AMMONIA AND NITRATE TMDLS FOR STONE DAM CREEK WATERSHED

FAULKNER COUNTY

ARKANSAS RIVER VALLEY ECOREGION
PLANNING SEGMENT 3F
USGS HUC 11110203

FINAL TMDL REPORT

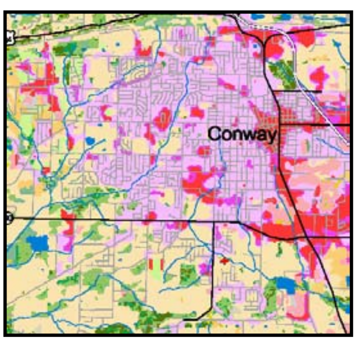
Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY, REGION 6, DALLAS, TX

AND THE

ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY

WATER DIVISION



Prepared by:

QUANTITATIVE ENVIRONMENTAL ANALYSIS, LLC AND

PARSONS

November 2003

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Water Division

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NOVEMBER 2003

EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act (CWA) requires states to identify water bodies not meeting state water quality standards (WQS) and to develop total maximum daily loads for pollutants in those water bodies. A total maximum daily load (TMDL) is the amount of a pollutant a water body can assimilate without exceeding the established water quality standard for that pollutant. Through a TMDL, pollutant loads can be distributed or allocated to point sources and nonpoint sources (NPS) discharging to the water body.

In July 1996, a water quality study was performed on Stone Dam Creek (ADEQ 1997). This investigation was conducted to determine the level of impact the point source dischargers to Stone Dam Creek were having on the water quality and aquatic inhabitants of the receiving stream. Results of this 1996 study concluded that several of the non-permitted constituents from the City of Conway Wastewater Treatment Plant (WWTP) cause a substantial change in water quality to Stone Dam Creek. In 1998, the State's 303(d) list identified nutrients and ammonia as the pollutants of concern on Stone Dam Creek. In 2002, the 303(d) list specified nitrate and ammonia and identified a priority ranking for Stone Dam Creek of medium (ADEQ 2002).

This creek has an estimated critical low flow in both winter (November to April) and summer (May to October) seasons of 0.1 cfs. As a result, nonpoint sources of nitrate and ammonia to the creek during critical conditions are relatively small. Nitrate and ammonia loads from a permitted service station (William Express #3059) are also relatively low, due to low flows. Therefore, flow in the creek is determined largely by the WWTP discharge. Nonpoint source loadings during wet conditions could be considered if more data were available to represent a runoff event. Currently, this TMDL is developed considering only point sources and low nonpoint source flows, but additional monitoring data is recommended to determine the impact of nonpoint sources from pastures on the water quality of the creek if implementation of point source controls as established in this TMDL do not result in water quality standards (WQS) attainment.

Due to the relatively small loading from nonpoint sources and the service station, this TMDL focuses on the Conway WWTP and assumes no load reduction for the nonpoint sources and service station. Both the ammonia and nitrate TMDLs are based on permitted flows, which is 6 million gallons per day (MGD) for the Conway WWTP. Table ES.1 summarizes the results of this TMDL for Stone Dam Creek for ammonia.

Table ES.1 Recommended TMDL for Ammonia

Season Source	Recommended TMDL (lb/day)
Summer	
LA: Watershed	0.038
WLA1: Conway WWTP	69.1
WLA2: Service Station	0.009
Total Load	**69.2**
Winter	
LA: Watershed	0.027
WLA1: Conway WWTP	124.2
WLA2: Service Station	0.009

Assuming nitrification in the creek, the resulting maximum allowable nitrate loads, are shown in Table ES.2.

Table ES.2 Recommended TMDL for Nitrate

Season Source	Recommended TMDL (lb/day)
Summer	
LA: Watershed	0.01
WLA1: Conway WWTP	471
WLA2: Service Station	0.07
Total Load	**471.1**
Winter	
LA: Watershed	0.02
WLA1: Conway WWTP	446
WLA2: Service Station	0.07
Total Load	**446.1**

No measurement of nitrate exists from the WWTP; therefore, no suggested load reductions are given. However, data at ARK051 suggest that the existing effluent nitrate concentrations are occasionally in excess of the regulatory limit.

This TMDL will require a reduction in ammonia loading from the WWTP. The presumptive approach to reducing ammonia is nitrification, which will result in an equal increase in the nitrate concentration. Because of the additional nitrate added to the effluent following increased nitrification, the WWTP will need to improve nitrate removal during the treatment processes to ensure the nitrate concentration is always below maximum values, even after enhanced nitrification.

ADEQ and USEPA will work together to develop recommendations for achieving the TMDL through existing mechanisms and programs. Recommendations could include:

- Consideration of ongoing ammonia and nitrate controls at the WWTP discharge.
- Synchronize the WWTP effluent monitoring with the in-stream monitoring at ARK051 to obtain a better understanding of the stream response to effluent discharges.
- If it is found that the water quality standards are not met, even after WWTP concentration reductions, consider wet-weather monitoring in the creek in an attempt to quantify nonpoint source loadings from pasture and urban lands.

This information can be used to better characterize the system and ensure that reductions in ammonia and nitrate from the WWTP will result in achieving the ammonia and nitrate standards in the creek. In addition, these data could aid in the development of a steady state water quality model to further evaluate system behavior.

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ACRONYMS AND ABBREVIATIONS

µg/L	Micrograms per liter
7Q10	7-day average, 10-year frequency low stream flow
ADEQ	Arkansas Department of Environmental Quality
CCC	Criterion continuous concentration
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CMC	Criterion maximum concentration
CPP	Continuing planning process
CWA	Clean Water Act
DMR	Discharge monitoring report
DO	Dissolved oxygen
HUC	Hydrologic unit code
LA	Load allocation
lbs/yr	Pounds per year
MCL	Maximum contaminant level
mg/L	Milligrams per liter
MGD	Million gallons per day
MOS	Margin of safety
NPDES	National Pollutant Discharge Elimination System
NPS	Non-point source
PCS	Permit Compliance System
TMDL	Total maximum daily load
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WLA	Wasteload allocation
WQS	Water quality standards
WWTP	Wastewater treatment plant

SECTION 1
INTRODUCTION

The State of Arkansas is required to develop total maximum daily loads (TMDL) for waters not meeting water quality standards in accordance with §303(d) of the Clean Water Act (CWA) and the U.S. Environmental Protection Agency (USEPA) Water Quality Planning and Management Regulations at 40 CFR 130.7. The quality of streams, lakes, and groundwater in the State is monitored by the Arkansas Department of Environmental Quality (ADEQ) and a variety of other partners. This information is used to determine whether water quality standards are being met and whether designated uses of the waters are being maintained. If waters are found not to be meeting established standards and consequently their beneficial uses, the previously cited acts and regulations require that the water body be listed on the State 303(d) list and that a TMDL be developed. Stone Dam Creek is listed on the Arkansas 2002 §303(d) list as being impaired for aquatic life uses and domestic drinking water supply. Other uses for Stone Dam Creek include secondary contact recreation and domestic, industrial, and agricultural supply. The 2002 priority ranking for Stone Dam Creek is medium (ADEQ 2002). The parameters of concern are ammonia nitrogen and nitrate nitrogen. This TMDL seeks to clearly address elements required by USEPA regulations and guidance to meet the requirements for TMDL development.

SECTION 2
STUDY AREA DESCRIPTION

The six major river basins in Arkansas are subdivided into 38 water quality planning segments based on hydrological characteristics, human activities, geographic characteristics, *etc*. The planning segments are further broken down into 492 smaller watersheds, based on discrete hydrological boundaries as defined by the U.S. Natural Resources Conservation Service. Stone Dam Creek is located in Arkansas River Basin, Planning Segment 3F, Arkansas River.

Stone Dam Creek originates in the City of Conway and flows south-southwest for about 1 mile before turning south-southeast (see Figure 2.1). At approximately 3 miles from its headwaters, the creek receives effluent from the City of Conway Wastewater Treatment Plant (WWTP) and then flows for approximately another mile before entering Lake Conway. The creek has a watershed size of 9 mi^2 from its headwaters to the confluence of Lake Conway. A 1997 TMDL report from the State indicates the stream gradient is 10-15 ft/mile and the substrate consists of "mud and silt, with an abundance of instream habitat in the form of beaver dams, tree tops, other woody debris, and over-hanging vegetation available to macroinvertiabrates, including fish." (ADEQ 1997). Additional information describing Stone Dam Creek is included in Table 2.1.

Table 2.1 Stone Dam Creek Characteristics

Description	Value	Source
Length	5 mi	National Hydrographic Dataset medium resolution
Width	1.6 ft	Assumed
Slope	0.002	Digital elevation model from National Elevation Dataset from Arkansas CAST
Drainage area	9 mi^2	Delineation using USEPA BASINS
Channel cover	Mud and silt	(ADEQ 1997)
Manning's n	0.05	(Daugherty, et al. 1985)
Designated Uses	Primary: Fishery use Secondary: Contact recreation Source water	(ADEQ 1997)

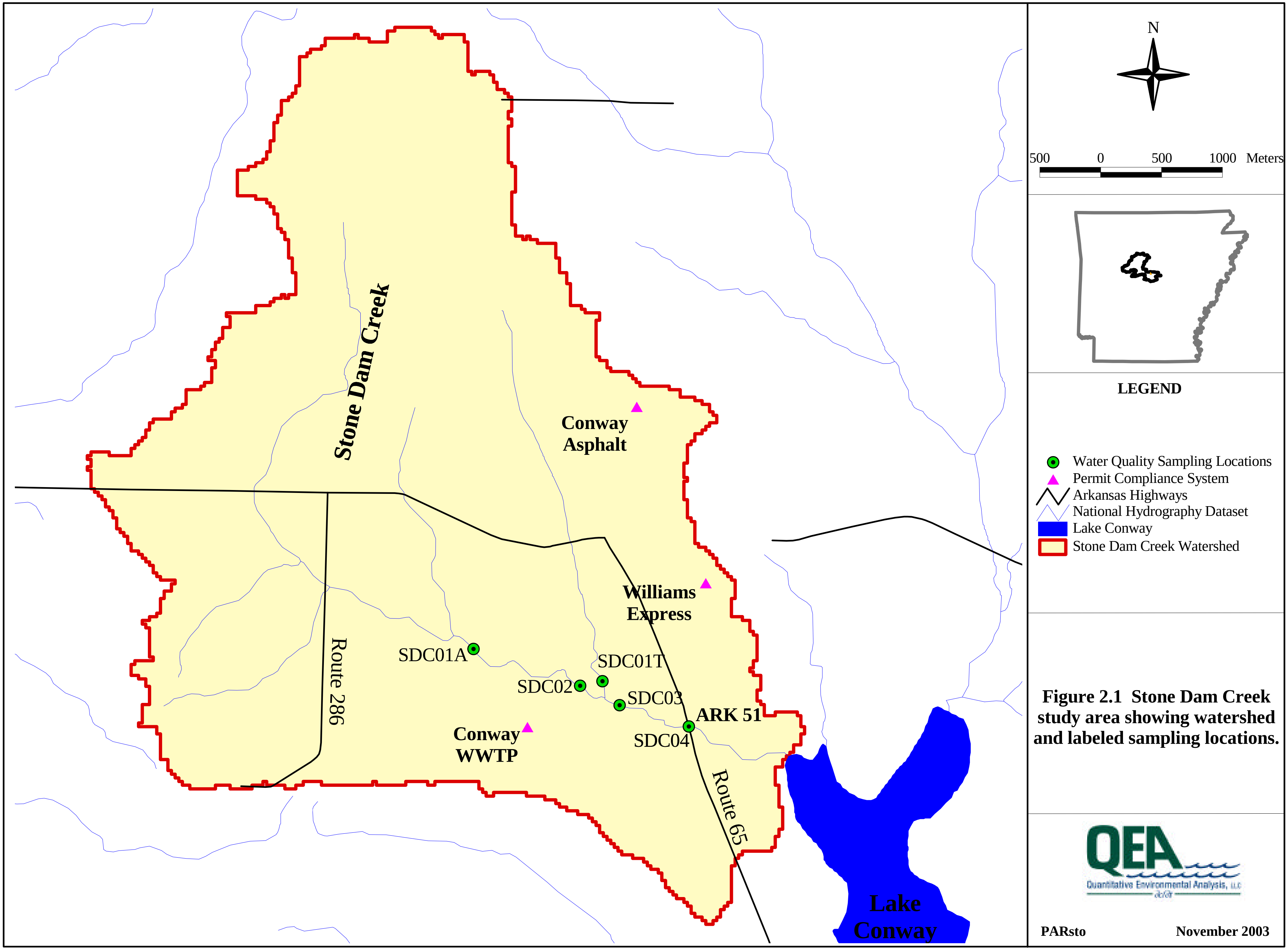

Figure 2.1 Stone Dam Creek study area showing watershed and labeled sampling locations.

