Source Tracking for Bacteria
North Canadian River

Association Of
Central Oklahoma Governments
Water Resources Division
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DRAFT

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EXECUTIVE SUMMARY

In summer 2003, ACOG staff sampled pathogen bacteria (enterococci, and E. coli) on the North Canadian River in Canadian, Oklahoma, and Pottawatomie Counties and calculated load duration curves which led eventually to the adoption of a Total Daily Maximum Load (TMDL) in 2009 for the river and several tributaries. This TMDL was incorporated into Oklahoma Pollutant Discharge Elimination System (OPDES) permits, especially those relating to storm water.

Another survey in 2011 collected information on flow, pathogen concentrations, and fluorescence on the North Canadian River. The fluorometer data was thought to help characterize the reaches of the river affected by human activity in the watershed such as sewage discharge. In addition, the data collection would indicate if the bacteria levels have significantly reduced since 2003. Since the 2003 collection, several Phase II programs in the various cities along this reach of the river have been initiated.

The bacteriological sampling performed in summer 2011 duplicated eight locations sampled in 2003. Fecal coliform in summer 2011 decreased significantly from the summer 2003 sampling event. However, there is no statistical difference between the e. coli concentrations between the two sampling events. Enterococci decreased in two of the sampled tributaries (Crutcho Creek and Choctaw Creek) as wells as the sampling location on Triple-X road (NC07).

Fluorometer data was inconclusive as a tool to define detergents (and thus failing septic tanks). The main stem of the river had consistent luminescence. The tributaries had higher luminescence, but had no relationship to flow or turbidity. In addition, the data did not correlate to the density or number of septic tanks in the watershed.

ACKNOWLEDGEMENT

This report was funded through the federal grant program authorized under the federal Clean Water Act Section 604(b) and administered through Region VI of the Environmental Protection Agency and the Oklahoma Secretary of Environment. We gratefully acknowledge the time and help these partnership agencies provide to further the goals of environmental stewardship both regionally and at a local scale.

A. INTRODUCTION

In summer 2003, ACOG staff sampled pathogen bacteria (enterococci, and E. coli) on the North Canadian River in Canadian, Oklahoma, and Pottawatomie Counties and calculated load duration curves which led eventually to the adoption of a Total Daily Maximum Load (TMDL) in 2009 for the river and several tributaries. This TMDL was incorporated into Oklahoma Pollutant Discharge Elimination System (OPDES) permits, especially those relating to storm water.

Although the study showed that pathogen levels in the river were in some locations nearly two orders of magnitude above water quality standards, the study did not address sources. Much discussion has ensued as to the nature of the sources, since water quality violations occurred in virtually all reaches of the river and all types of land use – both urban and rural.

Preliminary studies from the Indian Nations Council of Government (INCOG) has shown that the field use of a fluorometer may be instrumental in helping to define pathogen sources coming from human activity. Fluorometers are useful to determine human activity in areas of high bacteria because human sewage usually contains soaps which exhibit chemiluminescence.

A field survey was proposed to collect information on flow, pathogen concentrations, and fluorescence on the North Canadian River. The data would help characterize the reaches of the river affected by human activity in the watershed such as sewage discharge.

In addition, the data collection would indicate if the bacteria levels have significantly reduced since 2003. Since the 2003 collection, several Phase II programs in the various cities along this reach of the river have been initiated.

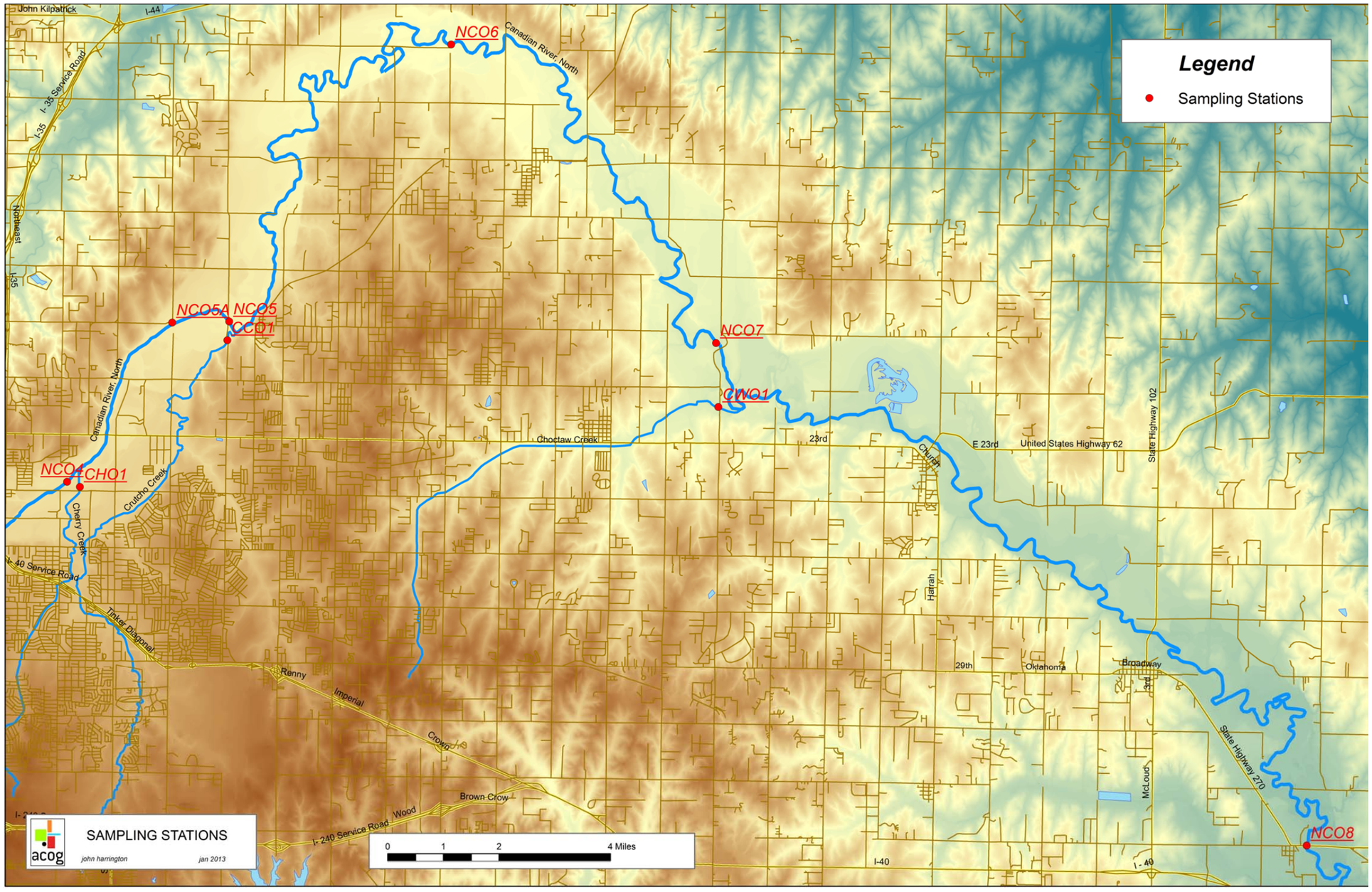
B. DATA COLLECTION ACTIVITY

B1. LOCATION AND TIME

Sampling locations are shown in Figure 1. These locations were part of the original pathogen TMDL sampling locations in 2003 and exhibited water quality violations that exceeded two orders of magnitude above state water quality standards. It was thought that fluorometer data would help to define sources if these violations are due to human activity issues. This information would allow communities affected by the new TMDL requirements to concentrate their efforts in areas where there would be the largest impact on the water quality. This information would also further test the usefulness of the fluorometer in several different watershed subbasins with different land use characteristics.

Data collection activity was commenced in July 2011 and completed in September 2011. All data locations were identical to the 2003 sampling program with the exception of Station NC05. At this location a very large beaver dam was built, which made flow measurements impossible to acquire due to the depth of the water. An alternate site was established a mile upstream at NC05A.

Figure 1 Station Locations



B2. QUALITY ASSURANCE

As part of the quality assurance process, it is necessary to address the quality of the data acquired in the survey. This section addresses the objectives of precision, accuracy, representativeness, completeness, and comparability.

B2.1. Precision

Acceptable precision and methodology is summarized in Table 1**Error! Reference source not found.**. Precision for the microbiological parameters of interest (E. coli, Fecal Coliform, Enterococci), was addressed by using a duplicate sample each week, rotating randomly among stations.

Duplicate samples are used to determine the variation of the value of the samples. Bacteria samples appear to have a high coefficient of variation compared to other water quality analyses because they have a positively skewed distribution (APHA, 1995). Because of this property, the data has been lognormally transformed for computation of the Relative Percentage Difference (RPD).

The calculation spreadsheet for this procedure is shown in Table 2. The acceptable precision was achieved 26 out of 27 times; five of those times the measurement was at the upper limits of detection. A possible transcription error may be the problem with the one poor precision result. The acceptable precision was achieved 96.3% of the time.

For comparative purposes, acceptable precision was achieved 66.7% of the time in the 2003 survey using the same collection techniques (Table 3).

Table 1 Acceptable Precision and Methodology Limits

Bacterial Analyses					
	Enterococci	E. Coli			
Practical Quantification Limit	1 cfu/100 ml	1 cfu/100 ml			
Detection Limit	1 cfu/100 ml	1 cfu/100 ml			
Turbidity & YSI 6820 Field Measurements					
	Turbidity	DO	Conductivity	pH	Temperature
Detection Limit	0.01 NTU	0.01 mg/L	100-1.0 uS/cm (range dependant)	0.01 SU	0.01° C
Method Precision (RPD) > 2 orders of magnitude above MDL	±10 percent	±10 percent	±10 percent	±10 percent	±10 percent
Method Precision (RPD) > 1 order of magnitude above MDL	±25 percent	±25 percent	±25 percent	±25 percent	±25 percent
Method Precision (RPD) < 1 order of magnitude above MDL	±50 percent	±50 percent	±50 percent	±50 percent	±50 percent

Table 2 Acceptable Precision and Methodology – 2011 Survey Bacteria

		RAW DATA			LOGNORMAL TRANSFORM			RFD			PRECISION		
DATE	LOCATION	ENTEROCOCCI	FECAL COLIFORM	E.COLI	ENTEROCOCCI	FECAL COLIFORM	E.COLI	ENTEROCOCCI	FECAL COLIFORM	E.COLI	ENTEROCOCCI	FECAL COLIFORM	E.COLI
7/14/11	AC01	1203.3	12.1	<1.0	3.08	1.08	0.00						
7/14/11	NC04	1119.9	28.8	31.8	3.05	1.46	1.50	0.00	0.07	#VALUE!	ACCEPTABLE	ACCEPTABLE	NOT ACCEPTABLE
7/19/11	AC02	38.4	27.2	38.5	1.58	1.43	1.59						
7/19/11	NC08	35.0	35.5	14.2	1.54	1.55	1.15	0.00	0.01	0.00	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE
8/1/11	AC01	2419.0	46.5	38.8	3.38	1.67	1.59						
8/1/11	NC05A	2419.0	56.3	47.9	3.38	1.75	1.68	0.00	0.00	0.00	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE
8/8/11	AC01	2419.0	2419.0	2419.0	3.38	3.38	3.38						
8/8/11	CH01	2419.0	2419.0	2419.0	3.38	3.38	3.38	0.00	0.00	0.00	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE
8/15/11	AC01	113.7	185.0	77.1	2.06	2.27	1.89						
8/15/11	NC05A	107.6	186.0	141.4	2.03	2.27	2.15	0.00	0.00	0.00	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE
8/22/11	AC01	648.8	135.4	172.5	2.81	2.13	2.24						
8/22/11	NC05A	727.0	165.8	143.9	2.86	2.22	2.16	0.00	0.00	0.00	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE
8/29/11	AC01	2419.0	547.5	770.1	3.38	2.74	2.89						
8/29/11	CH01	2419.0	770.1	770.1	3.38	2.89	2.89	0.00	0.00	0.00	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE
9/6/11	AC01	307.6	69.7	110.6	2.49	1.84	2.04						
9/6/11	CC01	275.5	88.6	123.6	2.44	1.95	2.09	0.00	0.00	0.00	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE
9/12/11	AC01	1553.1	214.3	547.5	3.19	2.33	2.74						
9/12/11	CH01	686.7	344.8	517.2	2.84	2.54	2.71	0.00	0.00	0.00	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE

Table 3 Acceptable Precision and Methodology – 2003 Survey Bacteria

Station	Date Collected:	E. Coli	Fecal Coliform	Enterococci			
NC05	5/20/2003	6.6%	0.4%	0.2%	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE
NC01	5/28/2003	7.0%	5.5%	4.9%	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE
NC03	5/27/2003	9.7%	5.5%	4.4%	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE
CH01	4/6/2003	3.4%	17.5%	0.9%	ACCEPTABLE	ACCEPTABLE NOT	ACCEPTABLE
OC01	3/6/2003	6.2%	0.0%	31.0%	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE NOT
NC08	6/18/2003	39.4%	68.5%	11.7%	ACCEPTABLE NOT	ACCEPTABLE NOT	ACCEPTABLE NOT
NC02	7/14/2003	0.5%	0.0%	6.7%	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE
CC01	7/29/2003	12.4%	6.7%	5.3%	ACCEPTABLE NOT	ACCEPTABLE	ACCEPTABLE
OC01	12/8/2003	0.0%	11.5%	0.0%	ACCEPTABLE	ACCEPTABLE NOT	ACCEPTABLE
NC02	8/18/2003	3.8%	29.2%	4.9%	ACCEPTABLE	ACCEPTABLE NOT	ACCEPTABLE
OC01	8/26/2004	3.2%	21.9%	8.1%	ACCEPTABLE	ACCEPTABLE NOT	ACCEPTABLE
NC01	2/9/2004	18.7%	15.4%	4.4%	ACCEPTABLE NOT	ACCEPTABLE NOT	ACCEPTABLE
NC01	8/9/2004	0.0%	0.0%	34.8%	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE NOT
CC01	9/16/2004	1.5%	24.7%	9.0%	ACCEPTABLE	ACCEPTABLE NOT	ACCEPTABLE
NC03	9/22/2004	4.7%	20.7%	48.2%	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE NOT

B2.2. Accuracy

Trip blank samples are utilized to determine if contamination of samples is possible during the implementation of field protocols. This also insures the accuracy of the measurement of interest. Table 4 displays the results of the blank samples analysis.

Table 4 Blank Data Collection

		BLANK DATA		
DATE	LOCATION	ENTEROCOCCI	FECAL COLIFORM	E.COLI
7/14/11	AC02	<1.0	<1.0	<1.0
7/26/11	AC01	<1.0	<1.0	<1.0
7/27/11	AC02	<1.0	<1.0	<1.0
8/2/11	AC02	<1.0	<1.0	<1.0
8/9/11	AC02	<1.0	<1.0	<1.0
8/16/11	AC02	<1.0	<1.0	<1.0
8/23/12	AC02	<1.0	<1.0	<1.0
8/30/12	AC02	<1.0	<1.0	<1.0
9/7/11	AC02	<1.0	<1.0	<1.0
9/14/12	AC02	<1.0	<1.0	<1.0

B2.3. Representativeness

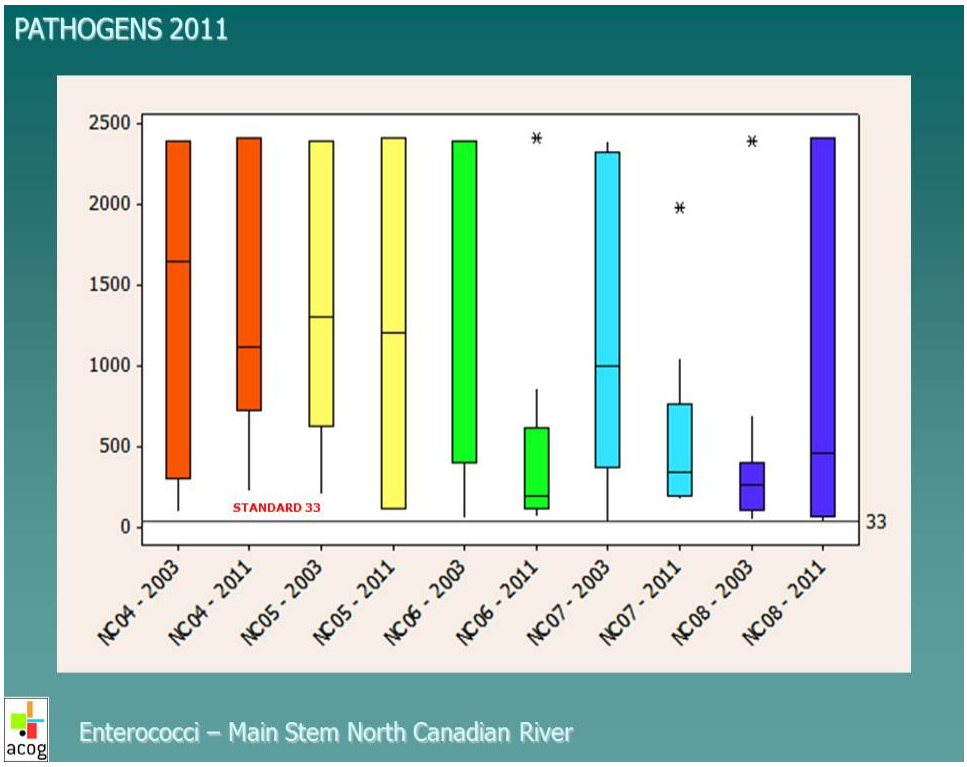
Representativeness of the bacteriological data is charted in Figure 2 to Figure 4. Although there is statistically significant differences in some of the groupings, the median of the population groups sampled in 2011 are within the same orders of magnitude as the 2003 population. Given the similarity of the sampling locations, sampling times, and the results, it can be concluded that the data set is representative of the conditions in the main stem and tributaries.

