City of Huntsville, Arkansas Section 2.306 Site Specific Water Quality Study: Town Branch, Holman Creek, and War Eagle Creek

March 2013

(Revised following ADEQ comments)

GBMc & Associates
Strategic Environmental Services

Section 2.306 Site Specific Water Quality Study: Town Branch, Holman Creek, and War Eagle Creek

---

Prepared for:

City of Huntsville, Arkansas
Huntsville, AR 72740

Prepared by:

GBM^c & Associates
219 Brown Lane
Bryant, AR 72022

March 2013

CONTENTS

CONTENTS (cont)

TABLES

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

1.1 Background

The City of Huntsville, Arkansas (Huntsville) discharges to Town Branch Creek then to Holman Creek, and then to War Eagle Creek in Segment 4K of the White River Basin. Holman Creek has been identified on the Arkansas 2008 303(d) list for Total Dissolved Solids (TDS) in excess of the domestic water supply use. In order to address the situation a 3rd party rulemaking process is being proposed. The Arkansas Department of Environmental Quality (ADEQ) has advised Huntsville that chloride could also be added to the list of pollutants associated with Holman Creek's presence on the 303(d) list, therefore both TDS and chloride will be addressed in the 3rd party rulemaking studies to be conducted pursuant to Section 2.306 of Regulation 2 (the Arkansas Water Quality Standards).

This Quality Assurance Project Plan (QAPP) for the project was originally submitted to the ADEQ for review on March 31, 2011. Comments from ADEQ and EPA were received, reviewed and the QAPP was modified and resubmitted to ADEQ on June 16, 2011. No additional comments on the QAPP were received.

The City of Huntsville WWTF is located within Segment 4K of the White River Basin, in Madison County Arkansas. Sampling reaches for the study are show in Figure 1.1. The receiving stream for the discharge is located in reach No. 959, USGS HUC 11010001 and is classified for secondary contact recreation, domestic water supply, industrial and agricultural water supply, fisheries, (Ozark Highlands) and other uses. The Huntsville WWTF facility is classified under Standard Industrial Classification code 4952 as a sewage treatment plant and is currently authorized to discharge wastewater through NPDES Outfall 001 (NPDES No. AR0022004) to Town Branch Creek.

The effective permit for the City of Huntsville WWTF contains a weekly monitoring requirement for TDS. For purposes of this study the WWTF also monitored chloride during the one-year field study period. Sulfate data collected recently from the facility indicates it could also cause instream exceedence of the Arkansas WQS. Therefore, sulfate has also been addressed in this report. The project described in the QAPP is intended to provide data in support of amendment of the water quality criteria and removal of the non-existing but designated Domestic Water Supply use.

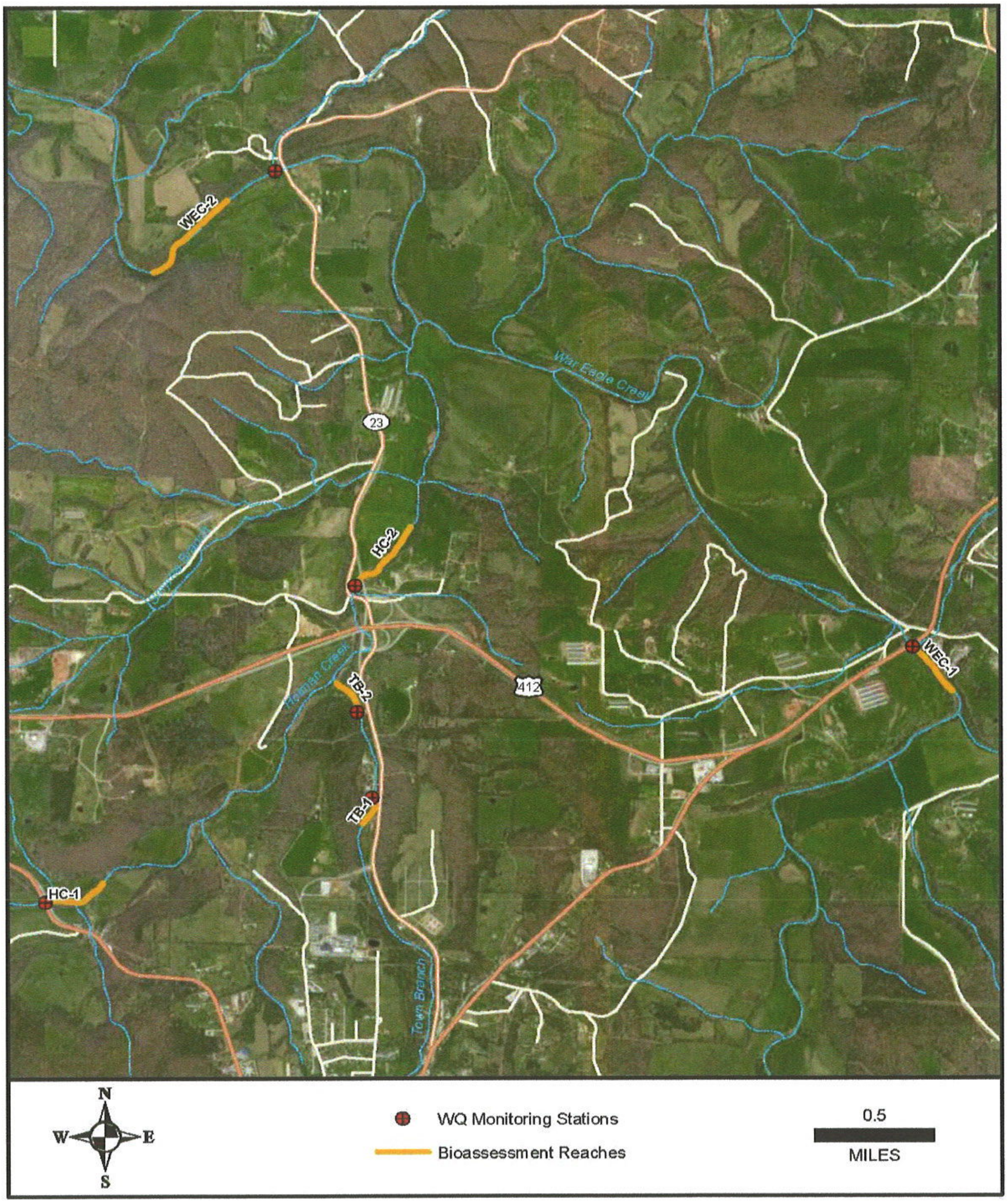


Figure 1.1. Sampling reaches used during this study of Town Branch, Holman Creek, and War Eagle Creek (July 2011- June 2012).

1.2 Study Focus and Objective

The focus of the study completed and described in this report is the discharge from the City of Huntsville WWTF outfall (Outfall 001), the Town Branch, Holman Creek and War Eagle Creek. The study was conducted pursuant to Reg. 2.306, which describes the procedures necessary to request removal of the Domestic Water Supply use, and modify certain criteria to make them less stringent. Other guidance for completing the study included the "Minerals Implementation Policy" (Appendix D, Arkansas CPP 2000), "Information Required in Applying for Site Specific Water Quality Standards Modification in Accordance with Section 2.306 of the WQS", and the "Administrative Guidance Document" (Arkansas CPP 2000).

The primary report objectives are to:
Propose, if warranted by the study results, site-specific water quality criteria for chloride, TDS, and sulfate that:

- reflect the current discharge concentrations of the City of Huntsville WWTF, and
- support the designated fishery use in the Town Branch, Holman Creek and War Eagle Creek downstream of the discharge, and
- support the existing domestic water supply use of Beaver Lake.

2.0 SIGNIFICANT FINDINGS AND RECOMMENDATIONS

2.1 Recommendations

The following recommendations are based on the information developed during this study of the Town Branch, Holman Creek and War Eagle Creek.

1. Criteria for the Town Branch, Holman Creek and War Eagle Creek should be amended as follows:

Town Branch from Point of Discharge of the City of Huntsville WWTP downstream to the confluence with Holman Creek.			**Holman Creek from the confluence with Town Branch downstream to the confluence with War Eagle Creek.**			**War Eagle Creek from the confluence with Holman Creek.**		
Site Specific Criteria Proposed			**Site Specific Criteria Proposed**			**Site Specific Criteria Proposed**		
Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)
185	525	41	185	525	41	185	525	41

2. It should be specified that a critical background flow of 4.0 cfs be applied by listing Town Branch, Holman Creek, and War Eagle Creek (with asterisks) in Reg. 2.511.
3. Removal of the Domestic Water Supply use is requested for Town Branch beginning at Latitude 36.112330°, Longitude -93.732833° and extending downstream to its confluence with Holman Creek at Latitude 36.118158°, Longitude -93.736039°; and for Holman Creek beginning at its confluence with Town Branch at Latitude 36.118158°, Longitude -93.736039° and extending downstream to its confluence with War Eagle Creek at Latitude 36.140824°, Longitude -93.729594°.

2.2 Significant Findings

1. The designated Fishery Uses for Town Branch, Holman Creek and War Eagle Creek are being maintained.
2. The whole effluent toxicity testing results for the City of Huntsville WWTF reveal an excellent toxicity record, containing only two historical records of sub-lethal test failure. Additional correlation analysis indicates that the observed toxicity was not associated with TDS.
3. Habitat quality of each of the reaches examined was classified as sub-optimal but the habitat quality of each was adequate to support the designated Fishery Use.
4. With respect to the macroinvertebrate community:
    a. A significant proportion of each downstream community was comprised of EPT taxa (>50% during the fall and >30% during the spring) which included 6-13 different taxa at each station.
    b. Key metric scores at each station indicated that the downstream reaches (TB-2, HC-2 and WEC-2) during the fall have greater taxa richness, a higher proportion of the sensitive EPT taxa, and lower biotic Index scores.
    c. The better performance of the macroinvertebrate community during the fall assessment, when background flow is lower and effluent percent higher, indicates that the point source discharge is not adversely affecting the biota.
    d. All biometric and multimetric paired scoring systems achieved scores sufficient to make a determination of full attainment of the Fishery Use.
5. The fish collections for each of the creeks evaluated were typical of Ozark Highlands Ecoregion fisheries (ADEQ 1987), in addition:
    a. The fish community at each downstream station was generally more diverse than its corresponding upstream reference station, and had similar richness.
    b. The fish communities at all stations were found to contain significant number of key and indicator taxa (6 or more) and a significant percent composition of ecoregion Key and Indicator Species as identified in Arkansas Regulation No. 2 (ADEQ, 2011).
    c. Sensitive darter species (greenside and rainbow) were found during the study at both upstream and downstream stations in Holman Creek and War Eagle Creek. War Eagle Creek also contained banded darters and yoke darters (both sensitive) at its upstream and downstream locations.

d. The aquatic life field study demonstrated that the designated Fishery Use was being maintained at all study reaches as demonstrated by the dominance of intolerant and intermediate species.
e. The Fishery Use was also determined to be fully supporting based on the ADEQ Community Similarity Index which shows that all stations were generally or mostly similar to Ecoregion Reference, and the downstream stations scored higher in every stream.

3.0 BACKGROUND

3.1 Introduction

The current permit for the City of Huntsville was effective June 1, 2011 and expires May 31, 2014. According to the Fact Sheet for the effective permit the facility design flow is 2.0 mgd. The facility discharges treated sanitary wastewater and industrial wastewater from a Butterball turkey processing facility. Approximately 80% of the flow from the WWTF originates from the turkey processing facility. The treatment system for the Huntsville WWTF, which underwent a $4.7 million dollar upgrade in 2008, consists of bar screen and grit removal, an anaerobic selector, an anoxic basin, an oxidation ditch, UV disinfection, and cascade aeration.

The Arkansas Water Quality Standards - Regulation No. 2 (ADEQ 2011) allows modification of water quality standards under various conditions. Specifically, Section 2.306 of the WQS allows the removal of a designated use other than a fishable or swimmable use, and for establishment of less stringent water quality criteria without affecting fishable or swimmable uses. This project report documents the information required to amend Regulation 2 through 3rd party rulemaking.

Holman Creek currently appears on the Arkansas 2008 303(d) list for TDS (category 5a) with a listed cause of municipal point source. The Holman Creek listing is continued in the Arkansas draft 2012 303(d) list for TDS with municipal point source as the listed cause.

3.2 Designated Uses – Water Quality Criteria

The designated uses for the Town Branch, Holman Creek and War Eagle Creek listed in the WQS are for Ozark Highland streams with watersheds both less than 10 mi^2 and greater than 10 mi^2. The designated uses for the streams are listed as follows.

Town Branch Creek

Secondary Contact Recreation
Industrial and Agricultural Water Supply
Seasonal Arkansas River Valley fishery
Domestic Water Supply Use
Calculated Ecoregion Reference stream values for Town Branch and – chloride 17.3 mg/L, sulfate 22.7 ml/L, and TDS 250 mg/L

Holman Creek and War Eagle Creek

Primary Contact Recreation
Industrial and Agricultural Water Supply
Perennial Arkansas River Valley fishery
Domestic Water Supply Use
Calculated Ecoregion Reference stream values for Holman Creek and War Eagle Creek – chloride 17.3 mg/L, sulfate 22.7 mg/L, and TDS 250 mg/L

In addition Reg. 2.511, Mineral Quality, states that "In no case shall discharges cause concentrations in any waterbody to exceed 250, 250, and 500 mg/L of chlorides, sulfates, and total dissolved solids, respectively, or cause concentrations to exceed the applicable limits in streams to which they are tributary, except in accordance with Reg. 2.306."

The designated Domestic Water Supply use is not an existing use in any of the creeks studied, as the summer time flows of each of the creeks in the vicinity of Huntsville is too small to ensure a continuous reliable source of water. However, War Eagle Creek flows approximately 27.5 miles to Beaver Lake (War Eagle Creek from its confluence with Holman Creek downstream to confluence with the White River arm of Beaver Lake is approximately 36.5 miles), and Beaver Lake does have an existing Domestic Water Supply use that requires criteria maintenance.

3.3 Permit Limitations

The effective permit for the facility (June 1, 2011 – May 31, 2014) contains both interim and final permit limits for Outfall 001, however for purposes of this study only the final limitations are shown (Table 3.1).

Table 3.1. Final Effluent Limitations for Outfall 001, Huntsville WWTF (NPDES AR 0022004).

Effluent Characteristics	**Discharge Limitations**			**Monitoring Requirements**	
	Mass (lbs/day, unless otherwise	Concentration (mg/L), unless otherwise specified)		Frequency	Sample Type
	Monthly Avg.	Monthly Avg.	7-Day Avg.		
Flow	N/A	Report, MGD	Report MGD (Daily Maximum)	once/day	totalizing meter
Carbonaceous Biochemical Oxygen Demand (CBOD5)	167	10	15	once/week	composite
Total Suspended Solids (TSS)	250	15	22.5	once/week	composite
Ammonia Nitrogen (NH3-					
(April-October)	26.7	1.6	3.9	once/week	composite
(November-March)	50.0	3.0	4.5	once/week	composite
Dissolved Oxygen	N/A	6.6 (Inst. Min.)		once/week	composite
Fecal Coliform Bacteria		(colonies/100 ml)			grab
	N/A	1000	2000	once/week	grab
Total Phosphorus	33.3	2.0	3.0	once/week	composite
Nitrate+Nitrite Nitrogen	166.8	10	15	once/week	grab
Total Dissolved Solids	Report	Report	Report	once/week	composite
pH	N/A	Minimum 6.0 ss.u.	Maximum 9.0 s.u.	once/week	grab
Chronic WET Testing	N/A	Report		once/quarter	composite

4.0 OUTFALL 001 CHARACTERIZATION

Appendix A contains discharge monitoring results (DMR) for the Huntsville WWTF for July 2011 through June 2012. Appendix B contains analytical reports and data that were collected from Outfall 001 for this study (July 2011 - June 2012).

4.1 Chloride, TDS, Sulfate and Discharge

During the study period July 2011- June 2012 monthly samples of Outfall 001 were obtained and analyzed for a number of parameters including chloride and TDS. Both the DMR data for TDS and the effluent chloride and sulfate data collected as part of the study are provided in Table 4.1.

Table 4.1. Chloride, sulfate, and TDS analyzed for Outfall 001 Huntsville WWTF during the study period.

Date	TDS (mg/L)	Chloride (mg/L)	Sulfate (mg/L)
7/6/2011	1042	420	45
7/11/2011	1100	320	48
7/13/2011	649	290	44
7/20/2011	889	370	47
7/27/2011	1548	590	45
8/3/2011	1146	430	41
8/10/2011	632	245	80
8/17/2011	495	185	26
8/24/2011	--	240	76
8/24/2011	640	200	84
8/31/2011	579	210	66
9/7/2011	1095	400	78
9/14/2011	718	250	65
9/14/2011	730	230	--
9/21/2011	538	190	73
9/28/2011	489	190	69
10/5/2011	603	190	83
10/12/2011	578	220	100
10/12/2011	710	22	8
10/19/2011	535	190	79
10/26/2011	530	180	44
11/2/2011	590	190	59
11/9/2011	280	70	40
11/16/2011	404	130	52
11/17/2011	430	130	--
11/22/2011	336	120	31
11/30/2011	393	100	40
12/7/2011	383	110	33
12/8/2011	430	10	--
12/14/2011	515	125	44

Date	TDS (mg/L)	Chloride (mg/L)	Sulfate (mg/L)
12/21/2011	331	90	40
12/28/2011	365	110	33
1/4/2012	392	140	39
1/11/2012	480	160	80
1/18/2012	480	130	72
1/18/2012	550	170	--
1/25/2012	505	180	66
2/1/2012	445	130	49
2/2/2012	480	140	--
2/8/2012	345	116	45
2/15/2012	422	140	52
2/22/2012	412	140	55
2/29/2012	878	300	60
3/14/2012	564	212	58
3/21/2012	251	88	37
3/27/2012	400	82	--
3/28/2012	372	206	57
4/4/2012	484	128	78
4/10/2012	500	140	83
4/11/2012	506	162	80
4/18/2012	735	230	88
4/25/2012	799	242	76
5/2/2012	659	240	16
5/9/2012	710	230	--
5/9/2012	606	220	57
5/16/2012	844	260	56
5/23/2012	852	272	56
5/30/2012	830	204	--
6/6/2012	668	274	36
6/13/2012	638	198	44
6/20/2012	647	196	47
6/21/2012	650	210	--
6/27/2012	649	220	58
Count	62	63	54.0
Max	1,548	590	99.9
Average	604	199	55.8
Minimum	251	10	7.5
95th Percentile	1,019	416	87
99th Percentile	1,300	590	93

In order to characterize the effluent constituents of chloride, sulfate, and TDS the data were examined for normality using histograms, Quantile Plots, and Shapiro-Wilk's test. The raw data for chloride and TDS were not normally distributed. Sulfate was normally distributed. Chloride data were not normal following transformation and therefore the 95th percentile value was calculated using a nonparametric formula from Gilbert (1987). The TDS data were normally distributed following transformation so it and the sulfate data were analyzed using an equation for determining percentiles of normally distributed data (Gilbert 1987). Results of the normality tests, data transformation, and percentile calculations are provided in Appendix C.

Monthly average and daily maximum discharged flow rates from the Huntsville WWTF during the study period as reported on DMRs are shown in Table 4.2

Table 4.2. Discharge flow rates from DMR's for Outfall 001 Huntsville WWTF during the study period.

Date	Monthly Average Flow (mgd)	Daily Maximum Flow (mgd)
July 2011	0.80	1.37
August 2011	0.80	1.37
September 2011	1.01	1.59
October 2011	1.02	1.53
November 2011	1.03	3.50
December 2011	1.32	1.97
January 2012	1.12	2.50
February 2012	1.32	2.14
March 2012	1.46	3.63
April 2012	1.10	1.53
May 2012	1.02	1.50
June 2012	0.91	1.28
Highest Monthly Average Flow	1.32	-----
Highest Daily Maximum Flow	-----	3.50

4.2 Salinity Toxicity Modeling

In accordance with the QAPP, the GRI-STR model was set up and run to determine the potential for toxicity given the specific ion analysis of the Huntsville WWTF effluent. In order to run the GRI-STR model to further evaluate proposed mineral levels and to predict toxicity potential based on dissolved mineral concentrations additional constituents were analyzed from samples collected from Outfall 001 during this study. The data used in the GRI-STR model are provided in Table 4.3.

