TMDL for Dog and Cat Creeks
Claremore, Oklahoma

Final Report

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SECTION 1

INTRODUCTION

In September 1988, INCOG conducted an intensive stream survey on Dog Creek and its tributaries Cat Creek and the Claremore Effluent Tributary. The purpose of this study was to gather sufficient data to develop a computer model with which to determine waste load allocations for the Claremore wastewater treatment plant (WWTP). The Claremore WWTP discharges into the effluent tributary to Cat Creek which is a tributary to Dog Creek. Dog Creek, in turn, is a tributary of the Verdigris River in Rogers County. The results of the modeling study were presented in the July 1989 INCOG report, "Claremore Wasteload Allocation Study Phase II: Modeling Report".

In the 1989 study it was determined that extreme advanced treatment levels would have to be achieved in order to protect designated beneficial uses in Dog Creek and its tributaries. Recommendations in the 1989 report were to conduct a verification (confirmed) study as recommended in the 1983 EPA Region 6 guidelines, "Criteria For Performing Waste Load Analysis".

INCOG received funding through the FY 89 604(b) grant program to conduct another intensive stream survey in order to develop a verification (confirmed) study of the 1989 wasteload allocation model. The water quality survey was performed in July of 1991 within the same stream segments. Results of the water quality and field sampling were presented in the February 1992 INCOG report, "Dog Creek Water Quality Survey Data Report".

The original 1988 field survey indicated that the dissolved oxygen (DO) sag was in an area upstream of Dog Creek river mile 10.56 (station 4I001 at Flint Road bridge). Therefore, additional sampling stations were located within this impacted segment in the 1991 verification survey in order to confirm and better characterize the DO sag. Also, additional stations were located downstream within a secondary DO sag area.

Results of the 1991 water quality data were used to develop a verification model. Because of potential nonpoint source (NPS) impacts in Dog Creek and the tributaries, the verification model was designed to allow consideration of several different options in developing future conditions. These were: 1) continuing to discharge with no improvements in effluent quality; 2) discharging at advnaced treatment levels; and 3) selection of a discharge point directly into Dog Creek which would eliminate any wastewater flow into the effluent tributary and Cat Creek.

Results of the 1993 verification study which received approval from the Oklahoma Department of Environmental Quality (ODEQ) and EPA Region VI, were presented in the April 1993 INCOG report, “Claremore Wasteload Allocation Verification Study, Final Modeling Report”. Because there were potential nonpoint sources identified in the 1993 study, INCOG recommended that a Phased TMDL (Total Maximum Daily Load) study be performed to characterize nonpoint sources.

INCOG obtained FY-95 104(b)(3) funds to conduct Phase I of the TMDL. This study resulted in field data being collected during dry weather (July 1998) and wet weather (September 1998) flows to identify potential nonpoint source areas of the watershed and to determine stream water quality downstream of the Claremore WWTP. These data are summarized in this report in Appendix A. INCOG also has created Geographic Information System (GIS) databases of digitized land uses for an area covering most of the Claremore city limits and south to the confluence of Dog Creek with the Verdigris River. These data (on a CD-ROM disk) were delivered to state and federal agencies and to the Office of Secretary of Environment and EPA Region VI as a part of the FY-95 104(b)(3) grant commitment.

INCOG, under intra-state agency agreement and in cooperation with the Oklahoma Conservation Commission (OCC) using FY-96 319(h) funds, jointly conducted an intensive summer stream survey in September 2000 to collect an updated calibration data set for use in the TMDL modeling presented in this report. The OCC collected additional land use and water quality data to be used to characterize water quality conditions in Dog Creek and tributaries prior to TMDL implementation.

The 1993 INCOG modeling effort used the steady-state one-dimensional model from EPA Region VI (QUAL-TX). However, the QUAL-TX model does not run on the newer Windows operating systems (after Windows 98). INCOG obtained a Microsoft Windows version of QUALTX called LAQUAL. This model was developed by the Louisiana Department of Environmental Quality and created by Bruce Wiland, P.E., of Wiland Consulting, Inc., the same programmer who wrote the QUALTX model for EPA Region VI. The advantage of using LAQUAL is its easier functionality in the Windows NT and Windows 2000 environment.

The City of Claremore and the surrounding rural areas of Rogers County have seen significant population and commercial growth. Consequently, the future growth projections used in the 1993 INCOG modeling study are herein revised to accommodate anticipated population to be served by the Claremore WWTP. Based upon the TMDL modeling studies, it has been determined that advanced wastewater treatment will be necessary for the Claremore WWTP to protect water quality in lower Dog Creek. This study is a confirmation of the two previous modeling studies.

INCOG has begun to work with Claremore and surrounding cities to determine a comprehensive wastewater treatment strategy for the Rogers and Tulsa County areas. This modeling report will therefore be used to determine the maximum allowable assimilative capacity of lower Dog Creek, lower Cat Creek and the Effluent Tributary from the Claremore WWTP. Any additional wastewater loads from Claremore and other entities will have to consider other receiving streams. INCOG has obtained FY-00 and FY-01 604(b) funds to conduct the Regional TMDL that will examine all receiving streams in the study area. The Dog/Cat Creek system will be a portion of the overall Regional TMDL. The draft Regional TMDL modeling report is expected to be completed in late 2002.

Dog Creek and its receiving stream tributaries are characterized by long pools with little summer base flow. Most of the study area is within the 100 year floodplain, and nearly all of the stream channel has dense riparian tree canopy. As a result, the dissolved oxygen budget of Dog Creek is driven by oxygen demanding substances (i.e. decay of CBOD, ammonia-N, organic nitrogen and sediment demands) with moderate to poor natural reaeration. Consequently, lower Dog Creek and its tributaries are not suitable for assimilating large waste loads.

In September 2001, INCOG prepared a draft modeling report for state and federal agency review. Comments were received from the ODEQ and the Oklahoma Conservation Commission. INCOG has made changes to the TMDL in addressing these comments with references being made in the report text to these changes. The draft TMDL report incorporated the small pond on the effluent tributary as a nonpoint source for ammonia-N in the model. Two calibration data sets (1991 and 2000) both showed ammonia-N concentrations increasing downstream of the pond, hence this source was input as a nonpoint source function (LAQUAL Data Card 19) in the model (as opposed to inputing it as a point source in the model). The OCC commented that the pond was not a typical nonpoint source (having no agricultural or other normal nonpoint source causative actions), that its hypereutrophic condition was likely due only to point source impacts (being just downstream of the Claremore WWTP), and that its impact on the stream was not significant when compared to the point source impacts.

INCOG re-examined the modeling and chemical data to determine another explanation for the increasing ammonia-N downstream of the pond. Included in this was determining if all of the ammonia-N could be accounted for from decay of organic nitrogen in the effluent itself. A model was created that set all ammonia-N decay rates (that is, oxidation of ammonia-N to nitrate-N) and other ammonia-N loss rates (e.g. settling rates) to zero while adjusting organic nitrogen (ORN) decay rates to just match declining ORN concentrations downstream. This analysis confirmed that all ammonia-N monitored downstream of the WWTP could be derrived solely from the decay of ORN in the effluent. The near anaerobic conditions within the pond would provide a suitable environment for the biological decay of ORN and ammonia-N.

INCOG also calculated the total oxygen demanding load from the “nonpoint source” ammonia-N used in the draft report to be less than 1% of total oxygen demanding load. For these reasons, the final TMDL removes the pond as a nonpoint source, and the TMDL model has been revised to set ORN decay and settling rates to calibrate on monitored ORN and ammonia-N without external (nonpoint) sources. Because of this, the wasteload allocation for Claremore had to be reduced further. However, this approach increases the certainty in the model (that is, the TMDL no longer having to rely upon uncertainties of quantifying the nonpoint source or the effectiveness of BMP imnplementation). This revision, along with the fact that this is a second verification study of the original 1989 INCOG modeling study, adds certainty to the TMDL.

Dog Creek has now had three credible calibration data sets collected. Three calibrated TMDL models have been developed, each with increasing certainty and confirmation of previous conclusions. The present study also incorporates analysis of an additional data set collected in 1998, along with detailed GIS-based land use characterization, to examine and characterize any potential nonpoint sources contributing significant loads to the stream under critical conditions. The data demonstrate that the stream is dominated by impacts from the point source and that there are no significant nonpoint sources that need to be accounted for in the TMDL model beyond the normal conservative model structure. For these reasons, the 5% Margin of Safety as proposed in the draft TMDL is retained in this final report.

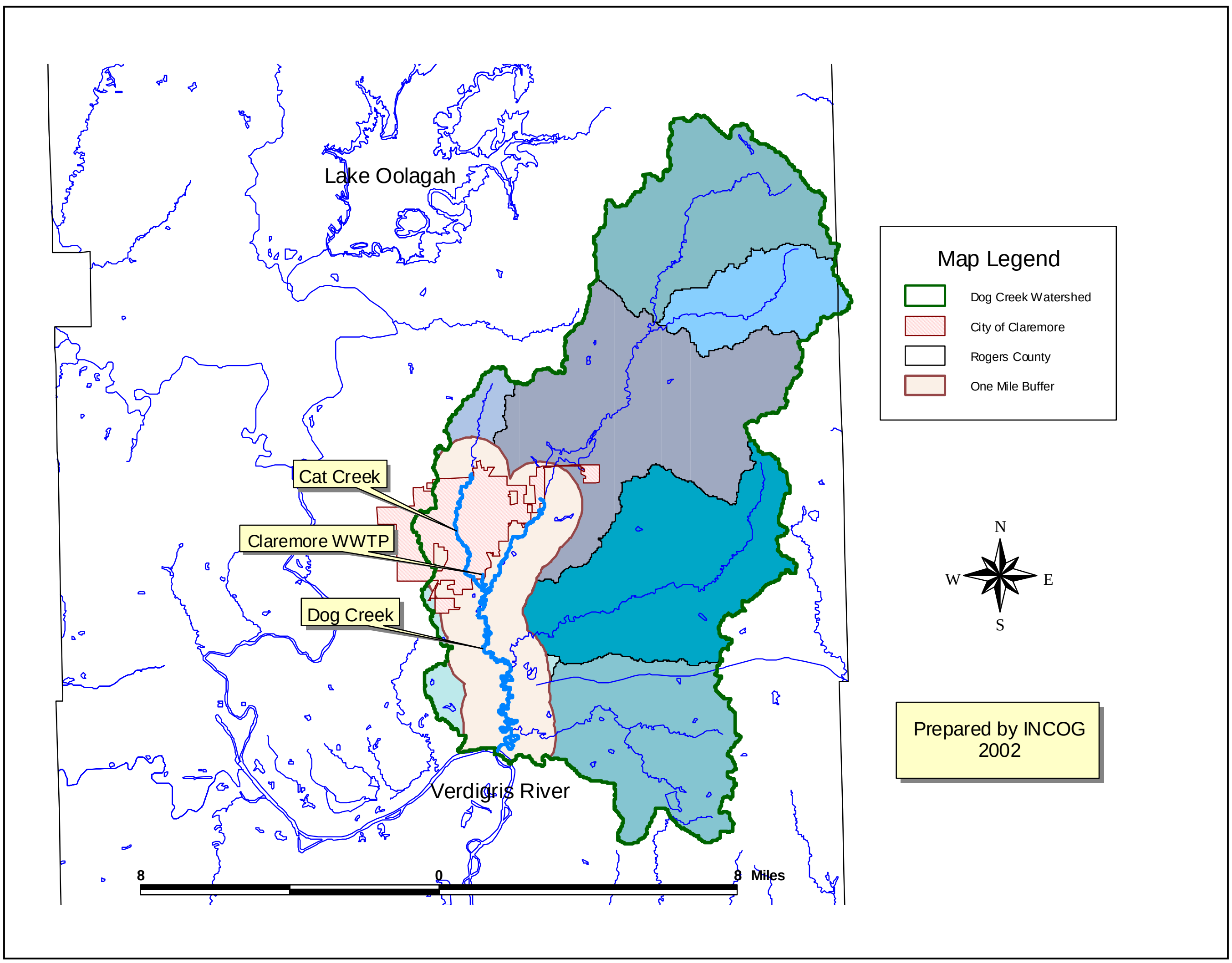
SECTION 2

PROJECT DESCRIPTION

DESCRIPTION OF PROJECT AREA

Figure 2.1 shows the location of the Dog Creek Watershed and sub-watersheds of major tributaries in Rogers County, Oklahoma. Figure 2.2 shows the location of all sampling sites used in the September 2000 calibration survey and the location of the Claremore wastewater treatment plant. The TMDL study area extends south from the WWTP to the Spavinaw Flowline about two miles north of the confluence of Dog Creek with the Verdigris River. River Mile designations and names for all sampling sites are presented in Table 2.1.

FIGURE 2.1: Location of Dog and Cat Creek Watersheds in Rogers County, Oklahoma



Lighter shaded area represents a one-mile buffer around Dog and Cat Creeks that was used to define land uses having the greatest potential to affect the TMDL.

FIGURE 2.2: Location of Sampling Sites Used in the 2000 Calibration Survey

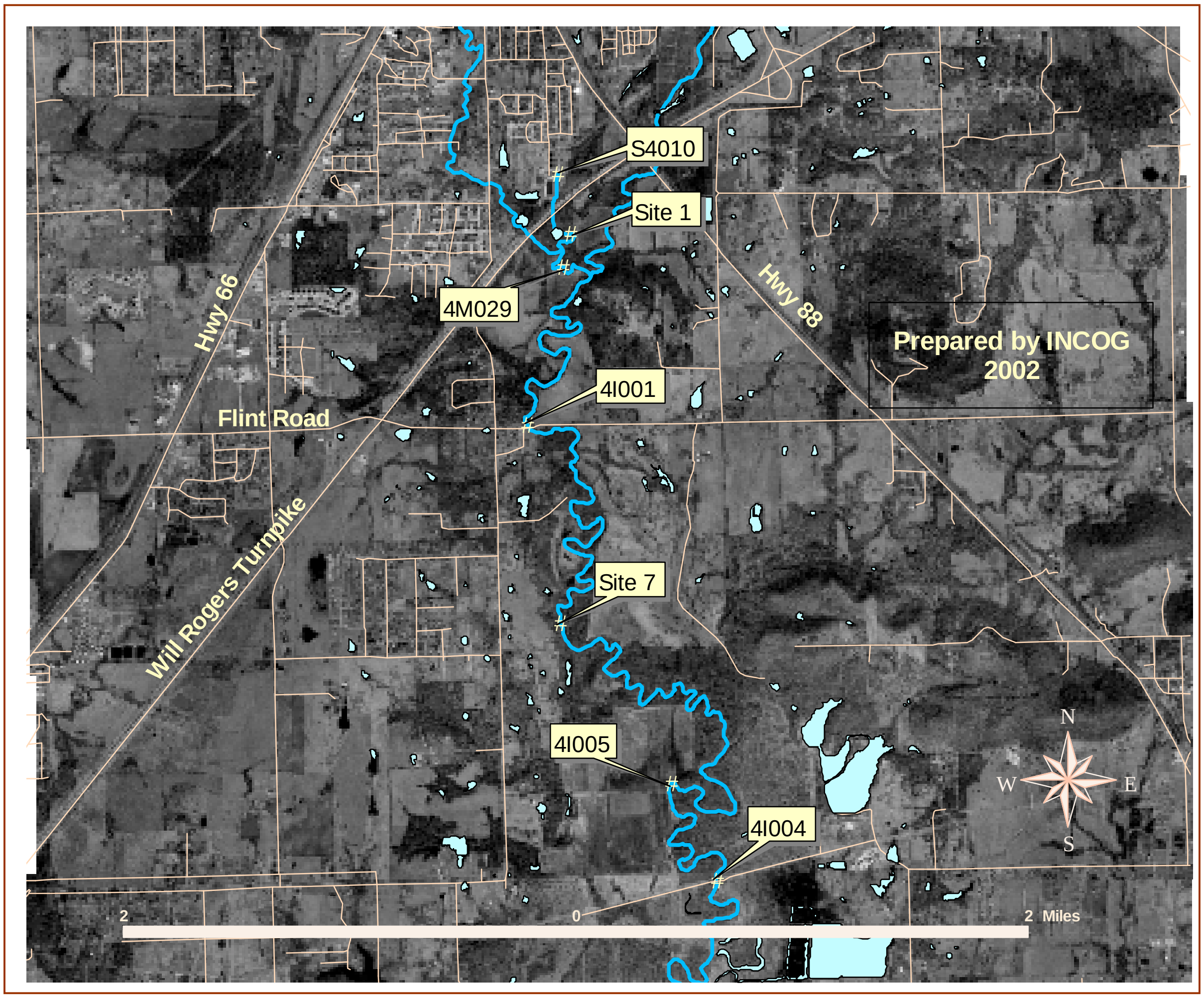


TABLE 2.1: Sampling Site Identifications and Locations

SITE ID	RIVER MILES	GENERAL NAME
S4010	12.97	Claremore WWTP Effluent
Site 1	12.63	Effluent trib downstream pond
4M029	12.34	Cat Creek downstream trib
4I005	10.56	Flint Road bridge
Site 7	8.66	McCombs property
4I005	6.22	Gordon property
4I004	5.25	Spavinaw flowline

Almost all of the study area is characterized by dense woods and thick underbrush. The lower Dog Creek channel itself is fairly uniform throughout the study reach with silted sandy clay sediments, occasional log jams, numerous fallen trees, thick over story of tree canopy along its banks, and extensive shallow pooling with only an occasional short riffle. The lower Cat Creek study segment is very similar to the upper reaches of Dog Creek. The effluent tributary begins at the Claremore treatment plant as an open channel with no tree canopy. There is some noticeable slope down to the turnpike culvert crossing where the slope changes to shallow pooled conditions. From the turnpike to the small pond, stream flows become more shallow and slow through thick woods and dense tree canopy. Streambed sediments in this area are mostly silt with large accumulations of organic material.

The effluent tributary continues downstream of the pond through dense forest. Just upstream of the entrance into Cat Creek, the streambed slope increases and narrows somewhat. Streambed sediments are not as silted in this reach, which continues on until the confluence with Cat Creek.

A small hypereutrophic pond downstream of the Will Rogers Turnpike receives flow from the effluent tributary along its northeast bank. Dye studies both in 1988 and again in 1991 confirmed that the flow from the tributary short circuits the pond following a direct path along the north bank to the outlet on the southeast side of the pond. Both dye studies indicated that there was no significant diffusion of effluent into the pond. However, the 1991 chemical data indicated that ammonia-N and BOD increased downstream. The 2000 survey data confirmed that ammonia-N (NH_3-N) continues to increase downstream in the vicinity of the pond for several sampling stations (from 0.84 mg/L in the effluent to 1.42 mg/L at Flint Road Bridge (Site 4I001). These downstream increases in NH_3-N are likely the result of decay of organic nitrogen in the effluent. This was demonstrated in empirical modeling as discussed in the Introduction. None of the chemical data sets (1988, 1991, 1998 and 2000) indicated that there were any significant sustained nonpoint sources within the study area that impacted the stream under critical conditions.

The land use patterns along the study area south of Claremore are characterized by a mosaic of forested and wooded areas, agricultural cultivation (mostly grains, hay and soybeans) and light to moderate cattle ranching. There are numerous rural residences and small subdivisions within the study area with the greatest home density being located within the Rogers County Rural Sewer District #1 boundaries. Figure 2.3 shows the digitized rural land uses for pasture, hay, grassland, and cropland within a one-mile buffer on either side of Dog and Cat Creeks in the study area. Figure 2.3 also shows the riparian corridor as forested areas along Dog and Cat Creeks within the one mile buffer. Also present on the map are the many rural residences that are on approximately five to 40 acre parcels that contain a variety of land uses. Many have grazing cattle or horses along with large yards and gardens. Table 2.2 lists the percent of each category of land use within the one mile buffer obtained from the INCOG digitized GIS database.

