SOLOMON BASIN TOTAL MAXIMUM DAILY LOAD

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

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Lower S. Fk. Solomon River **County:** Osborne

HUC 8: 10260014

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

Drainage Area: 87.4 square miles

Main Stem Segment: WQLS: 20 (Twin Creek) starting at confluence with South Fork Solomon River just above Waconda Lake in east-central Osborne County and traveling upstream to headwaters in south-central Osborne County (**Figure 1**).

Tributaries: East Twin Cr (29)

Designated Uses: Expected Aquatic Life Support, Secondary Contact Recreation, and Food Procurement for Main Stem Segment (Twin 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): Partially Supporting Aquatic Life

Monitoring Sites: Station 668 near Corinth

Period of Record Used: 1992, 1996 and 2000 for Station 668 (**Figure 2**)

Flow Record: Salt Creek near Ada (USGS Station 06876700; 1970-2002) flow duration matched to Twin Creek near Corinth (USGS Site 06874170)

Long Term Flow Conditions: 10% Exceedance Flows = 21 cfs**,** 95% = 0.04 cfs

Twin Creek Watershed
Dissolved Oxygen TMDL
HUC and Stream Segment Map

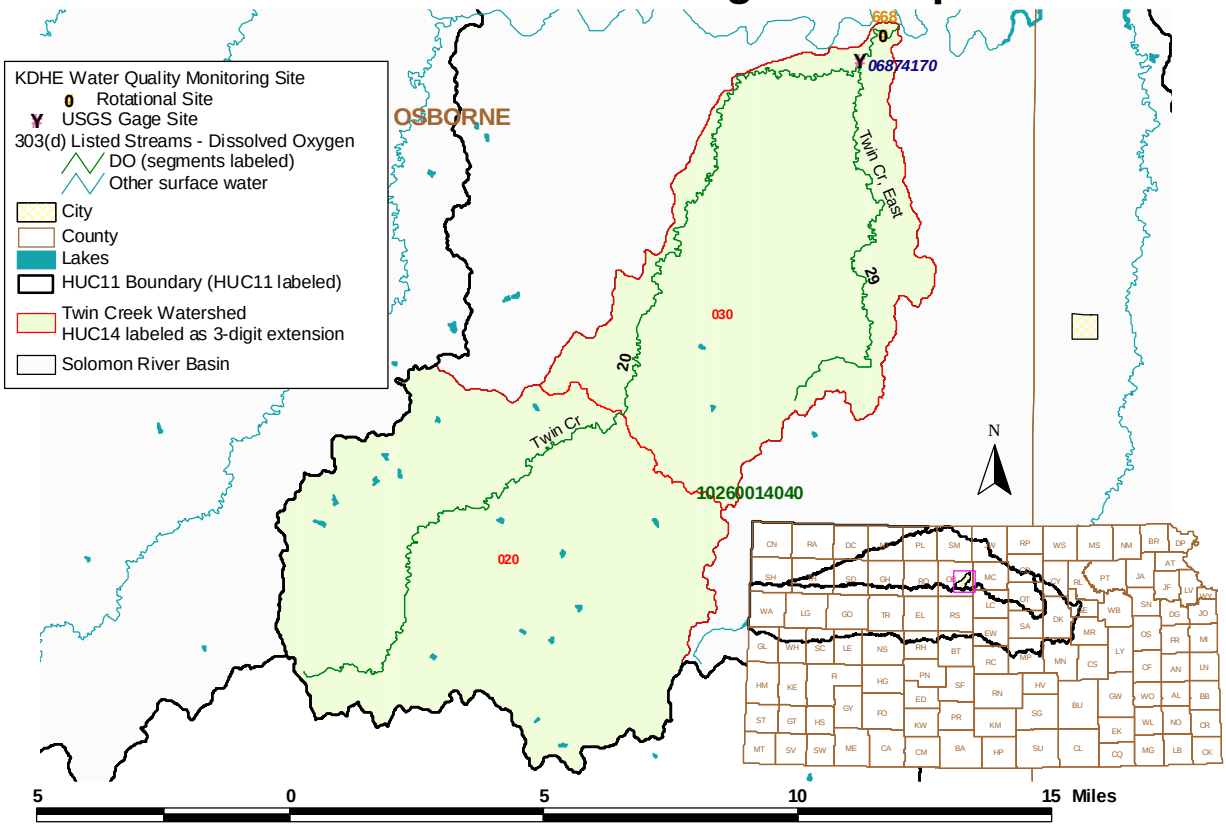

Figure 1

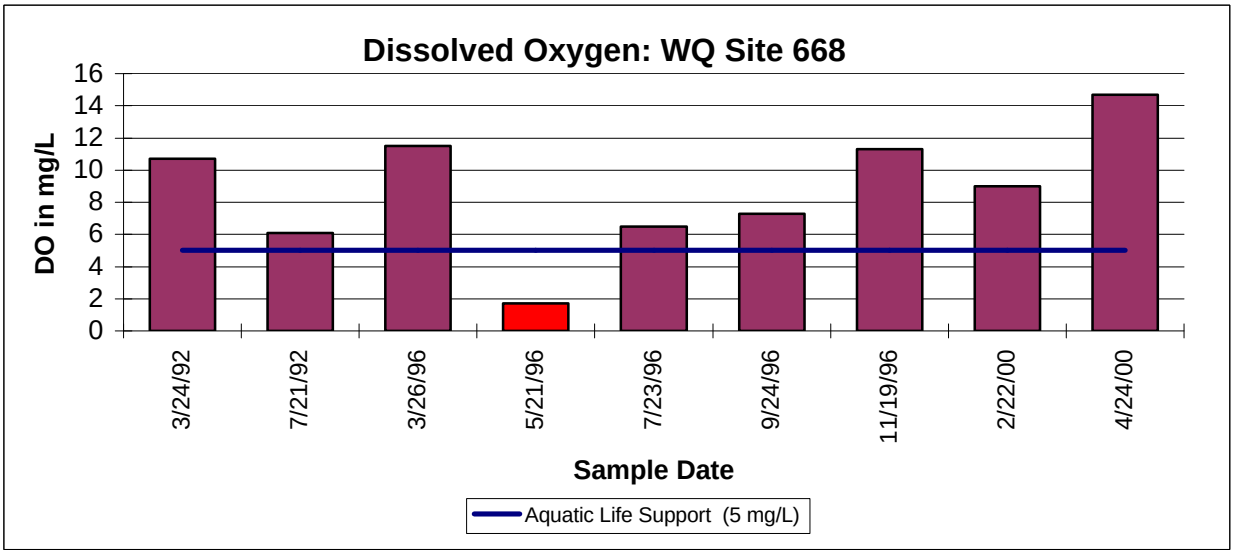

Figure 2

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 Twin Creek at Corinth 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 at 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**).