Table 4.3. Summary of ionic data used for GRI-STR salinity modeling (Huntsville WWTF Outfall 001).

Statistic	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)	Alk (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)
Minimum	10.00	7.50	238.00	68.00	61.00	2.80	23.00	110.00
Maximum	**590.00**	**99.89**	**1635.0**	**130.00**	**130.00**	**3.80**	**29.00**	**160.00**
Average	209.41	52.45	644.36	102.00	84.75	3.48	26.25	135.00
St Dev	86.92	17.34	220.53	25.87	30.79	0.46	2.50	23.80
Count	110.00	99.00	146.00	4.00	4.00	4.00	4.00	4.00

The maximum value measured for each mineral was input into the GRI-STR model to represent the worst case combination of minerals in the effluent. The model was run assuming organisms were exposed to 100% effluent (no dilution). Survival in the 100% effluent was predicted at >95% after 48-h of exposure for each organism. Control quality assurance standards allow for 90% survival, which is consistent with the predicted survival under worse case minerals levels. A summary of the results are provided in Table 4.4.

Table 4.4. Summary of results of GRI-STR Model.

Organism	Percent Survival at 48-h
Ceriodaphnia	98.7
Daphnia	96.8
Fathead Minnow	98.1

4.3 Whole Effluent Toxicity Testing

Whole effluent toxicity testing (biomonitoring) was implemented as a part of the NPDES program in Arkansas in the late 1980's. Biomonitoring generally involves the exposure of a fish species and an invertebrate species to various concentrations (dilutions) of effluent over a set period of time. The reaction (survival, growth, reproduction, etc.) of the organisms is monitored in the effluent dilutions each day and compared to the reaction of the same organisms in control water. Statistical analysis of the resulting data determines if the effluent causes a significant adverse affect on the organisms. Adverse effects that cause mortality are labeled as "lethal" and adverse effects that impact growth or reproduction are labeled as "sub-lethal."

The Huntsville WWTF NPDES permit requires chronic 7-day testing of *Ceriodaphina dubia* (ceriodaphnid) and *Pimephales promelas* (fathead minnow) at the critical effluent dilution of 100% effluent on a quarterly basis. Approximately 4 years of quarterly WET tests (from January 2009 – May 2012), a total of 14 tests, were obtained for the City of Huntsville WWTP. A summary of the WET tests is provided in Appendix D. The fathead minnow exhibited no significant adverse effects from the effluent during any of the past testing. The no observed effect concentration (NOEC) for both survival and growth was 100% effluent for every test conducted. The ceriodaphnid tests displayed no adverse survival effects to the effluent and had a survival NOEC of 100% effluent for each test conducted. The same was true of reproductive effects for 12 out of 14 tests examined. However, during two ceriodaphnid tests (April 2009 and April 2010) reproductive effects (sub-lethal) were observed. The reproductive NOEC in April 2009 and April 2010 was 75% effluent and 42% effluent, respectively. This indicates that at 100% effluent the ceriodaphnids were producing less young (at a statistically significant level) then they were in the control water. Over the past 2.5 years, 9 ceriodaphnid tests have been completed without a recurrence of the apparent sub-lethal toxicity.

Specific conductance measured during the WET tests ranged from 460 µs/cm to 1300 µs/cm with an average of 795 µs/cm. Regular dissolved minerals sampling and analysis began in 2010. By the middle of 2010 routine samples were being collected for analysis of TDS, chloride, and sulfate. TDS ranged from 430 mg/l to 933 mg/L. Specific conductance (SC) data can be used to estimate TDS using a factor of 0.65 (SC * 0.65 = TDS). The first sub-lethal test endpoint was realized in April 2009 with a SC of 1000 µs/cm (TDS~650 mg/L). The second sub-lethal affect occurred in April 2010 with a SC of 900 µs/cm (TDS~585). TDS was actually measured during the 2010 test and found to be 727 mg/L. Since April 2010 SC has been equal to or in excess of 1000 µs/cm on three occasions during WET testing and TDS has been in excess of 727 mg/l on four occasions, none of which caused an adverse affect on the ceriodaphnids. In addition, there is no significant correlation of TDS to either ceriodaphnid reproductive NOEC or number of young produced (Figures 4.1 & 4.2). That is, higher TDS was not related to poor organism performance. The R^2 values are very low, below 0.10, indicating no ability of TDS to be a predictor of toxicity in the WET tests conducted. The slope of the regression line was also <u>insignificant</u> (p-values in excess of 0.29) at the $\alpha=0.05$ level for each comparison, further indicating a lack of a linear relationship between the factors. Therefore, sub-lethal affects cannot be attributed to TDS.

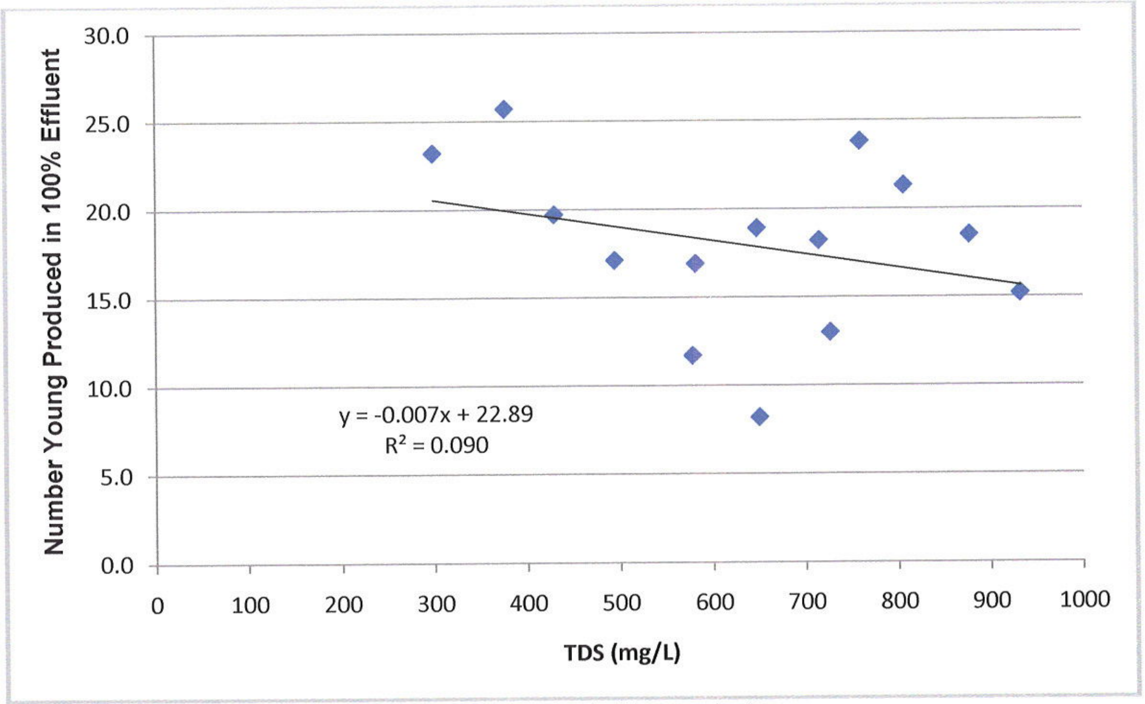


Figure 4.1. Regression analysis of TDS to ceriodaphnid reproduction.

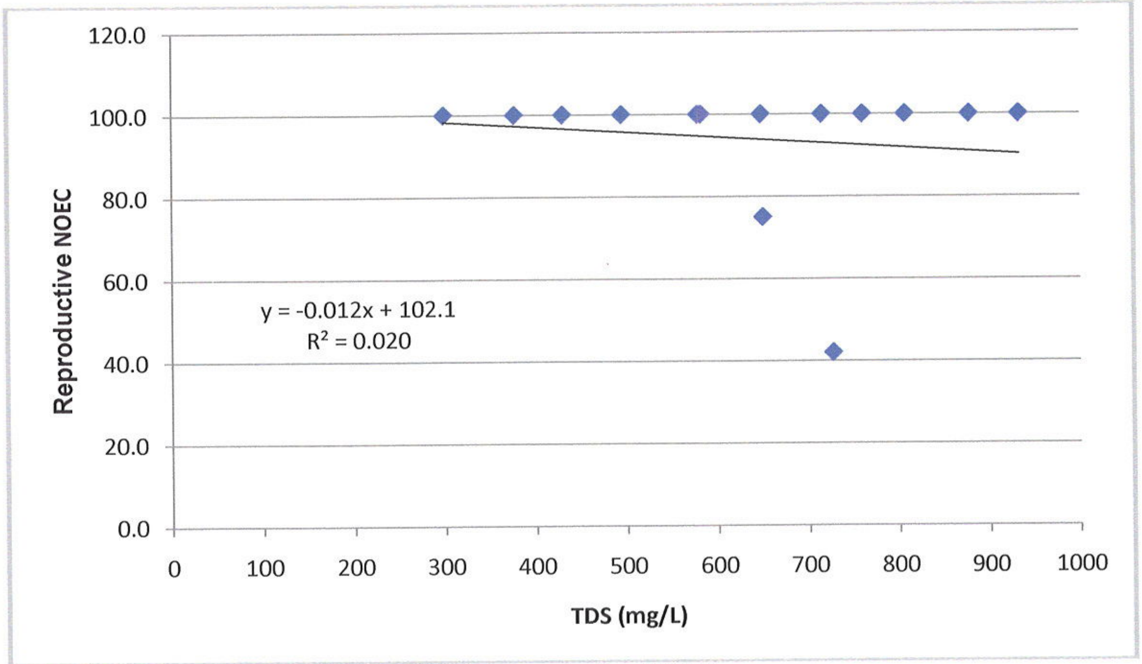


Figure 4.2. Regression analysis of TDS to reproductive NOEC.

4.4 Effluent *In-situ* Measurements

Each time samples were collected from the Huntsville WWTF Outfall 001 during the study *in-situ* measurements were also obtained. Table 4.5 provides the results of those measurements.

Table 4.5. *In-situ* measurements from Huntsville WWTF Outfall 001 during the study period (July 2011 – June 2012).

Date	Temp (°C)	DO mg/L	DO % Sat	Sp. Cond (μS)	pH (su)	Turb (ntu)
7/11/2011	27.6	6.8	87.1	1107	7.2	1.2
8/24/2011	26.4	6.1	76.0	1120	6.0	1.6
9/14/2011	22.5	5.3	62.1	1180	7.5	2.8
10/12/2011	21.2	7.5	84.0	1160	7.9	1.0
11/17/2011	15.8	8.7	87.8	620	7.5	1.0
12/8/2011	11.3	8.4	76.3	580	6.7	1.7
1/18/2012	10.8	8.0	72.0	797	7.3	1.8
2/2/2012	11.9	7.9	74.0	692	7.8	1.6
3/27/2012	17.2	7.9	86.0	574	7.8	4.1
4/10/2012	19.3	8.1	91.6	440	7.4	7.7
5/9/2012	22.3	7.5	86.3	976	7.9	2.3
6/21/2012	24.5	7.2	87.4	1072	7.7	1.8

5.0 FIELD STUDY

5.1 Introduction

A field study consisting of collection of physical, biological, *in-situ*, and water samples for laboratory analysis from stations located on the Town Branch Creek, Holman Creek, and War Eagle Creek (Figure 5.1). Monitoring stations used in the study were as follows:

1. TB-1, Town Branch Creek upstream of the Huntsville WWTF discharge.
2. TB-2, Town Branch Creek downstream from the Huntsville WWTF discharge.
3. HC-1, Holman Creek upstream of the confluence with Town Branch.
4. HC-2, Holman Creek downstream of the confluence with Town Branch.
5. WEC-1, War Eagle Creek upstream of the confluence with Holman Creek.
6. WEC-2, War Eagle Creek downstream from the confluence with Holman Creek.

As outlined in the QAPP for the project, the field study consisted primarily of habitat characterization, spring and fall macroinvertebrate collections, fall fish collection and twelve monthly collections of water quality samples, and *in-situ* and flow measurements.

5.2 Ambient Water Quality

Measurements of water quality at Stations TB-1, TB-2, HC-1, HC-2, WEC-1, and WEC-2 were made during 12 separate site visits completed during the study period. *In-situ* measurements consisting of pH, dissolved oxygen, temperature, and specific conductance were obtained on each trip. A sample for site analysis of turbidity was collected, along with samples for laboratory analysis of chloride, sulfate, TDS, calcium, magnesium, potassium, sodium, and alkalinity. Chloride and TDS samples were collected on each of the 12 sampling trips and sulfate, calcium, magnesium, potassium, sodium, and alkalinity were collected on four occasions. Ambient water quality data collected for this study are provided in Appendix B.

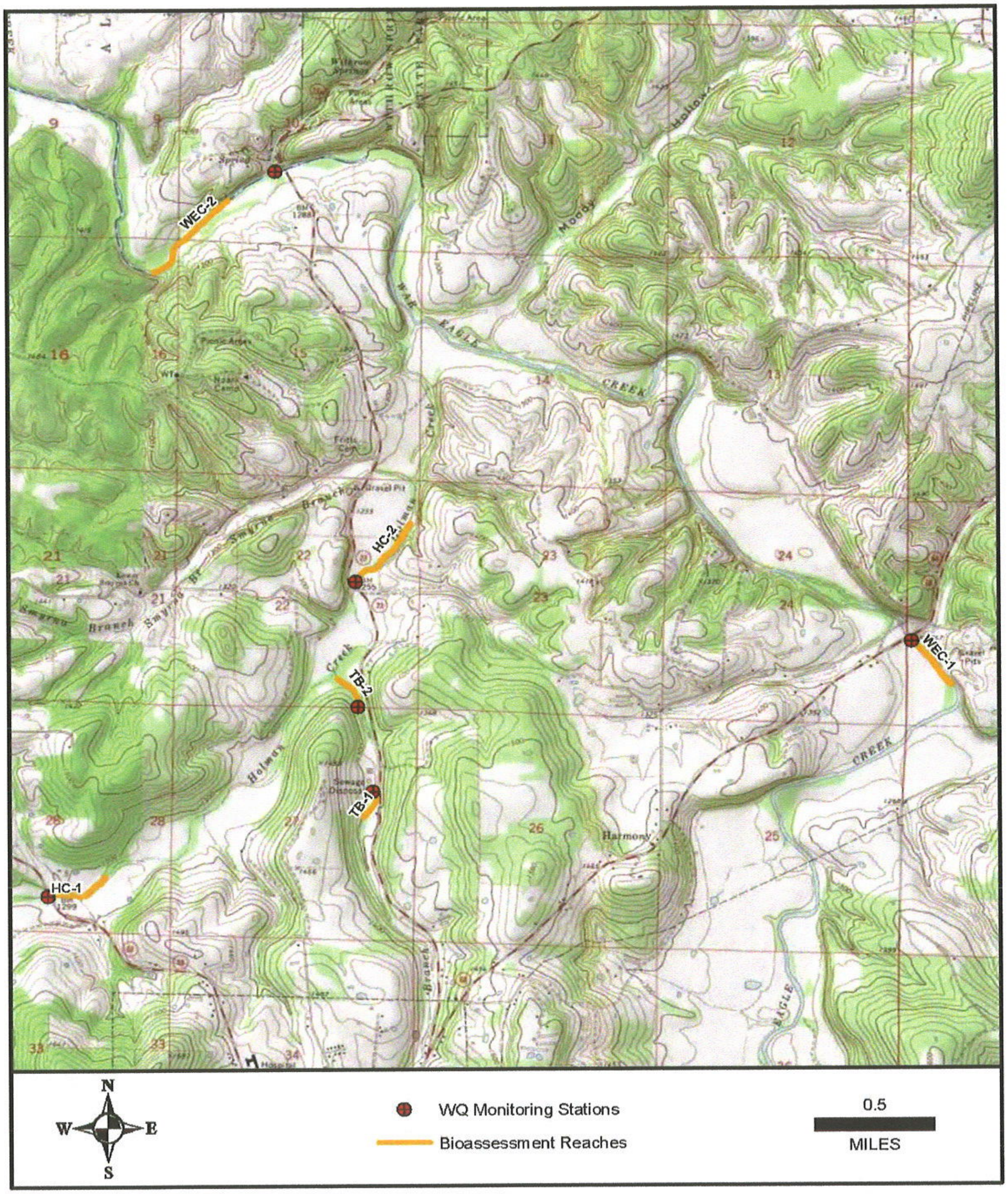


Figure 5.1. Monitoring stations used during this study of Town Branch, Holman Creek, and War Eagle Creek (July 2011- June 2012).

5.2.1 Total Dissolved Solids and Chloride Data

Summary statistics for chloride and TDS from Outfall 001 and the monitoring stations used for the study are shown in Table 5.1. The summary statistics are from the data collected during the monthly field trips conducted from July 2011 – June 2012. The Outfall 001 statistics are from the data provided in Table 4.1.

Table 5.1. Summary statistics for selected parameters (July 2011 – June 2012).

Station	Statistic	Chloride (mg/L)	TDS (mg/L)
TB-1	Minimum	7.6	150.0
	Maximum	27.0	230.0
	Average	17.6	195.0
	STD DEV	5.6	28.4
TB-2	Minimum	30.0	220.0
	Maximum	250.0	900.0
	Average	120.2	468.3
	STD DEV	70.2	209.8
HC-1	Minimum	3.4	79.0
	Maximum	15.0	270.0
	Average	7.7	156.7
	STD DEV	3.1	65.1
HC-2	Minimum	4.9	130.0
	Maximum	180.0	640.0
	Average	81.5	365.4
	STD DEV	66.4	209.0
WEC-1	Minimum	1.9	58.0
	Maximum	10.0	270.0
	Average	3.9	103.8
	STD DEV	2.0	55.6
WEC-2	Minimum	2.9	72.0
	Maximum	42.0	270.0
	Average	15.4	145.6
	STD DEV	13.3	64.4
Outfall 001	Minimum	22	251
	Maximum	590	1548
	Average	208	604
	STD DEV	96	236

As can be seen from Table 5.1 the minerals data from Outfall 001 is considerably higher than any of the ambient monitoring stations. From a comparison of the paired stations (TB-1 v. TB-2, HC-1 v. HC-2, and WEC-1 v. WEC-2) the influence of the discharge upon the stream systems can be evaluated. Town Branch, which receives the discharge, is most influenced, followed by Holman Creek. Minerals concentrations measured in War Eagle Creek at WEC-2 are only somewhat higher than at WEC-1, indicating that the influence of the discharge, with respect to TDS and chloride, is greatly diminished once it reaches War Eagle Creek. On an average basis the data shows that both chloride and TDS measured at WEC-2, downstream from the discharge, were lower than TB-1, upstream of the discharge. Figures 5.2 and 5.3 show the average concentrations of chloride and TDS measured during the study along with data from the USGS monitoring station for War Eagle Creek at Hindsville (USGS 07049000). The USGS Station at Hindsville is approximately 13 miles downstream from the Holman/War Eagle Creek confluence, or about half way between the confluence and Beaver Lake.