FIGURE 2.3: Land Uses Within One-Mile Buffer

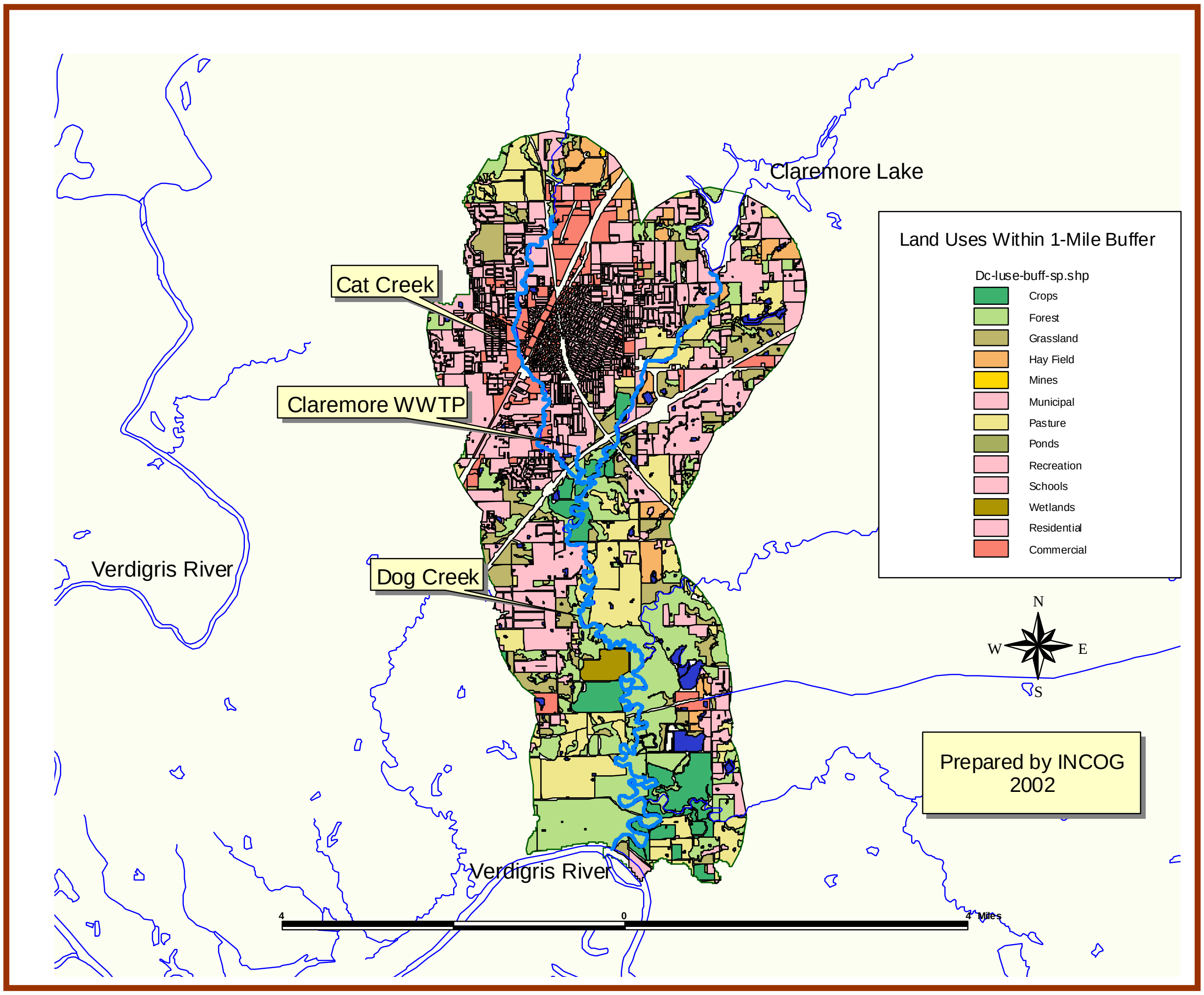


TABLE 2.2: Land Uses Within the One-Mile Buffer in Lower Dog Creek Watershed

Polygon	Sq Miles	Acres	% of Buffer
Crops	1.02	652.9	4.25
Forest	5.43	3478.1	22.64
Grassland	2.04	1306.4	8.51
Hayfield	0.9	575.1	3.75
Mines	0.01	3.4	0.04
Municipal	0.08	48.5	0.33
Pasture	3.0	1920.2	12.51
Ponds	0.44	280.7	1.83
Recreation	0.19	119.0	0.79
Schools	0.31	197.4	1.29
Wetlands	0.17	105.7	0.71
Sum :	**13.59**	**8687.4**	**56.67**
Residential	7.6	4866.8	31.69
Commercial	1.43	917.7	5.96
Sum :	**9.03**	**5784.5**	**37.66**
Other			5.70
		LU Sum:	**100.0**

During the 1988, 1991 and 2000 summer field surveys, there was no flow in the headwaters of Cat Creek, Dog Creek, Otter Creek, Panther Creek or the effluent tributary. The only flows in any stream segment were due to effluent from the Claremore wastewater treatment plant. Within the one-mile land use buffer 275 ponds were identified as well as 687 homes that were outside of the City of Claremore's sewer collection system and assumed to represent residences with septic tanks or on-site waste treatment systems. However, many of the residences to the south and west of Flint Road are likely connected to the Rogers County Rural Sewer District #1 service.

WATER QUALITY STANDARDS

The current (2002) Oklahoma Water Quality Standards (OWQS) designate Dog Creek and Cat Creek (Water Quality Management segment 121500) with the following Beneficial Uses:

1. Public and Private Water Supply;
2. Warm Water Aquatic Community;
3. Agriculture;
4. M & I Process and Cooling Water;
5. Primary Body Contact Recreation; and
6. Aesthetics.

The Effluent Tributary is listed in the 2000 OWQS for the following Beneficial Uses:

1. Emergency Water Supply;
2. Habitat Limited Aquatic Community;
3. Agriculture;
4. M & I Process and Cooling Water;
5. Secondary Body Contact Recreation; and
6. Aesthetics.

Dog Creek (WB Id # 121500-020360 and 121500-040010) is listed on the State of Oklahoma's most current (1998) 303(d) list of impaired waters as a Priority 1 for Nutrients (Cause Code 900). Cat Creek (WB Id # 121500-020390) is also listed as Priority 1 for Nutrients.

TREATMENT PLANT DISCHARGE DATA

The Claremore wastewater treatment plant employs the trickling filter process with a present summer base flow of around 2.0 MGD and a design flow of 2.6 MGD. The most recent improvements to the plant were in 1999 and 2000. The current NPDES discharge permit has all-season limits for a 30 day average of 20 mg/l BOD_5 and 30 mg/l TSS with a minimum of 5.0 mg/l dissolved oxygen in the final effluent.

DATA FROM 1998 INCOG WATER QUALITY SURVEY

In an effort to identify possible nonpoint sources in Dog Creek, as well as characterize the continued water quality problems, INCOG conducted two sampling events during the summer of 1998. The first survey, July 29, sampled seven sites for temperature and dissolved oxygen under dry conditions.

INCOG also collected samples for chemical analysis at five of the sites for 5 and 20 day BOD and CBOD, nutrients and fecal coliform. The DO sampling began prior to daybreak and proceeded at approximately three hour intervals until evening in order to measure DO maximum and minimum values. The second event, September 22, occurred during a runoff rainfall (1.99 inches recorded at the National Weather Service in Tulsa) at about 3:00 PM. The purpose of this event was to capture sufficient data under rainfall runoff conditions to compare to the July 29 dry weather sampling for potential nonpoint source identification. Results of these sampling events are presented in Appendix A.

Results of the 1998 dry and wet weather surveys indicated that no significant nonpoint sources are present within the study area that impact the stream under critical conditions. Some parameters (BOD_{20}, TKN, NH_3-N and FC) increased at one or more downstream sites during the rainfall event, while others showed overall no change or were lower than dry conditions (Ortho-P, TP, and Chl-a). Overall, both TP and Ortho-P were lower during runoff conditions, while FC was higher (>20,000 col/100 ml) in Dog and Cat Creeks.

SECTION 3

CALIBRATION MODEL

DEVELOPMENT OF MODEL PARAMETERS

The LAQUAL computer model (Version 4.00 December 18, 2000) was selected for modeling Dog Creek because of its utility in setting different element lengths and because of the use of the Texas Equation for calculating reaeration. LAQUAL is a one-dimensional, steady-state model developed by the Louisiana Department of Environmental Quality. LAQUAL is an improved version of QUAL-TX originally prepared by the Texas Water Commission and derived from the original QUAL-II stream model developed by Water Resource Engineers. LAQUAL operates in the Windows NT and 2000 operating systems, whereas QUAL-2E and QUAL-TX have not yet been fully updated.

Parameters selected for modeling in this TMDL verification study were dissolved oxygen (DO), ammonia-N (NH_3-N), organic nitrogen (ORN) and 20 day carbonaceous biochemical oxygen demand ($CBOD_{20}$ or UBOD). Algae was modeled by inputting chlorophyll concentrations in the Initial Conditions (LAQUAL Data Card 11) and varying the concentrations to calibrate nitrate-nitrogen (NO_3-N). No net algal production of dissolved oxygen was assumed in the algal simulation. Therefore, the Initial Conditions nitrate utilization represents all biological uptake of nitrate-N. No nonpoint sources were used in the TMDL model (see discussion in Introduction).

Although NPDES permit limits are set for five-day CBOD, all modeling was performed for ultimate CBOD (in this case assumed to be equivalent to $CBOD_{20}$). $CBOD_{20}$ was measured directly during the stream survey and used in the model. For making recommendations, modeling results in $CBOD_{20}$ were converted to $CBOD_5$ by the following equation:

$$CBOD_5 = CBOD_{20} / 2.3$$

Figure 3.1 shows the stream segments and how they were divided into model reaches. The sampling sites located on Figure 3.1 are those used both in the 1991 and 2000 field surveys. For the TMDL model, no changes were made to model segmentation from the 1993 INCOG verification model. A total of 20 model reaches were used, six on the effluent tributary, three on Cat Creek and 11 on Dog Creek. Each model reach was divided into computational elements. Table 3.1 lists the characteristics of each reach. The river miles used in the 1991 data report, the 1993 verification model and the present TMDL model were derived from measurements from aerial photographs of the entire study area (map scale of 1" = 200').

The hydraulic characteristics of each reach were originally based upon numerous cross section and flow measurements and time of travel dye studies on representative portions of each stream. The following exponential equations were used to calculate appropriate LA-QUAL coefficients and exponents for velocity and depth of each reach:

$$V = a*Q^b \qquad D = c*Q^d + e$$

Where: V = mean velocity (ft/sec)
Q = mean discharge (ft^3/sec)

D = mean depth (ft)
a,b,c,d,e = constants

Figure 3.1

CALIBRATION MODEL SEGMENTATION

(Not to Scale)

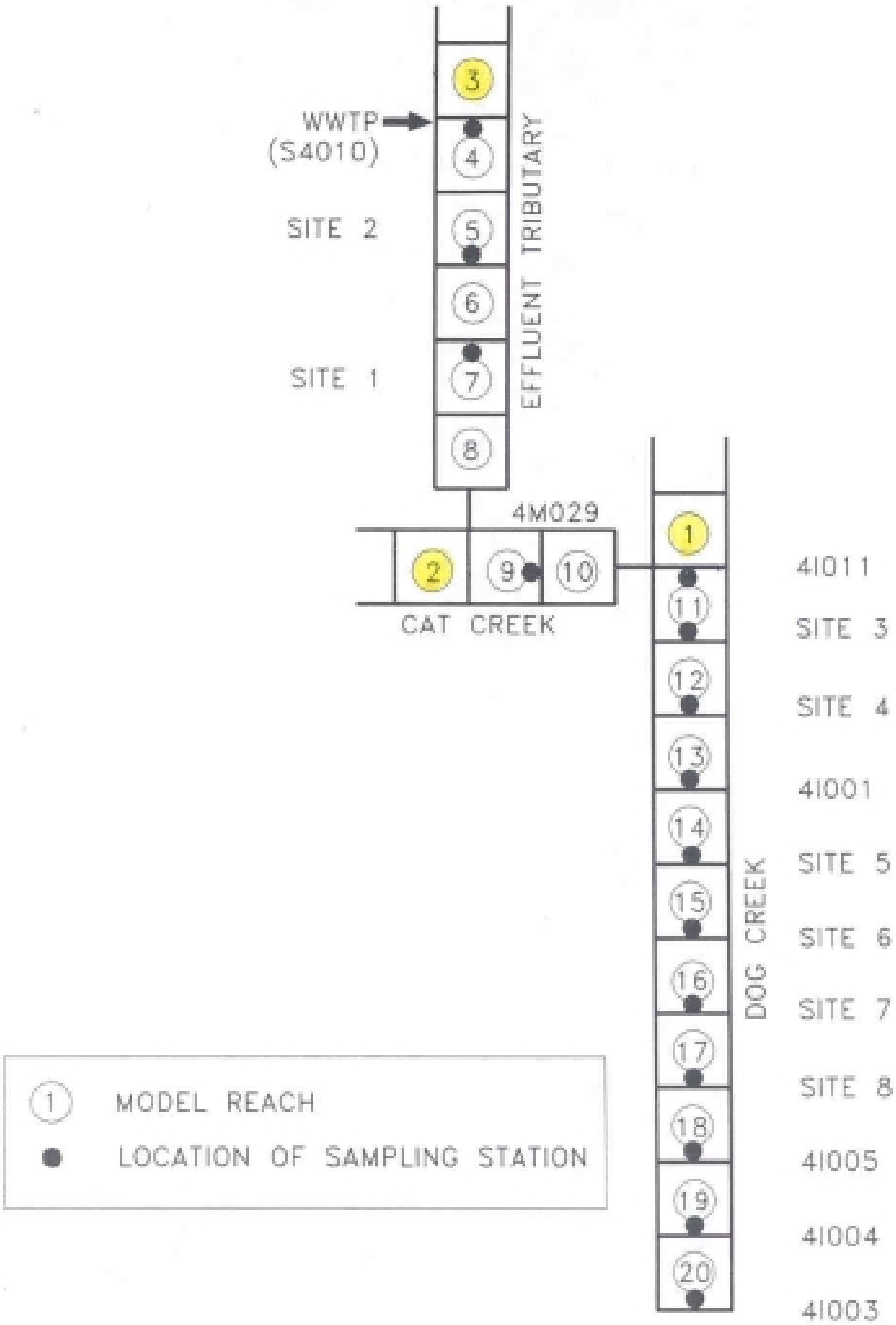


TABLE 3.1: TMDL Model Segment Descriptions

REACH	NAME	BEGIN REACH mi		END REACH mi	ELEM LENGTH mi	REACH LENGTH mi	ELEMS PER REACH	BEGIN RCH ELEM NUM	END ELEM NUM
1	Dog Creek headwater	12.94	TO	12.19	0.15	0.75	5	1	5
2	Cat Creek headwater	0.35	TO	0.3	0.01	0.05	5	6	10
3	Effluent Tributary headwater	0.54	TO	0.49	0.01	0.05	5	11	15
4	ET u/s of turnpike (S4010)	0.49	TO	0.35	0.02	0.14	7	16	22
5	ET u/s of pond (Site 2)	0.35	TO	0.26	0.018	0.09	5	23	27
6	Effluent trib pond	0.26	TO	0.18	0.01	0.08	8	28	35
7	Effl trib d/s of pond (Site 1)	0.18	TO	0.12	0.01	0.06	6	36	41
8	Effluent trib u/s of Cat Creek	0.12	TO	0	0.01	0.12	12	42	53
9	CC d/s of Effl trib (4M029)	0.3	TO	0.16	0.01	0.14	14	54	67
10	Cat Creek u/s of Dog Creek	0.16	TO	0	0.01	0.16	16	68	83
11	Upper Froman (4I011, Site 3)	12.19	TO	11.49	0.05	0.7	14	84	97
12	Lower Froman site (Site 4)	11.49	TO	11.22	0.03	0.27	9	98	106
13	Flint Road (4I001)	11.22	TO	10.56	0.06	0.66	11	107	117
14	Dry property (Site 5)	10.56	TO	10.04	0.04	0.52	13	118	130
15	Upper McCombs site (Site 6)	10.04	TO	9.38	0.06	0.66	11	131	141
16	Lower McCombs site (Site 7)	9.38	TO	8.66	0.06	0.72	12	142	153
17	Upper Gordon site (Site 8)	8.66	TO	7.46	0.12	1.2	10	154	163
18	Lower Gordon site (4I005)	7.46	TO	6.26	0.12	1.2	10	164	173
19	Spavinaw flowline (4I004)	6.26	TO	5.26	0.1	1	10	174	183
20	Peguot site (4I003)	5.26	TO	4.36	0.1	0.9	9	184	192

LAQUAL uses the exponents for velocity and depth to internally calculate the coefficients and exponents for stream width using the following equation:

$$W = e*Q^{f}$$

where: W = stream width (ft)
e and f = constants

Table 3.2 shows the hydraulic coefficients and exponents used in the LAQUAL model. The constants "e" and "f" are calculated internally in the LAQUAL program by the following relationship with the constants for velocity and depth:

$$a * c * e = 1$$

$$b + d + f = 1$$

Note that the constant "e" in the depth equation and "e" in the width equation are NOT the same.

TABLE 3.2: Hydraulic Coefficients and Exponents Used in the TMDL Model.

REACH	DEPTH "A"	DEPTH "B"	DEPTH "D"	DEPTH "E"
1	0.2	0.8	0.4	0.08
2	0.2	0.8	0.4	0.08
3	0.2	0.8	0.4	0.08
4	0.18	0.8	0.4	0.1
5	0.15	0.8	0.4	0.1
6	0.15	0.4	0.45	0.1
7	0.15	0.8	0.4	0.18
8	0.15	0.7	0.4	0.08
9	0.15	0.7	0.4	0.07
10	0.14	0.75	0.35	0.06
11	0.151	0.8	0.351	0.04
12	0.151	0.8	0.351	0.04
13	0.151	0.8	0.351	0.04
14	0.151	0.8	0.351	0.04
15	0.151	0.8	0.351	0.04
16	0.125	0.7	0.35	0.04
17	0.125	0.65	0.57	0.04
18	0.116	0.65	0.76	0.03
19	0.05	0.76	0.77	0.02
20	0.05	0.72	0.94	0.01

Decay rates for CBOD, ORN and NH_3-N were initially set for each model reach based upon the values used in the 1993 INCOG verification model. These rates are temperature dependant and are revised for the modeled temperature by the following relationship:

$$K\ [@20^{o}] = K\ [@T]\ /\ O^{(T-20)}$$

where:
T = ambient temperature (^{o}C)
K = rate of decay (per day)
O = appropriate theta (see EPA, 1985)

Temperature correction “Theta” values used in this modeling study were the LAQUAL default values:

NH_3 Decay	= 1.083
Bkgrnd NH_3 Source	= 1.074
Sediment O_2 Demand	= 1.065
CBOD Decay	= 1.047
CBOD Settling	= 1.024
ORN Decay	= 1.020
ORN Settling	= 1.024

The LAQUAL model documentation states that the reaeration rate temperature correction constant is temperature dependant and ranges between 1.017 at 50^{o}C and 1.024 at 0^{o}C.

The rates for decay of CBOD, NH_3-N and ORN were modified during the calibration procedure in order to achieve the best fit of the model output with actual summer 2000 field data for each parameter as well as measured dissolved oxygen. The order of calibration was organic nitrogen, ammonia-nitrogen, nitrate-nitrogen, $CBOD_{20}$ and dissolved oxygen.

As ORN is lost through both decay and settling, ammonia-nitrogen is produced. Therefore, ammonia-N increases as ORN is decayed, but it is lost as it is oxidized to nitrate-N. Dissolved oxygen balance depends on many different functions, such as CBOD and NH_3–N decay, benthos decay of CBOD and NH_3-N, and sediment oxygen demand (SOD). Algae was simulated in the model by inputting reach-specific chlorophyll-a concentrations in Initial Conditions (Card 11). The rate of utilization of nitrate-N depends upon the chlorophyll-a concentration in the reach. No net dissolved oxygen from algae was assumed as a global default (Card 3). In this fashion, the uptake of nitrate-N represents uptake of nitrate from all biological processes.

Rates for sediment oxygen demand (SOD) were initially based upon examination of streambed sediment composition and dissolved oxygen measurements during the 1991 and 2000 surveys. These estimates for SOD values were then modified during the calibration procedure for dissolved oxygen.

The Texas equation was selected to determine the rate of reaeration due to physical processes relating to stream depth and velocity. All survey measurements fell within the acceptable range of the Texas equation (depth of 0.6 to 3.0 feet and velocity of 0.03 to 1.0 foot per second). The equation used was:

$$K2 = 4.022 * V^{0.273} / D^{0.894}$$

where: K2 = reaeration (per day)
V = velocity (ft/sec)
D = depth (ft)

LAQUAL employs a number of global constants that are the same for all reaches. Some of the most important of these are:

CBOD O_2 uptake rate	1.0 mg O_2/mg CBOD
NH_3 O_2 uptake rate	4.33 mg O_2/mg NH_3
Barometric pressure	992.0 millibars ((National Weather Service for 9/13/00)

The Claremore wastewater treatment plant has an effluent flow monitoring system. The average daily effluent flow during the 2000 intensive survey was reported by the WWTP staff to be 1.86 MGD. This was converted to 2.88 cfs for LAQUAL model input for the effluent flow. All headwater flows were zero.