B2.4. Completeness

Table 5 shows the target goals and the actual data collected for flow data and bacteriological data. The completeness goal for the flow data was 95% overall – high flows at the beginning of data acquisition was a problem for two of the data collection sites. The bacteriological data was 98% complete. This met with the target goal of 90% established for completeness of all data acquisition, with no less than 80% for one station location.

All data attempted with the YSI field meter data was acquired (100% completeness).

Figure 2 Enterococci Data Boxplot



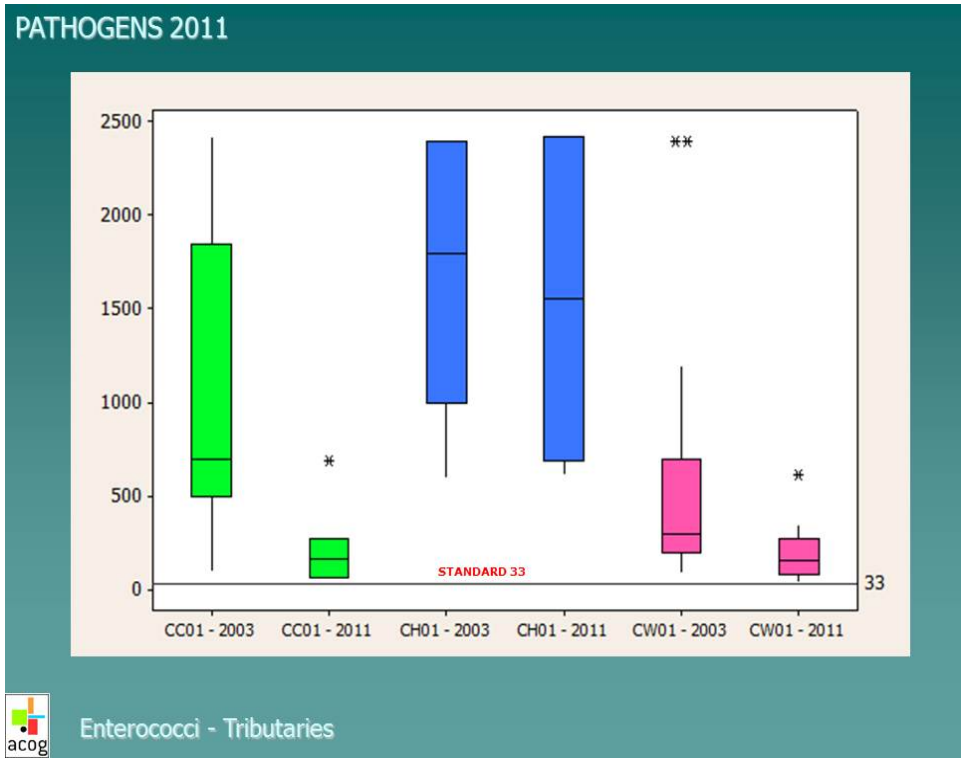
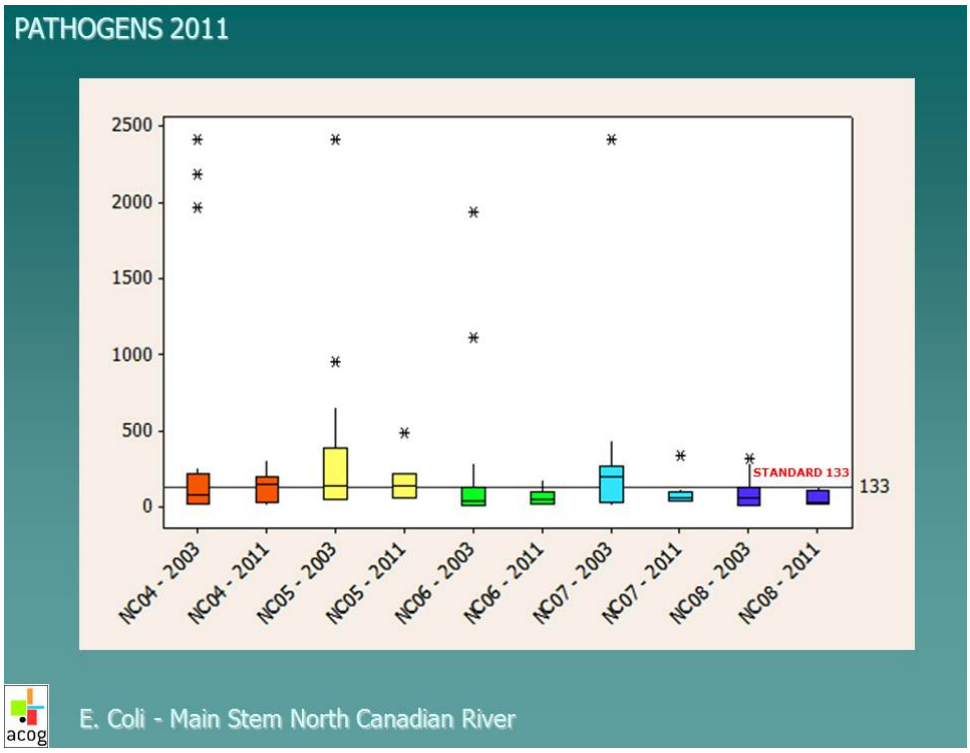


Figure 3 E. Coli Data Boxplot



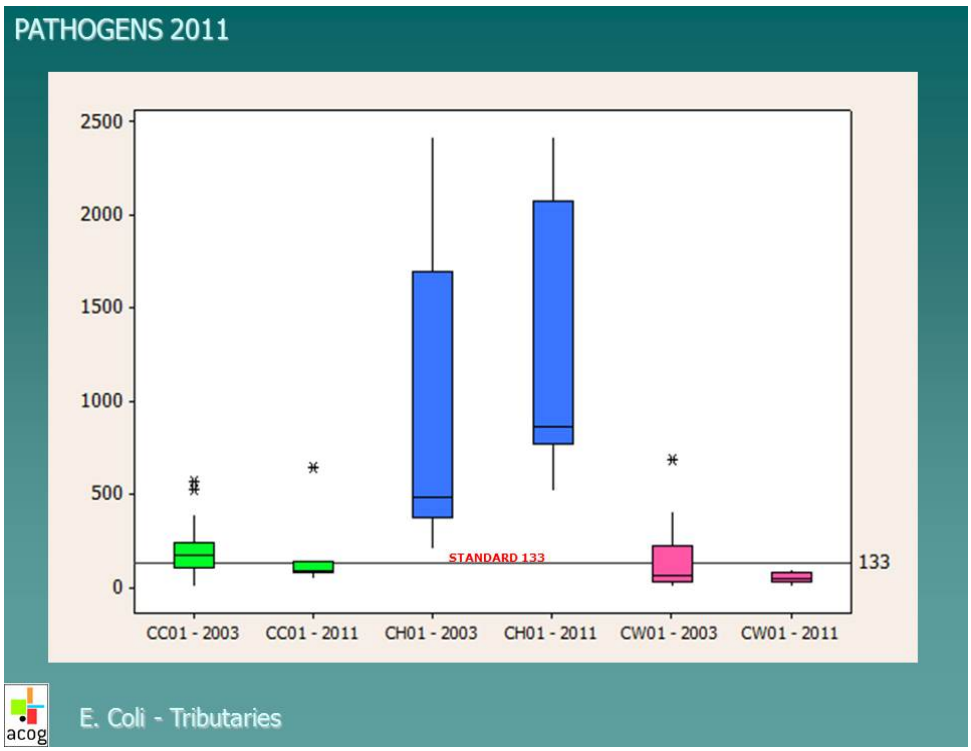
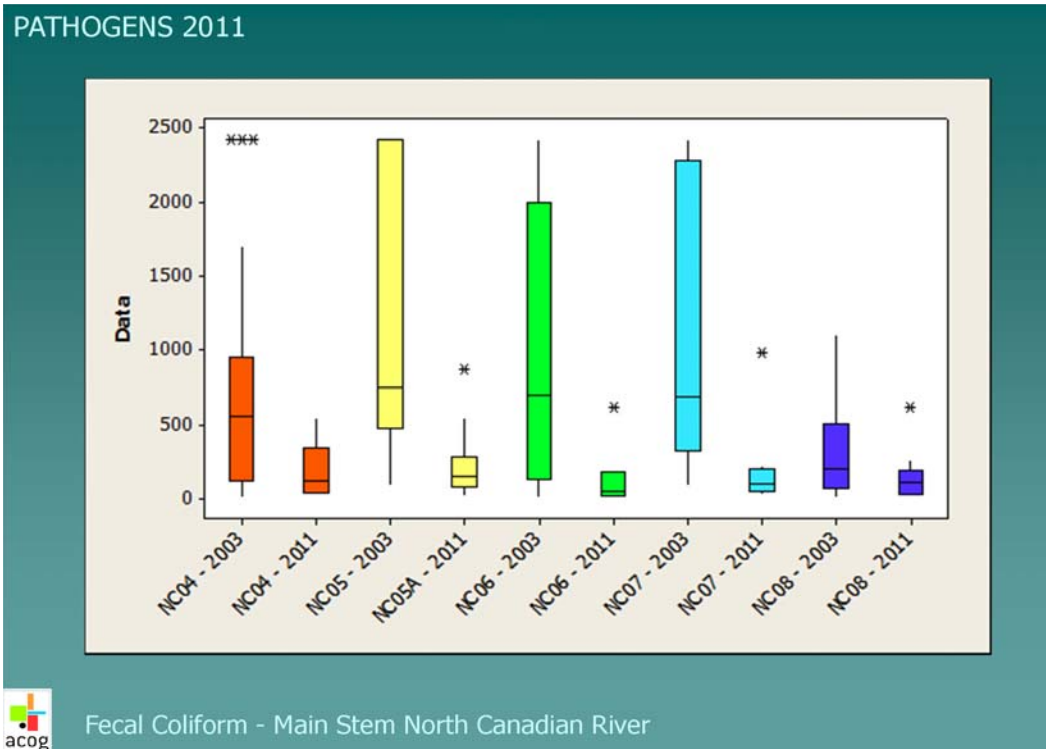


Figure 4 Fecal Coliform Data Boxplot



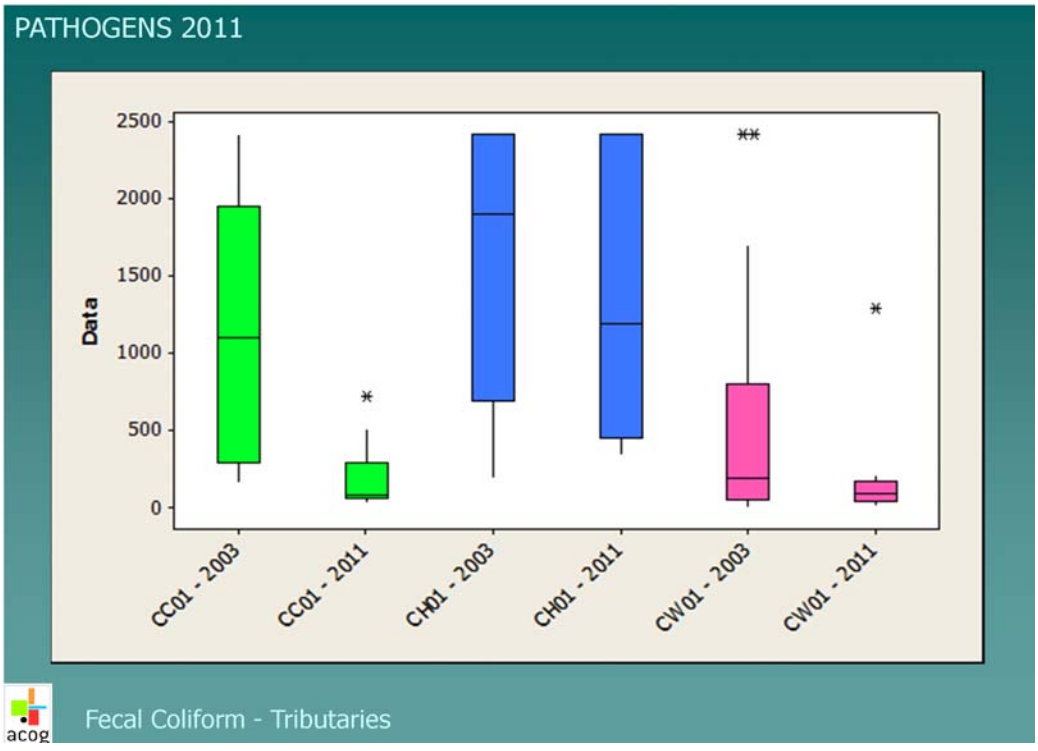


Table 5 Completeness Goals

BACTERIOLOGICAL SAMPLES								
DATE	NC04	CH01	CC01	NC05A	NC06	NC07	NC08	CW01
7/12/11	1	1	1					
7/14/11					1	1	1	1
7/18/11	1	1	1					
7/19/11					1	1	1	1
7/26/13	1	1	1	1				
7/27/13					1	1	1	1
8/1/11	1	1	1	1				
8/2/11					1	1	1	1
8/8/11	1	1	1	1				
8/9/11					1	1	1	1
8/15/11	1	1	1	1				
8/16/11					1	1	1	1
8/22/11	1	1	1	1				
8/23/11					1	1	1	1
8/29/11	1	1	1	1				
8/30/11					1	1	1	1
9/6/11	1	1	1	1				
9/7/13					1	1	1	1
9/12/13	1	1	1	1				
9/14/13					1	1	1	1
PLANNED BACTERIA SAMPLES	10	10	10	10	10	10	10	10
COMPLETED	10	10	10	8	10	10	10	10
	100%	100%	100%	80%	100%	100%	100%	100%
OVERALL COMPLETENESS	98%							

FLOW DATA								
DATE	NC04	CH01	CC01	NC05A	NC06	NC07	NC08	CW01
7/12/11	1	1	1					
7/14/11					1			1
7/18/11	1	1	1					
7/19/11					1	1	1	1
7/26/13	1	1	1	1				
7/27/13					1	1	1	1
8/1/11	1	1	1	1				
8/2/11					1	1	1	1
8/8/11	1	1	1	1				
8/9/11					1	1	1	1
8/15/11	1	1	1	1				
8/16/11					1	1	1	1
8/22/11	1	1	1	1				
8/23/11					1	1	1	1
8/29/11	1	1	1	1				
8/30/11					1	1	1	1
9/6/11	1	1	1	1				
9/7/13					1	1	1	1
9/12/13	1	1	1	1				
9/14/13					1	1	1	1
PLANNED BACTERIA SAMPLES	10	10	10	10	10	10	10	10
COMPLETED	10	10	10	8	10	9	9	10
	100%	100%	100%	80%	100%	90%	90%	100%
OVERALL COMPLETENESS	95%							

B2.5. Comparability

With the exception of station NC05, all station locations were identical to the 2003 survey. NC05 was sampled twice, but the location had very large beaver dams which made flow measurements impossible. The characteristics of the site had changed significantly in seven years and a decision was made to move the site one mile upstream. The 2003 NC05 dataset and the 2011 NC05A dataset are quite similar and one can probably compare the two on at least a qualitative basis.

All bacteriological samples were processed in the laboratory using the same methodology as the 2003 survey.

C. PROJECT RESULTS

C1. BACTERIA ANALYSIS

Several statistical analyses were used to determine if the water quality for the project area has improved and how the bacteriological standards in the Oklahoma Water Quality Standards compared with the 2011 dataset.

Using a rank-sum test (Mann-Whitney), the following table was generated to show the differences between the 2003 dataset with the 2011 dataset (Helsel, et al., 1992).

