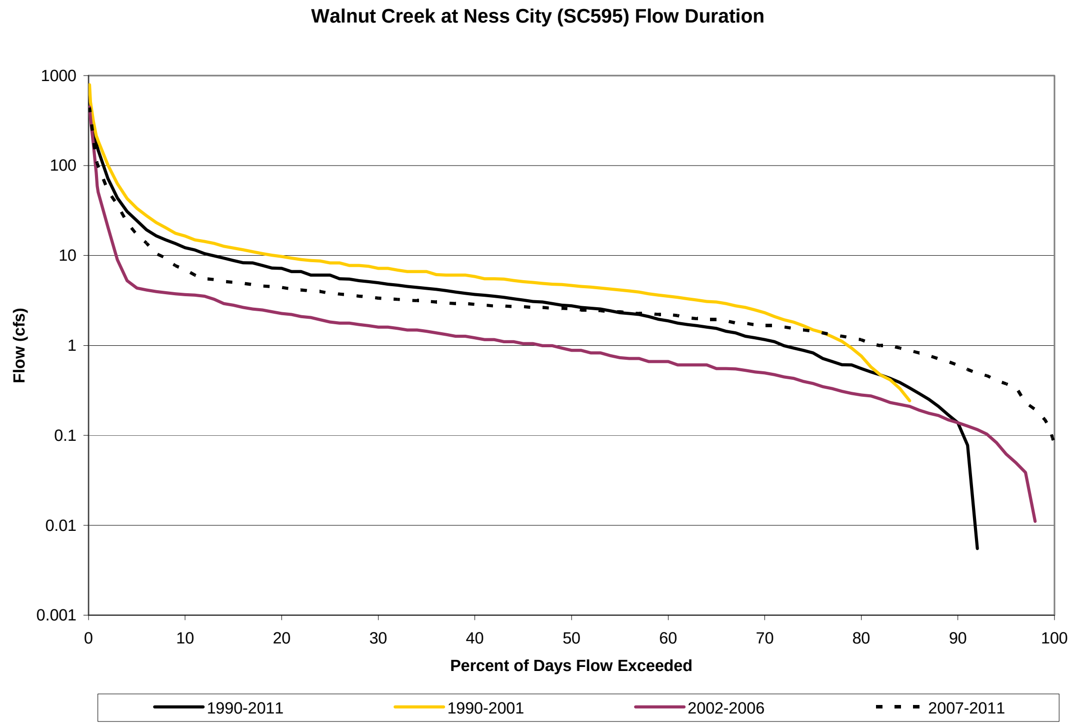


Figure 5. Estimated flow duration curve for Walnut Creek near Alexander based on USGS Gage 07141770.

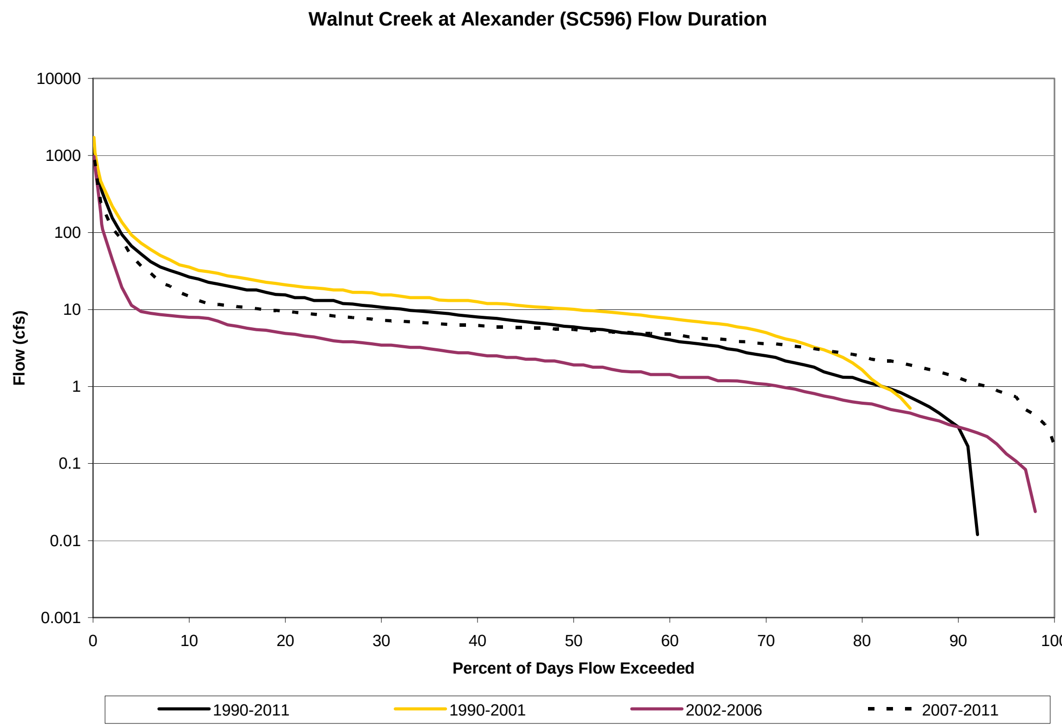
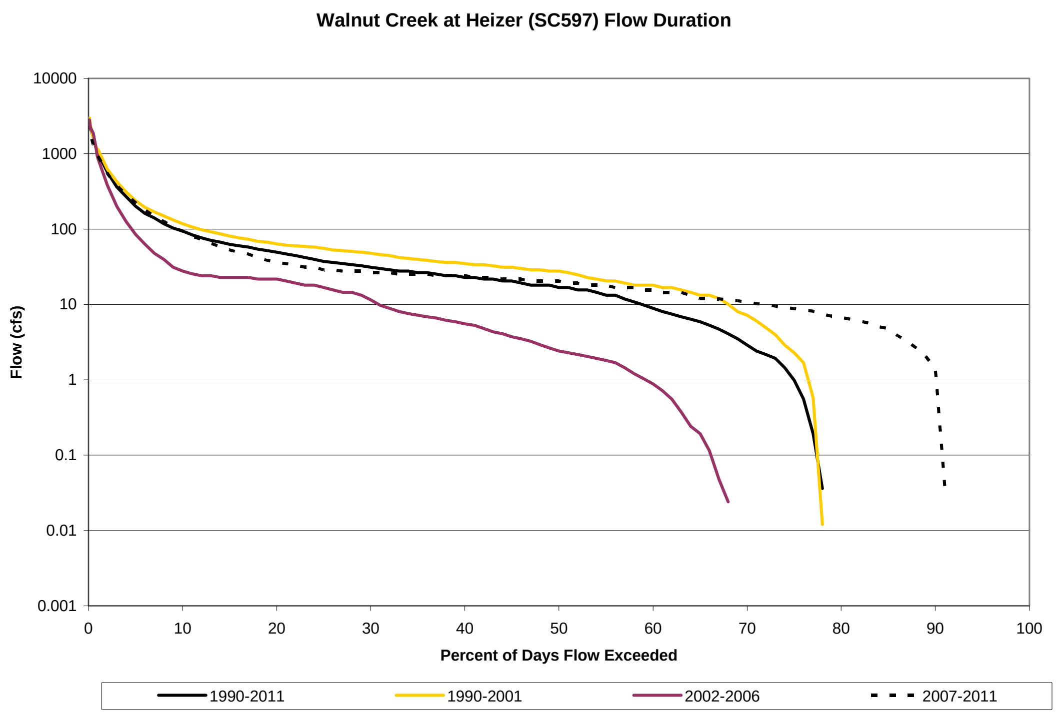


Figure 6. Estimated flow duration curve for Walnut Creek near Heizer based on USGS Gage 07141900.



As diversions for irrigation in the watershed have an impact on both the level and the quality of ground water in the area, data have been categorized into the summer or irrigation season (April-October) and the winter or irrigation off-season (March-November). Table 5 displays the seasonal averages in flow along Walnut Creek since 1990 and reveals flows during irrigation season are consistently higher than irrigation off-season flows. The wet period prior to 2002 is marked by substantially higher flows in both the irrigation season and the irrigation off-season while a pervasive dry period occurred from 2002 to 2006 with moderate flows returning during the 2007 to 2011 time frame.

Table 5. Seasonal average flows along Walnut Creek from Ness City (SC595) to Heizer (SC597).

Irrigation Season: April through October			
Walnut Cr Location	SC595 Ness City	SC596 Alexander	SC597 Heizer
1990-2001 Avg Flow (cfs)	17.3	37.5	99.6
2002-2006 Avg Flow (cfs)	5.30	11.5	29.7
2007-2011 Avg Flow (cfs)	9.01	19.5	85.0
Irrigation Off-Season: November through March			
Walnut Cr Location	SC595 Ness City	SC596 Alexander	SC597 Heizer
1990-2001 Avg Flow (cfs)	6.66	14.4	43.6
2002-2006 Avg Flow (cfs)	1.98	4.28	4.82
2007-2011 Avg Flow (cfs)	4.76	10.3	25.9

Current Conditions: Selenium concentrations have increased over the period of record in Walnut Creek at each of the KDHE sampling stations. Of the three stations, Ness City sees the highest concentrations of selenium with values dropping slightly at Alexander and even further at Heizer indicating dilution of the concentrations seen at Ness City due to the increase in flow at that site. The marked increase in selenium concentrations begins in 2002 with the beginning of the dry period and, although there is a slight improvement in concentrations during 2005 and 2006, average annual concentrations remain elevated even as the 2007-2011 period saw a return of moderate flows. Irrigation off-season averages are higher than summer averages at the three sites regardless of the period of record with Ness City and Heizer reporting their highest average selenium concentration during the winter of the 2007-2011 time period indicating lower flows during the winter season combined with the return of ground water that had mounded under irrigated lands during the summer are likely contributors to the higher winter averages. Exceedances above the chronic water quality standard of 5 μg/L occurred across all flow conditions at each of the stations with excursions occurring at a higher rate during the irrigation off-season as stream flow decreased.

Annual average selenium concentrations in Walnut Creek at Ness City are the highest of the three stations and averages range from 2.5 µg/L in 1991 to 9.9 µg/L in 2002 with a 1990-2011 average of 6.1 µg/L (Table 6). The highest single sample concentration of 11.9 µg/L occurred in September 2002 (Figure 7).

Figure 7. Selenium concentrations in Walnut Creek by season at Ness City with averages.

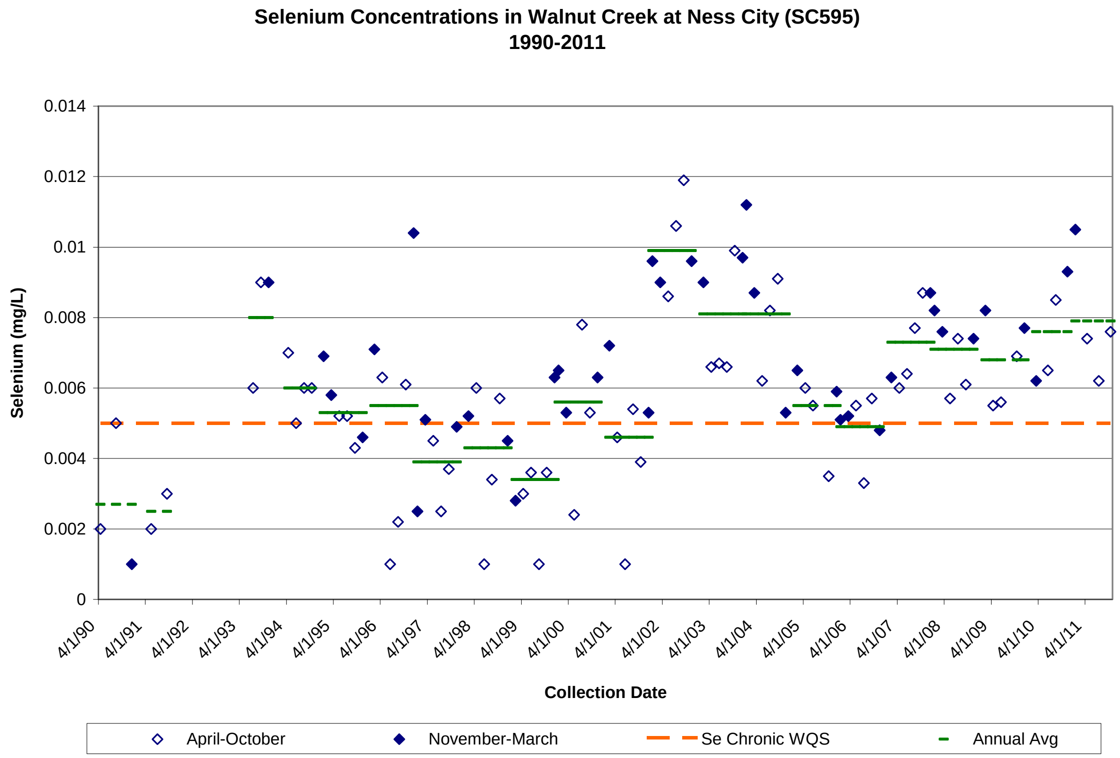


Table 6. Yearly average selenium in Walnut Creek at Ness City.

Year	Annual Avg (µg/L)	Year	Annual Avg (µg/L)
1990	2.7	**2001**	4.6
1991	2.5	**2002**	9.9
1992	No Data	**2003**	8.1
1993	8.0	**2004**	8.1
1994	6.0	**2005**	5.5
1995	5.3	**2006**	4.9
1996	5.5	**2007**	7.3
1997	3.9	**2008**	7.1
1998	4.3	**2009**	6.8
1999	3.4	**2010**	7.6
2000	5.6	**2011**	7.9

Annual averages at Alexander are slightly lower than those seen at Ness City with a 1990-2011 average of 5.6 µg/L. The single sample high with a selenium concentration of 15.8 µg/L occurred in January 2011 and contributed to 2011 having the highest annual average of 10.0 µg/L selenium (Figure 8). 1990 reported the lowest annual average for the period of record at 2.9 µg/L (Table 7).

Figure 8. Selenium concentrations in Walnut Creek by season near Alexander with annual averages.