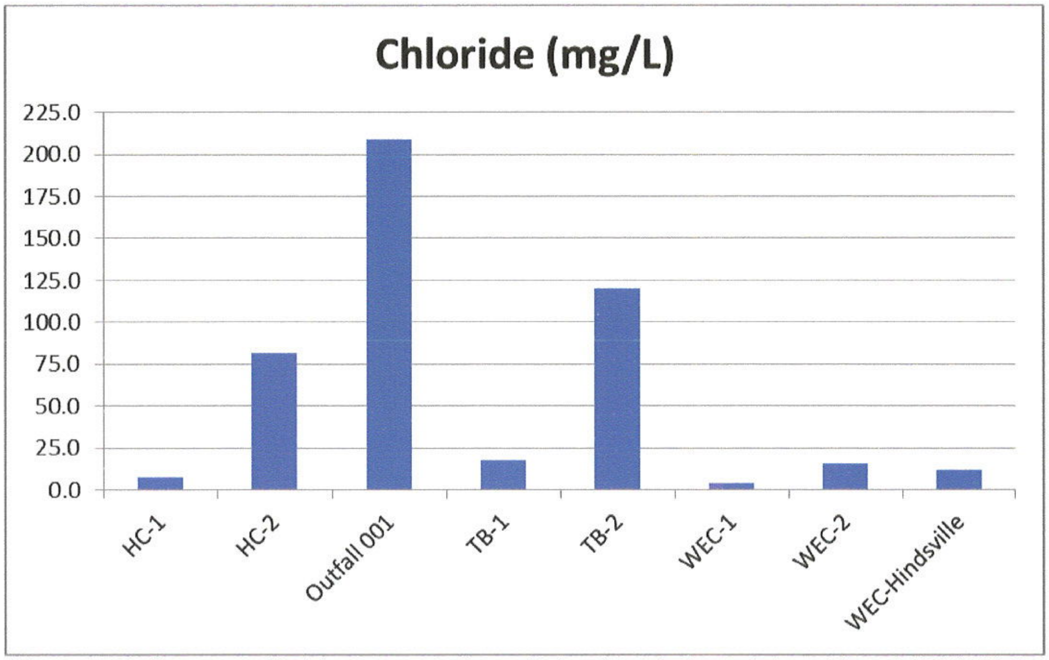


Figure 5.2. Average chloride concentrations during the study period and from USGS Station AR 07049000.

Other parameters analyzed by the laboratory, which were collected on four occasions during the study, are shown in Table 5.2, sulfate is included in this table.

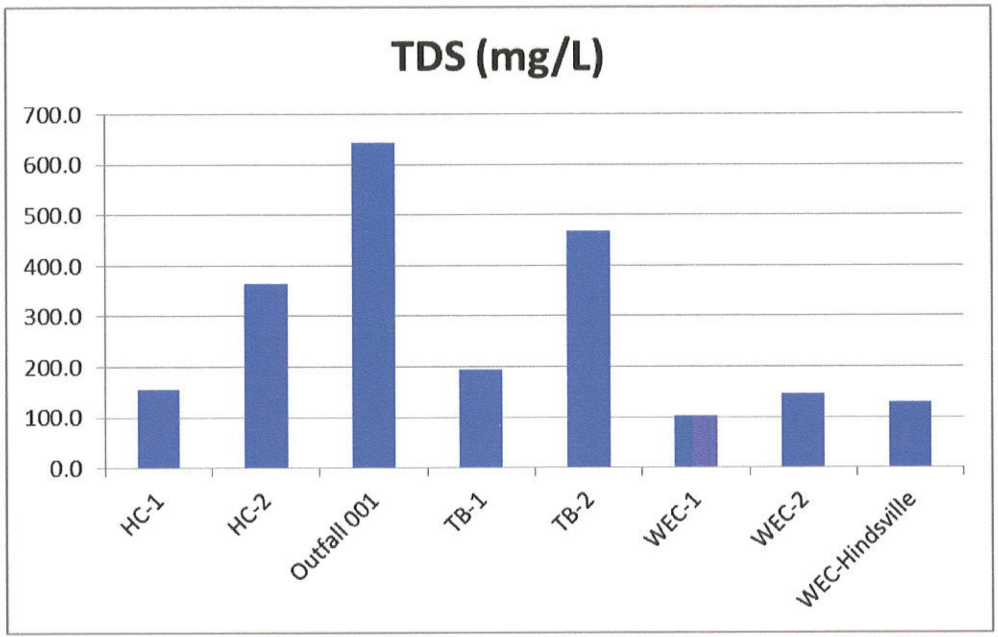


Figure 5.3. Average TDS concentrations during the study period and from USGS Station AR 07049000.

Table 5.2. Summary statistics of laboratory analyzed parameters obtained on four occasions during the study period (July 2011 – June 2012).

Station	Statistic	Sulfate (mg/L)	Alkalinity as $CaCo_3$ (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)
TB-1	Minimum	14.0	110.0	45.0	4.3	2.0	7.2
	Maximum	17.0	140.0	59.0	5.6	3.0	10.0
	Average	15.3	127.5	52.3	4.8	2.7	9.0
	St Dev	1.3	12.6	6.4	0.6	0.5	1.2
TB-2	Minimum	40.0	80.0	56.0	3.6	13.0	54.0
	Maximum	62.0	130.0	110.0	4.2	22.0	130.0
	Average	51.0	110.0	74.0	4.1	18.0	83.0
	St Dev	9.0	21.6	20.9	0.3	3.3	28.1
HC-1	Minimum	11.0	70.0	38.0	3.2	2.5	4.3
	Maximum	16.0	120.0	51.0	4.0	5.3	20.0
	Average	12.4	94.7	45.3	3.6	3.3	8.4
	St Dev	2.2	25.0	6.3	0.3	1.3	7.7
HC-2	Minimum	27.0	88.0	27.0	2.7	1.9	3.4
	Maximum	44.0	120.0	78.0	4.5	13.0	62.0
	Average	33.8	99.3	59.2	3.9	10.0	43.5
	St Dev	8.0	14.9	20.6	0.8	4.7	24.0
WEC-1	Minimum	6.3	47.0	17.0	2.0	1.5	2.1
	Maximum	9.4	270.0	32.0	3.1	2.5	3.5
	Average	7.3	132.0	23.8	2.6	2.1	2.9
	St Dev	1.4	120.6	6.7	0.5	0.5	0.6
WEC-2	Minimum	7.2	63.0	24.0	2.0	1.9	3.3
	Maximum	19.0	110.0	49.0	3.0	4.1	16.0
	Average	10.4	81.8	33.5	2.5	2.8	8.0
	St Dev	4.3	21.8	11.2	0.4	1.0	5.3
Outfall 001	Minimum	7.5	68.0	61.0	2.8	23.0	110.0
	Maximum	99.9	130.0	130.0	3.8	29.0	160.0
	Average	51.7	102.0	84.8	3.5	26.3	135.0
	St Dev	17.1	25.9	30.8	0.5	2.5	23.8

5.2.2 *In-Situ* Parameters

During the yearlong study *in-situ* parameters were measured at each study station and the outfall. Additionally, flow measurements were made and a sample collected and analyzed on-site for turbidity. The summary statistics for the measured in-situ parameters, turbidity, and flow are provided in Table 5.3.

Table 5.3. Summary statistics of in-situ parameters and flow (July 2011-June 2012).

Station	Statistic	Temp. (°C)	DO (mg/L)	DO (%)	Sp. Cond (uS)	pH	Turbidity (NTU)	Flow (cfs)
TB-1	Minimum	4.7	6.2	71.0	202.0	7.2	0.4	0.2
	Maximum	27.9	15.4	137.0	393.0	9.0	4.3	6.7
	Average	17.1	10.0	99.1	295.5	8.2	1.9	1.8
	St Dev	7.6	3.3	19.0	55.5	0.5	1.1	2.3
TB-2	Minimum	7.5	5.8	72.0	326.0	7.5	0.9	1.4
	Maximum	29.0	15.7	140.0	1070.0	9.4	3.8	9.7
	Average	18.6	9.3	97.2	673.4	8.1	2.0	3.3
	St Dev	7.3	3.0	18.8	272.9	0.5	1.0	2.7
HC-1	Minimum	8.3	6.6	75.5	116.0	7.2	1.0	0.0
	Maximum	29.2	14.6	126.0	355.0	8.3	9.8	45.5
	Average	18.0	9.5	98.6	223.5	7.7	3.2	6.9
	St Dev	6.8	2.0	13.2	77.0	0.3	2.9	13.7
HC-2	Minimum	5.4	5.8	71.8	198.0	7.6	0.4	0.9
	Maximum	30.6	15.1	132.0	980.0	8.5	13.5	38.3
	Average	18.4	9.5	97.8	486.3	8.0	2.5	9.7
	St Dev	8.2	2.9	15.1	269.3	0.3	3.6	12.9
WEC-1	Minimum	6.0	4.8	8.9	82.0	7.2	2.0	0.7
	Maximum	29.1	13.5	113.0	187.0	8.5	39.1	342.5
	Average	18.2	8.3	78.5	129.3	7.5	7.5	77.1
	St Dev	8.2	2.6	26.7	37.3	0.4	10.1	108.9
WEC-2	Minimum	5.8	7.4	82.3	105.0	6.5	2.0	5.3
	Maximum	27.9	13.6	126.0	402.0	7.8	408.0	412.1
	Average	17.2	9.8	100.5	217.4	7.3	38.8	95.9
	St Dev	7.6	2.2	13.6	109.3	0.5	116.3	129.8
Outfall 001[1]	Minimum	10.8	5.3	62.1	440.0	6.7	1.0	[1]
	Maximum	26.4	8.7	91.6	1180.0	7.9	7.7	[1]
	Average	18.5	7.5	80.3	837.4	7.5	2.5	[1]
	St Dev	5.5	1.0	8.9	271.9	0.4	1.9	[1]

[1] Flow data for Outfall 001 from DMR records is shown in Table 4.2.

5.2.1.1 Station TB-1

Individual measurement of chloride, sulfate, and TDS from Station TB-1 are provided in Table 5.4. The data from TB-1 were compared with the Calculated Ecoregion Reference Stream Values for the Ozark Highlands contained within Regulation 2, which are chloride – 17.3 mg/L, sulfate – 22.7 mg/L, and TDS – 250 mg/L. The data from TB-1 for chloride was 17.3

mg/L or higher on seven of 12 sampling events, sulfate was at 22.7 mg/L or below on all four sampling events and TDS was less than 250 mg/L for each sampling event.

Table 5.4. Results of flow measurements, and chloride, sulfate and TDS analysis from Station TB-1.

Date	Flow (cfs)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
7/7/2011	0.55	19.0	15.0	230.0
8/24/2011	0.87	22.0	17.0	230.0
9/14/2011	0.30	27.0	--	220.0
10/12/2011	0.82	18.0	14.0	180.0
11/17/2011	0.66	20.0	--	210.0
12/8/2011	1.66	12.0	--	170.0
1/18/2012	1.52	17.0	--	170.0
2/2/2012	6.45	12.0	--	150.0
3/27/2012	6.73	7.6	--	160.0
4/10/2012	1.88	13.0	15.0	190.0
5/9/2012	0.56	19.0	--	210.0
6/21/2012	0.16	24.0	--	220.0

5.2.1.2 Station TB-2

Station TB-2 is downstream of the Huntsville WWTF discharge to the system. For the parameters analyzed the station reflects the discharged concentrations of dissolved minerals as with a few exceptions the data were all above the Ecoregion Reference Stream Data. This was anticipated as it was the reason for conducting the study. Table 5.5 provides the analytical results for Station TB-2

Table 5.5. Results of flow measurements, and chloride, sulfate and TDS analysis from Station TB-2.

Date	Flow (cfs)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
7/7/2011	2.33	250	40	900
8/24/2011	1.86	150	62.0	530
9/14/2011	1.83	200	--	680
10/12/2011	2.51	130	50.0	620
11/17/2011	1.46	80	--	270
12/8/2011	2.06	42	--	250
1/18/2012	3.43	100	--	380
2/2/2012	8.06	41	--	240
3/27/2012	9.71	30	--	220
4/10/2012	2.68	79	52	420
5/9/2012	2.18	150	--	540
6/21/2012	1.39	190	--	570

5.2.1.3 Station HC-1

Station HC-1 is upstream of the confluence with Town Branch and the Huntsville WWTF discharge. Concentrations of chloride from HC-1 samples were all below the Ozark Highlands Calculated Ecoregion Reference Stream Values, with the exception of one measurement. All sulfate analyses were below the reference values and two of 12 samples contained TDS in concentration at or in excess of the reference data. The results are shown in Table 5.6

Table 5.6. Results of flow measurements, and chloride, sulfate and TDS analysis from Station HC-1.

Date	Flow (cfs)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
7/7/2011	0.42	5.0	11	210
8/24/2011	1.25	7.4	11	120
9/14/2011	0.04	9.5	13	210
10/12/2011	0.07	8.8	--	270
11/17/2011	1.37	7.7	16	250
12/8/2011	5.19	5.7	--	79
1/18/2012	3.96	6.6	--	100
2/16/2012	45.48	15.0	--	100
3/27/2012	27.17	3.4	--	90
4/10/2012	3.71	4.7	11	98
5/9/2012	0.54	5.9	--	140
6/21/2012	0.00	10.0	--	190

5.2.1.4 Station HC-2

Station HC-2 was located downstream of the confluence with Town Branch and the Huntsville WWTF discharge. Concentrations of the dissolved minerals measured at Station HC-2 were elevated relative to HC-1 and the Calculated Ecoregion Reference Stream Values. This reflects a continuing effect of the WWTF discharge into Town Branch. The concentrations of chloride measured were less than the Calculated Ecoregion Reference Stream Values on two occasions, during periods of higher upstream flow. Sulfate was higher than the Reference Data for all four sampling events, and TDS was higher than the reference values on six of 12 sampling days. Table 5.7 shows the results of analysis of dissolved minerals and flow for Station HC-2.

Table 5.7. Results of flow measurements, and chloride, sulfate and TDS analysis from Station HC-2.

Date	Flow (cfs)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
7/7/2011	2.62	150	27	630
8/24/2011	3.46	83	41	340
9/14/2011	1.63	180	--	610
10/12/2011	2.94	87	44	620
11/17/2011	2.51	27	--	180
12/8/2011	8.94	16	--	150
1/18/2012	9.97	38	--	210
2/16/2012	38.34	5	--	140
3/27/2012	34.81	10	--	130
4/10/2012	7.70	32	28	220
5/9/2012	0.89	92	--	370
6/21/2012	2.22	180	--	510

5.2.1.5 Station WEC-1

Station WEC-1 was located on War Eagle Creek upstream of the Holman Creek and War Eagle Creek confluence and is uninfluenced by the Huntsville WWFT discharge. Concentrations of dissolved minerals from the station are shown in Table 5.8. All of the measurements were below the Calculated Ecoregion Reference Stream Values.

Table 5.8. Results of flow measurements, and chloride, sulfate and TDS analysis from Station WEC-1.

Date	Flow (cfs)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
7/7/2011	3.40	3	6.4	110
8/24/2011	14.25	3.7	7.2	100.0
9/14/2011	0.86	3.6	--	100.0
10/12/2011	4.32	4.6	9.4	--*
11/17/2011	34.50	10.0	--	110.0
12/8/2011	113.81	3.4	--	70.0
1/18/2012	96.95	3.7	--	58.0
2/16/2012	238.28	3.4	--	88.0
3/27/2012	342.49	1.9	--	64.0
4/10/2012	61.43	2.5	6.3	72.0
5/9/2012	14.30	3.1	--	93.0
6/21/2012	0.65	4.1	--	110.0

*Laboratory measurements of 270 mg/L appears to be an error, the duplicate for the sample was 100 mg/L and conductivity for that day suggests that the lower duplicate value is more accurate.

5.2.1.6 Station WEC-2

Station WEC-2 was located on War Eagle Creek downstream from the confluence with Holman Creek and thus its chemical characteristics are influenced by the Huntsville WWTF discharge. Concentrations of chloride were below the Calculated Ecoregion Reference Stream Values on eight of 12 occasions. Sulfate concentration at WEC-2 was less than the Calculated Ecoregion Reference Stream Value on all sampling events, and TDS was less than the reference data for 11 of 12 measurements. Concentrations of dissolved minerals at WEC-2 were considerably lower than concentrations measured at HC-2, indicating a much reduced effect on War Eagle Creek from the WWTF discharge. Concentrations of dissolved minerals from the station are provided in Table 5.9.

Table 5.9. Results of flow measurements, and chloride, sulfate and TDS analysis from Station WEC-2.

Date	Flow (cfs)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
7/7/2011	13.55	22.0	7.2	270.0
8/24/2011	35.29	14.0	10.0	150.0
9/14/2011	6.51	42.0	--	230.0
10/12/2011	10.84	35.0	--	230.0
11/17/2011	48.56	7.0	19.0	110.0
12/8/2011	100.85	4.6	9.4	80.0
1/18/2012	122.86	6.6	--	94.0
2/16/2012	301.53	3.5	--	72.0
3/27/2012	412.10	2.9	--	82.0
4/10/2012	72.26	6.0	8.2	110.0
5/9/2012	21.67	15.0	--	160.0
6/21/2012	5.30	36.0	--	200.0

5.3 Habitat Characterization

Physical habitat in streams includes all those physical characteristics that influence or provide sustenance to biological attributes, both botanical and zoological, within the stream. Stream physical habitat varies naturally, as do biological characteristics; thus, habitat conditions differ even in the absence of point and anthropogenic non-point disturbance. Within a given ecoregion, stream drainage area, stream gradient, and the local geology are likely to be strong natural determinants of many aspects of stream habitat, because of their influence on discharge, flood stage, and stream energy (both static and kinetic). In addition, land-use activities or instream physical modifications, such as channelization, channel diversion or dam construction directly or indirectly impact the habitat in a stream. The objectives of a habitat characterization are to:

1) assess the availability and quality of habitat for the development and maintenance of benthic invertebrate and fish communities, and
2) evaluate the role of habitat quality in relation to biological integrity and overall stream system health.

There are three main headings for the components of the physical habitat characterization; each with several categories. Measurements for each of the components (14 categories total) are taken in ten equally spaced sub-reaches at each reach, and recorded on copies of a two-page field form entitled Stream Habitat Assessment (Semi-Quantitative), and include:

1) Channel Morphology
  a) Reach Length Determination
  b) Riffle-Pool Sequence
  c) Depth and Width Regime

2) Instream Structure
  a) Epifaunal Substrate
  b) Instream Habitat
  c) Substrate Characterization
  d) Embeddedness
  e) Sediment Deposition
  f) Aquatic Macrophytes and Periphyton

3) Riparian Characteristics
  a) Canopy Cover
  b) Bank Stability and slope
  c) Vegetative Protection
  d) Riparian Vegetative Zone Width
  e) Land-use Stream Impacts

Physical habitat measurements from a field habitat characterization are used in conjunction with water chemistry, temperature, macroinvertebrate and fish community analyses, and other data sources to determine the status of the target streams attainment of uses (e.g. fishing, swimming, aesthetics, or other recreation) and the water quality required to maintain those uses.

In addition to direct habitat feature measurements, habitat potential was evaluated using procedures adapted from EPA's rapid bioassessment protocols (Barbour et al. 1999). This procedure was used to numerically score each of 10 habitat features. This effort resulted in categorizing each survey reach as "optimal", "suboptimal", "marginal" or "poor" with respect to habitat providing the physical features necessary to support balanced populations of aquatic life.

5.3.1 Town Branch Creek

The Town Branch habitat assessment was completed in the fall of 2011 and spring 2012. Town Branch's watershed area is approximately 4.6 mi^2, (at its confluence with Holman Creek) the smallest watershed of the study. The habitat characterization at TB-1 covered 600 ft of total stream length. Photos of a typical portion of reach TB-1 are presented in Figure 5.4. The average bankfull width and depth of the stream were 30 ft and1.6 ft, respectively. Measured flow was 0.82 cfs on October 12th, 2011, with an average velocity of 0.27 fps. On April 20th, 2012, the measured flow was 1.88 cfs with an average velocity of 0.52 fps. The morphological characteristics were distributed between riffles, runs, and pools at 36%, 29%, and 36%, respectively. Instream stable habitat for TB-

1 measured 53% for macroinvertebrates and 56% for fish. Dominate substrate for the reach was boulder in riffles, boulder/cobble in runs and boulder/bedrock in pool habitats. In fall 2011, both the left and right banks at TB-1 had moderately unstable banks with average bank protection of 54% for the left and 53% for the right bank. In spring 2012, both the left and right banks were moderately stable with an average left bank vegetative protection of 53% for left bank and 54% on the right bank. Riparian protection average width was approximately 19.8 ft for the left and right banks. There were moderate industrial and urban land-use impacts along the stream corridor, mostly due to proximity to Hwy 23 and adjacent city property where the WWTP operates.

Figure 5.4. Typical habitat sampled at TB-1.