2.1 LAND USE

Figure 2.2 shows the land use distribution in the Stone Dam Creek watershed from a 1999 study performed by the Center for Advanced Spatial Technologies at the University of Arkansas. Within the City of Conway there are urban lands, primarily residential and industrial. After leaving Conway, the creek is mostly bordered by pasture land. Table 2.2 details the breakdown of the land use classifications identified in the 1999 study and its distribution in the Stone Dam Creek watershed. The watershed is primarily pasture land with a small amount of forest and urban area.

Table 2.2 Land Use Summary for Stone Dam Creek

Land Use	Area (ac)	Percent Area of Total
Agriculture: Crops	0	0
Coniferous Forest	0	0
Deciduous Alluvial Forest	202	3.5
Deciduous Swamp Forest	0	0
Deciduous Upland Forest	0	0
Herbaceous/Pasture/Forage	5027	87
Mixed Forest	0	0
Urban Commercial-Industrial	84	1.5
Urban Residential	448	8
Water	< 1	< 0.1
Total Acreage	5761	100

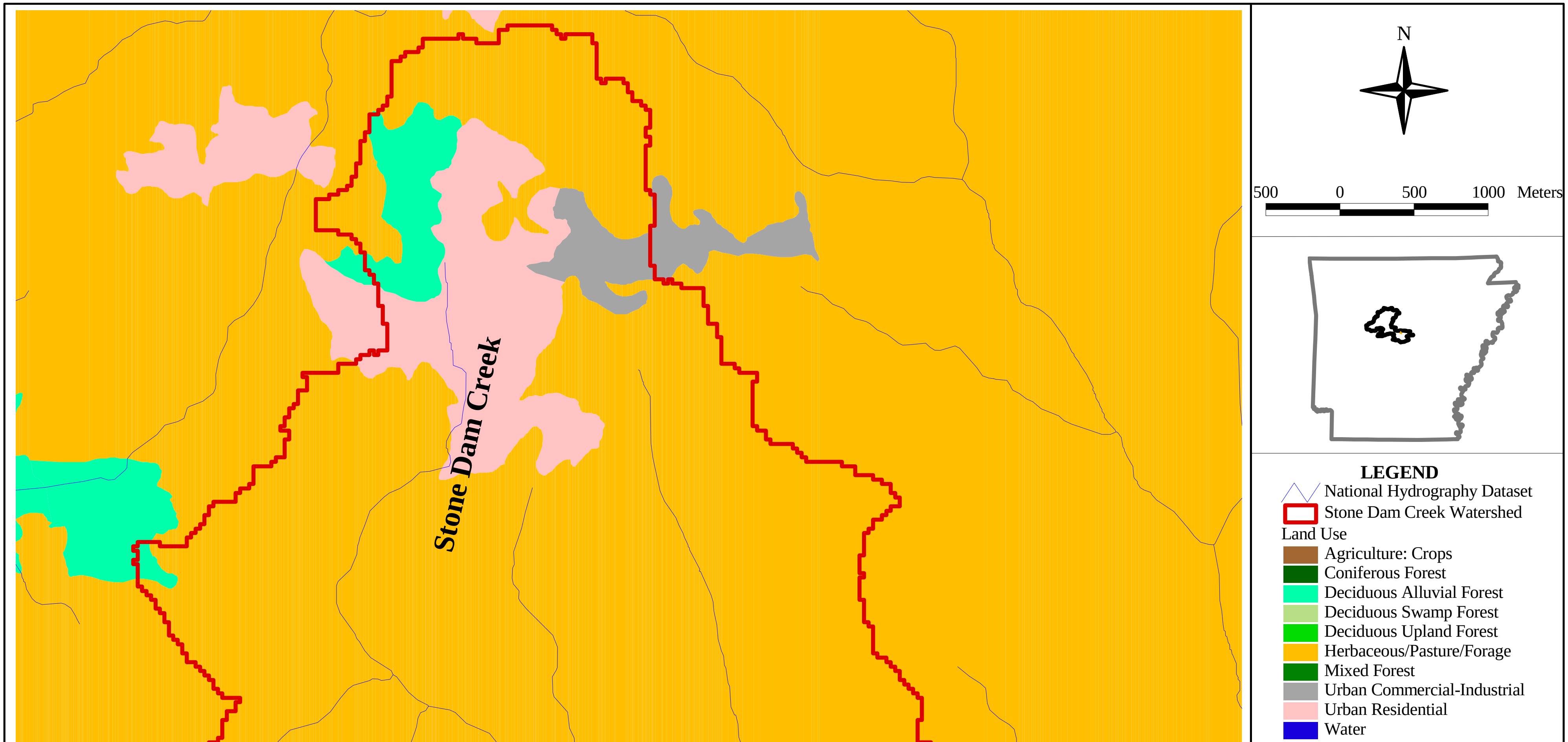

Figure 2.2 Stone Dam Creek land use.

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SECTION 3
PROBLEM DEFINITION

3.1 PROBLEM DEFINITION

In July 1996, a water quality study was performed on Stone Dam Creek (ADEQ 1997). This investigation was conducted to determine the level of impact point source dischargers to Stone Dam Creek were having on the water quality and aquatic inhabitants of the receiving stream. Results of this study concluded that several of the non-permitted constituents from the City of Conway WWTP cause a substantial change in water quality to Stone Dam Creek. Stone Dam Creek was listed on the Arkansas 2002 §303(d) list as being impaired for aquatic life uses and domestic drinking water supply. The parameters of concern are ammonia nitrogen and nitrate nitrogen. Most recently, the State 305(b) report stated,

Stone Dam Creek [is] *impaired by a municipal discharge with chronically toxic ammonia levels and nitrates exceeding the drinking water maximum contaminant level*. (ADEQ 2002b).

These studies prompted the development of TMDLs for both nitrate and ammonia on Stone Dam Creek.

3.2 ADEQ SURFACE WATER QUALITY STANDARDS

Major revisions in the Arkansas water quality standards in 1988 resulted in Stone Dam Creek being reclassified and a change to the dissolved oxygen (DO) standards. The designated uses of the stream are currently aquatic life, drinking water, secondary contact recreation, and domestic, industrial, and agricultural water supply. Due to the magnitude of the discharge from the Conway WWTP, Stone Dam Creek is designated as a perennial Arkansas River Valley fishery.

ADEQ has historically used the Safe Drinking Water Act minimum contaminate level (MCL) for nitrate of 10.0 mg/L as a use limiting criteria for waters with a drinking water designated use. To protect the drinking water designated use for Stone Dam Creek, the target for this TMDL will be established as 10 mg/L nitrate. Water quality data are available in the creek for only the combination of nitrite+nitrate, however, the concentration of nitrite is usually much less than that of nitrate in WWTP effluent and surface waters (Viessman and Hammer 1993). Therefore, measurements of nitrite+nitrate will be used, without modification, to specifically quantify nitrate.

ADEQ does not have a specific numeric standard for ammonia. However, high ammonia concentrations can cause impaired fisheries by creating an oxygen demand that lowers in-stream oxygen levels below State DO standards. In addition, ammonia at high levels is toxic to fish. Therefore, in the absence of a state numeric standard, the USEPA aquatic toxicity ammonia criterion was used to develop the TMDL for Stone Dam Creek

(USEPA 1999). Both the criterion maximum concentration (CMC, the 1-hour average concentration not to be exceeded more than once in 3 years), as well as the criterion continuous concentration (CCC, the 30-day average concentration not to be exceeded more than once in 3 years) are considered with the more stringent result serving as the water quality target for ammonia. In the event that ADEQ adopts, and EPA approves, a numeric ammonia criterion, this TMDL could be revised to reflect the state adopted value.

SECTION 4
DATA ASSESSMENT

Study area data relevant to this assessment were obtained from a variety of sources, including but not limited to ADEQ, USEPA, United State Geological Survey (USGS), and the University of Arkansas.

4.1 AMBIENT WATER QUALITY DATA

ADEQ maintains an ambient water quality station on Stone Dam Creek downstream of the City of Conway WWTP outfall and above the confluence of the creek with Lake Conway (see ARK051 station on Figure 2.1). This station has been sampled on an approximate bi-weekly interval from the early 1980's to present-day. The data from this station are discussed in the following sections. Appendix A (Tables A.1 and A.2) provides the results from individual measurements for the 1998-2003 data at ARK051.

4.1.1 Temperature and pH

All of the ARK051 results for field parameters (temperature and pH) are illustrated in Figure 4.1. Figure 4.2 shows probability plots of the recent data at ARK051 for these parameters. The results are also summarized in Table 4.1.

Table 4.1 Average Concentrations of Temperature and pH at ARK051

	All Seasons	Winter (Nov-Apr)	Summer (May-Oct)
Full Period of Record (4/1984 – 3/2003)			
Temperature (^oC)	19.4	13.7	25
pH	6.9	6.9	6.9
Recent Data (1/1998 – 3/2003)			
Temperature (^oC)	20.5	14.5	27
pH	6.8	6.7	6.8

4.1.2 Ammonia

The ARK051 ammonia measurements are illustrated in Figure 4.3. Figure 4.4 shows probability plots of the recent data at ARK051 for ammonia. Inspection of these plots indicates the frequency of violations of the water quality standard at this station.

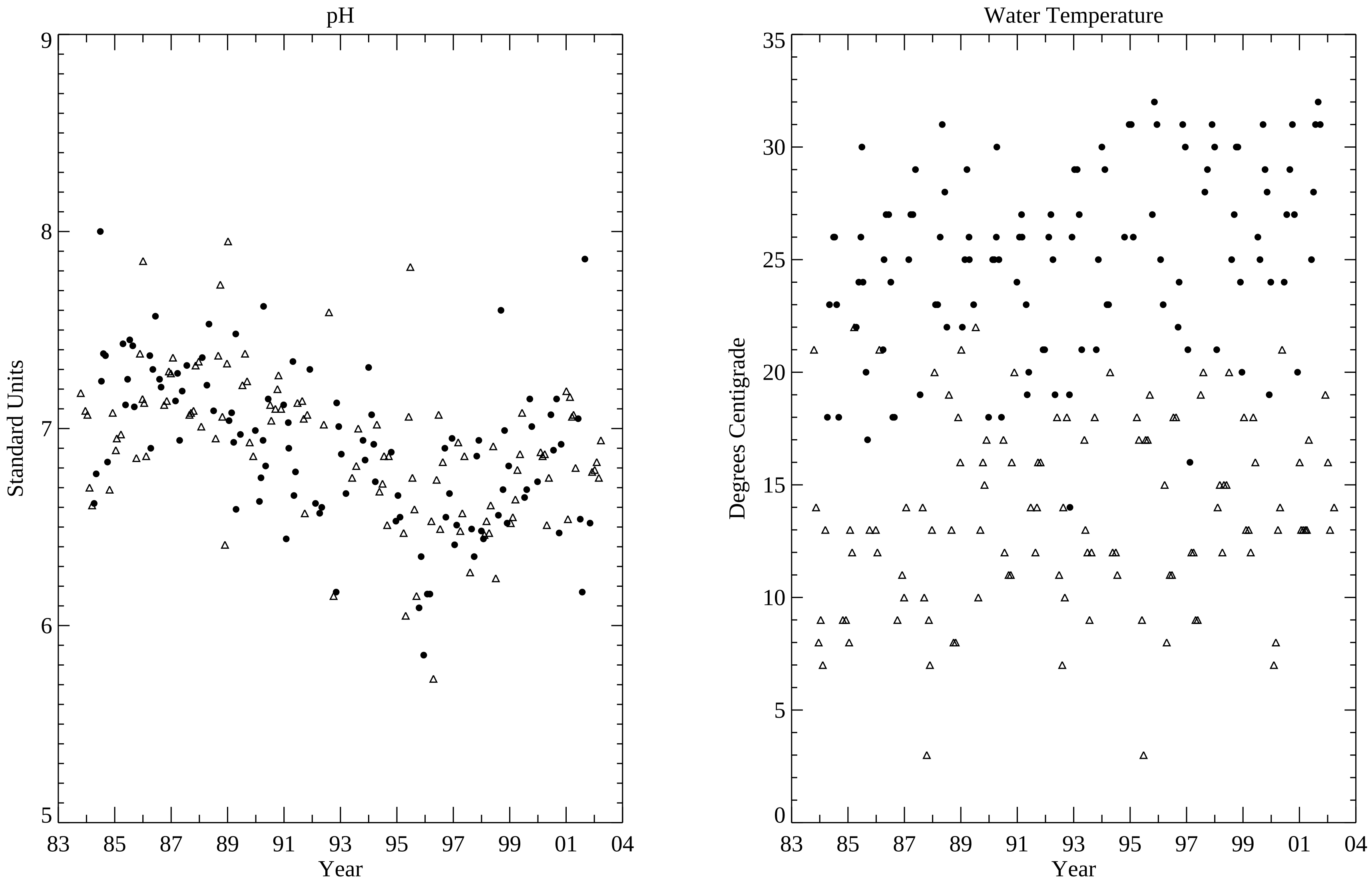


Figure 4.1 Temporal plot of ARK051 pH and Water Temperature data.

