MARAIS DES CYGNES BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody Assessment Unit: W Fk. Drywood Creek (Drywood Creek)
Water Quality Impairment: Dissolved Oxygen

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Marmaton **Counties**: Crawford, Bourbon

HUC 8 (11): 10290104 (030)

Drainage Area: 85 square miles

Ecoregion: Central Irregular Plains:
Wooded Osage Plains (40c)
Cherokee Plains (40d)

Main Stem Segments: WQLS: 19 and 323 (W Fk Drywood Creek) starting above the confluence with Cox Creek traveling upstream to the headwaters of W Fk. Drywood Creek in Crawford County.

Tributaries: Walnut Creek (47)
Bone Creek (9019)

Designated Uses: For main stem segments: Expected Aquatic Life Support, Primary Contact Recreation B (19) and C (323).

For tributary segments: Expected Aquatic Life Support, Primary Contact Recreation C (47), Secondary Contact Recreation b (9019).

2002, 2004, & 2006-303(d) Listing: Marais des Cygnes River Basin Streams

Impaired Use: Expected Aquatic Life Support

Water Quality Standard: The concentration of Dissolved Oxygen in surface waters shall not be lowered by the influence of artificial sources of pollution. Dissolved Oxygen (DO): 5 mg/L (K.A.R. 28-16-28e(d), Table 1g).

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Use under 2006-303(d): Not supporting Aquatic Life

Monitoring Sites: Station 617 on W Fk. Drywood Creek, 1 ½ miles West and 2 ½ miles South of Garland

Period of Record Used: 1993-2005 for Rotational Station 617

Flow Record: Drainage area flow duration estimated from USGS Gaging Station 06917380 on the Marmaton River near Marmaton, KS (1971-2005).

Long Term Flow Conditions: 90% Exceedance = 0.13 cfs, 75% Exceedance = 1.10 cfs, 50% Exceedance = 11.3 cfs, 25% Exceedance = 43.0 cfs, 10% Exceedance = 129 cfs,. The estimated Mean Flow established by USGS is 60.0 cfs (Perry, 2004).

Figure 1. Base Map of Drywood Creek Watershed.

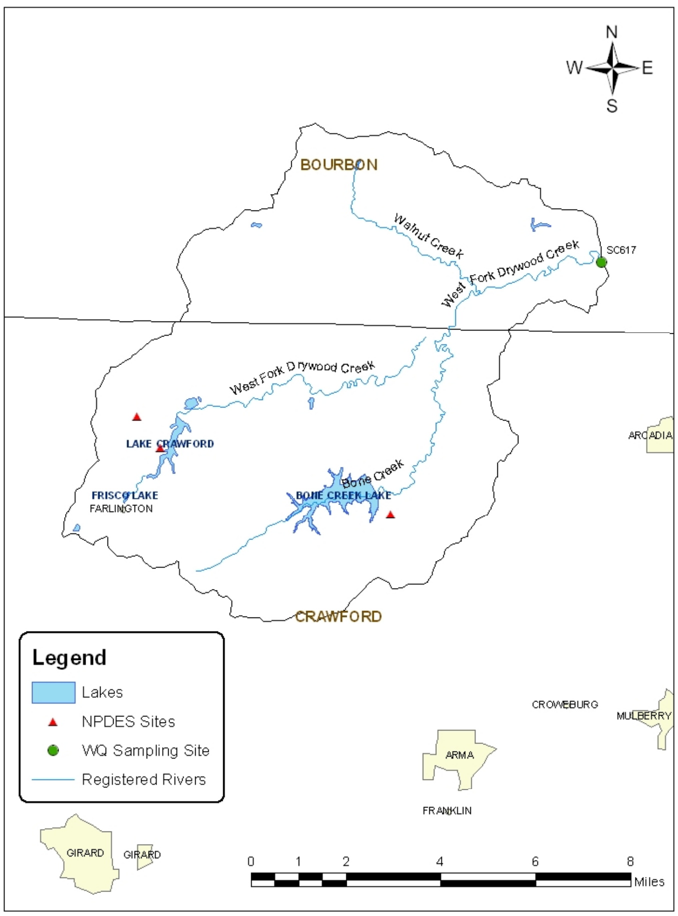
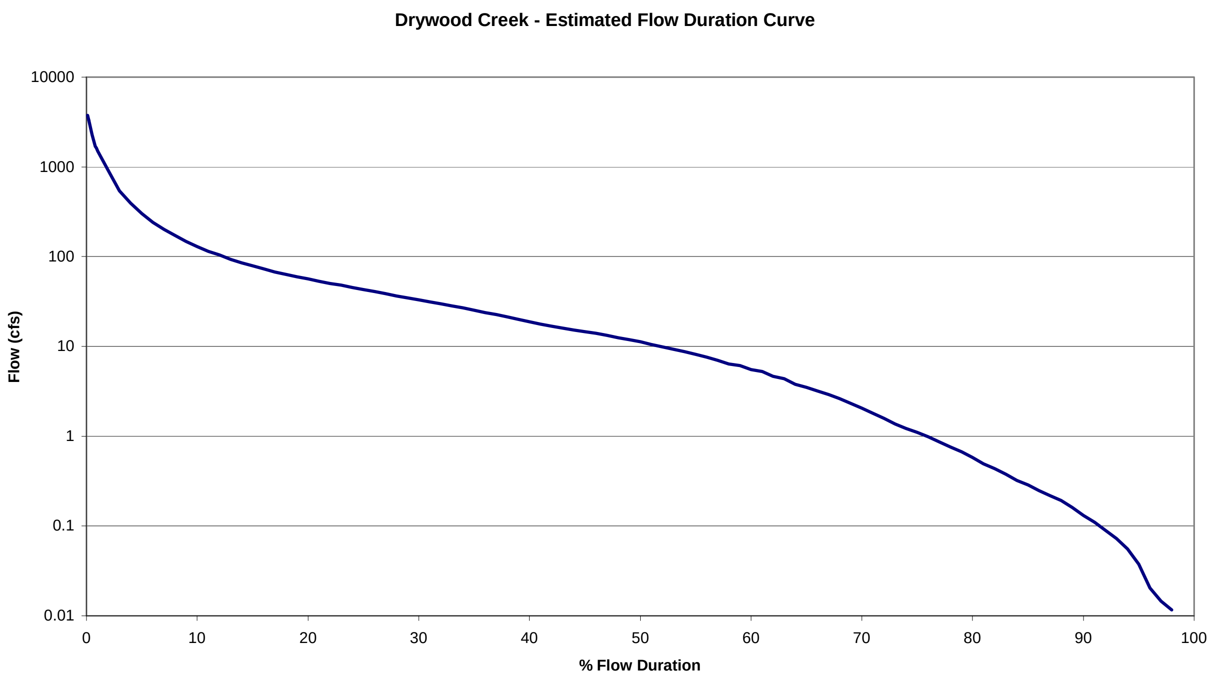


Figure 2. Flow Duration Curve for Drywood Creek.



Current Conditions: Since loading capacity varies as a function of the flow present in the stream, this TMDL represents a continuum of desired concentrations over all flow conditions, rather than fixed at a single value. Sampling data from station 617 was categorized into three defined seasons: Spring (April-June), Summer-Fall (July-October), and Winter (November-March). High flows and runoff equate to lower flow durations; baseflow and point source influence generally occur in the 75-99% range. The median flow is approximately the 50% flow exceedance value.

Sampling station 617 is a rotational station that typically is sampled bimonthly for one year, every four years. However, this station was sampled for three consecutive years from 1999 through 2001. DO concentrations are displayed in Figure 3.

Figure 3. DO concentrations on Drywood Creek at Station 617.

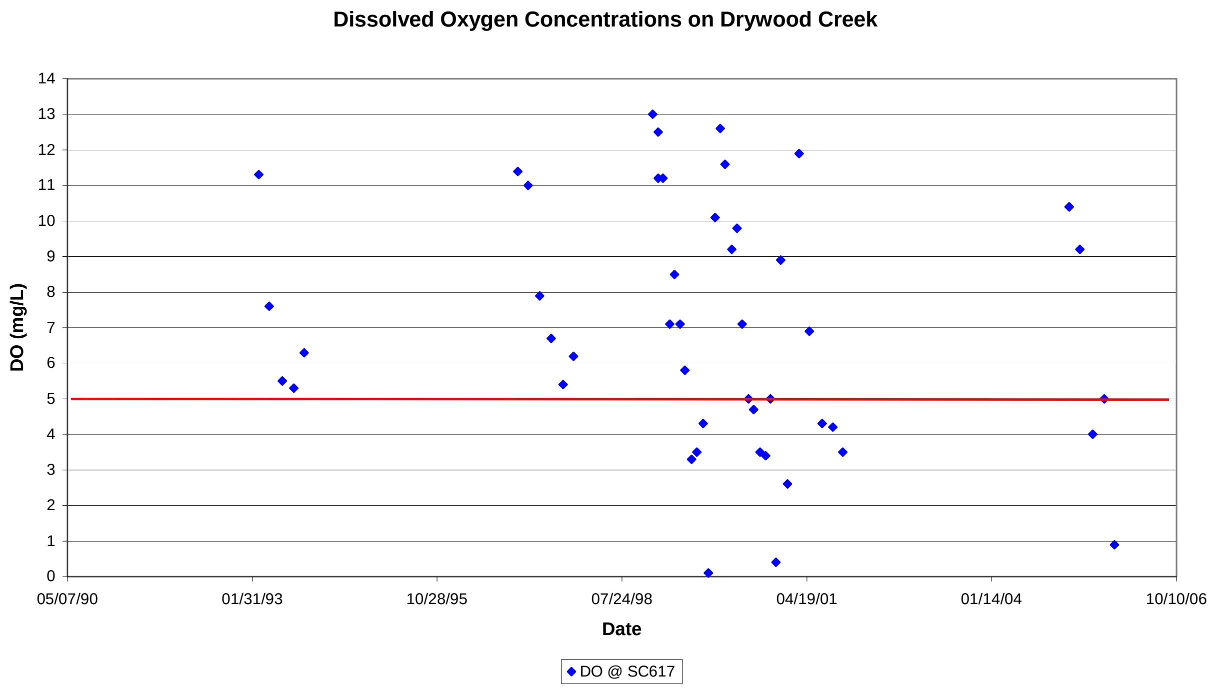


Figure 4. Monthly DO Average concentrations at Station 617.

