SOLOMON BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody/Assessment Unit: Browns Creek
Water Quality Impairment: Dissolved Oxygen

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Solomon River **County:** Jewell and Mitchell

HUC 8: 10260015

HUC 11 (HUC 14s)**:** **020** (010 and 020)

Drainage Area: 69.1 square miles

Main Stem Segment: WQLS: 15 (Browns Creek) starting at confluence with the Solomon River in north-central Mitchell County and traveling upstream to headwaters in south-central Jewell County (**Figure 1**).

Designated Uses: Expected Aquatic Life Support, Secondary Contact Recreation, and Food Procurement for Main Stem Segment (Browns Creek).

Impaired Use: Expected Aquatic Life Support

Water Quality Standard: Dissolved Oxygen (DO): 5 mg/L (KAR 28-16-28e(c)(2)(A))

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

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

Monitoring Sites: Station 716 near Solomon Rapids

Period of Record Used: 1996 and 2000 for Station 716 (**Figure 2**)

Flow Record: White Rock Creek near Burr Oak (USGS Station 06853800; 1970-2002) flow duration matched to Limestone Creek at Glen Elder (USGS Site 06875820) unit area discharge flow duration and proportioned to Browns Creek drainage area.

Long Term Flow Conditions: 10% Exceedance Flows = 11.1 cfs**,** 95% = 0.001 cfs

Dissolved Oxygen Watershed
Fecal Coliform Bacteria TMDL
HUC and Stream Segment Map