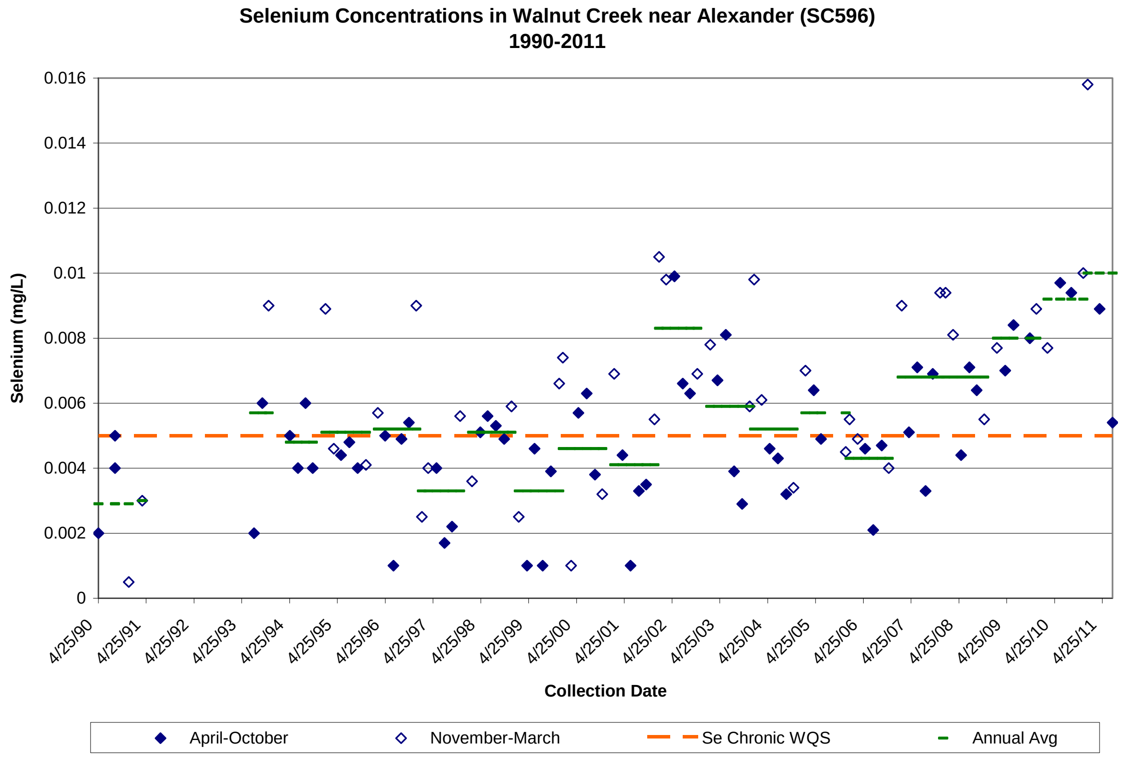


Table 7. Yearly average selenium in Walnut Creek near Alexander.

Year	Annual Avg (µg/L)	Year	Annual Avg (µg/L)
1990	2.5	**2001**	4.1
1991	3.0	**2002**	8.3
1992	No Data	**2003**	5.9
1993	5.7	**2004**	5.2
1994	4.8	**2005**	5.7
1995	5.1	**2006**	4.3
1996	5.2	**2007**	6.8
1997	3.5	**2008**	6.8
1998	5.1	**2009**	8.0
1999	3.3	**2010**	9.2
2000	4.6	**2011**	10.0

The average selenium concentration for 1990-2011 in Walnut Creek near Heizer comes in below the chronic water quality standard of 5 µg/L at 3.3 µg/L with a low annual average of 1.3 µg/L in 2006 and a high annual average in 2003 at 4.9 µg/L (Table 8). The single sample high occurred in December 2003 at 11.1 µg/L selenium (Figure 9).

Figure 9. Selenium concentrations in Walnut Creek by season near Heizer with annual averages.

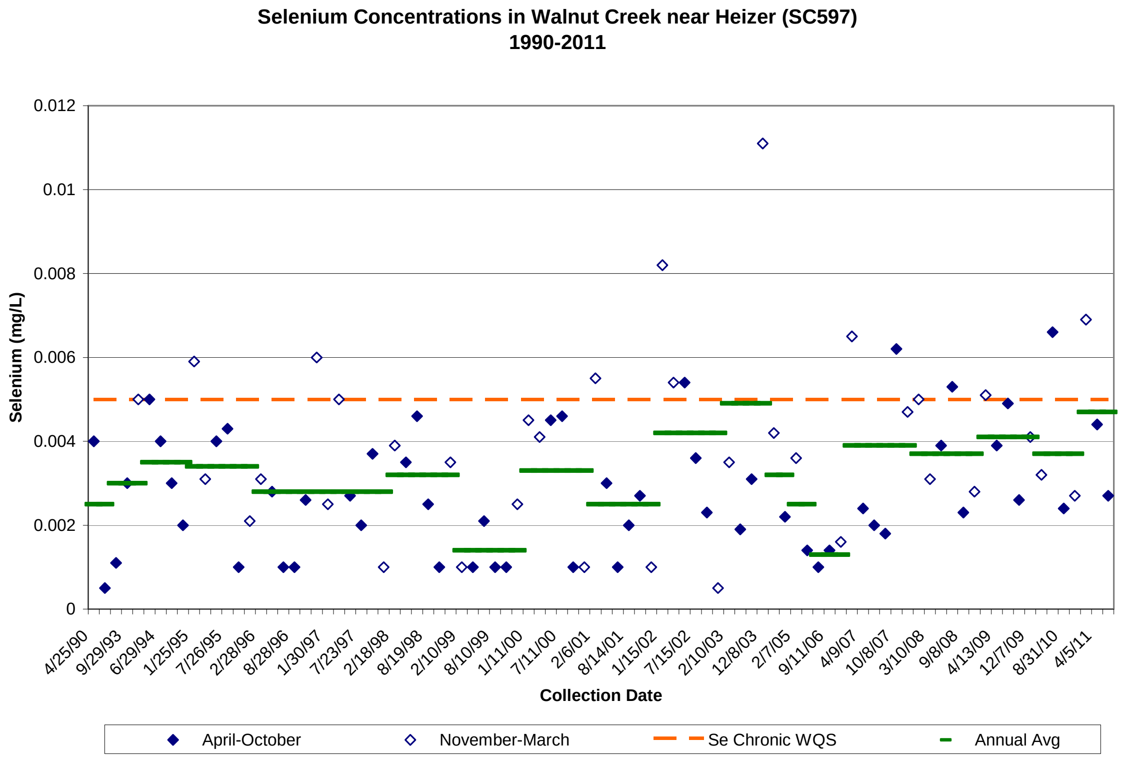


Table 8. Annual average selenium in Walnut Creek near Heizer.

Year	Avg (µg/L)	Year	Avg (µg/L)
1990	2.3	2001	2.5
1991	No Data	2002	4.2
1992	No Data	2003	4.9
1993	3.0	2004	3.2
1994	3.5	2005	2.5
1995	3.4	2006	1.3
1996	2.8	2007	3.9
1997	2.9	2008	3.7
1998	3.2	2009	4.1
1999	1.4	2010	3.7
2000	3.3	2011	4.7

Average and median selenium concentrations in Walnut Creek at Ness City by season are displayed in Figure 10 revealing that concentrations are higher during the Winter season when stream flows are unaffected by groundwater pumping for irrigation. As previously noted, concentrations increase over time with the average concentration of the winter season in 2007-2011 at 8.0 µg/L (Figure 10). 2002-2006 had the highest irrigation season average at 8.7 µg/L highlighting the effect of the decreased flow during the dry period on selenium concentrations (Table 9).

Figure 10. Box plot of selenium concentration in Walnut Creek at Ness City for the period of record.

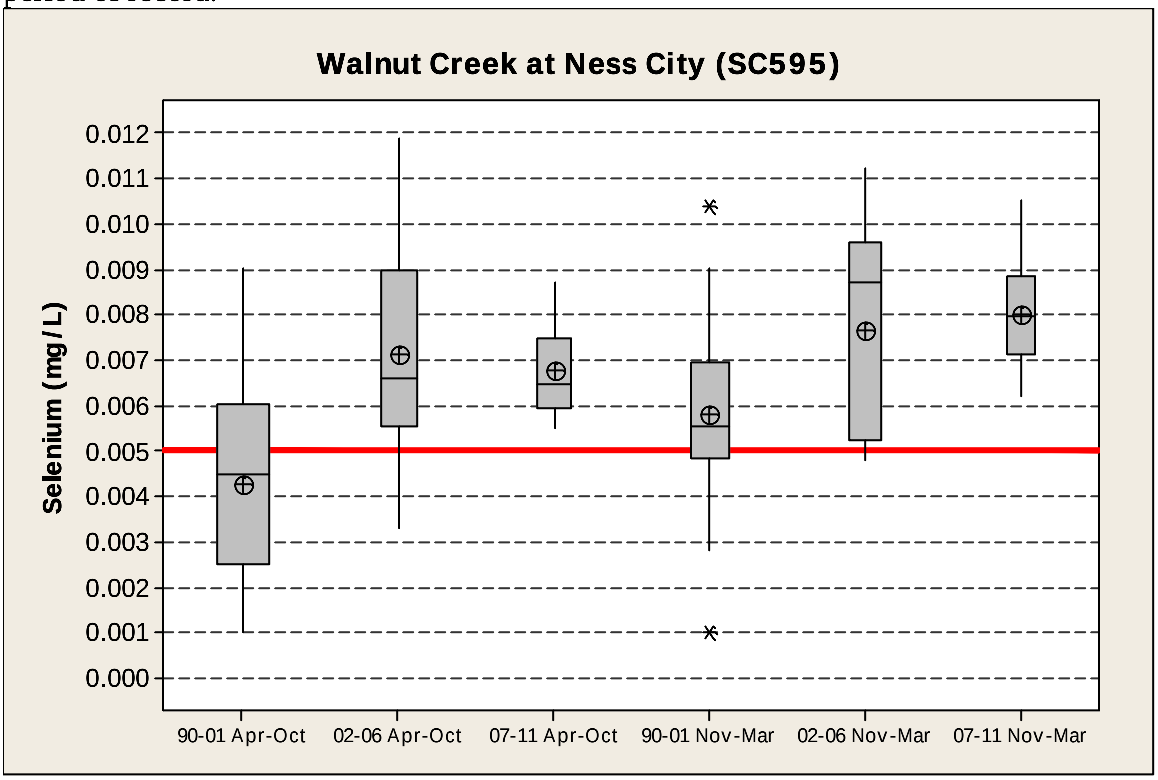


Table 9. Average and median selenium concentration by season in Walnut Creek at Ness City.

Period of Record	April-October		November-March		All Data	
	Median	Avg	Median	Avg	Median	Avg
1990-2001	4.5	4.3	5.6	5.8	5.1	4.8
2002-2006	6.6	7.1	8.7	7.7	6.6	7.4
2007-2011	6.5	6.8	8.0	8.0	7.4	7.3
All Data	5.7	5.5	6.5	6.9	6.0	6.1

Like Walnut Creek at Ness City, the 2007-2011 winter season recorded the highest average for the period of record at 9.2 µg/L for the sampling station on Walnut Creek near Alexander (Figure 11). The high summer season average also occurred during the 2007-2011 time frame at 6.9 µg/L (Table 10).

Figure 11. Box plot of selenium concentration in Walnut Creek near Alexander for the period of record.

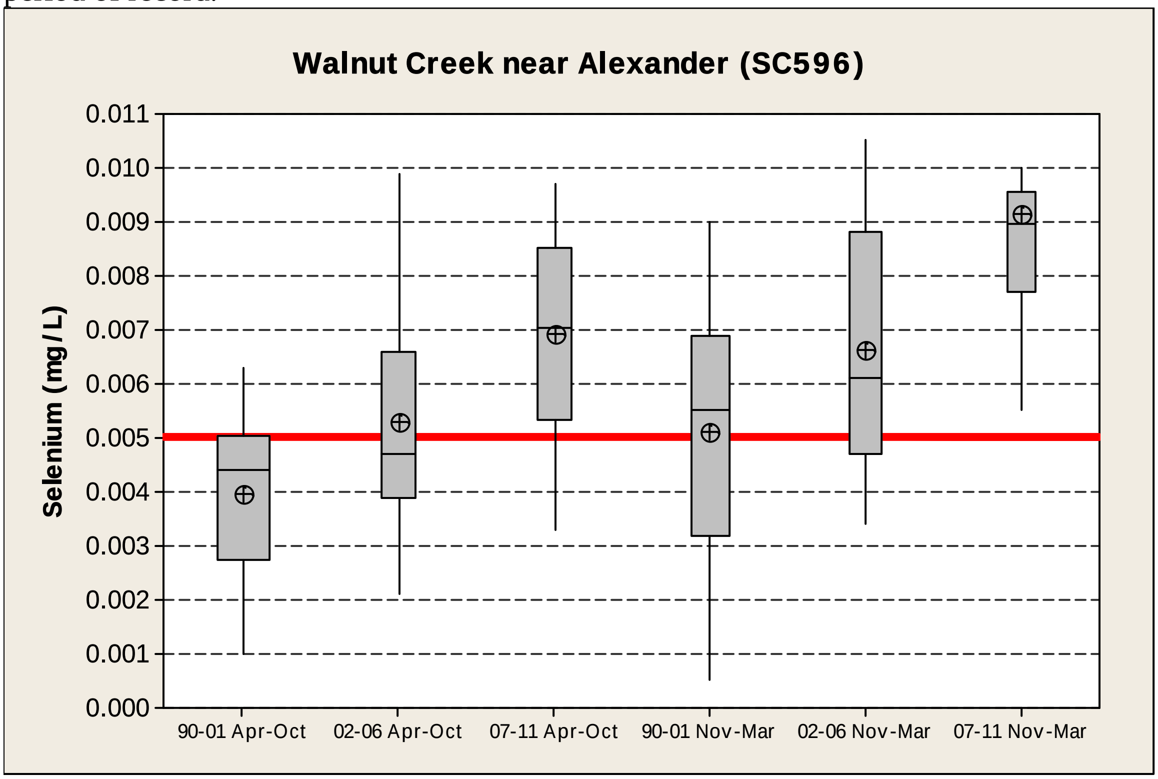


Table 10. Average and median selenium concentration by season in Walnut Creek near Alexander.

Period of Record	April-October		November-March		All Data	
	Median	Avg	Median	Avg	Median	Avg
1990-2001	4.4	4.0	5.5	5.2	4.5	4.4
2002-2006	4.7	5.3	6.1	6.6	5.7	5.9
2007-2011	7.1	6.9	9.0	9.2	7.9	7.9
All Data	4.9	5.0	6.4	6.6	5.4	5.6

Average selenium concentrations are lower at the downstream station near Heizer than the two upstream stations with a high average concentration of 4.8 mg/L occurring over the winter seasons during the 2002-2006 time period (Figure 12). The pattern of average and median selenium concentration over the period of record is similar to the two upstream stations with selenium concentrations increasing over the period of record (Table 11).

Figure 12. Box plot of selenium concentration in Walnut Creek near Heizer for the period of record.

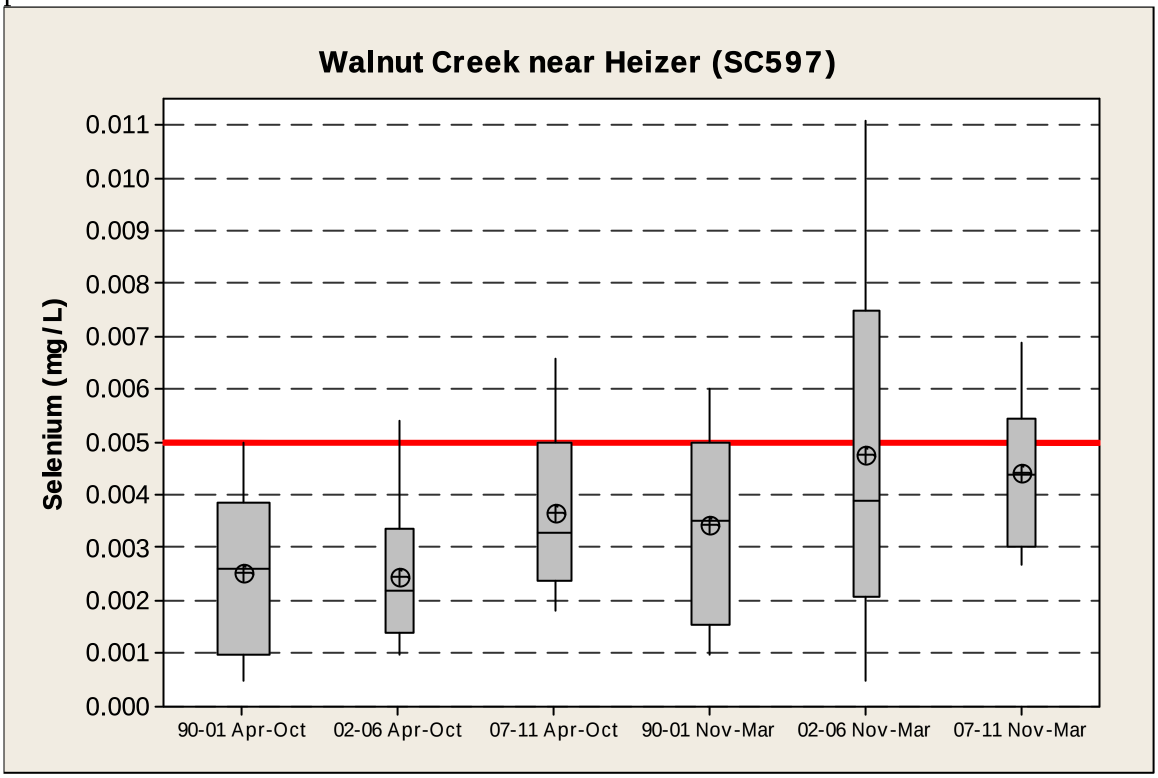


Table 11. Average and median Selenium concentration for summer and winter seasons in Walnut Creek near Heizer.

