SOLOMON RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Water Body/Assessment Unit: Upper South Fork Solomon River
Webster Lake Watershed
Water Quality Impairment: Selenium

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Upper South Fork Solomon

Counties: Graham, Rooks, Sheridan, Sherman, and Thomas

HUC 8: 10260013 **HUC 11** (14)**: 010** (010, 020, 030, 040, 050, 060) (Figure 1)
020 (010, 020, 030, 040, 050, 060, 070)
030 (010, 020, 030, 040, 050)
040 (010, 020, 030, 040, 050, 060)
050 (010, 020, 030, 040)

Ecoregion: Western High Plains, Flat to Rolling Cropland (25d)
Central Great Plains, Rolling Plains and Breaks (27b)

Drainage Area: Approximately 1,144 square miles.

Webster Lake (Not Impaired)

Conservation Pool: Area = 3,436 acres
Watershed Area: Lake Surface Area = 213:1
Maximum Depth = 12.0 meters (39.4 feet)
Mean Depth = 4.9 meters (16 feet)
Retention Time = 1.76 years (21.1 months)

Designated Uses: Primary and Secondary Contact Recreation; Expected Aquatic Life Support; Food Procurement; Irrigation

Authority: Federal (U.S. Bureau of Reclamation) and State (Kansas Dept. of Wildlife and Parks)

Upper South Fork Solomon River

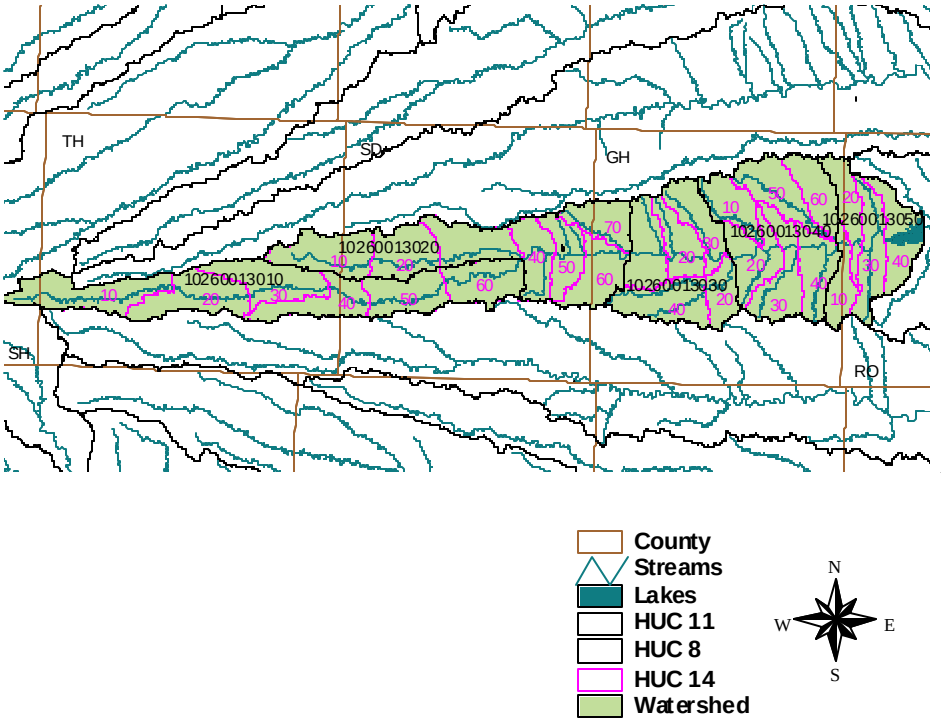
Main Stem Segment: WQLS: 4-part, 6, 7, 9, 10, 12, 14, & 16 (Upper South Fork Solomon River) starting at Webster Lake and traveling upstream to the headwater of the Upper South Fork Solomon River.

Tributaries:

Antelope Cr (13)
Brush Cr (17)
Coon Cr (8)
Foster Cr (19)
Jackson Branch (24)
Rock Cr (22)
Sand Cr (11, 15, & 27)
Skunk Cr (26)
Slate Cr (25)
South Martin Cr (23)
Spring Cr (5 & 817)
Storer Cr (20)
Wildhorse Cr (18)
Youngs Cr (21)

Figure 1

Webster Lake HUC 14



Designated Uses: Primary and Secondary Contact Recreation; Expected Aquatic Life Support; Drinking Water; Food Procurement; Groundwater Recharge, Industrial Water Supply, Irrigation; Livestock Watering on Main Stem Segments

2002 303(d) Listing: Webster Lake Basin Streams

Impaired Use: Expected Aquatic Life Support

Water Quality Standard: 5 Fg/liter for Chronic Aquatic Life (KAR 28-16-28e(c)(2)(F)(ii)

In stream segments where background concentrations of naturally occurring substances, including chlorides and sulfates, exceed the water quality criteria listed in table 1a of subsection (d), 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(ee), and available upon request from the department.
(K.A.R.28-16-28e(b)(9))

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Use under 2002 303(d): Not Supporting Expected Aquatic Life Support

Lake Monitoring Site: Station 012001 in Webster Lake (Figure 2).