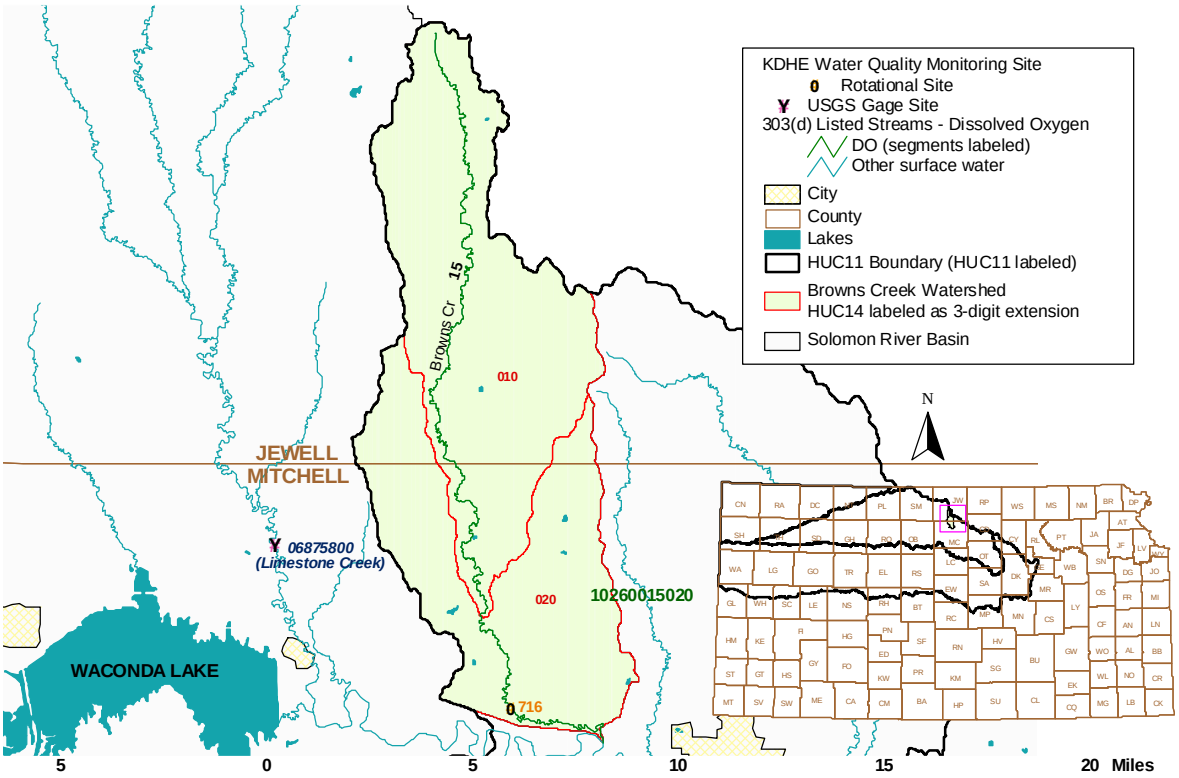

Figure 1

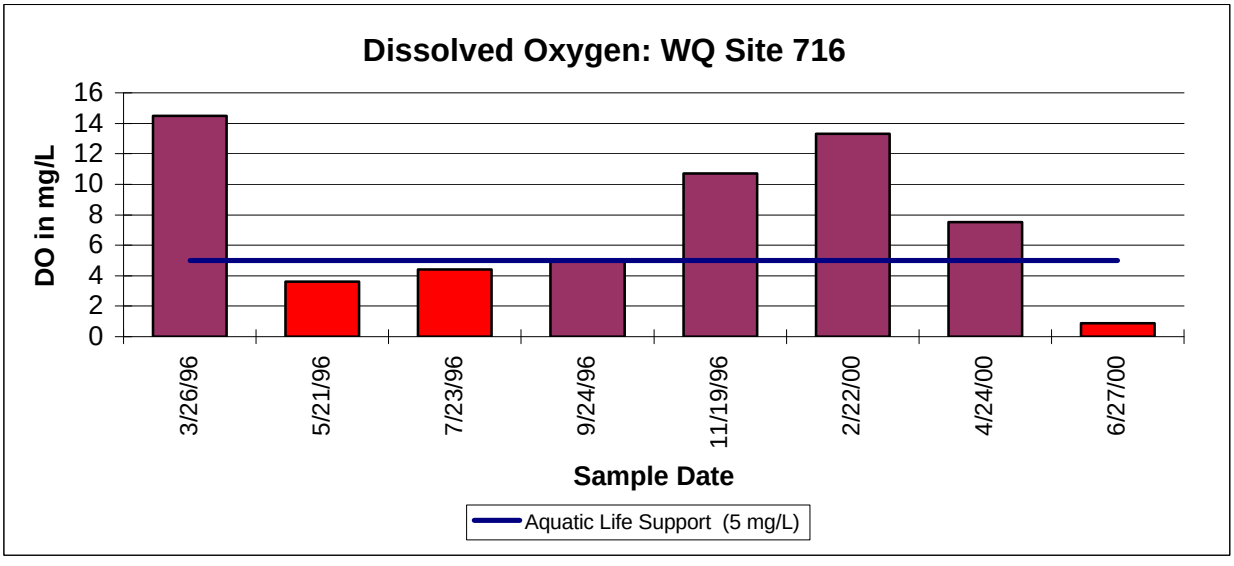

Figure 2

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 the 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 for Browns Creek near Solomon Rapids along the curve by the applicable water quality criterion and converting the units to derive a load duration curve of pounds of DO per day. This load curve graphically displays the TMDL since any point along the curve represents water quality at the standard for that flow. Historic excursions from water quality standards (WQS) are seen as plotted points *below* the load curves. Water quality standards are met for those points plotting *above* the applicable load duration curves (**Figure 3**).