Habitat assessment of reach TB-2, the downstream reach of Town Branch Creek, was also completed in October 2011 and in April 2012. The habitat characterization covered an average of 825 ft of total stream length. A typical portion of TB-2 is presented photographically in Figure 5.5. The average bankfull width and depth of the stream was 40.0 ft and 1.8 ft, respectively. Measured flow was 2.5 cfs in fall 2011 on the day of the survey with an average velocity of 0.13 fps. In spring 2012, measured flow was 2.68 cfs with an average velocity of 0.22 fps. The morphological characteristics were distributed between riffles, runs, and pools at 44.5%, 27.5%, and 37.5%, respectively. Instream stable habitat for TB-2 measured 64% for macroinvertebrates and 67% for fish. Dominate substrate for the reach was cobble and fine gravel in runs, while cobble was dominate for riffle and pool habitats. TB-2 stream bank stability in fall 2011 was moderately stable for both the left and right banks with average bank protection of 72% for the left bank and 75% for the right bank. In spring 2012, the left bank was stable with 80% vegetative protection and the right bank was moderately stable with 71% protection. Riparian protection average width was approximately 33 ft for the left and right banks. There were minor cattle land-use impacts along the stream corridor.

Figure 5.5. Typical habitat sampled at TB-2.

Using the measured and estimated characteristics as described above an overall habitat potential score was calculated. The potential score for TB-1 was 11.7 in fall 2011 and 12.7 in spring 2012, which placed it in the sub-optimal category for both seasons. The habitat score for TB-2 was 14.4 in fall 2011 and 13.8 in spring 2012, which placed it in the sub-optimal category for both years.

5.3.2 Holman Creek

The Holman Creek habitat assessment was completed in October 2011 and again in April 2012. Watershed area for Holman Creek is approximately 27.5 mi^2 (at its confluence with War Eagle Creek, excluding the Town Branch watershed). The habitat characterization at HC-1 covered approximately 1,394 ft of total stream length. A typical portion of reach HC-1 is presented photographically in Figure 5.6. The average bankfull width and depth (the point at which the stream enters its active floodplain) of the stream was 69.7 ft and 1.48 ft, respectively. Measured flow was 0.07 cfs in fall 2011 on the day of the survey with an average velocity of 0.05 fps. In spring 2012, the flow was higher on the day of the survey, 3.7 cfs, with an average velocity of 0.10 fps. On average, stream morphology was distributed between riffle (38%), run (30%), and pool (34%) habitat, respectively. Dominate substrate for the reach was cobble/coarse gravel in riffle, run, and coarse gravel in the pool habitats. Instream stable habitat for HC-1 measured 69% for macroinvertebrates and 67% for fish. Stream bank stability for HC-1 was moderately stable for the left bank and moderately unstable for the right with average bank protection of 77% for the left bank and 50% for the right bank in the fall of 2011. Both banks were moderately stable in the spring 2012 with an average bank protection of 74% for the left bank and 53% for the right bank. Riparian protection average width was approximately 30 ft for the left and right banks. There were minor to moderate pasture land-use impacts along the stream corridor. A detailed breakdown of the complete habitat characteristics at each reach is provided in Appendix E.

Figure 5.6. Typical habitat sampled at HC-1.

The habitat characterization for HC-2 covered approximately 1,238 ft of total stream length. A typical portion of reach HC-2 is presented photographically in Figure 5.7. The average bankfull width and depth of the stream were 62 ft and 2.9 ft, respectively. Measured flow in fall 2011 was 2.94 cfs on the day of the survey with an average velocity of 0.17 fps. In spring 2012, the flow was higher at 7.7 cfs with an average velocity of 0.58 fps. The morphological characteristics were distributed between riffles, runs, and pools on average at 28%, 30%, and 43%, respectively. Instream stable habitat for HC-2 measured 66% for macroinvertebrates and 66% for fish. Dominate substrate for the reach was coarse gravel in riffle, run, and pool habitats. Stream bank stability for HC-2 in fall 2011 was moderately stable on the right bank with 79% average bank protection and moderately unstable on left bank with 70% average bank protection. In spring 2012, the banks were moderately stable on the left and right banks with an average vegetative protection of 75% on right bank and 74% on left bank. Riparian protection average width was approximately 40 ft for the left and right banks. There were minor to moderate pasture land-use impacts along the stream corridor.

Figure 5.7. Typical habitat sampled at HC-2.

Using the measured physical characteristics described above an overall habitat potential score was established. The habitat potential score for HC-1 was 12.8 in fall 2011 and 13.8 in the spring 2012, which placed it in the sub-optimal category for both seasons. The potential score for HC-2 was 13.2 in fall 2011 and 14.6 in spring 2012, which placed it in the sub-optimal category for both seasons.

5.3.3 War Eagle Creek

The War Eagle Creek habitat assessment was completed in October 2011 and again in April 2012. Watershed area for War Eagle Creek is approximately 172 mi^2 (at its confluence with Holman Creek, excluding the Town Branch and Holman Creek watersheds), the largest watershed of the study. The habitat characterization at WEC-1 covered 1,300 ft of total stream length. A typical portion of reach WEC-1 is presented photographically in Figure 5.8. The average bankfull width and depth (the point at which the stream enters its active floodplain) of the stream was 71 ft and 2.7 ft, respectively. Measured flow was 4.3 cfs in fall 2011 on the day of the survey with an average velocity of 0.37 fps. In spring 2012, measured flow was 61.4 cfs with an average velocity of 0.76 fps. The morphological characteristics were distributed between riffles, runs, and pools at 15%, 19%, and 66%, respectively. Instream stable habitat for WEC-1 on average measured 51% for macroinvertebrates and 59% for fish. Dominate substrate for the reach was coarse gravel in riffle, run, and coarse gravel, silt, and clay for the pool habitats. Stream bank stability for WEC-1 in fall 2011 was moderately stable for the left and right banks with average bank protection of 76% for the left bank and 72% for the right bank. In spring 2012, both right and left banks were moderately stable with 61% vegetation protection on the left bank and 73% on the right bank. Riparian protection average width was approximately 27 ft for the left and right banks. There were minor urban (due to proximity to Highway Bridge) and moderate cattle land-use impacts along the stream corridor.

Figure 5.8. Typical habitat sampled at WEC-1.

The WEC-2 habitat characterization covered 1,900 ft of total stream length. A typical portion of reach WEC-2 is presented photographically in Figure 5.9. The average bankfull width and depth of the stream was 93.4ft and 1.9 ft, respectively. Measured flow in fall 2011 was 10.8 cfs with an average velocity of 0.45 fps. In spring 2012, the flow was 72.2 cfs with an average velocity of 0.71 fps. The morphological characteristics were distributed between riffles (14%), runs (11%), and pools (76%). Instream stable habitat for WEC-2 measured 43% for macroinvertebrates and 58% for fish. Dominate substrate for the reach was coarse gravel in riffle and runs, and coarse gravel/sand in pool habitats. Stream bank stability for WEC-2 in fall 2011 was moderately stable on the right bank with 74% average bank protection and moderately unstable on left bank with 77% average bank protection. In spring 2012, the right and left banks were moderately stable with 71% vegetative protection on the right bank and 65% on the left bank. Riparian protection average width was approximately 41.3 ft for the left and right banks. There were minor pasture land-use impacts along the stream corridor.

Figure 5.9. Typical habitat sampled at WEC-2.

Using the measured and estimated characteristics as described above an overall habitat potential score was calculated. The habitat potential score for WEC-1 was 13.9 in fall 2011 and 13.5 in spring 2012 which placed it in the sub-optimal category for both seasons. The potential score for WEC-2 was 12.9 in fall 2011 and 13.8 in spring 2012, which placed it in the sub-optimal category for both seasons. Tables 5.10, 5.11 and Figure 5.10 provide a summary of the habitat potential breakdown.

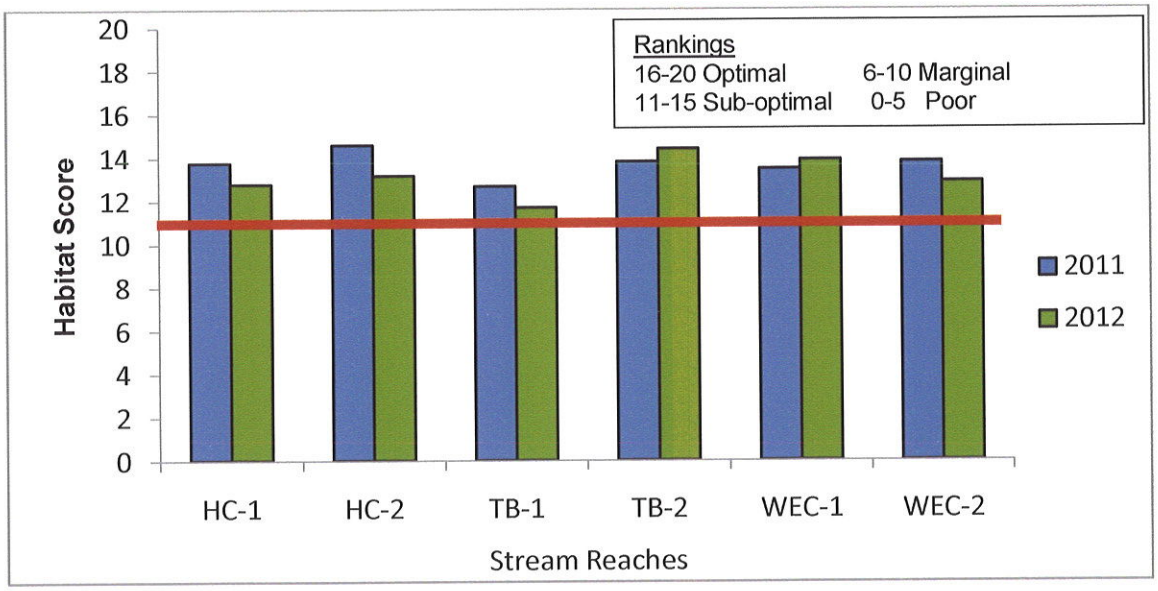


Figure 5.10. Summary of habitat quality in each biological assessment reach from the City of Huntsville. Red line indicates minimum score for sub-optimal habitat.

In summary, the following conclusions can be drawn concerning habitat:

1. Habitat scores at all stations for each season were in the sub-optimal category.
2. Habitat is sufficient in each reach to support healthy and diverse aquatic communities.

Table 5.10. Habitat potential summary scores for Town Branch, Holman Creek, and War Eagle Creek, October 2011.

	Reach					
Parameters	**TB-1**	**TB-2**	**HC-1**	**HC-2**	**WEC-1**	**WEC-2**
1. Epifaunal Substrate	12	16	16	16	16	12
2. Embeddedness	14	14	14	11	16	15
3. Velocity/Depth Regime	10	16	16	17	17	17
4. Channel Alteration	16	16	14	15	15	17
5. Sediment Deposition	13	12	15	12	12	5
6. Frequency of Riffles	16	19	14	17	17	16
7. Channel Flow Status	13	14	9	11	11	14
8. Bank Stability						
Left Bank	5	7	8	5	6	5
Right Bank	5	7	4	6	6	6
9. Vegetative Protection						
Left Bank	3	6	6	6	6	6
Right Bank	3	6	3	7	6	6
10. Riparian Vegetative Zone Width						
Left Bank	4	8	7	2	2	3
Right Bank	3	3	2	7	9	7
Score (Total)	117	144	128	132	139	129
Score Average	11.7	14.4	12.8	13.2	13.9	12.9
Ranking	S	S	S	S	S	S
Scores: 16-20 = optimal, 11-15 = sub-optimal, 6-10 = marginal, 0-5 = poor						

Table 5.11. Habitat potential summary scores for Holman Creek, Town Branch, and War Eagle Creek, April 2012.

	Reach					
Parameters	**TB-1**	**TB-2**	**HC-1**	**HC-2**	**WEC-1**	**WEC-2**
1. Epifaunal Substrate	12	14	15	14	15	9
2. Embeddedness	17	11	18	18	18	18
3. Velocity/Depth Regime	12	13	15	14	17	17
4. Channel Alteration	16	16	14	15	15	17
5. Sediment Deposition	13	15	20	15	11	12
6. Frequency of Riffles	19	17	14	19	17	15
7. Channel Flow Status	13	14	10	12	14	14
8. Bank Stability						
Left Bank	7	9	8	7	6	7
Right Bank	6	8	6	7	7.8	6.2
9. Vegetative Protection						
Left Bank	3	7	6	6	4	5
Right Bank	3	6	3	6	6	6
10. Riparian Vegetative Zone Width						
Left Bank	3	7	6	3	2	8
Right Bank	3	2	3	10	2	5
Score (Total)	127	138	138	146	135	138
Score Average	12.7	13.8	13.8	14.6	13.5	13.8
Ranking	S	S	S	S	S	S
Scores: 16-20 = optimal, 11-15 = sub-optimal, 6-10 = marginal, 0-5 = poor						

5.4 Benthic Macroinvertebrate Community

Benthic macroinvertebrates inhabit the sediment or live on the bottom substrates of streams, rivers and lakes. Macroinvertebrates are a fundamental linkage in food web dynamics of streams. They act as a middleman in the food web between organic matter resources such as algae, leaf litter, and detritus, and fishes (Allan, 1995). The presence of these organisms and their diversity and tolerance to environmental perturbation at an expected level reflects the maintenance of a systems biological integrity. Monitoring these assemblages is useful in assessing the Fisheries Use status of the water body and detecting trends in ecological condition.

5.4.1 Methods

Semi-quantitative benthic macroinvertebrate samples were collected in each of the six reaches, Town Branch (TB-1 and TB-2), Holman Creek (HC-1 and HC-2), and War Eagle Creek (WEC-1 and WEC-2) on October 11th, 12th, and 13th of 2011 and on April 10th and 11th of 2012. The Rapid Bioassessment Protocol for riffle dominated streams was used to sample 5m^2 of multiple habitat types (riffle, root-wads, emergent vegetation, undercut banks, deposition, etc.) using a 500 µm dip net. Samples collected from riffles were kept separately (independent) of all other habitat types that were combined. Samples were preserved in Kahle's solution and transported to the laboratory. Once in the laboratory, macroinvertebrate samples were subsampled using a Caton (1991) sorting tray. The entire sample was also examined for large or rare specimens included in the collection. Macroinvertebrates were sorted, ensuring each sample had 100 organisms ± 10% in each habitat type (i.e. riffle and multi-habitat) with a total of 200 ± 10%. Macroinvertebrates were then identified to the lowest practical taxonomic level, usually genus using taxonomic keys of Merritt and Cummings (Merritt et. al. 2008).

A series of macroinvertebrate metrics were analyzed for each reach. The two habitat types (riffle and multi-habitat) were combined for the community-level analyses. Taxa richness (number of taxa), Shannon-Wiener Diversity, biotic index, percent EPT taxa (Ephemeroptera, Plecoptera, and Trichoptera), EPT taxa richness, dominance of macroinvertebrate orders, and functional feeding group composition were of the primary metrics assessed. Biotic index was calculated using the Hilsenhoff Biotic Index (EPA, 1999). Tolerance values used in the calculations were assigned to each taxon based on tolerance values from Missouri Department of Natural Resources (MDNR, 2011) and EPA (Barbour, 1999). A multimetric biocriteria that was developed for Arkansas (Shackleford, 1988) was used in comparing the reference upstream section to the downstream section of each stream.

An ADEQ adaptation of rapid bioassessment protocol III developed by the Environmental Protection Agency was also used to compare the downstream sections of the streams to the upstream or reference reach using macroinvertebrate community metrics. A comprehensive listing of the macroinvertebrate taxa identified from the fall 2011 and spring 2012 samples can be found in Appendix F. A summary of biometric values are present in Table 5.12.

5.4.2 Results

5.4.2.1 Reach TB-1

In fall 2011, 29 different taxa were found at TB-1 with Shannon-Weiner diversity of 2.46. The biotic index for TB-1 was 6.47, indicating a fairly sensitive macroinvertebrate community. The macroinvertebrate community consisted of 59% EPT taxa, with eight different EPT taxa represented. Ephemeroptera (32.4%) was the dominant order found, with Diptera (27.3%), and Trichoptera (26.6%) following in the fall season. Collectors (51.6%) and filterers (28.1%) were the dominant functional feeding group at TB-1, indicating fine benthic organic matter may be a primary food source for the macroinvertebrate community.

In spring 2012, 30 different taxa were found at TB-1. Shannon-Weiner diversity was 2.29. The biotic index for TB-1 was 6.86. The macroinvertebrate community consisted of 42.9% EPT taxa, with 10 different EPT taxa represented. Diptera (48.7%) was the dominant order, followed by Trichoptera (24.9%). Collectors (58.1%) and filterers (31.6%) were the dominant functional feeding groups at TB-1 in the spring of 2012.

5.4.2.2 Reach TB-2

In fall 2011, 30 different taxa were found at TB-2 . Shannon-Weiner diversity was 2.07. The biotic index for TB-2 was 6.25, indicating a fairly sensitive macroinvertebrate community. The macroinvertebrate community consisted of 67.7% EPT taxa, with six different EPT taxa included. Trichoptera (55.5%) and Diptera (22.6%) were the dominant orders found at TB-2 in the fall of 2011. Filterers (56.5%) and collectors (31.1%) were the dominant functional feeding groups collected in the fall season.

In spring 2012, 24 different taxa were found at TB-2. Shannon-Weiner diversity was 2.48, which was higher than the fall season. The biotic index for TB-2 was 7.29, higher than in the fall. The macroinvertebrate community consisted of 33.3% EPT taxa, with six different EPT taxa. Diptera (41.1%) was the most dominant order, followed by Trichoptera (22.5%). Collectors (52%) and filterers (26.4%) were again the dominant functional feeding groups at TB-2 in the spring of 2012.

5.4.2.3 Reach HC-1

In fall 2011, 35 different taxa were found at HC-1. Shannon-Weiner diversity was 2.60. The biotic index at HC-1 was 5.81, a more sensitive community score than other reaches. The macroinvertebrate community consisted of 47.1% EPT taxa, with 13 different EPT taxa represented. Ephemeroptera (41.4%) and Diptera (30.3%) were the two most dominant orders in fall 2011. Collectors (55.7%) and scrapers (31.3%) were the two dominant functional feeding groups, indicating fine benthic organic matter and algae as primary food sources in Holman Creek at this reach.

In spring 2012, 30 different taxa were found at HC-1. Shannon-Weiner diversity was 2.27. The biotic index at HC-1 was 6.34 in the spring of 2012. The macroinvertebrate community consisted of 48.1% EPT taxa, with 14 different EPT taxa collected. Diptera (44.8%) and Ephemeroptera (37.2%) were the dominant orders present in the spring season. Collectors (71.9%) were the dominant functional feeding group with fewer scrapers (5.9%) present when compared to the fall season's macroinvertebrate community.

5.4.2.4 Reach HC-2

In fall 2011, 37 different taxa were found at HC-2. Shannon-Weiner diversity was 2.51. The biotic index at Holman Creek was 6.25 in the fall of 2011, again suggesting a fairly sensitive macroinvertebrate community. The macroinvertebrate community consisted of 56.6% EPT taxa, with nine different EPT taxa collected. Ephemeroptera (37.8%), Trichoptera (18.2%), and Coleoptera (18.0%) were the dominant orders in Holman Creek below the confluence with Town Branch. Collectors (44.2%) and scrapers (27.3%) were the dominant functional feeding groups in fall 2011.

In spring 2012, 34 different taxa were found at HC-2. Shannon-Weiner diversity was 2.14. The macroinvertebrate community consisted of 55.5% EPT taxa, with 13 different EPT taxa represented. The biotic index at HC-2 was 6.60 in the spring of 2012. Diptera (37.0%), Ephemeroptera (27.2%), and Trichoptera (27.1%) were the dominant orders found. Collectors (55.1%), and filterers (35.8%) were the most dominant functional feeding groups found in the spring of 2012 at HC-2.