Period of Record	Summer April-October		Winter November-March		All Data	
	Median	Avg	Median	Avg	Median	Avg
1990-2001	2.6	2.5	3.5	3.4	2.8	2.8
2002-2006	2.2	2.4	3.9	4.8	3.1	3.5
2007-2011	3.3	3.7	4.4	4.4	3.9	4.0
All Data	2.6	2.8	3.9	4.0	3.0	3.3

Selenium exceedances occurred across all flow conditions in Walnut Creek at Ness City with the frequency of exceedances increasing when stream flow is less than median flow (Figure 13). The average selenium concentrations for the summer and winter seasons are higher when flows are less than median flow suggesting the background source of selenium is being diluted by higher stream flows. The rate of exceedances steadily increases over the period of record culminating with all of the samples collected during the 2007-2011 time period exceeding the chronic selenium water quality standard of 5 μg/L (Table 12).

Figure 13. Load duration curve with selenium loading in Walnut Creek at Ness City (SC595) for the period of record.

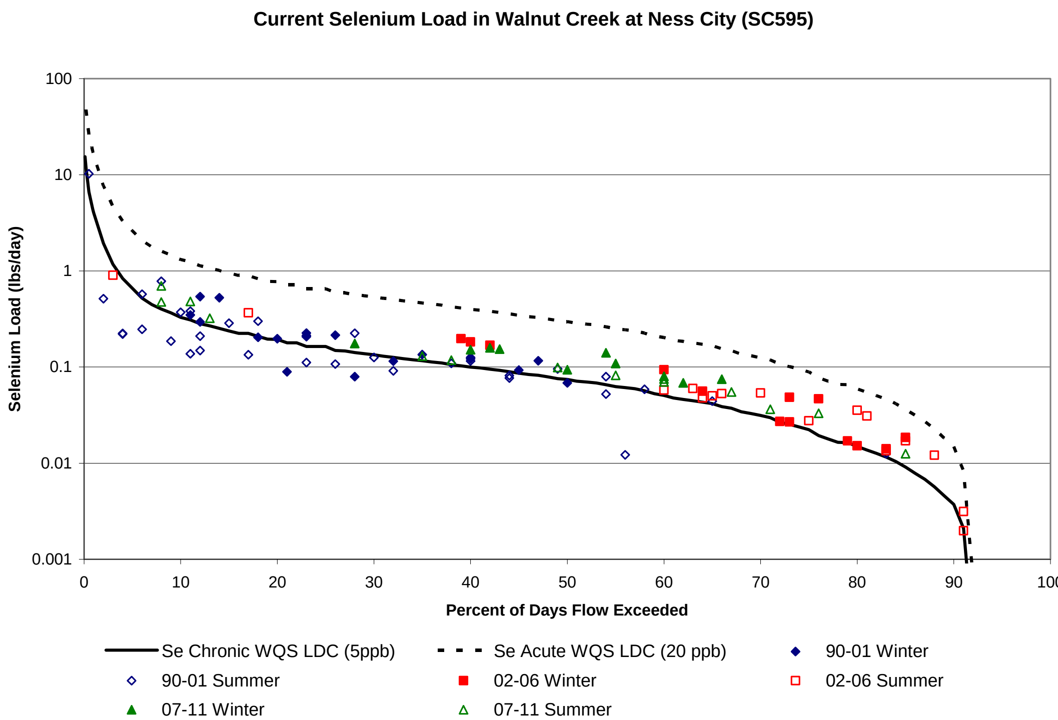


Table 12. Exceedances by flow and season for Walnut Creek at Ness City.

	Period of Record	**≥ 50% Flow ≤ 2.76 cfs**			**< 50% Flow > 2.76 cfs**			**All Flow**		
		Avg (μg/L)	# of Samples	%	Avg (μg/L)	# of Samples	# > 5 μg/L	Avg (μg/L)	# of Samples	# > 5 μg/L
April thru October (Summer)	1990-2001	4.0	3/8	38%	4.4	11/27	41%	4.3	14/35	40%
	2002-2006	7.3	13/14	93%	5.8	1/2	50%	7.1	14/16	88%
	2007-2011	7.1	8/8	100%	6.5	7/7	100%	6.8	15/15	100%
	1990-2011	**6.4**	**24/30**	**80%**	**4.9**	**19/36**	**53%**	**5.5**	**43/66**	**65%**
November thru March (Winter)	1990-2001	2.8	0/2	0%	6.2	13/16	81%	5.8	13/18	72%
	2002-2006	7.1	10/11	91%	9.1	3/3	100%	7.6	13/14	93%
	2007-2011	8.7	5/5	100%	7.6	4/4	100%	8.2	9/9	100%
	1990-2011	**7.1**	**15/17**	**88%**	**6.8**	**20/23**	**87%**	**6.9**	**35/41**	**85%**

Just as at Ness City, exceedances above the chronic selenium water quality standard occurred across all flow conditions in Walnut Creek near Alexander, however, the rate of exceedances is lower than that seen at Ness City (Figure 14). Average summer and winter selenium concentrations in Walnut Creek near Alexander at flows less than median flow are 5.9 µg/L and 6.6 µg/L, respectively, while seasonal averages were lower at 4.3µg/L and 6.5 µg/L when flows were greater than median (Table 13).

Figure 14. Load duration curve with selenium loading in Walnut Creek near Alexander for the period of record.

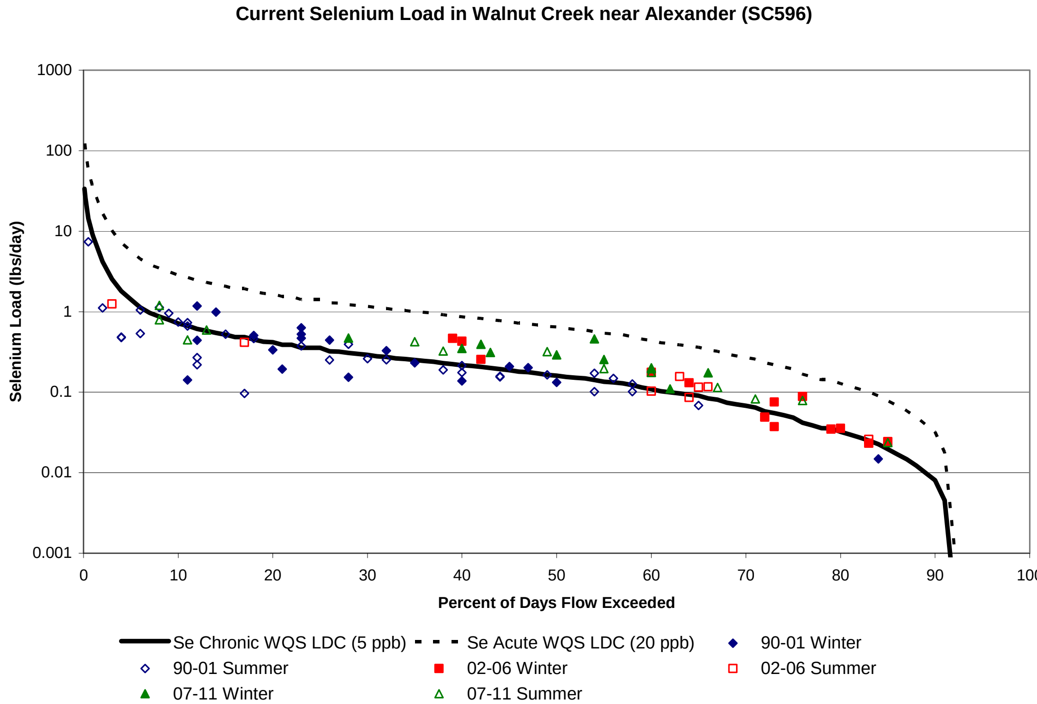


Table 13. Exceedances by flow and season for Walnut Creek near Alexander for the period of record.

	Period of Record	≥50% Flow ≤ 5.97 cfs			<50% Flow > 5.97 cfs			All Flow		
		Avg (µg/L)	# of Samples	%	Avg (µg/L)	# of Samples	# > 5 µg/L	Avg (µg/L)	# of Samples	# > 5 µg/L
April thru October (Summer)	1990-2001	4.5	2/6	33%	3.8	6/27	22%	4.0	8/33	24%
	2002-2006	5.6	6/13	46%	3.2	0/2	0%	5.3	6/15	40%
	2007-2011	7.5	7/7	100%	6.4	5/7	71%	6.9	12/14	86%
	1990-2011	**5.9**	**15/26**	**58%**	**4.3**	**11/36**	**31%**	**5.0**	**26/62**	**42%**
November thru March (Winter)	1990-2001	2.5	0/3	0%	5.6	10/16	63%	5.1	10/19	53%
	2002-2006	6.0	6/10	60%	8.8	3/3	100%	6.6	9/13	69%
	2007-2011	9.8	6/6	100%	8.2	4/4	100%	9.2	10/10	100%
	1990-2011	**6.6**	**12/19**	**63%**	**6.5**	**17/23**	**74%**	**6.5**	**29/42**	**69%**

The frequency of selenium exceedances decreases considerably in Walnut Creek near Heizer from the rate seen at the two upstream stations (Figure 15). And, although there is still an increase in the average selenium concentration over time regardless of flow condition, the Heizer station shows a higher percentage of exceedances in the summer when flows are greater than median flow and a higher percentage of exceedances in the winter when flows are less than median, the opposite of which is seen at the Ness City and Alexander stations (Table 14).

Figure 15. Load duration curve with selenium loading in Walnut Creek near Heizer for the period of record.

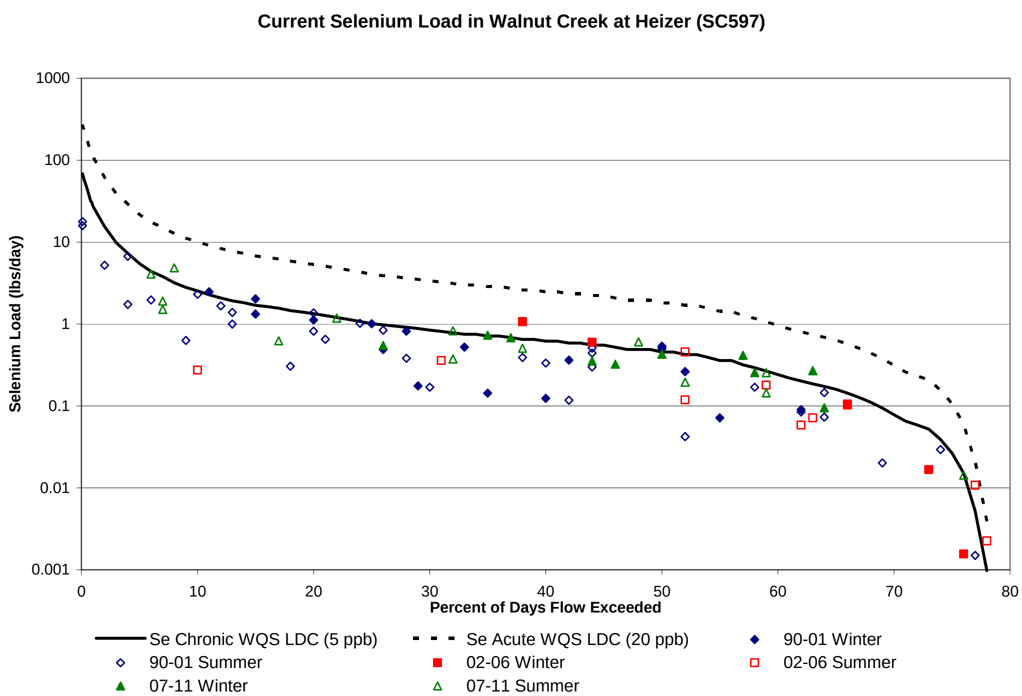
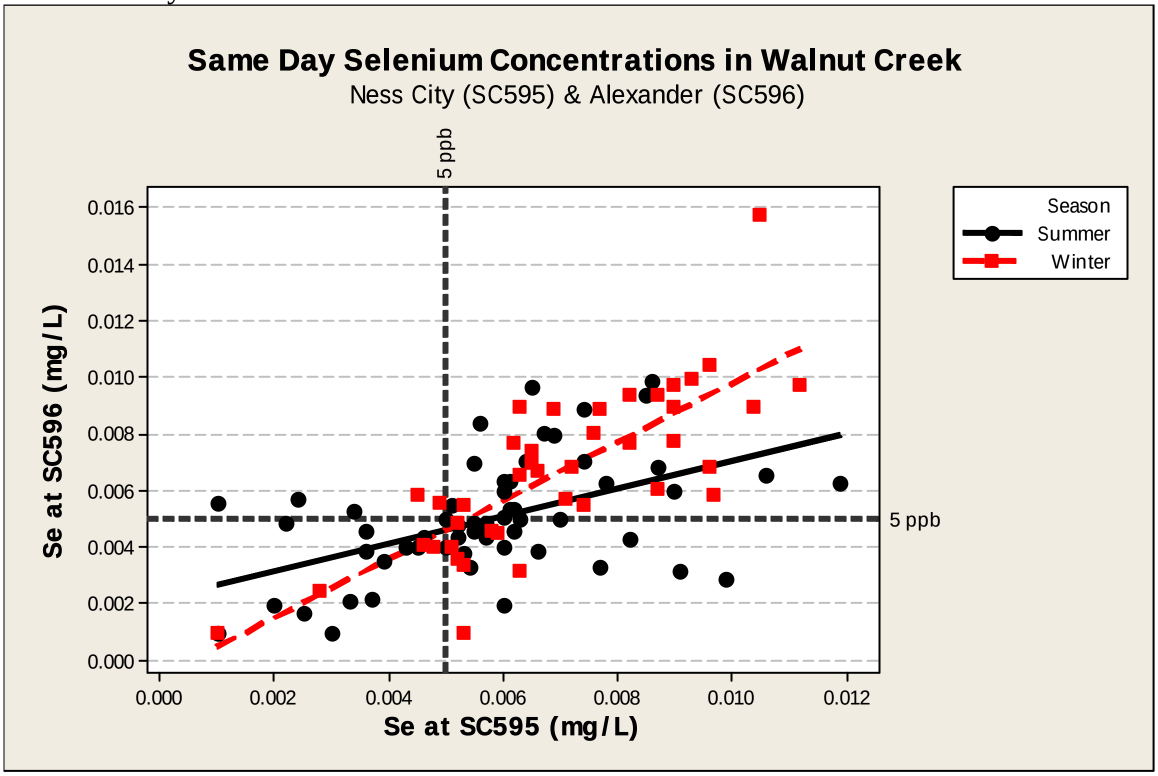


