SOLOMON BASIN TOTAL MAXIMUM DAILY LOAD

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

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Upper N. Fk. Solomon

County: Graham, Norton, Phillips, Rooks, Sheridan and Thomas

HUC 8: 10260011

HUC 11 (HUC 14s)**:** **030** (010, 020, 030 and 040)
040 (010, 020, 030 and 040)

Drainage Area: 348.4 square miles

Main Stem Segment: WQLS: 15 and 16 (Bow Creek) starting in north-central Rooks County and traveling upstream to headwaters in west-central Sheridan County (**Figure 1**).

Tributaries: S. Bow Cr (17)

Designated Uses: Expected Aquatic Life Support; Secondary Contact Recreation and Food Procurement Use for Main Stem Segments.

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, sulfates and selenium, exceed the water quality criteria listed in Table 1a of KAR 28-16-28e(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 KAR 28-16-28b(e). Background concentrations shall be established using the methods outlined in the AKansas implementation procedures: surface water,@ dated June 1, 1999... (KAR 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 Chronic Aquatic Life

Monitoring Sites: Station 545 near Stockton

Period of Record Used: 1990 –2001 for Station 545 (**Figure 2**)

Flow Record: Bow Creek near Stockton (USGS Station 06871500); 1970-2002.

Long Term Flow Conditions: Median Flow = 6.2 cfs

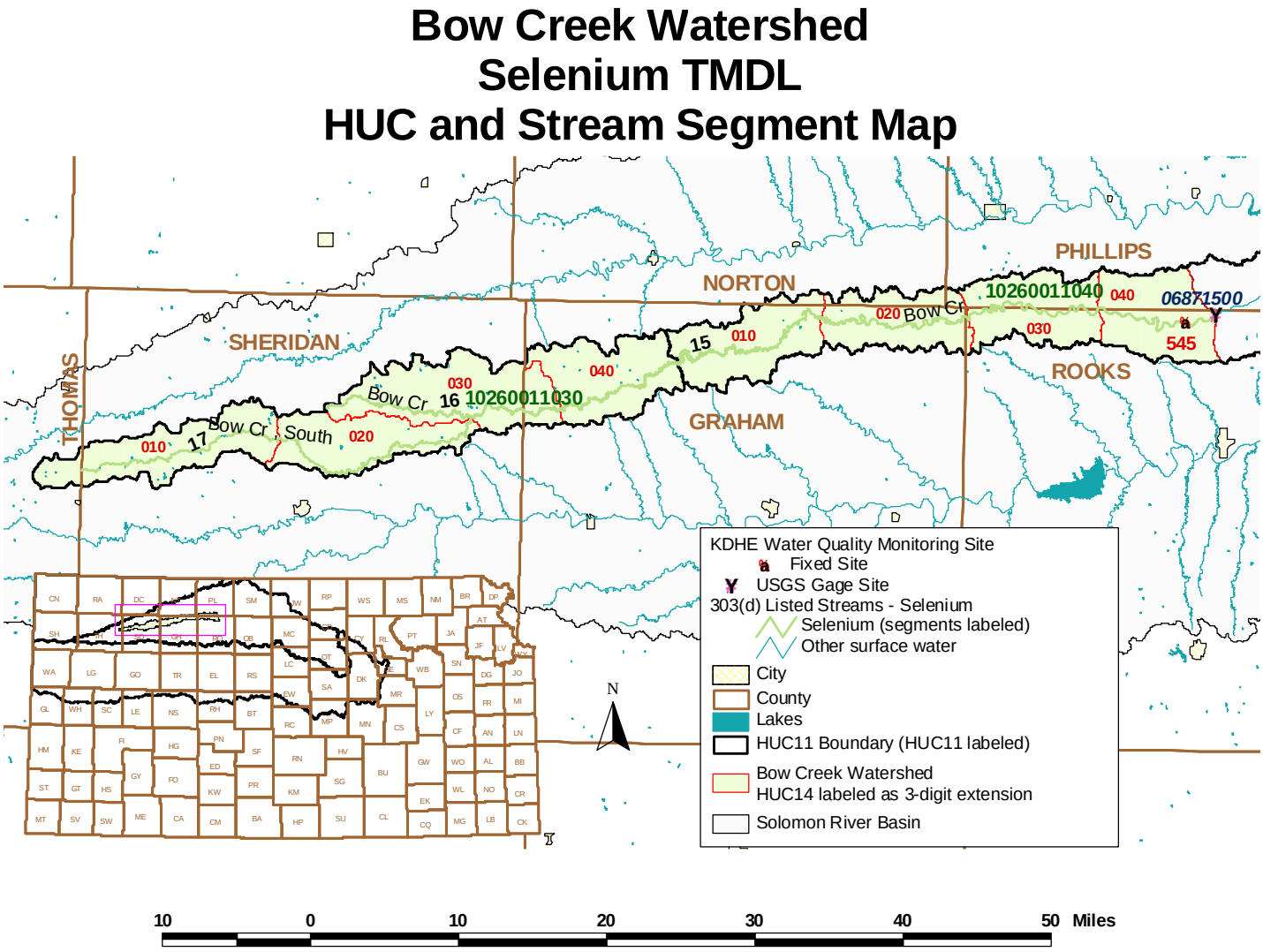

Figure 1

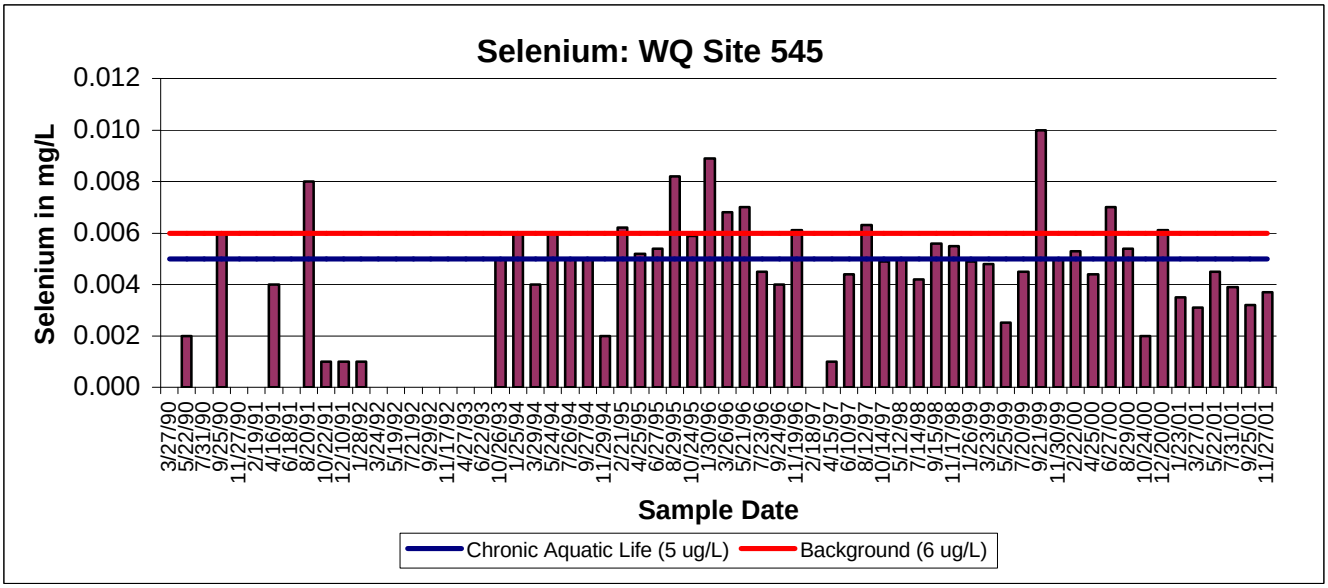

Figure 2