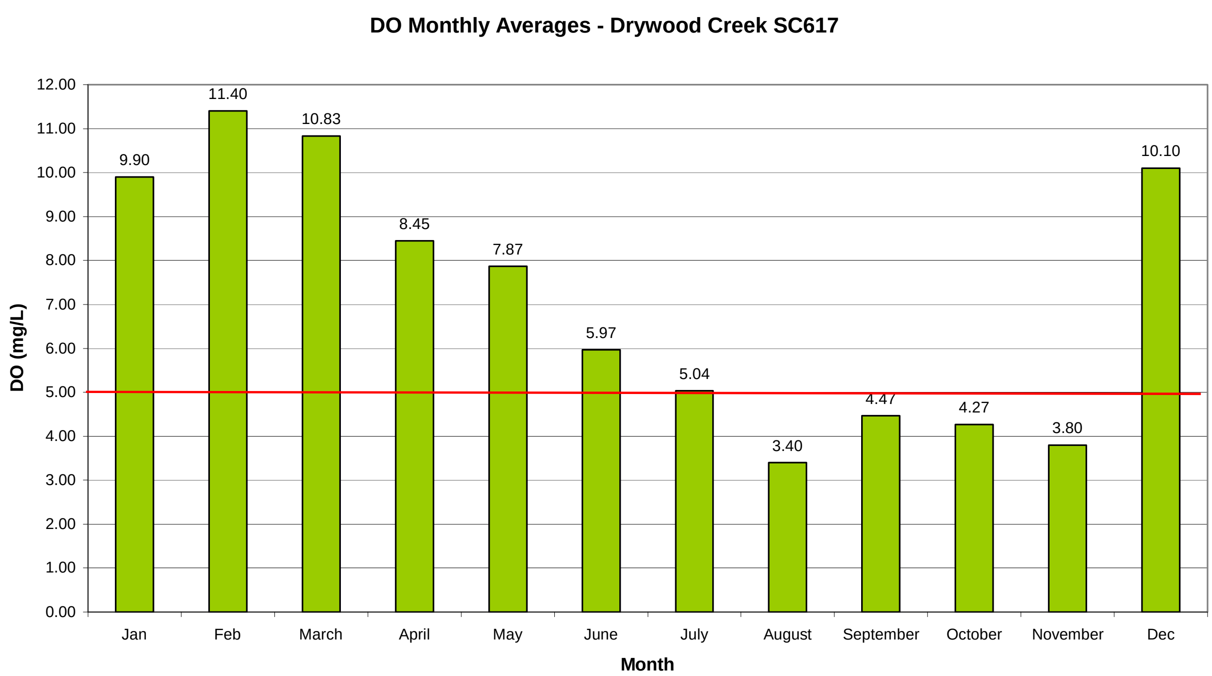
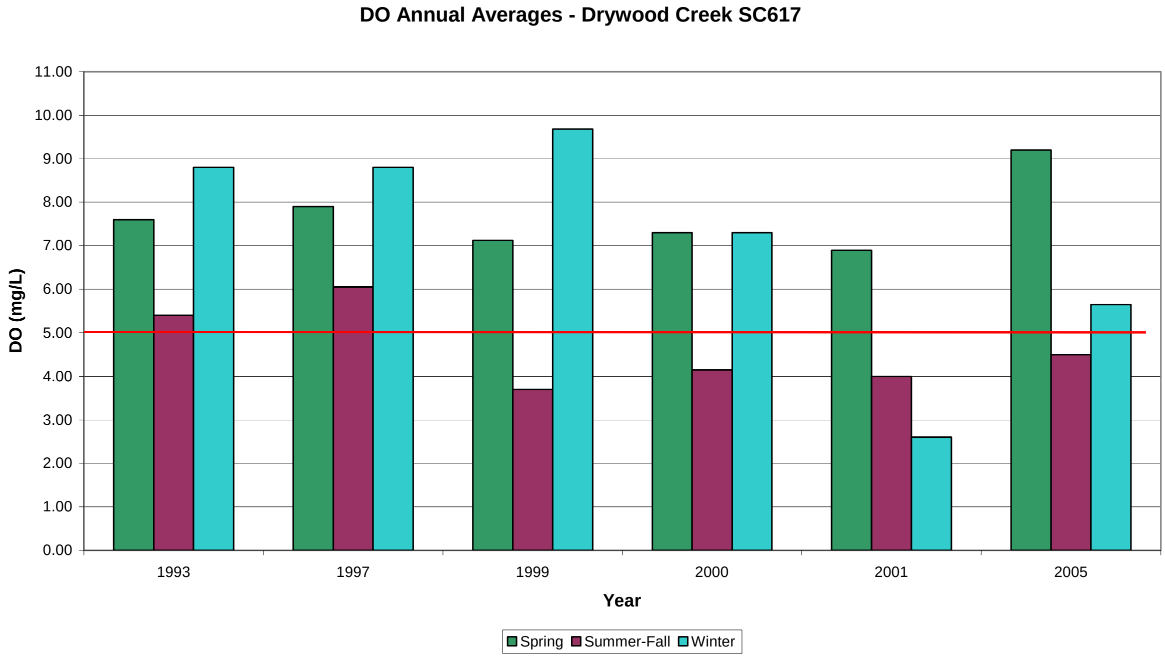


Figure 5. Annual Seasonal Sampling Averages at Station 617.



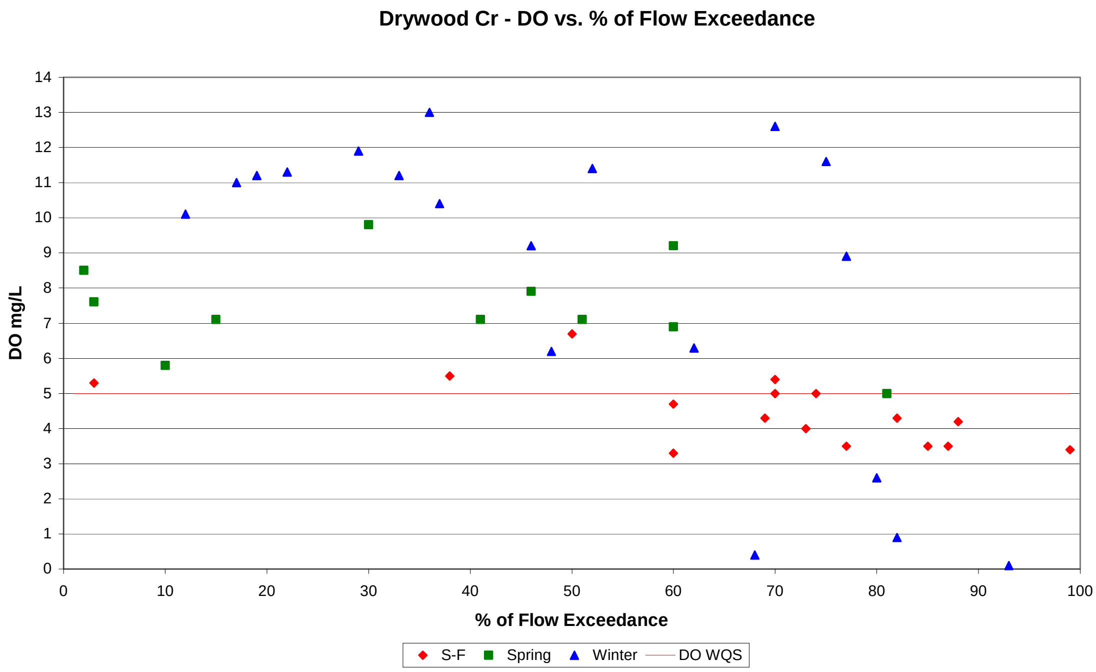
Average DO concentrations were the lowest during the months of July, August, September, October and November as seen in Figure 4. Seasonal annual average DO concentrations indicate that concentrations are the lowest in the Summer-Fall season. Overall annual averages were the lowest in 2000, 2001, and 2005 and were 6.77 mg/L, 5.57 mg/L, and 6.65 mg/L respectively.

Table 1. Number of Samples Under the DO Standard of 5mg/L by Flow.

Station	Season	0-10%	10-25%	25-50%	50-75%	75-90%	90–100%	Cum. Freq.
Drywood Creek – SC617	Spring	0/3	0/1	0/3	0/3	0/1	0/0	0/11 = 0%
	Summer-Fall	0/1	0/0	0/2	4/7	5/5	1/1	10/16 = 63%
	Winter	0/0	0/4	0/6	1/5	2/3	1/1	4/19 = 21%

As observed in Table 1 and Figure 6, the majority of the DO violations (< 5 mg/L) were observed during the Summer-Fall season at flows less than the median flow (50-100% flow exceedance). There were no violations observed during the Spring season, which coincides with spring rainfall, higher flows and runoff. The Winter Season contains several violations, particularly during low flow durations (75-100%).