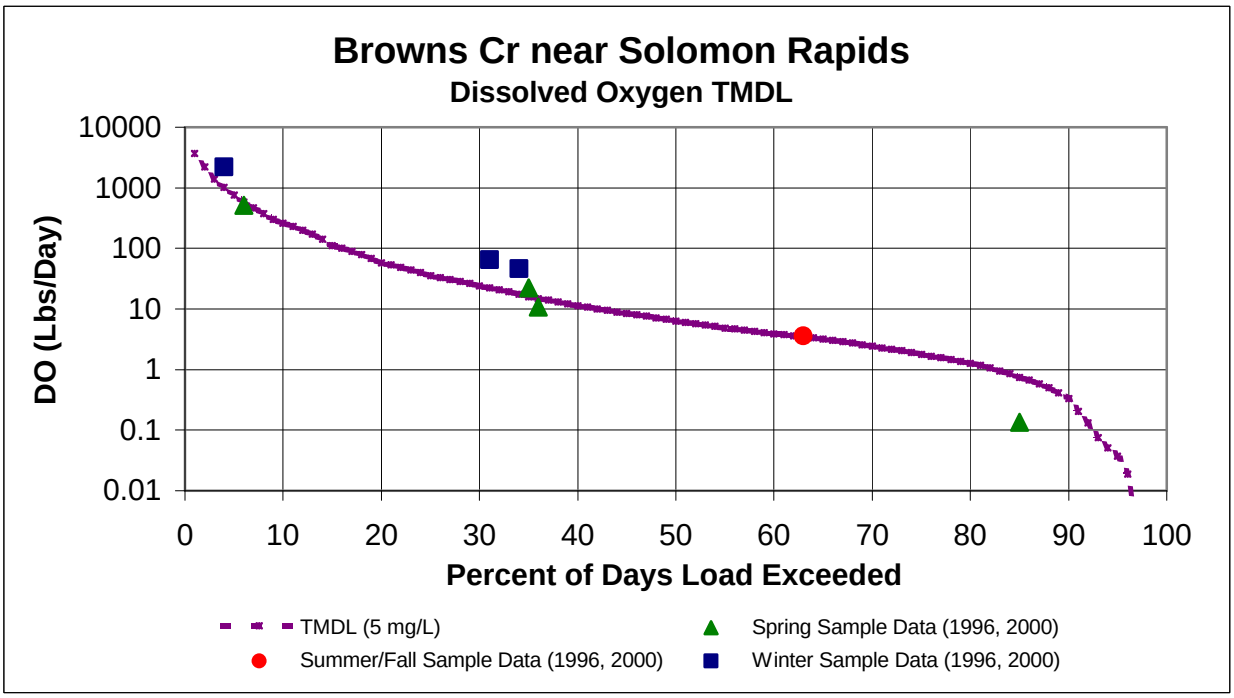

Figure 3

Excursions from water quality criterion were observed only in the Spring flow season (May-July). All sample data and their associated flow conditions are outlined in **Table 1**. Seventy-five percent of the Spring samples were below the aquatic life criterion. None of the Summer-Fall or Winter samples were under the aquatic life criterion. Overall, 38% of the samples were under the criterion. This would represent a baseline condition of non-support of the impaired designated use.

Table 1

NUMBER OF SAMPLES UNDER DISSOLVED OXYGEN STANDARD OF 5mg/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.**
Browns Creek nr Solomon Rapids (716)	Spring	1	0	1	0	1	0	3/4 = 75%
	Summer/Fall	0	0	0	0	0	0	0/1 = 0%
	Winter	0	0	0	0	0	0	0/3 = 0%

The DO excursions observed at monitoring site 716 generally occurred under low flow conditions (flows less than 1 cfs). Therefore a critical flow range can be identified as those flows in Browns Creek less than 1 cfs. Although a single DO sample was out of compliance under higher flow (7/23/96 in Table 3), it is believed that this DO excursion is actually a low flow incident whose flow error is manifested in the use of the White Rock Creek near Burr Oak gage station in estimating flows in the Browns Creek watershed on this sampling date (an anomalous high flow DO excursion was also generated for this same date in the sample dataset used to develop the Limestone Creek DO TMDL). The most likely explanation for the perceived discrepancy in flow is that a localized precipitation event occurred in the White Rock Creek drainage area that created a higher flow in White Rock Creek which translated in a illusory higher flow in Browns Creek due to the flow duration curve-match method employed to develop Load Duration Curves for watersheds that contain no permanent stream gages (see Section 2, Flow Record subsection).

A watershed comparison approach was initially used to develop this TMDL. The Carr Creek watershed (Water Quality Sampling Site 669 in the watershed was not impaired by low DO) has roughly similar land use characteristics (**Table 2**) to the Browns Creek watershed and is of comparable size. The Carr Creek watershed is within 15 miles to the west-southwest of the Browns Creek watershed in the Solomon Basin.

Table 2

Browns Cr Watershed (716)			Carr Cr Watershed (669)		
Land Use	Acres	% of Total	Land Use	Acres	% of Total
Cropland	33,570	75.9	Cropland	28,216	50.5
Grassland	9,663	21.9	Grassland	26,835	48.1
Residential	0	0	Residential	121	0.2
Water	48.4	0.1	Water	156	0.3
Woodland	934	2.1	Woodland	494	0.9
Total	44,215	100	Total	55,822	100

Table 3

Sample	DO		NH3		BOD		FCB		Nitrate		pH		Temp		Phos		Turbidity		Flow
Date	**716**	**669**	**716**	**669**	**716**	**669**	**716**	**669**	**716**	**669**	**716**	**669**	**716**	**669**	**716**	**669**	**716**	**669**	716
3/26/96	14.5	15	0.101	0.125	5.9	3.1	2	30	0.15	0.73	8.1	7.7	1	0	0.163	0.062	6.7	17.5	0.84
5/21/96	**3.6**	**5.1**	**0.404**	**0.597**	**5.9**	**3.8**	**130**	**700**	**0.23**	**0.67**	**7.8**	**7.7**	**18**	**19**	**0.541**	**0.26**	**12**	**21**	**0.55**
7/23/96	**4.4**	**5.3**	**0.438**	**0.401**	**3**	**3.5**	**420**	**320**	**0.22**	**0.78**	**7.8**	**7.6**	**20**	**21**	**0.37**	**0.242**	**26**	**81**	**21.77**
9/24/96	5	8	0.229	0.095	4.3	5.8	1500	160	1.08	0.67	7.6	7.9	13	14	0.637	0.159	305	55	0.13
11/19/96	10.7	10.9	0.062	0.087	7	6.4	6400	8400	1.94	2.5	7.5	7.5	5	4	0.498	0.372	160	108	38.01
2/22/00	13.3	11.7	0.02	0.02	1.86	1.98	10	10	0.46	0.49	7.8	7.9	10	10	0.08	0.03	1.4	2	0.65
6/27/00	**0.9**	**6.15**	**0.47**	**0.02**	**7.38**	**10.44**	**400**	**1500**	**1.94**	**0.22**	**7.5**	**7.7**	**20**	**23**	**0.36**	**0.223**	**24**	**27.5**	**0.03**
Average	7.49	8.88	0.25	0.2	5.0	5.0	1266	1589	0.86	0.87	7.7	7.7	12.4	13	0.38	0.2	76	45	
Average*	2.97	5.52	0.44	0.3	5.4	5.9	317	840	0.80	0.56	7.7	7.7	19.3	21	0.42	0.2	21	43.2	
Average **	10.93		0.12		4.0		504		0.56		7.8		8		0.29		104		