Current Conditions: 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 each sampling site 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. Load curves were established for the Aquatic Life 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 tons per day. These load curves represent the TMDL since any point along the curve denotes 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 3**).

Excursions were seen in each of the three defined seasons and are outlined in **Table 1**. Twenty-eight percent of the Spring samples and 53% of Summer-Fall samples were over the chronic aquatic life criterion. Forty-four percent of the Winter samples were over the chronic aquatic life criterion. Overall, 41% of the samples were over the criteria. This would represent a baseline condition of non-support of the impaired designated use.

Table 1

NUMBER OF SAMPLES OVER SELENIUM STANDARD OF 0.005 mg/L BY FLOW								
Station	**Season**	**0 to 10%**	**10 to 25%**	**25 to 50%**	**50 to 75%**	**75 to 90%**	**90 to 100%**	**Cum. Freq.**
Bow Creek nr Stockton (545)	Spring	3	1	0	1	0	0	5/18 = 28%
	Summer/Fall	0	0	4	1	0	3	8/15 = 53%
	Winter	1	4	2	1	0	0	8/16 = 44%

Desired Endpoints of Water Quality (Implied Load Capacity) at Site 545 over 2008 – 2012

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Chronic Aquatic Life Use. This TMDL will, however, be phased. The current

standard of 5 Fg/L of selenium was used to establish the TMDL. However, the Bow Creek system 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.