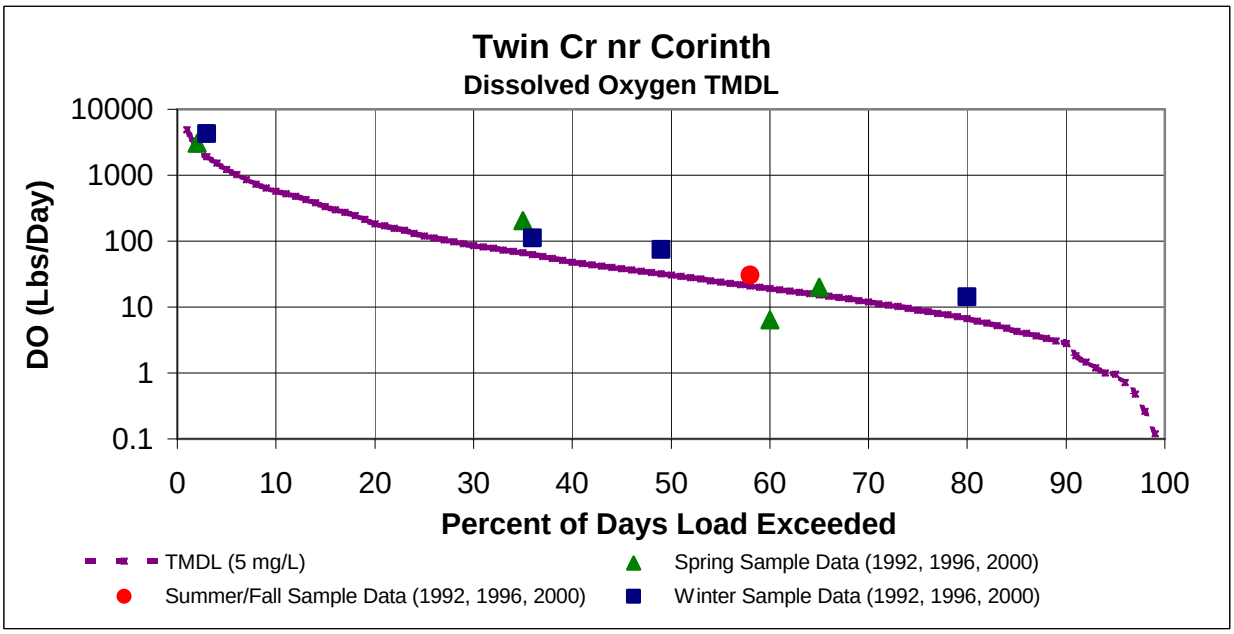

Figure 3

A singe excursion was observed in the Spring season. All sample data and their associated flow conditions are outlined in **Table 1**. Twenty-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, 11% of the samples were under the criterion. This would represent a baseline condition of partial 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.**
Twin Creek nr Corinth (668)	Spring	0	0	0	1	0	0	1/4 = 25%
	Summer/Fall	0	0	0	0	0	0	0/1 = 0%
	Winter	0	0	0	0	0	0	0/4 = 0%

A watershed comparison approach was taken in developing 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 Twin Creek watershed and is of comparable size. The Carr Creek watershed is located immediately to the east of the Twin Creek watershed.

Table 2

Twin Cr Watershed (668)			Carr Cr Watershed (669)		
Land Use	Acres	% of Total	Land Use	Acres	% of Total
Cropland	19,799	35.4	Cropland	28,216	50.5
Grassland	35,714	63.9	Grassland	26,835	48.1
Residential	0	0	Residential	121	0.2
Water	125	0.2	Water	156	0.3
Woodland	290.5	0.5	Woodland	494	0.9
Total	55,930	100	Total	55,822	100

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 site 668 to reference site 669 on sample date 5/21/96, the BOD and phosphorus concentrations were higher than the reference site 669. All other parameter concentrations were either higher at reference site 669 or similar in value.

A second comparison was made using the median BOD concentrations for those lower flow samples (less than 1.5 cfs) when DO was in compliance at site 668 and the BOD on the excursion date ("5/21/96" row to "Median*" row comparison). This comparison indicates BOD was markedly higher for the DO excursion sample at site 668 and indicates that, in addition to the naturally driven factor of lower flow which appears to exist during DO excursions, a probable oxygen demanding substance load is being added to the Twin Creek watershed upstream of site 668 and, under certain conditions, is also a probable factor influencing the DO violations. Using the median BOD concentration for lower flow conditions at site 668 when DO was compliant in Table 3 establishes the target BOD level for site 668 (2.85 mg/L).