Period of Record Used: Six surveys during 1986 - 2000

Elevation Record: Webster Reservoir near Stockton, KS (USGS Gage 6873100)

Stream Chemistry Monitoring Site: Station 547 near Damar (South Fork Solomon River)

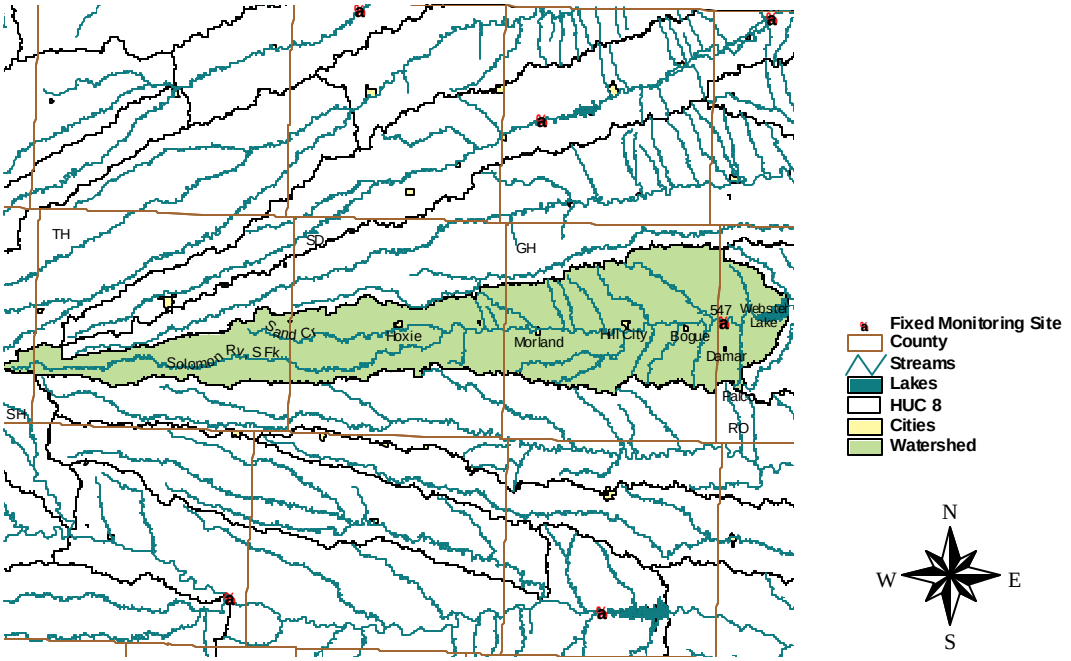
Period of Record Used: 1990 - 2002

Flow Record: South Fork Solomon River above Webster Reservoir, KS (USGS Gage 6873000)

Long Term Flow Conditions: Median Flow = 9.4 cfs

Figure 2

Webster Lake TMDL Reference Map



Current Condition: The average selenium concentrations in Webster Lake have been below the water quality standard of 0.005 mg/L every year since the 1986 monitoring period (Appendix A and the table below). In 1986, the average selenium concentration was 0.0110 mg/L. For the period of record that followed, the selenium concentration averaged 0.0027 mg/L. The load of selenium to Webster Lake is approximately 96.4 pounds per year. The sediment deposition in Webster Lake is minimal; the average selenium concentration of the sediment is 1.5 mg/kg in the channel.

Average Selenium Concentration in Webster Lake

Date	Selenium (mg/L)	Reservoir Forebay Elevation (ft)
7/30/86	0.0110	normal pool elevation = 1892.45
6/28/89	0.0010	1870.77
8/13/91	0.0025	1859.50
6/6/94	0.0040	1894.17
6/24/97	0.0031	1894.14
7/18/00	0.0020	1891.19

The concentrations of selenium in Webster Lake have been lower than the in-stream selenium concentrations in the Upper South Fork Solomon River during the six months prior to the lake sampling date (Figures 3 & 4). The selenium has been diluted by the volume of water in the lake.