Table 6 Rank-Sum Test 2003 vs. 2011

STATION	PARAMETER	H_0	P-VALUE	ACCEPT/REJECT H_0 AT α=0.05	CONCLUSION
CC01	Enterococci	2003 = 2011	0.0017	REJECT	DECREASE FROM 2003
CH01	Enterococci	2003 = 2011	0.3012	ACCEPT	SAME AS 2003
CW01	Enterococci	2003 = 2011	0.0141	REJECT	DECREASE FROM 2003
NC04	Enterococci	2003 = 2011	0.3751	ACCEPT	SAME AS 2003
NC05 & NC05A	Enterococci	2003 = 2011	0.9427	ACCEPT	SAME AS 2003
NC06	Enterococci	2003 = 2011	0.1243	ACCEPT	SAME AS 2003
NC07	Enterococci	2003 = 2011	0.0453	REJECT	DECREASE FROM 2003
NC08	Enterococci	2003 = 2011	0.7414	ACCEPT	SAME AS 2003
CC01	E. Coli	2003 = 2011	0.1524	ACCEPT	SAME AS 2003
CH01	E. Coli	2003 = 2011	0.1466	ACCEPT	SAME AS 2003
CW01	E. Coli	2003 = 2011	0.8364	ACCEPT	SAME AS 2003
NC04	E. Coli	2003 = 2011	0.7553	ACCEPT	SAME AS 2003
NC05 & NC05A	E. Coli	2003 = 2011	0.4574	ACCEPT	SAME AS 2003
NC06	E. Coli	2003 = 2011	0.6965	ACCEPT	SAME AS 2003
NC07	E. Coli	2003 = 2011	0.2437	ACCEPT	SAME AS 2003
NC08	E. Coli	2003 = 2011	0.8431	ACCEPT	SAME AS 2003
CC01	Fecal Coliform	2003 = 2011	0.0007	REJECT	DECREASE FROM 2003
CH01	Fecal Coliform	2003 = 2011	0.5663	ACCEPT	SAME AS 2003
CW01	Fecal Coliform	2003 = 2011	0.094	ACCEPT	SAME AS 2003
NC04	Fecal Coliform	2003 = 2011	0.0228	REJECT	DECREASE FROM 2003
NC05 & NC05A	Fecal Coliform	2003 = 2011	0.0012	REJECT	DECREASE FROM 2003
NC06	Fecal Coliform	2003 = 2011	0.0041	REJECT	DECREASE FROM 2003
NC07	Fecal Coliform	2003 = 2011	0.0006	REJECT	DECREASE FROM 2003
NC08	Fecal Coliform	2003 = 2011	0.1528	ACCEPT	SAME AS 2003

From Table 6 one can conclude that the two regulated bacteriological parameters (enterococci and e. coli) have populations that are not significantly different at the 95% degree of confidence, especially along the North Canadian River. Exceptions are the enterococci levels in Crutcho Creek (CH01), Choctaw Creek (CW01), and NC07 on the North Canadian River near Triple-X road. Fecal coliform, no longer a regulated parameter, has decreased significantly in the North Canadian River and in Crutcho Creek (CC01).

Bacteriological standards for water quality can be found in the Oklahoma Water Quality Standards. The waterbodies of concern are listed as being primary body contact waterbodies and are thus subject to §785:45-5-16. Primary Body Contact Recreation:

(a) Primary Body Contact Recreation involves direct body contact with the water where a possibility of ingestion exists. In these cases the water shall not contain chemical, physical or biological substances in concentrations that are irritating to skin or sense organs or are toxic or cause illness upon ingestion by human beings.

(b) In waters designated for Primary Body Contact Recreation the following limits for bacteria set forth in (c) of this section shall apply only during the recreation period of May 1 to September 30. The criteria for Secondary Body Contact Recreation will apply during the remainder of the year.

(c) Compliance with 785:45-5-16 shall be based upon meeting the requirements of one of the t options specified in (1) or (2) of this subsection (c) for bacteria. Upon selection of one (1) group or test method, said method shall be used exclusively over the time period prescribed therefor. Provided, where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, no criteria exceedances shall be allowed for any indicator group.

(1) *Escherichia coli (E. coli): The E. coli geometric mean criterion is 126/100 ml. For swimming advisory and permitting purposes, E. coli shall not exceed a monthly geometric mean of 126/100 ml based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. For swimming advisory and permitting purposes, no sample shall exceed a 75% one-sided confidence level of 235/100 ml in lakes and high use waterbodies and the 90% one-sided confidence level of 406/100 ml in all other Primary Body Contact Recreation beneficial use areas. These values are based upon all samples collected over the recreation period. For purposes of sections 303(d) and 305(b) of the federal Clean Water Act as amended, beneficial use support status shall be assessed using only the geometric mean criterion of 126/100 milliliters compared to the geometric mean of all samples collected over the recreation period.*

(2) Enterococci: The Enterococci geometric mean criterion is 33/100 ml. For swimming advisory and permitting purposes, Enterococci shall not exceed a monthly geometric mean of 33/100 ml based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. For swimming advisory and permitting purposes, no sample shall exceed a 75% one-sided confidence level of 61/100 ml in lakes and high use waterbodies and the 90% one-sided confidence level of 108/100 ml in all other Primary Body Contact Recreation beneficial use areas. These values are based upon all samples collected over the recreation period. For purposes of sections 303(d) and 305(b) of the federal Clean Water Act as amended, beneficial use support status shall be assessed using only the geometric mean criterion of 33/100 milliliters compared to the geometric mean of all samples collected over the recreation period.

Table 7 illustrates the results using the procedures outlined in the Oklahoma Water Quality Standards. As one can see, the waterbodies meet the e.coli standards with the exception of Cherry Creek. All the waterbodies fail the test for enterococci.

To summarize the analysis of the data, the main stem of the North Canadian River and Crutcho Creek showed a statistically significant decrease in the amount of fecal coliforms from 2003 to 2011. However, the regulatory bacteriological parameters enterococci and e.coli are essentially the same in 2011 as in 2003 for the main stem of the North Canadian River and Cherry Creek. Crutcho Creek and Choctaw Creek showed some improvement in 2011 from the 2003 dataset for enterococci.

All stations met the e.coli standard, but exceeded by two orders of magnitude the enterococci standard for Primary Body Contact Recreation.

Table 7 Geometric Means Test and 90% Confidence Level Standard

ENTEROCOCCI	CC01 - 2011	CH01 - 2011	CW01 - 2011	NC04 - 2011	NC05A - 2011	NC06 - 2011	NC07 - 2011	NC08 - 2011
	50.4	290.9	36.4	191.8	107.6	68.9	172.2	35.0
	63.7	613.1	38.8	222.4	116.9	112.6	178.9	40.2
	66.3	686.7	116.0	727.0	165.0	118.7	186.0	46.4
	93.3	980.4	155.3	770.1	648.8	195.6	201.4	93.3
	117.8	980.4	159.7	1119.9	727.0	198.9	224.7	127.4
	161.6	1119.9	172.6	1119.9	1203.3	280.9	344.1	461.1
	167.0	1553.1	178.2	2419.6	2419.6	365.4	435.2	1046.2
	275.5	1732.9	203.5	2419.6	2419.6	866.4	488.4	2419.6
	686.7	2419.6	344.8	2419.6	2419.6	2419.6	1046.2	2419.6
	866.4	2419.6	613.1	2419.6	2419.6	2419.6	1986.3	2419.6
GEOMETRIC MEAN	159.0	1075.8	149.0	1002.6	725.5	336.6	362.7	296.8
STANDARD	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0
% EXCEEDANCE	482%	3260%	451%	3038%	2198%	1020%	1099%	899%
90% ONE-SIDED CONFIDENCE LEVEL	287.4	1753	207.6	2420	2420	911	505	2420
STANDARD	108	108	108	108	108	108	108	108
E. COLI	CC01 - 2011	CH01 - 2011	CW01 - 2011	NC04 - 2011	NC05 - 2011	NC06 - 2011	NC07 - 2011	NC08 - 2011
	51.2	290.9	8.5	17.1	8.5	8.5	27.2	13.4
	79.4	517.2	29.5	17.5	47.9	17.5	43.7	14.2
	79.4	770.1	44.1	31.8	58.1	27.5	44.1	15.5
	82.3	866.4	45.9	37.3	67.0	30.9	45.7	21.6
	90.8	866.4	59.1	90.6	85.5	31.8	62.0	24.3
	104.6	1046.2	80.9	151.5	141.4	45.5	64.4	31.7
	123.6	1413.6	88.4	160.7	143.9	55.6	77.6	75.4
	141.4	2419.6	96.0	185	167.0	98.8	79.8	109.5
	142.1	2419.6	111.9	201.4	224.7	109.2	117.2	121.1
	648.8	2419.6	770.1	307.6	488.4	186.0	344.8	133.3
GEOMETRIC MEAN	115.1	1061.8	66.8	78.6	93.4	42.8	68.9	38.2
STANDARD	126.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0
% EXCEEDANCE	91%	843%	53%	62%	74%	34%	55%	30%
90% ONE-SIDED CONFIDENCE LEVEL	141	2420	96.5	185.5	168.7	99.1	80.9	109.8
STANDARD	406	406	406	406	406	406	406	406

C2. FLUOROMETER DATA ANALYSIS

Fluorometers are useful to determine human activity in areas of high bacteria because human sewage usually contains soaps which exhibit chemiluminescence. A fluorometer was used in this project to determine the usefulness of the unit to track areas of high bacteria and the location of the sources.

Chemiluminescence is the emission of light as a result of a chemical reaction without an apparent change in temperature. In nature there are many animals and plants that exhibit chemiluminescence, usually referred to as bioluminescence. Fungi can also exhibit bioluminescence (Bryner, 2009) as well as some algae. A fluorometer can be calibrated with a known source and wavelength, or calibrated with a consistent standard. Since it was not known what sources would be luminescing, a standard was made with water at the NC04 site at the beginning of the project and the meter was calibrated weekly against that water sample as a standard (Turner Designs, 2012).

The results are shown in Figure 5. Several relationships are immediately apparent. The mainstem data is quite different from the tributaries, indicating that the tributaries have more chemiluminescence. NC07 also has higher readings than the other mainstem data. NC07 is downstream from the North Canadian River WWTP; the flow in the river doubles at this point due to the effluent coming from the plant.

Using the Mann-Whitney test to compare the populations, a chart was created to show significant variations between the stations (Table 8). The analysis shows that NC05A, NC06, and NC08 have essentially the same luminescence; thus, one can consider this to be “background noise”. NC04 is at the headwaters of the system and has no inputs other than the dam system above 10th street; thus the luminescence is low.

NC07 is probably influenced by the treatment plant, and gives one confidence that the technique has some merit, since one can pick up the detergents that made it through the treatment process. However, the rather poor luminescence spike compared to the background suggests that using a fluorometer on the main stem of the North Canadian River may not be a fruitful endeavor.

The tributaries have much higher luminescence and are much different from one another. Assuming that this from detergents that have made it into the storm sewers or poorly maintained septic systems, a relationship with turbidity and flow should exist. Figure 6 shows this relationship, or lack thereof. It appears that some other luminescent agent that is independent of flow and turbidity is dominant in the tributaries. It is suspected that algae may be the culprit – if so, then there the fluorometer may have limited use.

As a further check on the fluorometer data, the number of septic tanks in each watershed was tallied up, using Census Bureau data (US Census Bureau, 2009). Although the Crutcho and Choctaw Creek watersheds had the highest number of septic tanks (248 and 291, respectively), the Cherry Creek watershed has only 14. It seems counterintuitive that the watershed with the most luminescence has the least septic tanks by an order of magnitude. It should be concluded that the fluorometer data in these watersheds probably is not a reliable indicator of detergents associated with failing septic tanks.

Figure 5 Fluorometer Data Chart

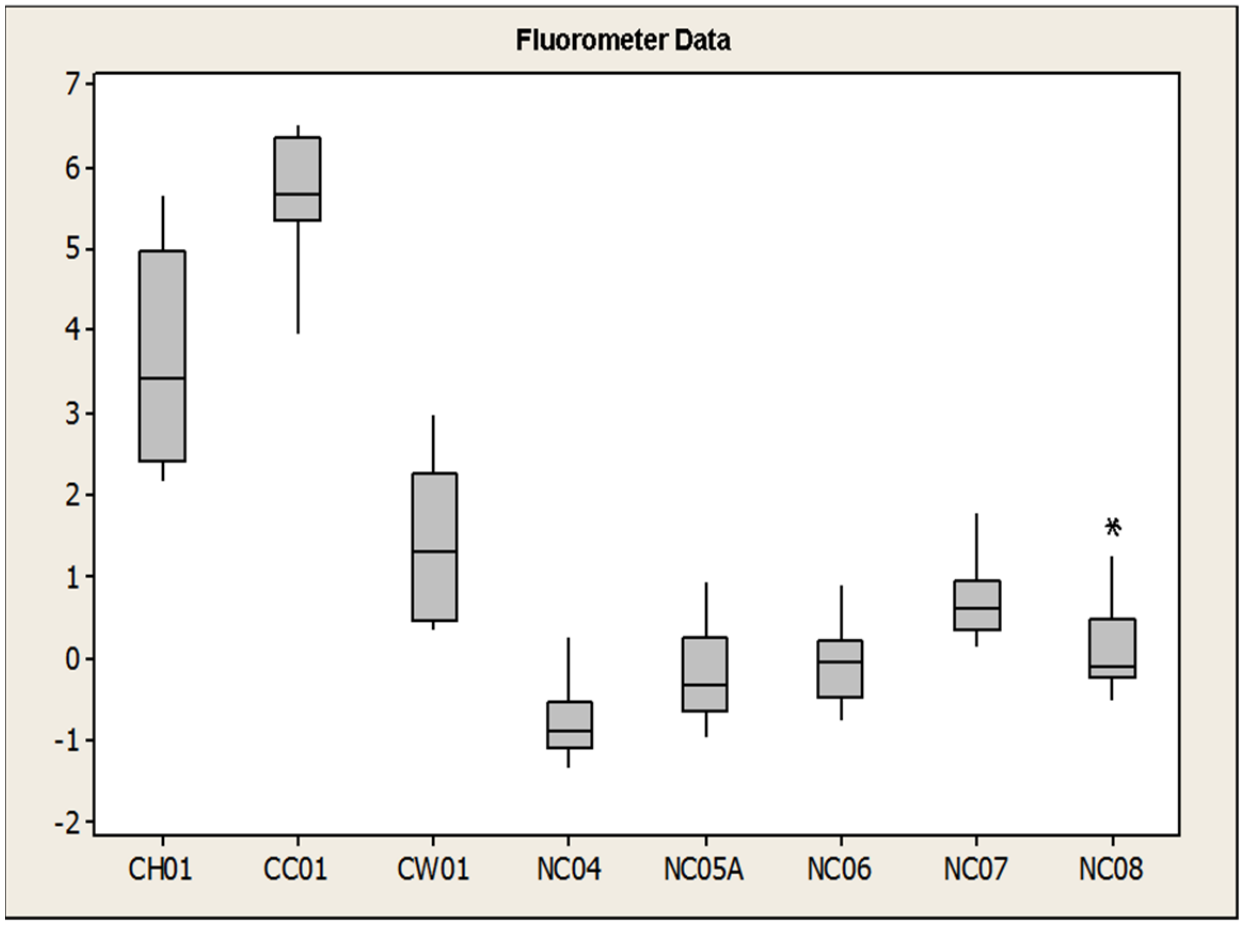
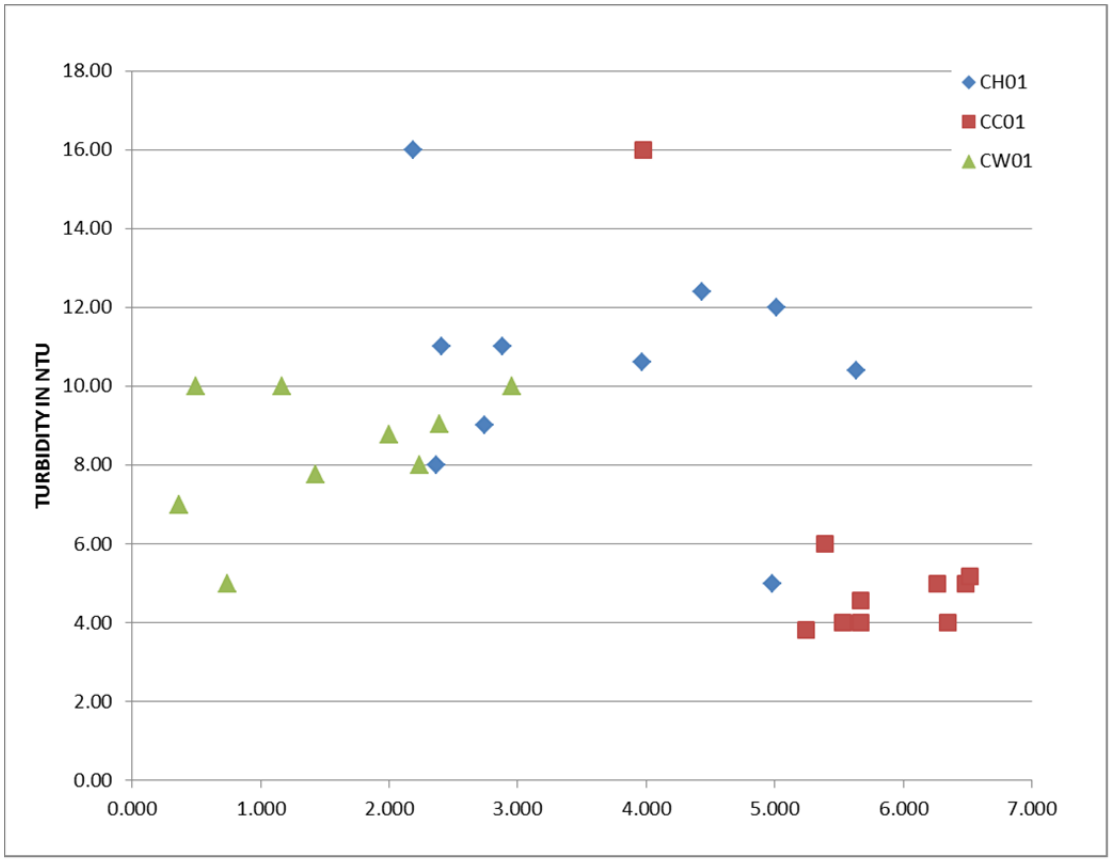