* Averages for Site 716 and 669 on DO exceedance dates at Site 716

** Averages for Site 716 on DO compliance dates at Site 716 with high flow DO compliance date removed.

The relationship of DO to ammonia, biochemical oxygen demand (BOD), fecal coliform bacteria (FCB), water temperature, turbidity, nitrate, phosphorus and pH were used in the comparison. **Table 3** outlines those water quality data for the samples taken on the same date for the two comparison sites. From **Table 3,** comparing parameter averages at site 671 to reference site 669, the phosphorus and turbidity averages were slightly higher than the reference site 669. All other parameter concentrations were similar in value.

Additional comparisons were made using the average concentrations for those samples when DO criterion was exceeded at site 716 ("Average*" row in Table 3) and the average concentrations for flows less than 1 cfs when DO was in compliance at Site 716 ("Average**" row in Table 3). Comparing both sites for the parameter averages associated with DO exceedances at site 716 indicates that although phosphorus, ammonia, turbidity and nitrate were higher at site 716 than the reference site, the average BOD in this comparison was similar. The final comparison utilized the DO exceedances and DO compliance sample group averages at site 716. From this comparison ammonia, BOD, nitrate, temperature and phosphorus were observed to be higher under DO exceedance conditions than those averages for the DO compliance conditions at site 669. Of particular interest in this comparison is the difference in temperature and BOD averages between these two conditions. This relationship was further explored by developing a regression of DO on BOD and temperature, the results of which are shown in **Table 4** below.

Table 4

Pred Eq: DO716 = 20.3 - 0.923 BOD_716 - 0.659 Temp_716

Predictor	Coef	SE Coef	T	P	VIF
Constant	20.323	2.444	8.32	0.004	
BOD_716	-0.9234	0.4016	-2.3	0.105	1
Temp_716	-0.6594	0.1118	-5.9	0.01	1
S = 1.840	R-Sq = 93.5%		R-Sq(adj) = 89.1%		
Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	145.294	72.65	21.45	0.02
Residual Error	3	10.161	3.387		
Total	5	155.455			
Source	DF	Seq SS			
BOD_716	1	27.413			
Temp_716	1	117.881			

Using the prediction equation in Table 4 and assuming a worst-case scenario for temperature in the stream of 20 degrees C, the maximum BOD that would still meet the DO criterion of 5 mg/L would be 2.3 mg/L.

The comparison and regression indicate high BOD was a probable contributing factor during the DO excursion samples at site 716 and indicates that, in addition to the naturally driven factor of lower flow which generally appears to exist during DO excursions, a probable oxygen demanding substance load is being added to the Browns Creek watershed upstream of site 716

and, under certain seasonal conditions, is also a probable factor influencing the DO violations. The target BOD level for Browns Creek watershed is established by the regression in Table 4 and was found to be 2.3 mg/L or less.

Desired Endpoints of Water Quality (Implied Load Capacity) at Site 716 over 2008 – 2012

The desired endpoint will be reduced biochemical oxygen demand from artificial sources such that average BOD concentrations remain below 2.3 mg/l in the stream under lower flow conditions and higher temperatures, which results in no excursions below 5 mg/l of DO detected between 2008 - 2012 attributed to these sources.

This desired endpoint should improve DO concentrations in the creek at lower flows. Seasonal variation is accounted for by this TMDL, since the TMDL endpoint is sensitive to the low flow/ higher temperature conditions in the watershed usually occurring in the defined Spring and Summer-Fall seasons.

This endpoint will be reached as a result of expected, though unspecified, reductions in organic loading from the various sources in the watershed resulting from implementation of corrective actions and Best Management Practices, as directed by this TMDL (see Implementation - Section 5). Sediment control practices such as buffer strips and grassed waterways should help reduce the non-point source BOD load under higher flows which, in turn, should help reduce the oxygen demand exerted by the sediment transported to the stream that may occur during the critical lower flow/higher temperature period. Achievement of this endpoint will provide full support of the aquatic life function of the creek and attain the dissolved oxygen water quality standard.

3. SOURCE INVENTORY AND ASSESSMENT

NPDES: There are no NPDES municipal permitted wastewater dischargers within the watershed that would contribute an oxygen demanding substance load to Site 716 (**Figure 4)**.