Figure 6. Seasonal DO concentrations in Drywood Creek relative to the percent of flow.

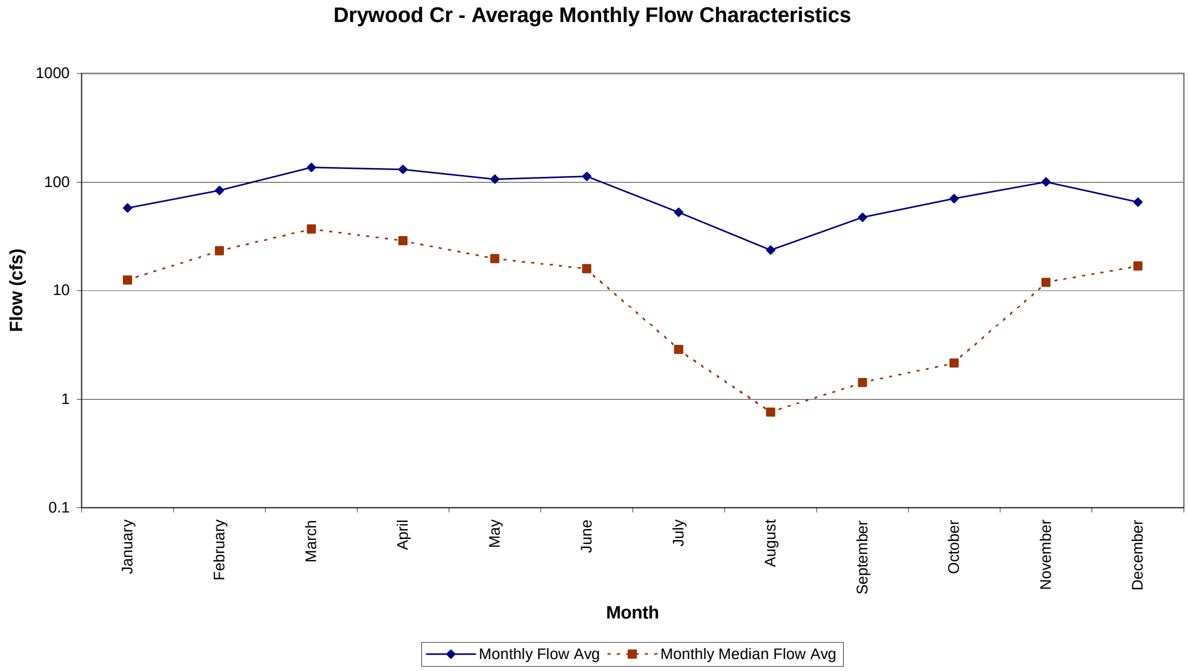


Estimated monthly streamflow along Drywood Creek, derived from flow data from USGS Gaging Station 06917380 along the Marmaton River, is illustrated in Figure 7. Months with the least amount of flow occur during the Summer-Fall season and correspond well with the months with lower average monthly DO concentrations. Flows during the Summer-Fall Season from the sampling years of 1999, 2000 and 2001 were the lowest as indicated in Table 2, which corresponds with the years with the lowest Summer-Fall Season DO concentration averages.

Table 2. Average Annual Seasonal flows on Drywood Creek in cfs.

Year	Spring	Summer-Fall	Winter
1993	138.7	101.7	73.1
1997	62.3	54.8	103.0
1999	200.5	11.6	59.8
2000	31.6	9.6	31.4
2001	58.1	15.2	72.3
2005	62.0	26.3	85.8

Figure 7. Monthly average flow in Drywood Creek.



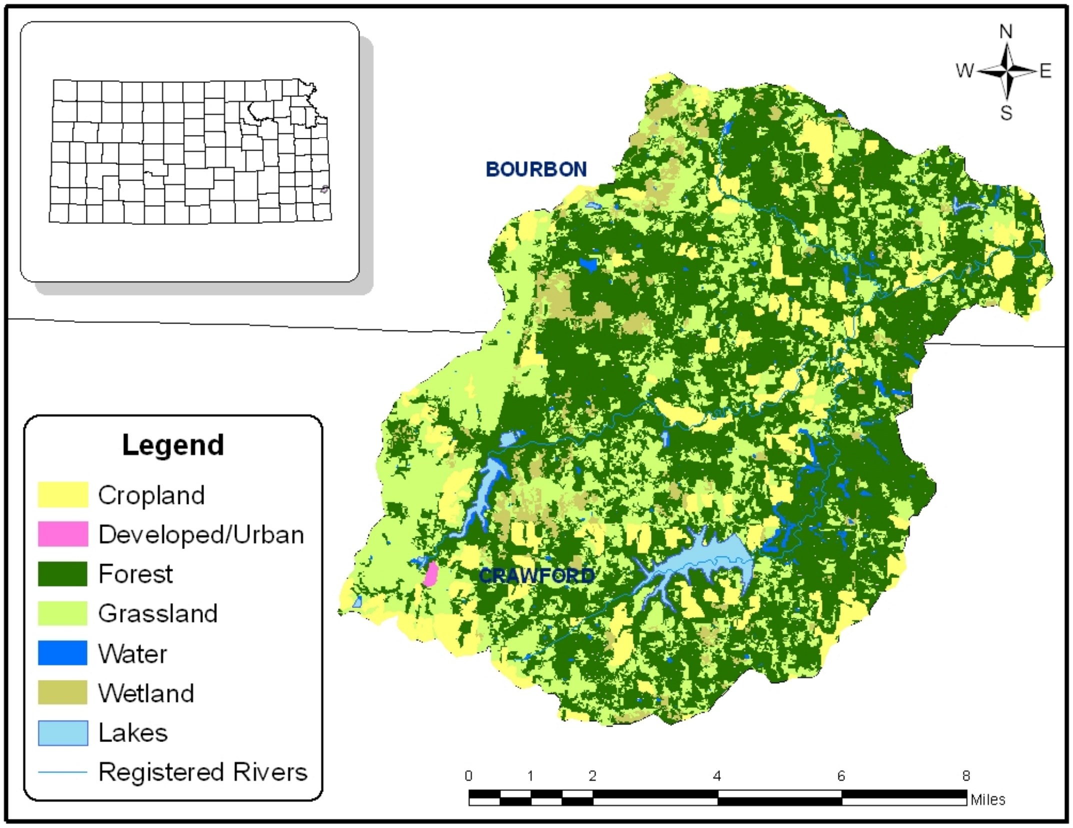
Desired Endpoints of Water Quality (Implied Load Capacity) for W. Fk. Drywood Creek at Site 617:

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Aquatic Life, indicated by dissolved oxygen concentrations of 5 mg/L or more. Seasonal variation is accounted for by this TMDL, since the TMDL endpoint is sensitive to the low flow and temperature conditions usually occurring in the Summer-Fall Season and higher DO levels occur during the Spring Season when flows are typically the highest. Low flow periods aggravate situations of deficient dissolved oxygen within this watershed. Achievement of the endpoint indicates any loads of oxygen-demanding substance 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

Land Use: As illustrated in Figure 8, the predominant land use in the Drywood Creek watershed is forest (including woodlands) and grasslands, which accounts for 55% and 29% of the watershed respectively. Approximately 11% of the land is occupied by cropland and 4% is wetlands. Urban areas occupy less than 1% of the watershed.

Figure 8. Land Use Map for the Drywood Creek Watershed.



NPDES: There are three NPDES dischargers within the Drywood Creek watershed. Currently, none of the facilities contribute enough flow to deliver loads down to the Drywood Creek monitoring site. The Crawford County Sewer District #4 facility serves homes surrounding Lake Crawford and has just recently been completed in 2006. The demand put on this facility will vary seasonally as the majority of the lake residences are only occupied during the warmer months. There has not been any discharge from this facility to date and discharge from the lagoon system is not expected to occur in the next couple of years. When this facility does discharge there are permit limits for Biochemical Oxygen Demand (BOD) (45 mg/L weekly avg., 30 mg/L monthly avg.), Total Suspended Solids (TSS) (120 mg/L weekly avg., 80 mg/L monthly avg.), pH (6.0-9.0), Ammonia (monitor), and Fecal Coliform (monitor). The Public Wholesale Water Supply District #11 - Bone Creek Water Treatment Plant, possesses an industrial permit for discharging wastewater generated from the treatment of their source water for public use. Sludge generated from the primary solids contact basins are routed to two of the cells at this facility and chlorinated filter backwash is directed to a smaller third cell. The discharge from the cells containing sludge is routed to the smaller cell and this cell discharges to Bone Creek via an outfall. The permit limits associated with the Bone

Creek facility do not include BOD, but does include limits on TSS (100 mg/L monthly avg.), Total Residual Chlorine (monitor), and pH (6.0-9.0). The Farlington Quarry #4 permit is an industrial discharge permit for seasonal de-watering and stormwater runoff utilizing portable equipment. There are no BOD limits associated with this permit.

Table 3. NPDES Permitted facilities within the Drywood Creek Watershed.

Facility	NPDES#	KS Permit #	Type	Rec Stream	Design Q (MGD)	Permit Expires
Crawford County Sewer District #4	KS0096741	M-MC52-OO01	3-Cell Lagoon	WF Drywood Cr via unnamed Trib via drainage ditch	0.030	3/31/09
Farlington Quarry #4	KS0115533	I-MC52-PO01	Seasonal discharge	WF Drywood Cr	NA	8/31/09
Public Wholesale Water Supply District #11 – Bone Creek Water Treatment Plant	KS0097101	I-MC52-PO02	3-Cell Lagoon	WF Drywood via Bone Creek	0.023	12/31/09

Livestock Waste Management Systems: There is not a registered, certified, or permitted confined animal feeding operation (CAFO) within the watershed. There are likely smaller animal feeding operations that exist within the watershed. According to the National Agricultural Statistics Service, the number of cattle averaged in the pasture from 2001-2006, based on the watershed area in Crawford County is approximately 6,000 head of cattle.