Table 8 Rank-Sum Test Fluorometer Data α = 0.95

	CH01	CC01	CW01	NC04	NC05A	NC06	NC07	NC08
CH01		0.0013	0.0017	0.0002	0.0004	0.0002	0.0002	0.0002
CC01	0.0013		0.0002	0.0002	0.0004	0.0002	0.0002	0.0002
CW01	0.0017	0.0002		0.0002	0.0016	0.0006	0.1041	0.0036
NC04	0.0002	0.0002	0.0002		0.0368	0.0058	0.0003	0.0022
NC05A	0.0004	0.0004	0.0016	0.0368		0.5636	0.0088	0.2303
NC06	0.0002	0.0002	0.0006	0.0058	0.5636		0.0046	0.6776
NC07	0.0002	0.0002	0.1041	0.0003	0.0088	0.0046		0.0211
NC08	0.0002	0.0002	0.0036	0.0022	0.2303	0.6776	0.0211	

Figure 6 Fluorometer Data vs. Turbidity and Flow



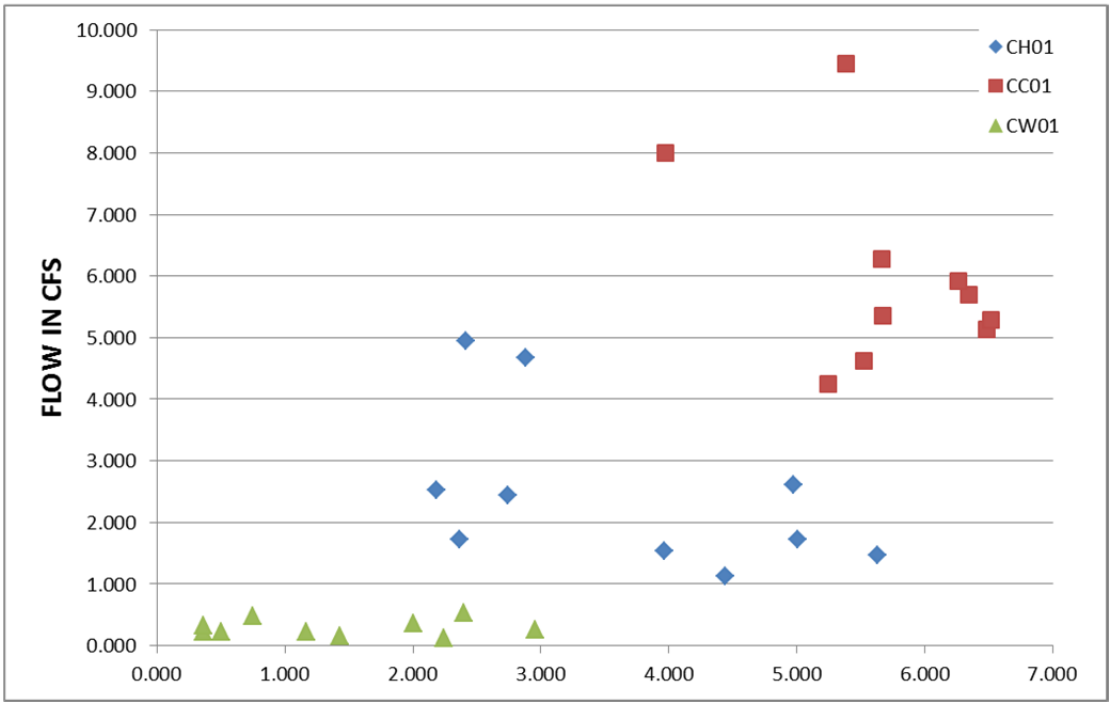
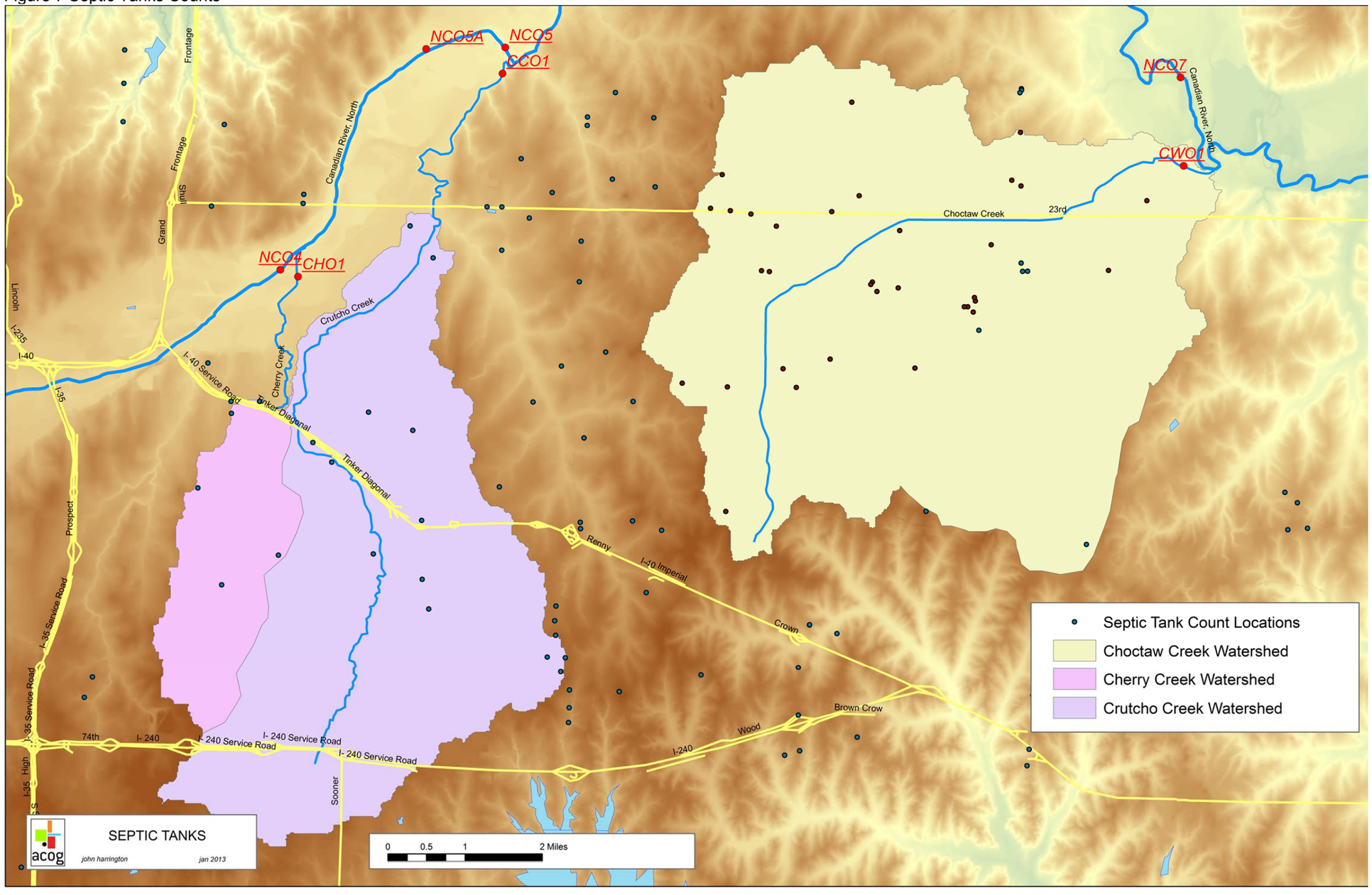


Figure 7 Septic Tanks Counts



D. CONCLUSIONS

Bacteriological sampling on the North Canadian River and several tributaries was performed in summer 2011 duplicating eight locations sampled in 2003. Fecal coliform in summer 2011 decreased significantly from the summer 2003 sampling event. However, there is no statistical difference between the e.coli concentrations between the two sampling events. Enterococci decreased in two of the sampled tributaries (Crutcho Creek and Choctaw Creek) as wells as the sampling location on Triple-X road (NC07).

Fluorometer data was inconclusive as a tool to define detergents (and thus failing septic tanks). The main stem of the river had consistent luminescence. The tributaries had higher luminescence, but had no relationship to flow or turbidity. In addition, the data did not correlate to the density or number of septic tanks in the watershed.

E. REFERENCES

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APPENDIX A BACTERIOLOGICAL DATA

Analysis Date	Sample No	Station	FLUOROMETER	TURBIDITY NTU	Enterococci	Fecal Coliform	E. Coli	Comments
12-Jul	4042.003	CC01	6.35	4.0	50.4	81.6	142.1	
18-Jul	4605.003	CC01	6.48	5.0	93.3	68.9	104.6	
26-Jul	4757.003	CC01	5.39	6.0	63.7	727.0	648.8	
1-Aug	4875.003	CC01	5.52	4.0	117.8	49.6	51.2	
8-Aug	5008.003	CC01	5.66	4.0	161.6	101.7	90.8	
15-Aug	5586.003	CC01	3.98	16.0	167.0	517.2	141.4	
22-Aug	5726.003	CC01	6.26	5.0	866.4	65.0	79.4	
29-Aug	5882.003	CC01	5.67	4.6	686.7	224.7	82.3	
6-Sep	6015.003	CC01	6.52	5.2	275.5	88.6	123.6	
12-Sep	6098.003	CC01	5.24	3.8	66.3	38.4	79.4	
12-Jul	4042.002	CH01	4.98	5.0	290.9	980.4	1413.6	
18-Jul	4605.002	CH01	5.01	12.0	980.4	365.4	290.9	
26-Jul	4757.002	CH01	2.41	11.0	613.1	2419.6	1046.2	
1-Aug	4875.002	CH01	2.36	8.0	1119.9	488.4	866.4	
8-Aug	5008.002	CH01	2.74	9.0	2419.6	2419.6	2419.6	
15-Aug	5586.002	CH01	2.19	16.0	1553.1	1413.6	866.4	
22-Aug	5726.002	CH01	2.88	11.0	980.4	2419.6	2419.6	
29-Aug	5882.002	CH01	3.97	10.6	2419.6	770.1	770.1	
6-Sep	6015.002	CH01	5.63	10.4	1732.9	1553.1	2419.6	
12-Sep	6098.002	CH01	4.44	12.4	686.7	344.8	517.2	
14-Jul	4315.003	CW01	2.96	10.0	613.1	1299.7	770.1	
19-Jul	4642.003	CW01	2.24	8.0	172.6	107.1	111.9	
27-Jul	4794.003	CW01	0.74	5.0	36.4	53.8	8.5	
2-Aug	4894.003	CW01	0.36	7.0	38.8	18.7	29.5	
9-Aug	5043.003	CW01	0.36	7.0	178.2	98.7	45.9	
16-Aug	5612.003	CW01	0.50	10.0	116.0	55.4	44.1	
23-Aug	5757.003	CW01	1.17	10.0	159.7	218.7	80.9	
30-Aug	5924.003	CW01	1.43	7.8	203.5	155.3	59.1	
7-Sep	6044.003	CW01	2.00	8.8	155.3	39.7	88.4	Samples 6044.001-.005 were added to incorrect batch on 9/7/2011.They were removed from that batch today an
14-Sep	6369.003	CW01	2.39	9.1	344.8	95.9	96.0	
12-Jul	4042.001	NC04	0.25	9.0	1119.9	28.8	31.8	
18-Jul	4605.001	NC04	-0.88	20.0	2419.6	157.6	185.0	
26-Jul	4757.001	NC04	-1.23	7.0	2419.6	547.5	201.4	
1-Aug	4875.001	NC04	-1.30	6.0	2419.6	35.5	17.5	
8-Aug	5008.001	NC04	-0.78	8.0	2419.6	435.2	160.7	
15-Aug	5586.001	NC04	-1.03	10.0	770.1	307.6	151.5	
22-Aug	5726.001	NC04	-0.94	7.0	191.8	26.2	17.1	
29-Aug	5882.001	NC04	-0.89	5.9	1119.9	73.3	37.3	
6-Sep	6015.001	NC04	-0.40	9.7	222.4	81.3	90.6	
12-Sep	6098.001	NC04	-0.57	10.7	727.0	224.7	307.6	
12-Jul	4042.004	NC05	0.74	9.0	648.8	16.8	8.5	
18-Jul	4605.004	NC05	0.47	18.0	2419.6	129.6	58.1	
26-Jul	4757.004	NC05A	-0.66	9.0	2419.6	866.4	224.7	
1-Aug	4875.004	NC05A	-0.94	9.0	2419.6	56.3	47.9	
8-Aug	5008.004	NC05A	-0.24	9.0	1203.3	547.5	488.4	
15-Aug	5586.004	NC05A	-0.66	11.0	107.6	186.0	141.4	
22-Aug	5726.004	NC05A	-0.39	7.0	727.0	165.8	143.9	
29-Aug	5882.004	NC05A	0.93	5.5	2419.6	120.1	85.5	
6-Sep	6015.004	NC05A	0.01	7.9	165.0	83.3	67.0	
12-Sep	6098.004	NC05A	0.35	3.8	116.9	166.4	167.0	

Analysis Date	Sample No	Station	FLUOROMETER	TURBIDITY NTU	Enterococci	Fecal Coliform	E. Coli	Comments
14-Jul	4315.001	NC06	0.32	34.0	365.4	613.1	109.2	
19-Jul	4642.001	NC06	0.91	16.0	2419.6	29.2	27.5	
27-Jul	4794.001	NC06	-0.35	19.0	280.9	46.2	45.5	
2-Aug	4894.001	NC06	-0.42	13.0	198.9	14.8	17.5	
9-Aug	5043.001	NC06	0.18	15.0	866.4	156.5	186.0	
16-Aug	5612.001	NC06	-0.72	21.0	68.9	44.3	31 .8	
23-Aug	5757.001	NC06	-0.10	20.0	112.6	186.0	8.5	
30-Aug	5924.001	NC06	0.15	17.8	2419.6	172.3	98.8	
7-Sep	6044.001	NC06	0.02	18.0	195.6	13.1	55.6	
14-Sep	6369.001	NC06	-0.65	23.4	118.7	8.6	30.9	
14-Jul	4315.002	NC07	1.42	56.0	435.2	980.4	344.8	
19-Jul	4642.002	NC07	1.77	15.0	172.2	30.1	27.2	
27-Jul	4794.002	NC07	0.69	17.0	1986.3	85.7	43.7	
2-Aug	4894.002	NC07	0.42	23.0	1046.2	45.7	45.7	
9-Aug	5043.002	NC07	0.42	23.0	488.4	139.6	64.4	
16-Aug	5612.002	NC07	0.18	30.0	178.9	81.3	79.8	
23-Aug	5757.002	NC07	0.18	30.0	224.7	214.3	44.1	
30-Aug	5924.002	NC07	0.62	18.6	344.1	193.5	77.6	
7-Sep	6044.002	NC07	0.81	20.9	201.4	53.0	62.0	Samples 6044.001-.005 were added to incorrect batch on 9/7/2011.They were removed from that batch today an
14-Sep	6369.002	NC07	0.59	21.2	186.0	101.7	117.2	
14-Jul	4315.004	NC08	1.26	124.0	2419.6	613.1	109.5	
19-Jul	4642.004	NC08	1.62	20.0	35.0	35.5	14.2	
27-Jul	4794.004	NC08	-0.32	20.0	2419.6	261.3	133.3	
2-Aug	4894.004	NC08	-0.22	19.0	2419.6	101.7	121.1	
9-Aug	5043.004	NC08	-0.12	21.0	1046.2	112.6	75.4	
16-Aug	5612.004	NC08	-0.51	25.0	40.2	26.2	15.5	
23-Aug	5757.004	NC08	-0.16	15.0	93.3	165.0	24.3	
30-Aug	5924.004	NC08	0.25	18.1	127.4	104.6	31.7	
7-Sep	6044.004	NC08	-0.08	23.7	461.1	13.5	13.4	Samples 6044.001-.005 were added to incorrect batch on 9/7/2011.They were removed from that batch today an
14-Sep	6369.004	NC08	-0.04	18.6	46.4	30.9	21.6	