Table 14. Exceedances by flow and season for Walnut Creek near Heizer for the period of record**.**

	Period of Record	**≥ 50% Flow ≤ 16.9 cfs**			**<50% Flow > 16.9 cfs**			**All Flow**		
		Avg (µg/L)	# of Samples	%	Avg (µg/L)	# of Samples	# > 5 µg/L	Avg (µg/L)	# of Samples	# > 5 µg/L
April thru October (Summer)	1990-2001	2.0	0/8	0%	2.7	0/25	0%	2.5	0/33	0%
	2002-2006	2.7	1/7	14%	1.4	0/2	0%	2.4	1/9	13%
	2007-2011	3.0	0/4	0%	3.9	3/10	30%	3.7	3/14	21%
	1990-2011	**2.5**	**1/19**	**5%**	**2.9**	**3/37**	**8%**	**2.8**	**4/56**	**7%**
November thru March (Winter)	1990-2001	3.5	2/5	40%	3.4	1/12	8%	3.4	3/17	18%
	2002-2006	4.1	1/6	17%	6.8	2/2	100%	4.8	3/8	38%
	2007-2011	5.0	2/5	40%	3.8	1/5	20%	4.4	3/10	30%
	1990-2011	**4.2**	**5/16**	**31%**	**3.9**	**4/19**	**21%**	**4.0**	**9/35**	**26%**

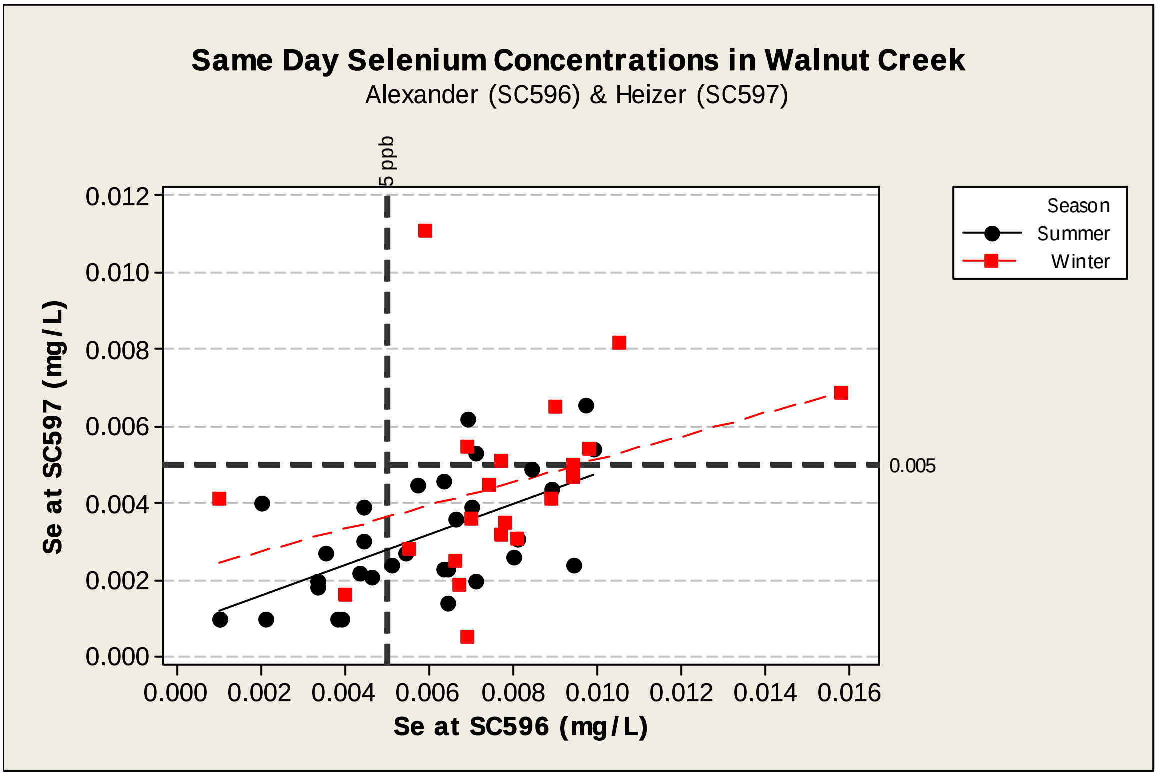
Relationships: Analysis of selenium concentrations in samples collected on the same day reveals a good correlation between concentrations seen at Ness City and those seen at Alexander indicating the load seen at SC595 is seen at SC596 and any increase in the concentrations at SC596 is proportional to increases seen at SC595 (Figure 17). Winter selenium concentrations have a better correlation with an R^2 value of 62% than the relationship of the summer concentrations with an R^2 value of 29% likely due to the higher winter concentrations at both sites and varying flow conditions brought on by spring and summer precipitation events.

Figure 17. Selenium concentrations for samples collected on the same day at Ness City and Heizer by season.



The correlation between the downstream station at Heizer and the middle station at Alexander begins to fall apart as the increased flow at Heizer dilutes concentrations seen at SC596 (Figure 18). Contrary to the correlation seen at the two upstream sites, summer selenium concentrations have a better correlation with an R^2 value of 32.1% than the relationship of the winter concentrations with an R^2 value of 22.1%.

Figure 18. Selenium concentrations for samples collected on the same day at Alexander and Heizer.



Typically, conductivity values decrease as stream flows increase due to the dilution of the ion concentrations in the stream by low ion concentration precipitation. In this case, however, dryer conditions from 2002 to 2006 resulted in a decrease in conductivity values in the creek while 2007 to 2011 saw conductivity values rise as more moderate stream flow returned (Figure 19) possibly indicating the drier conditions led to a reduction in the high ion concentration base flow to Walnut Creek. Seasonality is seen with elevated conductivity during the winter months and sharp decreases in early summer, followed by gradual increases as the irrigation progresses (Table 15).

Figure 19. Conductance values in Walnut Creek at KDHE sampling stations.

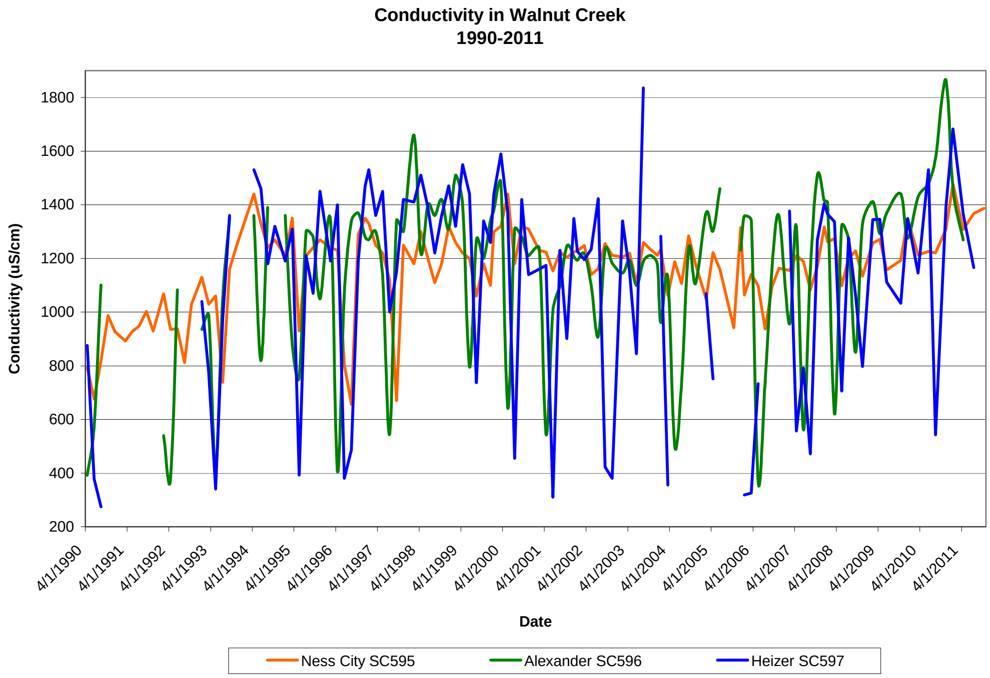


Table 15. Conductivity values and median flow by season for Walnut Creek.

Irrigation Season: April through October						
Location	SC595 Ness City		SC596 Alexander		SC597 Heizer	
Parameter	Avg Conductivity (µS/cm)	Median Flow (cfs)	Avg Conductivity (µS/cm)	Median Flow (cfs)	Avg Conductivity (µS/cm)	Median Flow (cfs)
1990-2001	1,084	3.0	1,120	8.3	1,086	26
2002-2006	1,151	0.47	1,050	1.3	854	1.0
2007-2011	1,221	1.6	1,208	4.3	1,016	19
Apr-Oct	1,127	1.8	1,122	4.8	1,015	16
Irrigation Off-Season: November through March						
Location	SC595 Ness City		SC596 Alexander		SC597 Heizer	
Parameter	Avg Conductivity (µS/cm)	Median Flow (cfs)	Avg Conductivity (µS/cm)	Median Flow (cfs)	Avg Conductivity (µS/cm)	Median Flow (cfs)
1990-2001	1,190	3.4	1,276	9.2	1,359	19
2002-2006	1,178	0.84	1,189	2.3	1,133	1.1
2007-2011	1,275	1.9	1,403	5.2	1,319	16
Nov-Mar	1,239	2.2	1,284	6.0	1,295	14

Regression analysis of the selenium concentration versus conductance and the sulfate concentration at the sampling sites along Walnut Creek shows the best correlation at Alexander with an R^2 value of 35% for the sulfate correlation and an R^2 value of 27% for the conductance correlation (Figure 21). The correlation between conductivity and selenium concentration is better at Heizer with an R^2 value of 23% than at Ness City with a correlation of 16% (Figure 20) while the correlation of sulfate with selenium concentration is slightly better at Ness City at 20% than at Heizer with an R^2 value of 18% (Figure 22). As can be seen in Table 16, selenium exceeds the 5 µg/L criterion 83%

of the time when conductivity is greater than 1,100 µS/cm and 92% of the time when sulfate concentrations are higher than 250 mg/L at Ness City. The frequency of the exceedances diminishes downstream at Alexander with 68% and 77% of the selenium values exceeding 5 µg/L when conductivity is greater than 1,100 µS/cm and sulfate is greater than 250 mg/L, respectively (Table 17) while at Heizer only 32% of the samples collected when conductivity was greater than 1,100 mS/cm exceeded the selenium criterion and 36% of the samples exceeded when sulfate concentrations were greater than 250 mg/L (Table 18) highlighting the effect of fresh water inflow to the creek below Alexander.

Figure 20. Selenium vs. sulfate and conductivity in Walnut Creek at Ness City.

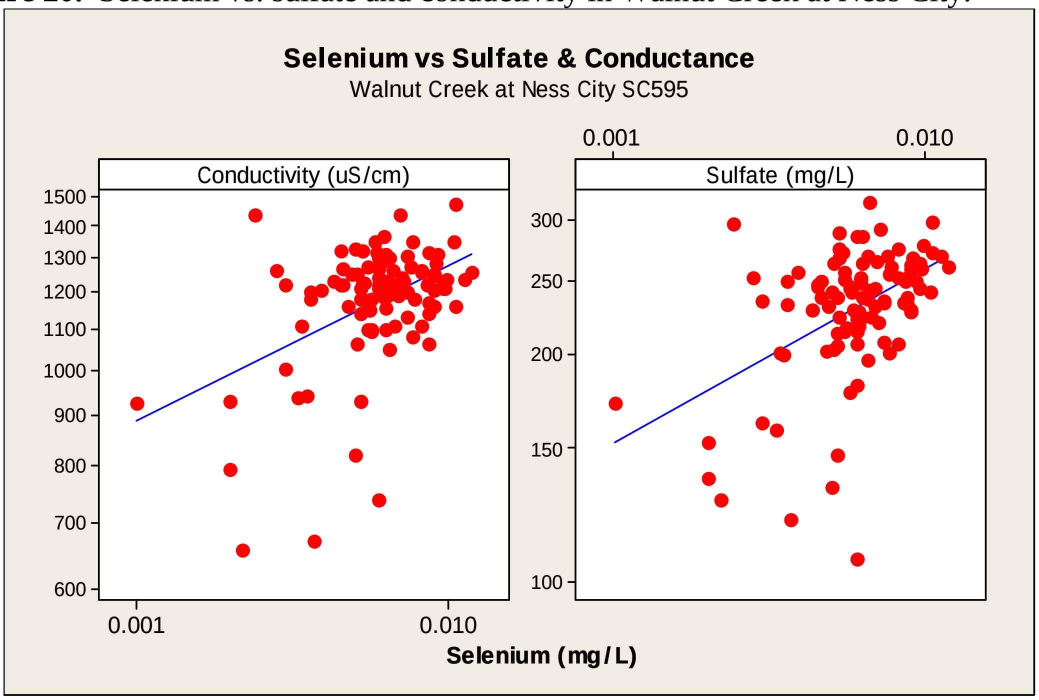


Table 16. Number of samples in each comparison of selenium with sulfate and specific conductance.

Conductivity at Ness City	Selenium at Ness City		Sulfate at Ness City	Selenium at Ness City	
	< 0.005 mg/L	≥ 0.005 mg/L		< 0.005 mg/L	≥ 0.005 mg/L
< 1,100 (µS/cm)	8	10	**< 250 mg/L**	19	46
≥ 1,100 (µS/cm)	14	70	**≥ 250 mg/L**	3	34

Figure 21. Selenium vs. sulfate and conductivity in Walnut Creek near Alexander.

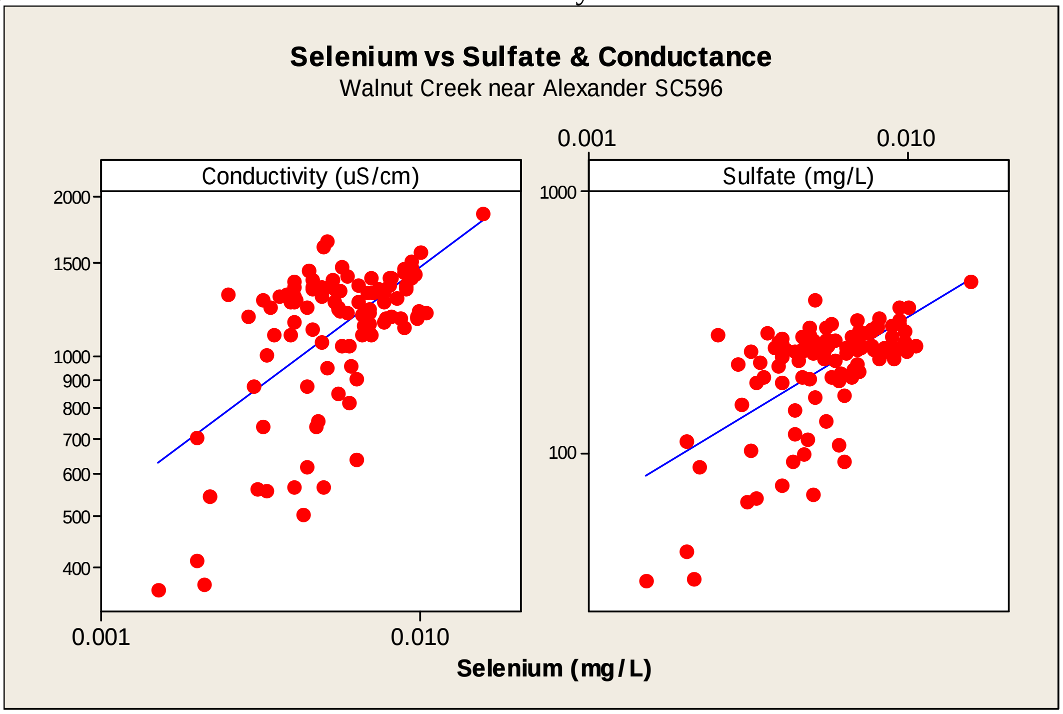


Table 17. Number of samples in each comparison of selenium with sulfate and specific conductance.