Figure 3

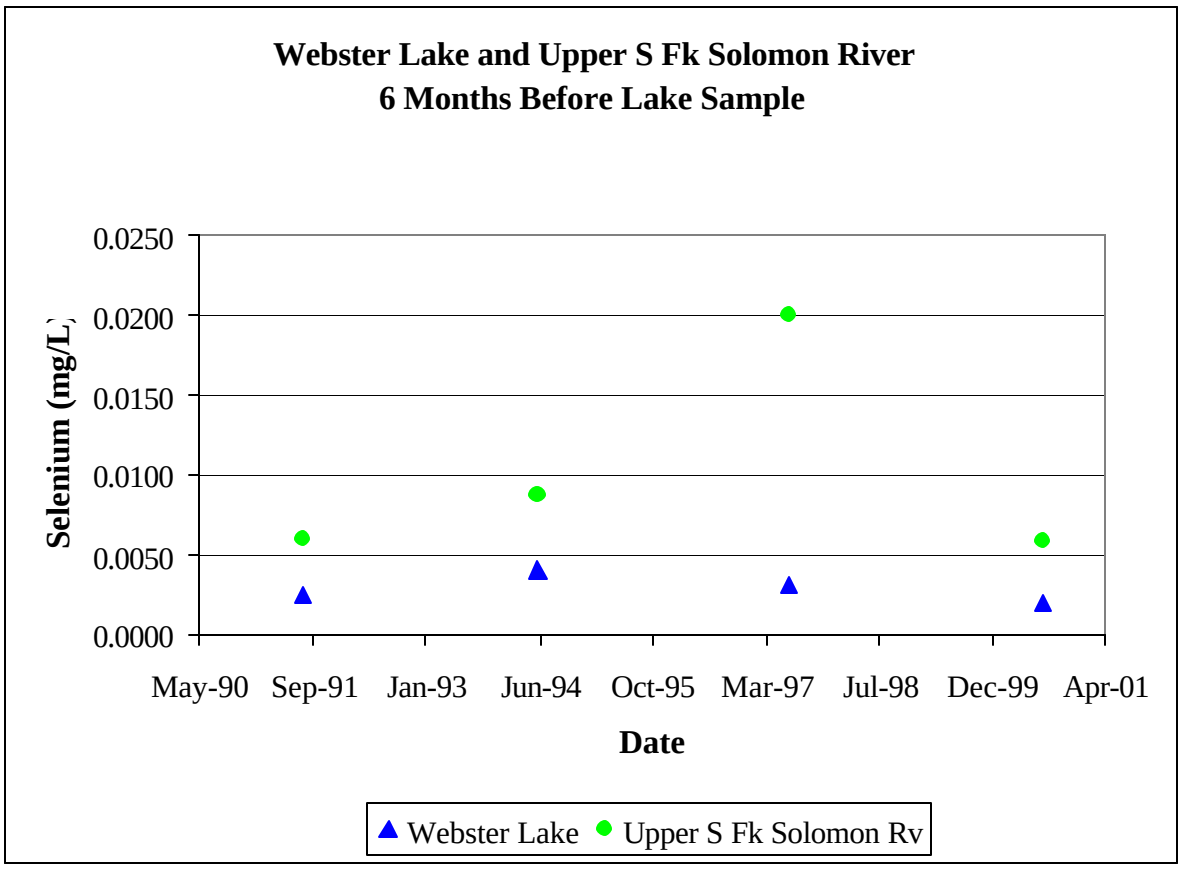
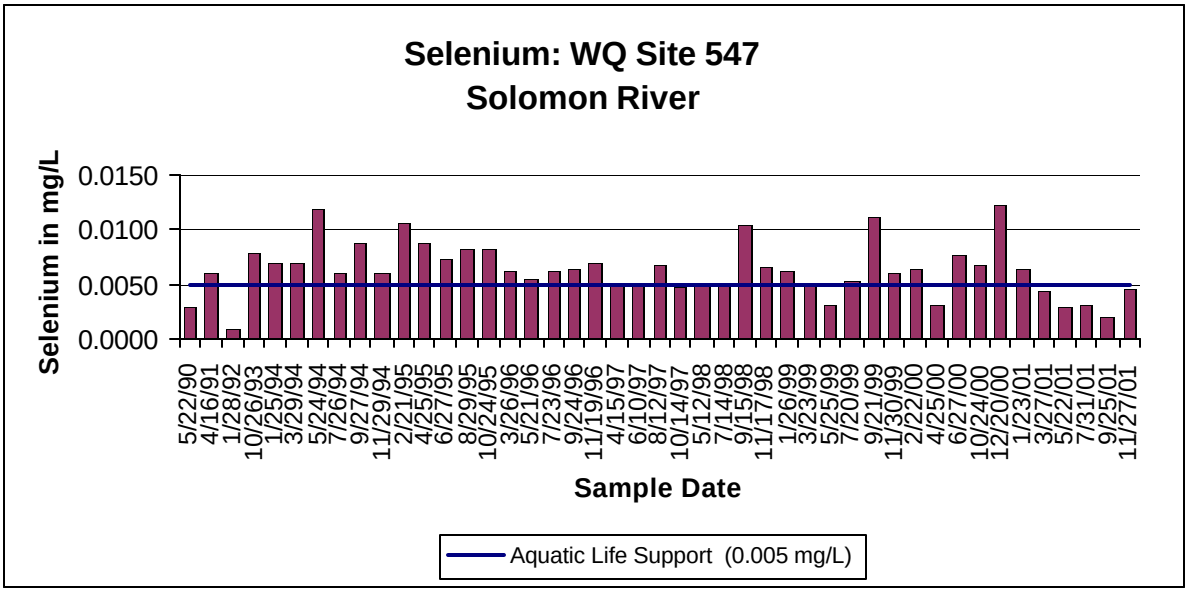
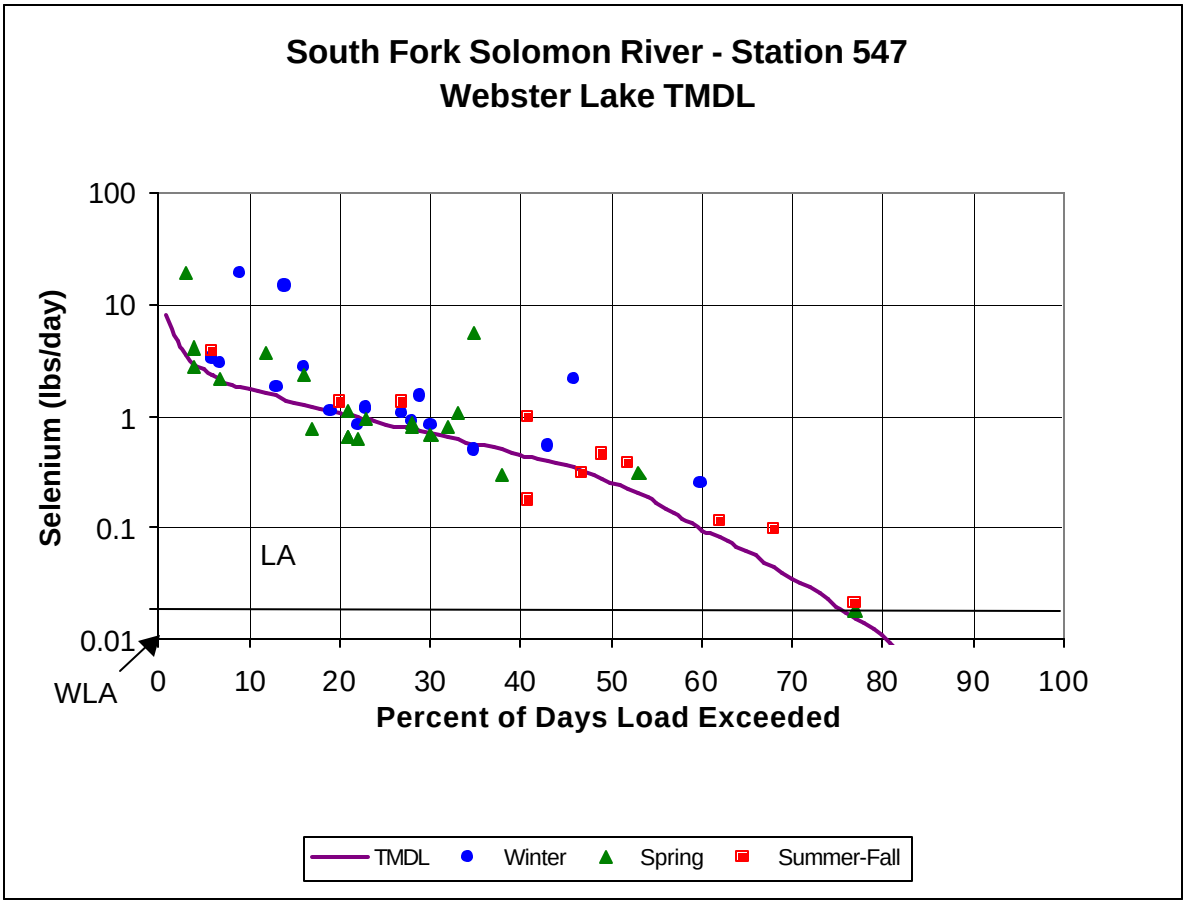