Table 3.3 summarizes all reach variable rates used in the verification calibration model. These rates were derived from field survey data as described above or were selected as most appropriate for each model reach and to provide a best fit of data during calibration.

TABLE 3.3: Rates of Reaction Used in the TMDL Calibration Model

REACH	AEROB BKGRND SOD	BOD DECAY	BOD SETT	BOD CONV TO SOD	ANAER BOD DECAY	ORG-N DECA	ORG-N SETT TO	ORGN CONV NH3 SRCE	NH3 DECA	NH3 SRCE	PHOS SRCE	DENIT RATE
1	60	0.1	0.01	0	0	0.05	0.01	0.1	0.3	0	0	0.1
2	60	0.1	0.01	0	0	0.05	0.01	0.1	0.3	0	0	0.1
3	60	0.1	0.01	0	0	0.05	0.01	0.1	0.3	0	0	0.1
4	200	0.9	2.1	0	0	1.8	0.8	0.1	0.4	0	0	0.1
5	200	0.9	2.1	0	1	1.8	0.8	0.1	0.4	0	0	0.1
6	300	0.9	2.1	0	1	1.8	0.8	0.1	0.4	0	0	0.1
7	150	0.7	2.1	0	0	0.9	0.1	0.1	0.4	0	0	0.1
8	140	0.6	2.1	0	0	0.9	0.1	0.1	0.4	0	0	0.1
9	140	0.6	2.1	0	0	0.9	0.1	0.1	0.4	0	0	0.1
10	130	0.9	2.1	0	0	0.9	0.1	0.1	0.6	0	0	0.1
11	160	0.8	1.5	0	0	0.4	0.3	0.1	0.6	0	0	0.1
12	180	0.8	0.1	0	0	0.4	0.3	0.1	0.6	0	0	0.1
13	190	0.7	0.1	0	0	0.4	0.3	0.1	0.6	0	0	0.1
14	240	0.6	0.1	0	0	0.05	0.3	0.1	0.6	-20	0	0.1
15	250	0.4	0.1	0	0	0.05	0.3	0.1	0.6	-20	0	0.1
16	260	0.3	0.1	0	0	0.01	0.2	0.1	0.6	-20	0	0.1
17	270	0.2	0.1	0	0	0.01	0.01	0.1	0.6	0	0	0.1
18	280	0.2	0.1	0	0	0.01	0.01	0.1	0.6	0	0	0.1
19	240	0.15	0.1	0	0	0.01	0.1	0.1	0.5	0	0	0.1
20	230	0.1	0.1	0	0	0.01	0.1	0.1	0.4	0	0	0.1

DEVELOPMENT OF MODEL CALIBRATION

Results from the INCOG 1989 and 1993 calibration models indicated the presence of a DO sag that extended downstream from the WWTP (Site S4010 at River Mile 12.97) to the Spavinaw flowline (Site 4I004 at River Mile 5.25). This was confirmed to still exist by the summer 2000 field data.

The calibration data used in the 1993 model indicated an elevated average DO concentration at Flint Road (Site 4I001 at River Mile 10.56, Model Reach #13)) that was not likely due to any stream recovery effects. Rather, the rise in the DO profile at this site in 1991 was due to the growth of attached filamentous algae just upstream of and at the 4I001 bridge. In fact, it is likely that the 1991 DO profile would not have shown any recovery until the end of the study segment at Reach 20. Site 4I001 is a bridge site on Flint Road. It has a large concrete bridge with open tree canopy and rip-rap on either side of the bridge allowing algae to grow.

The summer 2000 calibration data do not show the same magnitude in rise in average DO at 4I001. Both the pond site (Reach 6) and Flint Road (Reach 13) have significant open canopy to allow direct sunlight onto the stream water surface. This can result in increased algal growth and production of dissolved oxygen. For the TMDL model, reaeration and SOD adequately accounted for the DO profile in the 2000 data set.

The rapid decay of organic nitrogen downstream from the WWTP to Flint Road required high ORN decay and settling rates. This produced ammonia-N that increased downstream but was consistent with the observed NH_3-N measurements at the downstream sites. No additional background NH_3-N was added as nonpoint source for NH_3-N as all observed NH_3-N could be accounted for by decay of ORN in the effluent. Organic nitrogen decay and settling rates lessened downstream of Flint Road (4I001) as the concentration of ORN decreased in these reaches.

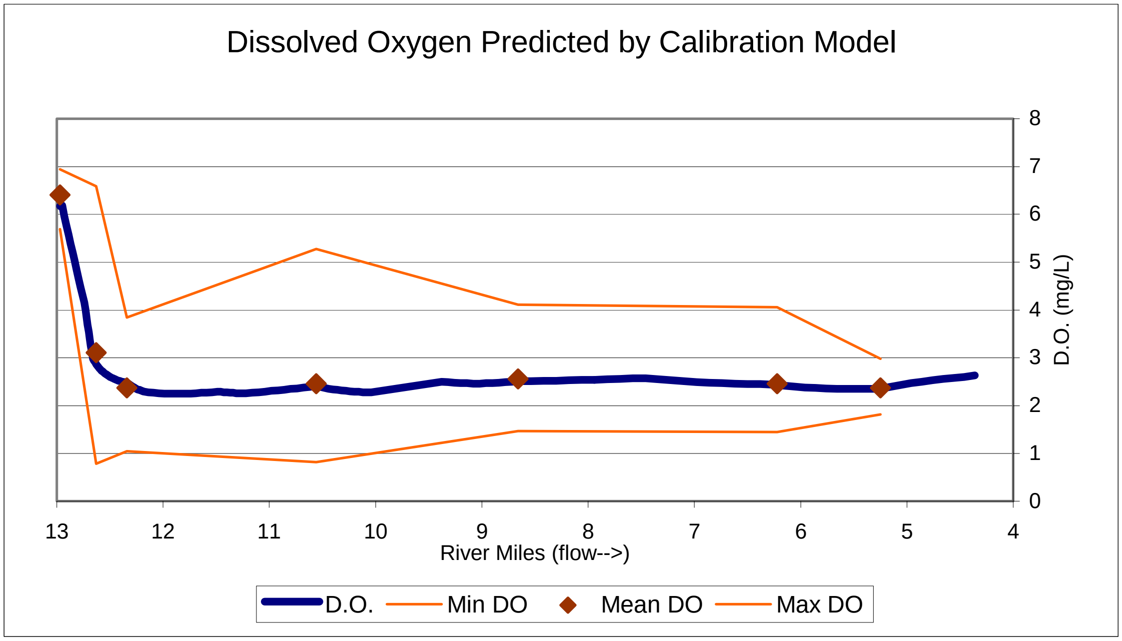
Downstream of 4I001, NH_3-N declined very rapidly (from 1.42 mg/L at mile 10.56 to 0.16 mg/L at mile 8.66). To account for this, a negative value for ammonia benthos source was used in the model. The negative benthos source decay of NH_3-N approximates utilization of ammonia-N by algae and other biological processes. In order to calibrate on the steady decline of nitrate-N downstream, algae was simulated by inputting reach-specific chlorophyll-a concentrations into Initial Conditions (Card 11), with the greatest concentrations in the upper reaches.

CBOD was calibrated by adjusting decay and settling rates according to measured $CBOD_{20}$ concentrations in the stream. There was a sharp decline in $CBOD_{20}$ between the WWTP (55.14 mg/L at mile 12.97) and Site 2 tributary sampling site just downstream of the pond (20.45 mg/L at mile 12.63). This decline was modeled by adjusting decay and settling rates. In the draft report it was assumed that the pond was acting as a sink for the CBOD, and a negative value of CBOD nonpoint source loading (Card 19 Nonpoint Source) was used to calibrate this decline and the influence of the pond. Based upon OCC comments and re-examination of the 1991 and 2000 calibration data, a more reasonable alternative was found than to use the pond as a CBOD sink. The decline in CBOD could be accounted for using settling and decay rates in the model reaches. The OCC also suggested that the time of travel be re-examined for these reaches. Using time of travel (TOT) data collected for the 1993 verification study, the WWTP flow in the model was set to the flows measured during the TOT studies and model predictions of velocity and TOT were then compared to field data. This procedure verified that all reaches in this CBOD decay area have appropriate stream velocities and times of travel. Therefore, the CBOD decay and settling rates are appropriate for these reaches.

After calibration was completed for ORN, NH_3-N, NO_3-N and $CBOD_{20}$, dissolved oxygen was calibrated by adjusting sediment oxygen demand (SOD) rates as described above. High SOD rates had to be used in the lower reaches of the model to calibrate the continuing DO sag in these lower reaches. This part of the stream is characterized by deeper pools, slower flow, and very dense riparian tree canopy. Nonpoint sources were not clearly evident in the lower reaches in the 2000 data set, however the long DO sag through site 4I004 at the Spavinaw flowline was also observed in the earlier studies by INCOG cited above. It is assumed that these stream reaches are being impacted by current loadings from the WWTP effluent. The long pools allow for accumulation of organic loads in the stream sediments that act as increased oxygen demand. Reduction of the loads from the WWTP in the future due to more restrictive permit limits should significantly reduce the SOD in these reaches.

Results of the TMDL Calibration Model are presented in Figures 3.2 through 3.4. Red lines represent minimum and maximum ranges of measured values. A printout of the LA-QUAL calibration model is presented in Appendix B.

FIGURE 3.2: Results of TMDL Calibration Model for Dissolved Oxygen and $CBOD_{20}$



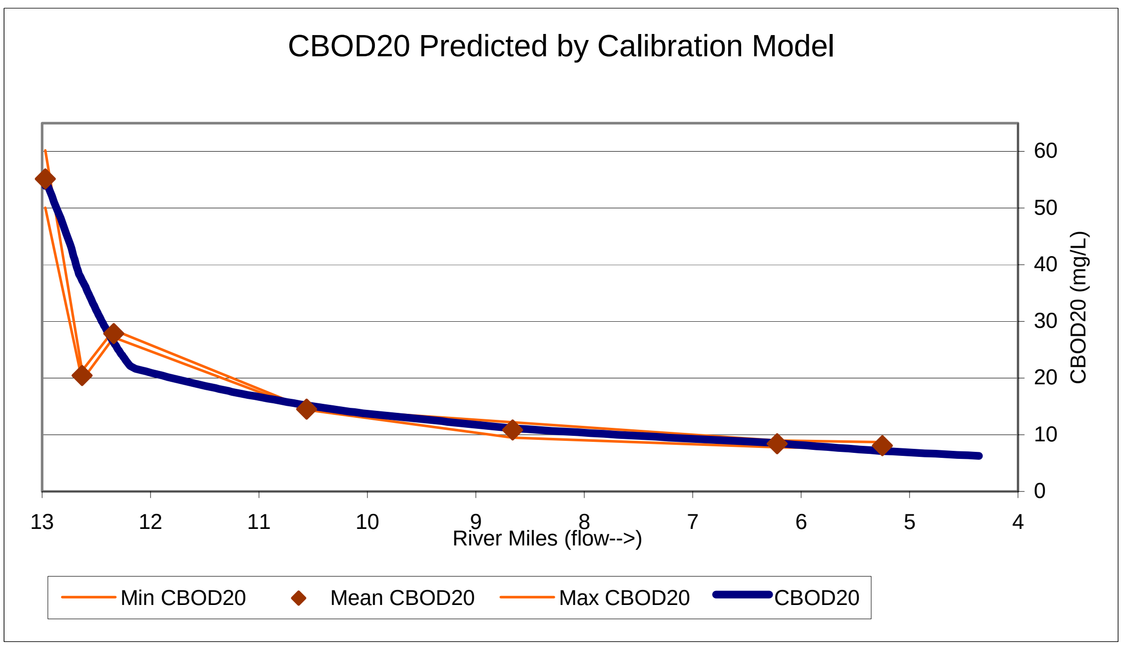
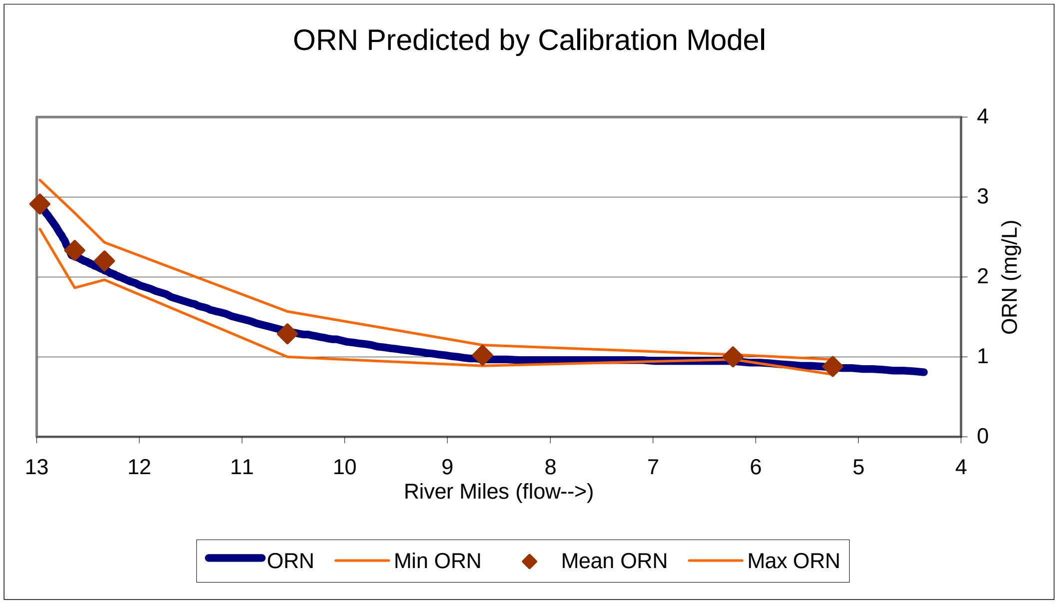


FIGURE 3.3: Results of TMDL Calibration Model for Organic and Ammonia Nitrogen



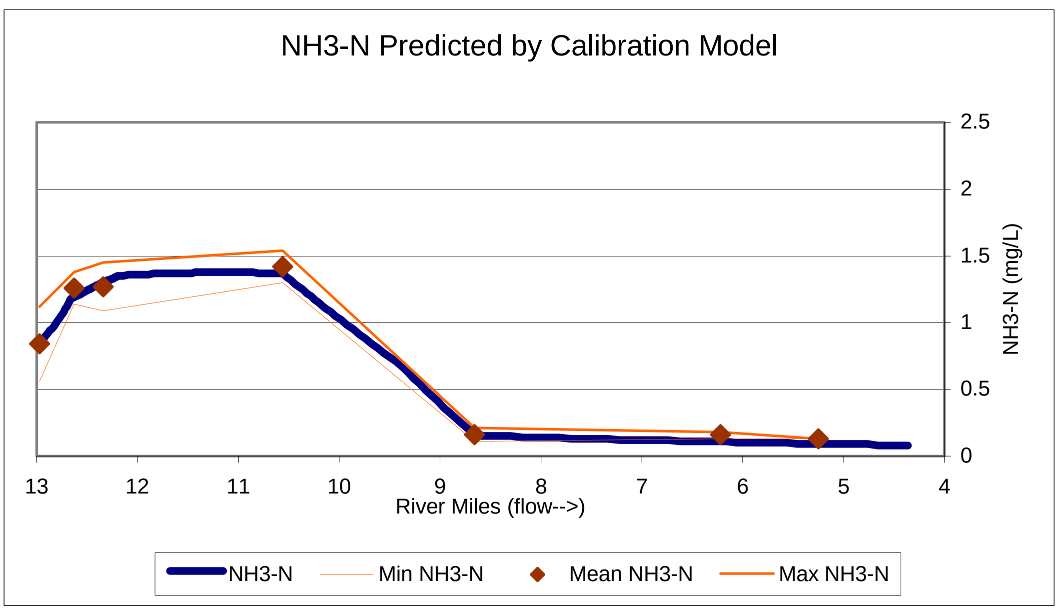
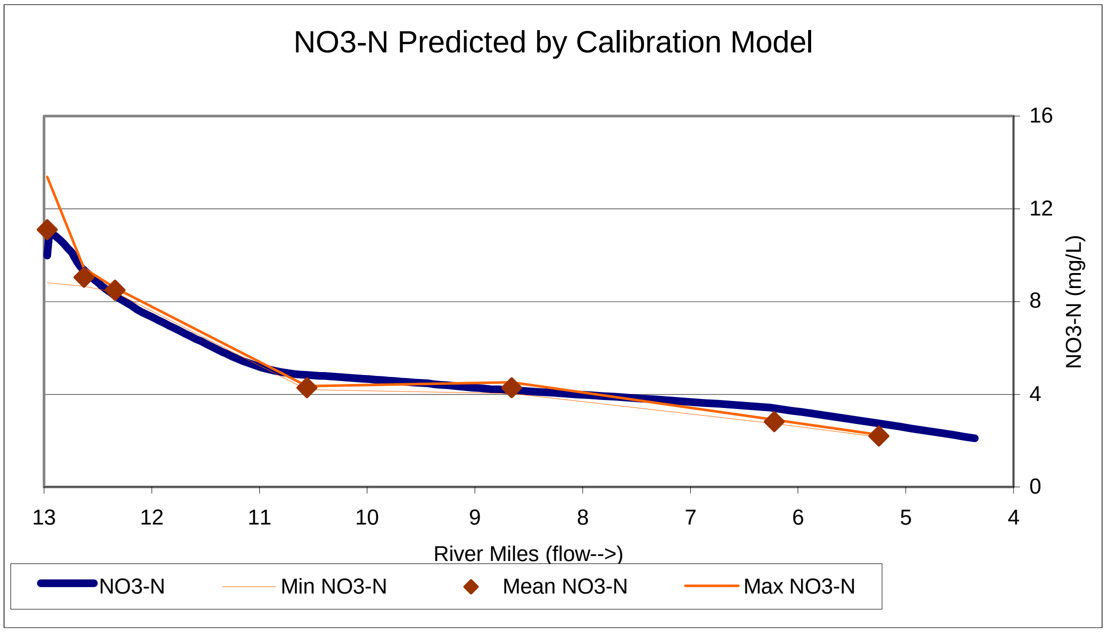


FIGURE 3.4: Results of TMDL Calibration Model for Nitrate Nitrogen



SECTION 4

MODELING FUTURE CONDITIONS

The low dissolved oxygen (DO) conditions measured in the September 13-14, 2000 water quality survey indicated that an advanced treatment wasteload allocation for the Claremore treatment plant will be necessary. The significant improvement coming from advanced treatment discharge will result in lower SOD and decay rates once the receiving stream achieves chemical equilibrium with the lower wasteload allocation.

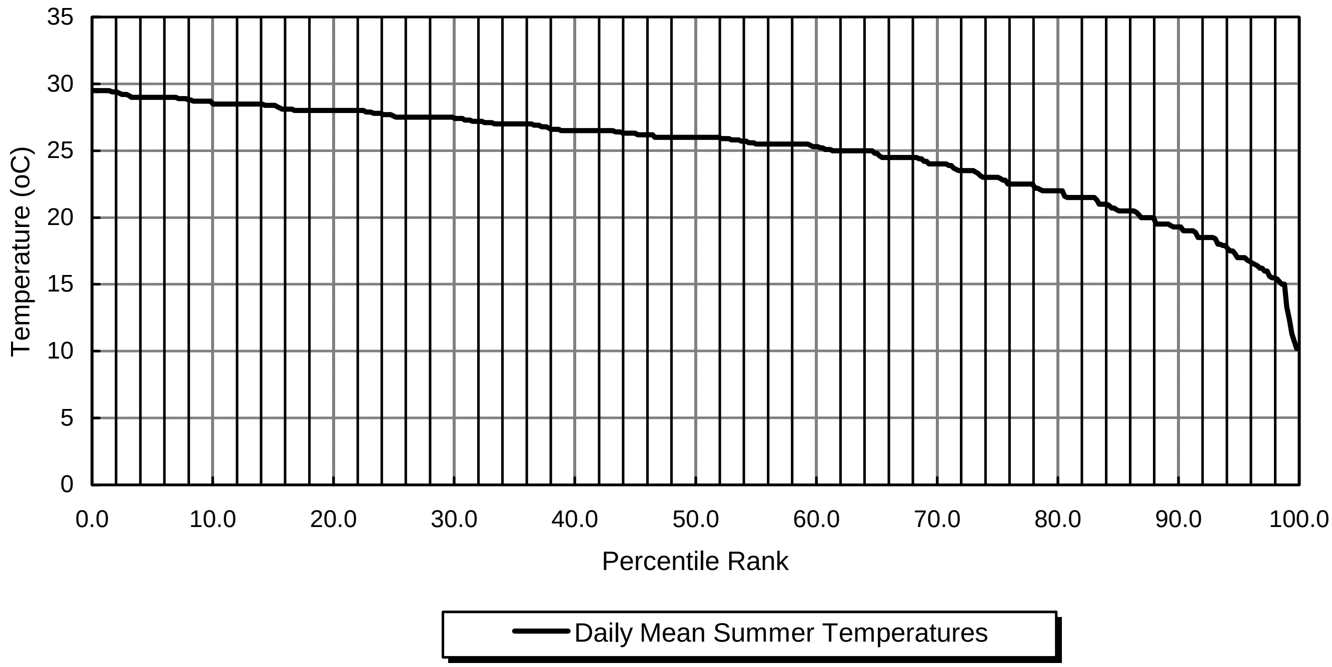
In August 1997 the US Geological Survey (USGS) installed a flow and temperature monitoring gage on Dog Creek at Site 4I001 (Flint Road Bridge)(USGS# 07178520). The flow measurements reflect discharges from the Claremore WWTP and any upstream flows from Dog Creek, Cat Creek and tributaries. The data collected during this four year period reflects conditions in Dog Creek during higher than normal seasonal average air temperatures and lower than normal rainfall. This favors a conservative assumption that critical conditions (i.e. low seasonal flows and high temperatures) are well represented by the USGS gage data.