Current Kansas Implementation Procedures for Surface Water allow for a numerical criterion based on natural background to be established from flows less than median in-stream flow. From current information, it appears that long-term increases in the total dissolved solids and selenium concentrations with time are a result of increased water consumption in the Bow Creek watershed. Therefore, the Phase Two of this TMDL will also be based on the current standard applied to flows within the contributing portions of the Bow Creek watershed to Site 545.

Seasonal variation has been incorporated in this TMDL through the documentation of the seasonal consistency of selenium level exceedances. 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 have been restored.

3. SOURCE INVENTORY AND ASSESSMENT

(Background and Historical Assessment based upon analysis provided by Don Whittemore, Kansas Geologic Survey)

Bow Creek near Stockton (station 545) had an average selenium concentration of 5.2 Fg/L during March 1990 to March 2003 for samples above the detection limit. The selenium concentration varied substantially over time, from a minimum of 1.0 Fg/L to 12.9 Fg/L.

Background Source Conditions: The main natural source of selenium in the Bow Creek watershed 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 this bedrock can have relatively high selenium content, too. 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 in the main stem.

Historical Assessment. There is no statistically significant correlation of detectable selenium concentrations with sulfate concentrations for Site 545 (**Figure 3)**.

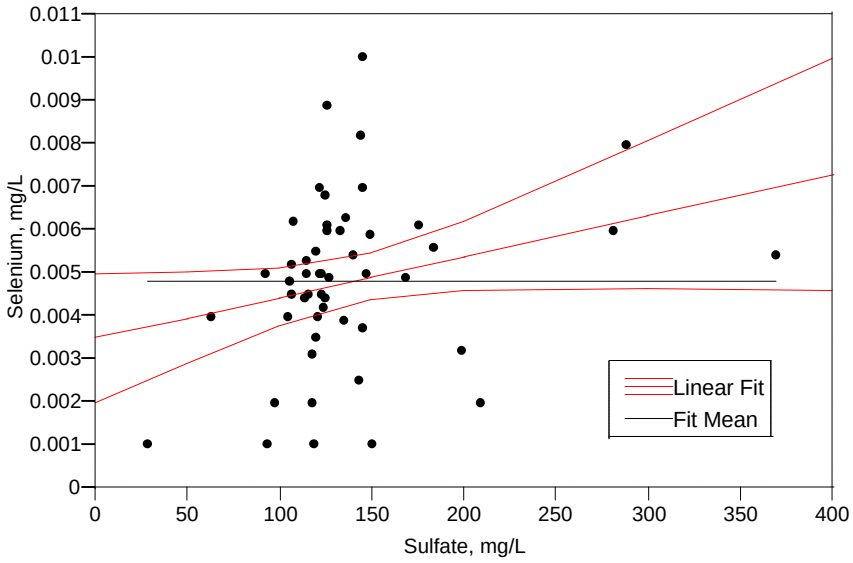

Figure 3

The lowest selenium concentrations at Site 545 often occurred during moderate to higher stream flow and the highest often at lower flow. This relationship between flow and selenium is shown in **Figure 4**. The best-fit power curve exhibits a general downward trend (not significant) for flow and selenium concentrations for samples collected at Site 545. This indicates that many of the highest selenium concentrations can be associated with groundwater discharge dominated lower flows but large exceedances can also be associated with runoff derived higher flows from precipitation that has infiltrated through high selenium soils or a combination of both. Long-term increases in the total dissolved solids and selenium concentrations with time as a result of increased water consumption in the Bow Creek watershed have probably also increased the selenium concentration within the main stem of 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[1]. Nolan and Clark[2] 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.

[1] Jacob, L.W., 1989, Selenium in agriculture and the environment: Soil Science Society America Special Publication No. 23, American Society Agronomy and Soil Science Society America, Madison, WI, 233 p.

[2] Nolan, B.T., and Clark, M.L., 1997, Selenium in irrigated agricultural areas of the western United States: Journal Environmental Quality 26 (3), 849-857.