5.4.2.5 Reach WEC-1

In fall 2011, 32 different taxa were found at the WEC-1. Shannon-Weiner diversity was 2.07. The biotic index for WEC-1 was 7.18 in the fall of 2011. EPT taxa (Ephemeroptera, Plecoptera, and Trichoptera) made up 52.4% of the macroinvertebrate community with nine different EPT taxa found. Diptera (39.1%) were the dominant order, followed by Ephemeroptera (25.8%), and Trichoptera (25.0%). Collectors (61.2%) were dominant functional feeding group, followed by filterers (27.7%), indicating fine benthic and suspended organic matter as a primary food source for the community.

In spring 2012, 30 different taxa were found at the WEC-1 with a Shannon-Weiner diversity was 2.31, higher than in the fall 2011. The biotic index for WEC-1 was 6.91 in the spring of 2012. EPT taxa composition was 33.9% of the macroinvertebrate community and the number of different EPT taxa increased to 13 in the spring of 2012. Diptera (58.4%) again was the dominant order, followed by Ephemeroptera (21.6%). Collectors (69.6%) were the dominant functional feeding group with fewer filterers (17.6%) compared to the fall of 2011.

5.4.2.6 Reach WEC-2

In fall 2011, 35 different taxa were found at WEC-2. Shannon-Weiner diversity was 2.41. The biotic index for WEC-2 was 6.78 in the fall of 2011, indicating a community slightly more sensitive to perturbation than the upstream reach. The macroinvertebrate community consisted of 65.1% EPT taxa with 10 different EPT taxa found. Ephemeroptera (53.3%) was the dominate order, followed by Diptera (15.9%). Collectors (60.4%) were the dominant functional feeding group in this reach.

In spring 2012, 33 different taxa were found at the WEC-2. Shannon-Weiner diversity was 2.60, higher than the fall season. The biotic index for WEC-2 was 6.89 in the spring of 2012, slightly higher than the fall season and again indicating a community slightly more sensitive than the upstream station for the same season. The macroinvertebrate community consisted of fewer EPT taxa, 32.8%, than in fall of 2011 with 11 different taxa. Diptera (52.3%) was the dominate order collected, followed by Ephemeroptera (23.2%). Collectors (62.4%) were the dominant functional feeding group with filterers (17.7%) as the next highest functional feeding group. Reach WEC-2, downstream of the Huntsville discharge, had very similar functional feeding group structure compared to the upstream WEC-1 reach.

5.4.3 Summary and Discussion

In fall 2011, taxa richness ranged from 29-37, and was higher in the downstream reaches of each of the three streams. Shannon-Weiner's diversity values ranged from 2.07-2.60 in the six stream reaches. The biotic index ranged from 5.81-7.18, with HC-1 having the lowest and WEC-1 the highest values. EPT taxa percentages of the macroinvertebrate community ranged from 47.1-67.7%, with 6-13 different EPT taxa. Ephemeroptera dominated the WEC-2, TB-1, HC-1, and HC-2 reaches, Trichoptera dominated the TB-2 reach, and Diptera dominated the WEC-1 reach in fall 2011 (Figure 5.11). Collectors dominated the functional feeding group at all reaches except the TB-2 reach, which was dominated by filterers.

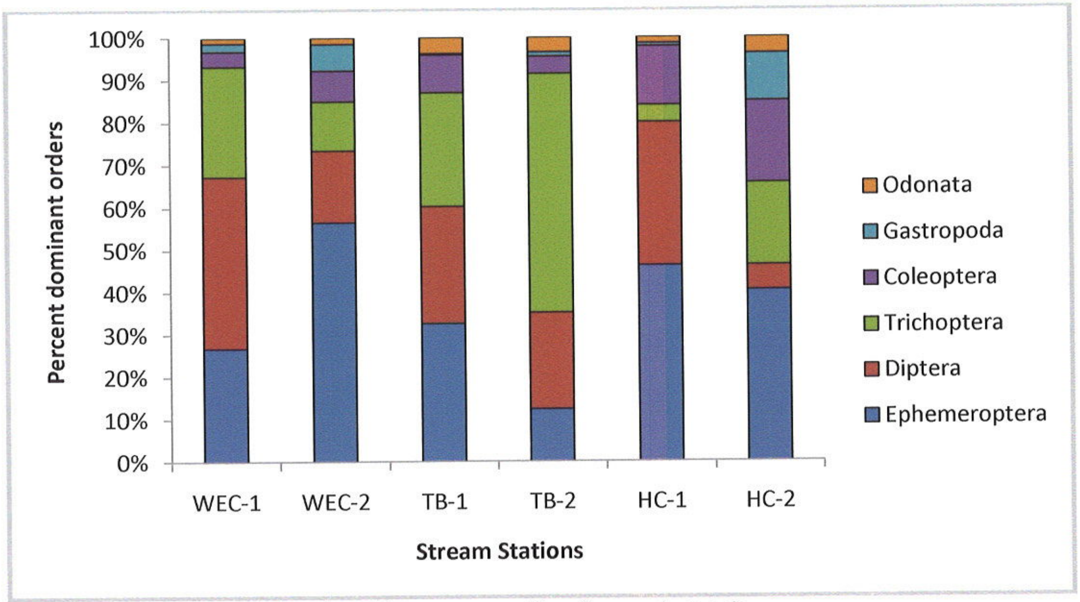


Figure 5.11. Fall 2011 dominant taxa composition for each reach.

In spring 2012, taxa richness ranged from 24-34, and Shannon-Weiner diversity values ranged from 2.14-2.60 in the six stream reaches. The biotic index ranged from 6.34-7.29, with HC-1 having the lowest and TB-2 had the highest biotic index. EPT taxa abundance ranged from 32.8-55.5%, with 6-14 different EPT taxa found. The order Diptera dominated all six of the stream reaches in the spring of 2012 (Figure 5.12). Collectors were the dominate functional feeding group at all of the stream reaches ranging from 52.0% to 71.9%. Overall, the communities represented by the collections in each stream reach were similar above and below the influence of the City of Huntsville wastewater discharge. The wastewater appears to have no adverse affect on the attainment of the Fisheries Use as measured by the macroinvertebrate community.

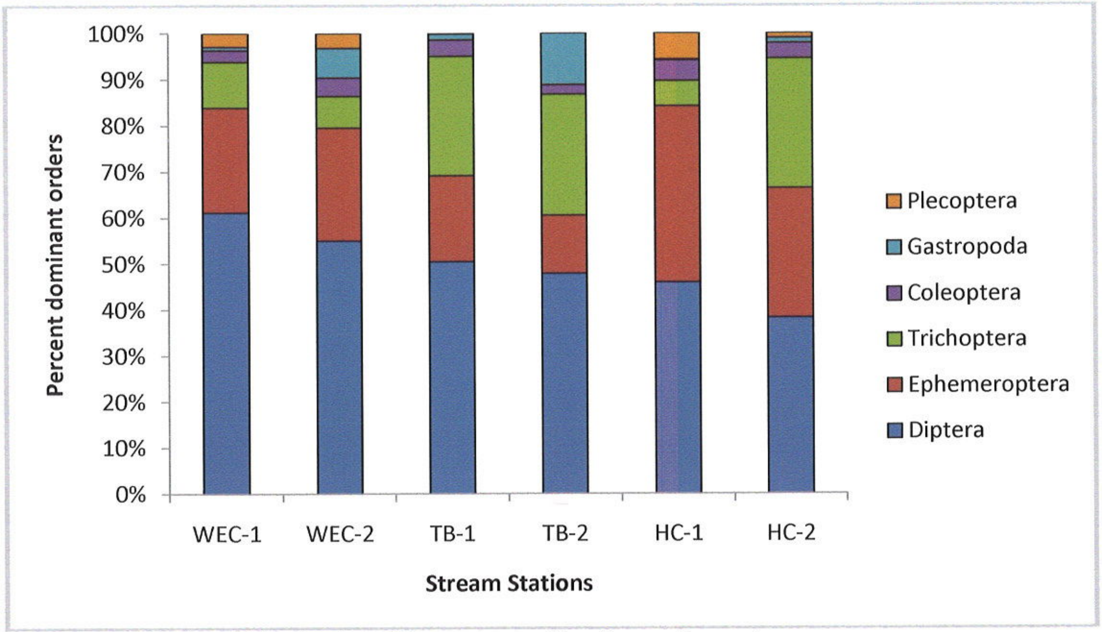


Figure 5.12. Spring 2012 dominant taxa composition for each reach.

A biometric scoring system was developed for Arkansas by the Arkansas Department of Pollution Control and Ecology (ADPCE) in the 1980's (Shackleford, 1988). The biometric scoring system was created to compare changes in the macroinvertebrate community structure and function in paired stream reaches. Paired streams reaches were used to analyze effects of nonpoint source and point source pollution on water quality. If water quality is altered, there is potential for macroinvertebrate communities to also be altered. The biometric scoring system is designed for comparison of a reach that has potential for water quality degradation from a suspected pollution source with a reach that is not influenced by the suspected pollution source and thus could be considered a reference site. This biometric approach measures metrics such as dominants in common, common taxa index, quantitative similarity index, taxa richness, indicator assemblage index, missing genera, and functional feeding group percentage similarity (Shackelford, 1986). The study design for the City of Huntsville involves three stream systems each with a reference reach upstream of effluent influence and a study reach downstream of the effluent discharge.

We completed the biometric analysis for each pair of stream reaches for the fall 2011. When we compared biometric scores for TB-1 and TB-2, and HC-1 and HC-2 each had minimal impairment, while WEC-1 and WEC-2 demonstrated no impairment (Figure 5.13). Town Branch's biometric score bordered between minimal impairment and no impairment but with rounding, minimal impairment was concluded. HC-1 and HC-2 biometric score was lowered by the Quantitative Similarity Index as there weren't as many taxa in common with each of the two sites. But with further evaluation, HC-2 has higher taxa richness than HC-1, indicating a more diverse community than the upstream reach. Overall, when comparing the biometric scores of the three downstream reaches to the three upstream they have no to minimal impairment for the fall of 2011, which indicates they are quite similar and are each in full attainment of the Fisheries Use (Figure 5.12).

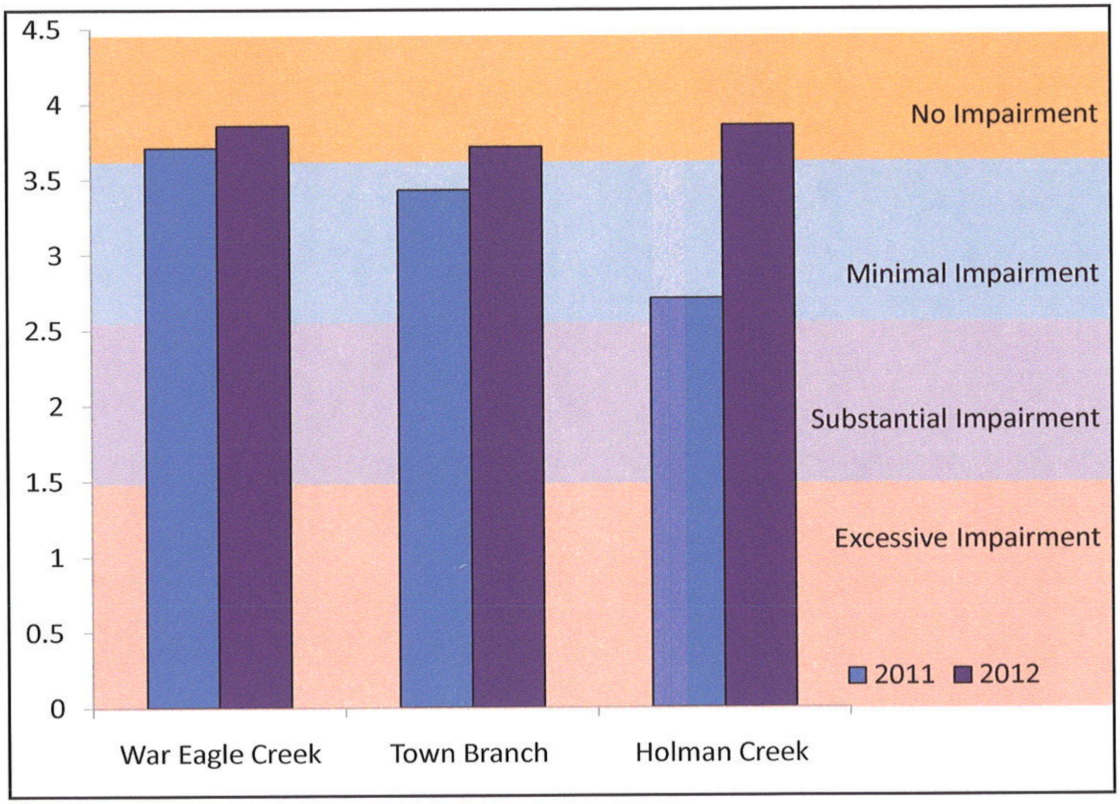


Figure 5.13. Comparison of downstream to upstream macroinvertebrate collections from fall 2011 and spring 2012 using the biometric scoring system developed for Arkansas by the Arkansas Department of Pollution Control and Ecology (Shakleford, 1988).

We completed the biometric analysis for each stream for the spring 2012; comparing each downstream reach to the upstream reference reach. WEC-1 and WEC-2, TB-1 and TB-2, and HC-1 and HC-2 all scored no impairment between the two reaches of each stream (Figure 5.13). Overall, when comparing the two reaches in each stream the downstream reach is quite similar to the reference reach (Table 5.13). Biometric analysis indicated that the streams are in full attainment of their designated Fisheries Use.

Table 5.12. Summary of biometric scoring system assessment from War Eagle, Town Branch, and Holman Creek in the fall of 2011.

Community Metric	WEC-1 Vs. WEC-2	TB-1 Vs. TB-2	HC-1 Vs. HC-2
Dominants in common	4	4	1
Common Taxa Index	3	3	2
Quantitative Similarity Index	3	3	1
Taxa Richness	4	4	4
Indicator Assemblage Index	4	4	4
Missing Taxa	4	4	4
Functional Group Percent Similarity	4	2	3
Mean Biometric Score	3.71	3.43	2.71
Aquatic Life Status	No Impairment	Minimal Impairment	Minimal Impairment

Table 5.13. Summary of biometric scoring system assessment from War Eagle, Town Branch, and Holman Creek in the spring of 2012.

Community Metric	WEC-1 Vs. WEC-2	TB-1 Vs. TB-2	HC-1 Vs. HC-2
Dominants in common	3	4	4
Common Taxa Index	4	3	4
Quantitative Similarity Index	4	4	4
Taxa Richness	4	3	4
Indicator Assemblage Index	4	4	4
Missing Taxa	4	4	4
Functional Group Percent Similarity	4	4	3
Mean Biometric Score	3.86	3.71	3.86
Aquatic Life Status	No Impairment	No Impairment	No Impairment

We also analyzed the data using ADEQs variation on Rapid Bioassessment Protocol III, developed by the Environmental Protection Agency (EPA) that compares upstream and downstream reaches of a stream using several different community metrics. The protocol (EPA 1989) was developed from compliance monitoring by the Vermont Department of Environmental Conservation in 1987 and discussions with other aquatic biologists. Metrics include taxa richness (ratio of study site to reference x 100), Hilsenhoff Biotic index (ratio of reference site to study site x 100), ratio of EPT and Chironomid abundances (ratio of study site to reference site x 100), % contribution of dominant taxon (scoring criteria evaluate actual percent contribution), EPT index (ratio of study site to reference x100), and community loss index (reference site taxa richness – taxa richness in common to both sites / study site taxa richness).

We completed the multimetric assessment of the macroinvertebrate communities for the fall 2011 season for each stream pair. We compared the upstream sections with the downstream sections using the six community metrics described above. When WEC-2 was compared with WEC-1, the downstream reach was considered not impaired. TB-2 was compared with the upstream section, TB-1, and was considered slightly impaired. HC-2 was compared with the upstream section, HC-1, and was considered slightly impaired (Table 5.14). Overall, the three downstream reaches of stream ranged from no impairment to slightly impaired. Generally scores attaining "slightly impaired" status or better are considered in attainment of designated uses. Therefore, the stream reaches assessed are in attainment of their Fishery Use based on the multimetric analysis.

Table 5.14. Summary of the macroinvertebrate multimetric assessment from War Eagle, Town Branch, and Holman Creek in the fall of 2011.

Community Metric	**WEC-1**	**WEC-2**	**TB-1**	**TB-2**	**HC-1**	**HC-2**
Taxa Richness	--	109.4	--	103.4	--	105.7
Hilsenhoff Biotic Index	--	105.9	--	103.5	--	93.0
EPT index	--	111.1	--	75.0	--	69.2
Community loss index	--	0.2	--	0.3	--	0.5
ratio of EPT and Chironomid abundance	140.2	449.3	245.3	308.7	164.9	1217.4
% Contribution of dominant taxa	24.8	33.6	19.5	38.8	17.5	27.7
Bioassessment Scores						
Taxa richness	6	6	6	6	6	6
Hilsenhoff Biotic Index	6	6	6	6	6	6
EPT index	6	6	6	2	6	0
Community loss index	6	6	6	6	6	4
Ratio of EPT and Chironomid abundance	6	6	6	6	6	6
% contribution of dominant taxa	4	2	6	2	6	4
Total Score	34	32	36	28	36	26
% Comparison to reference	94	89	100	78	100	72
Impairment Status	Reference	Nonimpaired	Reference	Slightly impaired	Reference	Slightly impaired

We completed the ADEQ multimetric assessment for each pair of streams' macroinvertebrate communities for the spring 2012 season. We compared the upstream reaches with the downstream reaches using the six community metrics described above. When WEC-2 was compared with WEC-1, the stream was considered not impaired. TB-2 was compared with the upstream reach, TB-1, and was considered slightly impaired. HC-2 was compared with the upstream reach, HC-1, and was considered slightly impaired (Table 5.15). The three downstream sections of stream ranged from no impairment to slightly impaired and are considered in attainment of their Fishery Use based on the multimetric analysis.

Table 5.15. Summary of the macroinvertebrate multimetric assessment from War Eagle, Town Branch, and Holman Creek in the spring of 2012.

Community Metric	**WEC-1**	**WEC-2**	**TB-1**	**TB-2**	**HC-1**	**HC-2**
Taxa Richness	--	110.0	--	80.0	--	113.3
Hilsenhoff Biotic Index	--	100.2	--	94.1	--	96.1
EPT index	--	84.6	--	60.0	--	92.9
Community loss index	--	0.2	--	0.4	--	0.1
ratio of EPT and Chironomid abundance	66.4	75.8	101.3	70.7	131.6	191.3
% Contribution of dominant taxa	34.8	28.4	24.6	18.6	21.4	22.9
Bioassessment Scores						
Taxa richness	6	6	6	4	6	6
Hilsenhoff Biotic Index	6	6	6	6	6	6
EPT index	6	4	6	0	6	6
Community loss index	6	6	6	6	6	6
Ratio of EPT and Chironomid abundance	4	6	6	4	6	6
% contribution of dominant taxa	2	4	4	6	4	4
Total Score	30	32	34	26	34	34
% Comparison to reference	83	89	94	72	94	94
Impairment Status	Reference	Nonimpaired	Reference	Slightly impaired	Reference	Nonimpaired

A summary of all macroinvertebrate metrics from fall 2011 is found in Table 5.16 and spring 2012 in Table 5.17. Based on the analysis of the macroinvertebrate community in each reach the following conclusions are provided:

1. A significant proportion of each downstream community was comprised of EPT taxa (>50% during the fall and >30% during the spring) which included 6-13 different taxa at each station.
2. Key metric scores at each station indicated that the downstream reaches (TB-2, HC-2 and WEC-2) during the fall have greater taxa richness, a higher proportion of the sensitive EPT taxa, and lower biotic Index scores.

3. The better performance of the macroinvertebrate community during the fall assessment, when background flow is lower and effluent percent higher, indicates that the point source discharge is not adversely affecting the biota.
4. All biometric and multimetric paired scoring systems achieved scores sufficient to make a determination of full attainment of the Fishery Use.

Table 5.16. Summary of macroinvertebrate metrics from War Eagle, Town Branch, and Holman Creek in the fall of 2011.