Duration Analysis was used to determine a site-specific mean daily average temperature for the summer period (June 16 – October 15). A Duration Analysis calculates the summer temperature that would be expected to exceed less than 10% of the time. Figure 4.1 shows the plot of ranked summer daily mean temperatures from the Flint Road USGS gage. The Duration Analysis 10% temperature is 28.5 ^{o}C. This value was used in all summer seasonal models for headwater, effluent, and Initial Conditions. A Spring temperature Duration Analysis of the USGS gage data was also performed. The results of this analysis calculated a 10% frequency of 25.0 ^{o}C which is the regulatory seasonal temperature for Spring.

The City of Claremore contracted with HDR Engineering, Inc. to develop population and WWTP flow projections for the City of Claremore for the year 2020 as part of the city's Sewer Master Plan. Information provided by Lee Chronister of HDR projects a year 2020 sewered service area population of 44,305. HDR recommends that an assumption of 100 gallons per capita per day (gcd) can be used to calculate a future WWTP effluent flow of 4.43 MGD for the year 2020.

The 1989 and 1993 INCOG wasteload allocation studies of Dog Creek used the seven day, two year (7Q2) low flow of 1.16 cfs designated for Dog Creek in the current Water Quality Management Plan for Oklahoma. The same 7Q2 was used for this report. Oklahoma's Water Quality Standards (WQS) for dissolved oxygen allow a regulatory minimum upstream flow of 1 cfs for NPDES permitting purposes. When a receiving stream has less than 1 cfs regulatory flow, an assumed 1 cfs is used in modeling. Since the effluent tributary has no designated upstream flow, an assumed minimum flow of 1 cfs was used. The Oklahoma WQS further requires that nuisance conditions be prevented when flows drop below the regulatory baseflow. The dissolved oxygen target value of 2.0 mg/l is assumed to protect against nuisance conditions. Therefore, a total of six models were created (three seasons with two flow conditions each). The models used in this TMDL are summarized in Table 4.1.

FIGURE 4.1: Results of Duration Analysis for Dog Creek Stream Temperatures



Ranked USGS Gage Summer Temperature Data for Dog Creek, August 1997 to September 2001

The Oklahoma Department of Environmental Quality specifies the minimum DO target value that must be met during the modeling process. The DO targets vary by season and by the designation of the Fisheries Beneficial Uses in the OWQS. Table 4.2 summarizes the DO targets used to develop each of the six models.

The ODEQ considers a routine effluent DO concentration to be 5.0 mg/l for summer conditions, 6.0 mg/l for spring and 7.0 mg/l for winter. The ODEQ allows higher effluent DO concentrations with the understanding that the permittee will be responsible for meeting the higher limits. For the wasteload allocations in this TMDL, effluent DO concentrations of 6.0 mg/l (77% saturation) for summer and 7.0 mg/l for spring and winter (85% and 74% saturation, respectively) were used. Claremore's present outfall has adequate physical passive aeration to meet these requirements. Also, WWTP upgrades to meet the more stringent wasteload allocations in this TMDL will include sufficient aeration of the effluent to meet these DO requirements.

TABLE 4.1: Summary of TMDL Future Models

MODEL	SEASON	7Q2 FLOWS USED
dc285q	Summer	Yes
dc285z	Summer	No
dc25q	Spring	Yes
dc25z	Spring	No
dc18q	Winter	Yes
dc18z	Winter	No

TABLE 4.2: Designated Dissolved Oxygen Targets for TMDL Models

SEASON	DO TARGET (mg/l)	USE DESIGNATION	STREAM SEGMENT
Summer	5.0	WWAC	Dog and Cat Creeks
	4.0	HLAC	Effluent tributary
Spring	6.0	WWAC	Dog and Cat Creeks
	5.0	HLAC	Effluent tributary
Winter	6.0	WWAC	Dog and Cat Creeks
	4.0	HLAC	Effluent tributary

A summer future model was developed that consisted of no changes to the calibrated model's attributes except:

1. Effluent flow was increased to future (2020) average daily flow (4.43 MGD = 6.85 cfs);

2. Effluent concentrations were set to 10 mg/L $CBOD_{20}$ and 2 mg/L NH_3-N);

3. All temperatures were set to summer conditions (28.5 ^{O}C);

4. For the summer seasonal model, headwater DOs were set to 6.6 mg/l (85% saturation) for Dog and Cat Creek and 6.21 mg/l (80% saturation) for the effluent tributary;

5. Headwater flow conditions of 7Q2 were set (1.00 cfs in the effluent tributary and 1.16 cfs in Dog Creek), and zero for Cat Creek;

6. A minimum headwater loading was set (2.0 mg/l $CBOD_{20}$, 0.15 mg/l NH_3-N).

7. CBOD settling rates in the effluent tributary and Cat Creek were lowered to reflect a significantly cleaner effluent.

8. SODs and decay rates for ammonia-N and CBOD were lowered to reflect a significantly improved quality effluent.

Table 4.3 lists the principal rates used in the seasonal models to reflect stream conditions after the new wasteload allocation has been established. It is assumed in these future condition models that:

1. The treatment plant has been consistently discharging at the advanced treatment level for a period of time sufficient to allow stream equilibration with the lower advanced treatment limits;

2. All stream channel segments have had time to carry the accumulation of excess organic material that has been accumulating from the existing discharge downstream through natural rainfall high flow scouring that occurs in this watershed; and

5. All stream segments, including Cat Creek and Dog Creek, have had time to come into full hydraulic and chemical equilibrium with the improvements to the WWTP.

The decay and settling rates presented in Table 4.3 were used in setting seasonal wasteload allocations. Results of all future seasonal models are presented in Table 4.4. All models assumed an effluent nitrate concentration of 7.0 mg/l and 1.5 mg/l for ORG-N. Minimum headwater nutrient concentrations were set at 2 / 0.15 / 0.05 mg/l, respectively for $CBOD_{20}$ / NH_3-N and ORG-N.

Results of seasonal modeling indicate that advanced treatment levels are needed at the Claremore wastewater treatment plant during all three seasons. Table 4.4 also presents seasonal models at zero headwater flow and the design flow of 6.85 cfs. The WQS at zero headwater flow for all three stream segments is the narrative standard to prevent noxious conditions. This is assumed to be a minimum of 2.0 mg/l DO. Figures 4.2 – 4.4 show results of TMDL model outputs for all three seasons with respect to DO target values.

Appendix C presents the results of spreadsheet analysis of the Margin of Safety and TMDL loads distributed between point source wasteload allocation (WLA), nonpoint source load allocation (LA), background source allocation (BA), and the Margin of Safety (MOS). The TMDL represents the total maximum daily load of all of these sources entering the stream. Because this is a dissolved oxygen based TMDL, the MOS calculations are based upon oxygen (O_2) demand of each parameter ($CBOD_{20}$ and NH_3-N), not just the mass of $CBOD_{20}$ and NH_3-N. That is, the mass of $CBOD_{20}$ is converted to O_2 demand (assumed to be a 1.0 conversion), while the mass of ammonia-N is converted to O_2 Demand by multiplying the mass of NH_3-N (lbs/d) by 4.33, which is the conversion factor to yield lbs/d of oxygen demand per pound of ammonia-N.

Each seasonal TMDL model's point source WLA was increased (i.e. NH_3-N increased) until the stream target DO was just met. This maximum WLA, added to the sum of all background sources (BA) and nonpoint sources (LA), represented 100% of the assimilative capacity of the stream. Data for the point source was then entered in the spreadsheet, along with all data pertaining to background sources (considered to be the loads from the two headwater flows of Dog Creek and the Effluent Tributary). A minimum of five percent (5%) MOS is assumed based upon requirements in the Oklahoma Continuing Planning Process document for a single source calibrated and confirmed model.

Table 4.5 summarizes the allocations for each TMDL component including the MOS calculated for each seasonal model.

TABLE 4.3: Summary of Rates Used in Seasonal TMDL Models

REACH	BKGRND SOD	AEROB BOD DECAY	BOD SETT	BOD CONV TO SOD	ANAER BOD DECAY	ORG-N DECA	ORG-N SETT TO	ORG-N TO NH3 SRCE	NH3 DECA	NH3 SRCE
1	60	0.1	0.01	0	0	0.05	0.01	0.1	0.3	0
2	60	0.1	0.01	0	0	0.05	0.01	0.1	0.3	0
3	60	0.1	0.01	0	0	0.05	0.01	0.1	0.3	0
4	100	0.6	0.1	0	0	1.8	0.8	0.1	0.3	0
5	100	0.6	0.1	0	1	1.8	0.8	0.1	0.3	0
6	90	0.5	0.1	0	1	1.8	0.8	0.1	0.3	0
7	90	0.5	0.1	0	0	0.9	0.1	0.1	0.3	0
8	85	0.5	0.1	0	0	0.9	0.1	0.1	0.3	0
9	85	0.4	0.1	0	0	0.9	0.1	0.1	0.3	0
10	80	0.4	0.1	0	0	0.9	0.1	0.1	0.3	0
11	70	0.4	0.1	0	0	0.4	0.3	0.1	0.3	0
12	70	0.4	0.1	0	0	0.4	0.3	0.1	0.3	0
13	65	0.4	0.1	0	0	0.4	0.3	0.1	0.3	0
14	65	0.4	0.1	0	0	0.05	0.3	0.1	0.3	-20
15	65	0.4	0.1	0	0	0.05	0.3	0.1	0.3	-20
16	60	0.3	0.1	0	0	0.01	0.2	0.1	0.3	-20
17	60	0.2	0.1	0	0	0.01	0.01	0.1	0.3	0
18	60	0.2	0.1	0	0	0.01	0.01	0.1	0.3	0
19	60	0.15	0.1	0	0	0.01	0.10	0.1	0.3	0
20	60	0.1	0.1	0	0	0.01	0.10	0.1	0.3	0

TABLE 4.4: Summary of Dissolved Oxygen Minimums For Each TMDL Model

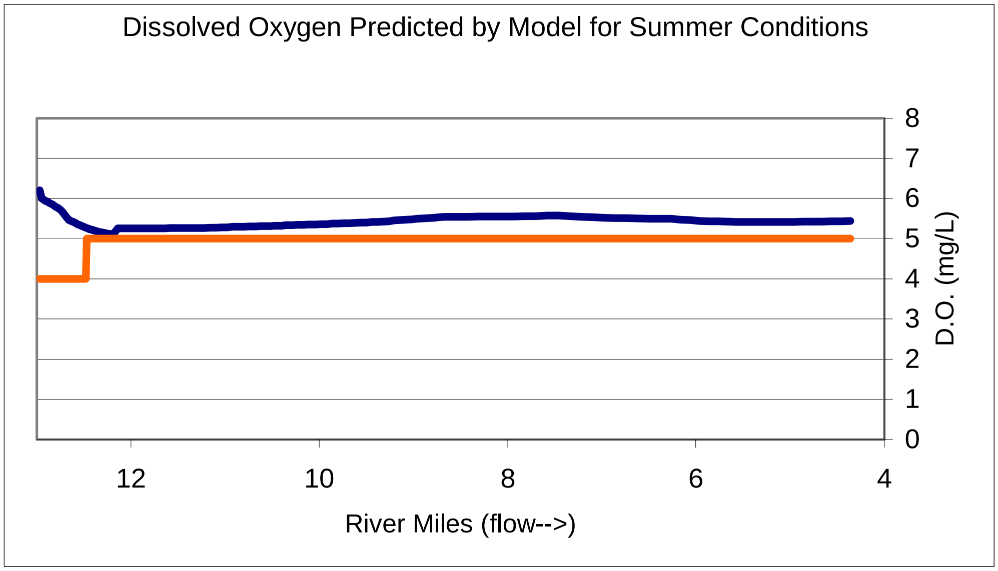
	MODEL	CBOD5	NH3-N	DO	MIN DO	REACH	TARGET
SUMMER	dc285q	10	2	6	5.10	10	5
	dc285z	10	2	6	4.83	11	2
SPRING	dc25q	9	2	7	6.13	10	6
	dc25z	9	2	7	5.83	19 / 20	2
WINTER	dc18q	15	8	7	6.20	20	6
	dc18z	15	8	7	5.45	20	2

TABLE 4.5: Summary of TMDL Seasonal Loads

ALLOCATION	SUMMER		SPRING		WINTER	
	Oxygen Demand (lbs/d)	Percent Of Total TMDL	Oxygen Demand (lbs/d)	Percent Of Total TMDL	Oxygen Demand (lbs/d)	Percent Of Total TMDL
WLA	1,170	84.4 %	1,085	87.4 %	2,554	91.8 %
BA	61	4.4 %	61	4.9 %	61	2.2 %
LA	0	0 %	0	0 %	0	0 %
MOS	155	11.2 %	96	7.7 %	167	6.0 %

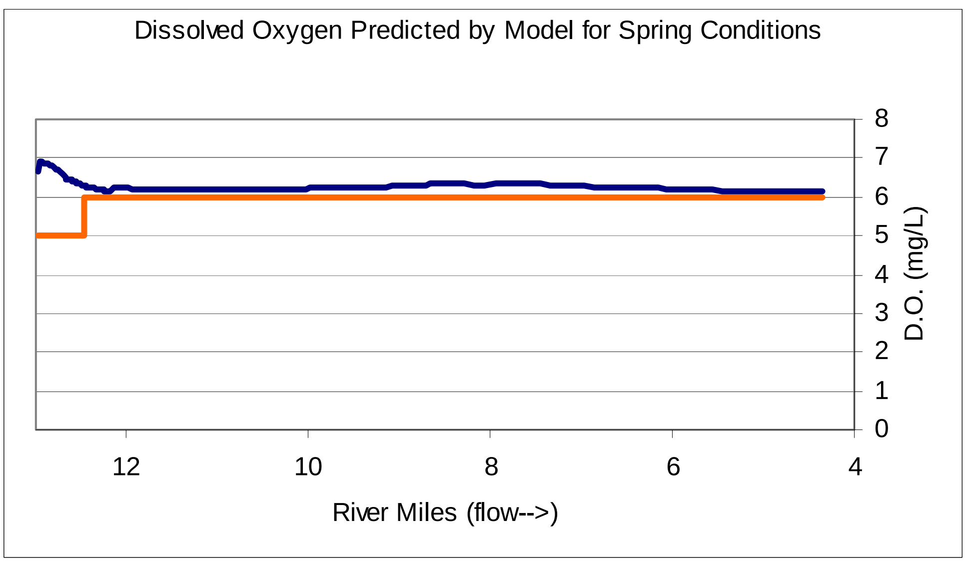
WLA = Point Source Waste Load Allocation
BA = Background source Allocation
LA = Nonpoint source Load Allocation
MOS = Margin of Safety

FIGURE 4.2: Summer TMDL Model Output



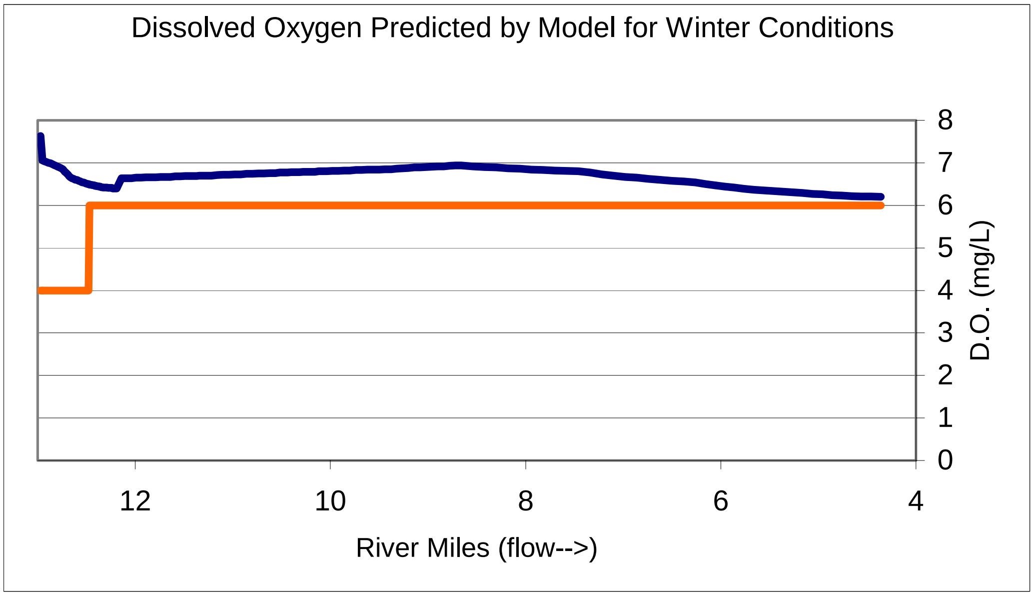
Red line = Summer season dissolved oxygen target
Blue line = Model predicted dissolved oxygen

FIGURE 4.3: Spring TMDL Model Output



Red line = Spring season dissolved oxygen target
Blue line = Model predicted dissolved oxygen

FIGURE 4.4: Winter TMDL Model Output



Red line = Winter season dissolved oxygen target
Blue line = Model predicted dissolved oxygen

SECTION 5

SENSITIVITY ANALYSIS

Once the model was calibrated, it was important to determine which of the numerous rates and conditions were most sensitive to predicted concentrations of dissolved oxygen. This was accomplished by varying the magnitude of a function and running the model to determine how the change affected dissolved oxygen. The LAQUAL model provides a special routine for sensitivity analysis that allows the user to specify the variable and magnitude of its change.

Twenty three model variables were selected, and each was run consecutively at ± 75% change (temperature parameters were run at ± 10 ^{o}C change). The summer future condition model 285q2 was selected because it represents summer low flow (critical) conditions of future loadings with the most strict wasteload allocation. The results of all sensitivity analyses are presented in Table 5.1.