Livestock Waste Management Systems: Seven operations are registered, certified or permitted within the watershed. Two of these seven facilities are located downstream of Site 716 and will not be considered during the assessment or allocation sections in this TMDL, since they do not contribute to the DO impairment at the monitoring site. The five remaining facilities (beef or dairy) are primarily located toward the western half of the watershed (**Figure 4**).

Non-discharging NPDES permits are issued for facilities with more than 1,000 animal units. No facilities in the watershed are of this size. For the facilities upstream of the monitoring site, the total potential animal units are 2,594 for all these facilities combined. The actual number of animal units on site is variable, but typically less than potential numbers.

Land Use: Most of the watershed is cropland (76% of the area) or grassland (22%). Most of the cropland is located in the lower three quarters of the watershed. According to the NRCS Riparian Inventory, there are about 5,300 acres of riparian area in the watershed, most of which is categorized as cropland (49%), pasture land (20%), forestland (12%), pasture/tree mix (10%) and crop/tree mix (8%) (**Figure 5**).

On-Site Waste Systems: The upper portion of the watershed's population density is low (3 person/mi^2) when compared to densities elsewhere in the Solomon Basin, while the lower portion's density is average (10 person/mi^2) (**Figure 5**). The rural population projection for Jewell County through 2020 shows a modest decline (about a 16% decrease). Mitchell County's projection through 2020 indicates only a slight decline (5% decrease). Based on 1990 census data, about 44% and 22% of the households in Jewell and Mitchell County, respectively, are on septic systems. While failing on-site waste systems can contribute oxygen demanding substance loads, their impact on the impaired segments is generally limited, given the small size of the rural population and magnitude of other sources in the watershed.