Table 3

Sample	DO		NH3		BOD		FCB		Nitrate		pH		Temp		Phos		Turbidity		Flow
Date	**668**	**669**	**668**	**669**	**668**	**669**	**668**	**669**	**668**	**669**	**668**	**669**	**668**	**669**	**668**	**669**	**668**	**669**	668
3/24/92	10.7	-----	0.06	-----	1.6	-----	10	-----	0.02	-----	7.7	-----	5	-----	0.07	-----	6	-----	0.25
7/21/92	6.1	5.5	0.05	0.05	3	6.7	10000	19000	0.8	0.8	7.8	7.6	19	19	1.07	0.96	500	400	91.98
3/26/96	11.5	15	0.01	0.125	2.9	3.1	56	30	1.12	0.73	7.5	7.7	2	0	0.037	0.062	4.1	17.5	1.19
5/21/96	**1.7**	**5.1**	**0.254**	**0.597**	**4.1**	**3.8**	**200**	**700**	**0.48**	**0.67**	**7.5**	**7.7**	**16**	**19**	**0.284**	**0.26**	**7**	**21**	**0.70**
7/23/96	6.5	5.3	0.441	0.401	2.8	3.5	500	320	0.88	0.78	7.4	7.6	24	21	0.178	0.242	26	81	0.57
9/24/96	7.3	8	0.197	0.095	3.5	5.8	270	160	3	0.67	7.7	7.9	11	14	0.064	0.159	5	55	0.77
11/19/96	11.3	10.9	0.043	0.087	6.1	6.4	6600	8400	2.29	2.5	7.7	7.5	4	4	0.304	0.372	76	108	70.08
2/22/00	9	11.7	0.02	0.02	2.16	1.98	70	10	0.43	0.49	7.9	7.9	10	10	0.05	0.03	4.4	2	2.31
4/24/00	14.7	6.15	0.57	0.02	1.44	10.4	120	1500	0.01	0.22	8.4	7.7	19	23	0.177	0.223	6.6	27.5	2.59
Median	9.0	7.08	0.06	0.091	2.9	4.8	200	510	0.8	0.7	7.7	7.7	11	17	0.177	0.233	6.6	41.3	1.19
Median*	9.0		0.13		2.85		163		1.0		7.6		8.0		0.09		5.5		0.67

* All samples with flow > 1.5 cfs removed and 5/21/96 sample removed

Desired Endpoints of Water Quality (Implied Load Capacity) at Site 668 over 2008 – 2012

The desired endpoint will be reduced biochemical oxygen demand from artificial sources such that median BOD concentrations remain below 2.85 mg/l in the stream under lower flow conditions 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 (due to a current lack of data under non-compliant conditions, the low flow is presently estimated as flow of 1.5 cfs or less). Seasonal variation is accounted for by this TMDL, since the TMDL endpoint is sensitive to the low flow 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 flow 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 668 (**Figure 4)**.

Livestock Waste Management Systems: A single operation is certified within the watershed. This facility (beef) is located near East Twin Creek toward the lower end 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. The watershed's total potential animal units are 488. The actual number of animal units on site is variable, but typically less than potential numbers.

Land Use: Most of the watershed is grassland (64% of the area) or cropland (35%). Most of the cropland is located in the upper and lower third of the watershed with the grassland either in the lower end of watershed or its west side. According to the NRCS Riparian Inventory, there are about 7,100 acres of riparian area in the watershed, most of which is categorized as pasture land (49%), cropland (19%), pasture/tree mix (13%), forest land (9%) and crop/tree mix (8%) (**Figure 5**).