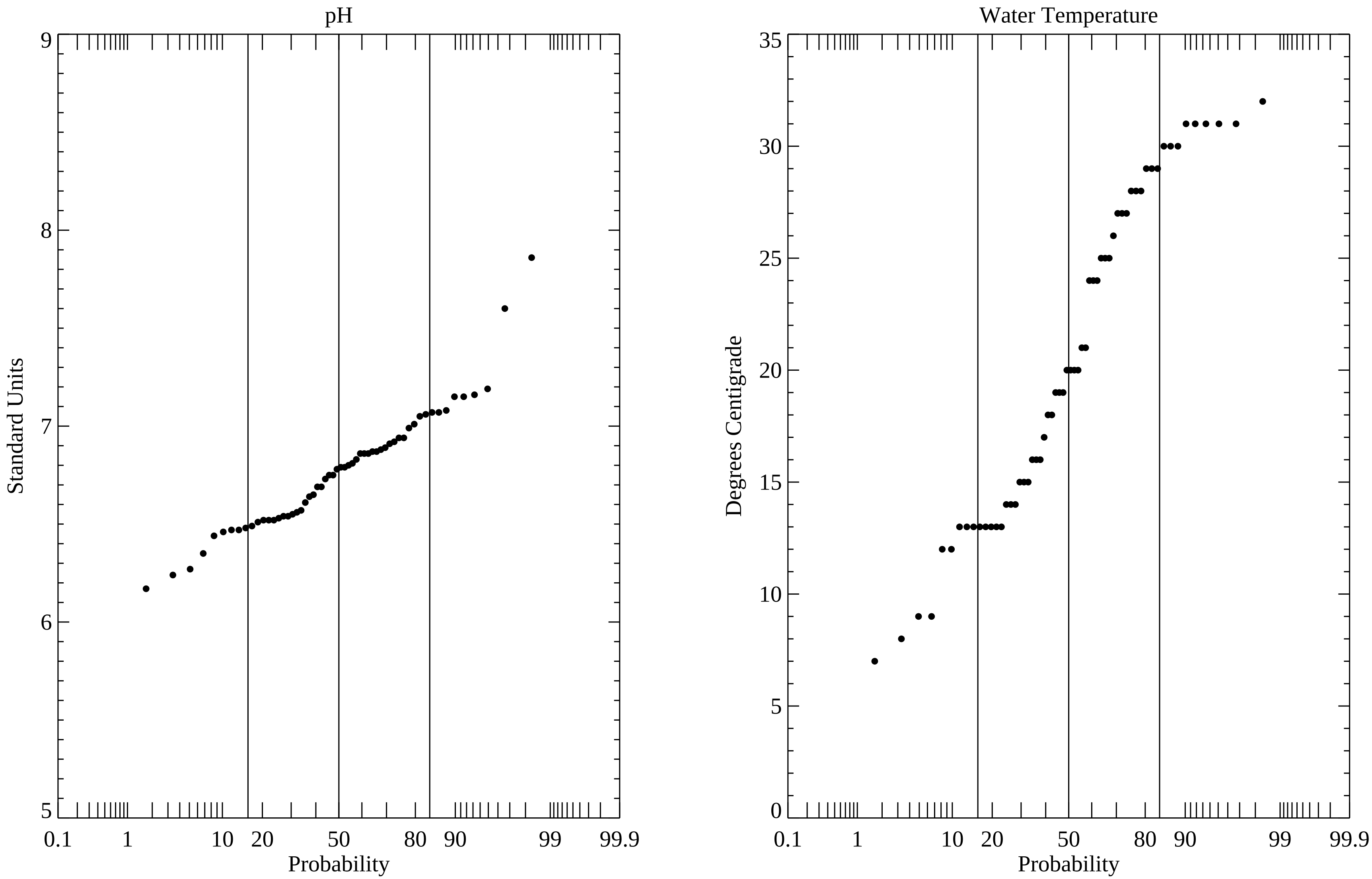


Figure 4.2 Probability plots of recent ARK051 pH and Water Temperature data (January 1998 - April 2003).

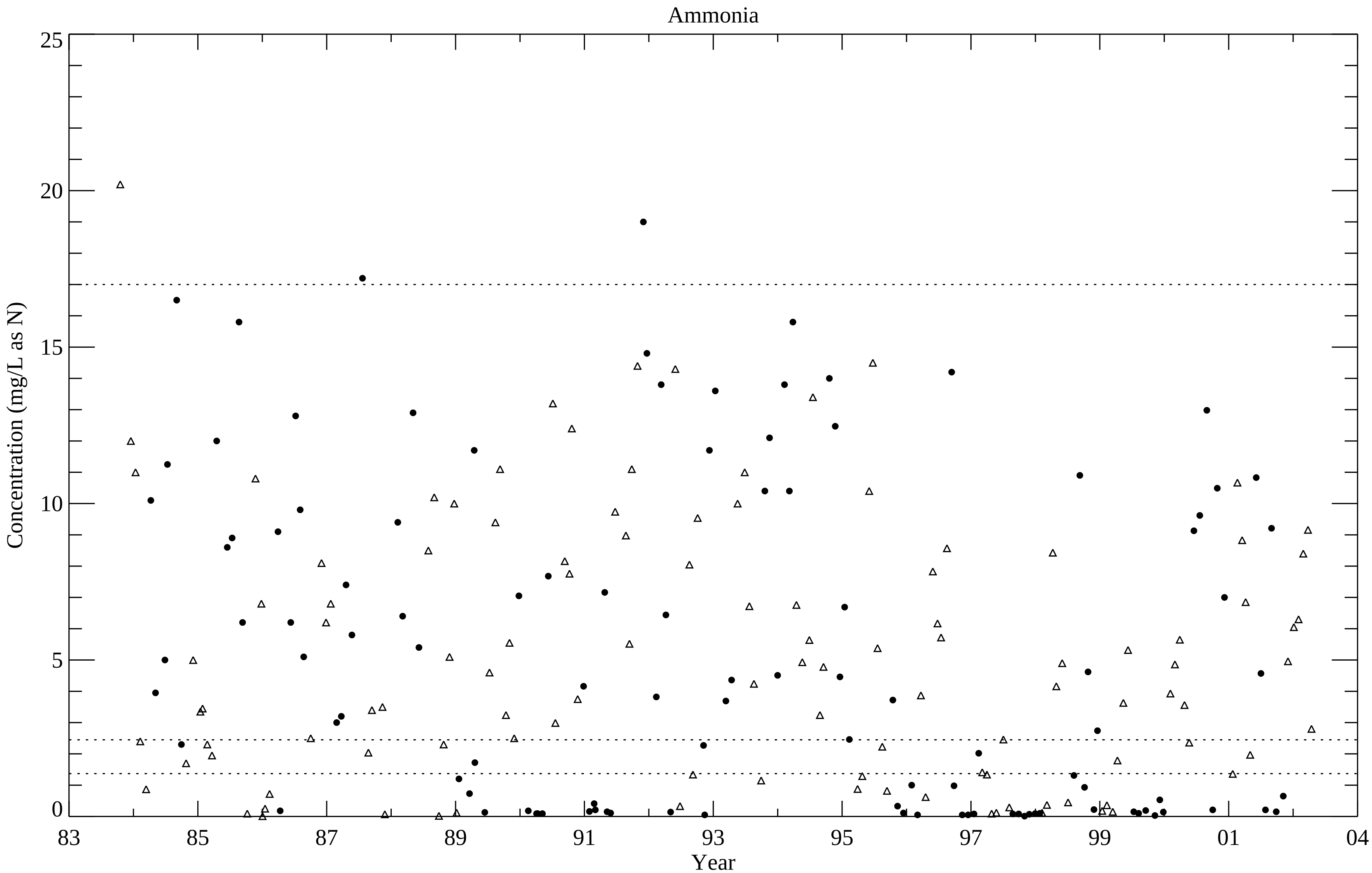


Figure 4.3 Temporal plot of ARK051 Ammonia data.

Notes:
1. The dashed line at 17 mg/l represents the CMC Standard for Ammonia for both seasons.
2. The dashed line at 2.45 mg/l represents the CCC Standard for Ammonia for the winter season.
3. The dashed line at 1.37 mg/l represents the CCC Standard for Ammonia for the summer season.

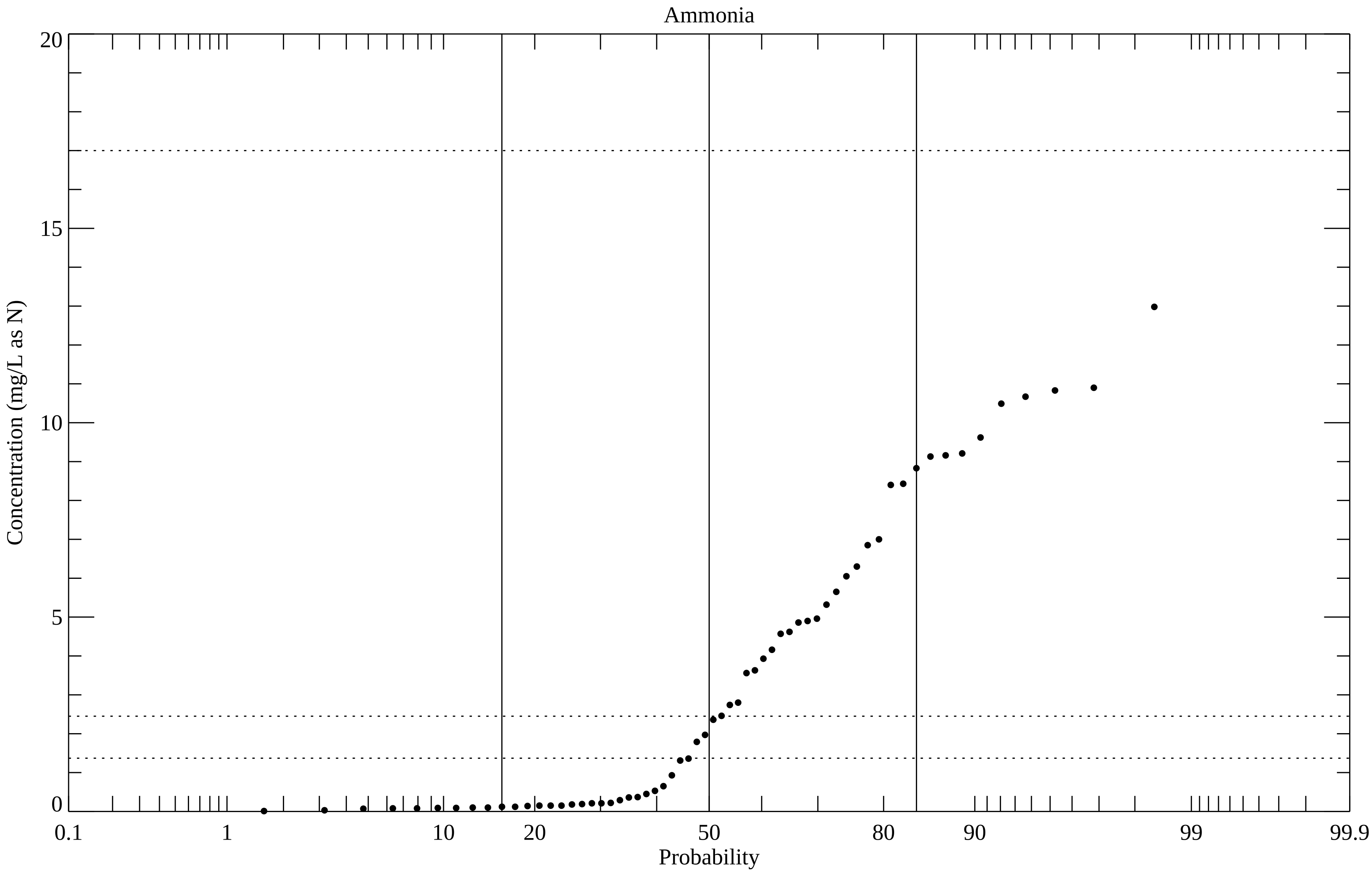


Figure 4.4 Probability plots of recent ARK051 Ammonia data (January 1998 - April 2003).

Notes:
1. The dashed line at 17 mg/l represents the CMC Standard for Ammonia for both seasons.
2. The dashed line at 2.45 mg/l represents the CCC Standard for Ammonia for the winter season.
3. The dashed line at 1.37 mg/l represents the CCC Standard for Ammonia for the summer season.

4.1.3 Nitrite+Nitrate

The ARK051 nitrite+nitrate measurements reported by ADEQ are illustrated in Figure 4.5. Figure 4.6 shows probability plots of the recent data at ARK051 for nitrite+nitrate, although it can be assumed that the percentage of nitrite in these measurements is insignificant. Inspection of these plots indicates the frequency of violations of the water quality standard (MCL of 10 mg/L for nitrate) at this station.