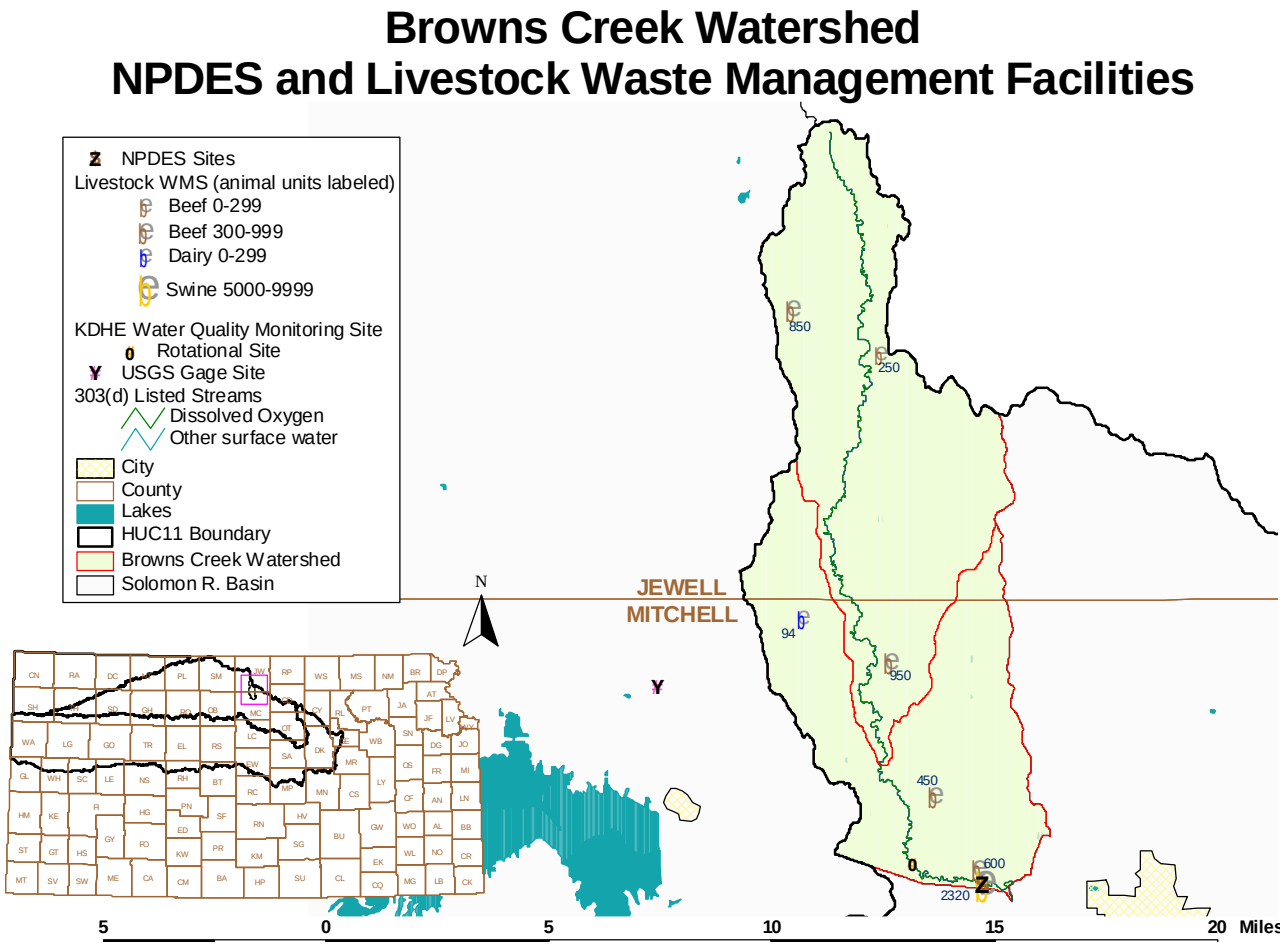

Figure 4

Contributing Runoff: The Solomon River Basin's (downstream of Waconda Reservoir) average soil permeability is 1.0 inches/hour according to NRCS STATSGO database. Essentially the entire watershed produces runoff even under relatively low (1.71"/hr) potential runoff conditions (~100%). Under very low (1.14"/hr) potential conditions, this potential contributing area is reduced to about 55%. 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 10% of this watershed, chiefly from the steepest slopes located near the main stem in the Browns Creek watershed.

Background Levels: Some organic enrichment may be associated with environmental background levels, including contributions from wildlife and stream side vegetation, but it is likely that the density of animals such as deer is fairly dispersed across the watershed and that the loading of oxygen demanding material is constant along the stream. In the case of wildlife, this loading should result in minimal loading to the streams below the levels necessary to violate the water quality standards. In the case of streamside vegetation, the loading should be greatest along the main stem of the watershed with its larger proportion of woodland near the stream.