Figure 4



Since loading capacity varies as a function of the flow present in the stream, this TMDL represents a continuum of desired loads over all flow conditions, rather than fixed at a single value. Sample data for the sampling sites were categorized for each of the three defined seasons: Spring (Apr-Jul), Summer-Fall (Aug-Oct) and Winter (Nov-Mar). High flows and runoff equate to lower flow durations; baseflow and point source influences generally occur in the 75-99% range. A Load curve was established for the Expected Aquatic Life Support criterion by multiplying the flow values along the curve by the applicable water quality criterion and converting the units to derive a load duration curve of pounds of selenium per day. This load curves represent the TMDL since any point along the curve represents water quality for the standard at that flow. Historic excursions from the water quality standard are seen as plotted points above the load curve. Water quality standards are met for those points plotting below the load duration curve (Figure 5).

Figure 5



Station 547: Excursions were seen in each of the three defined seasons and are outlined below. Sixty percent of Spring samples and 82% of Summer-Fall samples were over the aquatic life support criterion. Eighty-three percent of Winter samples were over the criterion. Overall, 73% of the samples were over the criteria. This would represent a potential baseline condition of non-support of the impaired designated use.

NUMBER OF SAMPLES OVER SELENIUM STANDARD OF 0.005 mg/L BY FLOW AND SEASON

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
South Fork Solomon River (547) Damar	Spring	2	3	5	1	1	0	12/20 = 60%
	Summer	1	1	3	3	1	0	9/11 = 82%
	Winter	3	5	6	1	0	0	15/18 = 83%

Interim Endpoints of Water Quality (Implied Load Capacity) at Station 547 over 2008 - 2012:

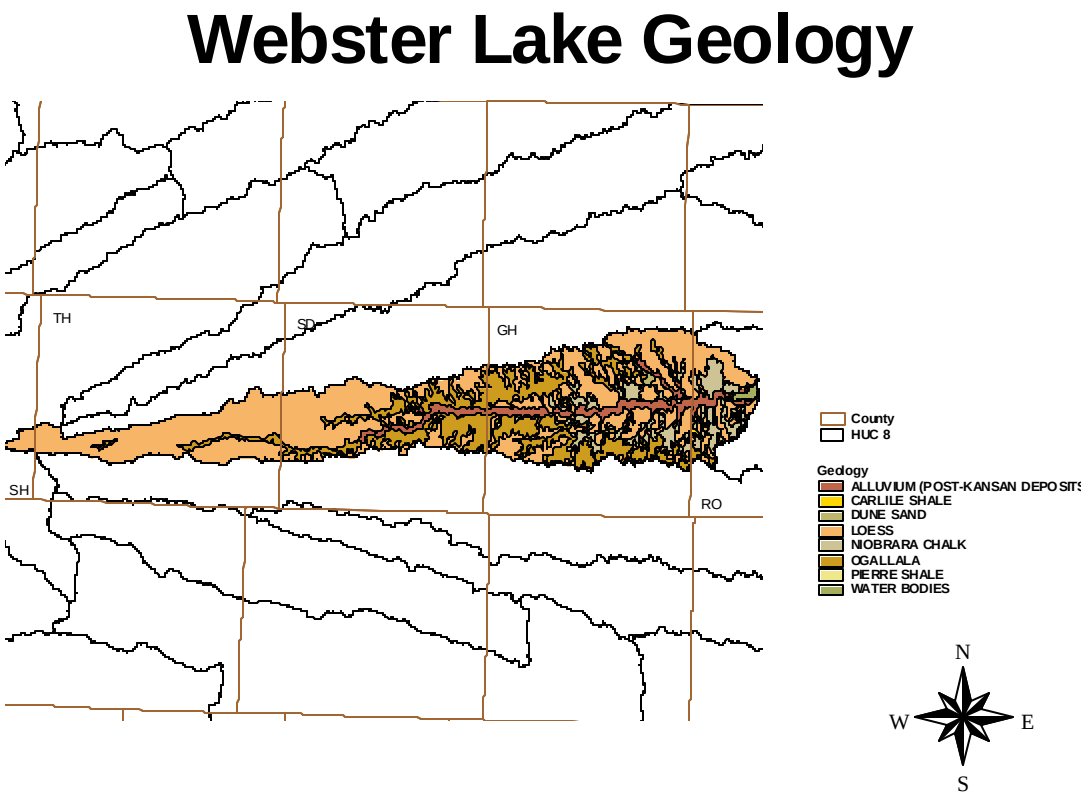
The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting chronic aquatic life support. The current standard of 0.005 mg/L of selenium was used to establish the TMDL. The Webster Lake Watershed is subject to loading of selenium from the underlying upper Cretaceous bedrock and its high selenium content. As such, the watershed's main stem often has elevated selenium levels from this natural source. Because some of this elevated selenium is tied to historic water consumption via surface water irrigation, the 0.005 mg/l endpoint will apply to all flows at Station 547.

Seasonal variation has been incorporated in this TMDL through the documentation of the seasonal consistency of elevated selenium levels. Achievement of the endpoints indicates 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.