Population Density: According to the 2000 census data from the U.S. Census Bureau, the population of the entire watershed is approximately 776 people, and therefore the population density for the watershed is low at approximately 9-people/square mile. The only urban area within the watershed is the residential homes around Lake Crawford and Farlington, with both locations accounting for a population estimate of 433 people. With the residents around Lake Crawford being seasonal, the population estimate is presumably higher than the actual population in the watershed.

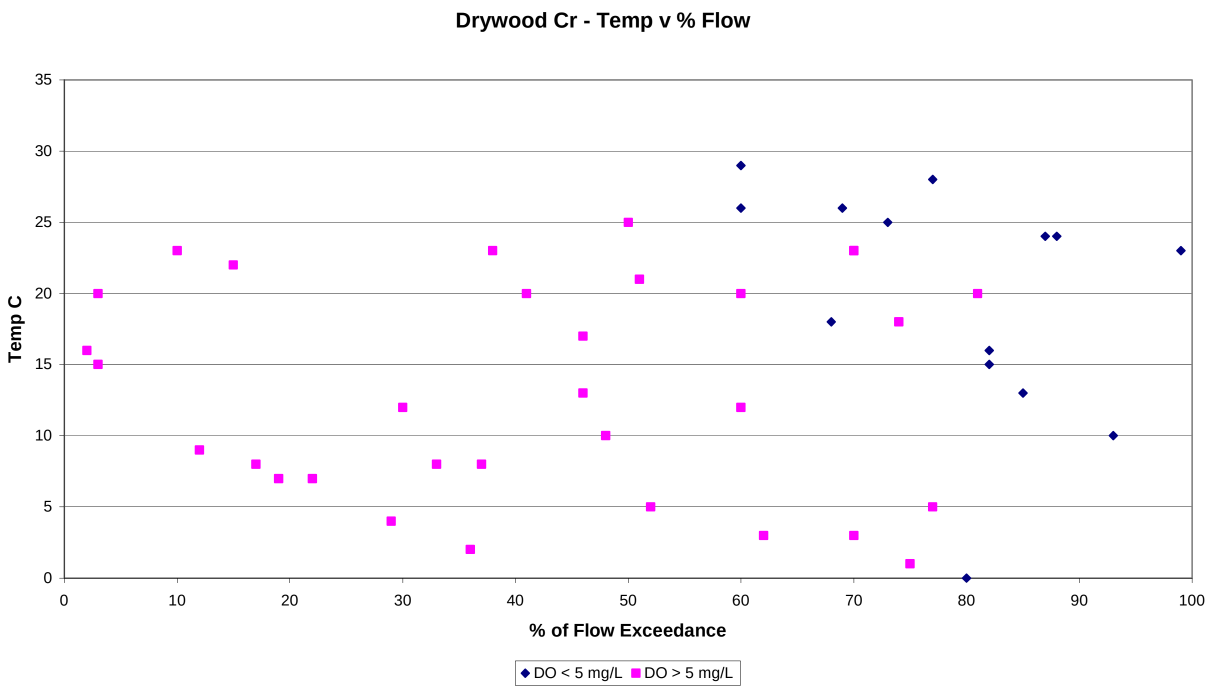
On-Site Waste Systems: Based on the 1990 census data, about 35% of the households in Bourbon County and 23% of the households in Crawford County utilize septic systems. The households within the watershed that are not served by the sewer system associated with the new Crawford County Sewer District #4 facility are presumably on septic systems. Though they are not likely to contribute to the DO impairment in Drywood Creek, failing on-site septic systems can contribute significant nutrient loadings within the watershed.

Contributing Runoff: About 77% of the Drywood Creek watershed produces runoff under low runoff conditions. The Drywood Creek watershed's average soil permeability is 0.98 inches/hour according to the NRCS STATSGO database, ranging from .01 inches/hour to 2.89 inches/hour. Only about 3% of the watershed has a soil permeability value greater than 1.29 inches/hour. Generally, storms producing less than 0.5 inches/hour of rain will generate runoff from 48% of this watershed. Runoff is primarily generated as infiltration excess with rainfall intensities greater than soil permeability. As the watersheds' soil profiles become saturated, excess overland flow is produced.

Correlation of DO with other Parameters: Results of the water quality analyses indicates that streamflow and temperature influence DO concentrations. The analyses between the data sets of compliant and non-compliant DO samples indicated that there is a statistically significant difference between the two data sets for streamflow and temperature, utilizing a two-sample T-test and the Kruskal-Wallis Test (see Appendix B). There was not a significant difference in regards to concentrations of BOD and TSS with these statistical tests. However, there is a relationship between higher BOD concentrations and low DO concentrations during the months of October and November when leaf fall is common.

Warmer stream temperatures and lower streamflows are prevalent in the Summer-Fall Season and correlate well with the observed DO violations in Drywood Creek.

Figure 9. Stream temperature in relation to percent flow for samples at Station 617.



KDHE discontinued sampling for BOD in 2001 and began utilizing Total Organic Carbon (TOC) analyses in late 2000 in lieu of BOD. KDHE conducted analyses in 2000 to determine if TOC concentrations could be utilized as a surrogate for BOD and whether a statistical translation could be made for this expression. KDHE utilized 675-paired sets of data in the analyses and concluded that there are relationships in the stream data. "The data suggest that, for effluent and point source related waters, the BOD/TOC ratio is almost one-to-one. Ambient waters have much lower ratios, suggesting that a portion of the TOC is in more refractory substances (i.e., cell walls, lignin, cellulose, etc.)"(Carney, 2000). The analysis of the paired ambient stream data was utilized for this report. The regression analyses for this group is summarized as follows:

R square = 0.34
P Value = <0.0001
For a TOC value of 10mg/L the most likely BOD concentration = 4.31 mg/L
Lower 95% BOD = 3.34 mg/L
Upper 95% BOD = 5.29 mg/L

BOD/TOC Ratio:
Arithmetic Mean = 0.44
Geometric Mean = 0.35
Median = 0.37

Generally, higher TOC concentrations indicate that more oxygen will be consumed by an ecosystem, which may result in an oxygen deficient stream system as the population increases among microorganism communities. The average TOC concentration for Drywood Creek is 7.5 mg/L under all flow conditions. Samples that had DO impairments had an average TOC concentration of 9.4 mg/L and samples that were DO compliant had an average TOC concentration of 5.6 mg/L.

Figure 10. Seasonal DO concentrations relative to temperatures at Station 617.

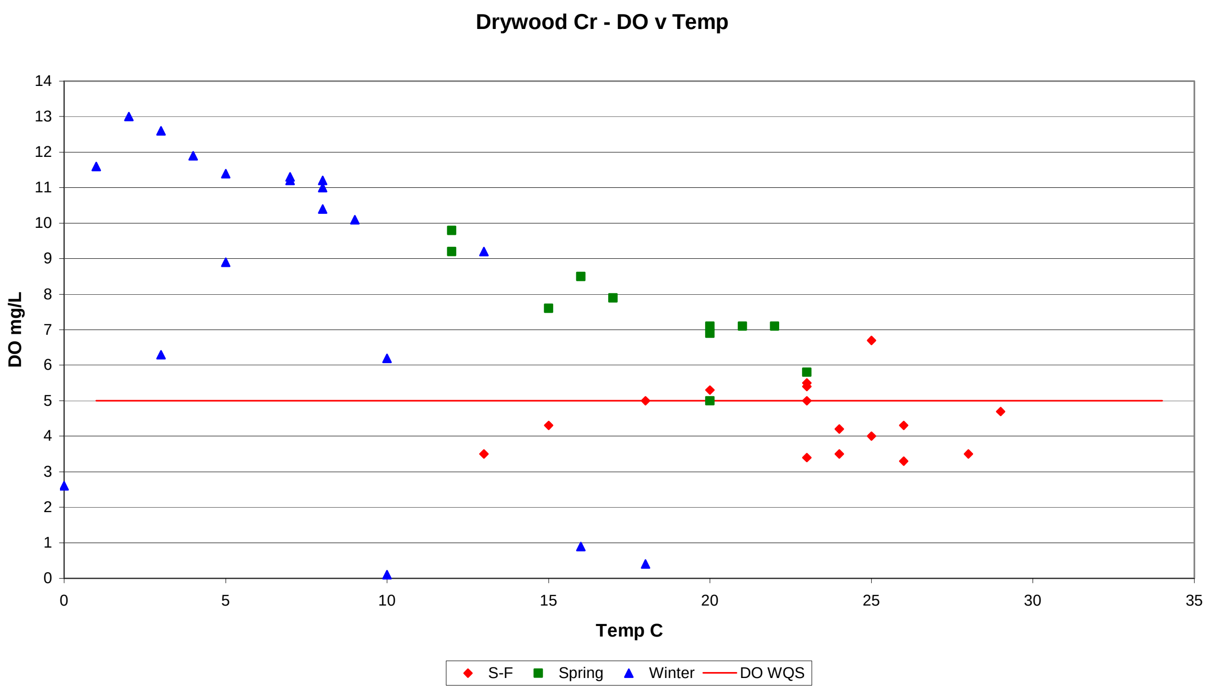


Figure 11. Seasonal DO concentrations relative to BOD concentrations at Station 617.