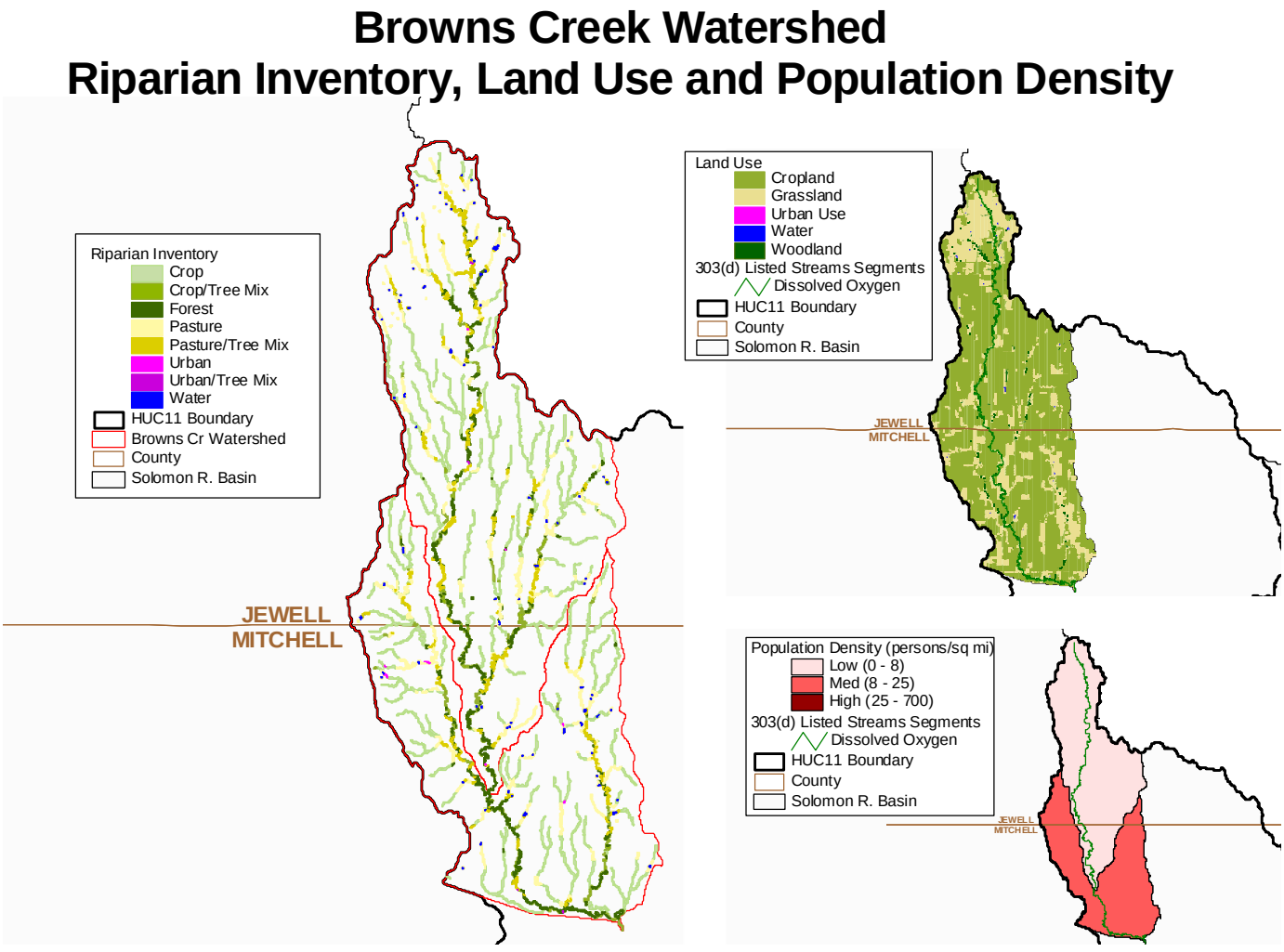

Figure 5

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

BOD is a measure of the amount of oxygen required to stabilize organic matter in a stream. As such, BOD is used as a benchmark measure to anticipate DO levels while it measures the total concentration of DO that will be demanded as organic matter degrades in a stream. It is presumed that reductions in BOD loads will reduce DO excursions under certain critical flow conditions. Therefore, any allocation of wasteloads and loads will be made in terms of BOD reductions. Yet, because DO is a manifestation of multiple factors, the initial pollution load reduction responsibility will be to decrease the BOD over the critical range of flows encountered in the Browns Creek system. These reductions have been based on the relationship between DO, BOD and stream temperature across a critical flow range for the samples taken at Water Quality Monitoring site 716 **(Tables 3 and 4)**. Allocations relate to the BOD levels seen in the Browns Creek system at site 716 for the critical lower flow conditions (0-1.7 cfs) and higher stream temperatures. Based on this relationship, BOD loads need to be reduced so that in stream median BOD at site 716 is 2.3 mg/L or less. Additional monitoring over time will be needed to further ascertain the relationship between BOD reductions of non-point sources, flow conditions, and DO levels along the stream.

For this phase of the TMDL the average condition is considered across the seasons to establish goals of the endpoint and desired reductions. Therefore, the target BOD levels were multiplied by the average daily flow for Browns Creek across all hydrologic conditions. This is represented graphically by the integrated area under the BOD load duration curve established by this TMDL (**Figure 6**). The area is segregated into allocated areas assigned to point sources (WLA) and nonpoint sources (LA). Future growth in wasteloads should be offset by reductions in the loads contributed by nonpoint sources. This offset along with appropriate limitations is expected to eliminate the impairment. This TMDL represents the "Best Professional Judgment" as to the expected relationship between physical factors, organic matter and DO.

Point Sources: A current Wasteload Allocation of zero is established by this TMDL because of the lack of discharging point sources located upstream of monitoring site 716. Should future point sources be proposed in the watershed and discharge into the impaired segments, the current Wasteload Allocation will be revised by adjusting current load allocations to account for the presence and impact of these new point source dischargers (**Figure 6**).

There will be a wasteload allocation of zero for state permitted CAFO's within the drainage because of requirements for no discharge of livestock waste except at 25 year, 24 hour storm events. Management of available freeboard and required holding capacities in these livestock waste management systems should ensure rare contribution of organic matter to Browns Creek, causing depletion of oxygen in the stream.

Non-Point Sources: Based on the prior assessment of sources, the distribution of excursions from water quality standards at site 716 and the relationship of those excursions to runoff conditions and seasons, non-point sources are seen as a contributing factor to the occasional DO excursions in the watershed.

The samples from the Browns Creek watershed show most DO violations occurred at flows less than 1.0 cfs. The Load Allocation assigns responsibility for reducing the in stream BOD levels

at site 716 to 2.3 mg/L across the 0.0 - 1.0 cfs range of the critical flow condition (29 - 99% exceedance) and maintaining the in stream BOD levels at site 716 to the historical levels of 4.3 mg/L for flows in excess of 1.0 cfs (which is the average of BOD samples for flows in Browns Creek above 1.0 cfs near Solomon Rapids)(**Figure 6**). Sediment control practices such as buffer strips and grassed waterways should help reduce the non-point source BOD load under higher flows as well as reduce the oxygen demand exerted by the sediment transported to the stream that may occur during the critical flow period.