3. SOURCE INVENTORY AND ASSESSMENT

Selenium background: The main natural source of selenium in the Webster Lake basin is from the weathering of upper Cretaceous bedrock that underlies the drainage basin. The upper Cretaceous bedrock, primarily the Niobrara Chalk, contains relatively high concentrations of selenium in comparison with other bedrock in Kansas. The bentonite beds and shales in the Chalk can be especially high in selenium. Soils weathered from the bedrock can have relatively high selenium content. Some plants growing in grasslands on soils containing high selenium concentration can accumulate enough selenium that they are toxic to livestock. Rainfall infiltrating through the high selenium soils and weathered bedrock leaches selenium. Water discharging from the soil and weathered bedrock transports dissolved selenium into streams. Evapotranspiration consumption of surface and ground water in the drainage basin then further increases the selenium concentration of the stream water.

Figure 6



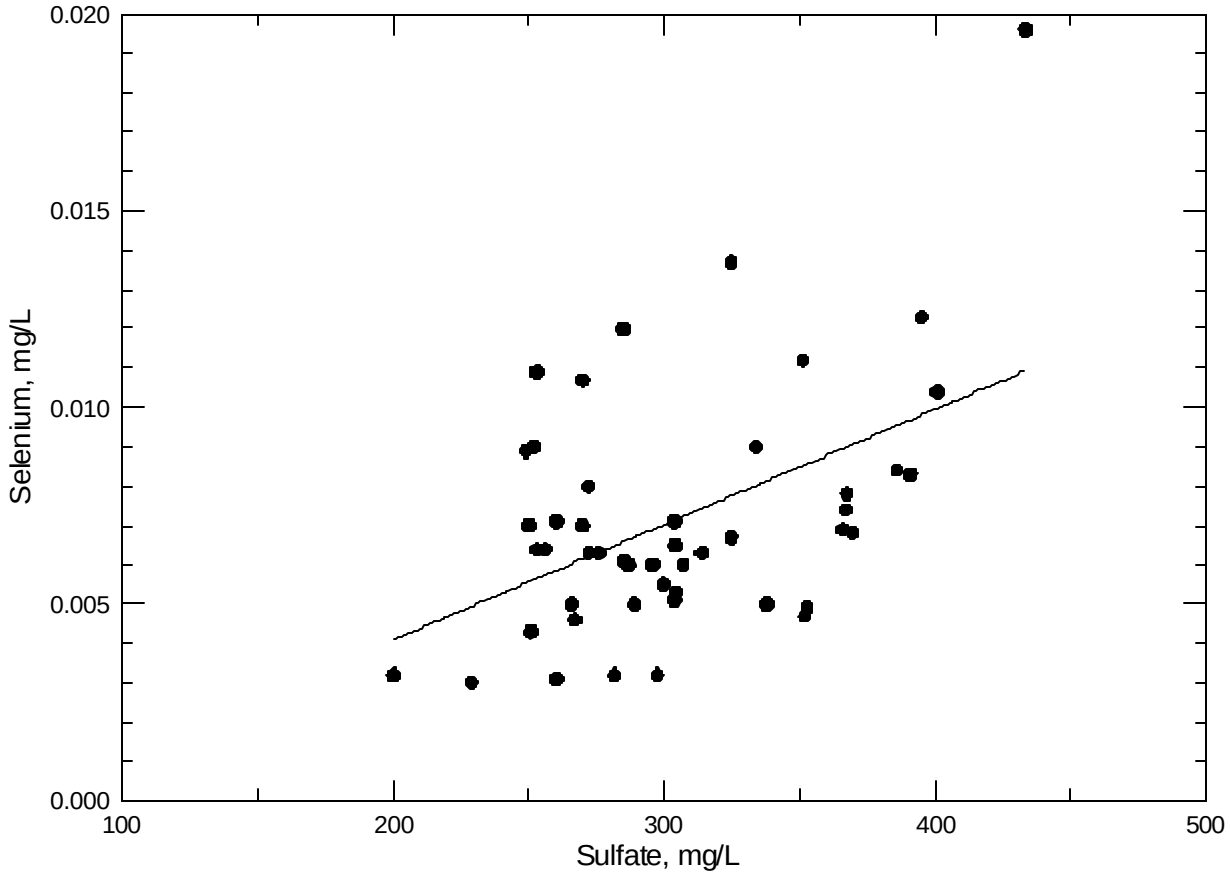
Factors controlling variations in selenium:

The selenium concentrations range from < 0.0010 mg/L to 0.0196 mg/L in the rivers and streams of the Webster Lake basin. The average concentration for detectable selenium is 0.0070 mg/L. There is a general, statistically significant correlation of selenium content with total dissolved solids as well as with sulfate concentration for station 547 on the Upper South Fork of the Solomon River (Figure 7). There is no substantial relationship between selenium content and flow at the Upper South Fork of the Solomon River. The best-fit power curve suggests increasing selenium levels with decreasing flow in the graph for the upper South Fork Solomon River near Damar (Figure 8).