Conductivity at Alexander	**Selenium at Alexander**		**Sulfate at Alexander**	**Selenium at Alexander**	
	< 0.005 mg/L	**≥ 0.005 mg/L**		**< 0.005 mg/L**	**≥ 0.005 mg/L**
< 1,100 (µS/cm)	16	9	**< 250 mg/L**	29	24
≥ 1,100 (µS/cm)	23	49	**≥ 250 mg/L**	10	34

Figure 22. Selenium vs. sulfate and conductivity in Walnut Creek near Heizer.

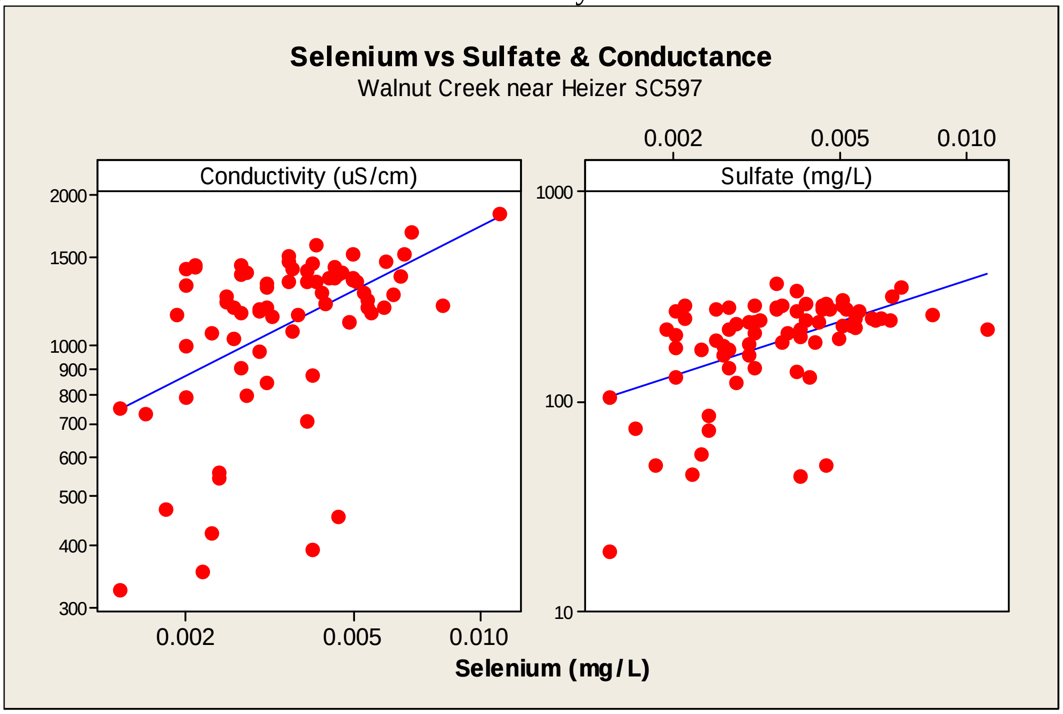


Table 18. Number of samples in each comparison of selenium with sulfate and specific conductance.

Conductivity at Heizer	**Selenium at Heizer**		**Sulfate at Heizer**	**Selenium at Heizer**	
	< 0.005 mg/L	**≥ 0.005 mg/L**		**< 0.005 mg/L**	**≥ 0.005 mg/L**
< 1,100 (µS/cm)	21	0	**< 250 mg/L**	41	8
≥ 1,100 (µS/cm)	36	17	**≥ 250 mg/L**	16	9

Desired Endpoints of Water Quality (Implied Load Capacity) on Walnut Creek at Ness City (SC595), Alexander (SC596), and Heizer (SC597):

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Aquatic Life Use which will ensure all other designated uses are protected. This TMDL will, however, be phased. Phase one is establish a selenium TMDL at SC595, SC596 and S597 using the current aquatic life water quality standard of 5 µg/L selenium for chronic exposure. However, the upper portion of the watershed is subject to selenium loading from the underlying upper Cretaceous bedrock making achievement of the water quality standard of 5 µg/L unlikely at Ness City (SC595) and Alexander (SC596). Because the selenium standard for chronic exposure is not achievable at the upper two stations due to natural contributions to the selenium load, site specific criteria are needed at Ness City (SC595) and Alexander (SC596).

Kansas Implementation Procedures for Surface Water allow for a numerical criterion based on natural background to be established for streams using the mean of at least five concentration observations for samples collected at or below median flow. The specific stream criteria to supplant the general standard will be developed following the appropriate administrative and technical Water Quality Standards processes and will be part of phase two of this TMDL. Meanwhile, the current chronic aquatic life criterion of 5 mg/L selenium will apply to all segments of this TMDL. The proposed alternate seasonal endpoints for Ness City (SC595) and Alexander (SC596) have been developed based on samples collected over 1990-2011 at flows equal to or less than median flow and are intended to be used as the water quality standard for chronic exposure to selenium at SC595 and SC596 once EPA approval is garnered (Table 19). The current aquatic life criterion for chronic exposure to selenium of 5 μg/L will remain in place at Heizer (SC597).

Seasonal variation has been incorporated in this TMDL through determination of the proposed seasonal water quality standards for chronic exposure selenium at SC595 and SC596. Achievement of the endpoints indicate loads 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.

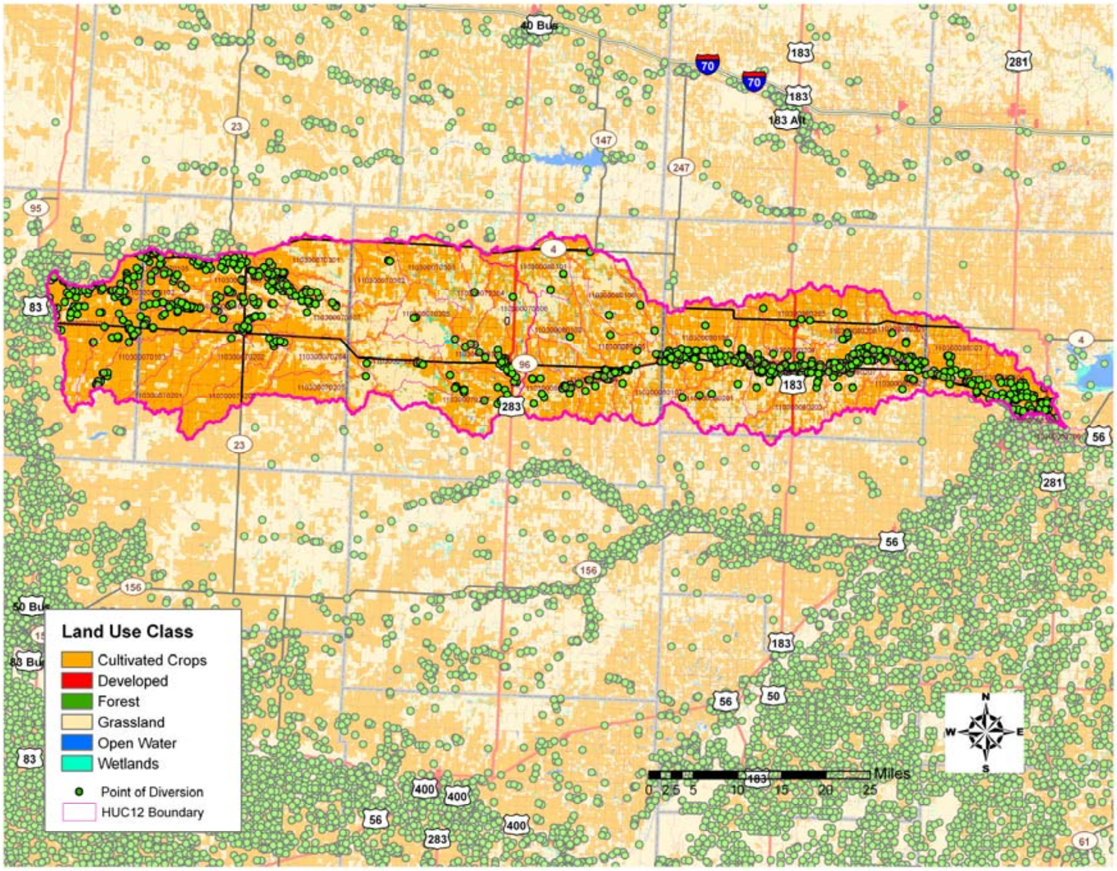
Table 19. Selenium Endpoints for KDHE sampling stations on Walnut Creek.

Stream	Station	CUSEGA	TMDL Endpoints Chronic WQS for AL		Proposed Background Concentrations to Supplant Chronic WQS for AL	
			Summer (Apr-Oct)	Winter (Nov-Mar)	Summer (Apr-Oct)	Winter (Nov-Mar)
Walnut Creek at Ness City	SC595	110300071	5 μg/L	5 μg/L	6.5 μg/L	7 μg/L
Walnut Creek near Alexander	SC596	110300086	5 μg/L	5 μg/L	6 μg/L	7 μg/L
Walnut Creek near Heizer	SC597	110300082	5 μg/L	5 μg/L	N/A	N/A

3. SOURCE INVENTORY AND ASSESSMENT

Land Use: The predominant land uses in the Walnut Creek Watershed are cropland (62%) and grassland (33%) according to the 2001 National Land Cover Data. Together they account for 95% of the total land area in the watershed with the remaining area consisting of developed land (3.4%), wetlands (0.80%), open water (0.60%) and forest (0.20%) (Figure 23). Agricultural practices such as tilling and irrigating may exacerbate the exposure of the selenium containing upper Cretaceous bedrock in the watershed.

Figure 23. Walnut Creek Watershed Land Use Map.



Livestock Waste Management Systems: There are sixty-four certified or permitted confined animal feeding operations (CAFOs) within Walnut Creek watershed. Eleven of the sixty-four operations are large enough to require an NPDES permit and the sum of animals in the watershed is 180,702 (see Appendix B). These permitted or certified livestock facilities have waste management systems designed to minimize runoff entering their operation or detaining runoff emanating from their facilities. In addition, they are designed to retain a 25-year, 24-hr rainfall/runoff event as well as an anticipated two weeks of normal wastewater from their operations. Typically, this rainfall event coincides with stream flow occurring less than 1-5% of the time.

According to the Kansas Agricultural Statistics, the estimated number of all cattle and cows from counties that are included within this watershed as of January 1, 2010 are: 295,000 for Scott, 67,000 for Lane, 38,000 for Ness, 22,000 for Rush and 118,000 for Barton County. Livestock numbers for Pawnee County are not discussed as the Walnut Creek watershed only slightly enters Pawnee County and there are no CAFOs in the watershed that lie within the county.

Point Sources: There are 16 NPDES permitted facilities in the Walnut Creek watershed (see Appendix A). Of these facilities, one is a manufacturer with a pretreatment permit to discharge to the City of Ransom municipal sewer, seven are non-overflowing lagoon systems and 2 are concrete manufacturing sites. These 10 facilities are prohibited from discharging to the Walnut Creek watershed and would only contribute a waste load under extreme precipitation or flooding events. The remaining 6 are permitted to discharge and two of the facilities are required to monitor quarterly for selenium when discharging, however, they have not discharged while under this monitoring requirement and there is no selenium data available for the outfall of these facilities (Table 20).

Table 20. NPDES discharging facilities in the Walnut Creek watershed.

NPDES Facility	Receiving Stream/ CUSEGA	Kansas Permit No.	Federal Permit No.	Type	Design Flow MGD	Selenium Limit	Permit Expires
City of Dighton	S. Fk. Walnut Cr/ 1103000710	M-UA10-OO01	KS0022527	3 Cell Lagoon	0.2	Monitor	9/30/16
City of Ransom	Bazine Dry Cr/ 110300089	M-UA34-OO01	KS0031453	3 Cell Lagoon	0.038	Monitor	3/31/16
City of Rush Center	Walnut Cr/ 110300085	M-UA36-OO01	KS0117102	Activated Sludge	0.035	No	12/31/11
City of LaCrosse	Sand Cr/ 110300083	M-UA23-OO01	KS0024643	Ozone/3 Cell Lagoon	0.14	No	6/30/16
City of Bison	Sand Cr/ 110300083	M-UA04-OO01	KS0116688	2 Cell Lagoon	0.030	No	3/31/16
City of Otis	Boot Cr/ 1103000815	M-UA31-OO01	KS0091758	3 Cell Lagoon	0.044	No	9/30/16

Points of Diversion & Irrigation Return Flow: According KGS WIMAS, there are 1,837 unique active points of diversion within the Walnut Creek Watershed (Figure 23). Of those, Rush County contains 42%, Lane County contains 21% and Barton, Ness and Scott counties each contain about 12% of the points. The portion of the Walnut Creek watershed that lies in Ness, Rush and Barton Counties is designated as an Intensive Groundwater Use Control Area (IGUCA) by the Kansas Water Office restricting groundwater allocations to approximately 22,700 acre-feet of water per year. Ground and surface water diversions within the Walnut Creek watershed located in Scott and Lane County are not subject to the IGUCA and about 18,000 acre-feet/year of groundwater diversions are reported for those two counties (Table 21). Surface water diversions in Barton County can be attributed to two water rights (439 and 39951) designated for recreational use and managed by the Kansas Department of Parks and Wildlife for diverting water to Cheyenne Bottoms Wildlife Refuge located northeast of the Walnut Creek watershed. Total county groundwater diversions are shown in Table 22 highlighting the extensive groundwater pumping that occurs in Scott, Lane and Barton Counties and a comprehensive list of diversions by county can be found in Appendix C.

Although usage is restricted within the Walnut Creek watershed, irrigation return flows are likely to increase the selenium concentrations in Walnut Creek through evapotranspiration and the leaching of selenium from soil in the watershed. Irrigation can also locally raise ground water tables and, in doing so, soluble forms of selenium in the water, bedrock or soils can be moved to the surface.

Table 21. Ground and surface water diversions and acres irrigated in the Walnut Creek watershed.

County	Period of Record	Ground Water		Surface Water	
		Avg Annual Diversion (AF)	Avg Annual Acres Irrigated	Avg Annual Diversion (AF)	Avg Annual Acres Irrigated
Scott	1990-2001	3,990	3,342	0	0
	2002-2006	3,272	3,204	0	0
	2007-2011	3,316	2,620	0	0
Lane	1990-2001	15,112	16,212	0	0
	2002-2006	15,980	15,015	0	0
	2007-2011	13,241	14,011	0	0
Ness	1990-2001	1,004	819	284	214
	2002-2006	920	1,077	100	92
	2007-2011	668	972	34	17
Rush	1990-2001	8,732	9,772	53	73
	2002-2006	9,801	11,271	52	63
	2007-2011	8,193	10,296	79	87
Barton	1990-2001	6,302	6,554	6,032	13
	2002-2006	6,607	8,156	10,757	0
	2007-2011	5,151	6,527	11,783	24

Table 22. Total groundwater diversions and acres irrigated by county 1990-2010.