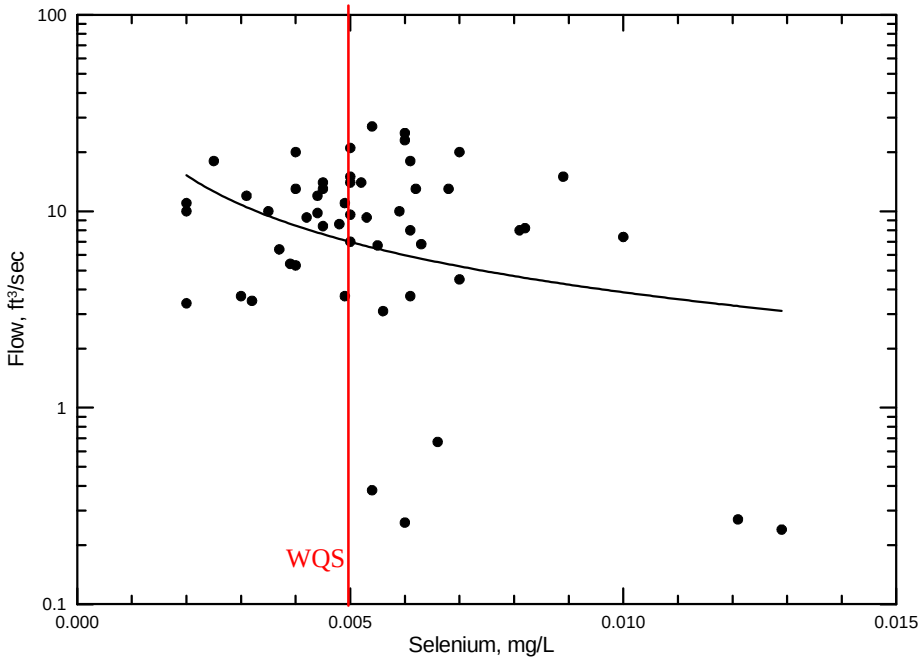

Figure 4

There are many irrigation wells in the Ogallala-High Plains aquifer underlying Sheridan, Thomas and Graham counties. There are a small number irrigation wells in the alluvial aquifer along the river in Rooks County upstream of water quality monitoring Site 545 (**Figure 5**).

Phreatophytes in the riparian corridor of the rivers and tributaries in the Bow Creek basin may also have 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.

3. SOURCE INVENTORY AND ASSESSMENT

NPDES: There are no NPDES permitted wastewater dischargers located within the watershed.