Long-term increases in the total dissolved solids and sulfate concentrations with time as a result of increased water consumption in the Solomon basin have probably also increased the selenium content of the streams and rivers in the basin. The main factor for the dissolved solids increase is the consumption of water by irrigation that leaves the residual dissolved salts, including selenium, in a smaller volume of water. Increases in selenium concentration of surface waters associated with irrigation and soils of high selenium content have been documented elsewhere in the United States (Jacobs, 1989). Nolan and Clark (1997) found that the presence or absence of Upper Cretaceous sediment and irrigation were the two most significant factors related to the selenium contents of surface and ground waters sampled as part of the National Irrigation Water Quality Program of the U.S. Department of the Interior. Phreatophytes in the riparian corridor of

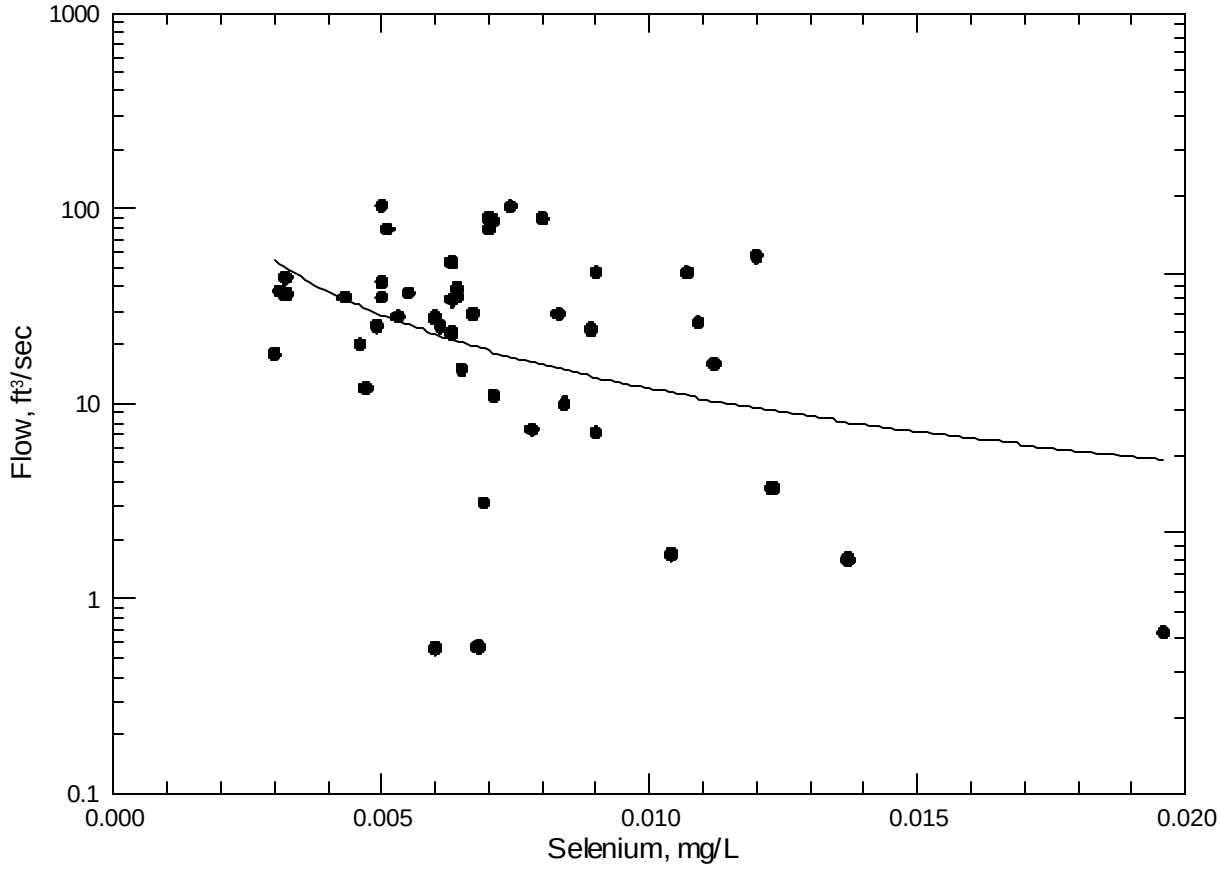
the rivers and tributaries in the Solomon basin have also increased the dissolved solids of shallow ground waters; concomitant increases in selenium contents in the shallow ground water discharged to streams would also be expected.

Figure 7. Selenium versus sulfate concentration for detectable levels of selenium in the upper South Fork Solomon River near Damar, station 547, during 1990 to early 2003.



Irrigation Return Flows: Irrigation practices have probably increased the concentration of selenium from natural sources. Irrigation reports from groundwater sources in 1998 indicate that 53,987 acres were irrigated in the watershed.

Figure 8. Variation in selenium concentration with flow in the upper South Fork Solomon River near Damar, station 547, during 1990 to early 2003. The line through the data points is a best-fit power curve.