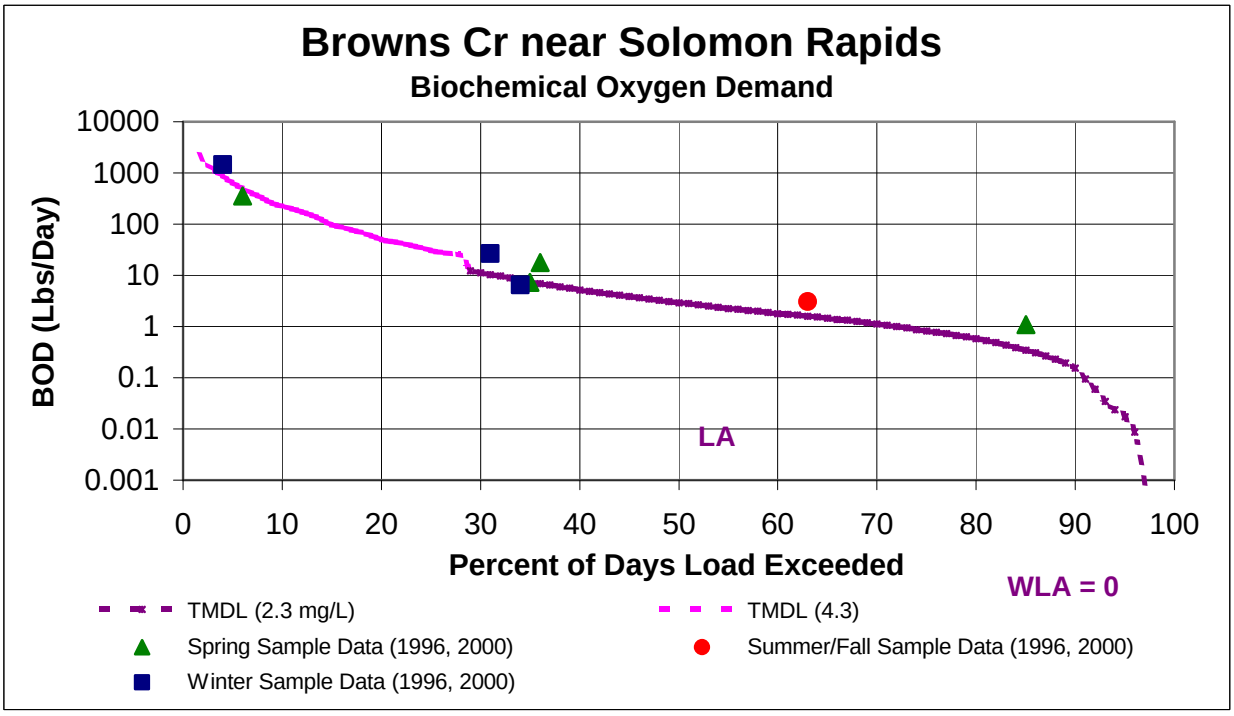

Figure 5

Defined Margin of Safety: The Margin of Safety will be implied based on conservative assumptions used to set the target BOD concentration, since sampling data indicates exceeding this value has seldom led to a dissolved oxygen violation.

State Water Plan Implementation Priority: Because of the small sample size currently available to assess the degree of impairment within the watershed, this TMDL will be a Medium Priority for implementation, pending collection of additional data to increase the confidence that impairment actually exists.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Solomon Basin (HUC 8: 10260015) with a priority ranking of 23 (Medium Priority for restoration work).

Priority HUC 11s and Stream Segments: Priority should be directed toward baseflow gaining stream segments along the main stem of Browns Creek.

5. IMPLEMENTATION

Desired Implementation Activities

1. None, unless impairment is verified by additional monitoring between 2004- 2008.

Implementation Programs Guidance

Ambient Water Quality Monitoring – KDHE

a. Continue to collect data on a bimonthly schedule in 2004 at rotational sampling site 716.

Unless impairment is confirmed by additional monitoring between 2004- 2008, no direction is needed on implementation programs.

Time frame for Implementation: Conditions will be evaluated based on additional monitoring between 2004- 2008.

Targeted Participants: None, until 2008 evaluation.

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 Station 716 will be reexamined to confirm the impaired status of the streams within this watershed. Should the case of impairment develop, source assessment, allocation and implementation activities will ensue.

Delivery Agents: None at this time. Status will be re-evaluated in 2008.

Reasonable Assurances:

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

1. K.S.A. 65-164 and 165 empowers the Secretary of KDHE to regulate the discharge of sewage into the waters of the state.

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

3. K.S.A. 2002 Supp. 82a-2001 identifies the classes of recreation use and defines impairment for streams.

4. K.A.R. 28-16-69 to -71 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 non-point 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.*

9. 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 Medium Priority consideration.

Effectiveness: Improvements in reducing oxygen demanding substance loads to streams can be accomplished through appropriate management and control systems, including buffer strips and riparian restoration projects.

6. MONITORING

KDHE will continue to collect bimonthly samples during 2004 at rotational Station 716 in order to assess the impairment driving this TMDL. Based on that sampling, the priority status of 303(d) listing will be evaluated in 2008. Should impaired status be verified, the desired endpoints under this TMDL will be refined and direct more intensive sampling will need to be conducted under specified seasonal low flow conditions over the period 2008-2012 to assess progress in this TMDLs implementation.

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 existence or degree of impairment that has occurred within the watershed of Browns 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 2004-2008. Therefore, the decision for delisting will come about in the preparation of the 2008 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.