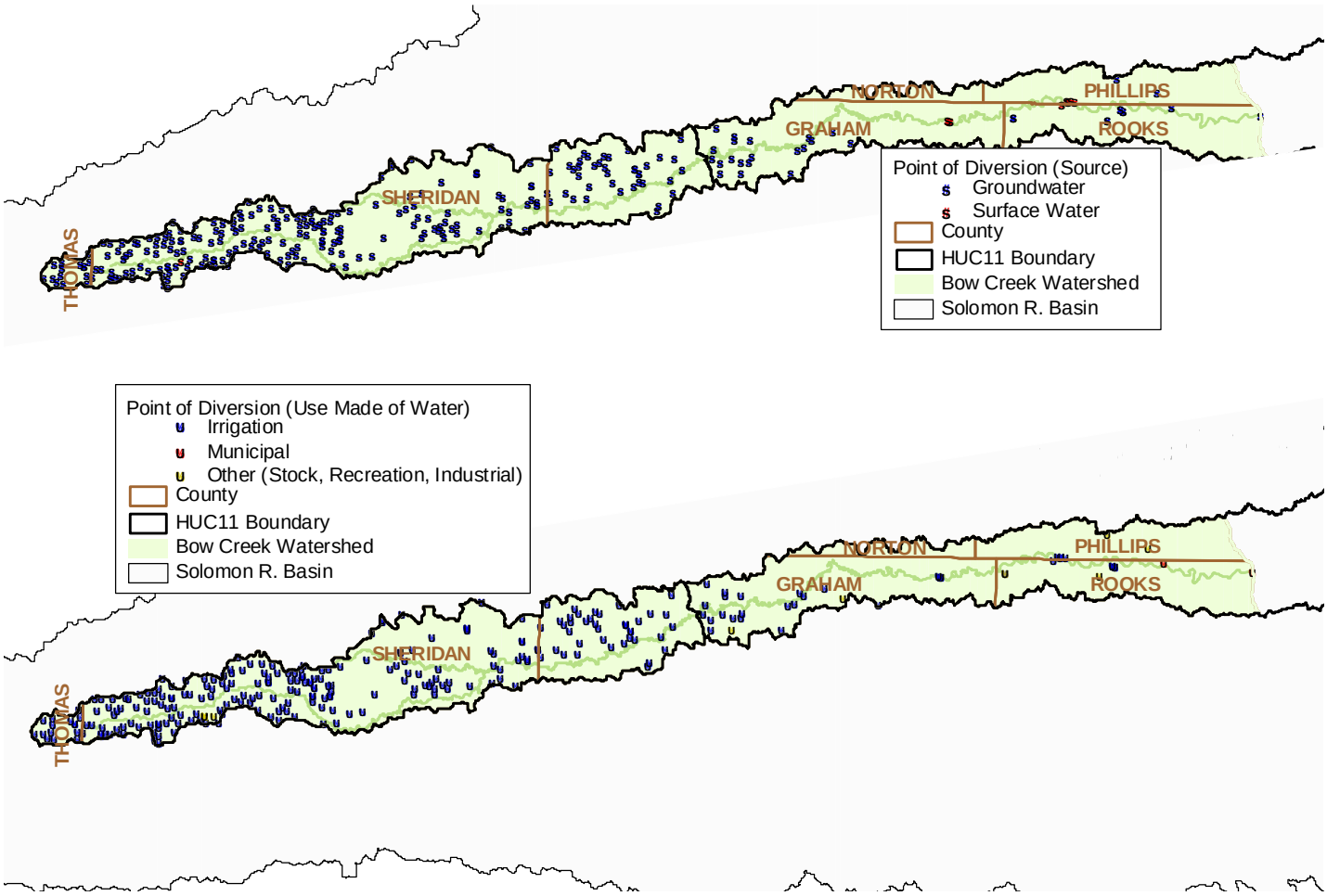

Figure 5

Contributing Runoff: The Bow Creek watershed's average soil permeability is 1.5 inches/hour according to NRCS STATSGO database. Most of the watershed produces runoff even under relatively low (1.71"/hr) potential runoff conditions (96%). Under very low (1.14"/hr) potential conditions, this potential contributing area is reduced dramatically to about 5%. 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 0.57"/hr of rain will only generate runoff from 1% of this watershed.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

Although the source of the dissolved selenium in the river water is natural, land and water use changes may have caused a long-term increase in the selenium concentration by increasing evapotranspiration consumption of water, resulting in the same residual dissolved solids in a

smaller water volume. Additional monitoring over time will be needed to determine the long-term changes related to increased evapotranspiration and to the effects on runoff from land use and water use changes and climatic variations.

There is no evidence of significant anthropogenic sources that directly contribute to the elevated selenium conditions in the Bow Creek watershed.

Point Sources: Due to a lack of discharging facilities within the watershed a Phase One Wasteload Allocation of zero is established. Any future NPDES and state permits will be conditioned such that discharges from the permitted facilities will not cause violations of applicable criteria.

Non-Point Sources: The elevated selenium concentrations predominately stem from background geologic sources.

The Load Allocation is based on the existing standard of 5 Fg/L for stream flows in excess of point source design flows and is shown in **Figure 6.** From this, the load allocation and is 0.167 lbs selenium per day at median flow (6.2 cfs).