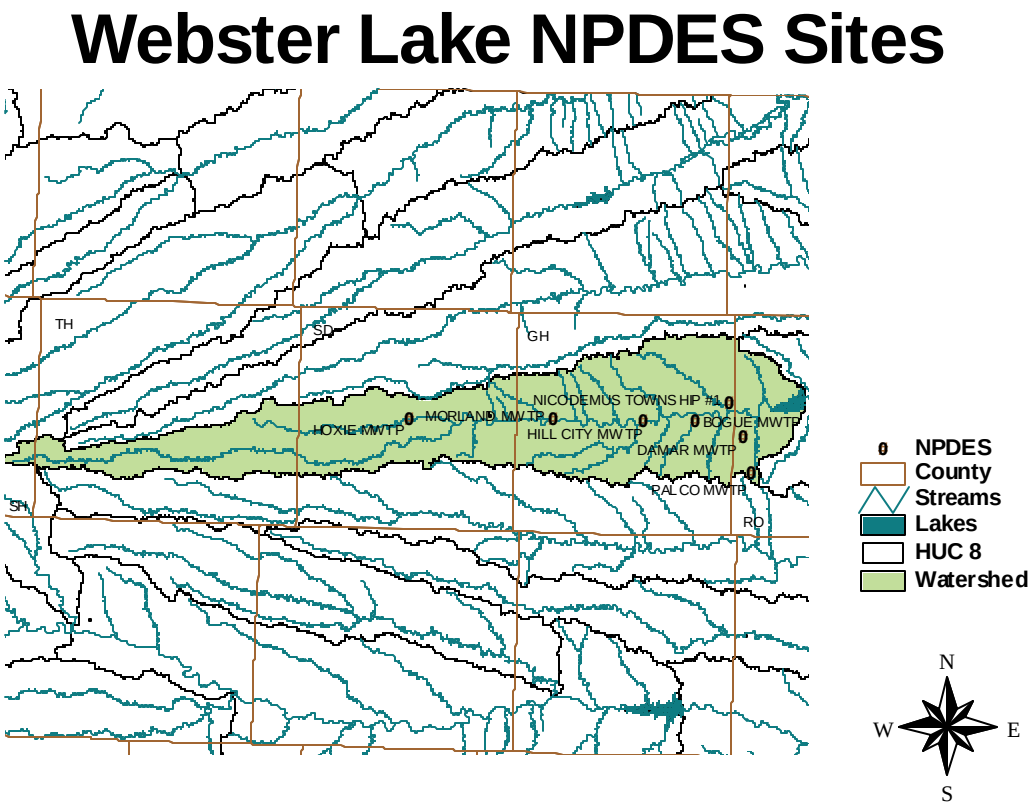


NPDES: Seven permitted waste treatment facilities are located within the watershed (Figure 9). Four are non-overflowing lagoons that are prohibited from discharging and three are discharging municipal waste treatment plants. The non-overflowing lagoons may contribute to the load under extreme precipitation events (flow durations exceeded under 5 percent of the time). Such events would not occur at a frequency or for a duration sufficient to cause an impairment in the watershed. Any anthropogenic selenium sources or hydrologic modifications increasing the selenium concentration would be minor in comparison with the natural selenium source in the watershed.

Since none of the municipal NPDES sites in the watershed are currently required to monitor for selenium in their effluent, average selenium concentrations for municipal sources were estimated based on the selenium in their influent. For mechanical plants, a one to one ratio was used to estimate the selenium in effluent from the cities in the watershed's finished water.

The Hill City and Hoxie MWTPs discharged 0.15 MGD and 0.13 MGD respectively based on monitoring data from last year. Palco MWTP did not discharge during the last year.

Figure 9



Waste Treatment Plants in the Webster Lake Watershed

Kansas NPDES Permit Number	Name	Type	Design Capacity (MGD)	Selenium Wasteload Allocation (lbs/day)
M-SO10-NO01	Damar MWTP	Three-cell Lagoon	Non-overflowing	0
M-SO19-OO01	Hill City MWTP	UV Disinfection	0.35	0.0187
M-SO20-OO01	Hoxie MWTP	Trickling Filter	0.2	0.0108
M-SO28-NO01	Morland MWTP	Three-cell Lagoon	Non-overflowing	0
M-SO30-OO01	Palco MWTP	Trickling Filter	0.03	0.0011
M-SO45-NO01	Nicodemus Township # 1	Two-cell Lagoon	Non-overflowing	0
M-SO07-NO01	Bogue MWTP	Three-cell Lagoon	Non-overflowing	0
		Total	**0.58**	**0.0306**

Contributing Runoff: The watershed's average soil permeability is 1.5 inches/hour according to NRCS STATSGO database. About 76.1% of the watershed produces runoff even under relatively low (1.5"/hr) potential runoff conditions. Runoff is chiefly generated as infiltration excess with rainfall intensities greater than soil permeabilities. As the watersheds' soil profiles become saturated, excess overland flow is produced. Generally, storms producing less than 0.5"/hr of rain will generate runoff from 4.3% of this watershed, chiefly along the stream channels.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

The source assessment has ascertained that natural selenium loading within the watershed is overwhelmingly responsible for the excursions seen at station 547.

Point Sources: Based on an estimated discharge volume from all point sources contributing to station 547 (0.9 cfs), a Wasteload Allocation of up to 0.0306 pounds per day will be established using the current estimated effluent concentrations reflecting each municipality's source water level of selenium. (Figure 5). Appendix B details the calculations used to estimate the Wasteload allocations.

Nonpoint Sources: The Load Allocation based on the existing standard of 0.005 mg/L across all flow conditions is shown in Figure 5 and is 0.2232 pounds per day at median flow (9.4 cfs).

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty of loading and the selenium endpoints for the Webster Lake Watershed. For the municipalities discharging to the Upper South Fork Solomon River, the selenium loads added by those facilities reflect the selenium content of their source water. Because of the small volumes of discharge associated with these facilities (0.9 cfs at design flow vs 9.4 cfs median streamflow; raises concentration 0.0002-0.0003 mg/l), the unlikelihood of the flows of the individual point sources and resulting wasteloads accumulating at station 547 because of the separation distances between the facilities and the losing nature of the South Fork Solomon and the prevalence of exceedances occurring at high flow, where wasteload impacts are negligible, the Margin of Safety implicitly assures the Wasteload Allocations will not cause an exceedance of the endpoint of this TMDL.

There are varying degrees of impact on selenium levels from historic irrigation within the drainage of Webster Lake. In the long term, the Load Allocations established by this TMDL reflect either the existing water quality standard or the background concentrations. The Margin of Safety implicitly assures these Load Allocations will achieve the endpoints of the TMDL through policies and objectives established under the Kansas Water Plan. Two objectives under the State Water Plan call for, by 2010; 1) reduction of water level decline rates within the Ogallala aquifer and implementation of enhanced water management in targeted areas; and, 2) reduction in the number of irrigation points of diversion for which the amount of water applied in acre-feet per acre exceeds an amount considered reasonable for the area and those [irrigation points of diversion] that overpump the amount authorized by their water rights. Pursuit of these two water conservation objectives will have water quality benefits, including assuring excessive irrigation will not directly or indirectly load surface waters with residual salts, thereby causing endpoints to be non-attained.

State Water Plan Implementation Priority: Because the selenium impairment in Webster Lake basin is primarily due to natural geologic sources, this TMDL will be a Low Priority for implementation.

Unified Watershed Assessment Priority Ranking: Webster Lake basin lies within the Upper South Fork Solomon (HUC 8: 10260013) with a priority ranking of 69 (Low Priority for restoration).