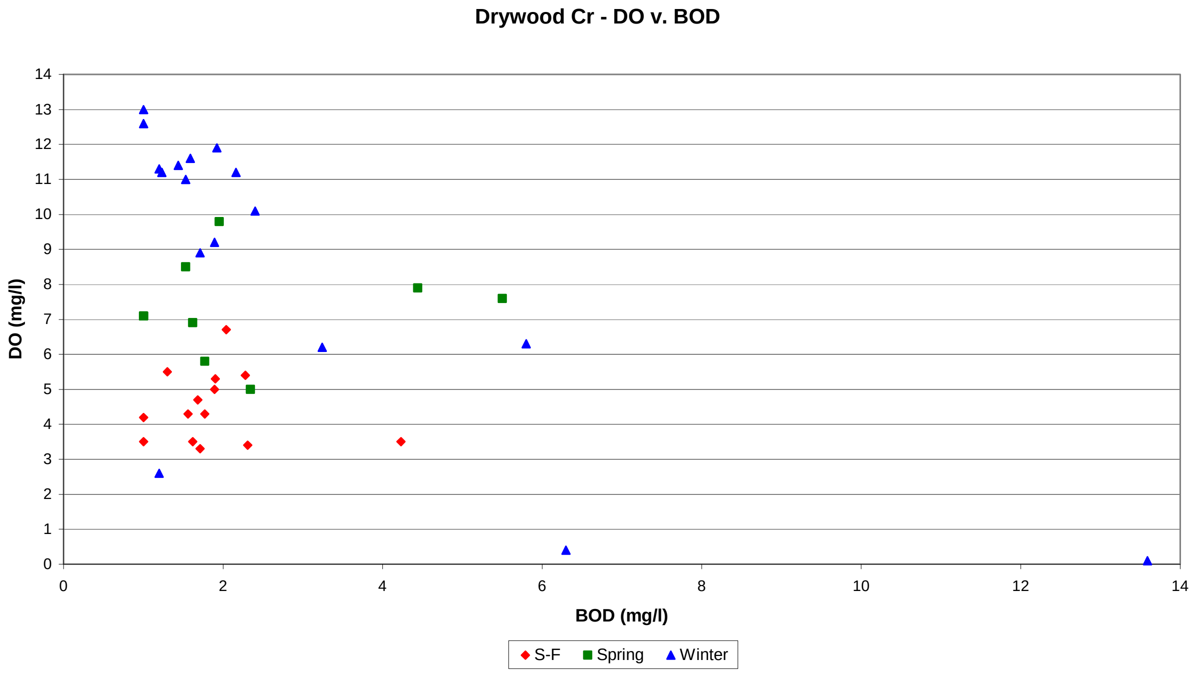


Figure 12. Seasonal DO concentrations relative to TOC concentrations at Station 617.

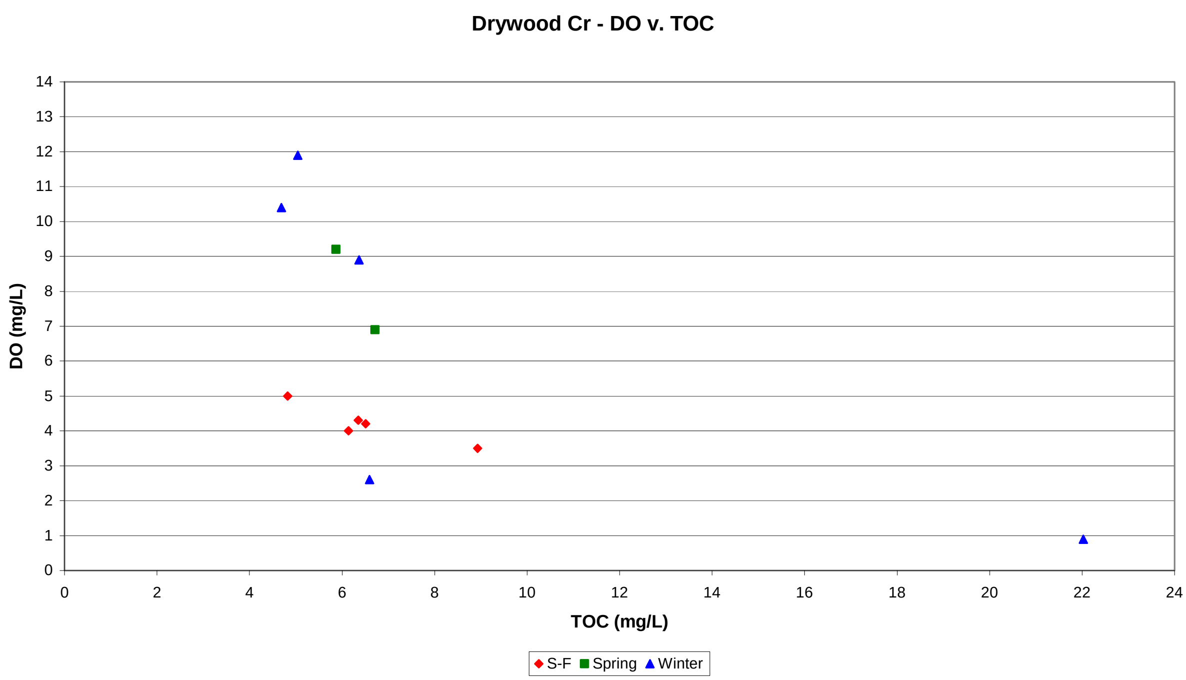


Table 4. Seasonal Cause and Effect Evaluation of Low DO. There were no violations in the Spring Season.

Factor	Season	S-F	Winter
Number of Samples < 5 mg/L DO	Delineator	10	4
Low Flow	Median Flow	10/10	4/4
High Temperature	15 deg C	9/10	2/4
High BOD	3 mg/L	1/10	2/4
High TOC	7.5 mg/L	1/10	1/4
High TSS	50 mg/L	0/10	0/4

There are a total of 14 samples that have DO violations over the three defined seasons, however none of these occurred in the Spring Season. All of the DO violations occurred under lower flow conditions. During the Summer-Fall and Winter seasons, 79% of the DO violations also occurred with elevated stream temperatures equal to or greater than 15 degrees Celsius. The three violations that occurred with higher BOD levels and the two violations that occurred with higher TOC concentrations all occurred in late October and early November, which may be attributed to the excessive build up of organic matter due to leaf accumulation in the stream.

Figure 13. DO concentrations relative to BOD concentrations for months (October and November) associated with leaf fall vs. all other months at Station 617.

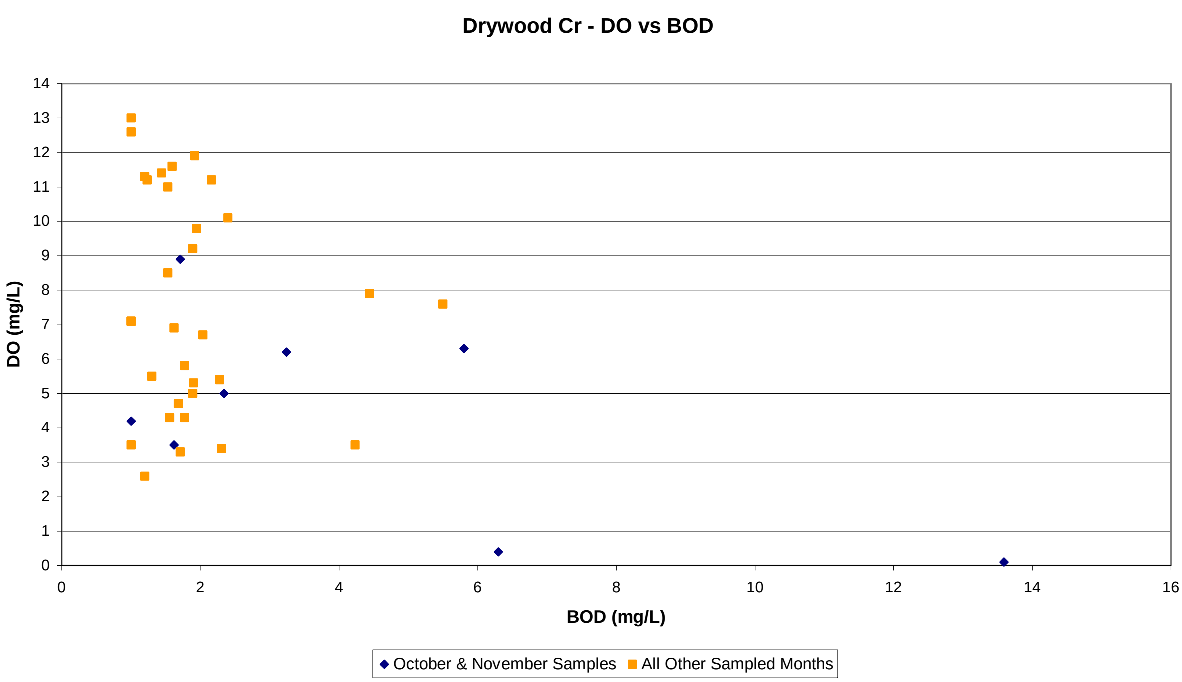
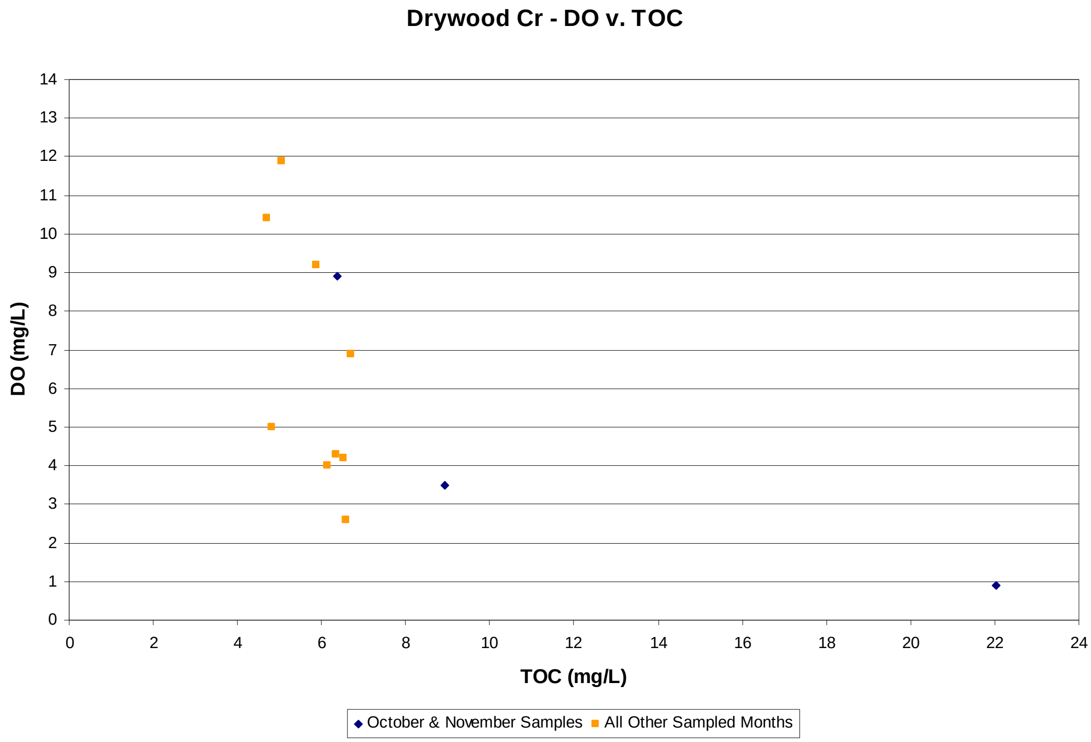