Parameter	**WEC-1**	**WEC-2**	**TB-1**	**TB-2**	**HC-1**	**HC-2**
COMMUNITY MEASURES						
Total number of Taxa (Richness)	32	35	29	30	35	37
EPT Richness	9	10	8	6	13	9
EPT % Abundance	52.4	65.1	59.0	67.7	47.1	56.6
Shannon-Weiner Diversity Index	2.07	2.41	2.46	2.07	2.6	2.51
PERCENTAGE OF DOMINANT ORDERS						
Gastropoda	1.8	5.9	0.3	1.0	0.6	10.5
Crustacea	0.6	0.3	0.3	0.2	7.0	0.4
Ephemeroptera	25.8	53.3	32.4	12.2	41.4	37.8
Odonata	1.2	1.3	3.8	3.5	1.3	3.6
Trichoptera	25.0	10.9	26.6	55.5	3.6	18.2
Coleoptera	3.5	6.9	8.9	4.0	12.4	18.0
Diptera	39.1	15.9	27.3	22.6	30.3	5.5
FUNCTIONAL FEEDING ASSEMBLAGE %						
Shredders	0.3	0.2	0.5	0.3	0.2	1.0
Scrapers	6.4	19.5	12.2	3.7	31.3	27.3
Filterers	27.7	16.4	28.1	56.5	4.3	20.0
Collectors	61.2	60.4	51.6	31.1	55.7	44.2
Predators	4.4	3.6	7.3	8.3	8.5	6.7
Biotic Index	7.18	6.78	6.47	6.25	5.81	6.25

Table 5.17. Summary of macroinvertebrate metrics from spring of 2012.

Parameter	WEC-1	WEC-2	TB-1	TB-2	HC-1	HC-2
COMMUNITY MEASURES						
Total number of Taxa (Richness)	30	33	30	24	30	34
EPT Richness	13	11	10	6	14	13
EPT % Abundance	33.9	32.8	42.9	33.3	48.1	55.5
Shannon-Weiner Diversity Index	2.31	2.60	2.29	2.48	2.27	2.14
PERCENTAGE OF DOMINANT ORDERS						
Annelia	1.1	1.8	0.9	10.1	0.7	1.0
Gastropoda	0.7	6.1	1.3	9.6	0.1	1.0
Ephemeroptera	21.6	23.2	17.9	10.8	37.2	27.2
Odonata	1.1	1.5	1.8	4.1	0.1	1.3
Plecoptera	2.9	3.1	0.1	0.0	5.6	1.1
Trichoptera	9.5	6.6	24.9	22.5	5.3	27.1
Coleoptera	2.4	3.7	3.4	1.8	4.4	3.3
Diptera	58.4	52.3	48.7	41.1	44.8	37.0
FUNCTIONAL FEEDING ASSEMBLAGE %						
Shredders	0.4	0.0	0.3	0.2	0.8	0.4
Scrapers	6.6	12.0	3.7	10.8	5.9	5.4
Filterers	17.6	17.7	31.6	26.4	12.2	35.8
Collectors	69.6	62.4	58.1	52.0	71.9	55.1
Predators	5.7	7.9	6.2	10.6	9.2	3.2
Biotic Index	6.91	6.89	6.86	7.29	6.34	6.60

5.5 Fish Community

The condition of the fish community (abundance, diversity, sensitivity, species present, etc.) is an indicator of the water quality and habitat quality of a water body. Monitoring the fish community is useful in assessing the fisheries use status of a water body and indicating potential perturbations to the system. Fish were collected from two sample reaches on three different streams with one upstream reach and one downstream reach (upstream and downstream from point source influence) during the fall of 2011. Reaches TB-1, WEC-1, and HC-1 are upstream of the City of Huntsville wastewater discharge influence. Reaches TB-2, WEC-2, and HC-2 are located downstream of the wastewater discharge influence.

A three-person crew of experienced field biologists conducted the sampling. The fish collections were made using a Smith-Root backpack electroshocker supplemented by seine hauls and/or block netting. The shocker is equipped with an automated timing mechanism which records the amount of time that electricity is actually being applied, or "pedal down time" (PDT). Fish community sampling was conducted prior to the collection of macroinvertebrate samples, habitat data, and all physiochemical parameters. Shocked fish were captured with hand held dip nets and held in buckets until the sampling was completed. The entire stream width within the sampling reach was sampled. Both PDT and the total collection time were recorded. The fish sampling was terminated when, in the opinion of the principal investigator, a representative collection had been obtained. Similar levels of effort in collection of fish were expended in all the study reaches. Sampling information was recorded on the Fish Community Collection Forms and general comments (perceived fishing efficiency, missed fish, and gear operation suggestions) were also recorded. A completed listing of fish collected at each station is presented in Appendix G.

At the end of each sampling reach effort, collected fish were preserved in formalin for later identification in the laboratory. Fish identifications were made according to the Fishes of Arkansas (Robinson, 1988) and The Fishes of Missouri (Pflieger, 1975) to species level. Several community metrics were then calculated to facilitate comparison of each downstream collection to the corresponding upstream reference sites (TB-1, HC-1, and WEC-1). The ADEQ ecoregion based community similarity index (CSI) was also calculated for each collection at the request of ADEQ. This index was developed by the ADEQ, based on years of ecoregion reference streams data and takes into consideration watershed size. The majority of the ADEQ data used to develop this index originates from perennial streams with watersheds greater than 20 mi^2. Therefore, smaller intermittent streams do not always score well with the CSI. For all stream reaches in this study, the Ozark Highland streams CSI was utilized.

5.5.1 Station TB-1

A total of 690 fish were collected during the 26.7 minute PDT sampling effort at the TB-1 station. This equates to a relative fish abundance of 25.4 fish/minute of PDT, the highest relative abundance of the study. The fish community had a taxa richness of 16 (Figure 5.14), one of the lowest of the study. Shannon-Wiener Diversity Index was 2.51, the lowest value of the study. The minnow family (Cyprinidae) had the highest taxa richness with 6 species. The sunfish (Centrarchidae) and minnow families were the dominant groups based on number of individuals and accounted for 81.4% and 7.4% of the total collection, respectively (Figure 5.15). Fish community trophic structure at TB-1 was dominated by herbivores (70.7%) and insectivores (26.5%) (Figure 5.16). Tolerance analysis of the fish community indicated that the community was dominated by pollution intermediate species at 50.0%, followed by species intolerant to perturbation at 45.2%, and pollution tolerant species at 4.8% (Figure 5.17). Table 5.18 provides fish community structure analysis that includes tolerance analysis for all stream reaches. The overall fish community condition at TB-1, as calculated using the ADEQ CSI for Ozark Highland streams, yielded a total score of 29 which is indicative of a "generally similar" fish community when compared to similar reference sites. Figure 5.18 illustrates fish CSI scores. At station TB-1, 49.9% of the total fish community was comprised of "Key and Indicator" species as defined by Arkansas Department of Environmental Quality (ADEQ) Regulation 2 for the Ozark Highlands Ecoregion. Figure 5.19 compares fish community "Key and Indicator" species at each station.

5.5.2 Station TB-2

The observed fish community at TB-2 included a total of 540 fish collected during the 28.4 minute PDT sampling effort. This equates to a relative fish abundance of 19.0 fish/minute of PDT. The fish community at TB-2 had a taxa richness of 16, the same as TB-1. Shannon-Wiener Diversity was 2.57. The minnow family had the highest taxa richness (6 species) and the highest percent of total individuals collected (76.5%), followed by sunfish accounting for 11.9%. The TB-2 fish community trophic structure was dominated by herbivores (66.1%) and insectivores (31.7%). The fish community was dominated by facultative species (intermediate in sensitivity, neither tolerant nor intolerant to perturbation) at 56.7%, followed by intolerant species (38.7%), and pollution tolerant species (4.6%). The overall fish community condition at TB-2 yielded a total score of 31 which indicates a "generally similar" to ecoregion reference sites. "Key and Indicator" species comprised 42.2% of the fish community at TB-2.

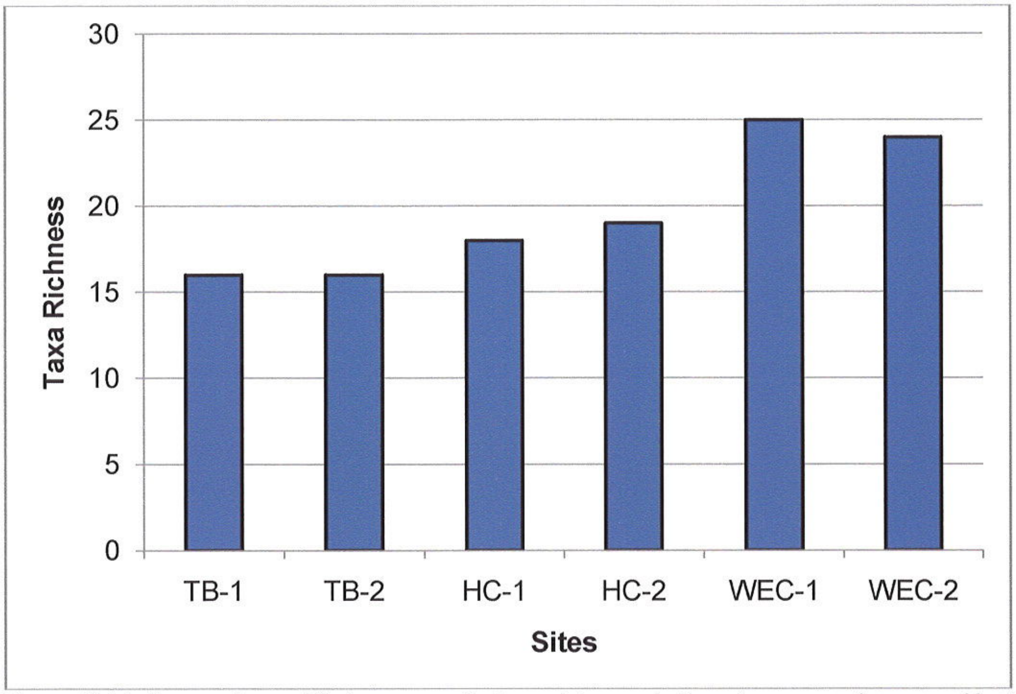


Figure 5.14. Comparison of fish community taxa richness in the stream reaches near Huntsville, AR.

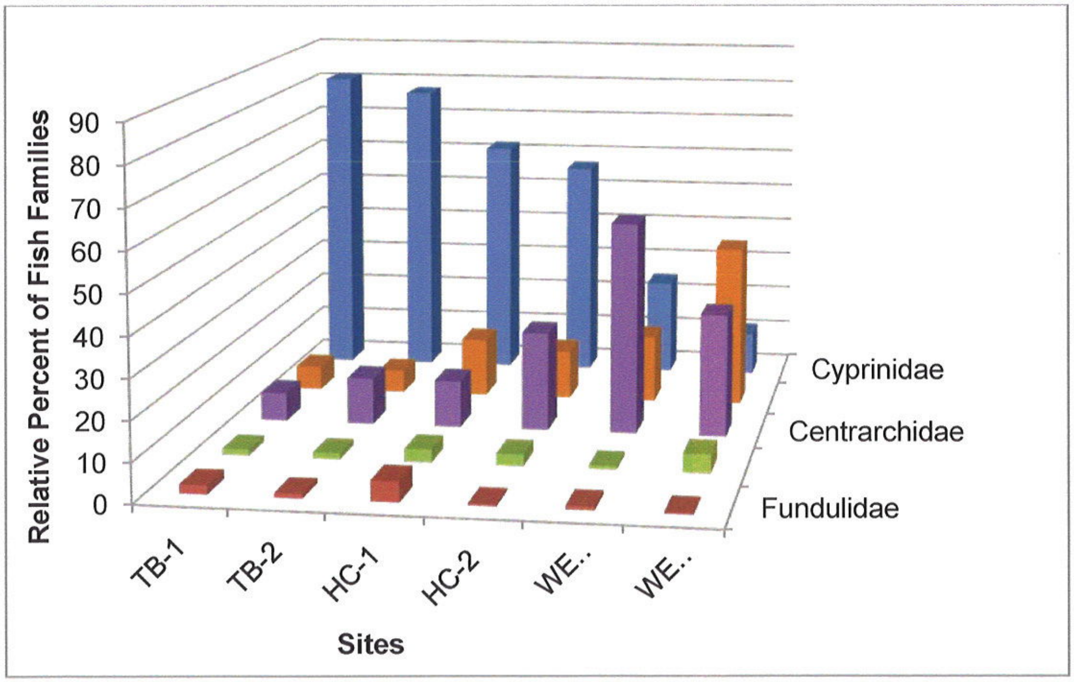


Figure 5.15 . Comparison of dominant fish families collected at each station near the City of Huntsville for fall 2011.

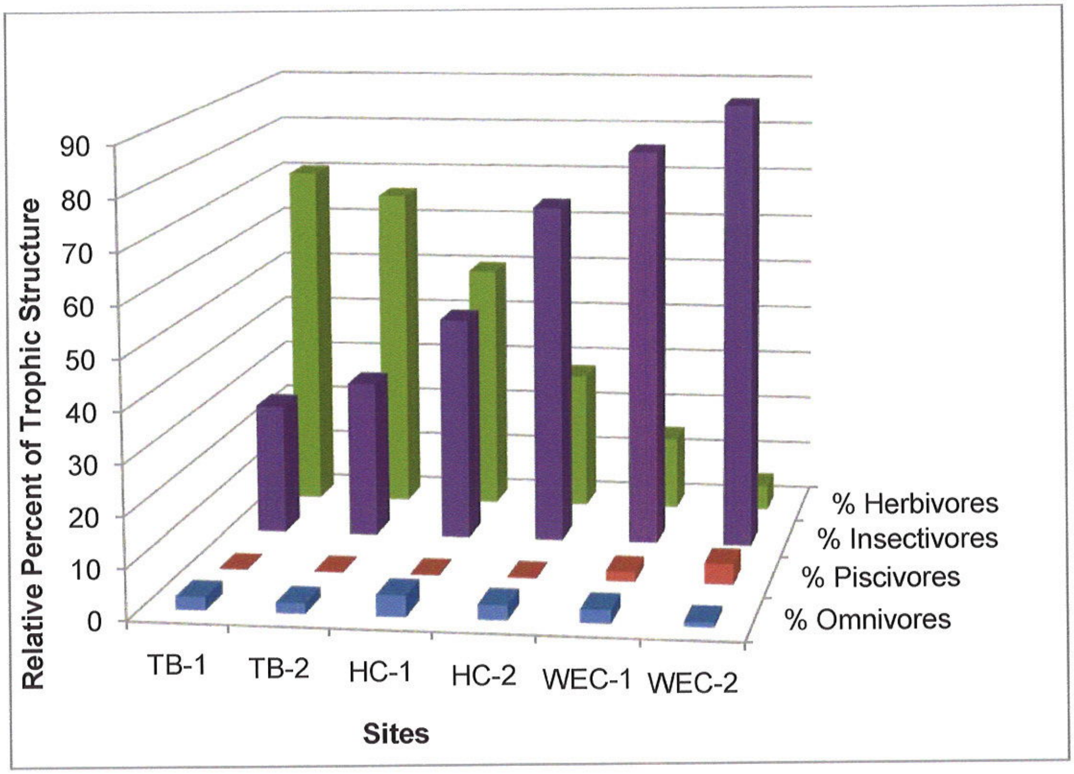


Figure 5.16. Comparisons of the community trophic structure in each stream reach near the City of Huntsville.

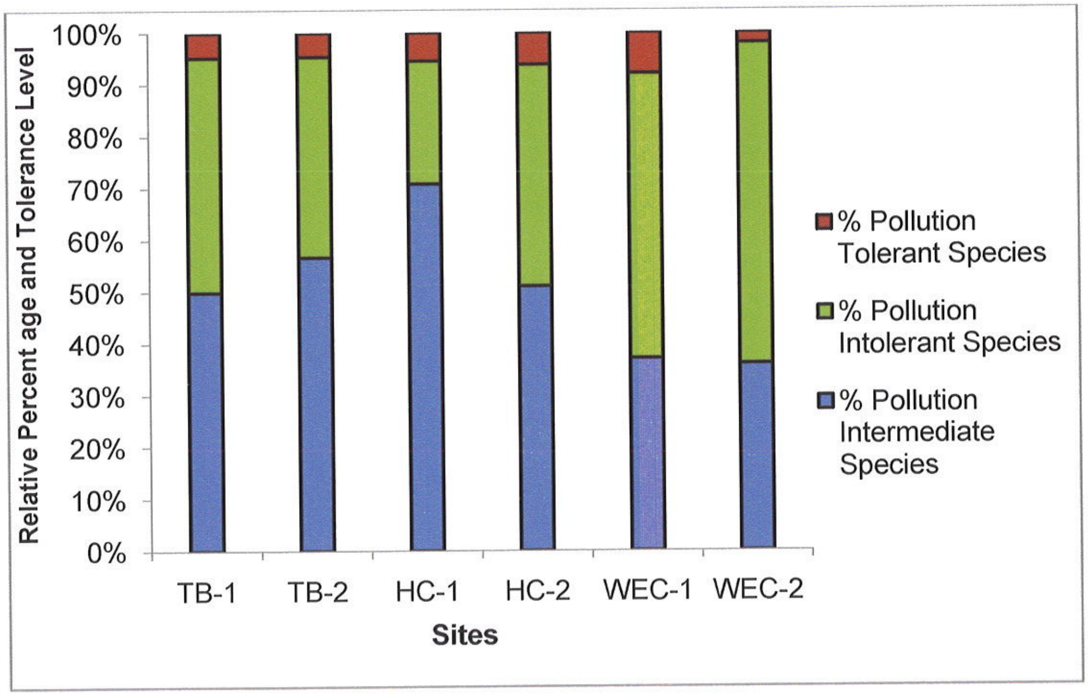


Figure 5.17. Comparison of percent composition of fish community tolerance to perturbation in the stream reaches near Huntsville, AR.

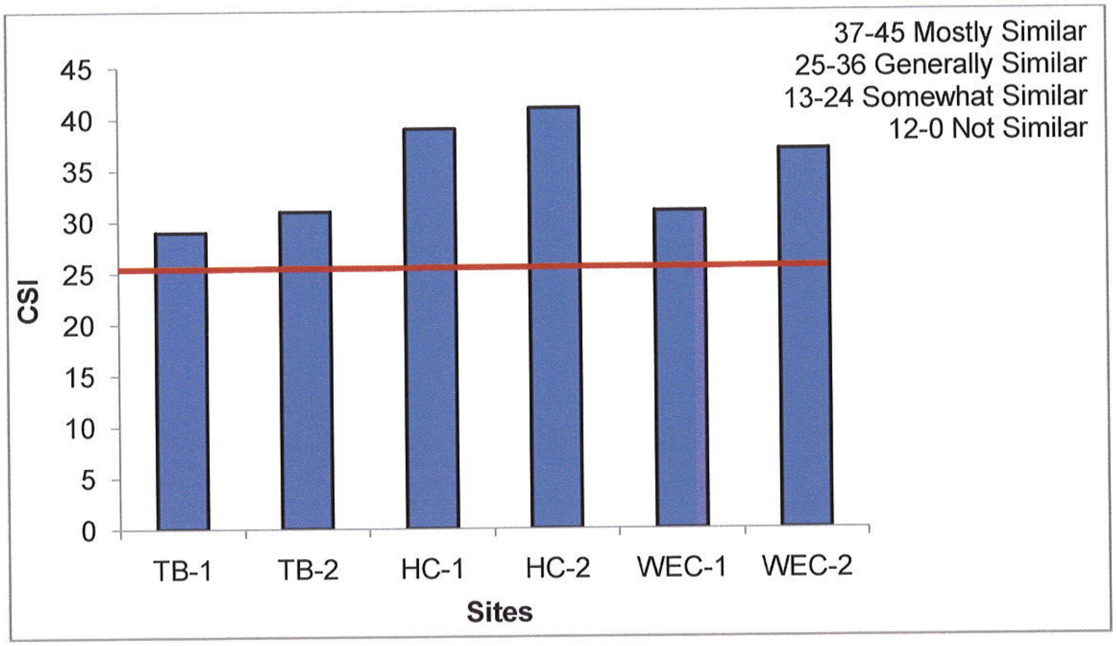


Figure 5.18. Summary of fish community similarity index at each stream reach near the City of Huntsville. Red line represents minimum biotic scores for support of Fisheries use.