4.2 INTENSIVE SURVEY DATA

ADEQ performed an intensive water quality survey on Stone Dam Creek over a 3-day period in July 1996 (ADEQ 1997). The monitoring stations for this survey are shown in Figure 2.1 (SDC*** stations). During this effort, diurnal oxygen was measured at select stations, along with temperature, at 5-minute intervals. Also during this time period, a single sample was collected at each station for nutrients, field parameters, and dissolved metals (see Table A.3 in Appendix A). Although this dataset provides a snapshot of the spatial variability of water quality in Stone Dam Creek, these data were not utilized in the TMDL development for the following reasons:

- More recent and representative data are available from the Discharge Monitoring Reports (DMRs - see Section 5.3) and ARK051 routine monitoring (Section 4.1). These data suggest that water quality in Stone Dam Creek has changed markedly since the 1996 intensive survey, calling into question the present day validity of using this intensive survey data to make water quality assessment determinations.
- Water quality measurements taken during the intensive survey were limited to a single day.
- Primary producers (*e.g.* phytoplankton and periphyton) were not measured during the sampling program. This lack of data would complicate the calibration of a model that simulates nutrient uptake through production.

For these reasons, the intensive survey data were not used in the TMDL analysis, but were considered as indicators of the system's historical behavior.

4.3 HYDROLOGY

Flows in Stone Dam Creek derive from both point sources and nonpoint sources. Critical low flow from nonpoint sources is needed to characterize the critical condition. However, a review of USGS flow gaging stations indicated that no stations are located within the Stone Dam Creek watershed. To estimate the critical low flow condition (*i.e.* 7-day average, 10-year frequency low stream [7Q10] flow) for both summer and winter, a gaging station in a nearby watershed with similar land use was chosen. The Cadron Creek gage (USGS #07261000) is located in Arkansas Planning Segment 3D (hydrologic unit code [HUC] 11110205) and drains similar land uses as those found

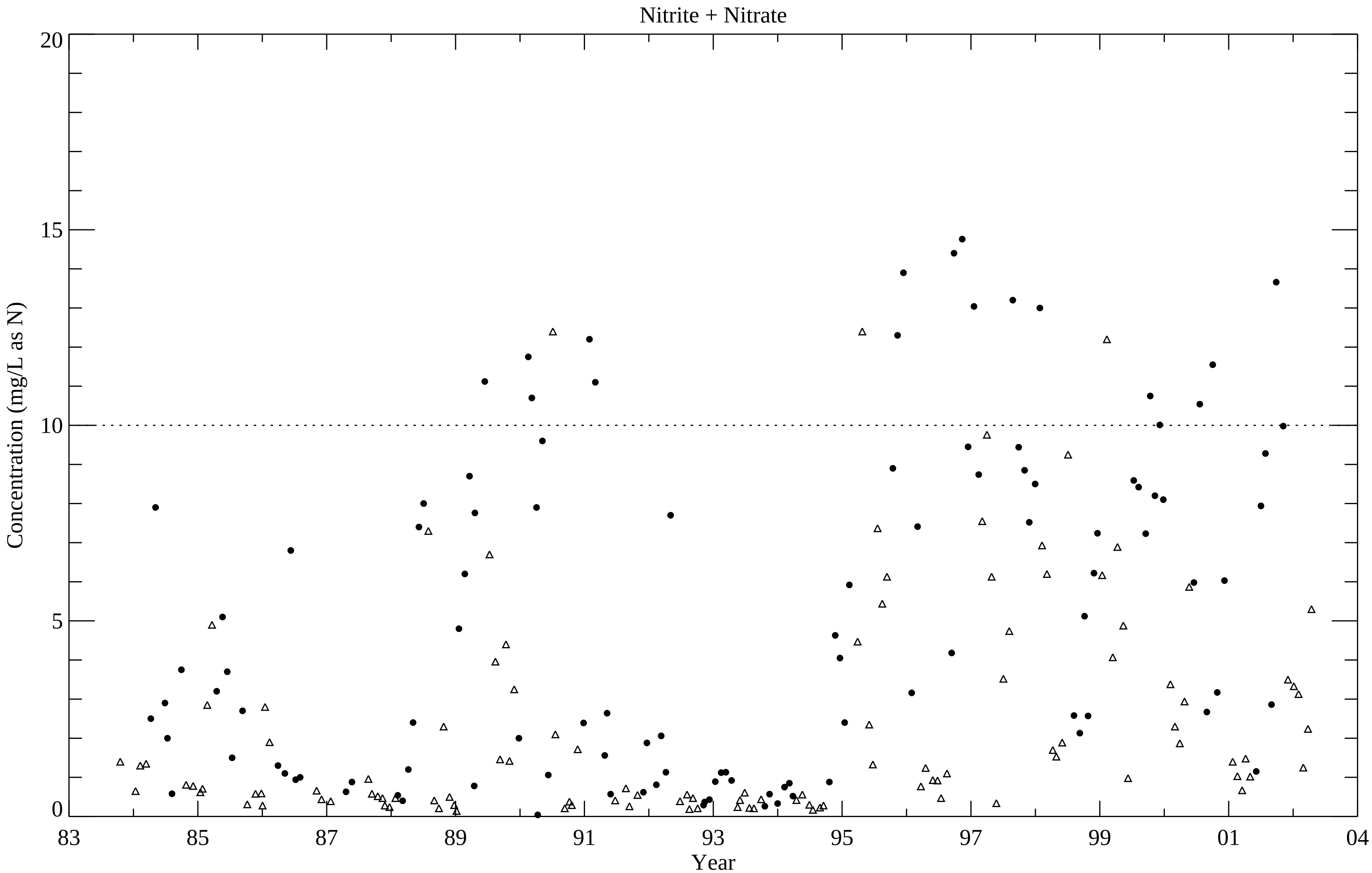


Figure 4.5 Temporal plot of ARK051 Nitrite + Nitrate data.

Note:
1. The dashed line at 10 mg/l represents the USEPA Drinking Water Standard for Nitrate.

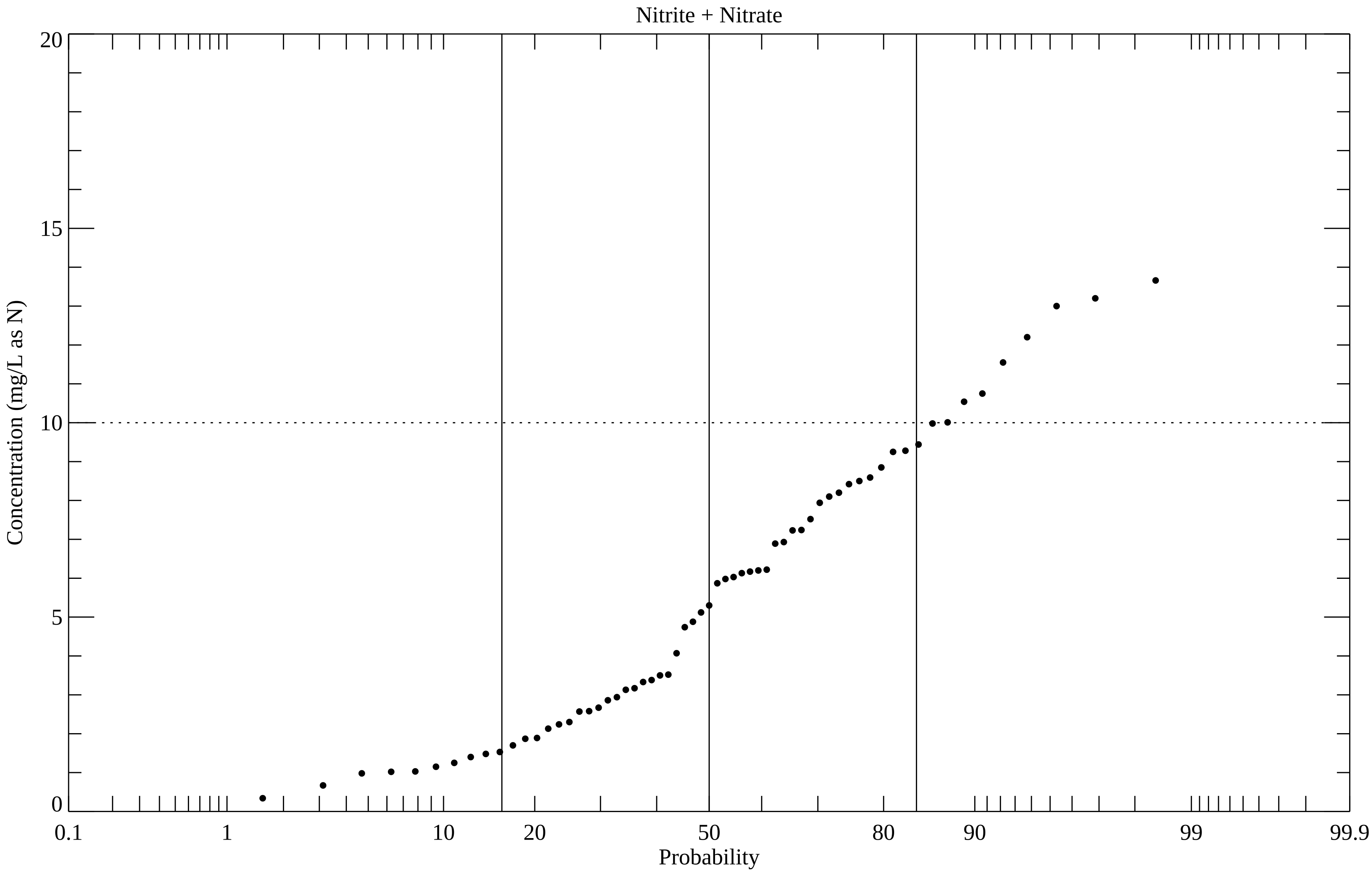


Figure 4.6 Probability plots of recent ARK051 Nitrite + Nitrate data (January 1998 - April 2003).

Note:
1. The dashed line at 10 mg/l represents the USEPA Drinking Water Standard for Nitrate.

around Stone Dam Creek. This gage drains 169 mi^2 and has a 48-year period of record (1954 – present). The analysis of flows on this creek for summer (May through October) and winter periods (November through April) yielded a 7Q10 of 0 cfs for both seasons.

Although these data suggest that an upstream condition of 0 cfs may occur in Stone Dam Creek, to account for potential dry weather watershed loadings in this TMDL determination, a background flow rate of 0.1 cfs is assumed in Stone Dam Creek. This flow rate is then augmented by the permitted flow rates for the WWTP and the service station to determine the TMDL under critical conditions.

4.4 NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES) DATA

Discharge monitoring reports (DMR) for all related point source dischargers to Stone Dam Creek were requested from the ADEQ. One primary discharger, the City of Conway WWTP, and two minor dischargers, were found to discharge to the creek. Because of the critical condition in Stone Dam Creek in both summer and winter, this discharge dominates water quality conditions in the creek. Figure 4.7 contains probability plots showing the information from recent DMRs (1998 – 2003). On these plots, both the monthly average of the monitored constituent, as well as the maximum recorded value for a given month are shown on the plots. Additional discussion of the available NPDES data is found in Section 5.

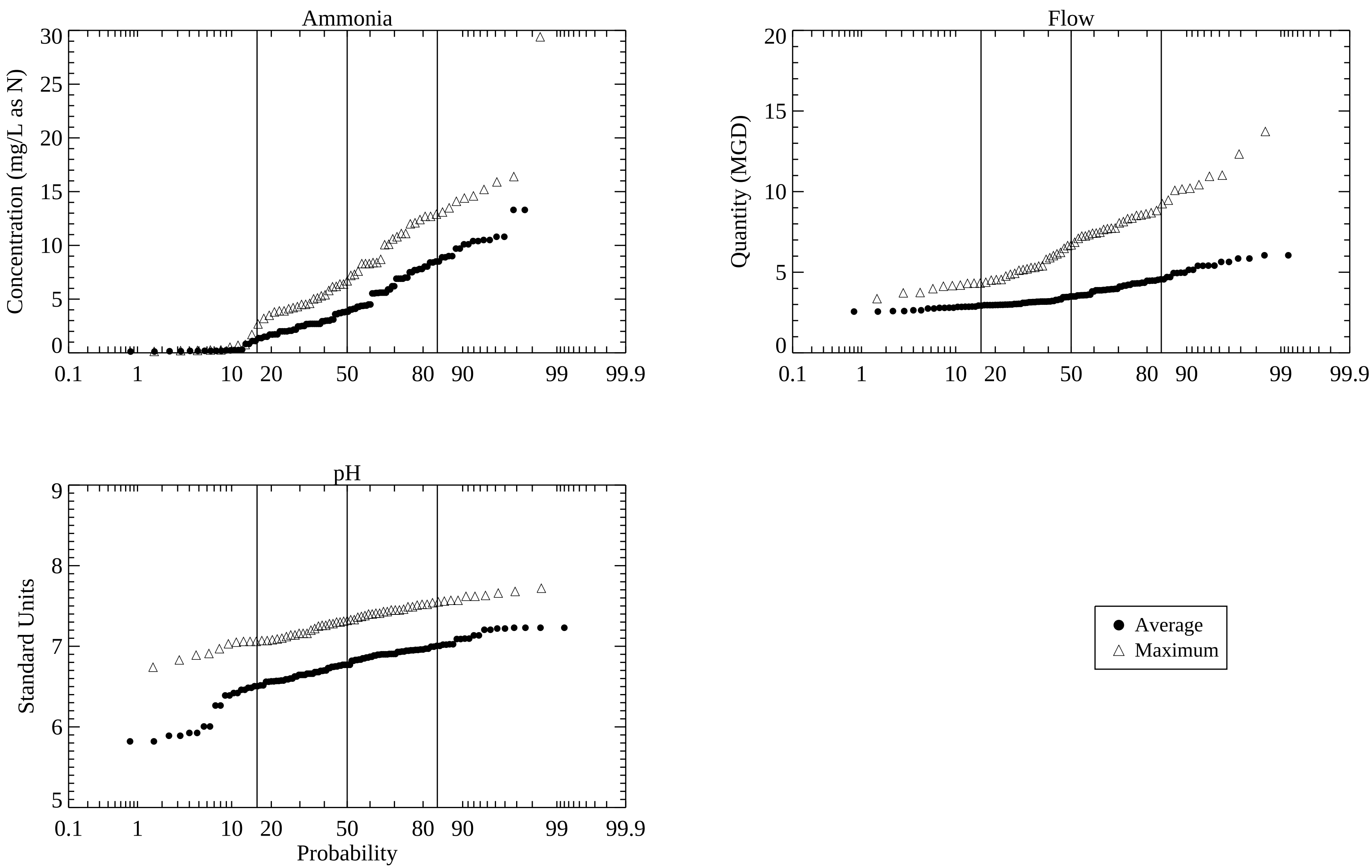


Figure 4.7 Probability plots of reported monthly average and monthly maximum values for select parameters at Conway WWTP (January 1998 - March 2003).