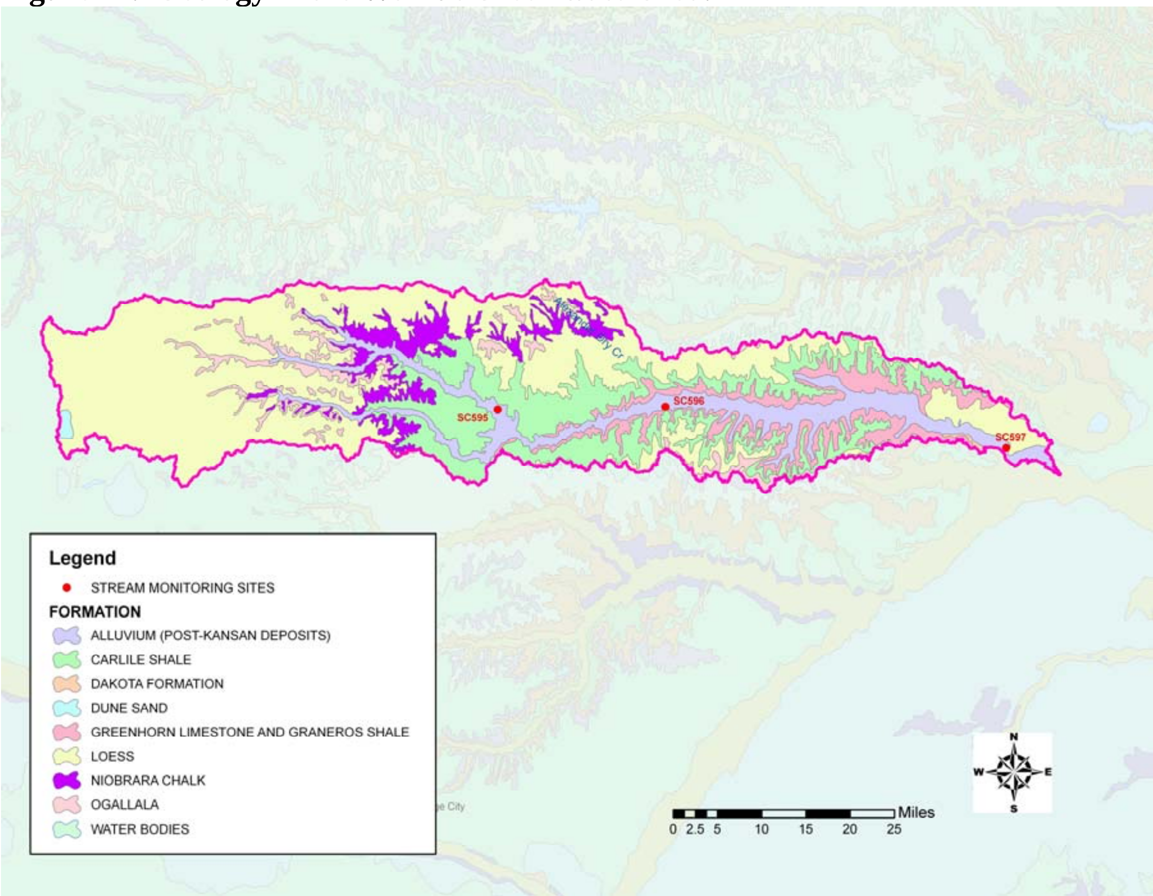
County	Period of Record	Average Annual Acre-Feet of Groundwater Diverted	Average Annual Acres Irrigated	Acre-Feet Per Acre
Scott	1990-2001	67,559	60,758	1.11
	2002-2006	61,652	57,463	1.07
	2007-2011	50,833	51,563	0.99
Lane	1990-2001	19,424	21,497	0.90
	2002-2006	19,843	19,378	1.02
	2007-2011	16,448	17,733	0.93
Ness	1990-2001	4,571	3,857	1.19
	2002-2006	4,566	4,062	1.12
	2007-2011	3,483	3,728	0.93
Rush	1990-2001	8,696	9,620	0.90
	2002-2006	9,681	11,062	0.88
	2007-2011	8,143	10,101	0.81
Barton	1990-2001	38,914	36,023	1.08
	2002-2006	41,809	38,658	1.08
	2007-2011	35,180	35,690	0.99

Background Levels: The main source of selenium in the Walnut Creek watershed is from the weathering of upper Cretaceous bedrock that underlies the drainage basin. The upper Cretaceous bedrock, primarily the Niobrara Chalk and Carlile Shale (Figure 24), contains relatively high concentrations of selenium in comparison with other bedrock in Kansas and the bentonite beds and shales in the chalk can be especially high in selenium.

Rainfall infiltrating through the high selenium soils and weathered bedrock also leaches selenium into the groundwater which then discharges into Walnut Creek, transporting dissolved selenium into the creek.

Source water data from communities along Walnut Creek indicate elevated selenium in wells since at least the 1990s especially those in proximity to the creek or influenced by the infiltration of irrigation water. Scott City, located outside the Walnut Creek watershed in Scott County reported a selenium value of 26 ppb in 2010, and Dighton (17 ppb, 2010), Ness City (33 ppb, 1997), and Alexander (25 ppb, 2006) have reported similar levels. Rush Center and Albert, downstream from Alexander on Walnut Creek do not have the same levels of selenium in their source water with a high selenium values of 3.6 ppb and 3.7 ppb (1990-2011) reported in 2009 at Rush Center and in 1995 at Albert suggesting selenium concentrations in groundwater is elevated by the presence of the Niobrara Chalk and Carlile Shale in the western portion of the watershed.

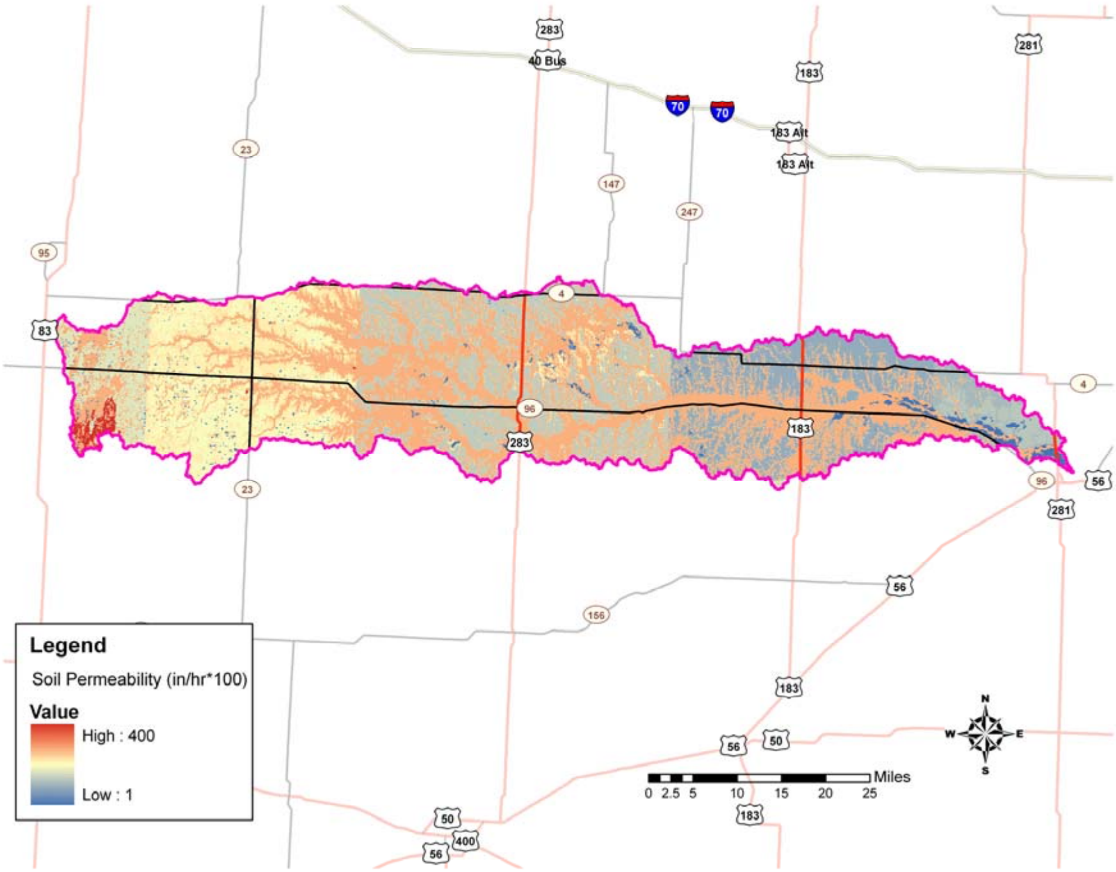
Figure 24. Geology in the Walnut Creek watershed.



Contributing Runoff: The watershed of Walnut Creek has a mean soil permeability value of 1.59 inches/hour, ranging from 0.01 inches/hour to 17.6 inches/hour according to NRCS STATSGO database (Figure 25). About 48% of the watershed has a permeability value less than 1.30 inches/hour, which contributes to runoff during low to extremely low rainfall intensity events while 25% has an extremely high permeability value of 13.0

inches/hour or higher. According to a USGS open-file report (Juracek, 2000), the threshold soil-permeability values are set at 3.43 inches/hour for very high, 2.86 inches/hour for high, 2.29 inches/hour for moderate, 1.71 inches/hour for low, 1.14 inches/hour for very low, and 0.57 inches/hour for extremely low soil-permeability. Runoff is primarily generated as infiltration excess when soil profiles become saturated and produce excess overland flow due to rainfall intensities that are greater than soil permeability.

Figure 25. Soil permeability in the Walnut Creek Watershed.



Population: The population in the watershed is approximately 9,055 people (5 people/mi^2) according to the 2000 U.S. Census Block information with 6,304 people residing within the cities in the watershed. As Table 23 reveals, population in the watershed is decreasing as the 2010 U.S. Census data shows a reduction of 523 people, or 8.3% of the population, within cities in the watershed.

Table 23. Population of cities in the Walnut Creek watershed.

City	2000 U.S. Census Population	2010 U.S. Census Population
Dighton	1,261	1,038
Utica	223	158
Ness City	1,534	1,449
Ransom	338	294
Brownell	48	29
Bazine	311	334
Alexander	75	65
Rush Center	176	170
La Crosse	1,376	1,342
Bison	235	255
Timken	83	76
Otis	325	282
Albert	181	175
Olmitz	138	114
Total	6,304	5781

On-Site Waste Systems: On-site waste systems are not a contributor to the selenium impairment in the watershed.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

The TMDL for selenium at each of the KDHE sampling stations on Walnut Creek has been established using the water quality standard for chronic exposure of aquatic life to selenium of 5 µg/L. However, natural selenium loading is being aggravated by irrigation practices within the watershed and is responsible for the excursions seen at the SC595 and SC596. Therefore, the TMDL will be staged in anticipation of alternative background concentrations for stations SC595 and SC596 that will replace the existing criterion for those stations once approval from the EPA is garnered. The TMDL for SC597, established at the current chronic water quality standard for selenium of 5 µg/L, is not eligible for assignment of background concentrations.

Point Sources: Unless point sources act to concentrate salts through reuse and evaporation or using processes such as reverse osmosis, they will tend to discharge water that is similar in selenium content to their source water. The six existing and potential point source contributors will be expected to put out an effluent that is less than the background concentrations designated for the creek. Table 24 lists the Wasteload Allocations that will be assigned to these point sources. Because of the dominant flow volume and elevated levels of selenium in the creek, relative to point source contributions, Wasteload Allocations will not bring attainment of water quality standards for selenium. In fact, wastewater discharges likely provide a flow base and dilution opportunities on the river.

Table 24. Wasteload Allocations of Selenium for Walnut Creek dischargers.

Facility	Station	Design Flow (MGD)	Design Flow (cfs)	Expected Selenium (μg/L)	Wasteload Allocation (lbs/day)
City of Dighton	SC595	0.2	0.31	5	0.0084
Total at 110300071		***0.2***	***0.31***	***5***	***0.0084***
City of Ransom	SC596	0.038	0.059	5	0.0016
Total at 110300086		***0.038***	***0.059***	***5***	***0.0016***
City of Rush Center	SC597	0.035	0.054	5	0.0015
City of LaCrosse	SC597	0.14	0.22	5	0.0059
City of Bison	SC597	0.030	0.046	5	0.0012
City of Otis	SC597	0.044	0.068	5	0.0018
Total at 110300082		***0.249***	***0.388***	***5 (Avg)***	***0.0105***
Overall Total	**All Stations**	**0.487**	**0.757**	**5 (Avg)**	**0.0204**

Non-Point Sources: Although the primary cause of the elevated selenium along Walnut Creek is the natural contribution from the geology and soils of the drainage area in the watershed aggravated by the historic pattern of irrigation return flow along the creek, a non-point source, the TMDL at SC595, SC596 and SC597 is established at the current aquatic life water quality standard for chronic exposure of 5 μg/L under all flow conditions and across all seasons. The proposed background concentrations at Ness City (SC595) and Alexander (SC596) are derived from the summer and winter average selenium concentrations of samples taken when the stream is at or below median flow. Following acceptance by the EPA, reductions made to meet the proposed background concentrations at SC595 and SC596 will likely lead to selenium levels below 5 μg/L at Heizer due to dilution. The TMDL assigned to the Walnut Creek stations along with the proposed background concentration loads are illustrated in Figures 26, 27 and 28 for each sampling station. Seasonal Load Allocations for various flow conditions at each sampling station is detailed in Tables 25, 26 and 27.

Figure 26. Selenium TMDL in Walnut Creek at Ness City, SC595, CUSEGA: 110300071.

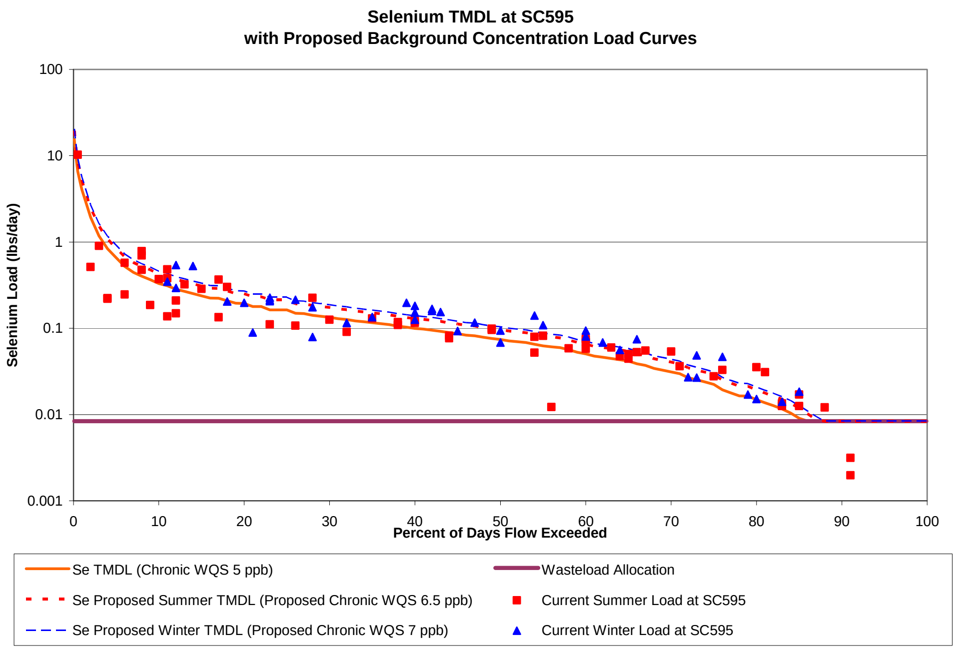


Table 25. Walnut Creek TMDL, Load Allocations, Wasteload Allocations and Margin of Safety under varying flow conditions for the current chronic Selenium WQS, the proposed summer (April-October) chronic selenium WQS and the proposed winter (November-March) chronic selenium WQS at Ness City (SC595).