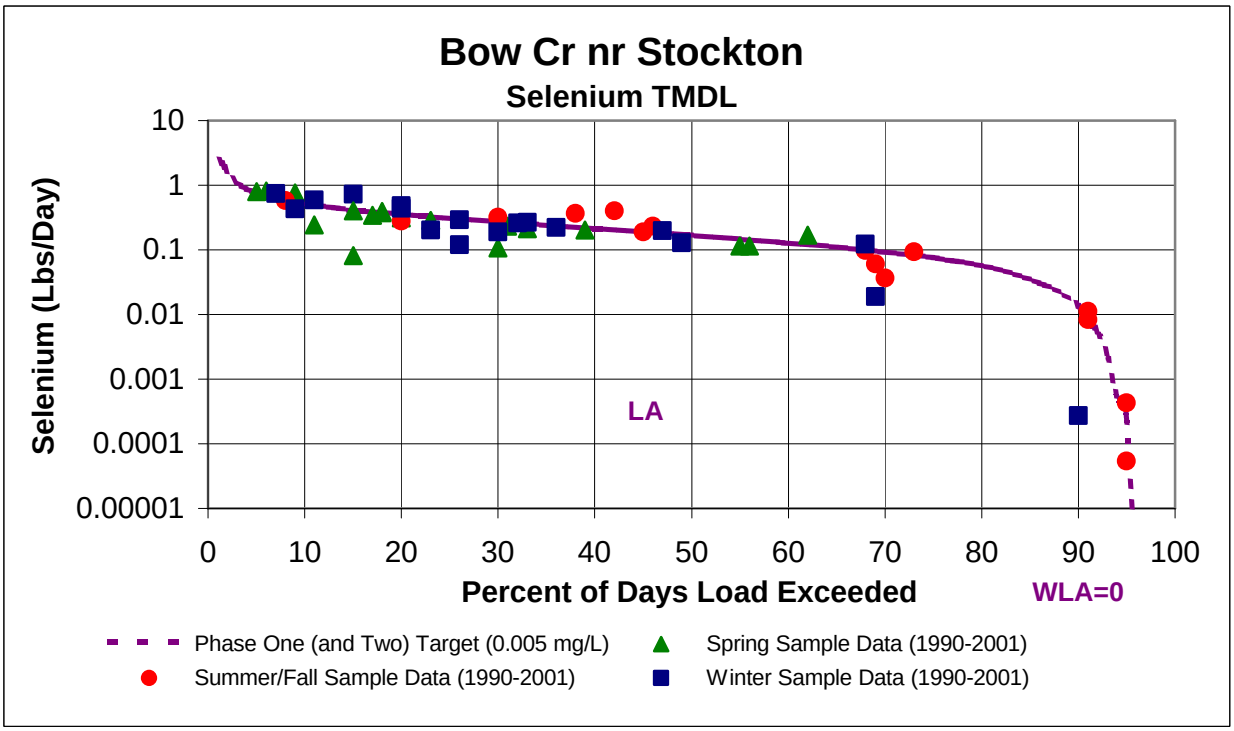

Figure 6

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty of loading and the selenium endpoints for the Bow Creek system. Since the greatest selenium concentrations have occurred during baseflow dominated conditions and the Phase One and Two targets are lower than these selenium levels, the margin of safety is considered implicit in this TMDL. The higher selenium concentrations at higher flows are usually of short duration and likely do not constitute chronic impairment of aquatic life.

State Water Plan Implementation Priority: Because the selenium impairment in the Bow Creek watershed is due to natural geologic sources, this TMDL will be a Low Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Upper North Fork Solomon Basin (HUC 8: 10260011) and is classified as a Category II watershed under the unified assessment.

Priority HUC 11s and Stream Segments: Because of the natural geologic contribution of this impairment, no priority subwatersheds or stream segments will be identified.

5. IMPLEMENTATION

Desired Implementation Activities

1. Monitor any future anthropogenic contributions of selenium loading to river.
2. Establish alternative background criterion.
3. Continue to minimize irrigation return flows into the stream.

Implementation Programs Guidance

NPDES and State Permits - KDHE

a. Future NPDES and state permits for facilities in the watershed will be issued 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 that might contribute selenium to the river as part of an overall Watershed Restoration and Protection Strategy.

Water Quality Standards and Assessment - KDHE

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

Water Right Management- KDA/DWR

a. Encourage proper use of tailwater control practices to minimize irrigation return flows

Timeframe for Implementation: Development of a background level-based water quality standard should be accomplished with the 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, sampled data from the Bow Creek watershed should indicate no evidence of increasing selenium levels relative to the conditions seen in 1990-2003.

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.

Reasonable Assurances:

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

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

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

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

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

5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan.*

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 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 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.

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

6. MONITORING

KDHE will continue to collect bimonthly samples at Station 545, including selenium samples, in each of the three defined seasons. Based on that sampling, the priority status will be evaluated in 2008 including application of 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 future NPDES and state permits for facilities. This monitoring will continually assess the contributions of selenium in the wastewater effluent released to the stream.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Solomon Basin were held October 3, 2002, 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: Public Hearings on the TMDLs of the Solomon Basin were held in Stockton on June 2, 2003.

Basin Advisory Committee: The Solomon Advisory Committee met to discuss the TMDLs in the basin on October 2, 2002, January 6 and March 3, 2003.

Milestone Evaluation: In 2008, evaluation will be made to confirm the degree of impairment that has occurred within the watershed of Bow Creek. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

Consideration for 303(d) Delisting: The stream 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 intervening 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 (CPP), the next anticipated revision will come with the adoption of the new EPA Watershed Rule which will emphasize implementation of TMDLs. At that time, incorporation of this TMDL will be made into the CPP. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process after Fiscal Year 2008.