APPENDIX B PHYSICAL AND CHEMICAL DATA

Analysis Date	Station	DATE	FLOW CF/S	TEMP °F	SpCond uS/cm	pH	Chloride mg/l	DO %	DO mg/l	NOTES
12-Jul	CC01	12-Jul	5.70	78.9	771	7.50	66.42	ND	ND	
18-Jul	CC01	18-Jul	5.14	80.1	709	7.65	120.00	25.50	2.04	
26-Jul	CC01	26-Jul	9.45	80.1	709	7.65	120.00	25.50	2.04	
1-Aug	CC01	1-Aug	4.62	80.1	870	7.50	124.25	22.40	1.79	
8-Aug	CC01	8-Aug	6.28	78.6	827	7.41	122.00	26.00	2.11	
15-Aug	CC01	15-Aug	8.00	78.9	659	7.45	98.98	75.50	6.11	
22-Aug	CC01	22-Aug	5.93	79.6	817	7.50	126.30	29.05	2.33	
29-Aug	CC01	29-Aug	5.36	79.8	796	7.47	135.90	29.65	2.38	
6-Sep	CC01	6-Sep	5.29	70.7	835	7.58	166.95	35.70	3.15	
12-Sep	CC01	12-Sep	4.24	73.9	800	7.54	178.25	33.60	2.86	
12-Jul	CH01	12-Jul	2.61	77.4	727	7.50	56.98	ND	ND	
18-Jul	CH01	18-Jul	1.73	78.6	811	8.60	207.70	ND	ND	
26-Jul	CH01	26-Jul	4.94	78.8	884	7.73	136.80	40.60	3.29	
1-Aug	CH01	1-Aug	1.72	79.3	563	7.62	94.67	53.10	4.28	
8-Aug	CH01	8-Aug	2.44	78.4	819	7.60	112.40	53.40	4.34	
15-Aug	CH01	15-Aug	2.52	77.3	740	7.54	110.80	55.30	4.54	
22-Aug	CH01	22-Aug	4.68	79.3	755	7.55	112.10	50.85	4.10	
29-Aug	CH01	29-Aug	1.54	78.9	779	7.55	117.55	41.25	3.34	
6-Sep	CH01	6-Sep	1.46	68.6	846	7.61	165.60	49.90	4.50	
12-Sep	CH01	12-Sep	1.13	71.5	790	7.65	162.10	55.60	4.85	
14-Jul	CW01	14-Jul	0.52	81.3	785	7.98	80.97	ND	ND	After 4" rainfall event
19-Jul	CW01	19-Jul	0.36	83.5	788	7.89	120.30	ND	ND	
27-Jul	CW01	27-Jul	0.16	82.3	882	7.84	121.40	17.40	1.36	
2-Aug	CW01	2-Aug	0.23	83.5	756	7.77	99.65	20.10	1.55	
9-Aug	CW01	9-Aug	0.22	ND	ND	ND	ND	ND	ND	
16-Aug	CW01	16-Aug	0.33	80.6	722	7.69	96.16	30.80	2.44	
23-Aug	CW01	23-Aug	0.22	81.1	743	7.61	111.85	21.25	1.68	
30-Aug	CW01	30-Aug	0.48	79.1	775	7.68	116.60	20.80	1.68	
7-Sep	CW01	7-Sep	0.12	64.7	739	7.72	161.40	36.30	3.42	
14-Sep	CW01	14-Sep	0.26	72.4	768	7.59	163.05	23.70	2.05	
12-Jul	NC04	12-Jul	44.13	79.5	1023	7.70	99.71	ND	ND	
18-Jul	NC04	18-Jul	19.66	81.1	1066	8.77	342.70	ND	ND	
26-Jul	NC04	26-Jul	29.99	79.7	1063	7.92	181.20	47.80	3.83	
1-Aug	NC04	1-Aug	27.75	82.7	1008	7.78	135.20	39.10	3.05	
8-Aug	NC04	8-Aug	24.50	77.1	1080	7.71	168.80	47.40	3.90	
15-Aug	NC04	15-Aug	32.49	77.8	988	7.81	166.80	65.60	5.36	
22-Aug	NC04	22-Aug	13.22	79.6	1149	7.66	206.00	53.80	4.32	
29-Aug	NC04	29-Aug	1.16	79.3	1873	7.72	369.50	61.40	4.93	
6-Sep	NC04	6-Sep	23.38	64.0	1358	7.98	265.10	73.70	6.99	
12-Sep	NC04	12-Sep	2.24	70.8	1314	7.93	308.05	61.75	5.43	

Analysis Date	Station	DATE	FLOW CF/S	TEMP °F	SpCond uS/cm	pH	Chloride mg/l	DO %	DO mg/l	NOTES
12-Jul	NC05	12-Jul	ND	82.0	950	8.20	90.85	ND	ND	
18-Jul	NC05	18-Jul	ND	82.2	960	9.25	265.50	ND	ND	
26-Jul	NC05A	26-Jul	33.50	79.7	1005	8.12	196.20	84.20	6.75	
1-Aug	NC05A	1-Aug	33.69	81.3	972	7.97	153.50	72.10	5.69	
8-Aug	NC05A	8-Aug	29.30	76.4	1121	8.03	192.60	91.85	7.61	
15-Aug	NC05A	15-Aug	30.40	77.1	992	8.00	178.70	84.15	6.93	
22-Aug	NC05A	22-Aug	16.29	78.4	1075	7.88	182.30	88.20	7.16	
29-Aug	NC05A	29-Aug	5.22	77.2	1143	8.38	258.90	81.70	6.72	
6-Sep	NC05A	6-Sep	24.44	61.4	1267	8.08	274.00	88.80	8.67	
12-Sep	NC05A	12-Sep	8.99	67.3	1269	7.94	269.70	91.50	8.35	
14-Jul	NC06	14-Jul	121.56	83.1	506	8.34	74.11	ND	ND	After 4" rainfall event
19-Jul	NC06	19-Jul	28.91	84.4	903	9.33	211.20	ND	ND	
27-Jul	NC06	27-Jul	41.13	82.3	1019	8.86	174.60	68.20	5.33	
2-Aug	NC06	2-Aug	34.98	84.7	979	8.62	131.60	64.10	4.89	
9-Aug	NC06	9-Aug	29.51	ND	ND	ND	ND	ND	ND	
16-Aug	NC06	16-Aug	45.66	81.4	811	8.49	131.00	75.80	5.98	
23-Aug	NC06	23-Aug	21.16	80.3	987	8.68	170.90	70.70	5.64	
30-Aug	NC06	30-Aug	24.42	78.8	900	8.88	142.80	66.40	5.38	
7-Sep	NC06	7-Sep	29.61	67.1	1240	8.61	265.70	80.30	7.35	
14-Sep	NC06	14-Sep	11.27	73.6	1193	8.77	254.10	72.70	6.21	
14-Jul	NC07	14-Jul	ND	82.9	740	8.20	85.62	ND	ND	After 4" rainfall event
19-Jul	NC07	19-Jul	88.51	82.4	1069	8.98	234.60	ND	ND	
27-Jul	NC07	27-Jul	100.68	81.1	1205	8.88	197.20	76.00	6.01	
2-Aug	NC07	2-Aug	92.79	83.8	1200	8.55	167.70	72.90	5.61	
9-Aug	NC07	9-Aug	87.78	ND	ND	ND	ND	ND	ND	
16-Aug	NC07	16-Aug	107.46	80.6	722	7.69	96.48	30.80	2.45	
23-Aug	NC07	23-Aug	84.10	79.3	1149	8.09	190.70	78.40	6.31	
30-Aug	NC07	30-Aug	71.27	76.8	1219	8.01	184.55	78.60	6.49	
7-Sep	NC07	7-Sep	87.24	67.7	1157	8.43	233.65	86.80	7.90	
14-Sep	NC07	14-Sep	55.69	74.0	1176	8.15	272.50	80.80	6.86	
14-Jul	NC08	14-Jul	ND	83.7	935	8.63	103.00	ND	ND	After 4" rainfall event
19-Jul	NC08	19-Jul	87.71	84.9	965	9.85	201.00	ND	ND	
27-Jul	NC08	27-Jul	72.84	82.0	1282	9.57	196.40	114.70	8.98	
2-Aug	NC08	2-Aug	61.70	84.5	1219	9.34	163.60	95.80	7.33	
9-Aug	NC08	9-Aug	67.44	ND	ND	ND	ND	ND	ND	
16-Aug	NC08	16-Aug	93.33	82.1	853	8.89	126.60	95.05	7.45	
23-Aug	NC08	23-Aug	59.03	81.5	1164	8.91	182.70	99.60	7.84	
30-Aug	NC08	30-Aug	44.11	76.7	1220	8.83	205.10	85.00	7.03	
7-Sep	NC08	7-Sep	71.99	67.0	1231	8.81	241.35	101.75	9.33	
14-Sep	NC08	14-Sep	58.92	73.9	1062	8.79	225.90	99.90	8.50	

APPENDIX C CHAIN OF CUSTODY PAPERWORK

DEQ OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION

Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names):	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104	JOHN HARRINGTON	

SAMPLE INFORMATION

Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	TESTING REQUIRED: For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC06	BACTEROLOGICAL SAMPLE	3	7/14/11	6:45 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC07	BACTEROLOGICAL SAMPLE	3		7:20 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CW01	BACTEROLOGICAL SAMPLE	3		8:17 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC08	BACTEROLOGICAL SAMPLE	3		9:05 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC02	BACTEROLOGICAL SAMPLE	3		5:50 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
		25		AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

AC02 20 AC PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	7/14/11 9:46	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

DEQ OKLAHOMA

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION

Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names): JOHN HARRINGTON	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104		

SAMPLE INFORMATION / **TESTING REQUIRED**

Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC06	BACTEROLOGICAL SAMPLE	3	7/14/11	6:48 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC07	BACTEROLOGICAL SAMPLE	3		7:20 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CW01	BACTEROLOGICAL SAMPLE	3		8:17 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC08	BACTEROLOGICAL SAMPLE	3		9:05 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC02	BACTEROLOGICAL SAMPLE	3		5:50 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
		25		AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

AC02 20 AC PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	7/14/11	9:46			
Relinquished By:	Agency:	Date/Time:		Received By:	Agency:	Date/Time:

☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail

707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION		
Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names): JOHN HARRINGTON	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104		

SAMPLE INFORMATION						TESTING REQUIRED
Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC04	BACTEROLOGICAL SAMPLE	3	7/18	610 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CH01	BACTEROLOGICAL SAMPLE	3		705 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CC01	BACTEROLOGICAL SAMPLE	3		852 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC05	BACTEROLOGICAL SAMPLE	3		847 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC01	BACTEROLOGICAL SAMPLE	3		627 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG					
Relinquished By:	Agency:	Date/Time: 7/18 9:19	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

DEQ OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION

Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names):	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104	JOHN HARRINGTON	

SAMPLE INFORMATION / TESTING REQUIRED

Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC06	BACTEROLOGICAL SAMPLE	3	7/19	645 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC07	BACTEROLOGICAL SAMPLE	3		757 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CW01	BACTEROLOGICAL SAMPLE	3		829 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC08	BACTEROLOGICAL SAMPLE	3		930 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC02	BACTEROLOGICAL SAMPLE	3		639 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

NC08 20AC PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG		☐ Hand delivered ☒ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time: 7/19 1020	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

DEQ OKLAHOMA

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION		
Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names):	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104	JOHN HARRINGTON	

SAMPLE INFORMATION						TESTING REQUIRED
Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC04	BACTEROLOGICAL SAMPLE	3	7/26/11	6:31 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CH01	BACTEROLOGICAL SAMPLE	3		7:16 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CC01	BACTEROLOGICAL SAMPLE	3		7:55 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC05 A	BACTEROLOGICAL SAMPLE	3		8:42 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC01	BACTEROLOGICAL SAMPLE	3		4:41 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

AC01 10CA, AC01A Drain

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG					
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

DEQ OKLAHOMA

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION		
Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names):	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104	JOHN HARRINGTON	

SAMPLE INFORMATION						TESTING REQUIRED
Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC06	BACTEROLOGICAL SAMPLE	3	7/27/11	644 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC07	BACTEROLOGICAL SAMPLE	3		745 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CW01	BACTEROLOGICAL SAMPLE	3		823 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC08	BACTEROLOGICAL SAMPLE	3		928 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC02	BACTEROLOGICAL SAMPLE	3		501 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

GET MORE Containers PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	7/27/11 10:08	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

DEQ OKLAHOMA

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION

Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names):	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104	JOHN HARRINGTON	

SAMPLE INFORMATION / **TESTING REQUIRED**

Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC04	BACTEROLOGICAL SAMPLE	3	8/1/12	6:38 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CH01	BACTEROLOGICAL SAMPLE	3		7:24 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CC01	BACTEROLOGICAL SAMPLE	3		8:11 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC05	BACTEROLOGICAL SAMPLE	3		8:58 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC01	BACTEROLOGICAL SAMPLE	3		8:04 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

AC0150CN

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	8/1/11 9:19	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

DEQ OKLAHOMA

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION		
Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names):	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104	JOHN HARRINGTON	

SAMPLE INFORMATION						TESTING REQUIRED
Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC06	BACTEROLOGICAL SAMPLE	3	8/2/11	6:47 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC07	BACTEROLOGICAL SAMPLE	3		7:49 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CW01	BACTEROLOGICAL SAMPLE	3		8:22 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC08	BACTEROLOGICAL SAMPLE	3		9:28 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC02	BACTEROLOGICAL SAMPLE	3		5:42 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

AC0220CA

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	8/2/11 10:05	☒ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

DEQ OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION

Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names):	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104	JOHN HARRINGTON	

SAMPLE INFORMATION / TESTING REQUIRED

Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC04	BACTEROLOGICAL SAMPLE	3	8/8/11	6:46 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CH01	BACTEROLOGICAL SAMPLE	3		7:28 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CC01	BACTEROLOGICAL SAMPLE	3		8:15 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC05 A	BACTEROLOGICAL SAMPLE	3		9:00 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC01	BACTEROLOGICAL SAMPLE	3		8:27 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

AC01101C · PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	8/8/11	9:11			
Relinquished By:	Agency:	Date/Time:		Received By:	Agency:	Date/Time:

☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail

707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

DEQ OKLAHOMA

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION		
Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names): JOHN HARRINGTON	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104		

SAMPLE INFORMATION						TESTING REQUIRED
Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC06	BACTEROLOGICAL SAMPLE	3	8/9/11	654 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC07	BACTEROLOGICAL SAMPLE	3		753 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CW01	BACTEROLOGICAL SAMPLE	3		821 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC08	BACTEROLOGICAL SAMPLE	3		928 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC02	BACTEROLOGICAL SAMPLE	3		544 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	8/9/11 10:05	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

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707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

DEQ OKLAHOMA

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION

Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names):	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104	JOHN HARRINGTON	

SAMPLE INFORMATION / TESTING REQUIRED

Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-369-1400
NC04	BACTEROLOGICAL SAMPLE	3	8/15/11	652 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CH01	BACTEROLOGICAL SAMPLE	3		729 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CC01	BACTEROLOGICAL SAMPLE	3		8:11 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC05A	BACTEROLOGICAL SAMPLE	3		856 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC01	BACTEROLOGICAL SAMPLE	3		658 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLERS COMMENTS

NC05AA50CN PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

LABORATORY COMMENTS

CUSTODY RECORD / MISCELLANEOUS

Relinquished By (Sampler): JOHN HARRINGTON	Agency: ACOG	Date/Time: 8/15/11 9:19	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency	Date/Time:
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency	Date/Time:

707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION		
Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names): JOHN HARRINGTON	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104		

SAMPLE INFORMATION						TESTING REQUIRED
Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC06	BACTEROLOGICAL SAMPLE	3	8/16/11	656 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC07	BACTEROLOGICAL SAMPLE	3		752 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CW01	BACTEROLOGICAL SAMPLE	3		820 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC08	BACTEROLOGICAL SAMPLE	3		927 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC02	BACTEROLOGICAL SAMPLE	3		647 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

AC0220CA GET Sample Bottles!