Figure 14. DO concentrations relative to TOC concentrations for months (October and November) associated with leaf fall vs. all other months at Station 617.



Background/Natural Contributions: Leaf litter and wastes derived from natural wildlife may add to the nutrient load. Much of the forested land cover buffers the streams within the watershed and may have significant effects on the DO concentrations within the stream during the fall and early winter months when significant leaf accumulations within the streambed are likely. The months of October and November demarcate the period when the majority of the leaves will fall, during these two months the BOD concentration average is 4.45 mg/L at Station 617. The BOD concentration average for the rest of the year was significantly less at 1.88 mg/L. The natural hydrological characteristics of the watershed influence DO concentrations during periods of low flow that are prevalent during the warmer summer months.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

The lack of sufficient dissolved oxygen is primarily caused by a combination of warmer stream temperatures and insufficient flow to provide re-aeration to the stream. 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. However, BOD loading appears to be naturally influenced by seasonal influences that may lead to DO impairments when the trees and shrubs within the riparian areas loose their leaves. The allocation of wasteloads and loads will be made in terms of BOD. All DO violations occurred during low flow conditions and the allocations will be made for low flow and high flow conditions. A translation to TOC will be made since BOD is no longer measured in streams.

Point Sources: Above Station 617, current Wasteload Allocations will be set for the Crawford County Sewer District #4 facility based on their current monthly average permit limit for BOD (30mg/L). Therefore, the Wasteload Allocation for BOD is 7.6 lbs/day for the Crawford County Sewer District #4 facility. This translates to an in-stream WLA of 0.52 lbs/day of BOD or 1.4 lbs/day of TOC (utilizing the median BOD/TOC ratio of 0.37 developed during KDHE's analysis as previously discussed) at site 617. The Crawford County Sewer District #4 facility is not seen as a contributor to the depressed dissolved oxygen seen along Drywood Creek because the facility has just recently been completed and has not discharged to date. When discharge does begin it is unlikely that the discharge will reach station 617 under low flow conditions. The analysis through the Streeter-Phelps DO model indicates that the present BOD permit limits for this facility maintains DO levels above 5 mg/L in the stream when there is no flow upstream of the discharge point during conditions when the stream temperatures are the warmest (see Appendix A).

There will be a Waste Load Allocation of zero for the Public Wholesale Water Supply District #11 – Bone Creek Treatment Plant, since the primary concern with this facility is total residual chlorine. The Waste Load Allocation for the Farlington Quarry #4 facility is also zero since this facility should not discharge except under extreme conditions and such conditions are not conducive to incidents of low dissolved oxygen within the Drywood Creek watershed.

Nonpoint Sources: The introduction of organic matter into Drywood Creek from runoff may cause incidents of low dissolved oxygen when flows are near the baseflow condition, or within the 50-75% flow exceedance duration. The Load Allocation assigns responsibility for maintaining the historical average in-stream BOD levels of 2.05 mg/L and the TOC concentrations to the current average of 5.6 mg/L, when no DO violations were observed at Site 617, for low flow conditions (50-100% flow duration). Since there has not been any DO violations observed during high flow conditions, the Load Allocation for high flow conditions (0-49% flow duration) is based on the maximum BOD concentration observed under these flow conditions, which is 5.5 mg/L. A conservative corresponding TOC Load Allocation for high flow conditions assigns responsibility for maintaining the current average TOC concentration of 7.5 mg/L. The associated BOD and TOC Load Allocations will be estimated at site 617 as indicated in Table 5.

Table 5. Drywood Creek TMDL, Daily Load Allocation at Station 617.

Flow Condition	LA - BOD (lbs/day)	LA – TOC (lbs/day)
Mean Flow – (60 cfs)	1782	2430
10% (129 cfs)	3831	5225
25% (43.0 cfs)	1277	1742
50% (11.3 cfs)	125	342
75% (1.10 cfs)	12.2	33.3
90% (0.13 cfs)	1.44	3.96

Natural/Seasonal Influences: Seasonal low flow and warmer stream temperatures are significant contributing factors leading to DO violations at site 617. Leaf litter may increase the organic materials, which tends to increase BOD concentrations within the stream on an annual basis when the deciduous trees within the riparian areas loose their leaves. However, the impact of leaf litter on the stream system will vary from year to year and will be more profound during periods of low streamflow. The stream should naturally rebound from the influx of organic material once the streamflow increases enough to flush the accumulated leaf and nutrient loads.

Figure 15. Drywood Creek DO TMDL expressed in lbs/day of BOD.

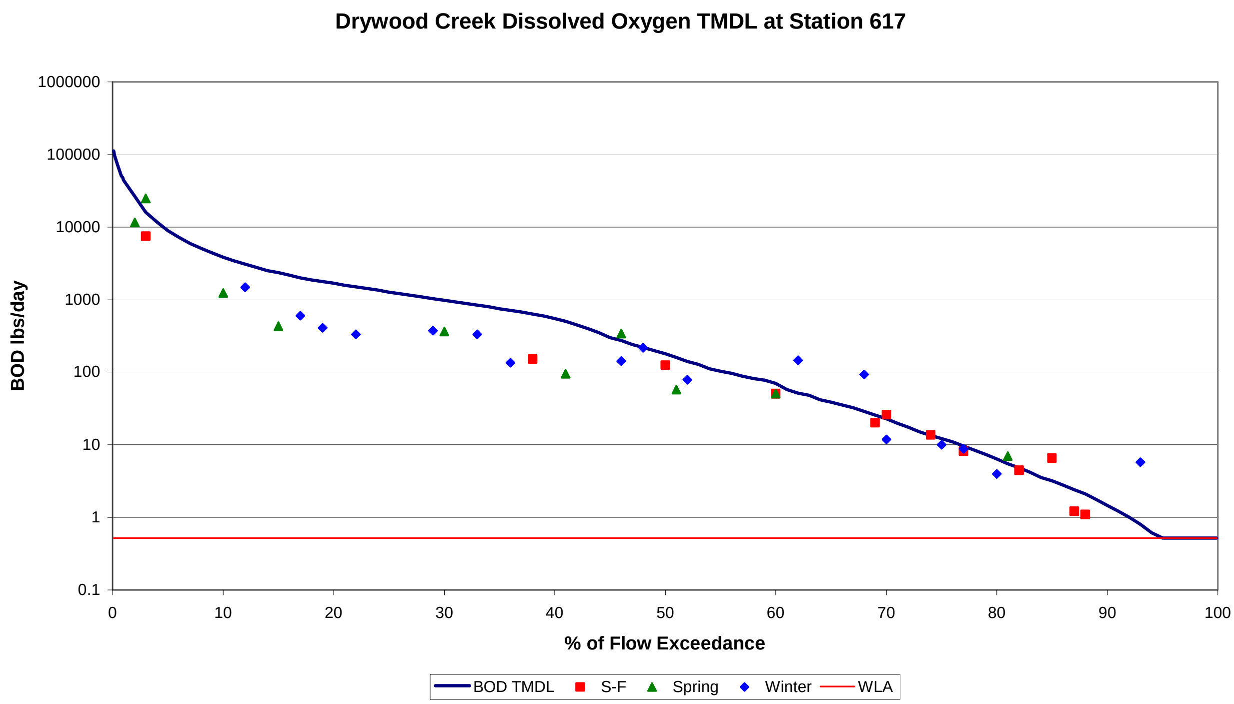
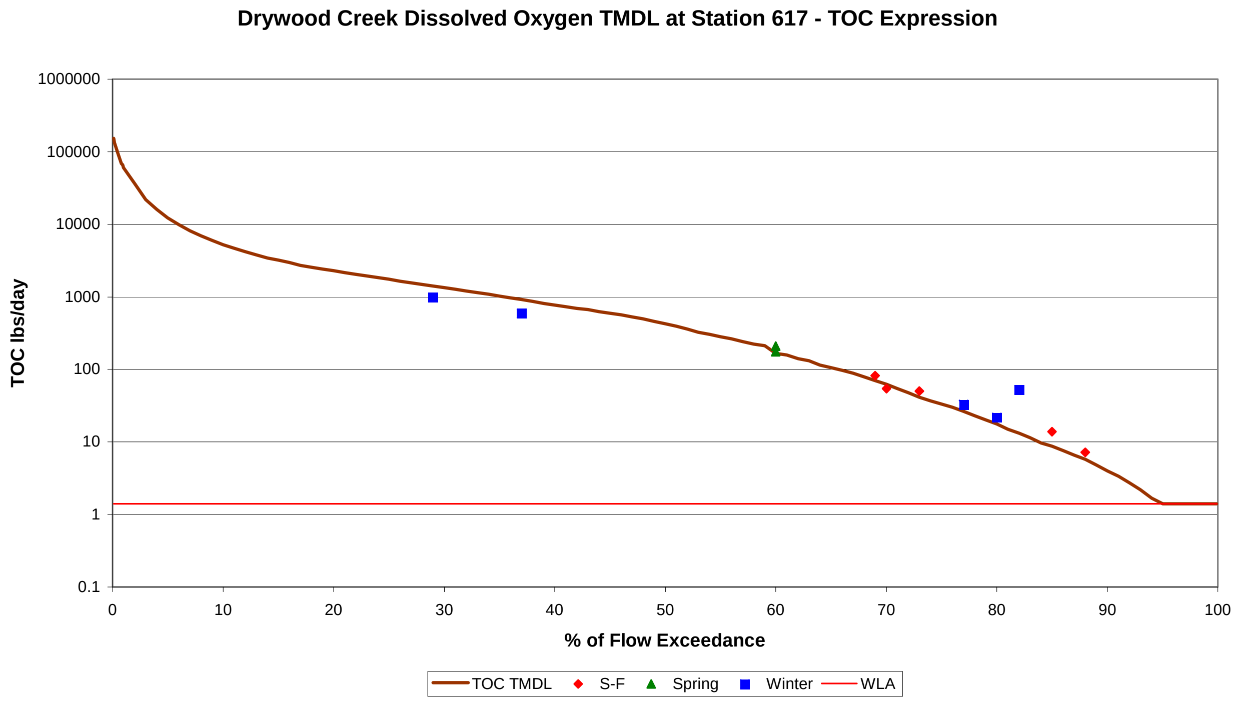