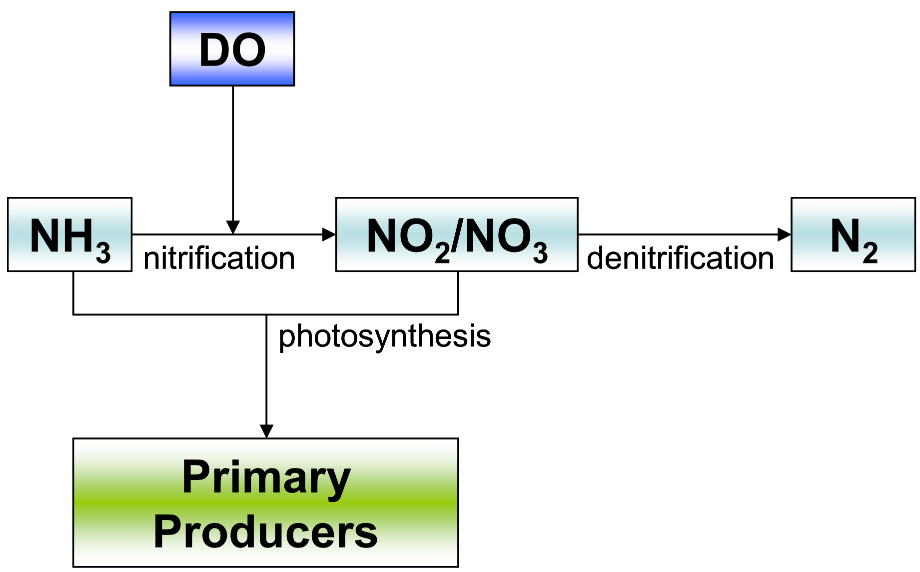
Average pH values were an average of the reported monthly minimum and maximum values.
Ammonia values, of 63.2 mg/L (average) and 102.9 mg/L (maximum), from January 31, 1999 are considered outliers and are not shown on this plot.

SECTION 5
IDENTIFICATION OF POLLUTANT SOURCES

5.1 NITROGEN PROCESSES

Nitrogen exists in many forms in the environment; however, a full model of all nitrogen forms is not necessary to capture the important processes occurring in Stone Dam Creek. Figure 5.1 shows the important nitrogen processes for this system. In general, there are two forms of nitrogen that are regulated: nitrate and ammonia. As illustrated in Figure 5.1, ammonia losses occur through nitrification and plant uptake. The nitrification of ammonia also causes a loss of oxygen at a ratio of 4.57:1 (4.57 mg/L O_2 lost for every 1 mg/L N nitrified). Nitrate loss mechanisms include uptake and denitrification (in anaerobic environments).

Figure 5.1 Important Nitrogen Processes in Stone Dam Creek



5.2 NITROGEN SOURCES

5.2.1 NPDES Permitted Discharges

ADEQ lists the NPDES permitted dischargers by Planning Segment in its 2002 305(b) report (ADEQ 2002b). Table 5.1 shows those dischargers listed in the 305(b) report whose primary receiving waters are Stone Dam Creek.

Table 5.1 NPDES Facilities with Nitrogen Limitations

NPDES No.	Facility Name	SIC Description	Permitted Flow (MGD)
AR0033359	City of Conway WWTP	Sewerage Systems	6
AR0043214	Rogers Group, Inc. – Conway Asphalt	Paving Mixtures and Blocks	Not Reported
AR0045071	Williams Express #3059	Gasoline Service Station	0.001

Of these three dischargers, only the City of Conway WWTP monitors for ammonia. The City of Conway WWTP reports monthly average concentrations and monthly maximum concentrations. None of the dischargers monitor nitrate in their effluent. Although the asphalt plant (NPDES No. AR0043214) does not have a reported design flow, recent reported flows on the USEPA permit compliance system (PCS) database show that this facility has an intermittent flow ranging from 0.00144 million gallons per day (MGD) to 0.373 MGD. The asphalt plant is unlikely to be a source of nitrogen, assuming the principal flow is from gravel washing. The service station has a stormwater permit and can be expected to be a source of some nitrate and ammonia, hence it will be included in the determination of loads.

5.2.2 Nonpoint sources

The critical condition for nonpoint source flow in Stone Dam Creek has been assumed to be 0.1 cfs. The ammonia and nitrate concentrations associated with this flow can be estimated from a nearby reference stream (Mill Creek, also in Faulkner County), as characterized in the Arkansas ecoregion study (ADPCE, 1987). The available data are from April, May, and August, hence, in Table 5.2, winter concentrations are based on April and May samples and summer concentrations are based on August samples. These data were used to establish a dry weather nonpoint source load to Stone Dam Creek.

Table 5.2 Concentrations in Mill Creek, Arkansas

Season	Average Ammonia (mg/L)	Average Nitrate (mg/L)
Summer	0.07	0.02
Winter	0.05	0.04

It should be noted that there are no data in this watershed from which nonpoint source loadings can be estimated. However, concentrations reported in other studies for runoff from pasture land are lower than the water quality targets for nitrate and ammonia. CH2M Hill (2000) sites nonpoint source concentrations of 0.4 mg/L nitrate and 0.1 mg/L ammonia from cropland and pasture. The nitrate estimate is approximately 25 times lower than the water quality target, and the ammonia estimate is about 13 times lower than the most stringent ammonia water quality target (see Sections 3.2 and 6.1.2 for a discussion of the water quality targets). These numbers indicate that, runoff from pasture land is not likely to cause an exceedance of the water quality targets in Stone Dam Creek. If WQS are not met after in this TMDL is issued, it will be necessary to conduct additional high flow studies to better quantify NPS loads and modify the TMDL accordingly.

SECTION 6
TMDL CALCULATIONS

6.1 AMMONIA

6.1.1 TMDL Target Determination

To determine the maximum allowable ammonia loading to Stone Dam Creek based on the ammonia standard for fish toxicity, both acute effect and chronic effects must be considered. Acute effects where salmonid fish are not present, are defined by the following Criterion Maximum Concentration (CMC) equation

$$CMC = \left(\frac{0.411}{1 + 10^{7.204 - pH}} + \frac{58.4}{1 + 10^{pH - 7.204}} \right) \qquad (6\text{-}1)$$

where: pH = instream pH value

The CMC value is a 1-hour average not to be exceeded more than once every 3 years. Chronic effects when early life stages are present are defined by the following Criterion Continuous Concentration (CCC) equation:

$$CCC = \left(\frac{0.0577}{1 + 10^{7.688 - pH}} + \frac{2.487}{1 + 10^{pH - 7.688}} \right) \bullet MIN\left(2.82, 1.45 \bullet 10^{0.028(25-T)}\right)$$

(6-2)

where: T = instream temperature in °C

The CCC value is a 30-day average not to be exceeded more than once every 3 years.

The CMC depends on pH and the CCC depends on both temperature and pH. Because the WWTP effluent dominates flow in the creek, the WWTP effluent data on temperature and pH will be used to specify these parameters in the creek. Conservative criteria for ammonia concentrations are calculated here, *i.e.* conservative temperature and pH values are used.

The CMC was calculated for the summer and winter periods as follows. The upper 90^{th} percentile of the pH values measured in the WWTP effluent in summer was selected to be conservative (higher pH values result in lower permissible concentrations; data collected 1998-2002). This value corresponds to a pH of 7.6. The CMC equation (Equation 6-1) was then used to determine a summertime CMC of 17.0 mg/L. Similarly for winter, the upper 90^{th} percentile pH value was 7.6 mg/L. Therefore, the wintertime CMC is identical to the summer CMC: 17.0 mg/L

To calculate the CCC for summer and winter, the following steps were taken. For summer, the upper 90^{th} percentile pH value used in the CMC calculation (7.6) was again used, along with the maximum temperature allowed by ADEQ (31°C, to be conservative). These were applied to the CCC equation (Equation 6-2), resulting in a summertime CCC of 1.37 mg/L. For the winter, the upper 90th percentile wintertime pH was used (again 7.6) with the maximum regulated temperature (22°C, to be conservative), resulting in a wintertime CCC of 2.45 mg/L. The water quality targets are summarized in Table 6.1.

Table 6.1 Instream Target Concentrations for Ammonia

Season	CCC (mg/L)	CMC (mg/L)
Summer	1.37	17.0
Winter	2.45	17.0

6.1.2 TMDL Load Calculation

Based on the conservatively calculated CMCs and CCCs, the TMDL for summer and winter can be found using the TMDL equation below.

$$TMDL = WLA1 + WLA2 + LA + MOS \tag{6.3}$$

$$C_{instream}Q_{instream} = C_{WWTP}Q_{WWTP} + C_{Service}Q_{Service} + C_{NPS}Q_{NPS} + MOS$$

where

$C_{instream}$	=	Instream target concentration
$Q_{instream}$	=	Instream total flow
C_{WWTP}	=	WWTP target concentration
Q_{WWTP}	=	WWTP flow
$C_{Service}$	=	Service stations target concentration
$Q_{Service}$	=	Service station flow
C_{NPS}	=	Nonpoint source concentration
Q_{NPS}	=	Nonpoint source flow
MOS	=	Margin of safety

This TMDL requires that the ammonia criteria (CMC and CCC – Section 6.1.1) to be met within the stream (i.e., $C_{instream}$). Because the WWTP discharge constitutes the majority of the flow in, and loading to, Stone Dam Creek during critical conditions, the background and service station loads will be held constant and a target percent reduction in WWTP concentration will be calculated. Based on the nonpoint and service station flows and concentrations, the WWTP permitted flow, and the target instream ammonia concentrations (CMC and CCC), the target WWTP concentration can be calculated by a mass balance. The final TMDL is summarized in Table 6.2. Details on the concentration and flows used for this TMDL are detailed in Section 6.1.3.

Table 6.2 Recommended TMDL for Ammonia

Season	Source	Recommended TMDL (lb/day)
Summer		
	LA: Watershed	0.038
	WLA1: Conway WWTP	69.1
	WLA2: Service Station	0.009
	Total Load	**69.2**
Winter		
	LA: Watershed	0.027
	WLA1: Conway WWTP	124.2
	WLA2: Service Station	0.009
	Total Load	**124.2**

The specific target ammonia concentrations depend on the temperature and pH of the effluent (see Section 6.1.1). In addition, achievement of the criteria concentrations will require reductions in both the overall average ammonia concentration in the effluent as well as individual monthly averages and extreme values. Furthermore, the required reduction will depend on the seasonal pattern of the ammonia concentrations: greater reductions will be required to the extent that extreme ammonia concentrations coincide with low (or zero) flow in the creek, and less reduction will be required to the extent that extreme values occur at times when nonpoint flows are available for dilution of the effluent. Therefore, the particular technology used to meet the TMDL requirements should consider both effects on average ammonia levels, effects on the distribution, or variance, of ammonia concentrations, and seasonal pattern of ammonia levels and nonpoint flows.

6.1.3 Percent Reductions

The calculations of percent reductions in concentration (and load) for summer and winter are illustrated here. The distribution of summer monthly averages and monthly maximums are presented in Figure 6.1. Superimposed on this figure are the CMCs and CCCs, which are to be compared to the monthly maximums and monthly averages, respectively. Also shown on this figure is a dashed vertical line denoting an exceedance probability of once in 3 years (based on USEPA guidance, equal to one monthly value in 36 months or 2.8 percent). Data values closest to the 2.8 percent level will be termed the extreme values.