Walnut Creek at Ness City – SC595 on CUSEGA 110300071					
Current Selenium Aquatic Life Chronic WQS 5 ppb TMDL	Flow	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
	Avg (9.51 cfs)	0.0084	0.2227	0.0257	0.2568
	10 % (12.2 cfs)	0.0084	0.2879	0.0329	0.3292
	25% (6.06 cfs)	0.0084	0.1389	0.0164	0.1637
	50% (2.76 cfs)	0.0084	0.0586	0.0074	0.0744
	75% (0.827 cfs)	0.0084	0.0117	0.0022	0.0223
	90% (0.138 cfs)	0.0084	0	0	0.0084
Proposed Summer Selenium Aquatic Life Chronic WQS 6.5 ppb TMDL	Flow	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
	Avg (9.51 cfs)	0.0084	0.2920	0.0334	0.3338
	10 % (12.2 cfs)	0.0084	0.3768	0.0428	0.4280
	25% (6.06 cfs)	0.0084	0.1831	0.0213	0.2128
	50% (2.76 cfs)	0.0084	0.0786	0.0097	0.0967
	75% (0.827 cfs)	0.0084	0.0177	0.0029	0.0290
	90% (0.138 cfs)	0.0084	0	0	0.0084
Proposed Winter Selenium Aquatic Life Chronic WQS 7 ppb TMDL	Flow	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
	Avg (9.51 cfs)	0.0084	0.3151	0.0360	0.3595
	10 % (12.2 cfs)	0.0084	0.4064	0.0461	0.4609
	25% (6.06 cfs)	0.0084	0.1979	0.0229	0.2292
	50% (2.76 cfs)	0.0084	0.0854	0.0104	0.1042
	75% (0.827 cfs)	0.0084	0.0198	0.0031	0.0313
	90% (0.138 cfs)	0.0084	0	0	0.0084

Figure 27. Selenium TMDL in Walnut Creek near Alexander, SC596, CUSEGA: 110300086.

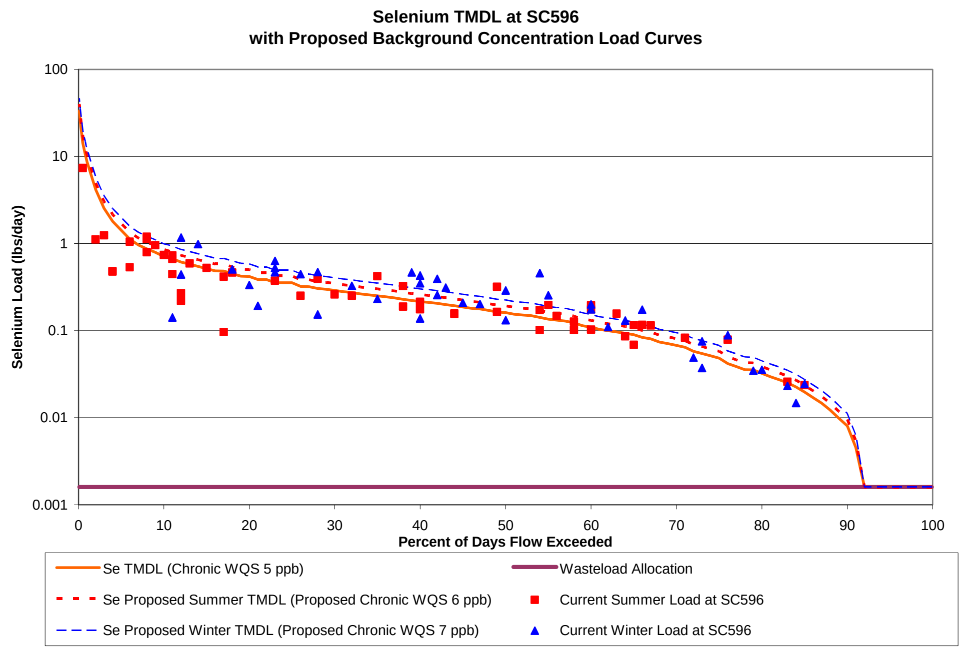


Table 26. Walnut Creek TMDL, Load Allocations, Wasteload Allocations and Margin of Safety under varying flow conditions for the current chronic Selenium WQS, the proposed summer (April-October) chronic selenium WQS and the proposed winter (November-March) chronic selenium WQS at Alexander (SC596).

Walnut Creek at Ness City – SC596 on CUSEGA 110300086					
Current Selenium Aquatic Life Chronic WQS 5 ppb TMDL	Flow	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
	Avg (20.6 cfs)	0.0016	0.4990	0.0556	0.5562
	10 % (26.4 cfs)	0.0016	0.6397	0.0713	0.7126
	25% (13.1 cfs)	0.0016	0.3174	0.0354	0.3544
	50% (5.97 cfs)	0.0016	0.1434	0.0161	0.1611
	75% (1.79 cfs)	0.0016	0.0419	0.0048	0.0483
	90% (0.30 cfs)	0.0016	0.0057	0.0008	0.0081
Proposed Summer Selenium Aquatic Life Chronic WQS 6 ppb TMDL	Flow	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
	Avg (20.6 cfs)	0.0016	0.5991	0.0667	0.6674
	10 % (26.4 cfs)	0.0016	0.7680	0.0855	0.8551
	25% (13.1 cfs)	0.0016	0.3811	0.0425	0.4252
	50% (5.97 cfs)	0.0016	0.1724	0.0193	0.1933
	75% (1.79 cfs)	0.0016	0.0506	0.0058	0.0580
	90% (0.30 cfs)	0.0016	0.0071	0.0010	0.0097
Proposed Winter Selenium Aquatic Life Chronic WQS 7 ppb TMDL	Flow	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
	Avg (20.6 cfs)	0.0016	0.6992	0.0779	0.7787
	10 % (26.4 cfs)	0.0016	0.8962	0.0998	0.9976
	25% (13.1 cfs)	0.0016	0.4449	0.0496	0.4961
	50% (5.97 cfs)	0.0016	0.2014	0.0226	0.2255
	75% (1.79 cfs)	0.0016	0.0593	0.0068	0.0677
	90% (0.30 cfs)	0.0016	0.0086	0.0011	0.0113

Figure 28. Selenium TMDL in Walnut Creek near Heizer, SC597, CUSEGA: 110300082.

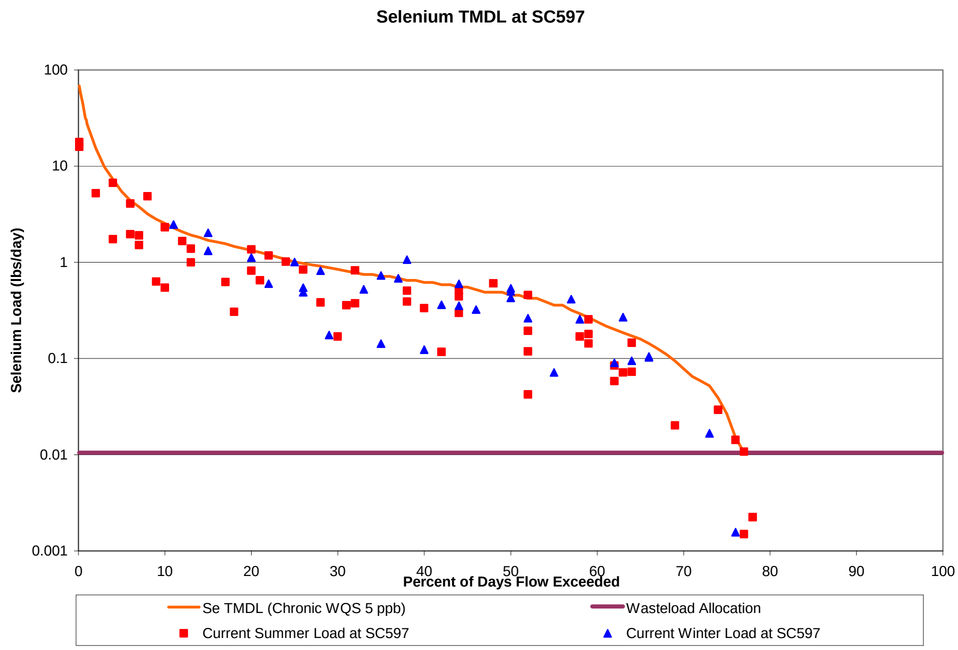


Table 27. Walnut Creek TMDL, Load Allocations, Wasteload Allocations and Margin of Safety under varying flow conditions during all seasons for the current chronic Selenium WQS at Heizer.

Walnut Creek at Heizer – SC597 on CUSEGA 110300082					
Current Selenium Chronic WQS 5 ppb TMDL	Flow	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
	Avg (59.3 cfs)	0.0105	1.4305	0.1601	1.6011
	10% (99.9 cfs)	0.0105	2.2721	0.2536	2.5362
	25% (32.3 cfs)	0.0105	0.8967	0.1008	1.0080
	50% (14.6 cfs)	0.0105	0.3992	0.0455	0.4552
	75% (0.85 cfs)	0.0105	0.0135	0.0027	0.0267
	90% (0.0 cfs)	0.0105	0	0	0.0105

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty of variable selenium loads and the endpoints of the TMDL. The margin of safety is explicitly set at 10% of the calculated selenium load which compensates for the lack for knowledge about the relationship between the allocated loadings and the resulting water quality. Additionally, an implicit margin of safety is tied to the conservative assumption that discharging NPDES permittees continuously discharge and the entire wasteload allocation will be seen at the respective KDHE sampling stations regardless of flow in Walnut Creek. Furthermore, Kansas Biological Survey (KBS) work on the impact of the electrical plant discharging to Dry Walnut Creek showed that despite higher selenium concentration in the creek the accumulation of selenium in fish was low (KBS, report No. 172).

State Water Plan Implementation Priority: Because this watershed's selenium load is predominately natural in source, this TMDL will be a Low Priority for implementation.

Unified Watershed Assessment Priority Ranking: The upper portion of this watershed lies within the Upper Walnut Creek Basin (HUC 8:11030007) with a priority ranking of 46 (Medium Priority for restoration work). The lower portion of this watershed lies within the Lower Walnut Creek Basin (HUC 8: 11030008) which is classified as a Category II watershed by 1999 Unified Watershed Assessment Framework and consequently does not have a priority ranking assigned to it.

Priority HUC 12: Because of the natural geologic contribution of this impairment, no priority subwatersheds will be identified.

5. IMPLEMENTATION

Desired Implementation Activities

1. Monitor any anthropogenic contributions of Selenium loading to Walnut Creek.
2. Establish alternative background concentrations for Walnut Creek at Ness City and Alexander according to Kansas Implementation Procedures: Surface Water Quality Standards.

Implementation Programs Guidance

NPDES and State Permits - KDHE

a. Direct existing municipal and industrial permitted facilities along Walnut Creek to monitor selenium levels in effluent at detection levels at or below 5 μg/L.
b. Apply appropriate effluent limits on discharges from facilities with significant selenium content.
c. Coordinate new permits to renew in concert with existing permits discharging to the Walnut Creek watershed to facilitate allocation of current and future wasteloads.

Water Quality Standards and Assessment – KDHE

a. Replace existing selenium criteria with seasonal background concentrations of selenium for Walnut Creek between Ness City and Heizer in accord with the second stage endpoints of this TMDL.
b. Request EPA finalize its aquatic life criteria.
c. Incorporate revised selenium criteria into Kansas surface water quality standards once criteria are finalized by EPA.

Division of Water Resources – KDA

a. Ensure future water use or management activities in the watershed do not reduce or impede streamflow during low flow conditions.

Timeframe for Implementation: Development of a background level based water quality standard should be accomplished with the water quality standards revision after 2016.

Targeted Participants: The primary participants for implementation will be KDHE.

Milestone for 2016: In accordance with the TMDL development schedule for the State of Kansas, the year 2016 marks the next cycle of 303(d) activities in the Upper Arkansas Basin. At that point in time, data from Walnut Creek will be reexamined to confirm the impaired status of Walnut Creek at Ness City and Alexander and the suggested background concentration and to assess the improved condition in Walnut Creek at Heizer.

Delivery Agents: The primary delivery agents for program participation will be the Kansas Department of Health and Environment.

Reasonable Assurances:
Authorities: The following authorities may be used to direct activities in the watershed to reduce pollution and to assure allocations of pollutant to point and nonpoint sources can be attained:

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 Upper Arkansas 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 Fund 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. Additionally, $2 million has been allocated between the State Water Plan Fund and EPA 319 funds to support implementation of Watershed Restoration and Protection Strategies. This watershed and its TMDL are a Low Priority consideration for funding.

Effectiveness: Minimal control can be exerted on natural contributions to loading.

6. MONITORING

KDHE will continue its quarterly sampling schedule on Walnut Creek in order assess the selenium impairment. Based on these sampling results and implementation of new background concentrations, the status of the 303(d) listing will be evaluated in 2022.

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 Upper Arkansas Basin.

Public Hearing: A Public Hearing on the Upper Arkansas River Basin was held in Garden City on September 20, 2012 to receive comments.

Basin Advisory Committee: The Upper Arkansas River Basin Advisory Committee met to discuss these TMDLs on April 4, 2012 in Jetmore and September 20, 2012 in Garden City.

Milestone Evaluation: In accordance with the TMDL development schedule for the State of Kansas, the year 2016 marks a future cycle of 303(d) activities in the Upper Arkansas Basin. At that point in time, sample data from Walnut Creek at SC595, SC596 and SC597 will be reexamined to assess improved conditions in the stream. Should the impairment remain adjustments to source assessment, allocation, and implementation activities may occur.

Consideration for 303(d) Delisting: Walnut Creek will be evaluated for delisting under section 303(d), based on the monitoring data over 2012-2021. Therefore, the decision for delisting will come about in the preparation of the 2022-303(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 may 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. Recommendations of this TMDL will be considered in the Kansas Water Plan implementation decisions under the State Water Planning Process for Fiscal Years 2012-2021.

Developed 1/9/13

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Kansas Department of Health and Environment, Division of Environment, Bureau of Water. December 6, 2004. Kansas Surface Water Quality Standards, Table of Numeric Criteria.

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Appendix A.

NPDES permitted facilities in the Walnut Creek watershed.