Figure 16. Drywood Creek DO TMDL expressed as lbs/day of TOC.



Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty of loading and the dissolved oxygen endpoint for the Drywood Creek watershed and is considered implicit in this TMDL. Conservative assumptions have been made with the new Crawford County Sewer District #4 facility by assuming they discharge permitted BOD concentrations at design flow, along with higher temperatures during low flow conditions. The most conservative assumption is that the flow from this facility reaches monitoring station 617 under low flow conditions, when in fact the facility is currently not discharging at all and future discharges will be limited by seasonal demand. A conservative assumption for nonpoint sources has been established by setting BOD Load Allocations throughout the year under all flow conditions when nonpoint BOD loadings are probably related to runoff during higher flow events. The loads associated with runoff events may deposit nutrient enriched sediment within the streambed, which may contribute to observed loadings at lower flow conditions as the streamflow subsides from a runoff event. The translating TOC target load has been conservatively set for low flow conditions based on the average TOC concentration for DO compliant samples. The conservative high flow target load for TOC is greater than 50% lower than an appropriate regression based BOD/TOC ratio that translates the BOD concentration utilized for the BOD target load to an applicable TOC concentration. The high flow target TOC load is based on the average TOC concentration over all flow conditions for all samples that had TOC analyses performed. The conservative assumption is that nonpoint BOD and TOC loads actually enter the stream and transit down to the monitoring station and contribute to the DO impairment.

State Water Plan Implementation Priority: Because low dissolved oxygen levels in Drywood Creek are often related to natural seasonal conditions resulting in higher temperatures during times of lower flow and when leaf fall is likely, this TMDL will be a Low priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Marmaton River Subbasin (HUC 8: 10290104) with a priority ranking of 17 (High Priority for restoration work).

Priority HUC 11s and Stream Segments: Priority should be directed toward the main segments of W Fk. Drywood Creek (19 and 323). The entire Drywood Creek watershed lies within the HUC 11: 10290104030.

5. IMPLEMENTATION

Desired Implementation Activities

1. Renew state and federal permits and inspect permitted facilities for permit compliance.
2. Maintain conservation tillage and contour farming to minimize cropland erosion.
3. Install grass buffer strips where needed along stream and drainage channels in the watershed.
4. Ensure proper on-site waste system operations in proximity to main-stream segments.
5. Ensure that labeled application rates of chemical fertilizers are being followed and implement runoff control measures.
6. Implement nutrient management plans to manage manure land applications and runoff potential.

Implementation Programs Guidance

NPDES and State Permits- KDHE

a. Maintain permit limits and monitoring requirements for Crawford County Sewer District #4 and ensure compliance.
b. New Livestock permitted facilities will be inspected for integrity of applied pollution prevention technologies.
c. New Registered livestock facilities with less than 300 animal units will apply pollution prevention technologies.
d. Manure management plans will be implemented.

Nonpoint Source Pollution Technical Assistance – KDHE

a. Support Section 319 demonstration projects for reduction of sediment runoff from agricultural activities as well as nutrient management.
b. Provide technical assistance on practices geared to the establishment of vegetative buffer strips.
c. Provide technical assistance on nutrient management for livestock facilities in the watershed and practices geared towards small livestock operations which minimize impacts to stream resources.
d. Guide federal programs such as the Environmental Quality Improvement Program, which are dedicated to priority subbasins through the Unified Watershed Assessment, to priority watershed and stream segments within those subbasins identified by this TMDL.
e. Assess conditions through the Marais des Cygnes WRAPS and evaluate implementation activities in 2012.

Water Resource Cost Share and Nonpoint Source Pollution Control Programs – SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.
b. Apply conservation farming practices and/or erosion control structures, including no-till, terraces and contours, sediment control basins, and constructed wetlands.
c. Re-evaluate nonpoint source pollution control methods.
d. Install livestock waste management systems for manure storage.
e. Implement manure management plans.

Riparian Protection Program – SCC

a. Develop riparian restoration projects.

Buffer Initiative Program – SCC

a. Install grass buffer strips near streams.
b. Leverage Conservation Reserve Enhancement Program to hold riparian land out of production.

Extension Outreach and Technical Assistance – Kansas State University

a. Educate agricultural producers on sediment, nutrient, and pasture management.
b. Educate livestock producers on livestock waste management and manure applications and nutrient management planning.
c. Provide technical assistance on livestock waste management systems and nutrient management planning.
d. Provide technical assistance on buffer strip design and minimizing cropland runoff.
e. Encourage annual soil testing to determine capacity of field to hold phosphorus.

f. Continue to educate residents, landowners, and watershed stakeholders about nonpoint source pollution.

Local Environmental Protection Program – KDHE

a. Inspect on-site waste systems within one mile of priority stream segments.

Timeframe for Implementation: Conditions will be evaluated based on additional monitoring from 2008-2012.

Targeted Participants: The primary participants for implementation will be KDHE, as well as agricultural and livestock operations immediately adjacent to the streams within the watershed. Conservation district personnel and county extension agents should conduct a detailed assessment of sources adjacent to streams within the watershed over 2008-2009. Implemented activities should be targeted for:

1. Areas of denuded riparian vegetation along the targeted main stem.
2. Facilities without water quality controls
3. Unbuffered cropland adjacent to the stream
4. Sites where drainage runs through or adjacent to livestock areas
5. Sites where livestock have full access to the stream and it is their primary water supply
6. Poor riparian areas
7. Failing on-site waste systems

Milestone for 2012: In accordance with the TMDL development schedule for the State of Kansas, the year 2012 marks the next cycle of 303(d) activities in the Marais des Cygnes Basin. At that point in time, data from site 617 should indicate evidence of improved dissolved oxygen levels at lower flow conditions.

Delivery Agents: The primary delivery agents for program participation will be KDHE and the Kansas State University Extension Service.

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 through –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 nonpoint source pollution.

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

8. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan*, including selected Watershed Restoration and Protection Strategies.

9. The *Kansas Water Plan* and the Marais des Cygnes River 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 and should not receive funding at this time.

Effectiveness: Effective controls can be placed on municipal and livestock waste to minimize wastewater and oxygen demanding substances entering Drywood Creek. Improvements in reducing oxygen demanding substance loads to streams can also be accomplished through appropriate management and control systems, including buffer strips and riparian restoration projects.

6. MONITORING

KDHE will continue to collect bimonthly samples, including DO measurements, in each of the three defined seasons for one year every four years, at Station 617. Based on that sampling, the priority status of the 303 (d) listing will be evaluated in 2012. Should the impairment status continue, the desired endpoints under this TMDL may be refined and consideration may be given to direct more intensive sampling to be conducted under specified seasonal low flow conditions over the period 2013-2015. The stream will be evaluated for possible delisting in 2016.