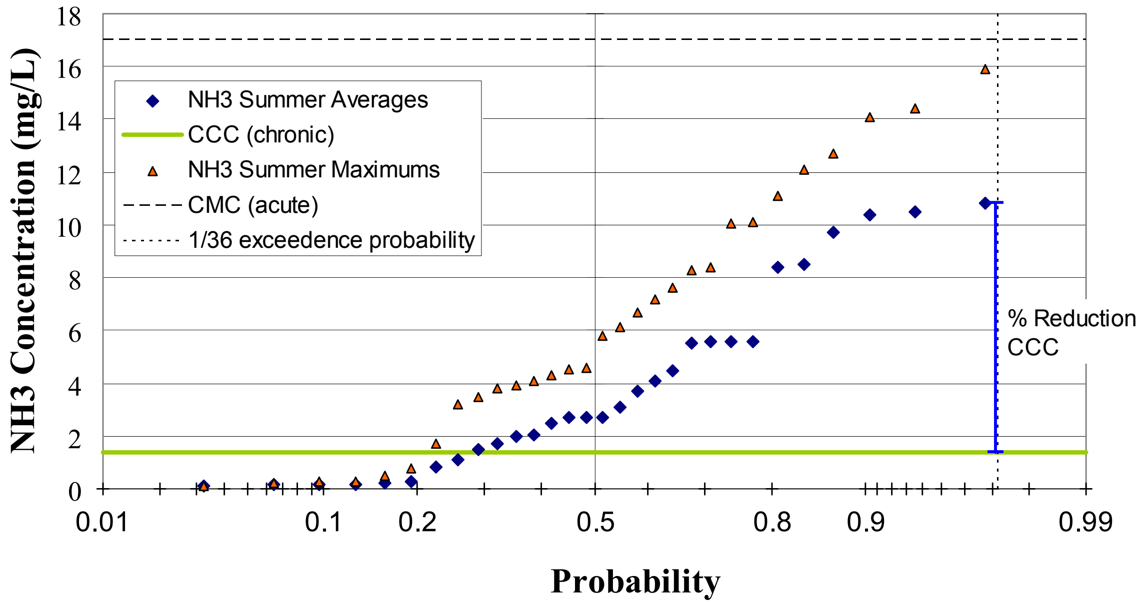


Figure 6.1 Probability Plot of Summertime Ammonia Monthly Maximums and Monthly Averages at the Conway WWTP

The summer maxima are all lower than the CMC, and thus this criterion is satisfied under present conditions (Figure 6.1). 70% of the summer monthly averages exceed the CCC, however. The monthly average ammonia concentration that occurs with a frequency of 1 in 3 years must be reduced by 87 percent. The median of the monthly averages must also be reduced, although by a smaller percentage, to achieve the CCC.

Similar steps were followed for the winter period (Figure 6.2). In this case, based on the highest winter average, the monthly maximums will require a 42 percent decrease to meet the CMC. The monthly maximum (29 mg/L) upon which this decrease is based appears to be an outlier; thus, the required decrease is uncertain. The winter monthly average ammonia concentration that occurs with a frequency of 1 in 3 years must be reduced by 81 percent to meet the CCC . As for summer, the median of the winter monthly averages is also greater than the CCC and must be reduced. Presumably, an 81 percent reduction in the monthly averages will result in at least a 42 percent reduction in the monthly maximums, thereby meeting the CMC criteria (whether or not the maximum value is an outlier). These calculations are summarized in Tables 6.3-6.6.

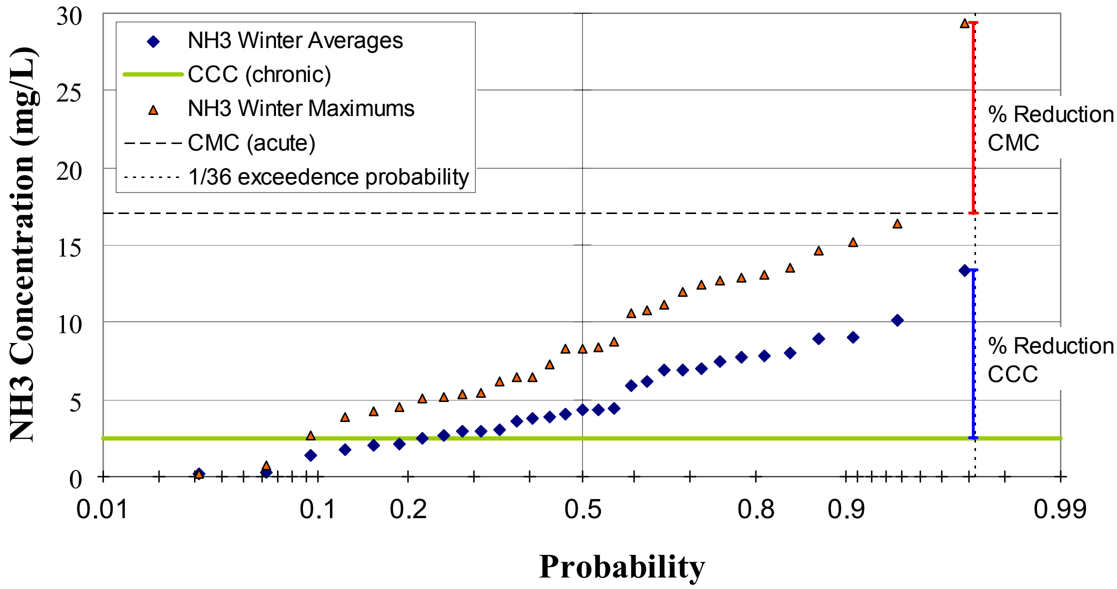


Figure 6.2 Probability Plot of Wintertime Ammonia Monthly Maximums and Monthly Averages at the Conway WWTP (Note: January 31, 1999 measurements of 63.2 mg/L, average, and 102.9, maximum were considered outliers and are not shown on this plot.)

Table 6.3 Estimation of Existing Ammonia Loads based on Extreme Value of Monthly Averages

Season Source	Permitted or Estimated Flow (cfs)	Extreme Value of Monthly Averages (mg/L)	Estimated Load (lb/day)
Summer			
Watershed	0.1	0.07 (Literature)[1]	0.038
Conway WWTP	9.3	10.8 (Data)	542
Service Station	0.0015	1.1 (Literature)[2]	0.009
Total Load			**542**
Winter			
Watershed	0.1	0.05 (Literature)[1]	0.027
Conway WWTP	9.3	13.3 (Data)	667
Service Station	0.0015	1.1 (Literature)[2]	0.009
Total Load			**667**

1 ADPCE (1987)
2 Schueler (1997)

Table 6.4 Calculation of Required Percent Reductions in Ammonia Concentration based on Extreme Value of Monthly Averages (CCC Value)

A	B	C	D	E	F	G	H
	Existing Load (lb/d)	Sum of Flows (cfs)	Estimated Existing Stream Conc. (mg/L)	Target Stream Conc. (CCC, mg/L) $C_{instream}$	Existing WWTP Conc. (mg/L)	Target WWTP Conc. (mg/L)	Percent Reduction
Season	*[Table 6.3]*	*[Table 6.3]*	*[=colB/colC]*	*[See text]*	*[Table 6.3]*	*[See text]*	*[=(colF-colG)/colF]*
Summer	542	9.4	10.7	1.37	10.8	1.38	87%
Winter	667	9.4	13.2	2.45	13.3	2.48	81%

The target WWTP concentration is calculated by rearranging the TMDL equation (Eqn. 6.3) from Section 6.1.2 to:

$$C_{WWTP} = \frac{C_{instream} * Q_{instream} - \text{NPS Load (LA)} - \text{Service Station Load (WLA2)}}{Q_{WWTP}}$$

Table 6.5 Estimation of Existing Ammonia Loads based on Extreme Value of Monthly Maximums

Season Source	Permitted or Estimated Flow (cfs)	Extreme Value of Monthly Maximums (mg/L)	Estimated Load (lb/day)
Summer			
Watershed	0.1	0.07 (Literature)[1]	0.038
Conway WWTP	9.3	15.9 (Data)	798
Service Station	0.0015	1.1 (Literature)[2]	0.009
Total Load			**798**
Winter			
Watershed	0.1	0.05 (Literature)[1]	0.027
Conway WWTP	9.3	29.4 (Data)	1475
Service Station	0.0015	1.1 (Literature)[2]	0.009
Total Load			**1475**

[1]ADPCE (1987)
[2]Schueler (1997)

Table 6.6 Calculation of Required Percent Reductions in Ammonia Concentration based on Extreme Value of Monthly Maximums (CMC Value)

Season	Existing Load (lb/d)	Sum of Flows (cfs)	Estimated Existing Stream Conc. (mg/L)	Target Stream Conc. (CMC, mg/L) $C_{instream}$	Existing WWTP Conc. (mg/L)	Target WWTP Conc. (mg/L)	Percent Reduction
Summer	798	9.4	15.7	17.0	15.9	17.2	0%
Winter	1475	9.4	29.1	17.0	29.4	17.2	42%

For both the summer and winter periods, the CCC is more stringent, requiring an estimated 87 percent reduction in the summer and an 81 percent reduction in the winter (Table 6.4).

There are several sources of uncertainty associated with the percent reductions in the WWTP effluent required to meet the conditions of the TMDL. First, the winter maximum appears to be an outlier. Second, the correlation between nonpoint flow and effluent ammonia concentrations is uncertain, producing uncertainty in the reductions in effluent ammonia that are required to meet instream criteria. Third, impacts of future process improvements on correlations between effluent pH, temperature, and ammonia are not known. Fourth, treatment improvements that reduce overall average ammonia concentrations, individual monthly averages, and maximum ammonia concentrations can be used to meet the TMDL, so specific reduction goals cannot be specified without consideration of the operational improvements to be employed.

6.1.4 Margin of Safety

The CWA requires that TMDLs take into consideration a margin of safety (MOS). USEPA guidance allows for the use of implicit or explicit expressions of the MOS or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a percentage of the load is factored into the TMDL calculation as an MOS, the MOS is explicit. The following conservative assumptions were made providing an implicit MOS, as an explicit MOS was not considered appropriate.

- The maximum allowable temperature was used for the ammonia toxicity standard calculations.
- The upper 10 percent pH value was used for the ammonia toxicity standard calculations.
- Fish early life stages were assumed to be present in Stone Dam Creek for the ammonia toxicity standard calculation.

6.2 NITRATE

6.2.1 TMDL Target Determination

Because the WWTP does not monitor nitrate concentrations, this TMDL establishes the allowable nitrate concentration in the WWTP effluent, but does not calculate a percent reduction from current conditions.

The regulatory target is 10 mgN/L nitrate. The number of exceedences, as well as the average value of these exceedences is presented in Table 6.7.

Table 6.7 Exceedences of Nitrate Concentrations at ARK051 (1998 – 2003)

Season	Number of Exceedences	Average Concentration of Exceedences (mg/L)
Summer	7	11.8
Winter	1	12.2

The standard of 10 mg/L must be met at ARK051. The concentration of nitrate at ARK051 is influenced by both the load of nitrate from the WWTP as well as instream nitrification of ammonia released from the plant between the WWTP discharge and ARK051. This was estimated by comparing average ammonia concentrations in the WWTP effluent and at ARK051. Assuming no ammonia losses due to uptake, the difference in ammonia concentration provides an upper-bound estimate of the amount of ammonia nitrified in the stream. The average ammonia concentrations measured at the WWTP and ARK051 (1998 to present) are presented in Table 6.8.

Table 6.8 Estimate of In-Stream Nitrification Based on Average Ammonia Concentrations at WWTP and ARK051

Season	NH_3-N Concentration WWTP (mg/L)	NH_3-N Concentration ARK051 (mg/L)	NH3-N Nitrified (mg/L)
Summer	3.9	3.2	0.7
Winter	5.0	3.8	1.2

Based on these values, the estimated maximum quantity of ammonia nitrified in this reach of Stone Dam Creek is 1.2 mg/L in the winter and 0.7 mg/L in the summer.

6.2.2 TMDL Calculation

The TMDL for nitrate is calculated using the same equation as for ammonia (Eqn. 6.3). For this calculation, the allowable concentrations and flows to determine WLA1, WLA2, and LA are necessary. Nitrate loads due to watershed sources and the service station can be estimated from permitted flows and the literature. These flows and concentrations are detailed in Table 6.9.

Table 6.9 Estimation of Existing Nitrate Nonpoint and Service Stations Loads

Season Source	Permitted or Estimated Flow (cfs)	Estimated Concentration (mg/L)	Estimated Load (lb/day)
Summer			
LA: Watershed	0.1 (Estimated)	0.02 (Literature) [1]	0.01
WLA2: Service Station	0.0015 (Permitted)	8.9 (Literature) [2]	0.07
Winter			
LA: Watershed	0.1	0.04 (Literature) [1]	0.02
WLA2: Service Station	0.0015	8.9(Literature) [2]	0.07

[1]ADPCE (1987)
[2]Schueler (1997)

Assuming nitrification, the resulting maximum allowable nitrate concentrations in the WWTP discharge are shown in Table 6.10.