Table 5.1: Results of Sensitivity Analysis

SENSITIVITY VARIABLE	LOWEST PERCENT CHANGE	Effluent Trib Min DO (mg/l)	Cat Creek Min DO (mg/l)	Dog Creek Min DO (mg/l)	HIGHEST PERCENT CHANGE	Effluent Trib Min DO (mg/l)	Cat Creek Min DO (mg/l)	Dog Creek Min DO (mg/l)
Summer Model	**0**	**6.30**	**6.13**	**6.15**	**0**	**6.30**	**6.13**	**6.15**
BOD decay	**-75**	6.61	6.57	6.49	**75**	5.96	5.71	5.75
BOD settling	**-75**	6.30	6.13	6.09	**75**	6.30	6.14	6.19
Ammonia decay	**-75**	6.40	6.28	6.35	**75**	6.20	6.00	5.99
Organic-N decay	**-75**	6.31	6.14	6.19	**75**	6.30	6.13	6.11
Organic-N settling	**-75**	6.30	6.14	6.15	**75**	6.30	6.13	6.15
Background SOD	**-75**	6.57	6.52	6.66	**75**	6.04	5.75	5.46
Bkground NH3 Benthos	**-75**	6.30	6.13	6.04	**75**	6.30	6.13	6.18
Initial Chlorophyll	**-75**	6.30	6.13	6.15	**75**	6.30	6.13	6.15
Initial Temperature	**-75**	6.67	7.66	7.71	**75**	3.84	2.88	2.24
Headwater Flow	**-75**	6.22	6.02	5.93	**75**	6.36	6.22	6.31
Headwater BOD	**-75**	6.31	6.14	6.16	**75**	6.30	6.13	6.14
Headwater DO	**-75**	1.76	5.81	2.84	**75**	6.71	6.46	6.15
Headwater ammonia	**-75**	6.30	6.14	6.16	**75**	6.30	6.13	6.14
Headwater nitrate	**-75**	6.30	6.13	6.15	**75**	6.30	6.13	6.15
Headwater Temperature	**-75**	6.30	6.13	6.15	**75**	6.30	6.13	6.15
Headwater organic-N	**-75**	6.30	6.13	6.15	**75**	6.30	6.13	6.15
Wasteload Flow	**-75**	5.91	5.75	6.11	**75**	6.47	6.34	6.08
Wasteload temperature	**-75**	6.30	6.13	6.15	**75**	6.30	6.13	6.15
Wasteload DO	**-75**	2.40	3.05	4.07	**75**	6.61	6.70	6.16
Wasteload BOD	**-75**	6.61	6.57	6.50	**75**	5.95	5.70	5.72
Wasteload ammonia	**-75**	6.40	6.27	6.34	**75**	6.21	6.00	5.76
Wasteload nitrate	**-75**	6.30	6.13	6.15	**75**	6.30	6.13	6.15
Wasteload organic-N	**-75**	6.31	6.14	6.19	**75**	6.30	6.13	6.10

Grey shaded cells are parameters that resulted in a DO change of greater than 10 %.

SECTION 6

CONCLUSIONS

A water quality survey was conducted in July 1991 in order to develop a verification (confirmation) model of the original 1989 INCOG wasteload allocation model for Dog Creek and its tributaries receiving effluent from the Claremore WWTP. The original 1989 calibrated model predicted that extreme advanced treatment levels would have to be implemented in order to meet primary WQS in Dog Creek during critical flow and temperature conditions.

The 1993 verification calibrated model had the advantage of additional sampling stations within the stream reaches predicted to have the severest impacts from the WWTP. Because of the increased number of sampling stations, the 1993 model addressed potential impacts from the tributary pond which were measured during the 1991 water quality survey.

Because potential nonpoint sources were indicated in the 1993 study, a Phased TMDL was recommended along with postponement of permit revisions until a confirmation TMDL could be performed. INCOG collected additional water quality data in 1998, and between 1999 and 2001 the OCC collected monthly and quarterly water quality data at many of the 1991 survey sites in order to characterize Dog Creek and Cat Creek and develop a summer calibration data set. This confirmation TMDL modeling report incorporates the previous modeling approach and uses the recent data to re-calibrate the future TMDL models.

This TMDL has confirmed the previous TMDL studies which concluded that sustained advanced treatment levels at the WWTP are required to protect water quality in Dog and Cat Creeks. Table 4.4 presents the results of all seasonal models under conditions of both zero headwater flow and headwater flow of 7Q2. All three seasons will require advanced treatment.

SECTION 7

RECOMMENDATIONS

Based upon the results of seasonal modeling under future flow conditions, the following recommendations are made:

1. In order to characterize improvements to the receiving stream, additional water quality studies should be conducted after stream equilibration with completed WWTP improvements and revised advanced treatment permit limits;

2. The modeling of future conditions in this present report should be amended, as needed, based upon new stream data after stream equilibrium has been achieved and additional data has been collected.

3. The City of Claremore should consider redirecting the point of discharge south to the Verdigris River. This option is presently being considered as part of the Regional TMDL under development for Rogers County.

4. The following wasteload allocations are recommended:

SEASON	$CBOD_5$	NH_3-N	DO
Summer	10	2	6
Spring	9	2	7
Winter	15	8	7

These allocations assume stream equilibrium with the improved effluent quality, a headwater flow of 7Q2, and maximum design flows from the WWTP (i.e. 4.43 MGD).

APPENDIX A

Summary of 1998 INCOG Water Quality Surveys

FIGURE A.1: Summer 1998 Dry and Wet Weather Survey Data for BOD_{20} and $CBOD_{20}$

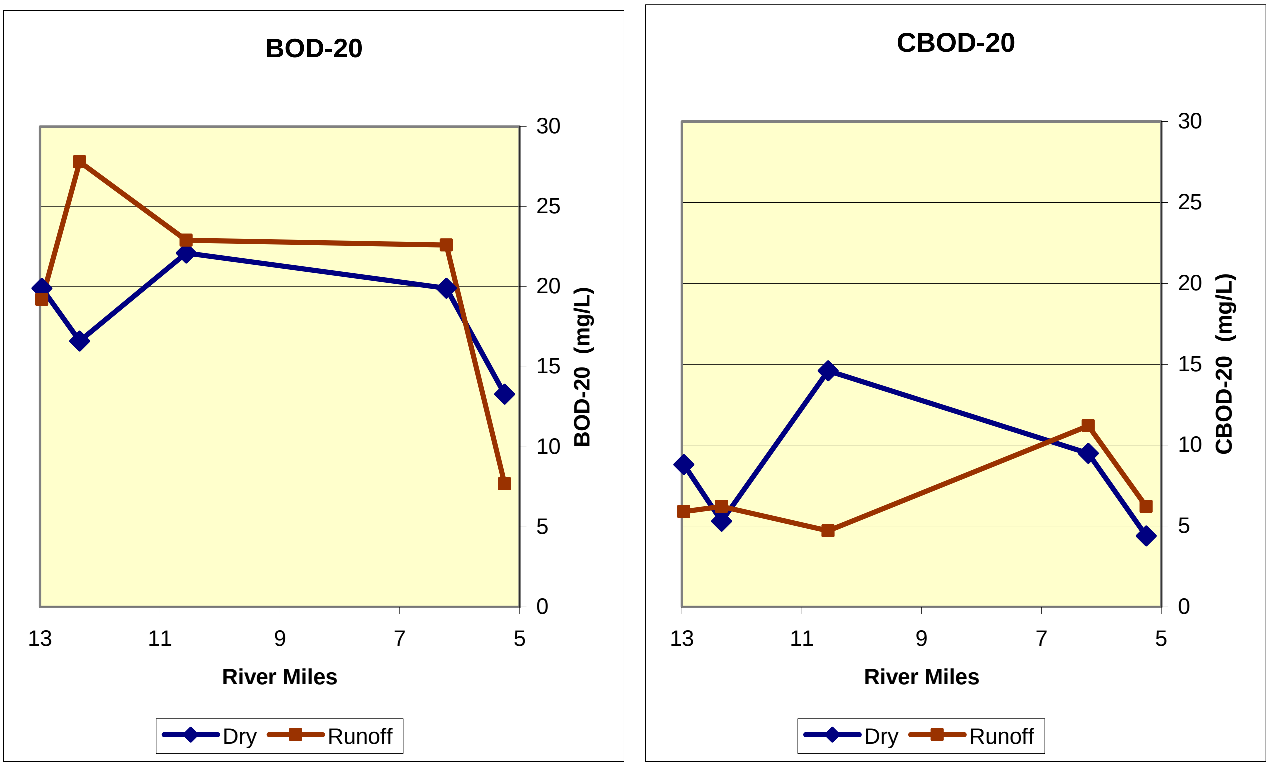


FIGURE A.2: Summer 1998 Dry and Wet Weather Survey Data for Ortho and Total P

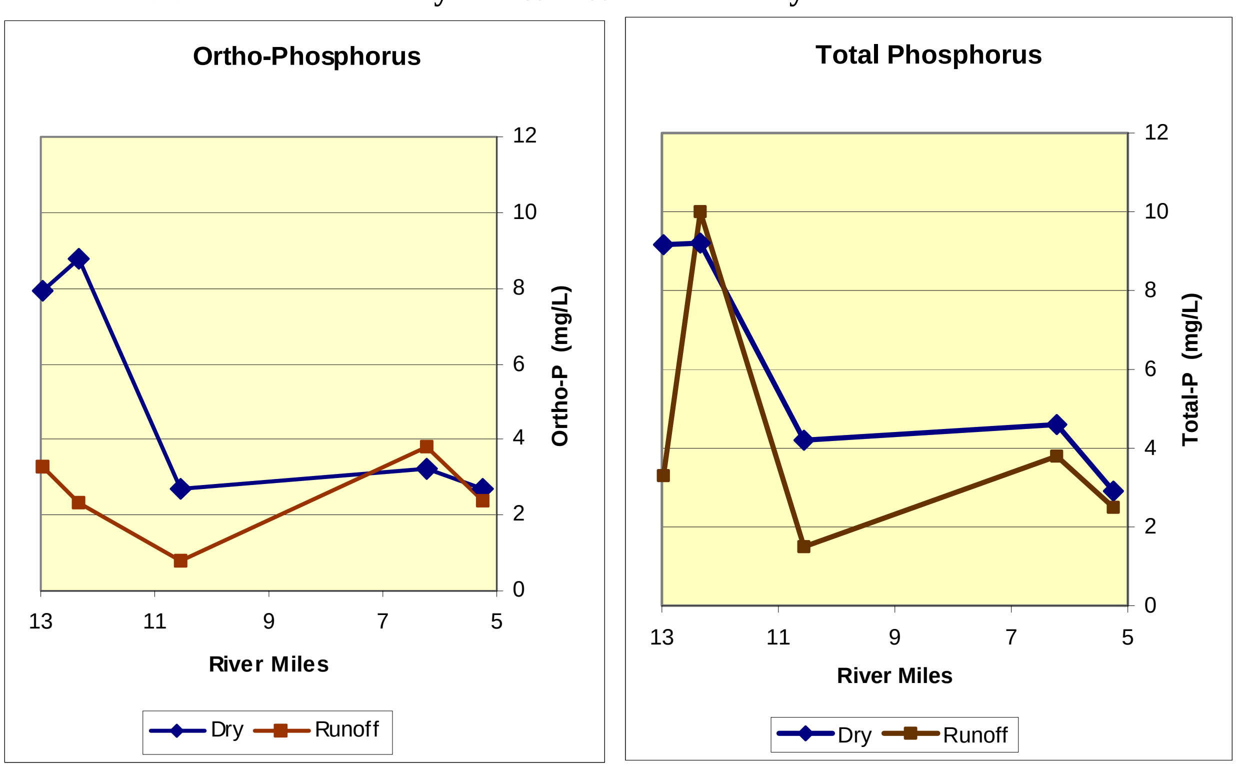


FIGURE A.3: Summer 1998 Dry and Wet Weather Survey Data for NH_3-N and TKN

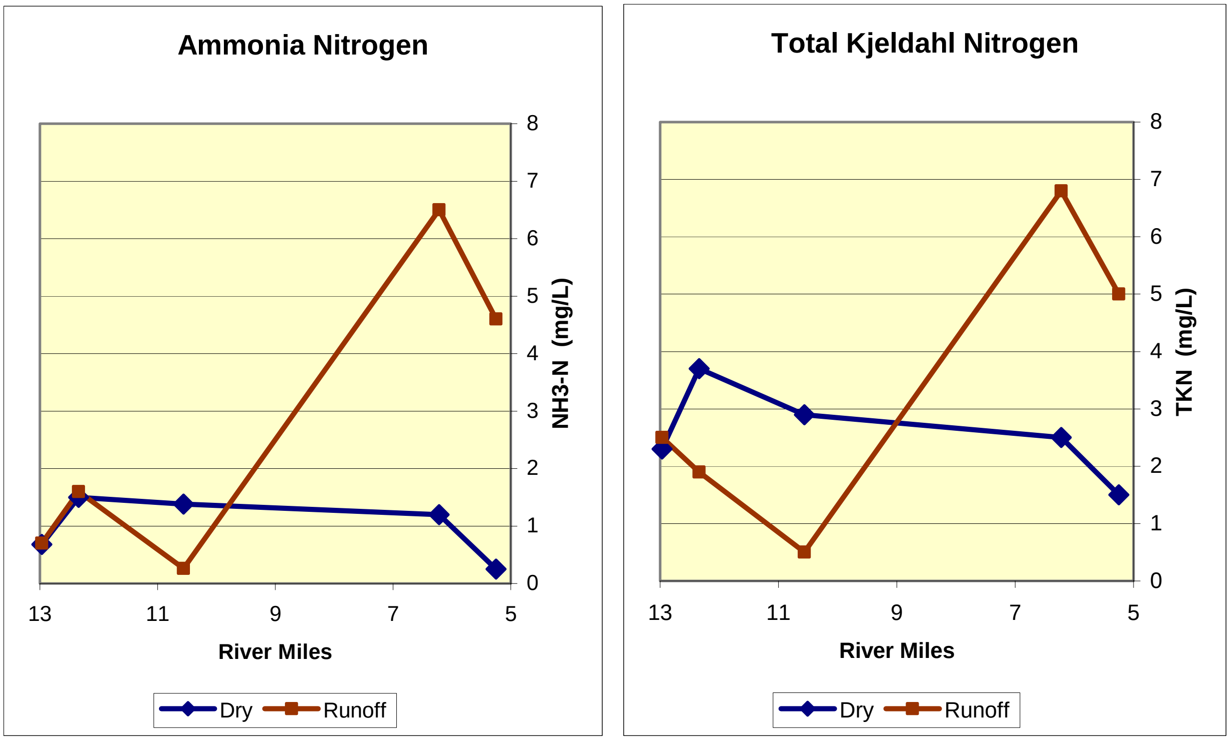


FIGURE A.4: Summer 1998 Dry and Wet Weather Survey Data for FC and Chl-a

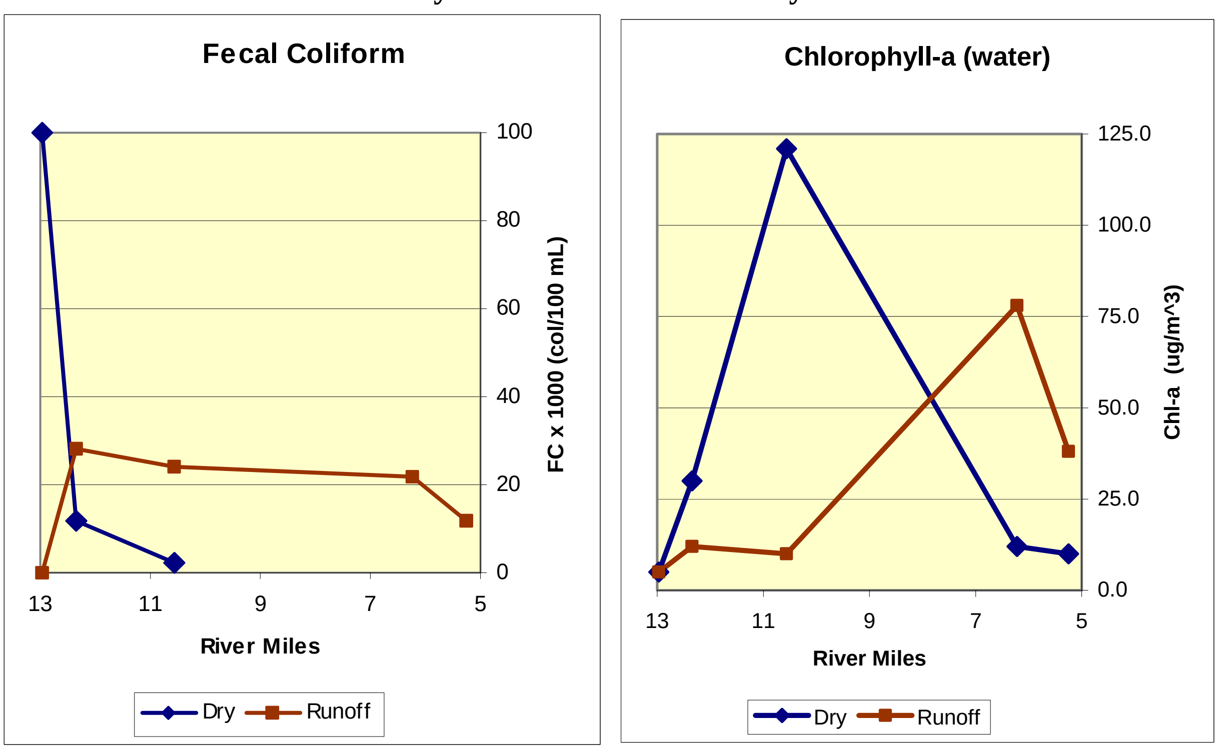
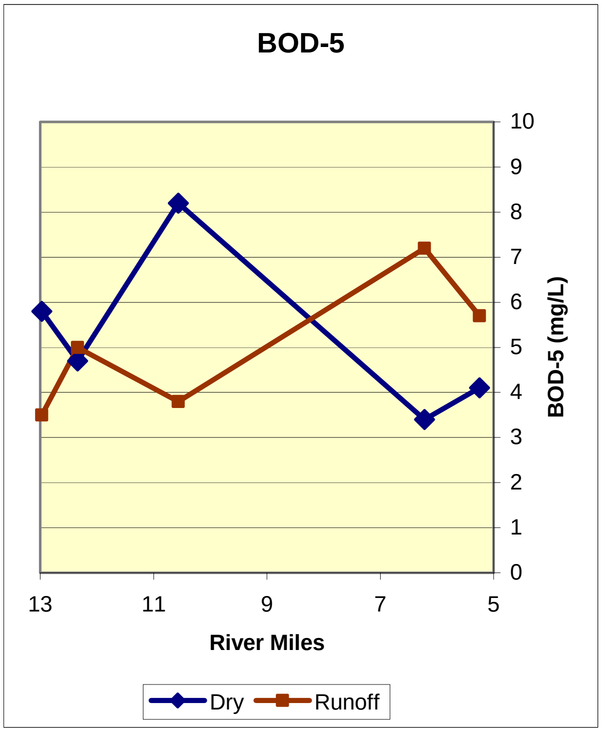


FIGURE A.5: Summer 1998 Dry and Wet Weather Survey Data for BOD_5 and $CBOD_5$



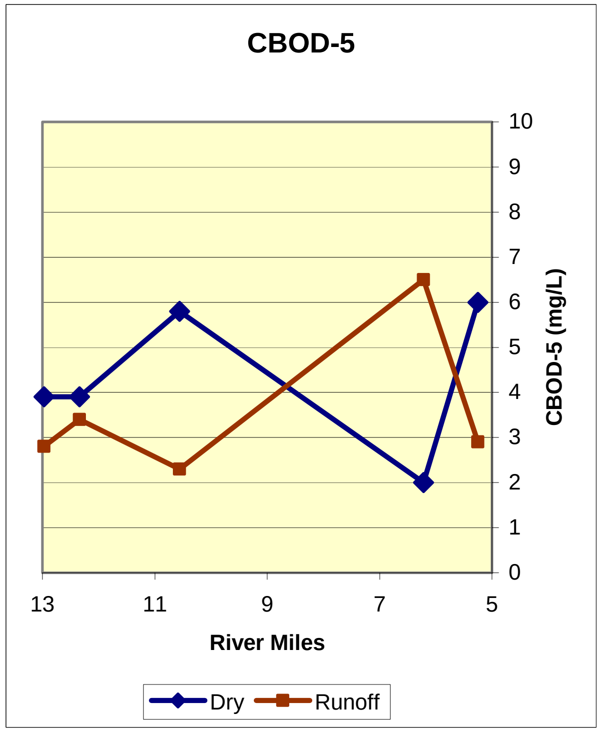
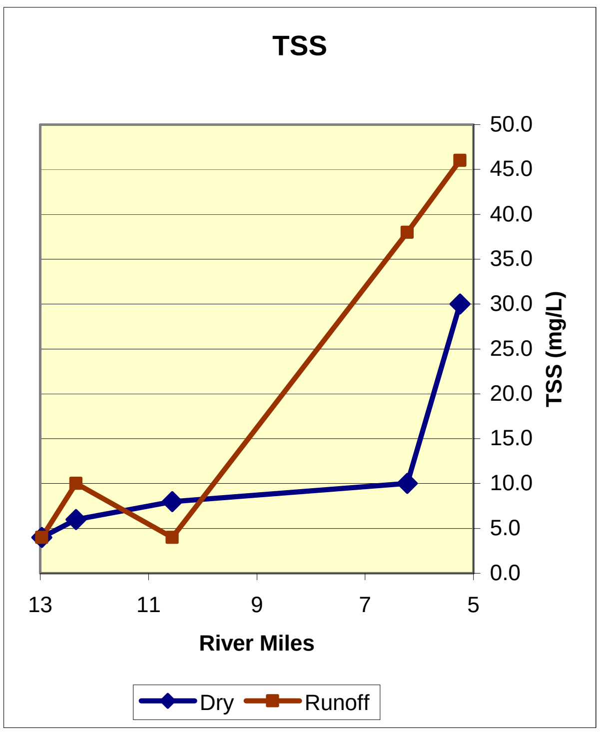