7. FEEDBACK

Public Notice: Public meetings to discuss TMDLs in the Marais des Cygnes Basin have been held since 2001. An active Internet Web site was established at www.kdheks.gov/tmdl/ to convey information to the public on the general establishment of TMDLs in the Marais des Cygnes Basin and these specific TMDLs.

Public Hearing: A Public Hearing on these Marais des Cygnes Basin TMDLs was held in Ft. Scott on May 31, 2007.

Basin Advisory Committee: The Marais des Cygnes Basin Advisory Committee met to discuss these TMDLs on June 22, 2006 in Pomona, November 29, 2006 in Williamsburg, December 18, 2006 in Ft. Scott, January 30, 2007 in Ottawa, March 13, 2007 in Ft. Scott and May 17, 2007 in Ottawa.

Milestone Evaluation: In 2012, evaluation will be made as to implementation of management practices to minimize the nonpoint source runoff contributing to this impairment. Subsequent decisions will be made regarding the implementation approach, priority of allotting resources for implementation and the need for additional or follow up implementation in this watershed at the next TMDL cycle for this basin in 2012.

Consideration for 303d Delisting: Drywood Creek will be evaluated for delisting under Section 303d, based on the monitoring data over the period 2008-2015. Therefore, the decision for delisting will come about in the preparation of the 2016 303d list. Should modifications be made to the applicable water quality criteria during the implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision would come in 2007, 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 2008-2015.

Bibliography

Carney, E.C., May 4, 2000. Kansas Department of Health and Environment Memorandum regarding: Comparison of historic BOD and TOC data in Kansas.

Perry, C.A., D.M. Wolock and J.C. Artman, 2004. Estimates of Low Duration, Mean Flow, and Peak-Discharge Frequency Values for Kansas Stream Locations, USGS Scientific Investigations Report 2004-5033.

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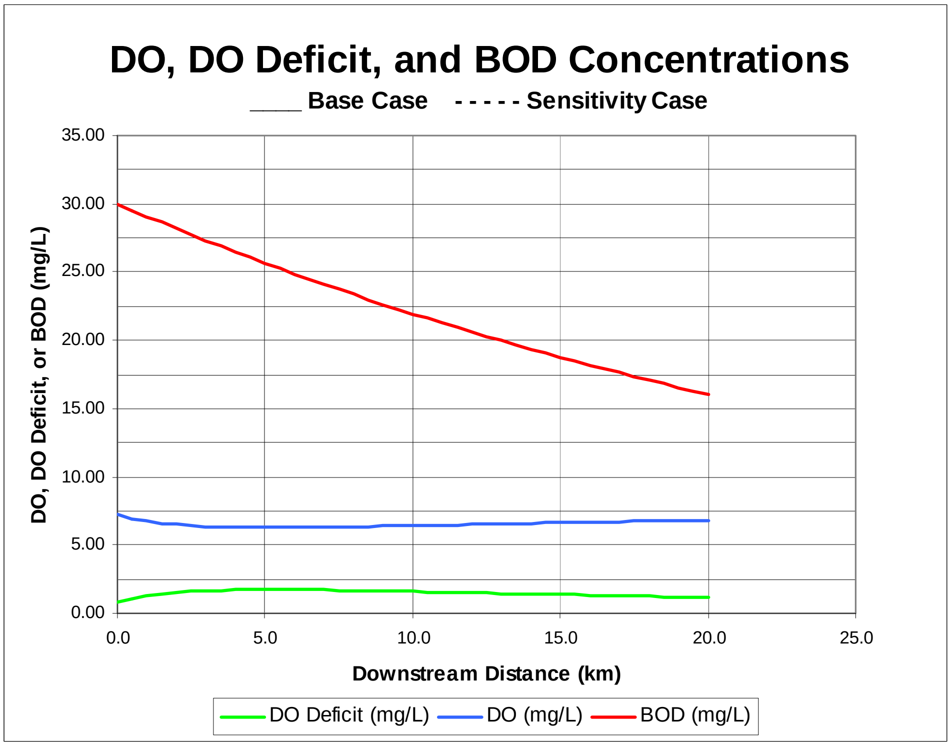
Appendix A. Streeter Phelps Output for Crawford County Sewer District #4 facility to sampling site 617 on Drywood Creek.

Variable	Units	Base Simulation	Sensitivity Simulation
Minimum DO	mg/L	6.28	
Max deficit	mg/L	1.74	
Location	km	5.19	
Time	day	0.54	



Distance (km)	Travel Time (day)	DO Deficit (mg/L)	DO (mg/L)	BOD (mg/L)
0.0	0.00	0.81	7.20	30.00
0.5	0.05	1.06	6.95	29.53
1.0	0.10	1.25	6.76	29.08
1.5	0.16	1.40	6.61	28.62
2.0	0.21	1.51	6.50	28.18
2.5	0.26	1.59	6.42	27.74
3.0	0.31	1.65	6.36	27.31
3.5	0.36	1.69	6.32	26.89
4.0	0.41	1.71	6.30	26.47
4.5	0.47	1.73	6.28	26.06
5.0	0.52	1.74	6.28	25.66
5.5	0.57	1.74	6.28	25.26
6.0	0.62	1.73	6.28	24.87
6.5	0.67	1.72	6.29	24.48
7.0	0.72	1.71	6.31	24.10
7.5	0.78	1.69	6.32	23.73
8.0	0.83	1.67	6.34	23.36
8.5	0.88	1.65	6.36	23.00
9.0	0.93	1.63	6.38	22.64
9.5	0.98	1.61	6.40	22.29
10.0	1.04	1.59	6.42	21.94
10.5	1.09	1.57	6.45	21.60
11.0	1.14	1.54	6.47	21.27
11.5	1.19	1.52	6.49	20.94
12.0	1.24	1.50	6.51	20.61
12.5	1.29	1.48	6.53	20.29
13.0	1.35	1.46	6.56	19.98
13.5	1.40	1.43	6.58	19.67
14.0	1.45	1.41	6.60	19.36
14.5	1.50	1.39	6.62	19.06
15.0	1.55	1.37	6.64	18.77
15.5	1.61	1.35	6.66	18.47
16.0	1.66	1.33	6.68	18.19
16.5	1.71	1.31	6.70	17.91
17.0	1.76	1.29	6.73	17.63
17.5	1.81	1.27	6.74	17.35
18.0	1.86	1.25	6.76	17.08
18.5	1.92	1.23	6.78	16.82
19.0	1.97	1.21	6.80	16.56
19.5	2.02	1.19	6.82	16.30
20.0	2.07	1.17	6.84	16.05

Streeter-Phelps DO Sag Model - Drywood Creek Watershed
Single Reach - Single Load

1 cfs = .0283 m^3/s
0.25 mph =0 .11176 m/s

		Elev (ft)	Dist (km) to 617	Min DO	Crit Dist DO
0.0013270	Design Flow (Crawford Cnty Sewer)	950	16.50	6.28	5.19

Elevation Correction (DO)

Elevation	**950**	ft
Correctn Factor (DO_{sat})	0.9696	mg/L

Distance (km)
Flow (m^3/s)
Concentration (mg/L)
Temp (C)
Vel (m/s)

Unless modified by upstream pt. source, upstream BOD set as target for basin
Upstream DO (where appropriate) elevation corrected and set at 90% sat.

Velocity	0.11176		
BOD coef	0.23	Theta	1.056
O2 coef	(see Calc K_r)	Theta	1.024

		Flow	BOD	DO	T	Dist (km)	Slope (ft.mi)	Calc K_r	
1	**Crawford**	0.0013270	30	7.2	25	16.50	14.63	3.94	
	Upstream	0	0	0	0	-----			
	Result at Site 617(Drywood.)	0.001327	17.91	6.7	25				Elev = 800 ft

Kr Values (Foree 1977) using	0.42 (0.63 + 0.4S^1.15)
for q < 0.05 where q = cfs/mi^2 and	S (ft/mile)

Appendix B – Two Sample T-Test and Kruskal-Wallis Test Results for significantly different parameters for DO compliant and non-compliant samples.

Stream Flow for DO compliant and non-compliant (exceed) samples = Significantly Different

Two-Sample T-Test for FlowCFS

Group	N	Mean	StDev	SE Mean
Compliant	32	118	301	53
Exceed	14	1.49	1.9	0.51

Difference = mu (Compliant) – mu (Exceed)
Estimate for difference: 116.215
95% CI for difference: (7.595, 224.835)
T-Test of difference = 0 (vs not =) : T-Value = 2.18
P-Value = 0.037 DF= 31

Kruskal-Wallis Test on FlowCFS

Group	N	Median	Ave. Rank	Z
Compliant	32	15.9914	29.3	4.46
Exceed	14	0.5379	10.1	-4.46
Overall	46		23.5	

H = 19.93 DF = 1 P = 0.000
H = 19.93 DF = 1 P = 0.000 (adjusted for ties)

Stream Temperature for DO compliant and non-compliant (exceed) samples = Significantly Different

Two-sample T for Temp_Cent

Group	N	Mean	StDev	SE Mean
Compliant	32	13.22	7.59	1.3
Exceed	14	19.79	8.21	2.2

Difference = mu (Compliant) – mu (Exceed)
Estimate for difference: -6.56696
95% CI for difference: (-11.88748, -1.24644)
T-Test of difference = 0 (vs not =): T-Value = -2.55
P-Value = 0.018 DF = 23

Kruskal-Wallis Test on Temp_Cent

Group	N	Median	Ave Rank	Z
Compliant	32	12.50	20.0	-2.7
Exceed	14	23.50	31.6	2.7
Overall	46		23.5	

H = 7.28 DF = 1 P = 0.007