Table 6.10 Calculation of Target Nitrate Concentration in the WWTP Effluent

Season	Target NO_3 Concentration at ARK051 (mg/L) $C_{instream}$	Estimation of Nitrification (mg/L)	Target NO_3 Concentration in Creek Immediately Downstream of WWTP (mg/L)	Target NO_3 Concentration in WWTP Effluent (mg/L)
Summer	10.0	0.7	9.3	9.4
Winter	10.0	1.2	8.8	8.9

The target nitrate concentration in the WWTP effluent is calculated in a similar manner as the ammonia, by rearranging Eqn 6.3:

$$C_{WWTP} = \frac{C_{instream} * Q_{instream} - \text{NPS Load (LA)} - \text{Service Station Load (WLA2)}}{Q_{WWTP}}$$

Based on these effluent concentrations, the WLA for the WWTP can be determined at the permitted flow (6 MGD), as shown in Table 6.11.

Table 6.11 Recommended WLA1 for Nitrate for Conway WWTP

Season	NO_3 Concentration in WWTP Effluent (mg/L)	WLA1 (lb/d)
Summer	9.4	471
Winter	8.9	446

In summary, the recommended TMDL for nitrate for Stone Dam Creek is detailed in Table 6.12.

Table 6.12 Recommended TMDL for Nitrate

Season	Source	Recommended TMDL (lb/day)
Summer		
	LA: Watershed	0.01
	WLA1: Conway WWTP	471
	WLA2: Service Station	0.07
	Total Load	**471.1**
Winter		
	LA: Watershed	0.02
	WLA1: Conway WWTP	446
	WLA2: Service Station	0.07
	Total Load	**446.1**

Based on the relatively small loading of the nonpoint and service station sources, and the observation of nitrate exceedences at ARK051, it is likely that the Conway WWTP effluent occasionally exceeds the target nitrate concentration. Thus, this TMDL will require a reduction in nitrate in the WWTP effluent. This TMDL will also require a reduction in the ammonia loading from the WWTP. The presumptive approach to reducing ammonia is nitrification, which will result in an equal increase in the nitrate concentration. Thus, because of the additional nitrate that would be added to the effluent following increase nitrification, the WWTP will need to improve nitrate removal in its treatment processes to ensure that the nitrate concentration is always below the values given in Table 6.11, even after enhanced nitrification.

6.2.3 Margin of Safety

The CWA requires that TMDLs take into consideration a MOS. USEPA guidance allows for the use of implicit or explicit expressions of the MOS or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a percentage of the load is factored into the TMDL calculation as an MOS, the MOS is explicit. The following conservative assumptions were made providing an implicit MOS, as an explicit MOS was not considered appropriate.

- Assumed maximum estimated nitrification in Stone Dam Creek from WWTP discharge to ARK051.
- No loss of nitrite or nitrate in the creek is assumed to occur due to plant uptake or denitrification.

6.3 ONGOING AND FUTURE POLLUTANT LOADING REDUCTIONS

Because the WWTP discharge constitutes the majority of the flow in Stone Dam Creek during critical conditions, the allowable concentrations for ammonia and nitrate given in Section 6 should be the focal point of the permitting process. Conservatively, an average monthly concentration of ammonia of 1.38 mg/L in the summer and 2.48 mg/L in the winter should not be exceeded more than once every three years. The nitrate concentrations of 9.4 mg/L (summer) and 8.9 mg/L (winter) should not be exceeded in the WWTP effluent. In addition, it is suggested that the WWTP begin to monitor nitrate from their discharge in order to quantify their input and gain a better understanding of nitrogen processes occurring in the creek.

It should also be noted that because TMDL will require a reduction in the ammonia loading from the WWTP, careful consideration to its method of reduction within the treatment process should occur. The presumptive approach to reducing ammonia is nitrification, which will result in an equal increase in the nitrate concentration. Thus, because of the additional nitrate that would be added to the effluent following increase nitrification, the WWTP will need to improve nitrate removal in its treatment processes to ensure that the nitrate concentration is below the maximum values, even after enhanced nitrification

6.4 ADAPTIVE MANAGEMENT RECOMMENDATIONS

ADEQ and USEPA will work together to develop recommendations for achieving the TMDL through existing mechanisms and programs. Recommendations could include:

- Consideration of ongoing ammonia and nitrate controls at the WWTP discharge.
- Synchronize the WWTP effluent monitoring with the in-stream monitoring at ARK051 to obtain a better understanding of the stream response to effluent discharges.
- If it is found that the water quality standards are not met, even after WWTP concentration reductions, consider wet-weather monitoring in the creek in an attempt to quantify nonpoint source loadings from pasture and urban lands.

This information can be used to enhance the understanding of the system and ensure that a reduction of ammonia and nitrate from the WWTP will maintain the ammonia and nitrate water quality target in the creek. If, following implementation of effluent controls and additional monitoring, water quality criteria are still violated, the new monitoring data would provide the basis for the development of a steady state water quality model which could be used to guide further WWTP improvements.

SECTION 7
PUBLIC PARTICIPATION

When USEPA establishes a TMDL, 40 C.F.R. § 130.7(d)(2) requires USEPA to publish a public notice and seek comments concerning the TMDL. USEPA prepared these TMDLs pursuant to the consent decree required by Sierra Club V. Whitman, Case No. LR-C-99-114 (E.D. Ark). Federal regulation requires that public notice be provided through the Federal Register and through newspapers published in the local area. The Federal Register notice was issued on October 1, 2003 (Volume 68, Number 190, and page 56632). No comments were received by USEPA during the 30-day public comment period. USEPA has provided notice to ADEQ that these TMDLs have been made final. USEPA has requested ADEQ to incorporate the TMDL into the state Water Quality Management Plan.

SECTION 8
LIST OF REFERENCES

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APPENDIX A
SUMMARY OF ADEQ WATER QUALITY DATA

Table A.1 Recent ARK051 Nutrient Data

Date	Ammonia	NO2_NO3_N	Ortho-phosphate	Total Phosphorus	TKN	TOC	BOD
	(mg/L as N)	(mg/L as N)	(mg/L as P)	(mg/L as P)	(mg/L)	(mg/L)	(mg/L)
01/13/1998	0.09	6.13	1.21	1.48	1.31	8.70	1.97
02/10/1998	0.12	0.34	0.04	0.45	1.51	6.60	5.67
03/24/1998	2.46	3.52	1.16	1.35	3.79	8.70	3.20
04/28/1998	0.29	4.74	0.85	0.94	1.94	9.30	3.64
05/19/1998	0.08	13.20	2.89	2.98	0.59	9.40	3.14
06/23/1998	0.08	9.44	2.25	--	1.22	9.60	2.57
07/28/1998	0.01	8.85	2.49	2.58	1.24	9.40	4.99
08/25/1998	0.07	7.52	1.85	2.05	1.42	8.50	3.90
09/29/1998	0.09	8.50	2.43	2.56	0.99	0.00	2.16
10/27/1998	0.10	13.00	2.19	2.28	0.05 (BDL)	7.80	1.40
11/09/1998	0.12	6.93	1.80	1.90	0.51	8.30	2.21
12/08/1998	0.37	6.20	1.20	1.37	1.49	9.00	2.29
01/12/1999	8.43	1.70	1.29	1.58	11.97	12.70	4.08
02/02/1999	4.16	1.53	0.80	1.17	5.98	9.80	2.40
03/09/1999	4.90	1.89	0.81	1.01	7.60	--	5.18
04/13/1999	0.45	9.25	1.72	2.08	1.34	12.30	5.57
05/18/1999	1.31	2.58	0.57	0.77	3.12	10.80	6.56
06/22/1999	10.90	2.13	1.95	2.02	15.10	12.34	7.14
07/20/1999	0.93	5.12	1.60	1.79	--	7.49	5.41
08/10/1999	4.62	2.57	2.41	2.75	6.95	8.70	5.60
09/14/1999	0.22	6.22	1.39	1.45	--	6.52	2.21
10/05/1999	2.74	7.24	2.23	2.27	3.29	7.50	--
11/02/1999	0.18	6.17	0.80	1.05	1.00	6.52	--
11/30/1999	0.36	12.20	1.73	1.91	0.70	4.10	1.77
01/04/2000	0.15	4.07	0.74	1.08	1.68	9.30	4.64
02/01/2000	1.79	6.89	1.14	1.48	4.05	10.60	7.41
03/07/2000	3.63	4.88	1.08	1.43	--	9.19	6.94
04/04/2000	5.32	0.98	0.79	0.99	6.87	7.86	6.85
05/08/2000	0.15	8.59	1.00	1.13	0.48	7.34	2.08
06/06/2000	0.10	8.42	1.48	1.62	0.89	6.34	1.61
07/18/2000	0.19	7.23	1.70	1.76	--	8.42	1.58
08/14/2000	(BDL)	10.75	2.34	2.31	0.62	4.87	1.54
09/11/2000	0.03	8.20	2.25	--	--	6.90	0.72
10/10/2000	0.53	10.01	1.97	2.19	--	7.31	--
10/31/2000	0.14	8.10	1.92	2.20	--	5.39	1.47
12/12/2000	3.93	3.38	0.84	1.10	5.32	9.60	--
01/08/2001	4.86	2.30	0.92	1.11	7.05	6.49	3.34
02/06/2001	5.65	1.87	0.82	1.04	8.71	8.44	3.01

Date	Ammonia	NO2_NO3_N	Ortho-phosphate	Total Phosphorus	TKN	TOC	BOD
	(mg/L as N)	(mg/L as N)	(mg/L as P)	(mg/L as P)	(mg/L)	(mg/L)	(mg/L)
03/06/2001	3.56	2.94	0.51	0.64	4.67	1.60	4.10
04/03/2001	2.36	5.87	1.20	1.45	3.51	7.74	5.19
05/01/2001	9.13	5.98	1.86	2.11	11.22	10.30	7.58
06/05/2001	9.62	10.54	3.71	2.67	--	9.67	6.13
07/17/2001	12.98	2.67	2.40	2.49	13.57	8.56	5.55
08/21/2001	0.21	11.55	2.75	2.71	(BDL)	7.24	1.91
09/17/2001	10.49	3.17	2.10	2.27	16.10	8.43	5.73
10/30/2001	7.00	6.03	2.98	3.15	8.14	8.46	3.70
11/27/2001	--	--	--	2.29	15.35	7.48	>6.21
12/18/2001	1.36	1.40	0.19	0.27	2.42	6.70	3.11
01/15/2002	10.67	1.03	1.71	1.86	13.75	9.48	--
02/12/2002	8.83	0.67	2.09	2.24	12.72	9.33	>8.6
03/05/2002	6.85	1.48	0.85	1.10	--	9.38	>8.4
04/01/2002	1.97	1.02	0.51	0.67	3.16	7.62	7.10
05/07/2002	10.83	1.15	0.97	1.12	14.55	8.34	5.41
06/04/2002	4.57	7.94	2.26	2.48	9.43	--	3.27
07/01/2002	0.21	9.28	3.08	3.18	2.26	7.25	5.00
08/06/2002	9.21	2.86	2.15	2.30	14.64	8.17	7.47
09/03/2002	0.15	13.66	2.29	--	(BDL)	7.26	3.69
10/15/2002	0.65	9.98	2.07	2.15	--	9.00	3.17
11/12/2002	4.96	3.50	1.87	2.01	5.86	9.34	5.10
12/17/2002	6.05	3.33	1.65	1.56	7.46	8.94	4.32
01/14/2003	6.30	3.13	1.62	1.87	8.14	8.23	>8
02/11/2003	8.40	1.25	1.60	1.71	11.40	15.50	>8.3
03/11/2003	9.16	2.24	1.70	2.00	?11.0	11.30	>7.62
04/01/2003	2.80	5.30	1.24	1.48	4.01	10.50	6.76

Table A.2 Recent ARK051 Field Parameters Data.