Priority HUC 11s: Because of the natural geologic contribution of this impairment, stream reaches overlying the Niobrara Chalk will be the focus of this TMDL.

5. IMPLEMENTATION

Desired Implementation Activities

1. Monitor any anthropogenic contributions of selenium loading to the lake and river.
2. Establish an alternative background criterion.
3. Evaluate impacts of irrigation best management practices to abate salt loading.

Implementation Programs Guidance

NPDES and State Permits - KDHE

a. Municipal permits for facilities in the watershed will be renewed after 2004 with selenium monitoring and any appropriate permit limits, which protect the aquatic life criteria.

Non-Point Source Pollution Technical Assistance - KDHE

a. Evaluate any potential anthropogenic activities which might contribute selenium to the lake as part of an overall Watershed Restoration and Protection Strategy.

b. Evaluate impact of irrigation return flows on selenium loading to streams.

Water Quality Standards and Assessment - KDHE

a. Establish background levels of selenium for the river and tributaries.

Subbasin Management - DWR

a. Evaluate Best Management Practices for irrigation which decrease salt loading to streams.

Time Frame for Implementation: Development of a background level-based water quality standard should be accomplished with the next water quality standards revision.

Targeted Participants: Primary participants for implementation will be KDHE and DWR.

Milestone for 2008: The year 2008 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, additional monitoring data from the Webster Lake basin will be

reexamined to confirm the impaired status of the watershed and the suggested background concentration. Should the case of impairment remain, source assessment, allocation and implementation activities will ensue.

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

Reasonable Assurances:

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

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.*

6. The *Kansas Water Plan* and the Solomon Basin Plan provide the 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 to programs supporting water quality protection. This watershed and its TMDL are a Low Priority consideration and should not receive funding until irrigation best management practices demonstrate potential reductions in salt concentration.

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

6. MONITORING

KDHE will continue to collect samples at permanent Station 547. Based on that sampling, the priority status will be evaluated in 2007 including application of a numeric criterion based on background concentrations. Should impaired status remain, the desired endpoints under this TMDL will be refined and direct more intensive sampling will need to be conducted under specified seasonal flow conditions over the period 2008-2012.

Monitoring of selenium levels in effluent will be a condition of NPDES and state permits for facilities. This monitoring will continually assess the functionality of the systems in reducing selenium levels in the effluent released to the streams upstream of Webster Lake.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Solomon Basin were held January 7 and March 3, 2003 in Stockton. An active Internet Web site was established at http://www.kdhe.state.ks.us/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Solomon Basin.

Public Hearing: A Public Hearing on the TMDLs of the Solomon Basin was held in Stockton on June 2, 2003.

Basin Advisory Committee: The Solomon Basin Advisory Committee met to discuss the TMDLs in the basin on October 3, 2002, January 7, March 3, and June 2, 2003.

Milestone Evaluation: In 2008, evaluation will be made as to the degree of implementation which has occurred within the watershed and current condition of Webster Lake. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

Consideration for 303(d) Delisting: The lake will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2008-2012. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the ten-year 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 will come in 2004 which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2004-2008.

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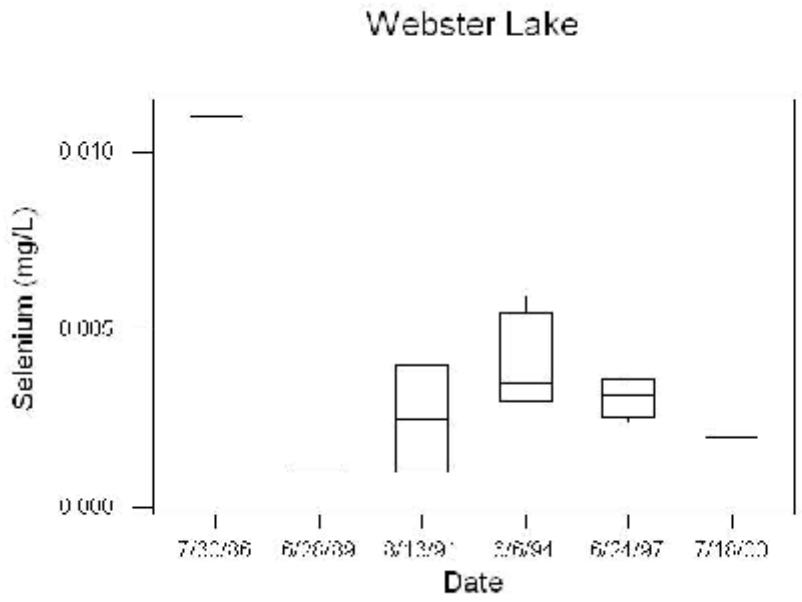
Appendix A - Boxplot



Appendix B - Wasteload Allocation

Permit Number	Facility	Public Water Supply Used to Calculate Influent	Type	Design Flow	Selenium in Influent	Selenium in Effluent	Selenium (lb/day)
M-SO10-NO01	DAMAR MWTP		3-cell Lagoon	Non-overflowing	0.0	0.0	0
M-SO19-OO01	HILL CITY MWTP	City of Hill City	UV Disinfection	0.35	0.0064	0.0064	0.0187
M-SO20-OO01	HOXIE MWTP	City of Hoxie	Trickling Filter	0.2	0.0065	0.0065	0.0108
M-SO28-NO01	MORLAND MWTP		3-cell Lagoon	Non-overflowing	0.0	0.0	0
M-SO30-OO01	PALCO MWTP	City of Palco	Trickling Filter	0.03	0.0045	0.0045	0.0011
M-SO45-NO01	NICODEMUS TOWNSHIP #1		2-cell Lagoon	Non-overflowing	0.0	0.0	0
M-SO07-NO01	BOGUE MWTP		3-cell Lagoon	Non-overflowing	0.0	0.0	0
						Total	0.0306

Approved January 21, 2004