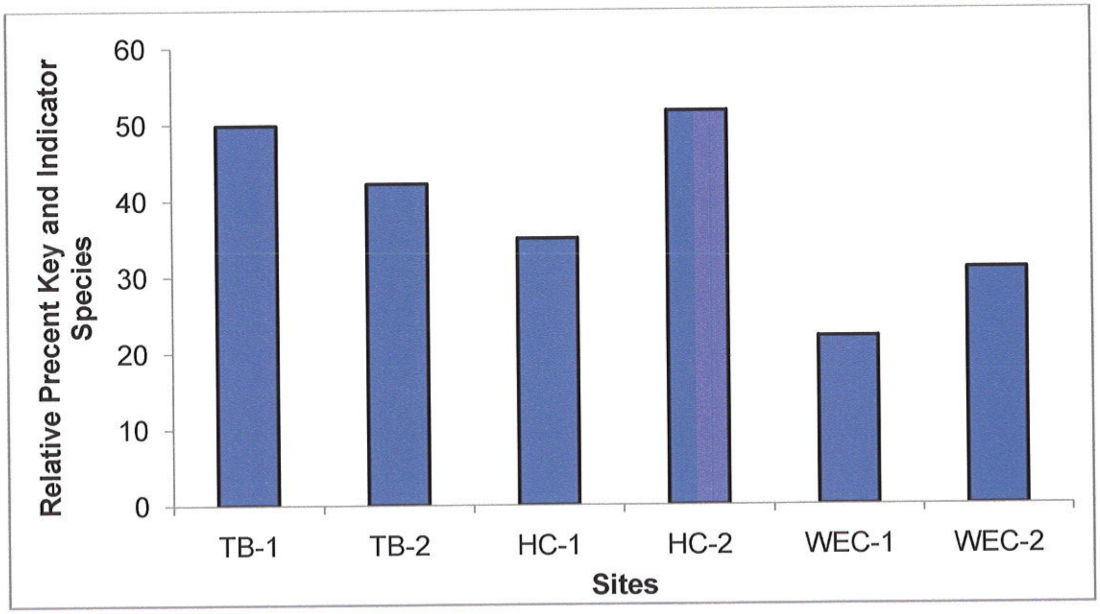


Figure 5.19. Percent of ecoregion "key and indicator" species collected from each stream reach near the city of Huntsville.

Table 5.18. Fish community analysis on Town Branch, Holman, and War Eagle Creek near the City of Huntsville for fall 2011.

Parameter	Station					
COMMUNITY MEASURES	**TB-1**	**TB-2**	**HC-1**	**HC-2**	**WEC-1**	**WEC-2**
Richness (Total Number of Taxa)	16	16	18	19	25	24
Darter Richness (Number of Taxa)	2	1	3	3	6	5
Sunfish Richness (Number of Taxa)	4	4	3	4	5	7
% Pollution Tolerant Species	4.8	4.6	5.4	6.1	7.9	2.1
% Pollution Intermediate Species	50.0	56.7	70.8	51.0	37.1	36.0
% Pollution Intolerant Species	45.2	38.7	23.8	42.6	55.0	61.9
% Diseased	0.0	0.0	0.0	0.0	0.0	0.0
Diversity Indices (Shannon-Wiener)	2.51	2.50	2.72	3.05	2.84	3.32
Abundance, fish collected/minute	25.4	18.7	15.9	13.4	16.8	11.9
Number of Key & Indicator Species Taxa	6	6	6	7	8	7
% Key & Indicator Species	49.9	41.2	32.1	51.7	19.2	20.4
Pedal down time (minutes)	26.7	28.4	24.5	30.4	25.4	24.7
TROPHIC STRUCTURE						
% Omnivores	2.6	2.0	4.2	2.9	2.6	0.9
% Piscivores	0.1	0.2	0.2	0.2	2.0	4.1
% Insectivores	26.5	31.7	45.3	68.9	80.4	90.0
% Herbivores	70.7	66.1	50.2	27.9	14.8	5.0
PERCENT OF 5 DOMINANT FAMILY GROUPS						
CYPRINIDAE	81.4	77.8	62.3	57.1	24.9	11.2
CATOSTOMIDAE	0.0	0.4	1.0	1.2	0.5	2.0
FUNDULIDAE	2.3	1.1	5.1	0.5	0.9	0.3
POECILIIDAE	0.0	0.0	0.0	0.0	0.2	0.0
COTTIDAE	1.0	1.3	1.0	0.0	0.5	8.2
ICTALURIDAE	1.6	1.5	3.3	2.9	0.9	4.8
CENTRARCHIDAE	7.4	12.1	12.1	25.5	54.5	31.6
PERCIDAE	6.2	5.8	15.1	12.7	17.4	41.8
PETROMYZONTIDAE	0.0	0.0	0.0	0.0	0.2	0.0
Total % of 5 Dominant Groups	99.0	98.5	97.9	99.5	98.6	97.6
FISH CSI	29	31	39	41	31	37

5.5.3 Station HC-1

A total of 408 fish were collected during the 24.5 minute PDT sampling effort at HC-1, equating to a relative fish abundance of 16.7 fish/minute of PDT. The fish community at HC-1 had a taxa richness of 18 and Shannon-Wiener Diversity was 2.84. The minnow family had the highest taxa richness (6 species), accounting for 64.0%, followed by the darter family (Percidae) at 14.5% of the total individuals collected at HC-1. The fish community trophic structure at HC-1 was dominated by herbivores accounting for 50.2% of the individuals collected, followed by insectivores at 45.3%. HC-1 was dominated by species with intermediate tolerance to perturbation at 70.8%, followed by species intolerant of perturbation (23.8%), and pollution tolerant species at 5.4%. The CSI at HC-1 yielded a total score of 39 which is indicative of a "mostly similar" fish community when compared to similar reference sites. "Key and Indicator" species comprised 35.0% of the fish community at HC-1.

5.5.4 Station HC-2

The observed fish community at HC-2 included a total of 408 fish collected during the 30.4 minute PDT sampling effort. This equates to a relative fish abundance of 13.4 fish/minute of PDT, the lowest relative abundance of the study. The fish community at HC-2 had a taxa richness of 19 and a Shannon-Wiener Diversity Index of 3.05. The minnow family had the highest taxa richness (7 species), and was also the dominate family accounting for 57.1% of total fishes collected. The sunfish family accounted for the second highest relative abundance of 25.5% for the total fish community. The HC-2 fish community trophic structure was dominated by insectivores accounting for 68.9% followed by herbivores at 27.9%. The fish community was dominated by intermediate pollution tolerant species at 51.0%, followed by species intolerant to perturbation at 42.6%, and pollution tolerant species at 6.1%. HC-2 had close to twice the relative abundance of species intolerant to perturbation than the upstream reach, HC-1. The CSI score of 41 indicates a 'generally similar' community at station HC-2, compared to similar reference sites. "Key and Indicator" species comprised 51.7% of the fish community at HC-2.

5.5.5 Station WEC-1

A total of 453 fish were collected during the 25.4 minute PDT sampling effort at the WEC-1 station. This equates to a relative fish abundance of 17.8 fish/minute of PDT. The fish community had a taxa richness of 25, the highest of the study and Shannon-Wiener Diversity was 3.02. Both the minnow and darter family had the highest taxa richness with 6 species in each family. The sunfish and minnow families were the dominant groups based on number of individuals and accounted for 51.2% and 27.4% of the total collection, respectively. Fish community trophic structure at WEC-1 was dominated by insectivores (80.4%) and herbivores (14.8%). Tolerance analysis of the fish community indicated that the community was dominated by species intolerant to perturbation at 55.0%, followed pollution intermediate species by at 37.1%, and pollution tolerant species at 7.9%. The overall fish community condition at WEC-1 yielded a total score of 31 which is indicative of a "generally similar" fish community, when compared to similar reference sites. At station WEC-1, 22.1% of the total fish community was comprised of "Key and Indicator" species, the lowest in the study.

5.5.6 Station WEC-2

A total of 339 fish were collected during the 24.7 minute PDT sampling effort at the WEC-2 station. This equates to a relative fish abundance of 13.7 fish/minute of PDT. The fish community had a taxa richness of 24 and Shannon-Wiener Diversity was 3.37, the highest of the study. Both the minnow and darter families had the highest taxa richness with 6 species in each family. The darter and sunfish families were the dominant groups based on number of individuals and accounted for 49.6% and 27.4% of the total collection, respectively. Fish community trophic structure at WEC-2 was dominated by insectivores (90.0%) and herbivores (5.0%). Tolerance analysis of the fish community indicated that the community was dominated by species intolerant to perturbation at 69.1%, followed pollution intermediate species at 36.0%, and pollution tolerant species at 2.1%. The overall fish community condition at WEC-2 yielded a total score of 37 which is indicative of a "mostly similar" fish community, when compared to similar reference sites. At station WEC-2, 24.7% of the total fish community was comprised of "Key and Indicator" species.

5.5.7 Summary

According to the CSI for Ozark Highland streams, fish communities at three of the study reaches were found to be 'generally similar' when compared to reference streams in that ecoregion (IBI 25-36). The other three stream reaches scored 'mostly similar' (IBI 37-45) when compared to the reference streams found in the Ozark Highland ecoregion. Both reaches at Town Branch Creek were 'mostly similar'. TB-2 had a slightly higher CSI score than the upstream reach, TB-1, because TB-2 had a higher relative abundance of the catfish family (Ictaluridae).The Ictaluridae metric in the CSI for Ozark Highland streams scores highest, 5, if a stream has moderate percentage (>2%) of catfish. The CSI gives a score of 3 if the Ictaluridae relative proportions are 1-2%, and give a score of 1 for <1% or >3% bullheads. The Ictaluridae percentage metric score was the only metric that TB-1 and TB-2 did not have in common, TB-2 scored a 5, and TB-1 scored a 3, giving TB-2 a slightly higher score.

Both reaches at Holman Creek were 'mostly similar'; the downstream reach scored higher than the upstream reach. HC-1 had fewer sensitive taxa than the downstream reach, which contributed to HC-1's lower CSI score. The only pair of stations to be in two different CSI categories was WEC-1 and WEC-2. WEC-2 had a higher CSI score because it had higher relative abundance of Ictaluridae and more key species than WEC-1. In general, all fish communities were dominated by species intolerant and intermediate to perturbation. Diversity of fish communities was highest at the War Eagle Creek but no reach scored below 2.5 which is above average for the range of Shannon-Weiner diversity index (range 0-4). The lowest diversity value was from TB-1 (2.51) just upstream of the City of Huntsville WWTP discharge. The smaller watershed size of Town Branch, and smaller stream size in general, are likely the reason for the lower diversity and richness in those reaches. Station WEC-1 had the highest species richness with 25 species, while stations TB-1 and TB-2 both had the lowest species richness of 16. The percent of "Key and Indicator" species was greatest at stations HC-2 (51.7%) and lowest at WEC-1 (22.1%).

Fish community trophic structure was split, half the sites (TB-1, TB-2, and HC-1) were dominated by herbivores and the other half (HC-2, WEC-1, and WEC-2) were dominated by insectivores. Herbivores followed insectivores in abundance or vice versa at all stations, comprising as much as 90.0% of the total fish community or as little as 5.0%. Fishes from the minnow family dominated the communities at TB-1 (81.4%), TB-2 (76.5%), HC-1 (64.0%), and HC-2 (57.1%), while station WEC-1 was dominated by individuals from the sunfish family (51.2%), and WEC-2 was dominated by the darter family (49.6%). Percidae and Centrarchidae relative proportions increased with larger watershed area, the highest numbers of darters and sunfish were found in the two War

Eagle Creek reaches. Cyprinidae relative proportions were highest in the smallest watershed stream, Town Branch, and lowest in the largest watershed stream, War Eagle Creek. Overall, the fish communities from each reach are healthy and representative of streams in full attainment of their Fisheries use. Raw fish numbers for all study reaches are provided in Table 5.19.

5.5.8 Conclusions

Based on the results of the fish collections, the following conclusions are provided:

1. The fish community at the downstream station was generally more diverse than its corresponding upstream reference station and had similar richness.
2. The fish communities at all stations were found to contain significant number of key and indicator taxa (6 or more) and a significant percent composition of ecoregion Key and Indicator Species as identified in Arkansas Regulation No. 2 (ADEQ 2011).
3. Sensitive darter species (greenside and rainbow) were found during the study at both upstream and downstream stations in Holman Creek and War Eagle Creek. War Eagle Creek also contained banded darters and yoke darters (both sensitive) at its upstream and downstream locations.
4. The aquatic life field study demonstrated that the designated Fishery use was being maintained at all study reaches as demonstrated by the dominance of intolerant and intermediate species.
5. The Fishery Use was also determined to be fully based on the ADEQ CSI, which shows that all stations were generally or mostly similar to Ecoregion Reference, and the downstream stations scored higher in every stream.

Table 5.19. Raw fish numbers for stations of the Town Branch, Holman Creek, and War Eagle Creek in fall 2011.

Scientific Name	Common Name	TB-1	TB-2	HC-1	HC-2	WEC-1	WEC-2
PETROMYZONTIDAE							
Ichthyomyzon spp.		0	0	0	0	1	0
CYPRINIDAE							
Campostoma anomalum	central stoneroller	237	219	176	49	47	12
Cyprinella whipplei	steelcolor shiner	0	1	0	17	25	5
Luxilus pilsbryi[1]	duskystripe shiner	35	39	39	87	16	5
Luxilus chrysocephalus	striped shiner	21	5	0	0	0	0
Notropis boops	bigeye shiner	0	0	0	2	4	0
Notropis atherinoides	emerald shiner	0	0	0	0	0	3
Notropis nubilis[2]	ozark minnow	251	138	20	65	20	5
Notropis telescopus	telescope shiner	0	0	0	1	0	0
Phoxinus erythrogster[2]	southern redbelly dace	0	0	9	0	0	0
Pimehpales notatus	bluntnose minnow	13	11	8	12	12	3
Semotilus atromaculatus	creek chub	5	0	9	0	0	0
CATOSTOMIDAE							
Hypentelium nigricans[1]	northern hog sucker	0	2	4	3	2	3
Moxostoma duquesnei	black redhorse	0	0	0	2	0	1
Moxostoma erythrurm	golden redhorse	0	0	0	0	0	2
FUNDULIDAE							
Fundulus olivaceus	blackspotted topminnow	0	0	2	2	4	1
Fundulus catenatus	northern studfish	16	6	18	0	0	0
POECILIIDAE							
Gambusia affinis	mosquitofish	0	0	0	0	1	0
ICTALURIDAE							
Noturus exilis[1]	slender madtom	8	10	12	7	1	0
Noturus albater[2]	ozark madtom	0	0	0	0	2	14
Ameiurus natalis	yellow bullhead	3	7	1	5	1	0
CENTRARCHIDAE							
Ambloplites constellatus[1]	ozark bass	0	0	0	1	3	4
Lepomis cyanellus	green sunfish	12	7	4	8	23	4
Lepomis gulosus	warmouth	0	0	0	0	0	2
Lepomis macrochirus	bluegill sunfish	1	3	0	1	1	3
Lepomis megalotis	longear sunfish	37	53	42	94	199	72
Micropterus salmoides	largemouth bass	0	0	1	0	0	1
Micropterus dolomieu[1]	smallmouth bass	1	1	0	0	0	0

Scientific Name	Common Name	TB-1	TB-2	HC-1	HC-2	WEC-1	WEC-2
Micropterus punctulatus	spotted bass	0	0	0	0	6	7
PERCIDAE							
Etheostoma blennioides	greenside darter	1	0	3	3	10	7
Etheostoma caeruleum[1]	rainbow darter	42	31	55	48	54	50
Etheostoma juliae	yoke darter	0	0	0	0	8	87
Etheostoma punctulatum	stippled darter	0	0	1	0	0	0
Etheostoma stigmaeum	speckled darter	0	0	0	0	3	2
Etheostoma zonale	banded darter	0	0	0	0	7	22
Percina caproides	Logperch	0	0	0	1	1	0
COTTIDAE							
Cottus carolinae[2]	banded sculpin	7	7	4	0	2	24
Total Fish Collected		690	540	408	408	453	339

[1] Ozark Highlands Ecoregion Key Species
[2] Ozark Highlands Ecoregion Indicator Species

6.0 WATERSHED DESCRIPTION

Town Branch and Holman Creek are part of the larger War Eagle Creek Watershed in Madison county north Arkansas. The entire watershed is approximately 200 square miles in size, with Holman Creek occupying 27 mi^2 and Town Branch 4.6 mi^2. War Eagle Creek is part of the Beaver Lake watershed which is a major water supply reservoir for North West Arkansas. Land use assessment was completed for the War Eagle Creek watershed using 2006 LULC data (USGS 2006). The War Eagle Creek watershed is dominated by forest (74%) and pasture (19%) land uses (Figure 6.1). A smaller but growing portion of the watershed is developed area (1.1%) which includes homes, business, schools, roadways, parking lots, etc. The majority of the development is in the Town Branch sub-watershed, which contains most of the City of Huntsville and is 28% developed land area, while the remainder of the city and surrounding sub-urban housing area is contained in the Holman Creek sub-watershed which has 10% developed land uses. A summary of the land uses in each sub-watershed is provided in Appendix H.

Soils in the watershed are dominated by Nixa-Clarksville-Noark and Enders-Leesburg in the upland areas and Cedar-Leadville-Cleora in the War Eagle Creek floodplain. The soils are mostly gravely loam or cherty silt loam with good drainage and land surface slopes vary from gently sloping to very steep. Soils in the flood plain of War Eagle Creek are gravelly sandy loam with flatter slopes.

War Eagle Creek has an 8 digit hydrologic unit code (HUC) of 11010001 and is in ADEQ planning segment 4K. A TMDL for nitrate was completed for Holman Creek in 2001, and it is now categorized as 4a on the 2008 Arkansas 303(d) list. Holman Creek currently appears on the Arkansas 2008 303(d) list for TDS (category 5a) with a listed cause of municipal point source. War Eagle Creek appears on the 2008 303(d) list for Beryllium (category 5d) with cause listed as unknown.

Two watershed management plans have been prepared for Beaver Lake that includes War Eagle Creek. The first plan was completed by the ANRC as part of their Watershed Management Strategy for non-point source priority watersheds in 2004 (ARNC 2004). The more recent plan, the Beaver Lake Watershed Protection Strategy (Tetra Tech, 2009) was completed for the Northwest Arkansas Council in 2009 (updated in 2012). Both plans seek to determine the major sources of point and non-point source pollution. The ANRC lists agricultural operations and rural roads (un-paved roads) as the leading sources of sediment and nutrient pollution in the watershed. The newer and more comprehensive Beaver Lake Watershed Protection Strategy lists stream channel erosion and pasture/agriculture as the two primary sources of sediment and nutrients. However, model projections into the future predict that the watershed in and around Huntsville will experience dramatic growth in development which will become the No.2 source of nutrients and sediments by 2055. Controlled growth through use of construction best management practices (BMP), stream riparian buffer zones, city good housekeeping practices and storm water BMP's in and around Huntsville will be key in preventing water quality degradation in the future, should the growth projections prove accurate.