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	8/16/11 10:07	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

9800-QSF3-R1.0-042811 - Page 1 of 1

707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION		
Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names): JOHN HARRINGTON	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104		

SAMPLE INFORMATION						TESTING REQUIRED
Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC04	BACTEROLOGICAL SAMPLE	3	8/22/11	701 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CH01	BACTEROLOGICAL SAMPLE	3		737 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CC01	BACTEROLOGICAL SAMPLE	3		820 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC05A	BACTEROLOGICAL SAMPLE	3		903 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC01	BACTEROLOGICAL SAMPLE	3		915 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

AC01 50CN

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	8/22/11 9:37	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION		
Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names): JOHN HARRINGTON	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104		

SAMPLE INFORMATION						TESTING REQUIRED
Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC06	BACTEROLOGICAL SAMPLE	3	8/23/11	706 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC07	BACTEROLOGICAL SAMPLE	3		806 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CW01	BACTEROLOGICAL SAMPLE	3		831 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC08	BACTEROLOGICAL SAMPLE	3		937 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC02	BACTEROLOGICAL SAMPLE	3		541 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

AC02ZOCA

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	8/23/11 10:17	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

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DEQ OKLAHOMA Department of Environmental Quality

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION		
Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names): JOHN HARRINGTON	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104		

SAMPLE INFORMATION						TESTING REQUIRED
Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC04	BACTEROLOGICAL SAMPLE	3	8/29/11	703 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CH01	BACTEROLOGICAL SAMPLE	3		740 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CC01	BACTEROLOGICAL SAMPLE	3		824 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC05A	BACTEROLOGICAL SAMPLE	3		904 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC01	BACTEROLOGICAL SAMPLE	3		704 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

CH01OHC

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	8/29/11 9:24	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

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AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION		
Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names):	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104	JOHN HARRINGTON	

SAMPLE INFORMATION						TESTING REQUIRED
Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC06	BACTEROLOGICAL SAMPLE	3	8/30/11	712 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC07	BACTEROLOGICAL SAMPLE	3		807 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CW01	BACTEROLOGICAL SAMPLE	3		836 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC08	BACTEROLOGICAL SAMPLE	3		940 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC02	BACTEROLOGICAL SAMPLE	3		719 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

AC0220CA

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	8/30/11 10:18	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

9800-QSF3-R1.0-042811 - Page 1 of 1

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AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION		
Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names): JOHN HARRINGTON	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104		

SAMPLE INFORMATION						TESTING REQUIRED
Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC04	BACTEROLOGICAL SAMPLE	3	9/6/11	705 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CH01	BACTEROLOGICAL SAMPLE	3		745 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CC01	BACTEROLOGICAL SAMPLE	3		832 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC05A	BACTEROLOGICAL SAMPLE	3		923 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC01	BACTEROLOGICAL SAMPLE	3		823 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

CC011DCC PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	9/6/11 9:43	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

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DEQ OKLAHOMA

AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION		
Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names): JOHN HARRINGTON	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104		

SAMPLE INFORMATION						TESTING REQUIRED
Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC06	BACTEROLOGICAL SAMPLE	3	9/7/11	724 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC07	BACTEROLOGICAL SAMPLE	3		823 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CW01	BACTEROLOGICAL SAMPLE	3		852 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC08	BACTEROLOGICAL SAMPLE	3		957 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC02	BACTEROLOGICAL SAMPLE	3		714 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

AC02206A

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	9/7/11 10:34	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

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AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION		
Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names): JOHN HARRINGTON	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104		

SAMPLE INFORMATION						TESTING REQUIRED
Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC04	BACTEROLOGICAL SAMPLE	3	9/12/11	708 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CH01	BACTEROLOGICAL SAMPLE	3		744 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CC01	BACTEROLOGICAL SAMPLE	3		831 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC05A	BACTEROLOGICAL SAMPLE	3		913 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC01	BACTEROLOGICAL SAMPLE	3		809 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

CH0110HC

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	9/12/11 938	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

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AD HOC CHAIN OF CUSTODY

PROJECT INFORMATION

Company/Individual Name: ASSOCIATION OF CENTRAL OK GOVTS	Samplers (Print Names): JOHN HARRINGTON	Project Name: (Lab Use Only)
Company/Individual Zip Code: 73104		

SAMPLE INFORMATION / **TESTING REQUIRED**

Sample Location or Address (Please include ZIP code)	Sample Description	# of Containers	Date (M/D/Y)	Time (Circle AM or PM)	Matrix	For assistance selecting the proper testing or for general inquiries call 1-800-869-1400
NC06	BACTEROLOGICAL SAMPLE	3	9/14/11	719 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC07	BACTEROLOGICAL SAMPLE	3		818 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
CW01	BACTEROLOGICAL SAMPLE	3		845 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
NC08	BACTEROLOGICAL SAMPLE	3		953 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
AC02	BACTEROLOGICAL SAMPLE	3		723 AM PM	W	FECAL COLIFORM, ENTEROCOCCI, E. COLI
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		
				AM PM		

SAMPLER'S COMMENTS

PLEASE SEND FULL CHAIN OF CUSTODY TO ACOG FAX 405-234-2264

SAMPLE RECEIVING COMMENTS

AC0220CA

CUSTODY RECORD MUST BE SIGNED

Relinquished By (Sampler):	Agency:	Date/Time:		Received By:	Agency:	Date/Time:
JOHN HARRINGTON	ACOG	9/14/11 10:33	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail			
Relinquished By:	Agency:	Date/Time:	☐ Hand delivered ☐ Courier (FedEx, UPS, etc.) ☐ US Mail	Received By:	Agency:	Date/Time:

707 NORTH ROBINSON, P.O. BOX 1677, OKLAHOMA CITY, OKLAHOMA 73101-1677

APPENDIX D CALIBRATION DATA

Radius	2.00	
d+R (Wetted Depth)	2.75	
Depth (h)	1.25	
Angle	1.79	
Area of Chord	1.63	
Wetted Area	10.94	sq in
Wetted Area	0.08	sq ft
Volume	5.00	gal
Volume in cf	0.67	cf
Time	34.50	sec
Flow Rate	0.02	cfs
Flow Velocity	0.26	ft/s

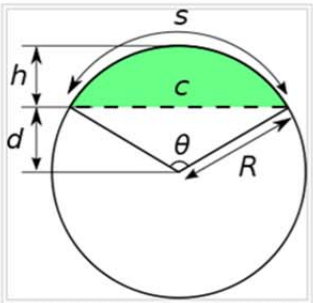
60-SECOND REV	Velocity FT/S
18	0.30

Error	15.0%	
FLOW METER CALIBRATION		
DATE 08-14-2011		

Formulas [edit]

Let **R** be the radius of the circle, **θ** is the central angle, **c** the chord length, **s** the arc length, **h** the height of the segment, and **d** the height of the triangular portion.

- The radius is $R = h + d = h/2 + c^2/8h$
- The arc length is $s = R\theta$
- The chord length is $c = 2R\sin\frac{\theta}{2} = R\sqrt{2 - 2\cos\theta}$
- The height is $h = R(1 - \cos\frac{\theta}{2}) = R - \sqrt{R^2 - \frac{c^2}{4}}$
- The angle is $\theta = 2\arccos\frac{d}{R}$



A circular segment (in green) is enclosed between a secant/chord (the dashed line) and the arc whose endpoints equal the chord's (the arc shown above the green area).

Area [edit]

The area of the circular segment is equal to the area of the circular sector minus the area of the triangular portion.

$$A = \pi R^2 \cdot \frac{\theta}{2\pi} - \frac{R^2 \sin\theta}{2} = \frac{R^2}{2}(\theta - \sin\theta)$$

Radius	**2.00**	
d+R (Wetted Depth)	**2.88**	
Depth (h)	**1.13**	
Angle	**1.95**	
Area of Chord	**2.03**	
Wetted Area	**10.53**	**sq in**
Wetted Area	**0.07**	**sq ft**
Volume	**5.00**	**gal**
Volume in cf	**0.67**	**cf**
Time	**34.40**	**sec**
Flow Rate	**0.02**	**cfs**
Flow Velocity	**0.27**	**ft/s**

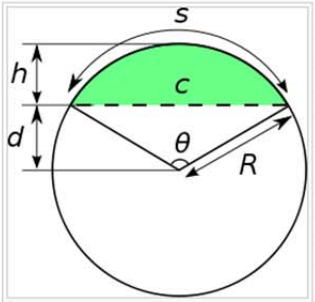
180-SECOND REV	Velocity FT/S
44	0.24

Error	**-8.7%**	
FLOW METER CALIBRATION		
DATE 08-21-2011		

Formulas [edit]

Let **R** be the radius of the circle, **θ** is the central angle, **c** the chord length, **s** the arc length, **h** the height of the segment, and **d** the height of the triangular portion.

- The radius is $R = h + d = h/2 + c^2/8h$
- The arc length is $s = R\theta$
- The chord length is $c = 2R\sin\frac{\theta}{2} = R\sqrt{2 - 2\cos\theta}$
- The height is $h = R(1 - \cos\frac{\theta}{2}) = R - \sqrt{R^2 - \frac{c^2}{4}}$
- The angle is $\theta = 2\arccos\frac{d}{R}$



A circular segment (in green) is enclosed between a secant/chord (the dashed line) and the arc whose endpoints equal the chord's (the arc shown above the green area).

Area [edit]

The area of the circular segment is equal to the area of the circular sector minus the area of the triangular portion.

$$A = \pi R^2 \cdot \frac{\theta}{2\pi} - \frac{R^2 \sin\theta}{2} = \frac{R^2}{2}(\theta - \sin\theta)$$

Radius	2.00	
d+R (Wetted Depth)	2.88	
Depth (h)	1.13	
Angle	1.95	
Area of Chord	2.03	
Wetted Area	10.53	sq in
Wetted Area	0.07	sq ft
Volume	5.00	gal
Volume in cf	0.67	cf
Time	34.00	sec
Flow Rate	0.02	cfs
Flow Velocity	0.27	ft/s

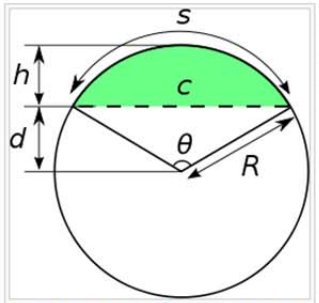
180-SECOND REV	Velocity FT/S
46	0.26

Error	-5.2%
FLOW METER CALIBRATION	
DATE 08-28-2011	

Formulas [edit]

Let **R** be the radius of the circle, **θ** is the central angle, **c** the chord length, **s** the arc length, **h** the height of the segment, and **d** the height of the triangular portion.

- The radius is $R = h + d = h/2 + c^2/8h$
- The arc length is $s = R\theta$
- The chord length is $c = 2R\sin\frac{\theta}{2} = R\sqrt{2 - 2\cos\theta}$
- The height is $h = R(1 - \cos\frac{\theta}{2}) = R - \sqrt{R^2 - \frac{c^2}{4}}$
- The angle is $\theta = 2\arccos\frac{d}{R}$



A circular segment (in green) is enclosed between a secant/chord (the dashed line) and the arc whose endpoints equal the chord's (the arc shown above the green area).

Area [edit]

The area of the circular segment is equal to the area of the circular sector minus the area of the triangular portion.

$$A = \pi R^2 \cdot \frac{\theta}{2\pi} - \frac{R^2 \sin\theta}{2} = \frac{R^2}{2}(\theta - \sin\theta)$$

Radius	**2.00**	
d+R (Wetted Depth)	**2.75**	
Depth (h)	**1.25**	
Angle	**1.79**	
Area of Chord	**1.63**	
Wetted Area	**10.94**	**sq in**
Wetted Area	**0.08**	**sq ft**
Volume	**5.00**	**gal**
Volume in cf	**0.67**	**cf**
Time	**34.30**	**sec**
Flow Rate	**0.02**	**cfs**
Flow Velocity	**0.26**	**ft/s**

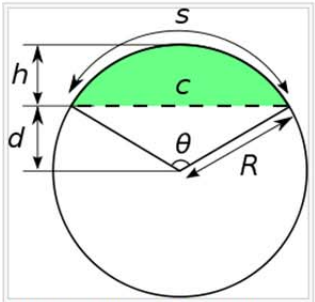
180-SECOND REV	Velocity FT/S
45	0.25

Error	**-2.6%**
FLOW METER CALIBRATION	
DATE 09-05-2011	

Formulas [edit]

Let **R** be the radius of the circle, **θ** is the central angle, **c** the chord length, **s** the arc length, **h** the height of the segment, and **d** the height of the triangular portion.

- The radius is $R = h + d = h/2 + c^2/8h$
- The arc length is $s = R\theta$
- The chord length is $c = 2R\sin\frac{\theta}{2} = R\sqrt{2 - 2\cos\theta}$
- The height is $h = R(1 - \cos\frac{\theta}{2}) = R - \sqrt{R^2 - \frac{c^2}{4}}$
- The angle is $\theta = 2\arccos\frac{d}{R}$



A circular segment (in green) is enclosed between a secant/chord (the dashed line) and the arc whose endpoints equal the chord's (the arc shown above the green area).

Area [edit]

The area of the circular segment is equal to the area of the circular sector minus the area of the triangular portion.

$$A = \pi R^2 \cdot \frac{\theta}{2\pi} - \frac{R^2 \sin\theta}{2} = \frac{R^2}{2}(\theta - \sin\theta)$$

Radius	**2.00**	
d+R (Wetted Depth)	**2.63**	
Depth (h)	**1.38**	
Angle	**1.63**	
Area of Chord	**1.25**	
Wetted Area	**11.31**	**sq in**
Wetted Area	**0.08**	**sq ft**
Volume	**5.00**	**gal**
Volume in cf	**0.67**	**cf**
Time	**35.80**	**sec**
Flow Rate	**0.02**	**cfs**
Flow Velocity	**0.24**	**ft/s**

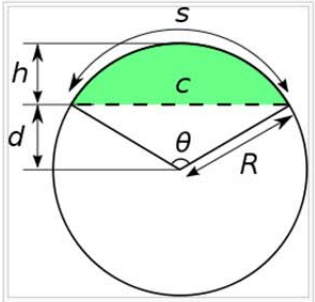
180-SECOND REV	Velocity FT/S
43	0.24

Error	**0.5%**
FLOW METER CALIBRATION	
DATE 09-11-2011	

Formulas [edit]

Let **R** be the radius of the circle, **θ** is the central angle, **c** the chord length, **s** the arc length, **h** the height of the segment, and **d** the height of the triangular portion.

- The radius is $R = h + d = h/2 + c^2/8h$
- The arc length is $s = R\theta$
- The chord length is $c = 2R\sin\frac{\theta}{2} = R\sqrt{2 - 2\cos\theta}$
- The height is $h = R(1 - \cos\frac{\theta}{2}) = R - \sqrt{R^2 - \frac{c^2}{4}}$
- The angle is $\theta = 2\arccos\frac{d}{R}$



A circular segment (in green) is enclosed between a secant/chord (the dashed line) and the arc whose endpoints equal the chord's (the arc shown above the green area).

Area [edit]

The area of the circular segment is equal to the area of the circular sector minus the area of the triangular portion.

$$A = \pi R^2 \cdot \frac{\theta}{2\pi} - \frac{R^2 \sin\theta}{2} = \frac{R^2}{2}(\theta - \sin\theta)$$

CALIBRATION WORK SHEET

Date of Calibration: 7/12/11
Technician: John Harrington

Sonde ID: 05A2409 AA

Note: New ROX DO, pH, conduct probes

RP DO membrane changed? Y N
RP DO membrane o-ring changed? Y N

Note: Wait 3 to 6 hours before calibrating for unattended deployments; run in Discrete mode for 10 minutes to accelerate burn in. (Rapid Pulse DO Only)

Turbidity wiper changed? Y N
ROX DO wiper changed? (Y) N
BGA-PC wiper changed? Y N
Chlorophyll wiper changed? Y N
BGA-PE wiper changed? Y N
Rhodamine wiper changed? Y N

Note: If parking problems occur with optical probes having a serial number 07L (Dec 07) or older, be sure the firmware is 3.06 or later. Parking issues with optical probes having a serial number prior to 07L may be related to a dirty wiper body or pad.

Record sonde battery voltage: _____ (if applicable)

Record the following diagnostic numbers after calibration.