FIGURE A.6: Summer 1998 Dry and Wet Weather Survey Data for TSS and Nitrate-N



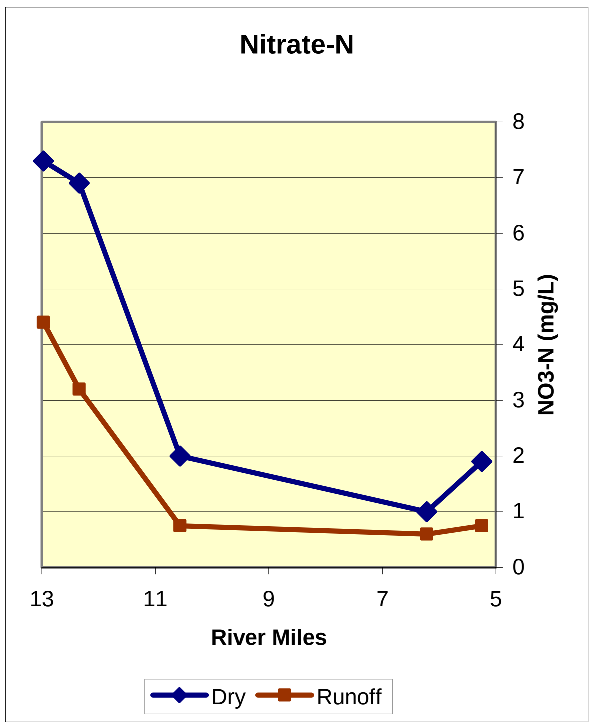
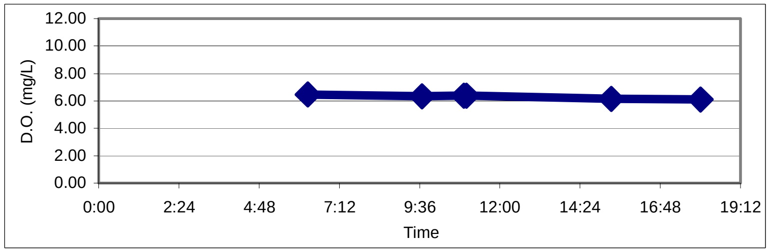
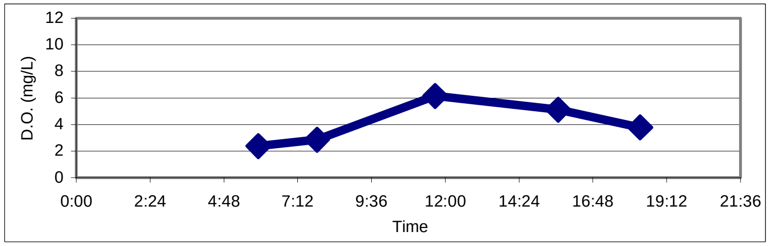


TABLE A.1: Summary of Dissolved Oxygen for Dry Weather Sampling

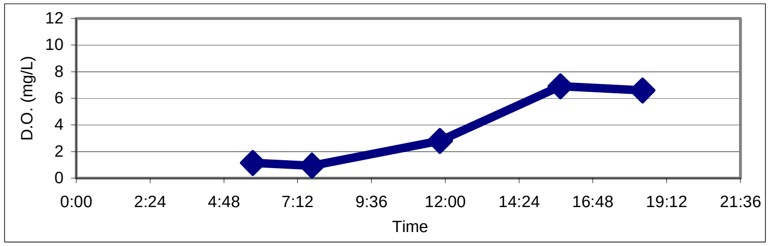
Sample Station S4010 (WWTP)					
Time	Temp (C)	pH (s.u.)	COND (us/cm	D.O. (mg/L)	Duplicate?
6:15	26.97	7.45	682	6.46	N
9:40	27.07	7.38	623	6.33	N
10:55	27.58	7.37	596	6.40	N
11:00	28.16	7.36	595	6.39	**Y**
15:20	28.57	7.23	600	6.16	N
18:00	29.43	7.28	592	6.10	N



Sample Station Site 2 (u/s Pond)					
Time	Temp (C)	pH (s.u.)	COND (us/cm	D.O. (mg/L)	Duplicate?
5:55	26.89	7.26	693	2.37	N
7:50	26.78	7.25	673	2.86	N
11:40	27.85	7.39	594	6.14	N
15:40	28.82	7.25	600	5.11	N
18:20	29.43	7.17	592	3.78	N



Sample Station Site 1 (d/s Pond)					
Time	Temp (C)	pH (s.u.)	COND (us/cm	D.O. (mg/L)	Duplicate?
5:45	27.12	7.09	659	1.13	N
7:40	26.97	7.08	671	0.93	N
11:50	27.97	7.18	648	2.79	N
15:45	29.42	7.36	634	6.91	N
18:25	30.45	7.35	627	6.58	N



Sample Station 4m029 (Cat Creek)					
Time	Temp (C)	pH (s.u.)	COND (us/cm	D.O. (mg/L)	Duplicate?
5:35	27.2	7.17	647	2.22	N
7:30	27.01	7.16	660	1.95	N
12:00	27.83	7.23	664	3.46	N
15:55	29.04	7.28	622	4.70	N
15:57	29.04	7.28	622	4.70	N
18:35	29.71	7.29	613	4.09	N

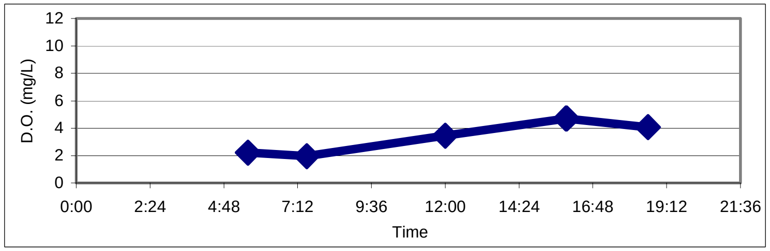
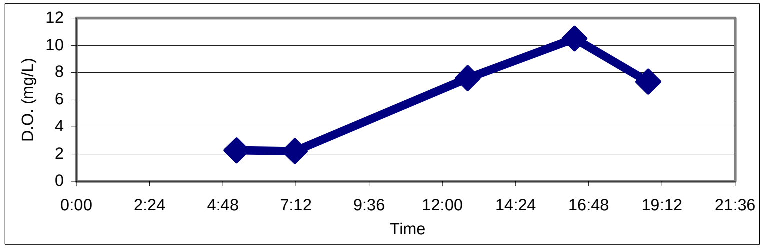
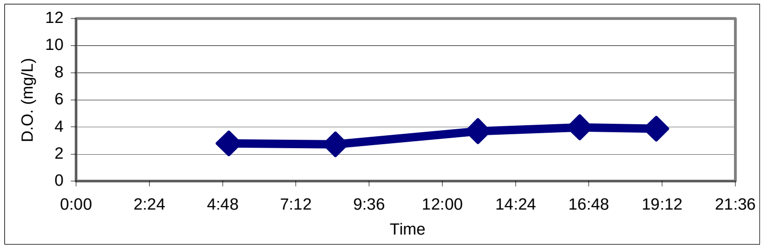


TABLE A.1 (Continued): Summary of Dissolved Oxygen for Dry Weather Sampling

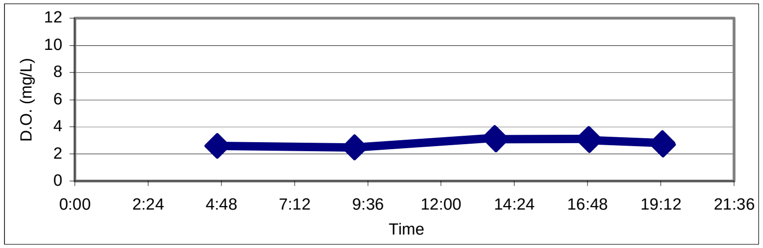
Sample Station 4I001 (Flint Road)					
Time	Temp (C)	pH (s.u.)	COND (us/cm	D.O. (mg/L)	Duplicate?
5:15	27.62	7.20	534	2.26	N
7:10	27.35	7.20	534	2.23	N
12:50	28.55	7.55	526	7.60	N
16:20	29.64	8.04	528	10.51	N
18:45	29.68	7.58	533	7.32	N



Sample Station 4I005 (Gordon)					
Time	Temp (C)	pH (s.u.)	COND (us/cm	D.O. (mg/L)	Duplicate?
5:00	27.61	7.24	483	2.79	N
8:30	27.62	7.22	491	2.72	N
13:10	28.84	7.29	500	3.68	N
16:30	29.38	7.29	510	3.98	N
19:00	29.38	7.30	524	3.87	N



Sample Station 4I004 (Spavinaw)					
Time	Temp (C)	pH (s.u.)	COND (us/cm	D.O. (mg/L)	Duplicate?
4:40	27.71	7.20	492	2.58	N
9:10	27.76	7.19	481	2.47	N
13:45	29.02	7.23	470	3.18	N
13:48	28.96	7.21	471	3.06	**Y**
16:50	29.22	7.18	479	3.10	N
16:51	29.14	7.18	479	3.02	**Y**
19:15	29.18	7.18	482	2.78	N
19:16	29.08	7.16	483	2.69	**Y**



APPENDIX B: DOG CREEK CALIBRATION MODEL OUTPUT FILE

```
LA-QUAL for Windows Version 4.00
Louisiana Department of Environmental Quality

          Output produced at 18:46 on 08/07/2002



          $$$ DATA TYPE 1 (TITLES AND CONTROL CARDS) $$$

          CARD TYPE       CONTROL TITLES

          CNTROL01        LAQUAL - DOG CREEK SUMMER 2000 CALIBRATION: dccalibf
          CNTROL02        DSCHG TO EFFL TRIB, HWTR FLOW: zero cfs, TEMP = 25.7
          CNTROL03  YES   ECHO DATA INPUT
          CNTROL04  YES   INTERMEDIATE SUMMARY
          CNTROL05   NO   CAPSULE SUMMARY
          CNTROL06   NO   FINAL REPORT
          CNTROL07   NO   LOADING SUMMARY
          CNTROL08  YES   SPECIAL REPORT
          CNTROL09   NO   LINE PRINTER PLOT
          CNTROL10   NO   GRAPHICS CAPABILITY
          CNTROL11   NO   SEQUENCING OUTPUT
          CNTROL12   NO   METRIC UNITS
          CNTROL13  YES   OXYGEN DEPENDENT RATES
          CNTROL14   NO   SENSITIVITY ANALYSIS
          CNTROL15   NO   FLOW AUGMENTATION
          CNTROL16   NO   OVERLAY PLOT
          ENDATA01



          $$$ DATA TYPE 2 (MODEL OPTIONS) $$$

          CARD TYPE       MODEL OPTION

          MODOPT01   NO   TEMPERATURE
          MODOPT02   NO   SALINITY
          MODOPT03   NO   CONSERVATIVE MATERIAL  I =
          MODOPT04   NO   CONSERVATIVE MATERIAL II
          MODOPT05  YES   DISSOLVED OXYGEN
          MODOPT06  YES   BIOCHEMICAL OXYGEN DEMAND
          MODOPT07  YES   NITROGEN
          MODOPT08   NO   PHOSPHORUS
          MODOPT09   NO   CHLOROPHYLL A
          MODOPT10   NO   MACROPHYTES
          MODOPT11   NO   COLIFORM
          MODOPT12   NO   NONCONSERVATIVE MATERIAL =
          ENDATA02



          $$$ DATA TYPE 3 (PROGRAM CONSTANTS) $$$

          CARD TYPE       DESCRIPTION OF CONSTANT                        VALUE
```

```
PROGRAM         FINAL REPORT TYPE                =        1.00000
PROGRAM         SPECIAL REPORT TYPE              =        1.00000
PROGRAM         BAROMETRIC PRESSURE (MBARS)      =      992.00000
PROGRAM         INHIBITION CONTROL VALUE         =        4.00000
PROGRAM         KL MINIMUM (M/DAY)               =        0.60000
PROGRAM         K2 MAXIMUM                       =      100.00000
PROGRAM         ALGAE OXYGEN PROD                =        0.00000
PROGRAM         N ALGAL UPTAKE                   =        0.10000
PROGRAM         N PREFERENCE                     =        1.00000
PROGRAM         OXYGEN DEPENDENCE THRESHOLD      =        2.00000
ENDATA03


$$$ DATA TYPE 4 (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS) $$$

CARD TYPE     RATE CODE     THETA VALUE

ENDATA04


$$$ CONSTANTS TYPE 5 (TEMPERATURE DATA) $$$

CARD TYPE       DESCRIPTION OF CONSTANT                         VALUE

ENDATA05


$$$ DATA TYPE 6 (ALGAE CONSTANTS) $$$

CARD TYPE       DESCRIPTION OF CONSTANT                         VALUE

ENDATA06


$$$ DATA TYPE 7 (MACROPHYTE CONSTANTS) $$$

CARD TYPE       DESCRIPTION OF CONSTANT                         VALUE

ENDATA07


$$$ DATA TYPE 8 (REACH IDENTIFICATION DATA) $$$
                                                     BEGIN        END     ELEM    REACH     ELEMS  BEGIN    END
CARD TYPE  REACH  ID  NAME                           REACH       REACH   LENGTH   LENGTH   PER RCH  ELEM   ELEM
                                                        mi          mi       mi       mi            NUM    NUM

REACH ID      1   DC  Dog Creek headwater            12.94  TO  12.19   0.1500     0.75       5      1      5
REACH ID      2   CC  Cat Creek headwater             0.35  TO   0.30   0.0100     0.05       5      6     10
REACH ID      3   ET  Effluent Tributary headwater    0.54  TO   0.49   0.0100     0.05       5     11     15
REACH ID      4   ET  ET u/s of turnpike (S4010)      0.49  TO   0.35   0.0200     0.14       7     16     22
REACH ID      5   ET  ET u/s of pond (Site 2)         0.35  TO   0.26   0.0180     0.09       5     23     27
REACH ID      6   ET  Effluent trib pond              0.26  TO   0.18   0.0100     0.08       8     28     35
REACH ID      7   ET  Effl trib d/s of pond (Site 1)  0.18  TO   0.12   0.0100     0.06       6     36     41
```

REACH ID	8	ET	Effluent trib u/s of Cat Creek	0.12	TO	0.00	0.0100	0.12	12	42	53
REACH ID	9	CC	CC d/s of Effl trib (4M029)	0.30	TO	0.16	0.0100	0.14	14	54	67
REACH ID	10	CC	Cat Creek u/s of Dog Creek	0.16	TO	0.00	0.0100	0.16	16	68	83
REACH ID	11	DC	Upper Froman (4I011, Site 3)	12.19	TO	11.49	0.0500	0.70	14	84	97
REACH ID	12	DC	Lower Froman site (Site 4)	11.49	TO	11.22	0.0300	0.27	9	98	106
REACH ID	13	DC	Flint Road (4I001)	11.22	TO	10.56	0.0600	0.66	11	107	117
REACH ID	14	DC	Dry property (Site 5)	10.56	TO	10.04	0.0400	0.52	13	118	130
REACH ID	15	DC	Upper McCombs site (Site 6)	10.04	TO	9.38	0.0600	0.66	11	131	141
REACH ID	16	DC	Lower McCombs site (Site 7)	9.38	TO	8.66	0.0600	0.72	12	142	153
REACH ID	17	DC	Upper Gordon site (Site 8)	8.66	TO	7.46	0.1200	1.20	10	154	163
REACH ID	18	DC	Lower Gordon site (4I005)	7.46	TO	6.26	0.1200	1.20	10	164	173
REACH ID	19	DC	Spavinaw flowline (4I004)	6.26	TO	5.26	0.1000	1.00	10	174	183
REACH ID	20	DC	Peguot site (4I003)	5.26	TO	4.36	0.1000	0.90	9	184	192

ENDATA08

$$$ DATA TYPE 9 (ADVECTIVE HYDRAULIC COEFFICIENTS) $$$

CARD TYPE	REACH	ID	VELOCITY "A"	VELOCITY "B"	DEPTH "D"	DEPTH "E"	DEPTH "F"	MANNINGS "N"
HYDR-1	1	DC	0.20000000	0.800	0.400	0.080	0.000	0.040
HYDR-1	2	CC	0.20000000	0.800	0.400	0.080	0.000	0.040
HYDR-1	3	ET	0.20000000	0.800	0.400	0.080	0.000	0.040
HYDR-1	4	ET	0.18000001	0.800	0.400	0.100	0.000	0.030
HYDR-1	5	ET	0.15000001	0.800	0.400	0.100	0.000	0.050
HYDR-1	6	ET	0.15000001	0.400	0.450	0.100	0.000	0.050
HYDR-1	7	ET	0.15000001	0.800	0.400	0.180	0.000	0.050
HYDR-1	8	ET	0.15000001	0.700	0.400	0.080	0.000	0.030
HYDR-1	9	CC	0.15000001	0.700	0.400	0.070	0.000	0.040
HYDR-1	10	CC	0.14000000	0.750	0.350	0.060	0.000	0.040
HYDR-1	11	DC	0.15099999	0.800	0.351	0.040	0.000	0.040
HYDR-1	12	DC	0.15099999	0.800	0.351	0.040	0.000	0.040
HYDR-1	13	DC	0.15099999	0.800	0.351	0.040	0.000	0.040
HYDR-1	14	DC	0.15099999	0.800	0.351	0.040	0.000	0.040
HYDR-1	15	DC	0.15099999	0.800	0.351	0.040	0.000	0.040
HYDR-1	16	DC	0.12500000	0.700	0.350	0.040	0.000	0.040
HYDR-1	17	DC	0.12500000	0.650	0.570	0.040	0.000	0.040
HYDR-1	18	DC	0.11600000	0.650	0.760	0.030	0.000	0.040
HYDR-1	19	DC	0.05000000	0.760	0.770	0.020	0.000	0.040
HYDR-1	20	DC	0.05000000	0.720	0.940	0.010	0.000	0.040

ENDATA09

$$$ DATA TYPE 10 (DISPERSIVE HYDRAULIC COEFFICIENTS) $$$

CARD TYPE	REACH	ID	TIDAL RANGE	DISPERSION "A"	DISPERSION "B"	DISPERSION "C"	DISPERSION "D"

ENDATA10

$$$ DATA TYPE 11 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	ID	TEMP	SALIN	DO	NH3	NO3+2	PHOS	CHL A	MACRO

INITIAL	1	DC	25.70	1.00	5.00	0.02	0.02	0.00	8.00	0.00
INITIAL	2	CC	25.70	1.00	5.00	0.02	0.02	0.00	8.00	0.00
INITIAL	3	ET	25.70	1.00	5.00	0.02	0.02	0.00	8.00	0.00
INITIAL	4	ET	25.70	1.00	5.00	0.50	1.00	0.00	180.00	0.00
INITIAL	5	ET	25.70	1.00	5.00	0.50	1.00	0.00	220.00	0.00
INITIAL	6	ET	25.70	1.00	5.00	0.50	1.00	0.00	250.00	0.00
INITIAL	7	ET	25.70	1.00	5.00	0.50	1.00	0.00	200.00	0.00
INITIAL	8	ET	25.70	1.00	5.00	0.50	1.00	0.00	180.00	0.00
INITIAL	9	CC	25.70	1.00	5.00	0.50	1.00	0.00	160.00	0.00
INITIAL	10	CC	25.70	1.00	5.00	0.50	1.00	0.00	120.00	0.00
INITIAL	11	DC	25.70	1.00	5.00	0.50	1.00	0.00	110.00	0.00
INITIAL	12	DC	25.70	1.00	5.00	0.50	1.00	0.00	110.00	0.00
INITIAL	13	DC	25.70	1.00	5.00	0.50	1.00	0.00	100.00	0.00
INITIAL	14	DC	25.70	1.00	5.00	0.50	1.00	0.00	20.00	0.00
INITIAL	15	DC	25.70	1.00	5.00	0.50	1.00	0.00	20.00	0.00
INITIAL	16	DC	25.70	1.00	5.00	0.50	1.00	0.00	20.00	0.00
INITIAL	17	DC	25.70	1.00	5.00	0.50	1.00	0.00	10.00	0.00
INITIAL	18	DC	25.70	1.00	5.00	0.50	1.00	0.00	10.00	0.00
INITIAL	19	DC	25.70	1.00	5.00	0.50	1.00	0.00	10.00	0.00
INITIAL	20	DC	25.70	1.00	5.00	0.50	1.00	0.00	10.00	0.00