Date	Turbidity	TSS	TDS	Dissolved Oxygen	pH	Air Temp.	Water Temp.	DO % Saturation
		(mg/L)	(mg/L)	(mg/L)		(°C)	(°C)	(%)
01/13/1998	16.0	9.5	282	6.70	6.57	5	9	58.0
02/10/1998	336.0	339.5	70	8.60	6.86	13	9	74.4
03/24/1998	18.0	--	383	--	--	16	19	--
04/28/1998	33.0	24.0	208	5.30	6.27	20	20	58.3
05/19/1998	6.6	6.5	555	7.40	6.49	35	28	94.5
06/23/1998	6.8	8.0	400	5.00	6.35	33	29	65.0
07/28/1998	4.7	9.0	564	8.60	6.86	30	--	--
08/25/1998	7.8	10.0	423	7.40	6.94	40	31	99.6
09/29/1998	8.6	10.5	464	5.10	6.48	32	30	67.5
10/27/1998	12.0	9.0	456	6.40	6.44	27	21	71.8
11/09/1998	12.0	8.0	297	5.40	6.46	11	14	52.4
12/08/1998	17.0	8.0	331	5.90	6.53	15	15	58.5
01/12/1999	17.0	8.0	299	6.90	6.47	14	12	64.0
02/02/1999	8.9	24.5	284	8.30	6.61	19	15	82.3
03/09/1999	69.0	37.5	241.5	10.30	6.91	15	15	102.1
04/13/1999	15.0	23.5	380	7.40	6.24	19	20	81.4
05/18/1999	77.0	50.5	193	5.60	6.56	27	25	67.8
06/22/1999	8.9	9.5	493	8.30	7.60	31	27	104.2
07/20/1999	8.3	12.5	503	6.50	6.69	33	30	86.0
08/10/1999	6.2	9.0	463	7.20	6.99	33	30	95.3
09/14/1999	31.0	21.0	329	4.10	6.52	28	24	48.7
10/05/1999	5.2	5.5	468	4.40	6.81	23	20	48.4
11/02/1999	32.0	24.0	248	6.50	6.52	14	18	68.7
11/30/1999	11.0	8.0	411	7.00	6.55	12	13	66.4
01/04/2000	42.0	32.0	260	8.40	6.64	4	13	79.7
02/01/2000	18.0	15.0	408	9.60	6.79	13	12	89.1
03/07/2000	--	15.0	333	6.20	6.87	24	18	65.5
04/04/2000	19.0	14.5	310.5	7.40	7.08	13	16	75.0
05/08/2000	18.0	16.5	318.5	5.60	6.65	27	26	69.0
06/06/2000	8.1	8.5	373	6.50	6.69	22	25	78.7
07/18/2000	6.0	7.5	525	0.00	7.15	35	31	--
08/14/2000	4.5	10.0	606	5.40	7.01	34	29	70.2
09/11/2000	3.6	4.0	397	2.80	--	32	28	35.8
10/10/2000	6.7	4.0	322	4.80	--	19	19	51.7
10/31/2000	8.3	10.0	469	--	6.73	28	24	--
12/12/2000	--	15.0	295	--	6.88	0	7	--
01/08/2001	14.0	12.0	298	10.71	6.86	9	8	90.4
02/06/2001	19.0	17.8	335.5	9.58	6.87	15	13	90.9

Date	Turbidity	TSS	TDS	Dissolved Oxygen	pH	Air Temp.	Water Temp.	DO % Saturation
		(mg/L)	(mg/L)	(mg/L)		(°C)	(°C)	(%)
03/06/2001	12.0	9.3	287.5	9.40	6.51	14	14	91.2
04/03/2001	20.0	33.5	320	8.37	6.75	28	21	93.9
05/01/2001	13.0	31.0	455.5	7.70	7.07	23	24	91.5
06/05/2001	6.9	14.0	419	6.16	6.89	27	27	77.3
07/17/2001	10.0	15.5	448	5.46	7.15	30	29	71.0
08/21/2001	7.6	7.2	479.5	7.67	6.47	32	31	103.2
09/17/2001	9.6	30.0	420.5	4.06	6.92	26	27	51.0
10/30/2001	6.7	7.8	403.5	6.42	--	22	20	70.6
11/27/2001	11.0	13.5	351	6.07	7.19	10	16	61.5
12/18/2001	25.0	8.3	142.5	9.57	6.54	14	13	90.8
01/15/2002	8.4	10.0	338	9.45	7.16	15	13	89.7
02/12/2002	13.0	13.5	282	9.51	7.06	12	13	90.3
03/05/2002	21.0	19.3	252	10.27	7.07	21	13	97.5
04/01/2002	14.0	14.0	116.5	8.32	6.80	18	17	86.1
05/07/2002	5.4	11.0	418	8.70	7.05	27	25	105.3
06/04/2002	7.1	8.8	450.5	6.01	6.54	26	28	76.8
07/01/2002	7.2	12.3	--	8.70	6.17	33	31	117.1
08/06/2002	5.2	13.2	414	12.91	7.86	31	32	176.7
09/03/2002	10.0	21.8	490	8.37	--	30	31	112.7
10/15/2002	11.0	8.0	492	--	6.52	22	--	--
11/12/2002	13.0	8.8	446	4.87	6.78	13	19	52.5
12/17/2002	15.7	5.8	313	6.88	6.79	19	16	69.7
01/14/2003	12.2	8.2	347	8.12	6.83	8	13	77.1
02/11/2003	20.2	6.8	252	--	6.75	16	--	--
03/11/2003	16.0	4.3	520	7.58	6.94	12	14	73.5
04/01/2003	20.2	9.8	277	--	--	--	--	--

Table A.3 Intensive Survey from July 9, 1996 (See Figure 2.1. for locations).

Station_ID	SDC01A	SDC01E	SDC02	SDC01T	SDC03	SDC04
DO (mg/L)	3.5	3	3.3	5.1	5	10.7
pH (SU)	7.1	6.8	6.8	7.6	6.9	8
Water Temp (C)	29.5	29.5	29	30.5	29.5	31.1
CBOD (mg/L)	0.7	2.8	2.9	2	2.7	5.5
NH3-N (mg/L)	<0.05	2.1	2.06	<0.05	1.76	<0.05
CL (mg/L)	7.2	59.8	60	10.5	59.7	49.8
NO3-N (mg/L)	0.15	13.4	13	0.15	12.4	10.6
0-PHOS (mg/L)	<0.03	3.04	3.13	<0.03	2.92	2.15
T-PHOS (mg/L)	0.04	3.86	3.55	0.11	3.32	2.56
SO4 (mg/L)	8.7	211	183.6	29.9	211	140.8
TOC (mg/L)	9	11.3	11.4	10.2	11.5	12
TSS (mg/L)	4	1.5	1.5	20.5	8	15.5
TDS (mg/L)	92	503	502	135	489	379
Hardness (mg/L)	50	83	84	66	84	NA
Dissolved Metals						
Al (ug/L)	<16.0	24.9	26.7	<16.0	26.9	NA
B (ug/L)	24.1	662.6	670.5	104.3	585	NA
Ba (ug/L)	25.9	5.4	6.1	30.3	9.2	NA
Be (ug/L)	<2.0	<2.0	<2.0	<2.0	<2.0	NA
Ca (ug/L)	14.7	28.4	28.7	18.4	28.6	NA
Cd (ug/L)	<0.5	<0.5	<0.5	<0.5	<0.5	NA
Co (ug/L)	<3.0	<3.0	<3.0	<3.0	<3.0	NA
Cr (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0	NA
Cu (ug/L)	<2.0	<2.0	<2.0	<2.0	<2.0	NA
Fe (ug/L)	180	89.5	87.8	83	105	NA
K (mg/L)	1.4	12.8	12.9	1.7	12.9	NA
Mg (mg/L)	3.2	3	3	4.8	3	NA
Mn (ug/L)	118	55	61.6	316	117	NA
Na (mg/L)	8.3	117.8	118.1	14.6	109.6	NA
Ni (ug/L)	<5.0	14.7	14.8	<5.0	14.6	NA
Pb (ug/L)	<2.0	<2.0	<2.0	<2.0	<2.0	NA
V (ug/L)	<5.0	<5.0	<5.0	<5.0	<5.0	NA
Zn (ug/L)	5.4	25.5	25.8	2.7	26	NA

APPENDIX B
SUMMARY OF POINT SOURCE EFFLUENT DATA

Table B.1 NPDES Data for Conway WWTP

Date	BOD	Flow*	Ammonia	DO (Min. Conc.)	pH (Min.)	pH (Max.)	Total Phosphorus**	TSS
	(mg/L)	(MGD)	(mg/L)	(mg/L)			(mg/L)	(mg/L)
Jan-98	2.13	5.41	--	--	6.14	6.83	--	3.36
Feb-98	1.62	5.85	2.16	3.1	6.23	7.09	--	3.00
Mar-98	2.34	6.05	1.37	5.5	6.22	6.91	2.00	3.15
Apr-98	3.06	4.56	2.70	4.6	5.66	7.12	--	3.34
May-98	2.18	3.90	0.23	5.0	5.76	7.08	--	4.75
Jun-98	1.90	3.61	0.12	4.4	6.26	6.89	3.00	2.35
Jul-98	2.08	3.93	0.19	4.3	6.17	6.97	--	1.67
Aug-98	2.65	3.50	0.15	4.6	6.24	7.16	--	1.42
Sep-98	2.20	2.79	0.19	4.0	6.16	7.16	2.30	1.79
Oct-98	1.68	2.96	0.26	4.2	6.06	7.06	--	4.30
Nov-98	2.52	2.86	0.18	5.1	5.79	6.74	--	2.40
Dec-98	2.20	3.58	9.00	4.6	6.19	7.06	3.60	2.05
Jan-99	4.20	4.95	63.20	4.1	6.43	7.43	--	2.43
Feb-99	1.90	3.97	3.60	4.4	6.22	7.07	--	2.06
Mar-99	3.21	3.95	6.20	4.8	6.40	7.10	2.10	2.41
Apr-99	2.71	4.97	1.72	3.7	5.87	7.05	--	7.23
May-99	2.10	3.15	2.46	4.5	4.98	7.03	--	3.20
Jun-99	3.08	3.28	10.50	2.1	6.13	7.41	2.70	3.13
Jul-99	2.20	2.64	3.10	3.4	4.38	7.40	--	2.40
Aug-99	2.24	2.56	5.57	2.8	6.53	7.36	--	2.30
Sep-99	1.98	2.59	2.68	1.9	6.32	7.49	3.00	2.16
Oct-99	2.50	2.85	3.70	6.7	6.52	7.66	--	2.20
Nov-99	1.90	2.93	2.94	7.4	6.44	7.57	--	2.10
Dec-99	1.50	3.11	0.30	7.9	6.10	7.26	2.50	2.00
Jan-00	2.70	3.17	4.03	8.1	6.00	7.49	--	2.40
Feb-00	2.50	3.32	4.29	8.7	5.87	7.16	--	2.20
Mar-00	2.70	4.31	2.00	7.2	6.13	7.07	2.90	3.30
Apr-00	1.80	3.81	4.37	7.2	6.09	7.72	--	3.40
May-00	1.90	3.57	2.00	7.2	6.26	7.38	--	3.10
Jun-00	2.00	3.88	1.50	6.4	6.42	7.37	--	2.70
Jul-00	2.30	2.99	2.70	6.4	6.46	7.28	--	3.10
Aug-00	2.70	3.03	1.10	6.6	6.15	7.51	--	2.90
Sep-00	1.60	2.87	2.06	4.7	6.04	7.14	2.80	3.60
Oct-00	1.00	3.04	0.83	4.3	6.13	7.26	--	1.90
Nov-00	2.90	4.53	2.99	5.7	6.29	7.25	--	2.60
Dec-00	3.10	3.56	3.83	8.0	4.31	7.33	2.40	4.70
Jan-01	3.50	4.22	5.90	8.7	6.33	7.54	--	5.00
Feb-01	3.60	5.64	3.78	7.0	6.50	7.40	--	9.60
Mar-01	2.70	4.35	7.00	8.3	6.17	7.55	1.30	7.40
Apr-01	2.20	3.22	2.50	7.8	6.34	7.20	--	3.90

Date	BOD	Flow*	Ammonia	DO (Min. Conc.)	pH (Min.)	pH (Max.)	Total Phosphorus**	TSS
May-01	2.80	3.45	8.50	5.9	6.90	7.56	--	4.20
Jun-01	3.09	4.48	5.53	6.7	6.37	7.57	3.70	4.12
Jul-01	2.98	2.98	8.41	4.4	6.79	7.62	--	4.59
Aug-01	1.90	2.97	1.70	4.0	5.95	7.06	--	1.90
Sep-01	2.70	2.75	10.80	3.7	6.73	7.31	2.30	3.60
Oct-01	2.27	2.80	10.40	4.0	6.26	7.41	--	2.88
Nov-01	2.54	3.19	13.30	7.4	6.78	7.68	--	3.83
Dec-01	2.38	4.70	8.03	8.0	6.50	7.30	0.68	5.20
Jan-02	2.30	3.88	10.10	8.6	6.82	7.45	--	3.60
Feb-02	3.30	4.30	8.89	8.8	6.92	7.52	--	6.40
Mar-02	4.40	5.40	6.90	6.5	6.69	7.22	1.70	8.90
Apr-02	5.00	4.11	7.50	6.2	6.53	7.52	--	4.00
May-02	2.90	3.46	9.70	3.7	5.90	7.46	--	3.80
Jun-02	1.90	3.14	5.60	4.9	6.38	7.14	1.10	3.00
Jul-02	2.20	3.18	4.50	2.8	5.84	7.45	--	2.10
Aug-02	2.14	3.10	5.60	6.3	6.36	7.63	--	1.90
Sep-02	2.60	2.96	2.70	5.6	4.40	7.45	3.50	2.60
Oct-02	1.90	3.18	4.10	7.5	6.37	7.33	--	2.00
Nov-02	2.20	3.00	3.00	5.8	6.45	7.32	--	1.60
Dec-02	3.60	4.17	4.40	6.8	6.03	7.43	2.30	3.20
Jan-03	2.50	3.50	6.90	9.1	6.50	7.30	--	2.80
Feb-03	3.00	5.15	7.70	8.0	6.64	7.28	--	2.40
Mar-03	2.50	4.47	7.80	7.2	6.57	7.62	2.10	2.40

* Flow measured as average quantity.
**Total Phosphorus measured as average concentration on a quarterly basis.