6560 Conductivity cell constant 4.81101 Range 5.0 ± .45
Integrated conductivity cell constant ~ Range 5.0 ± .70
pH mv Buffer 7 _____ Range 0 ± 50 mv
~~pH mv Buffer 4~~ _____ Range +180 ± 50 mv*
pH mv Buffer 10 -146.95 Range -180 ± 50 mv *

*Note: Millivolt span between pH 4 and 7 should be ≈ 165 to 180 mv
Millivolt span between pH 7 and 10 should be ≈ 165 to 180 mv

DO charge (RP only) _____ Range 25 to 75
DO gain _____ Range 0.7 to 1.4
ODO gain _____ Range 0.85 to 1.15

Turbidity standard used in calibration _____
Manufacturer and part number _____

Barometric Pressure: _____ mmHg

DO % Calculated – (BARO mmHg divided by 7.6) = % saturation
Example: 760 ÷ 7.6 = 100.0%

Depth Calibration - If zero was entered, record barometric pressure at time of calibration _____ mmHg

Depth Calibration - If offset depth was entered, record value _____ meters/feet and pressure _____ mmHg

Depth Calibration (Vented) – Acceptable calibration constant: 0.0 psig ± 0.15 _____

Record Calibration Values

	Standard	Pre Cal / Post Cal
Temperature	29.0	28.1 / ~~28.9~~ Sonde
Conductivity	1143	/ 1143
pH 7	~	/ 6.96
~~pH 4~~		/
pH 10		/ 9.79
ORP		/
Turbidity	514	/
Turbidity	52.6	/
Turbidity ~~0~~	5.2	/
CL Chlorophyll ~~Chlorophyll~~	495	/ 96.3
Chlorophyll		/
DO RP		/
DO ROX		/
BGA PE/PC		/
BGA PE/PC		/
Rhodamine		/

Notes: CANNOT Calibrate new DO SENSOR - NEED TO ORDER NEW ADAPTER 6025AS 8/ DB-9 from YSI

CALIBRATION WORK SHEET

Date of Calibration: 7/13/2011 Sonde ID: _____

Technician: John Harrington

New DO ROX

RP DO membrane changed? Y N *Note: Wait 3 to 6 hours before calibrating for unattended deployments; run in Discrete mode for 10 minutes to accelerate burn in. (Rapid Pulse DO Only)*

RP DO membrane o-ring changed? Y N

Turbidity wiper changed? Y N Chlorophyll wiper changed? Y N

ROX DO wiper changed? Y N BGA-PE wiper changed? Y N

BGA-PC wiper changed? Y N Rhodamine wiper changed? Y N

Note: If parking problems occur with optical probes having a serial number 07L (Dec 07) or older, be sure the firmware is 3.06 or later. Parking issues with optical probes having a serial number prior to 07L may be related to a dirty wiper body or pad.

Record sonde battery voltage: _____ (if applicable)

Record the following diagnostic numbers after calibration.

				Record Calibration Values Standard	Pre Cal / Post Cal
6560 Conductivity cell constant	498545	Range 5.0 ± .45		Temperature 28.8	27.6 Sonde
Integrated conductivity cell constant		Range 5.0 ± .70		Conductivity 1363	1413
pH mv Buffer 7	-12.8	Range 0 ± 50 mv		pH 7	/
pH mv Buffer 4		Range +180 ± 50 mv*		pH 4	/
pH mv Buffer 10	-48.1	Range -180 ± 50 mv *		pH 10	/
*Note: Millivolt span between pH 4 and 7 should be ≈ 165 to 180 mv				ORP	/
Millivolt span between pH 7 and 10 should be ≈ 165 to 180 mv				Turbidity	/
DO charge (RP only)		Range 25 to 75		Turbidity	/
DO gain		Range 0.7 to 1.4		Turbidity 0.5	/
ODO gain		Range 0.85 to 1.15	Cl	~~Chlorophyll~~ 98	180
				Chlorophyll	/
Turbidity standard used in calibration	Hach Stablcal			DO RP	/
Manufacturer and part number				DO ROX	/
				BGA PE/PC	/
Barometric Pressure: _____ mmHg				BGA PE/PC	/
DO % Calculated – (BARO mmHg divided by 7.6) = % saturation				Rhodamine	/

Example: 760 ÷ 7.6 = 100.0%

Depth Calibration - If zero was entered, record barometric pressure at time of calibration _____ mmHg

Depth Calibration - If offset depth was entered, record value _____ meters/feet and pressure _____ mmHg

Depth Calibration (Vented) – Acceptable calibration constant: 0.0 psig = 0.15 _____

Notes:

CALIBRATION WORK SHEET

Date of Calibration: 7/12/2011 Sonde ID: _____
Technician: J.H

RP DO membrane changed? Y N *Note: Wait 3 to 6 hours before calibrating for unattended*
RP DO membrane o-ring changed? Y N *deployments; run in Discrete mode for 10 minutes to accelerate burn in. (Rapid Pulse DO Only)*

Turbidity wiper changed? Y N Chlorophyll wiper changed? Y N
ROX DO wiper changed? Y N BGA-PE wiper changed? Y N
BGA-PC wiper changed? Y N Rhodamine wiper changed? Y N

Note: If parking problems occur with optical probes having a serial number 07L (Dec 07) or older, be sure the firmware is 3.06 or later. Parking issues with optical probes having a serial number prior to 07L may be related to a dirty wiper body or pad.

Record sonde battery voltage: _____ (if applicable)

Record the following diagnostic numbers after calibration.

6560 Conductivity cell constant 4.98565 Range 5.0 ± .45
Integrated conductivity cell constant _____ Range 5.0 ± .70
pH mv Buffer 7 -18.44 Range 0 ± 50 mv
pH mv Buffer 4 _____ Range +180 ± 50 mv*
pH mv Buffer 10 -58.7 Range -180 ± 50 mv *
*Note: Millivolt span between pH 4 and 7 should be ≈ 165 to 180 mv
Millivolt span between pH 7 and 10 should be ≈ 165 to 180 mv
DO charge (RP only) _____ Range 25 to 75 -161.97
DO gain _____ Range 0.7 to 1.4
ODO gain _____ Range 0.85 to 1.15 0.1

Turbidity standard used in calibration _____
Manufacturer and part number _____

Barometric Pressure: _____ mmHg
DO % Calculated – (BARO mmHg divided by 7.6) = % saturation
Example: 760 ÷ 7.6 = 100.0%

Depth Calibration - If zero was entered, record barometric pressure at time of calibration _____ mmHg
Depth Calibration - If offset depth was entered, record value _____ meters/feet and pressure _____ mmHg
Depth Calibration (Vented) – Acceptable calibration constant: 0.0 psig ± 0.15 _____

Record Calibration Values	Standard	Pre Cal / Post Cal
Temperature	_____	____Sonde
Conductivity	1412	1 / 1413
pH 7	6.56	1 7.14
pH 4	✓	1
pH 10	12.5	1 10.01
ORP	_____	1
Turbidity	5.2	4.0 / 5.0
Turbidity	526	50. / 50.
Turbidity 0.5	514	496 / 494
Chlorophyll	44.5	1 10.2
Chlorophyll	_____	1
DO RP	_____	1
DO ROX	_____	1
BGA PE/PC	_____	1
BGA PE/PC	_____	1
Rhodamine	_____	1

Notes:

CALIBRATION WORK SHEET

Date of Calibration: 7/24/11 Sonde ID: _____
Technician: JH

RP DO membrane changed? Y N *Note: Wait 3 to 6 hours before calibrating for unattended*
RP DO membrane o-ring changed? Y N *deployments; run in Discrete mode for 10 minutes to accelerate burn in. (Rapid Pulse DO Only)*
Turbidity wiper changed? Y N Chlorophyll wiper changed? Y N
ROX DO wiper changed? Y N BGA-PE wiper changed? Y N
BGA-PC wiper changed? Y N Rhodamine wiper changed? Y N

Note: If parking problems occur with optical probes having a serial number 07L (Dec 07) or older, be sure the firmware is 3.06 or later. Parking issues with optical probes having a serial number prior to 07L may be related to a dirty wiper body or pad.

Record sonde battery voltage: _____ (if applicable)

Record the following diagnostic numbers after calibration.

6560 Conductivity cell constant _____ Range 5.0 ± .45
Integrated conductivity cell constant _____ Range 5.0 ± .70
pH mv Buffer 7 ~~-12.0~~ -11.9 Range 0 ± 50 mv
pH mv Buffer 4 _____ Range +180 ± 50 mv*
pH mv Buffer 10 -119.2 Range -180 ± 50 mv *
***Note:** Millivolt span between pH 4 and 7 should be ≈ 165 to 180 mv
Millivolt span between pH 7 and 10 should be ≈ 165 to 180 mv
DO charge (RP only) _____ Range 25 to 75
DO gain _____ Range 0.7 to 1.4
ODO gain _____ Range 0.85 to 1.15

Turbidity standard used in calibration _____
Manufacturer and part number _____

Barometric Pressure: 28.31 mmHg
DO % Calculated – (BARO mmHg divided by 7.6) = % saturation
Example: 760 ÷ 7.6 = 100.0%

	Record Calibration Values Standard	Pre Cal / Post Cal
Temperature	79.8 (Source)	82 (Temp Sonde)
Conductivity	1380	1413
pH 7	6.89	7.00
pH 4	_____	_____
pH 10	11.8	10.00
ORP	_____	_____
~~Turbidity~~ Cl-	121	100
Turbidity	_____	_____
Turbidity 0.5	_____	_____
Chlorophyll	_____	_____
Chlorophyll	_____	_____
DO RP	_____	_____
DO ROX	84.2 %	~~96.8~~ 94.5 %
BGA PE/PC	_____	_____
BGA PE/PC	_____	_____
Rhodamine	_____	_____

Depth Calibration - If zero was entered, record barometric pressure at time of calibration 28.31 ~~JH~~ mmHg
Depth Calibration - If offset depth was entered, record value _____ meters/feet and pressure _____ mmHg
Depth Calibration (Vented) – Acceptable calibration constant: 0.0 psig ± 0.15 _____

Notes: Turbidity

5	5
50	53
500	499

Flowmeter

5.0	141.1
0.25	2.069

CALIBRATION WORK SHEET

Date of Calibration: 8/7/11 Sonde ID: YSI 6820
Technician: JMH

RP DO membrane changed? Y N *Note: Wait 3 to 6 hours before calibrating for unattended*
RP DO membrane o-ring changed? Y N *deployments; run in Discrete mode for 10 minutes to accelerate burn in. (Rapid Pulse DO Only)*
Turbidity wiper changed? Y N Chlorophyll wiper changed? Y N
ROX DO wiper changed? Y N BGA-PE wiper changed? Y N
BGA-PC wiper changed? Y N Rhodamine wiper changed? Y N

Note: If parking problems occur with optical probes having a serial number 07L (Dec 07) or older, be sure the firmware is 3.06 or later. Parking issues with optical probes having a serial number prior to 07L may be related to a dirty wiper body or pad.

Record sonde battery voltage: _____ (if applicable)

Record the following diagnostic numbers after calibration.

6560 Conductivity cell constant _____ Range 5.0 ± .45
Integrated conductivity cell constant _____ Range 5.0 ± .70
pH mv Buffer 7 _____ Range 0 ± 50 mv
pH mv Buffer 4 _____ Range +180 ± 50 mv*
pH mv Buffer 10 _____ Range -180 ± 50 mv *
***Note:** Millivolt span between pH 4 and 7 should be ≈ 165 to 180 mv
Millivolt span between pH 7 and 10 should be ≈ 165 to 180 mv
DO charge (RP only) _____ Range 25 to 75
DO gain _____ Range 0.7 to 1.4
ODO gain _____ Range 0.85 to 1.15

Turbidity standard used in calibration _____
Manufacturer and part number _____

Barometric Pressure: _____ mmHg
DO % Calculated – (BARO mmHg divided by 7.6) = % saturation
Example: 760 ÷ 7.6 = 100.0%

Depth Calibration - If zero was entered, record barometric pressure at time of calibration _____ mmHg
Depth Calibration - If offset depth was entered, record value _____ meters/feet and pressure _____ mmHg
Depth Calibration (Vented) – Acceptable calibration constant: 0.0 psig ± 0.15 _____

	Record Calibration Values		
	Standard	Pre Cal / Post Cal	
Temperature	75.5	75.18	Sonde
Conductivity	1443	1413 /	
pH 7	7.13	7.00 /	
pH 4	~~10.2~~	~~10.00~~ /	
pH 10	10	10.2 / 10.0	
ORP	95.0	95.8 / 95.8	
Turbidity	500	500 / 533	
Turbidity	50	56 /	
Turbidity	~~0.35~~	5 / 5	
Chlorophyll	100.	98.2 / 100.0	
~~Chlorophyll~~	~~50~~ 5	73.21 / 72.95 / 70.74	
~~DO RP~~	0.25	-0.681 / -0.716 / -0.845	
DO ROX		/	
BGA PE/PC		/	
BGA PE/PC		/	
Rhodamine		/	

Notes:

CALIBRATION WORK SHEET

Date of Calibration: 7/31/11 Sonde ID: _____
Technician: JMH

RP DO membrane changed? Y (N)
RP DO membrane o-ring changed? Y (N)

Note: Wait 3 to 6 hours before calibrating for unattended deployments; run in Discrete mode for 10 minutes to accelerate burn in. (Rapid Pulse DO Only)

Turbidity wiper changed? Y (N) Chlorophyll wiper changed? Y (N)
ROX DO wiper changed? Y (N) BGA-PE wiper changed? Y (N)
BGA-PC wiper changed? Y (N) Rhodamine wiper changed? Y (N)

Note: If parking problems occur with optical probes having a serial number 07L (Dec 07) or older, be sure the firmware is 3.06 or later. Parking issues with optical probes having a serial number prior to 07L may be related to a dirty wiper body or pad.

Record sonde battery voltage: _____ (if applicable)

Record the following diagnostic numbers after calibration.

6560 Conductivity cell constant _____ Range 5.0 ± .45

Integrated conductivity cell constant _____ Range 5.0 ± .70

pH mv Buffer 7 _____ Range 0 ± 50 mv

pH mv Buffer 4 _____ Range +180 ± 50 mv*

pH mv Buffer 10 _____ Range -180 ± 50 mv *

***Note:** Millivolt span between pH 4 and 7 should be ≈ 165 to 180 mv

Millivolt span between pH 7 and 10 should be ≈ 165 to 180 mv

DO charge (RP only) _____ Range 25 to 75

DO gain _____ Range 0.7 to 1.4

ODO gain _____ Range 0.85 to 1.15

Turbidity standard used in calibration _____

Manufacturer and part number _____

Barometric Pressure: _____ mmHg

DO % Calculated – (BARO mmHg divided by 7.6) = % saturation

Example: 760 ÷ 7.6 = 100.0%

Record Calibration Values	Standard	Pre Cal / Post Cal
Temperature	~~76.5~~ 82.0	~~76.5~~ 78.43 Sonde
Conductivity	1531	/ 1413
pH 7	~~7.56~~	7.05 / 7.00
pH 4		/
pH 10	9.97	/ 10.0
ORP		/
Turbidity	*5.0	5 / 5
Turbidity	50.0	50 / 53
Turbidity 0.5	500.0	496 / 496
~~Chlorophyll~~ Cl	129.0	/ 100.00
Chlorophyll		/
DO RP		/
DO ROX	95.0	/
~~BGA PE/PC~~ FI 5	224.8 / 213.8	/
BGA PE/PC FI.25	15.50	/
Rhodamine		/

Depth Calibration - If zero was entered, record barometric pressure at time of calibration _____ mmHg

Depth Calibration - If offset depth was entered, record value _____ meters/feet and pressure _____ mmHg

Depth Calibration (Vented) – Acceptable calibration constant: 0.0 psig ± 0.15 _____

Notes:

CALIBRATION WORK SHEET

Date of Calibration: 8-15-2011 Sonde ID: YSI 6820
Technician: JMH

RP DO membrane changed? Y N *Note: Wait 3 to 6 hours before calibrating for unattended*
RP DO membrane o-ring changed? Y N *deployments; run in Discrete mode for 10 minutes to accelerate burn in. (Rapid Pulse DO Only)*

Turbidity wiper changed? Y N Chlorophyll wiper changed? Y N
ROX DO wiper changed? Y N BGA-PE wiper changed? Y N
BGA-PC wiper changed? Y N Rhodamine wiper changed? Y N

Note: If parking problems occur with optical probes having a serial number 07L (Dec 07) or older, be sure the firmware is 5.06 or later. Parking issues with optical probes having a serial number prior to 07L may be related to a dirty wiper body or pad.

Record sonde battery voltage: _____ (if applicable)

Record the following diagnostic numbers after calibration.