ENDATA11

$$$ DATA TYPE 12 (REAERATION, SEDIMENT OXYGEN DEMAND, BOD COEFFICIENTS) $$$

CARD TYPE	REACH	ID	K2 OPT	K2 "A"	K2 "B"	K2 "C"	BKGRND SOD	AEROB BOD DECAY	BOD SETT	BOD CONV TO SOD	ANAER BOD DECAY
COEF-1	1	DC	11.	0.000	0.000	0.000	60.000	0.100	0.010	0.000	0.000
COEF-1	2	CC	11.	0.000	0.000	0.000	60.000	0.100	0.010	0.000	0.000
COEF-1	3	ET	11.	0.000	0.000	0.000	60.000	0.100	0.010	0.000	0.000
COEF-1	4	ET	11.	0.000	0.000	0.000	200.000	0.900	2.100	0.000	0.000
COEF-1	5	ET	11.	0.000	0.000	0.000	200.000	0.900	2.100	0.000	1.000
COEF-1	6	ET	11.	0.000	0.000	0.000	300.000	0.900	2.100	0.000	1.000
COEF-1	7	ET	11.	0.000	0.000	0.000	150.000	0.700	2.100	0.000	0.000
COEF-1	8	ET	11.	0.000	0.000	0.000	140.000	0.600	2.100	0.000	0.000
COEF-1	9	CC	11.	0.000	0.000	0.000	140.000	0.600	2.100	0.000	0.000
COEF-1	10	CC	11.	0.000	0.000	0.000	130.000	0.900	1.500	0.000	0.000
COEF-1	11	DC	11.	0.000	0.000	0.000	160.000	0.800	0.100	0.000	0.000
COEF-1	12	DC	11.	0.000	0.000	0.000	180.000	0.800	0.100	0.000	0.000
COEF-1	13	DC	11.	0.000	0.000	0.000	190.000	0.700	0.100	0.000	0.000
COEF-1	14	DC	11.	0.000	0.000	0.000	240.000	0.600	0.100	0.000	0.000
COEF-1	15	DC	11.	0.000	0.000	0.000	250.000	0.400	0.100	0.000	0.000
COEF-1	16	DC	11.	0.000	0.000	0.000	260.000	0.300	0.100	0.000	0.000
COEF-1	17	DC	11.	0.000	0.000	0.000	270.000	0.200	0.100	0.000	0.000
COEF-1	18	DC	11.	0.000	0.000	0.000	280.000	0.200	0.100	0.000	0.000
COEF-1	19	DC	11.	0.000	0.000	0.000	240.000	0.150	0.100	0.000	0.000
COEF-1	20	DC	11.	0.000	0.000	0.000	230.000	0.100	0.100	0.000	0.000

ENDATA12

$$$ DATA TYPE 13 (NITROGEN AND PHOSPHORUS COEFFICIENTS) $$$

CARD TYPE	REACH	ID	ORG-N DECA	ORG-N SETT	ORGN CONV TO NH3 SRCE	NH3 DECA	NH3 SRCE	PHOS SRCE	DENIT RATE

COEF-2	1	DC	0.05	0.01	0.10	0.30	0.00	0.00	0.10
COEF-2	2	CC	0.05	0.01	0.10	0.30	0.00	0.00	0.10
COEF-2	3	ET	0.05	0.01	0.10	0.30	0.00	0.00	0.10
COEF-2	4	ET	1.80	0.80	0.10	0.40	0.00	0.00	0.10
COEF-2	5	ET	1.80	0.80	0.10	0.40	0.00	0.00	0.10
COEF-2	6	ET	1.80	0.80	0.10	0.40	0.00	0.00	0.10
COEF-2	7	ET	0.90	0.10	0.10	0.40	0.00	0.00	0.10
COEF-2	8	ET	0.90	0.10	0.10	0.40	0.00	0.00	0.10
COEF-2	9	CC	0.90	0.10	0.10	0.40	0.00	0.00	0.10
COEF-2	10	CC	0.90	0.10	0.10	0.60	0.00	0.00	0.10
COEF-2	11	DC	0.40	0.30	0.10	0.60	0.00	0.00	0.10
COEF-2	12	DC	0.40	0.30	0.10	0.60	0.00	0.00	0.10
COEF-2	13	DC	0.40	0.30	0.10	0.60	0.00	0.00	0.10
COEF-2	14	DC	0.05	0.30	0.10	0.60	-20.00	0.00	0.10
COEF-2	15	DC	0.05	0.30	0.10	0.60	-20.00	0.00	0.10
COEF-2	16	DC	0.01	0.20	0.10	0.60	-20.00	0.00	0.10
COEF-2	17	DC	0.01	0.01	0.10	0.60	0.00	0.00	0.10
COEF-2	18	DC	0.01	0.01	0.10	0.60	0.00	0.00	0.10
COEF-2	19	DC	0.01	0.10	0.10	0.50	0.00	0.00	0.10
COEF-2	20	DC	0.01	0.10	0.10	0.40	0.00	0.00	0.10

ENDATA13

$$$ DATA TYPE 14 (ALGAE AND MACROPHYTE COEFFICIENTS) $$$

CARD TYPE	REACH	ID	SECCHI DEPTH	ALGAE: CHL A	ALGAE SETT	ALG CONV TO SOD	ALGAE GROW	ALGAE RESP	MACRO GROW	MACRO RESP

ENDATA14

$$$ DATA TYPE 15 (COLIFORM AND NONCONSERVATIVE COEFFICIENTS) $$$

CARD TYPE	REACH	ID	COLIFORM DIE-OFF	NCM DECAY	NCM SETT	NCM CONV TO SOD

ENDATA15

$$$ DATA TYPE 16 (INCREMENTAL DATA FOR FLOW, TEMPERATURE, SALINITY, AND CONSERVATIVES) $$$

CARD TYPE	REACH	ID	OUTFLOW	INFLOW	TEMP	SALIN	CM-I	CM-II	INFLOW/DIST

ENDATA16

$$$ DATA TYPE 17 (INCREMENTAL DATA FOR DO, BOD, AND NITROGEN) $$$

CARD TYPE	REACH	ID	DO	BOD	ORG-N	NH3	NO3+2

ENDATA17

$$$ DATA TYPE 18 (INCREMENTAL DATA FOR PHOSPHORUS, CHLOROPHYLL, COLIFORM, AND NONCONSERVATIVES) $$$

CARD TYPE	REACH	ID	PHOS	CHL A	COLI	NCM

ENDATA18

$$$ DATA TYPE 19 (NONPOINT SOURCE DATA) $$$

CARD TYPE	REACH	ID	BOD	ORG-N	COLI	NCM	DO
NONPOINT	6	ET	0.00	0.00	0.00	0.00	0.00
NONPOINT	7	ET	0.00	0.00	0.00	0.00	0.00
NONPOINT	8	ET	0.00	0.00	0.00	0.00	0.00
NONPOINT	9	CC	0.00	0.00	0.00	0.00	0.00
NONPOINT	13	DC	0.00	0.00	0.00	0.00	0.00

ENDATA19

$$$ DATA TYPE 20 (HEADWATER FOR FLOW, TEMPERATURE, SALINITY AND CONSERVATIVES) $$$

CARD TYPE	ELEMENT	NAME	UNIT	FLOW	TEMP	SALIN	CM-I	CM-II
HDWTR-1	1	Dog Creek	0	0.00000	25.700	1.000	0.000	0.000
HDWTR-1	6	Cat Creek	0	0.00000	25.700	1.000	0.000	0.000
HDWTR-1	11	Effluent trib	0	0.00000	25.700	1.000	0.000	0.000

ENDATA20

$$$ DATA TYPE 21 (HEADWATER DATA FOR DO, BOD, AND NITROGEN) $$$

CARD TYPE	ELEMENT	NAME	DO	BOD	ORG-N	NH3	NO3+2
HDWTR-2	1	Dog Creek	6.21	2.00	0.05	0.15	0.05
HDWTR-2	6	Cat Creek	6.21	2.00	0.05	0.15	0.05
HDWTR-2	11	Effluent trib	5.85	2.00	0.05	0.15	0.05