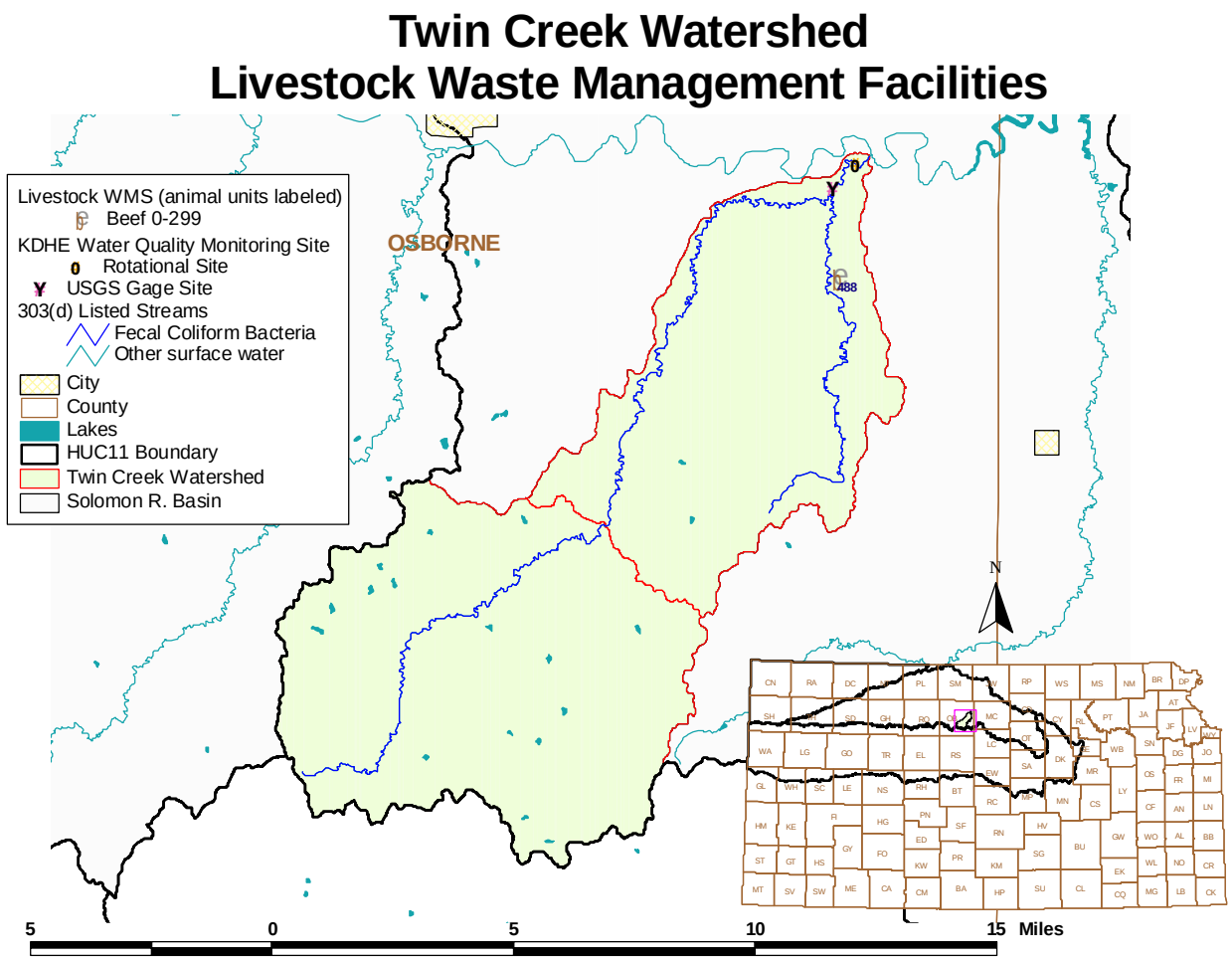

Figure 4

On-Site Waste Systems: The watershed's population density is low when compared to densities elsewhere in the Solomon Basin (less than 2 person/mi^2) (**Figure 5**). The rural population projection for Osborne County through 2020 shows a modest decline (about 19% decrease). Based on 1990 census data, about 27% of the households in Osborne County are on septic systems. While failing on-site waste systems can contribute organic substance loadings, 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.

Contributing Runoff: The South Fork Solomon River (between Waconda and Webster Lakes) watershed's average soil permeability is 1.3 inches/hour according to NRCS STATSGO database. Most of the watershed produces runoff even under relatively low (1.71"/hr) potential runoff conditions (97.5%). 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 6% of this watershed, chiefly from the lower end of the watershed, including areas along the main stem in the Twin Creek watershed.