6560 Conductivity cell constant _____ Range 5.0 ± .45
Integrated conductivity cell constant _____ Range 5.0 ± .70
pH mv Buffer 7 _____ Range 0 ± 50 mv
pH mv Buffer 4 _____ Range +180 ± 50 mv*
pH mv Buffer 10 _____ Range -180 ± 50 mv *
*Note: Millivolt span between pH 4 and 7 should be ≈ 165 to 180 mv
Millivolt span between pH 7 and 10 should be ≈ 165 to 180 mv
DO charge (RP only) _____ Range 25 to 75
DO gain _____ Range 0.7 to 1.4
ODO gain _____ Range 0.85 to 1.15

Turbidity standard used in calibration _____
Manufacturer and part number _____

Barometric Pressure: _____ mmHg
DO % Calculated = (BARO mmHg divided by 7.6) = % saturation
Example: 760 ÷ 7.6 = 100.0%

Depth Calibration - If zero was entered, record barometric pressure at time of calibration _____ mmHg
Depth Calibration - If offset depth was entered, record value _____ meters/feet and pressure _____ mmHg
Depth Calibration (Vented) - Acceptable calibration constant: 0.0 psig ± 0.15 _____

Notes:

Record Calibration Values	Standard	Pre Cal / Post Cal
Temperature	79.0	76.6 Sonde
Conductivity	1413	1431 / 1413
pH 7	7.0	6.96 / 6.96
pH 4		/
pH 10	10	10.03 / 10.03
ORP		/
Turbidity	500	536 /
Turbidity	50	56 /
Turbidity 0.5	5	6 /
Chlorophyll		/
Chlorophyll	1 hr	95% 96.2%
DO RP		/
DO ROX		/
F1 5 ~~BGA PE/PC~~		72.09 / 70.67 / 68.36
F10.25 ~~BGA PE/PC~~		-0.308 / -0.290 / -0.415
Rhodamine		/

CALIBRATION WORK SHEET

Date of Calibration: 8/24/11 Sonde ID: YSI 6820
Technician: JMH

RP DO membrane changed? Y N *Note: Wait 3 to 6 hours before calibrating for unattended*
RP DO membrane o-ring changed? Y N *deployments; run in Discrete mode for 10 minutes to accelerate burn in. (Rapid Pulse DO Only)*
Turbidity wiper changed? Y N Chlorophyll wiper changed? Y N
ROX DO wiper changed? Y N BGA-PE wiper changed? Y N
BGA-PC wiper changed? Y N Rhodamine wiper changed? Y N

Note: If parking problems occur with optical probes having a serial number 07L (Dec 07) or older, be sure the firmware is 3.06 or later. Parking issues with optical probes having a serial number prior to 07L may be related to a dirty wiper body or pad.

Record sonde battery voltage: _____ (if applicable)

Record the following diagnostic numbers after calibration.

6560 Conductivity cell constant _____ Range 5.0 ± .45
Integrated conductivity cell constant _____ Range 5.0 ± .70
pH mv Buffer 7 _____ Range 0 ± 50 mv
pH mv Buffer 4 _____ Range +180 ± 50 mv*
pH mv Buffer 10 _____ Range -180 ± 50 mv *
***Note:** Millivolt span between pH 4 and 7 should be ≈ 165 to 180 mv
Millivolt span between pH 7 and 10 should be ≈ 165 to 180 mv
DO charge (RP only) _____ Range 25 to 75
DO gain _____ Range 0.7 to 1.4
ODO gain _____ Range 0.85 to 1.15

Turbidity standard used in calibration _____
Manufacturer and part number _____

Barometric Pressure: _____ mmHg
DO % Calculated – (BARO mmHg divided by 7.6) = % saturation
Example: 760 ÷ 7.6 = 100.0%

Depth Calibration - If zero was entered, record barometric pressure at time of calibration _____ mmHg
Depth Calibration - If offset depth was entered, record value _____ meters/feet and pressure _____ mmHg
Depth Calibration (Vented) – Acceptable calibration constant: 0.0 psig ± 0.15 _____

Record Calibration Values	Standard	Pre Cal / Post Cal
Temperature	79.6	75.6 Sonde
Conductivity	1413	1424/1413
pH 7	7.0	7.02/7.00
pH 4		/___
pH 10	10.0	10.05/10.0
~~ORP~~ C1	180	98.6/200.0
Turbidity	5	6 /___
Turbidity	50	56 /___
Turbidity ~~0~~	500	529 /___
F1 Chlorophyll	35	70.21/___
F1 Chlorophyll	0.25	5.538/___
DO RP	95.0	95.6/95.0
DO ROX		/___
BGA PE/PC		/___
BGA PE/PC		/___
Rhodamine		/___

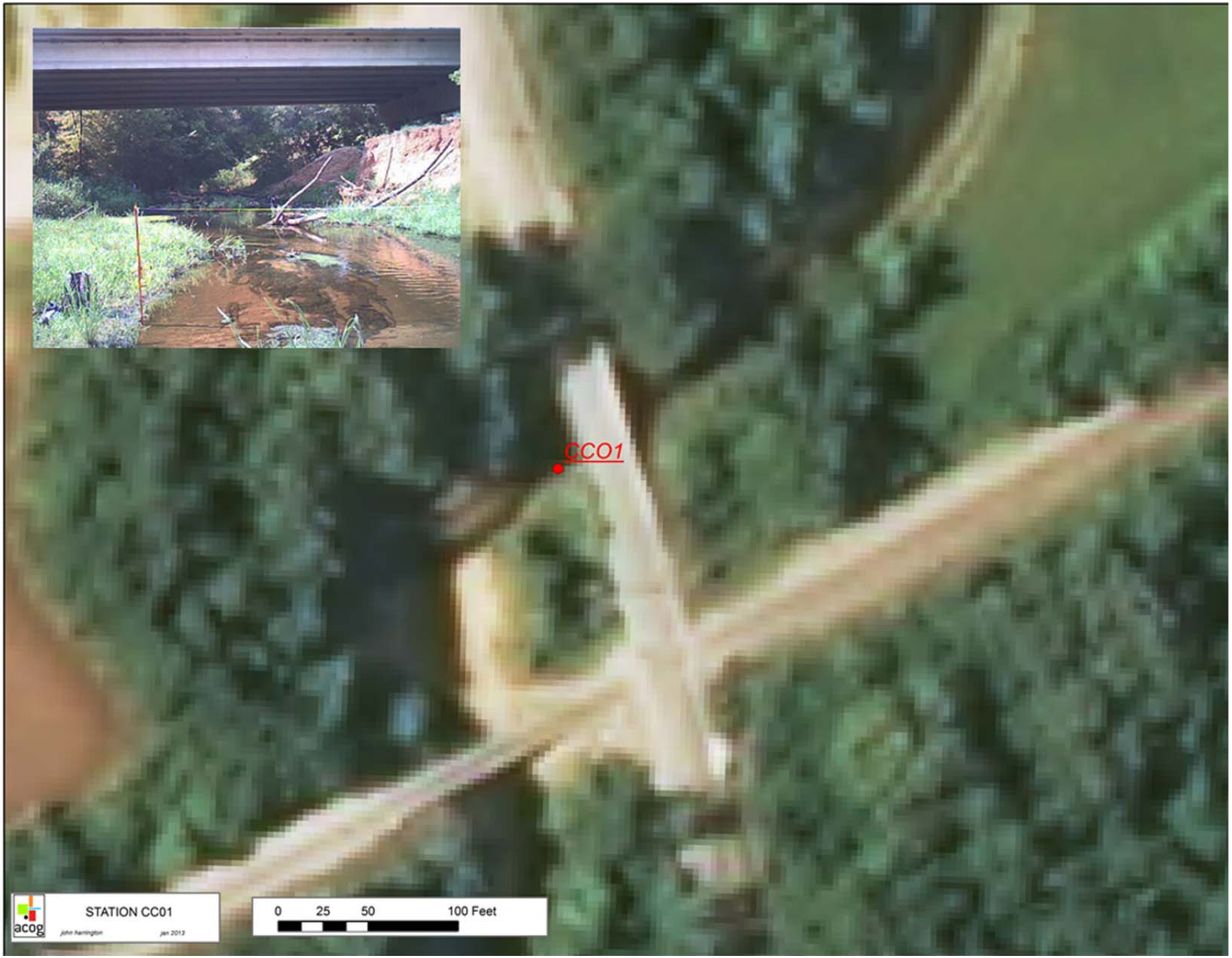
Notes: Order more conduct solution (1)

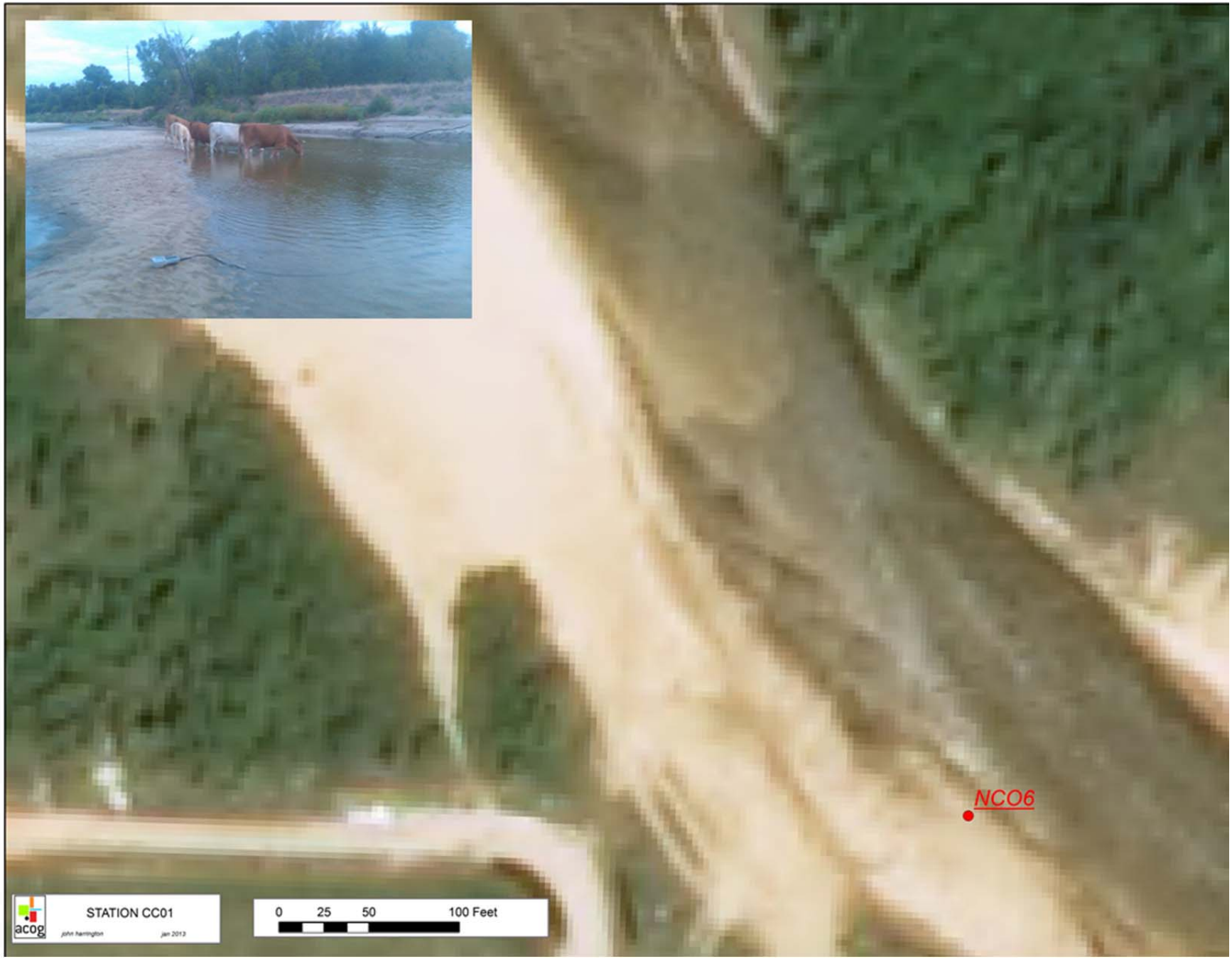
APPENDIX E PICTURES AND AERIALS


NCO4
STATION NC04
john harrington
jan 2013
0 25 50 100 Feet


CH01
STATION CH01
john harrington
jan 2013
0 25 50 100 Feet


NCO5A
STATION NC05A
john harrington
jan 2013
0 25 50 100 Feet

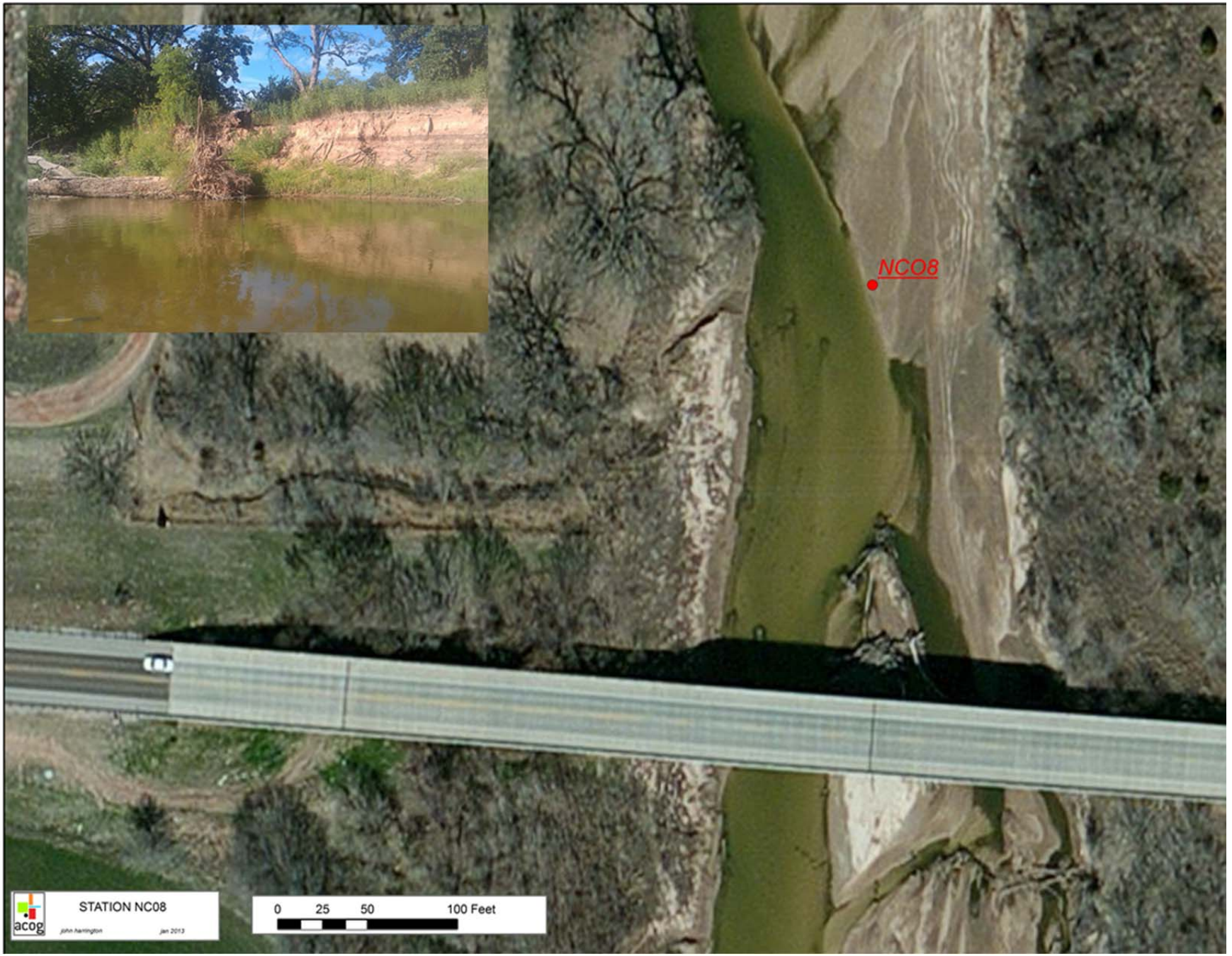

CCO1
STATION CC01
john harrington
jan 2013
0 25 50 100 Feet


NCO6
STATION CC01
john harrington
jan 2013
0 25 50 100 Feet


NCO6
STATION NC06
john harrington
jan 2013
0 25 50 100 Feet


NC07
STATION NC07
john harrington
jan 2013
0 25 50 100 Feet


CW01
STATION CW01
john harrington
jan 2013
0
25
50
100 Feet


NCO8
STATION NC08
john harrington
jan 2013
0 25 50 100 Feet