ENDATA21

$$$ DATA TYPE 22 (HEADWATER DATA FOR PHOSPHORUS, CHLOROPHYLL, COLIFORM, AND NONCONSERVATIVES) $$$

CARD TYPE	ELEMENT	NAME	PHOS	CHL A	COLI	NCM

ENDATA22

$$$ DATA TYPE 23 (JUNCTION DATA) $$$

CARD TYPE	JUNCTION ELEMENT	UPSTRM ELEMENT	NAME

```
JUNCTION          54      10       Effluent trib / Cat Creek confluence
JUNCTION          84       5       Cat Creek / Dog Creek confluence
ENDATA23


$$$ DATA TYPE 24 (WASTELOAD DATA FOR FLOW, TEMPERATURE, SALINITY, AND CONSERVATIVES) $$$

CARD TYPE  ELEMENT   NAME                          FLOW      TEMP       SAL      CM-I     CM-II

WSTLD-1       16     WWTP Effluent              2.88000    25.700     1.000     0.000     0.000
ENDATA24


$$$ DATA TYPE 25 (WASTELOAD DATA FOR DO, BOD, AND NITROGEN) $$$

                                                                    % BOD                            %
CARD TYPE     ELEMENT   NAME                           DO       BOD      RMVL     ORG-N       NH3    NITRIF     NO3+2

WSTLD-2          16     WWTP Effluent                6.40     55.14      0.00      2.91      0.84      0.00     11.09
ENDATA25


$$$ DATA TYPE 26 (WASTELOAD DATA FOR PHOSPHORUS, CHLOROPHYLL, COLIFORM, AND NONCONSERVATIVES) $$$

CARD TYPE     ELEMENT   NAME                         PHOS     CHL A      COLI       NCM

ENDATA26


$$$ DATA TYPE 27 (LOWER BOUNDARY CONDITIONS) $$$

CARD TYPE          CONSTITUENT                    CONCENTRATION

ENDATA27


$$$ DATA TYPE 28 (FLOW AUGMENTATION DATA) $$$

CARD TYPE        REACH       AVAIL HDWS       TARGET            ORDER OF AVAIL SOURCES

ENDATA28


$$$ DATA TYPE 29 (SENSITIVITY ANALYSIS DATA) $$$

CARD TYPE       PARAMETER     COL 1     COL 2     COL 3     COL 4     COL 5     COL 6     COL 7     COL 8

ENDATA29


$$$ DATA TYPE 30 (PLOT CONTROL CARDS) $$$
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ENDATA30

$$$ DATA TYPE 31 (OVERLAY PLOT DATA) $$$

ENDATA31

1

.....NO ERRORS DETECTED IN INPUT DATA

.....HYDRAULIC CALCULATIONS COMPLETED

.....TRIDIAGONAL MATRIX TERMS INITIALIZED

.....OXYGEN DEPENDENT RATES CONVERGENT IN 13 ITERATIONS

.....CONSTITUENT CALCULATIONS COMPLETED

***** WARNING: NEGATIVE CONCENTRATIONS SET TO ZERO FOR Nitrate+Nitrite Nitrogen

1INTERMEDIATE REPORT

Dissolved Oxygen — LAQUAL - DOG CREEK SUMMER 2000 CALIBRATION: dccalibf

mg/L — DSCHG TO EFFL TRIB, HWTR FLOW: zero cfs, TEMP = 25.7

ID	RCH	ELEM	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
DC	1	1	6.55	6.55	6.55	6.55	6.35					
DC	11	84	2.28	2.27	2.26	2.25	2.25	2.25	2.25	2.25	2.25	2.26
DC	11	94	2.27	2.27	2.28	2.29						
DC	12	98	2.29	2.28	2.28	2.27	2.27	2.26	2.26	2.26	2.26	
DC	13	107	2.27	2.28	2.29	2.31	2.32	2.33	2.35	2.36	2.38	2.39
DC	13	117	2.41									
DC	14	118	2.39	2.37	2.35	2.34	2.33	2.32	2.31	2.30	2.29	2.29
DC	14	128	2.28	2.28	2.28							
DC	15	131	2.30	2.32	2.34	2.36	2.38	2.40	2.42	2.44	2.46	2.48
DC	15	141	2.50									
DC	16	142	2.49	2.48	2.47	2.47	2.46	2.46	2.47	2.47	2.48	2.49
DC	16	152	2.50	2.51								
DC	17	154	2.51	2.52	2.52	2.53	2.54	2.54	2.55	2.56	2.57	2.57
DC	18	164	2.55	2.53	2.51	2.49	2.48	2.47	2.46	2.45	2.45	2.44
DC	19	174	2.42	2.40	2.38	2.37	2.36	2.35	2.35	2.35	2.35	2.35
DC	20	184	2.39	2.43	2.47	2.50	2.53	2.56	2.58	2.60	2.63	
CC	2	6	6.55	6.55	6.55	6.55	3.18					
CC	9	54	2.57	2.56	2.55	2.54	2.53	2.52	2.52	2.51	2.50	2.50
CC	9	64	2.49	2.49	2.48	2.48						
CC	10	68	2.46	2.45	2.43	2.42	2.40	2.39	2.38	2.36	2.35	2.34
CC	10	78	2.33	2.33	2.32	2.31	2.30	2.30				
ET	3	11	6.55	6.55	6.55	6.55	6.17					
ET	4	16	6.18	5.97	5.76	5.57	5.38	5.19	5.02			
ET	5	23	4.83	4.65	4.48	4.32	4.16					
ET	6	28	4.00	3.84	3.69	3.54	3.39	3.25	3.11	2.98		
ET	7	36	2.94	2.91	2.87	2.84	2.81	2.78				
ET	8	42	2.76	2.73	2.72	2.70	2.68	2.66	2.65	2.63	2.62	2.60
ET	8	52	2.59	2.58								

1INTERMEDIATE REPORT
Effective BOD
mg/L

LAQUAL - DOG CREEK SUMMER 2000 CALIBRATION: dccalibf
DSCHG TO EFFL TRIB, HWTR FLOW: zero cfs, TEMP = 25.7

ID	RCH	ELEM	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
DC	1	1	0.00	0.00	0.00	0.00	12.04					
DC	11	84	21.67	21.41	21.17	20.92	20.68	20.44	20.20	19.97	19.73	19.51
DC	11	94	19.28	19.06	18.83	18.62						
DC	12	98	18.49	18.36	18.23	18.10	17.97	17.85	17.72	17.60	17.48	
DC	13	107	17.26	17.04	16.83	16.61	16.41	16.20	16.00	15.79	15.60	15.40
DC	13	117	15.21									
DC	14	118	15.09	14.98	14.87	14.75	14.64	14.53	14.42	14.31	14.21	14.10
DC	14	128	13.99	13.89	13.78							
DC	15	131	13.66	13.55	13.43	13.32	13.20	13.09	12.98	12.86	12.75	12.64
DC	15	141	12.53									
DC	16	142	12.41	12.29	12.17	12.05	11.94	11.82	11.70	11.59	11.48	11.37
DC	16	152	11.25	11.15								
DC	17	154	11.00	10.85	10.71	10.57	10.43	10.29	10.16	10.02	9.89	9.76
DC	18	164	9.64	9.51	9.39	9.27	9.16	9.04	8.92	8.81	8.70	8.59
DC	19	174	8.43	8.28	8.12	7.98	7.83	7.69	7.55	7.41	7.27	7.14
DC	20	184	7.04	6.94	6.84	6.75	6.65	6.56	6.47	6.37	6.26	
CC	2	6	0.01	0.00	0.00	0.00	30.76					
CC	9	54	30.83	30.45	30.08	29.71	29.35	28.99	28.64	28.29	27.94	27.60
CC	9	64	27.26	26.93	26.60	26.28						
CC	10	68	25.98	25.69	25.40	25.11	24.83	24.55	24.27	24.00	23.73	23.46
CC	10	78	23.20	22.94	22.68	22.42	22.17	21.91				
ET	3	11	0.01	0.00	0.00	0.00	53.92					
ET	4	16	54.10	53.08	52.09	51.11	50.15	49.20	48.28			
ET	5	23	47.30	46.34	45.40	44.48	43.58					
ET	6	28	42.89	42.22	41.56	40.90	40.26	39.63	39.01	38.40		
ET	7	36	38.01	37.62	37.24	36.86	36.49	36.11				
ET	8	42	35.68	35.25	34.82	34.40	33.98	33.57	33.17	32.77	32.37	31.98
ET	8	52	31.59	31.21								

1INTERMEDIATE REPORT
Organic Nitrogen
mg/L

LAQUAL - DOG CREEK SUMMER 2000 CALIBRATION: dccalibf
DSCHG TO EFFL TRIB, HWTR FLOW: zero cfs, TEMP = 25.7

ID	RCH	ELEM	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
DC	1	1	0.00	0.00	0.00	0.00	1.25					
DC	11	84	1.97	1.94	1.92	1.89	1.87	1.85	1.82	1.80	1.78	1.75
DC	11	94	1.73	1.71	1.69	1.67						
DC	12	98	1.66	1.64	1.63	1.62	1.61	1.59	1.58	1.57	1.56	
DC	13	107	1.54	1.51	1.49	1.47	1.45	1.42	1.40	1.38	1.36	1.34
DC	13	117	1.32									
DC	14	118	1.31	1.30	1.29	1.28	1.28	1.27	1.26	1.25	1.24	1.23
DC	14	128	1.22	1.22	1.21							
DC	15	131	1.19	1.18	1.17	1.16	1.15	1.13	1.12	1.11	1.10	1.09
DC	15	141	1.08									
DC	16	142	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	0.99	0.98
DC	16	152	0.98	0.97								
DC	17	154	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
DC	18	164	0.96	0.96	0.96	0.95	0.95	0.95	0.95	0.95	0.95	0.95
DC	19	174	0.94	0.93	0.93	0.92	0.91	0.90	0.89	0.89	0.88	0.87
DC	20	184	0.86	0.86	0.85	0.85	0.84	0.83	0.83	0.82	0.81	

CC	2	6	0.00	0.00	0.00	0.00	2.16					
CC	9	54	2.16	2.16	2.15	2.14	2.14	2.13	2.13	2.12	2.11	2.11
CC	9	64	2.10	2.10	2.09	2.08						
CC	10	68	2.08	2.07	2.07	2.06	2.05	2.05	2.04	2.04	2.03	2.03
CC	10	78	2.02	2.01	2.01	2.00	2.00	1.99				
ET	3	11	0.00	0.00	0.00	0.00	2.87					
ET	4	16	2.87	2.84	2.80	2.77	2.73	2.70	2.66			
ET	5	23	2.63	2.59	2.55	2.52	2.48					
ET	6	28	2.46	2.43	2.40	2.38	2.35	2.33	2.30	2.27		
ET	7	36	2.27	2.26	2.26	2.25	2.25	2.24				
ET	8	42	2.24	2.23	2.22	2.22	2.21	2.20	2.20	2.19	2.19	2.18
ET	8	52	2.17	2.17								

1INTERMEDIATE REPORT
Ammonia Nitrogen   LAQUAL - DOG CREEK SUMMER 2000 CALIBRATION: dccalibf
mg/L   DSCHG TO EFFL TRIB, HWTR FLOW: zero cfs, TEMP = 25.7

ID	RCH	ELEM	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
DC	1	1	0.00	0.00	0.00	0.00	0.66					
DC	11	84	1.35	1.36	1.36	1.36	1.36	1.36	1.37	1.37	1.37	1.37
DC	11	94	1.37	1.37	1.37	1.37						
DC	12	98	1.37	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	
DC	13	107	1.38	1.38	1.38	1.38	1.38	1.38	1.37	1.37	1.37	1.37
DC	13	117	1.37									
DC	14	118	1.34	1.32	1.29	1.27	1.25	1.22	1.20	1.17	1.15	1.12
DC	14	128	1.10	1.08	1.05							
DC	15	131	1.02	0.98	0.95	0.91	0.88	0.84	0.81	0.77	0.74	0.71
DC	15	141	0.67									
DC	16	142	0.63	0.58	0.54	0.49	0.45	0.41	0.36	0.32	0.28	0.24
DC	16	152	0.20	0.15								
DC	17	154	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.13	0.13	0.13
DC	18	164	0.13	0.12	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.11
DC	19	174	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09
DC	20	184	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08	
CC	2	6	0.00	0.00	0.00	0.00	1.25					
CC	9	54	1.25	1.26	1.26	1.27	1.27	1.27	1.28	1.28	1.28	1.29
CC	9	64	1.29	1.30	1.30	1.30						
CC	10	68	1.31	1.31	1.31	1.32	1.32	1.32	1.32	1.33	1.33	1.33
CC	10	78	1.34	1.34	1.34	1.35	1.35	1.35				
ET	3	11	0.00	0.00	0.00	0.00	0.86					
ET	4	16	0.86	0.88	0.90	0.92	0.94	0.95	0.97			
ET	5	23	0.99	1.01	1.03	1.05	1.07					
ET	6	28	1.08	1.10	1.11	1.12	1.14	1.15	1.17	1.18		
ET	7	36	1.18	1.19	1.19	1.20	1.20	1.20				
ET	8	42	1.21	1.21	1.21	1.22	1.22	1.23	1.23	1.23	1.24	1.24
ET	8	52	1.25	1.25								

1INTERMEDIATE REPORT
Nitrate+Nitrite Nitrogen   LAQUAL - DOG CREEK SUMMER 2000 CALIBRATION: dccalibf
mg/L   DSCHG TO EFFL TRIB, HWTR FLOW: zero cfs, TEMP = 25.7

ID	RCH	ELEM	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
DC	1	1	0.00	0.00	0.00	0.00	0.00					
DC	11	84	7.67	7.55	7.44	7.32	7.20	7.09	6.97	6.86	6.74	6.62
DC	11	94	6.51	6.39	6.28	6.16						
DC	12	98	6.09	6.02	5.96	5.89	5.82	5.76	5.69	5.63	5.57	

DC	13	107	5.45	5.35	5.25	5.16	5.09	5.02	4.96	4.92	4.88	4.85
DC	13	117	4.84									
DC	14	118	4.82	4.81	4.80	4.79	4.78	4.76	4.75	4.74	4.73	4.71
DC	14	128	4.70	4.69	4.67							
DC	15	131	4.65	4.63	4.61	4.59	4.57	4.55	4.53	4.51	4.49	4.47
DC	15	141	4.44									
DC	16	142	4.41	4.39	4.36	4.34	4.31	4.29	4.27	4.24	4.22	4.21
DC	16	152	4.19	4.17								
DC	17	154	4.14	4.10	4.07	4.03	3.99	3.96	3.92	3.89	3.85	3.82
DC	18	164	3.78	3.74	3.70	3.66	3.62	3.59	3.55	3.51	3.47	3.43
DC	19	174	3.36	3.29	3.23	3.16	3.09	3.02	2.95	2.89	2.82	2.75
DC	20	184	2.68	2.61	2.53	2.46	2.39	2.32	2.25	2.17	2.10	
CC	2	6	0.00	0.00	0.00	0.00	8.05					
CC	9	54	8.69	8.65	8.61	8.58	8.54	8.51	8.47	8.44	8.41	8.38
CC	9	64	8.34	8.31	8.28	8.25						
CC	10	68	8.23	8.20	8.17	8.14	8.11	8.08	8.06	8.03	8.00	7.97
CC	10	78	7.95	7.92	7.89	7.87	7.84	7.81				
ET	3	11	0.00	0.00	0.00	0.00	9.97					
ET	4	16	11.02	10.95	10.87	10.80	10.72	10.64	10.56			
ET	5	23	10.47	10.38	10.28	10.18	10.08					
ET	6	28	10.00	9.92	9.84	9.76	9.69	9.62	9.55	9.48		
ET	7	36	9.44	9.39	9.35	9.31	9.27	9.23				
ET	8	42	9.19	9.14	9.10	9.06	9.01	8.97	8.93	8.89	8.85	8.81
ET	8	52	8.77	8.73								

1INTERMEDIATE REPORT
Total Nitrogen
mg/L

LAQUAL - DOG CREEK SUMMER 2000 CALIBRATION: dccalibf
DSCHG TO EFFL TRIB, HWTR FLOW: zero cfs, TEMP = 25.7

ID	RCH	ELEM	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
DC	1	1	0.00	0.00	0.00	0.00	1.90					
DC	11	84	10.99	10.85	10.71	10.57	10.43	10.30	10.16	10.02	9.89	9.75
DC	11	94	9.61	9.48	9.34	9.20						
DC	12	98	9.12	9.04	8.96	8.88	8.81	8.73	8.65	8.58	8.50	
DC	13	107	8.36	8.23	8.12	8.01	7.91	7.82	7.74	7.67	7.61	7.56
DC	13	117	7.53									
DC	14	118	7.48	7.43	7.39	7.34	7.30	7.25	7.21	7.16	7.11	7.07
DC	14	128	7.02	6.98	6.93							
DC	15	131	6.87	6.80	6.73	6.66	6.60	6.53	6.46	6.39	6.33	6.26
DC	15	141	6.19									
DC	16	142	6.11	6.03	5.95	5.87	5.79	5.71	5.64	5.57	5.50	5.43
DC	16	152	5.36	5.29								
DC	17	154	5.25	5.21	5.18	5.14	5.10	5.06	5.02	4.98	4.94	4.90
DC	18	164	4.86	4.82	4.78	4.74	4.70	4.65	4.61	4.57	4.53	4.49
DC	19	174	4.41	4.33	4.25	4.18	4.10	4.02	3.94	3.87	3.79	3.71
DC	20	184	3.63	3.55	3.47	3.39	3.31	3.23	3.16	3.08	2.99	
CC	2	6	0.00	0.00	0.00	0.00	11.46					
CC	9	54	12.11	12.07	12.03	11.99	11.95	11.91	11.88	11.84	11.81	11.77
CC	9	64	11.74	11.71	11.67	11.64						
CC	10	68	11.61	11.58	11.55	11.52	11.49	11.45	11.42	11.39	11.36	11.33
CC	10	78	11.30	11.27	11.24	11.21	11.18	11.15				
ET	3	11	0.00	0.00	0.00	0.00	13.70					
ET	4	16	14.75	14.66	14.57	14.48	14.39	14.29	14.19			
ET	5	23	14.09	13.98	13.86	13.75	13.63					
ET	6	28	13.54	13.44	13.35	13.27	13.18	13.10	13.01	12.93		
ET	7	36	12.89	12.84	12.80	12.76	12.71	12.67				
ET	8	42	12.63	12.58	12.54	12.49	12.45	12.40	12.36	12.32	12.27	12.23

ET	8	52	12.19	12.15								

1INTERMEDIATE REPORT
Chlorophyll a LAQUAL - DOG CREEK SUMMER 2000 CALIBRATION: dccalibf
μg/L DSCHG TO EFFL TRIB, HWTR FLOW: zero cfs, TEMP = 25.7

ID	RCH	ELEM	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
DC	1	1	28.40	48.80	69.20	89.60	110.00					
DC	11	84	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00
DC	11	94	110.00	110.00	110.00	110.00						
DC	12	98	108.89	107.78	106.67	105.56	104.44	103.33	102.22	101.11	100.00	
DC	13	107	92.73	85.45	78.18	70.91	63.64	56.36	49.09	41.82	34.55	27.27
DC	13	117	20.00									
DC	14	118	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
DC	14	128	20.00	20.00	20.00							
DC	15	131	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
DC	15	141	20.00									
DC	16	142	19.17	18.33	17.50	16.67	15.83	15.00	14.17	13.33	12.50	11.67
DC	16	152	10.83	10.00								
DC	17	154	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
DC	18	164	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
DC	19	174	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
DC	20	184	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	
CC	2	6	38.40	68.80	99.20	129.60	160.00					
CC	9	54	157.14	154.29	151.43	148.57	145.71	142.86	140.00	137.14	134.29	131.43
CC	9	64	128.57	125.71	122.86	120.00						
CC	10	68	119.38	118.75	118.13	117.50	116.88	116.25	115.63	115.00	114.38	113.75
CC	10	78	113.13	112.50	111.88	111.25	110.63	110.00				
ET	3	11	42.40	76.80	111.20	145.60	180.00					
ET	4	16	185.71	191.43	197.14	202.86	208.57	214.29	220.00			
ET	5	23	226.00	232.00	238.00	244.00	250.00					
ET	6	28	243.75	237.50	231.25	225.00	218.75	212.50	206.25	200.00		
ET	7	36	196.67	193.33	190.00	186.67	183.33	180.00				
ET	8	42	178.33	176.67	175.00	173.33	171.67	170.00	168.33	166.67	165.00	163.33
ET	8	52	161.67	160.00								

1INTERMEDIATE REPORT
Temperature LAQUAL - DOG CREEK SUMMER 2000 CALIBRATION: dccalibf
deg C DSCHG TO EFFL TRIB, HWTR FLOW: zero cfs, TEMP = 25.7

ID	RCH	ELEM	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
DC	1	1	25.70	25.70	25.70	25.70	25.70					
DC	11	84	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70
DC	11	94	25.70	25.70	25.70	25.70						
DC	12	98	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	
DC	13	107	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70
DC	13	117	25.70									
DC	14	118	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70
DC	14	128	25.70	25.70	25.70							
DC	15	131	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70
DC	15	141	25.70									
DC	16	142	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70
DC	16	152	25.70	25.70								
DC	17	154	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70
DC	18	164	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70
DC	19	174	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70

DC	20	184	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	
CC	2	6	25.70	25.70	25.70	25.70	25.70					
CC	9	54	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70
CC	9	64	25.70	25.70	25.70	25.70						
CC	10	68	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70
CC	10	78	25.70	25.70	25.70	25.70	25.70	25.70				
ET	3	11	25.70	25.70	25.70	25.70	25.70					
ET	4	16	25.70	25.70	25.70	25.70	25.70	25.70	25.70			
ET	5	23	25.70	25.70	25.70	25.70	25.70					
ET	6	28	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70		
ET	7	36	25.70	25.70	25.70	25.70	25.70	25.70				
ET	8	42	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70
ET	8	52	25.70	25.70								

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.....EXECUTION COMPLETED

APPENDIX C

TMDL and Margin of Safety Spreadsheet

CALCULATE TMDL Margin of Safety (MOS) FOR AMMONIA-N AND CBOD

= Sum
= Calculated
= Data entry

Section I: Maximum Assimilative Capacity

	NAMES	NH3-N Mass (lbs/d)	NH3-N O2 Demand (lbs/d)	CBOD5 Mass (lbs/d)	UBOD O2 Demand (lbs/d)	TOTAL O2 Demand UBOD+NH3 (lbs/d)	
PS 1 Max WLA:	Claremore	109.73	475.13	369.46	849.76	1324.89	WLA 1
PS 2 Max WLA:	0.00	0.00	0.00	0.00	0.00	0.00	WLA 2
Headwater 1:	Dog Cr	0.94	4.06	12.51	28.76	32.83	BA 1
Headwater 2:	Cat Cr	0.00	0.00	0.00	0.00	0.00	BA 2
Headwater 3:	Effl Trib	0.81	3.50	10.78	24.80	28.30	BA 3
TOTALS:		111.48	482.69	392.75	903.32	1386.02	

	Facility Names	CBOD5 (mg/l)	NH3-N (mg/l)	Flow MGD	
PS 1 Max WLA:	Claremore	10.00	2.97	4.43	= WLA that just meets target DO
PS 2 Max WLA:					= WLA that just meets target DO

	Stream Names	CBOD5 (mg/l)	NH3-N (mg/l)	Upstream Flow (MGD)	Upstream Flow (cfs)
Headwater 1:	Dog Cr	2.00	0.15	0.75	1.16
Headwater 2:	Cat Cr	2.00	0.15	0.00	0.00
Headwater 3:	Effl Trib	2.00	0.15	0.65	1.00

FACILITY:	Claremore WWTP
SEASON:	**Summer**
MODEL:	dc285q
DATE:	**7-Aug-02**

	NPS Oxygen Demand (lbs/day)	
NPS Loads (lbs/d)	0.00	LA

Maximum Assimilatative Capacity: 1386.02 (lbs/day)

= Max'ed Point sources + Background + NPS

Section II: Waste Load Allocations

	NAMES	NH3-N Mass (lbs/d)	NH3-N O2 Demand (lbs/d)	CBOD5 Mass (lbs/d)	UBOD O2 Demand (lbs/d)	TOTAL O2 Demand UBOD+NH3 (lbs/d)
PS1 Proposed WLA:	Claremore	73.89	319.95	369.46	849.76	1169.72
PS2 Proposed WLA:		0.00	0.00	0.00	0.00	0.00
TOTALS:		73.89	319.95	369.46	849.76	1169.72

	NAMES	CBOD5 (mg/l)	NH3-N (mg/l)	Flow MGD	
PS1 Proposed WLA:	Claremore	10.00	2.00	4.43	= Proposed permit limits
PS2 Proposed WLA:					

Section III: Margin Of Safety

Max Assimilative Capacity (lbs/day)	Wasteload Allocations (lbs/day)	Background Allocations (lbs/day)	Load Allocation (lbs/day)	Reserved Capacity (lbs/day)	Margin Of Safety (%)
1386.02	1169.72	61.13	0.00	155.18	11.2%

CALCULATE TMDL Margin of Safety (MOS) FOR AMMONIA-N AND CBOD

= Sum
= Calculated
= Data entry

Section I: Maximum Assimilative Capacity

	NAMES	NH3-N Mass (lbs/d)	NH3-N O2 Demand (lbs/d)	CBOD5 Mass (lbs/d)	UBOD O2 Demand (lbs/d)	TOTAL O2 Demand UBOD+NH3 (lbs/d)	
PS 1 Max WLA:	Claremore	96.06	415.94	332.52	764.79	1180.73	WLA 1
PS 2 Max WLA:	0.00	0.00	0.00	0.00	0.00	0.00	WLA 2
Headwater 1:	Dog Cr	0.94	4.06	12.51	28.76	32.83	BA 1
Headwater 2:	Cat Cr	0.00	0.00	0.00	0.00	0.00	BA 2
Headwater 3:	Effl Trib	0.81	3.50	10.78	24.80	28.30	BA 3
TOTALS:		97.81	423.50	355.80	818.35	1241.85	

	Facility Names	CBOD5 (mg/l)	NH3-N (mg/l)	Flow MGD	
PS 1 Max WLA:	Claremore	9.00	2.60	4.43	= WLA that just meets target DO
PS 2 Max WLA:					= WLA that just meets target DO

	Stream Names	CBOD5 (mg/l)	NH3-N (mg/l)	Upstream Flow (MGD)	Upstream Flow (cfs)
Headwater 1:	Dog Cr	2.00	0.15	0.75	1.16
Headwater 2:	Cat Cr	2.00	0.15	0.00	0.00
Headwater 3:	Effl Trib	2.00	0.15	0.65	1.00

FACILITY:	Claremore WWTP
SEASON:	Spring
MODEL:	dc25q
DATE:	7-Aug-02

	NPS Oxygen Demand (lbs/day)	
NPS Loads (lbs/d)	0.00	LA

Maximum Assimilatative Capacity:	1241.85	(lbs/day)

= Max'ed Point sources + Background + NPS

Section II: Waste Load Allocations

	NAMES	NH3-N Mass (lbs/d)	NH3-N O2 Demand (lbs/d)	CBOD5 Mass (lbs/d)	UBOD O2 Demand (lbs/d)	TOTAL O2 Demand UBOD+NH3 (lbs/d)
PS1 Proposed WLA:	Claremore	73.89	319.95	332.52	764.79	1084.74
PS2 Proposed WLA:		0.00	0.00	0.00	0.00	0.00
TOTALS:		73.89	319.95	332.52	764.79	1084.74

	NAMES	CBOD5 (mg/l)	NH3-N (mg/l)	Flow MGD	
PS1 Proposed WLA:	Claremore	9.00	2.00	4.43	= Proposed permit limits
PS2 Proposed WLA:					

Section III: Margin Of Safety

Max Assimilative Capacity (lbs/day)	Wasteload Allocations (lbs/day)	Background Allocations (lbs/day)	Load Allocation (lbs/day)	Reserved Capacity (lbs/day)	Margin Of Safety (%)
1241.85	1084.74	61.13	0.00	95.99	7.7%

CALCULATE TMDL Margin of Safety (MOS) FOR AMMONIA-N AND CBOD

= Sum
= Calculated
= Data entry

Section I: Maximum Assimilative Capacity

	NAMES	NH3-N Mass (lbs/d)	NH3-N O2 Demand (lbs/d)	CBOD5 Mass (lbs/d)	UBOD O2 Demand (lbs/d)	TOTAL O2 Demand UBOD+NH3 (lbs/d)	
PS 1 Max WLA:	Claremore	333.99	1446.19	554.19	1274.64	2720.84	WLA 1
PS 2 Max WLA:	0.00	0.00	0.00	0.00	0.00	0.00	WLA 2
Headwater 1:	Dog Cr	0.94	4.06	12.51	28.76	32.83	BA 1
Headwater 2:	Cat Cr	0.00	0.00	0.00	0.00	0.00	BA 2
Headwater 3:	Effl Trib	0.81	3.50	10.78	24.80	28.30	BA 3
TOTALS:		335.74	1453.76	577.48	1328.21	2781.96	

	Facility Names	CBOD5 (mg/l)	NH3-N (mg/l)	Flow MGD	
PS 1 Max WLA:	Claremore	15.00	9.04	4.43	= WLA that just meets target DO
PS 2 Max WLA:					= WLA that just meets target DO

	Stream Names	CBOD5 (mg/l)	NH3-N (mg/l)	Upstream Flow (MGD)	Upstream Flow (cfs)
Headwater 1:	Dog Cr	2.00	0.15	0.75	1.16
Headwater 2:	Cat Cr	2.00	0.15	0.00	0.00
Headwater 3:	Effl Trib	2.00	0.15	0.65	1.00

FACILITY:	Claremore WWTP
SEASON:	Winter
MODEL:	dc18q
DATE:	7-Aug-02

	NPS Oxygen Demand (lbs/day)	
NPS Loads (lbs/d)	0.00	LA

Maximum Assimilatative Capacity:	2781.96	(lbs/day)

= Max'ed Point sources + Background + NPS

Section II: Waste Load Allocations

	NAMES	NH3-N Mass (lbs/d)	NH3-N O2 Demand (lbs/d)	CBOD5 Mass (lbs/d)	UBOD O2 Demand (lbs/d)	TOTAL O2 Demand UBOD+NH3 (lbs/d)
PS1 Proposed WLA:	Claremore	295.57	1279.82	554.19	1274.64	2554.46
PS2 Proposed WLA:		0.00	0.00	0.00	0.00	0.00
TOTALS:		295.57	1279.82	554.19	1274.64	2554.46

	NAMES	CBOD5 (mg/l)	NH3-N (mg/l)	Flow MGD	
PS1 Proposed WLA:	Claremore	15.00	8.00	4.43	= Proposed permit limits
PS2 Proposed WLA:					

Section III: Margin Of Safety

Max Assimilative Capacity (lbs/day)	Wasteload Allocations (lbs/day)	Background Allocations (lbs/day)	Load Allocation (lbs/day)	Reserved Capacity (lbs/day)	Margin Of Safety (%)
2781.96	2554.46	61.13	0.00	166.38	6.0%

References

EPA, 1983. "EPA Region VI Guidelines, Criteria for Performing Waste Load Analysis"

INCOG, 1989. "Claremore Wasteload Allocation Study Phase II: Modeling Report"

INCOG, 1992. "Dog Creek Water Quality Survey Data Report"

INCOG, 1993. "Claremore Wasteload Allocation Verification Study, Final Modeling Report"

ODEQ, 2000. "Oklahoma Continuing Planning Process"

OWRB, 1998. "Oklahoma Water Quality Standards" Title 785 OAC, Chapter 45, Section 785:45-5-12(e)

Abbreviations

AT	Advanced Treatment of municipal wastewater
BA	Background source load allocation
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
Card ##	LAQUAL model data input category (e.g. Card 19 = nonpoint source data)
CBOD	Carbonaceous BOD
cfs	Cubic feet per Second
CPP	Continuing Planning Process
DO	Dissolved Oxygen
FC	Fecal Coliform
GIS	Geographic Information System
HLAC	Habitat Limited Aquatic Community
INCOG	Indian Nations Council of Governments
LA	Load Allocation for nonpoint sources
MGD	Million Gallons per Day
MOS	Margin of Safety
NH_3-N	Ammonia Nitrogen
NO_3-N	Nitrate Nitrogen
NPDES	National Pollutant Discharge Elimination System
OCC	Oklahoma Conservation Commission
ODEQ	Oklahoma Department of Environmental Quality
ORN	Organic Nitrogen
OWQS	Oklahoma Water Quality Standards
SOD	Sediment Oxygen Demand
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids
UBOD	Ultimate BOD (equivalent to $CBOD_{20}$)
USGS	US Geological Survey
WLA	Wasteload Allocation
WWAC	Warm Water Aquatic Community
WWTP	Wastewater Treatment Plant