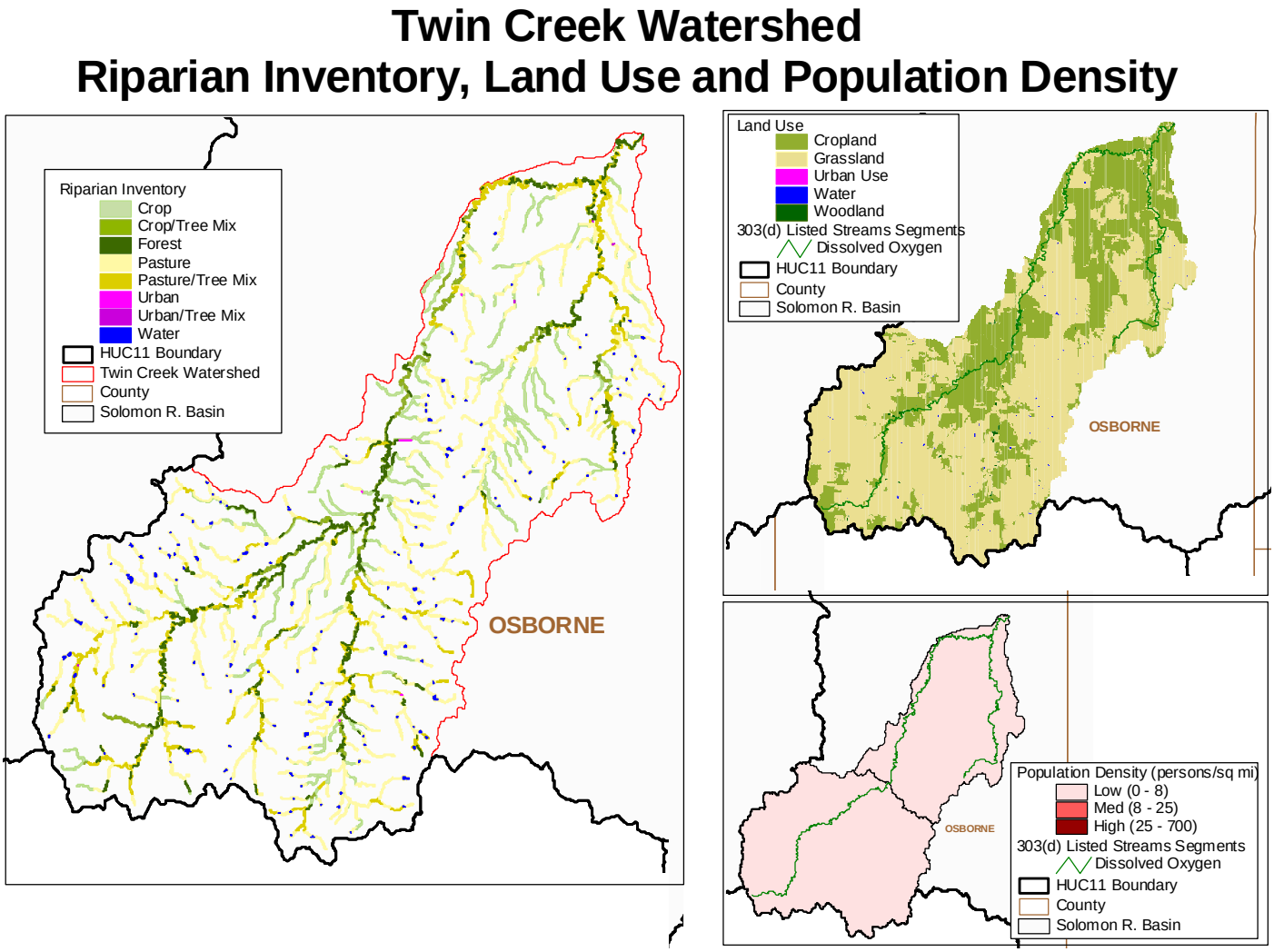

Figure 5

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.