Kansas Permit No.	Federal Permit No.	Facility	Type	Receiving Stream	Design Flow MGD	Permit Expires
I-UA10-PR01	KSG110058	Concrete Industries – Dighton	Stormwater runoff	Non-discharging	N/A	9/30/12
M-UA10-OO01	KS0022527	City of Dighton	3 cell lagoon	S. Fk. Walnut Cr	0.2	9/30/16
M-UA42-NO01	KSJ000259	City of Utica	2 cell lagoon	Non-discharging	N/A	6/30/12
I-UA28-PR01	KSG110057	Concrete Industries – Ness City	Earthen basin	Non-discharging	N/A	9/30/12
M-UA28-NO01	KSJ000269	City of Ness City	3 cell lagoon	Non-discharging	N/A	5/31/12
M-UA34-OO01	KS0031453	City of Ransom	3 cell lagoon	Bazine Dry Cr	0.038	3/31/16
P-UA34-OO01	KSP000045	Deines Corp.	Pre-treatment	Ransom MWWTP	N/A	6/30/15
M-UA03-NO01	KSJ000290	City of Bazine	3 cell lagoon	Non-discharging	N/A	5/31/12
M-UA02-NO01	KSJ000289	City of Alexander	2 cell lagoon	Non-discharging	N/A	5/31/12
M-UA36-OO01	KS0117102	City of Rush Center	Activated sludge	Walnut Cr	0.035	12/31/11
M-UA23-OO01	KS0024643	City of Lacrosse	3 cell lagoon	Sand Cr	0.14	6/30/16
M-UA04-OO01	KS0116688	City of Bison	2 cell lagoon	Sand Cr	0.030	3/31/16
M-UA31-OO01	KS0091758	City of Otis	3 cell lagoon	Boot Cr	0.044	9/30/16
M-UA01-NO01	KSJ000288	City of Albert	2 cell lagoon	Non-discharging	N/A	10/31/12
M-UA30-NO01	KSJ000271	City of Olmitz	3 cell lagoon	Non-discharging	N/A	1/31/12
C-UA16-NO01	KSJ000533	All Seasons Mobile Home Park	2 cell lagoon	Non-discharging	N/A	3/31/12

Appendix B.

Confined Animal Feeding Operations (CAFO) in the Walnut Creek watershed.

Kansas Permit Number	Federal NPDES Permit Number	Type	County	Animal Total
A-UASC-C008	KS0115151	Beef	Scott	9000
A-UASC-C025	KS0094153	Beef	Scott	8450
A-UASC-C021	KS0095869	Beef	Scott	4500
N-UALE-4787	N/A	Beef	Lane	300
A-UALE-BA04	N/A	Beef	Lane	950
A-UALE-BA01	N/A	Beef	Lane	500
A-UALE-C004	KS0115177	Beef	Lane	44,000
A-UALE-S002	N/A	Swine	Lane	2,100
A-UALE-B004	N/A	Beef	Lane	850
A-UALE-C002	KS0115096	Beef	Lane	12,000
A-UALE-S005	N/A	Swine	Lane	3,350
A-UALE-B005	N/A	Beef	Lane	999
A-UALE-B006	N/A	Beef	Lane	950
A-UALE-C005	KS0098582	Beef	Lane	3,750
A-UALE-B001	N/A	Beef	Lane	750
A-UALE-BA03	N/A	Beef	Lane	950
A-UANS-BA02	N/A	Beef	Ness	600
A-UANS-BA03	N/A	Beef	Ness	200
A-UANS-BA04	N/A	Beef	Ness	210
A-UANS-BA06	N/A	Beef	Ness	999
A-UANS-BA07	N/A	Beef	Ness	800
A-UARH-BA09	N/A	Beef	Rush	150
A-UARH-BA21	N/A	Beef	Rush	150
A-UARH-BA22	N/A	Beef	Rush	200
A-UARH-BA14	N/A	Beef	Rush	220
A-UARH-BA12	N/A	Beef	Rush	500
A-UARH-BA18	N/A	Beef	Rush	300
A-UARH-BA06	N/A	Beef	Rush	400
A-UARH-BA11	N/A	Beef	Rush	100
A-UARH-BA20	N/A	Beef	Rush	310
A-UARH-BA13	N/A	Beef	Rush	850
A-UARH-BA07	N/A	Beef	Rush	500
A-UARH-BA10	N/A	Beef	Rush	600
A-UARH-BA08	N/A	Beef	Rush	250
A-UARH-BA19	N/A	Beef	Rush	500
A-UARH-BA03	N/A	Beef	Rush	250
239	N/A	Beef	Rush	40
A-UARH-BA04	N/A	Beef	Rush	700
A-UARH-BA16	N/A	Beef	Rush	500
A-UARH-C004	KS0097497	Beef	Rush	1,200
A-UARH-B010	N/A	Beef	Rush	131
A-UARH-B012	N/A	Beef	Rush	800
A-UARH-B014	N/A	Beef	Rush	350
A-UARH-C005	KS0094846	Beef	Rush	1,950
A-UARH-B015	N/A	Beef	Rush	200
A-UARH-B006	N/A	Beef	Rush	150
A-UARH-B013	N/A	Beef	Rush	800
A-UARH-B001	N/A	Beef	Rush	800

A-UARH-B002	N/A	Beef	Rush	950
A-UARH-BA04	N/A	Beef	Rush	140
1087	N/A	Beef	Rush	800
A-UARH-BA15	N/A	Beef	Rush	70
A-UARH-B011	N/A	Beef	Rush	300
A-UARH-BA01	N/A	Beef	Rush	40
A-UARH-B003	N/A	Beef	Rush	400
A-UARH-C001	N/A	Beef	Rush	2,000
A-UABT-BA04	N/A	Beef	Barton	250
A-UABT-BA08	N/A	Beef, Swine	Barton	120
A-UABT-SA04	N/A	Beef, Swine, Sheep	Barton	175
A-UABT-B004	N/A	Beef	Barton	999
A-UABT-B003	N/A	Beef	Barton	999
A-UABT-C002	KS0040576	Beef	Barton	35,000
A-UABT-C001	KS0040606	Beef	Barton	28,000
A-UABT-C005	KS0088536	Beef	Barton	1,350

Appendix C. Ground and surface water diversions in the Walnut Creek Watershed.

IND: Industrial;
IRR: Irrigation;
MUN: Municipal;
REC: Recreation;
STK: Stock Watering

Year	Ground Water Usage (Acre-Feet)						Acres Irrigated with Ground Water	Surface Water Usage (Acre-Feet)			Acres Irrigated with Surface Water
	IND	IRR	MUN	REC	STK	Total Ground Water Diverted		IRR	REC	Total Surface Water Diverted	
Scott County											
1990	0	2,692	0	0	34	2,727	2,943	0	0	0	0
1991	0	3,229	0	0	59	3,288	3,166	0	0	0	0
1992	0	3,452	0	0	48	3,500	3,158	0	0	0	0
1993	0	3,421	0	0	141	3,562	3,139	0	0	0	0
1994	0	3,861	0	0	99	3,959	3,145	0	0	0	0
1995	0	4,033	0	0	112	4,145	3,170	0	0	0	0
1996	0	4,752	0	0	54	4,806	3,492	0	0	0	0
1997	0	4,179	0	0	64	4,243	3,513	0	0	0	0
1998	0	4,833	0	0	30	4,863	3,577	0	0	0	0
1999	0	4,047	0	0	57	4,104	3,404	0	0	0	0
2000	0	4,312	0	0	78	4,390	3,680	0	0	0	0
2001	0	4,227	0	0	70	4,297	3,711	0	0	0	0
2002	0	3,737	0	0	48	3,785	4,024	0	0	0	0
2003	0	2,706	0	0	55	2,760	3,689	0	0	0	0
2004	0	2,782	0	0	47	2,829	3,030	0	0	0	0
2005	0	3,455	0	0	74	3,529	2,681	0	0	0	0
2006	0	3,422	0	0	37	3,458	2,597	0	0	0	0
2007	0	1,924	0	0	25	1,949	1,851	0	0	0	0
2008	0	2,340	0	0	34	2,374	2,584	0	0	0	0
2009	0	3,457	0	0	37	3,493	2,639	0	0	0	0
2010	0	5,419	0	0	28	5,447	3,404	0	0	0	0
Lane County											
1990	2.2	20,204	384	0	648	21,237	18,187	0	0	0	0
1991	3.2	20,259	406	0	663	21,331	18,272	0	0	0	0
1992	0.42	12,941	300	0	349	13,590	15,237	0	0	0	0
1993	0.59	9,609	281	0	338	10,229	13,341	0	0	0	0
1994	0.59	15,633	339	0	418	16,390	13,670	0	0	0	0
1995	0.41	16,834	319	0	426	17,580	16,471	0	0	0	0
1996	0.92	12,429	291	0	358	13,079	16,318	0	0	0	0
1997	0.53	11,786	325	0	398	12,509	16,162	0	0	0	0
1998	0.63	11,683	364	0	356	12,404	17,032	0	0	0	0
1999	0.26	12,753	317	0	370	13,441	17,463	0	0	0	0
2000	0.79	14,106	403	0	383	14,893	17,450	0	0	0	0
2001	0.08	13,848	367	0	447	14,662	14,936	0	0	0	0
2002	0.31	15,745	379	0	325	16,448	15,446	0	0	0	0
2003	0.36	17,207	365	0	418	17,990	14,875	0	0	0	0
2004	0.25	15,343	356	0	473	16,173	15,400	0	0	0	0
2005	0.18	12,727	356	0	476	13,559	14,842	0	0	0	0
2006	0.28	14,866	345	0	517	15,729	14,510	0	0	0	0
2007	0.36	10,596	306	0	431	11,333	14,385	0	0	0	0
2008	0.16	14,164	327	0	431	14,921	13,861	0	0	0	0
2009	0.25	12,511	294	0	406	13,212	13,452	0	0	0	0
2010	0.43	12,724	342	0	432	13,499	14,344	0	0	0	0

Year	Ground Water Usage (Acre-Feet)						Acres Irrigated with Ground Water	Surface Water Usage (Acre-Feet)			Acres Irrigated with Surface Water
	IND	IRR	MUN	REC	STK	Total Ground Water Diverted		IRR	REC	Total Surface Water Diverted	
Ness County											
1990	0	1982	338	0	0	2,321	1,206	219	101	320	251
1991	0	2173	388	0	0	2,561	1,580	244	96	340	253
1992	0	250	355	0	0	605	642	68.8	101	170	156
1993	0	56.7	272	0	0	329	174	13.4	274	287	26
1994	0	790	323	0	0	1,113	1,049	596	102	698	294
1995	0	512	296	0	0	808	1,044	314	0	314	298
1996	0	505	292	0	0	798	746	123	0	123	225
1997	0	245	267	0	0	512	502	242	0	242	254
1998	0	279	265	0	0	545	364	317	0	317	302
1999	0	325	263	0	0	588	593	169	0	169	164
2000	0	578	293	0	0	870	914	217	0	217	210
2001	0	715	285	0	0	1,000	1,017	217	0	217	161
2002	0	821	293	0	0	1,113	1,324	156	0	156	114
2003	0	839	271	0	0	1,110	1,187	29.7	0	29.7	40
2004	0	418	251	0	0	668	868	92.3	0	92.3	130
2005	0	600	263	0	0	862	1,025	168	0	168	125
2006	0	578	266	0	0	845	982	52.4	0	52.4	50
2007	0	344	260	0	0	603	805	1.2	0	1.20	4
2008	0	374	254	0	0	628	948	5.83	0	5.83	5
2009	0	378	226	0	0	604	899	124	0	124	50
2010	0	557	278	0	0	835	1,236	5.42	0	5.4	8
Rush County											
1990	0	13,600	602	0	0.090	14,202	11,377	0	0	0	0
1991	0	15,915	644	0	0.090	16,559	11,682	3.33	0	3.33	6
1992	0	993	531	0	0.040	1,524	4,539	0	0	0	0
1993	0	1,220	498	0	0.110	1,718	3,924	29.4	0	29.4	50
1994	0	9,876	573	0	0.230	10,450	10,863	64.3	0	64.3	83
1995	0	10,459	565	0	0.170	11,024	10,757	49.3	0	49.3	40
1996	0	7,201	578	0	0.140	7,779	10,015	78.2	0	78.2	67
1997	0.250	5,083	584	0	0.240	5,667	9,936	72.2	0	72.2	68
1998	0.100	6,033	551	0	0.130	6,585	10,133	101	0	101	106
1999	0.300	6,496	550	0	0.100	7,046	10,847	107	0	107	128
2000	0.220	9,902	634	0	0.080	10,537	11,298	67.1	0	67.1	212
2001	0.410	11,052	636	0	0.070	11,688	11,892	61.3	0	61.3	118
2002	0.410	11,659	628	0	0.090	12,287	11,765	85.1	0	85.1	132
2003	0.450	11,238	599	0	0.050	11,837	11,522	47.0	0	47.0	37
2004	0.710	5,054	630	0	0.060	5,685	11,160	53.0	0	53.0	75
2005	0.640	8,460	600	0	0.030	9,060	11,166	22.4	0	22.4	23
2006	0.600	9,510	625	0	0.020	10,135	10,744	51.5	0	51.5	50
2007	0.160	7,434	570	0	14.3	8,019	10,297	42.8	0	42.8	43
2008	0.190	6,050	540	0	14.5	6,605	10,081	51.1	0	51.1	80
2009	0.370	8,439	472	0	3.01	8,915	10,242	144	0	144	143
2010	0.340	8,630	599	0	4.63	9,234	10,564	77.0	0	77.0	81

Year	Ground Water Usage (Acre-Feet)						Acres Irrigated with Ground Water	Surface Water Usage (Acre-Feet)			Acres Irrigated with Surface Water
	IND	IRR	MUN	REC	STK	Total Ground Water Diverted		IRR	REC	Total Surface Water Diverted	
Barton County											
1990	53.0	6,822	667	1.10	270	7,814	7,373	0	9,590	9,590	0
1991	58.7	10,231	700	0	379	11,369	8,415	0	827	827	0
1992	39.0	1,525	577	0	247	2,388	4,587	0	664	664	0
1993	28.1	1,679	582	0	217	2,506	4,642	0	464	464	10
1994	42.1	6,897	777	0	301	8,017	6,622	10.0	2,037	2,047	35
1995	60.9	5,538	728	0	347	6,673	6,765	8.00	5,522	5,530	0
1996	33.4	5,400	660	0	425	6,518	6,866	0	6,590	6,590	0
1997	2.04	3,654	643	0	373	4,672	6,481	0	15,717	15,717	40
1998	1.41	4,778	672	0	436	5,887	6,595	60.0	11,479	11,539	0
1999	1.47	4,284	631	0	378	5,294	6,760	0	3,457	3,457	35
2000	18.5	5,844	705	18.0	470	7,056	6,904	9.58	8,027	8,037	0
2001	44.4	6,229	657	2.15	503	7,435	6,635	0	7,922	7,922	35
2002	26.7	6,119	695	0	461	7,301	7,022	12.3	12,468	12,480	0
2003	6.36	6,706	647	11.0	441	7,811	6,868	0	7,754	7,754	0
2004	4.14	3,512	558	0	453	4,527	13,027	0	11,682	11,682	0
2005	2.34	5,139	583	1.00	524	6,249	6,939	0	12,802	12,802	0
2006	2.09	5,777	566	3.00	801	7,149	6,922	0	9,066	9,066	0
2007	1.66	4,488	580	0	728	5,798	6,474	0	12,422	12,422	15
2008	18.7	3,149	585	0	678	4,431	6,645	0	0	0	0
2009	8.36	4,426	493	0	530	5,458	6,428	17.8	6,552	6,570	40
2010	3.14	4,044	344	0	525	4,916	6,560	3.00	28,138	28,141	40