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 estimated critical low flow range encountered in the Twin Creek system. These reductions have been based on the relationship between DO and BOD across a estimated critical flow range for the samples taken at Water Quality Monitoring site 668 in the presence or absence of DO excursions **(Table 3)**. Allocations relate to these BOD levels under compliant DO concentrations seen in the Twin Creek system at site 668 for the estimated critical lower flow conditions (0-1.5 cfs). Based upon this relationship, BOD loads at site 668 need to be reduced so that in stream median BOD is 2.85 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 median condition is considered across the seasons to establish goals of the endpoint and desired reductions. Therefore, the target median BOD levels were multiplied by the average daily flow for Twin 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 of 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 668. 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 Twin 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 668 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.

Because of the presently small sample size and the existence of only a single DO excursion in the watershed's data set, the critical flow condition had to be estimated. The current samples

from the Twin Creek watershed indicate DO violations would generally occur at lower flows (probably less than 1.5 cfs). The Load Allocation assigns responsibility for reducing the in stream BOD levels at site 668 to 2.85 mg/L across all flow conditions including the estimated critical flow range (**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.

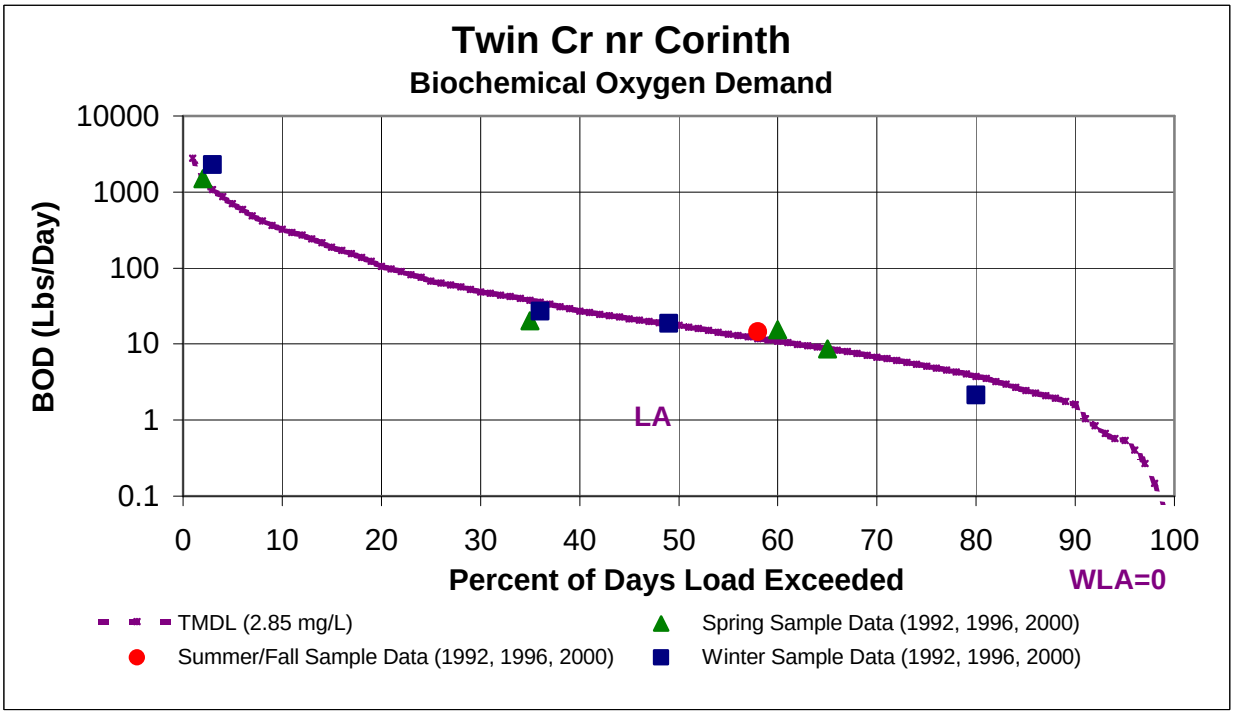

Figure 6

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 an impairment actually exists.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Lower S. Fk. Solomon River Basin (HUC 8: 10260014) with a priority ranking of 45 (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 Twin 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 668.

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 668 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 loading 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 668 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 Twin 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.