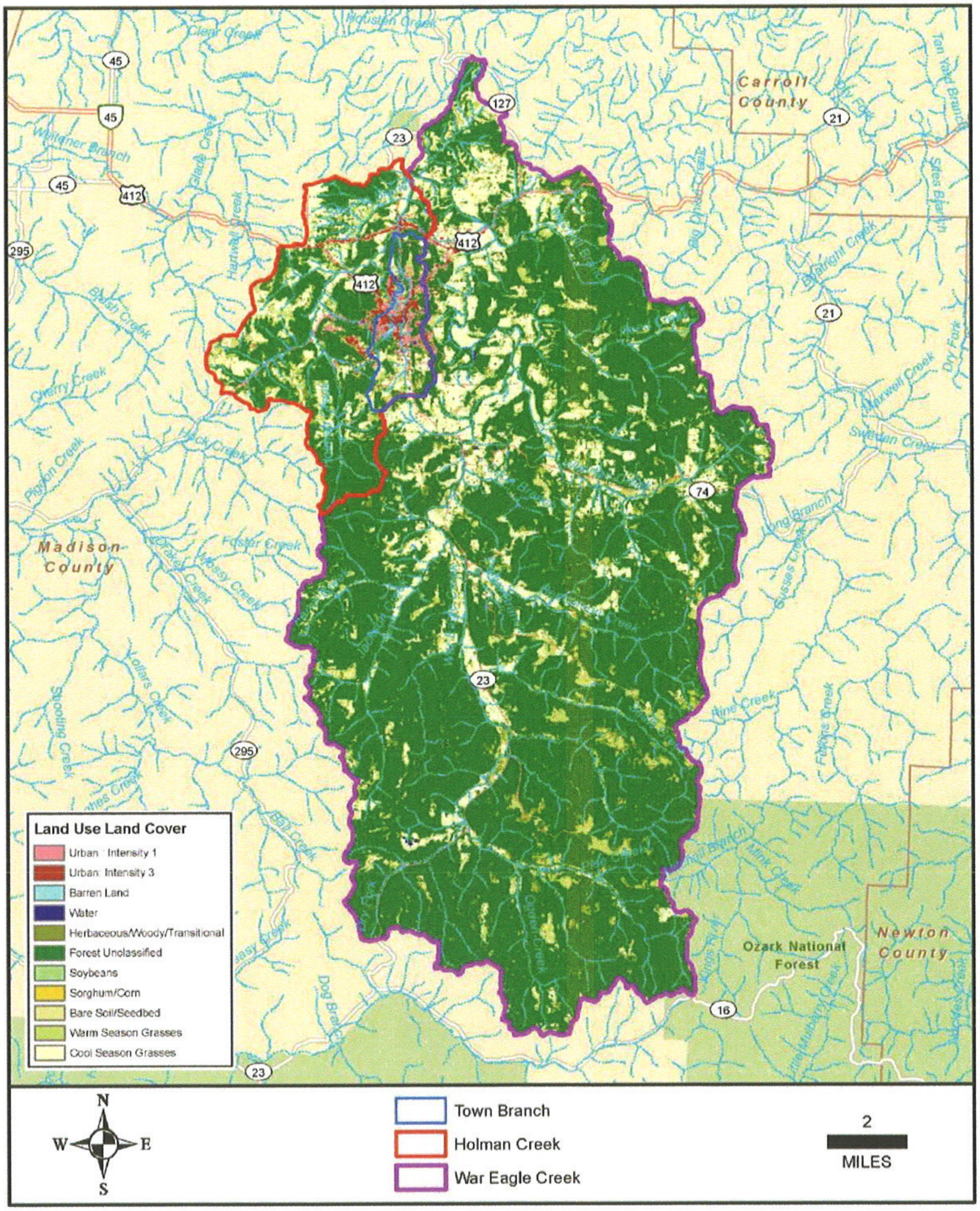


Figure 6.1. Land use and land cover map of War Eagle Creek watershed, including Holman Creek and Town Branch.

Cursory watershed and stream channel observations were made during this study, on each stream system, as part of the bioassessments. Observations indicate that stream bank erosion and cattle use of the stream riparian corridor are potentially significant sources of both sediment and nutrients to the watershed. Control of these sources could improve water quality, particularly in Holman Creek and War Eagle Creek. In addition, Town Branch runs through the center of Huntsville and appears to receive uncontrolled storm water runoff from impervious areas in town. This runoff will cause unusually high peak flows in the stream that will tend to degrade the channel and carry large sediment loads. Control of surface runoff near Town Branch through use of infiltration swales, bioretention and other storm water handling BMP's would benefit Town Branch's channel stability and water quality and could serve to increase baseflow during dry summer periods.

7.0 EXISTING LOADINGS OF DISSOLVED MINERALS

7.1 Chloride, TDS and Sulfate Water Quality Criteria

Calculation of site specific criteria for chloride, TDS and sulfate requires knowledge of regulatory background flow and concentrations, and effluent flow and concentration data. In this situation the City of Huntsville WWTF effluent is the only discharge to Town Branch, therefore the City's effluent and upstream flow and background concentration are considered in the calculations. Additional scenarios were developed for Holman Creek and War Eagle Creek which receive the WWTF effluent further downstream.

7.2 Mass Balance

The following mass balance equations were used to calculate site specific criteria concentrations (SSC) for chloride, TDS, and sulfate:

For Town Branch (downstream from the City of Huntsville WWTP discharge), Holman Creek (downstream of the confluence with Town Branch) and War Eagle Creek (downstream of the confluence with Holman Creek) calculation of the site specific criteria is as follows:

$$SSC = [(Qb \times Cb) + (Qe \times Ce) / (Qb + Qe)$$

Where:

Qb = The background flow of the receiving stream (4.0 cfs)

Cb = The background concentration of chloride, sulfate or TDS in the receiving stream (ecoregion background values)

Qe = The discharge (design) flow of the City of Huntsville WWTF

Ce = The effluent concentrations of chloride, sulfate or TDS from the City of Huntsville WWTF (estimated 95th percentile from data obtained during this study and from DMR data)

7.2.1 Methods

The procedure for evaluating instream concentrations and developing permit limits for dissolved minerals can be found in *ADEQ Discharge Permit, Toxic Control Implementation Procedure* in Arkansas' 1995 Continuing Planning Process (CPP). The values used for the background concentration are chloride (6 mg/L) and TDS (143 mg/L) in accordance with the CPP in Appendix D, *Mineral Implementation Policy*, for streams in the Ozark Highlands with a 7Q10 flow rate of less than 100 cfs. A background flow of 4 cfs was used in each stream, as allowed for determining instream mineral concentrations in the WQS. As stated in Appendix D of the referenced CPP, the critical flow of 4.0 cfs "provides for maintenance of the ecoregion mineral standard in all perennial fishery streams 50 percent of the time or more." The background flow for each calculation (for all three streams) was 4 cfs, i.e., the flows were not added together, so 4.0 cfs rather than 12 cfs upstream flow was used for the War Eagle Creek calculations. Use of 4.0 cfs is also consistent with the Reg 2 definition of critical flow as used for minerals criteria implementation. The City of Huntsville WWTF Outfall 001 effluent concentrations for chloride, TDS, and sulfate were derived from DMR data collected by City personnel during the study period and data collected during the monthly field sampling trips conducted during the period (7/6/2011 through 6/27/2012). The effluent data from the City of Huntsville WWTF were checked for normality, transformed if needed and 95th and 99th percentile values for chloride TDS, and sulfate calculated. Procedures used in the effluent data percentile calculation process are provided in Appendix C. The resulting percentile values are provided in Table 7.1.

Table 7.1. Quantiles of effluent data.

	Percentile Value		
Percentile	**TDS (mg/L)**	**Chloride (mg/L)**	**Sulfate(mg/L)**
99th	1300	590	93
95th	1019	416	87

The process generally utilized to establish minerals site specific criteria uses the 99th percentile of the effluent data to back calculate the new instream standards. To afford additional conservatism, the lower 95th percentile was utilized to calculate the site specific criteria for minerals in each of the three streams, Town Branch, Holman Creek, and War Eagle Creek.

7.2.2 Calculations for Town Branch.

The calculations used to determine the site specific criteria (SSC) for Town Branch, immediately below the Huntsville WWTF are as follows:

$SSC_{chloride}$=
[(4 cfs x 6 mg/L) + (3.1 cfs x 416 mg/L) /(4 cfs + 3.1 cfs)] = 185 mg/L

SSC_{TDS}=
[(4 cfs x 143 mg/L) + (3.1 cfs x 1019 mg/L) /(4 cfs + 3.1 cfs)] = 525 mg/L

$SSC_{sulfate}$=
[(4 cfs x 6 mg/L) + (3.1 cfs x 87 mg/L) /(4 cfs + 3.1 cfs)] = 41 mg/L

Values used in the calculation process for the determination of the site specific criteria for Town Branch are shown in Table 7.2.

Table 7.2. Calculation values, and the recommended site specific criteria for Town Branch.

Parameters	Chloride	TDS	Sulfate
Qb, cfs	4.0	4.0	4.0
Cb, mg/L	6.0	143.0	6.0
Qe, cfs	3.1	3.1	3.1
Ce, mg/L	416	1019	87
Site Specific Criteria (mg/L)	185	525	41

7.2.3 Calculations for Holman Creek

The calculations used to determine the SSC for
Holman Creek, below the confluence with Town Branch are as follows:

$SSC_{chloride}=$
[(4 cfs x 6 mg/L) + (3.1 cfs x 416 mg/L) /(4 cfs + 3.1 cfs)] = 185 mg/L

$SSC_{TDS}=$
[(4 cfs x 143 mg/L) + (3.1 cfs x 1019 mg/L) /(4 cfs + 3.1 cfs)] = 525 mg/L

$SSC_{sulfate}=$
[(4 cfs x 6 mg/L) + (3.1 cfs x 87 mg/L) /(4 cfs + 3.1 cfs)] = 41 mg/L

Values used in the calculation process for the determination of the site specific criteria for Holman Creek were as shown in Table 7.3.

Table 7.3. Calculation values, and the recommended site specific criteria for Holman Creek.

Parameters	Chloride	TDS	Sulfate
Qb, cfs	4.0	4.0	4.0
Cb, mg/L	6.0	143.0	6.0
Qe, cfs	3.1	3.1	3.1
Ce, mg/L	416	1019	87
Site Specific Criteria (mg/L)	185	525	41

7.2.4 Calculations for War Eagle Creek

The calculations used to determine the site specific criteria for War Eagle Creek are as follows:

$SSC_{chloride}=$
[(4 cfs x 6 mg/L) + (3.1 cfs x 416 mg/L) /(4 cfs + 3.1 cfs)] = 185 mg/L

$SSC_{TDS}=$
[(4 cfs x 143 mg/L) + (3.1 cfs x 1019 mg/L) /(4 cfs + 3.1 cfs)] = 525 mg/L

$SSC_{sulfate}=$
[(4 cfs x 6 mg/L) + (3.1 cfs x 87 mg/L) /(4 cfs + 3.1 cfs)] = 41 mg/L

Values used in the calculation process for the determination of the site specific criteria for War Eagle Creek were as shown in Table 7.4.

Table 7.4. Calculation values, and the recommended site specific criteria for War Eagle Creek.

Parameters	Chloride	TDS	Sulfate
Qb, cfs	4.0	4.0	4.0
Cb, mg/L	6.0	143.0	6.0
Qe, cfs	3.1	3.1	3.1
Ce, mg/L	416	1019	87
Site Specific Criteria (mg/L)	185	525	41

The site specific criteria determined through the calculation process were then compared with the existing criteria. Table 7.5 provides this comparison.

Table 7.5. Comparison of proposed site specific criteria amendments and existing criteria for each stream.

Town Branch from Point of Discharge of Huntsville WWTP downstream to the confluence with Holman Creek			**Holman Creek from the confluence with Town Branch downstream to the confluence with War Eagle Creek**			**War Eagle Creek from the confluence with Holman Creek downstream to Beaver Lake**		
Site Specific Criteria Proposed			**Site Specific Criteria Proposed**			**Site Specific Criteria Proposed**		
Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)
185	525	41	185	525	41	185	525	41
Calculated Ecoregion Reference Stream Values								
Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)
17.3	250	22.7	17.3	250	22.7	17.3	250	22.7

7.3 Drinking Water Use Water Quality Criteria

7.3.1 Drinking Water Use Removal

Fisheries uses are not the only use that drives minerals implementation (permitting) in Arkansas. In Arkansas the Domestic Water Supply use contains EPA's secondary drinking water recommendations for chloride, sulfate, and TDS. According to the Arkansas WQS (Reg. 2.511) and the Arkansas CPP (Appendix D) the Domestic Water Supply use applies at the critical flow (7Q10) with chloride, sulfate, and TDS, criteria of 250 mg/l, 250 mg/L and 500 mg/l, respectively.

Town Branch and Holman Creek are small (watershed sizes less than 30mi^2) un-gauged streams and assumed to have a 7Q10 of 0 cfs. At this flow level the Domestic Water Supply use criteria become the permit limits at the end of pipe. Under this scenario the Domestic Water Supply use criteria are the more restrictive. Town Branch and Holman Creek are small streams (3rd order or smaller) and are intermittent in nature. These streams do not have existing drinking water uses, and do not contain adequate volumes of water to be utilized in the future for such purposes. Therefore, it is recommended and requested that the Domestic Water Supply use be removed from Town Branch and Holman Creek. In fulfillment of this request, the Domestic Water Supply use criteria would no longer apply and the proposed SSC presented in Table 7.4 will apply.

War Eagle Creek is a much larger stream than Holman Creek or Town Branch. It has a watershed size of approximately 200 square miles at the confluence of Holman Creek, nearly an order of magnitude larger than Holman Creek, and is a gauged stream with a USGS station (No.07049000) located near Hindsville, Arkansas. The 7Q10 of War Eagle Creek was calculated using data from this gauging station. The station has a discontinuous period of record. Data exists for 1952-1970 and then a break in the data occurs until 1999, when it picks up again. The period of record used for the 7Q10 analysis was the newer data ranging from 1999-2012. Pearson Log III methodology was utilized for the calculation of the 7Q10. A detailed description of the 7Q10 analysis is provided in Appendix I. The resulting 7Q10 value for War Eagle Creek, at the Hindsville station, is 9.5 cfs.

7.3.2 Mass Balance Evaluation of War Eagle Creek

The calculated 7Q10 value of 9.5 cfs for War Eagle Creek at Hindsville was then applied to a mass balance calculation to determine the instream concentration of minerals at this critical flow level. The same discharge flow and background mineral levels used in determination of the SSC were utilized for this mass balance evaluation, to determine if the proposed 95th percentile values of the SSC would meet the Domestic Water Supply Use criteria of 250 mg/L chloride, 500 mg/L TDS, and 250 mg/L sulfate in War Eagle Creek at Hindsville, where the gauge is located. The mass balance calculations are as follows:

Chloride =
[(9.5 cfs x 6 mg/L) + (3.1 cfs x 416 mg/L) /(9.5 cfs + 3.1 cfs)] = 107 mg/L < 250 mg/L

TDS =
[(9.5 cfs x 143 mg/L) + (3.1 cfs x 1019 mg/L) /(9.5 cfs + 3.1 cfs)] = 359 mg/L < 500 mg/L

Sulfate =
[(9.5 cfs x 6 mg/L) + (3.1 cfs x 87 mg/L) /(9.5 cfs + 3.1 cfs)] = 26 mg/L < 250 mg/L

The resulting instream concentration of minerals, at the proposed levels, result in values considerably less than the Domestic Water Supply criteria. Therefore, it is not necessary to remove any drinking water uses from War Eagle Creek downstream of Hindsville. To evaluate the section of War Eagle Creek between Hindsville and the confluence with Holman Creek, flow in War Eagle Creek at the confluence of Holman Creek was estimated using a watershed size based methodology. The watershed size of War Eagle Creek at Hindsville is 263 mi2 and it has a 7Q10 of 9.5 cfs at that location. The 9.5 cfs equates to 0.036 cfs/square mile of watershed area. The watershed area of War Eagle Creek at the confluence of Holman Creek is 200 mi2 which equates to a 7Q10 flow of 7.2 cfs (200 mi2*0.036 cfs). The mass balance calculations using this 7Q10 flow are as follows:

Chloride =
[(7.2 cfs x 6 mg/L) + (3.1 cfs x 416 mg/L) /(7.2 cfs + 3.1 cfs)] = 130 mg/L < 250 mg/L

TDS =
[(7.2 cfs x 143 mg/L) + (3.1 cfs x 1019 mg/L) /(7.2 cfs + 3.1 cfs)] = 407 mg/L < 500 mg/L

Sulfate =
[(7.2 cfs x 6 mg/L) + (3.1 cfs x 87 mg/L) /(7.2 cfs + 3.1 cfs)] = 30 mg/L < 250 mg/L

The resulting instream concentration of minerals, at the proposed levels, result in values less than the Domestic Water Supply Use criteria. Therefore, it is not necessary to remove the Domestic Water Supply Use from any section of War Eagle Creek in the study area.

8.0 ALTERNATIVE ANALYSES

This section summarizes the analyses of alternatives for the Huntsville WWTF to meet projected water quality based effluent projected limitations for chloride, sulfate, and TDS. Current discharge concentrations of chloride, TDS and sulfate would not be anticipated to maintain the projected water quality based effluent limits that would likely be assigned during the next permit renewal. In addition to examining the development of site specific criteria, alternatives to amending the water quality criteria were considered.

The primary source of dissolved minerals discharged from the WWTP is from an industrial discharger to the system, the Butterball LLC turkey processing facility. Butterball owns and operates a turkey processing facility in the City of Huntsville, located at 1294 N. College Street. Effluent from the Butterball facility makes up approximately 80% of the total volume of wastewater received by and treated at the City's WWTF. Butterball contributes the majority of the chloride and

TDS loads that are ultimately discharged by the WWTF. However, the recent increase in sulfate levels discharged by the Huntsville WWTF is believed to be the result of aluminum sulfate additions by the WWTF which have recently been implemented to meet new (June 2011) discharge limits for total phosphorus.

Alternatives were examined to determine if the projected water quality based permit limits for chloride, TDS and sulfate could be met by the City of Huntsville without amending the water quality criteria. These alternatives were as follows:

1) no action,
2) no discharge, or removal of the industrial source,
3) treatment,
4) source reduction/pollution prevention,
5) Water Quality Standards modification.

8.1 No Action

No action would maintain the current discharge situation. The projected limits for chloride, and TDS in the next revision of the Huntsville's NPDES permit would be expected to be exceeded the first month of their effective date and put the City of Huntsville in a non-compliance situation. Non-compliance with the projected permit limits is not an acceptable alternative for the City or ADEQ.

8.2 No Discharge, or Removal of the Industrial Source

The no discharge alternative is not a feasible option for the City under any circumstance. It is anticipated that removal of the discharge from the Butterball Turkey Processing Facility would substantially reduce loads of TDS and chloride and would likely allow compliance with projected permit limits for TDS and chloride. In order to cease discharge the Butterball Facility would either have to cease operations in Huntsville, or obtain an NPDES permit to discharge directly, which would only serve to transfer the minerals issues to a different permittee.

8.3 Treatment

EPA has no Best Available Technology (BAT) for removal of chloride, sulfate, or TDS from waste streams. While ion exchange and reverse osmosis treatment technologies exist, these methods currently are not cost effective on a large scale and are not typically recommended for treatment of waters prior to discharge. Also, the concentrated reject streams generated from such processes present their own unique set of potential environmental risks.

The technical limitations and uncertain environmental effects of concentrated waste streams generated from ion exchange and reverse osmosis treatment make the treatment alternative infeasible when other alternatives are considered.

Despite these limitations, the City of Huntsville and Butterball have investigated the capital and annual operating costs to install advanced treatment for reduction of dissolved minerals in the effluent coming from the turkey processing plant. Specifically, the treatment process includes ultra-filtration, reverse osmosis, and concentration/crystallization of the facility effluent in addition to ancillary storage and equipment. Information on the treatment system cost estimates are provided in Appendix J.

The estimated capital cost ($30.1 million) and annual operating cost ($4.6 million) would be overly burdensome and place the facility at a significant competitive disadvantage. These costs would jeopardize the continued operation of the Butterball Facility, the largest employer in Madison County. The consequence of the loss of the Butterball Facility would likely prove to be disastrous for the City of Huntsville, Madison County and the surrounding northwest Arkansas community. This region relies heavily on the economic impact of the Butterball facility. The facility employs almost 700 citizens and provides them an annual payroll of more than $22,000,000. It also acts as a critical client/customer to a number of local businesses and pays more than $138,000 in local property taxes.

8.4 Source Reduction/Pollution Prevention

Butterball owns and operates a turkey processing facility in the City of Huntsville, located at 1294 N. College Street. Effluent from the Butterball facility makes up approximately 80% of the total volume of wastewater received by and treated at the City's WWTF. Butterball contributes the majority of the chloride and TDS that is ultimately discharged by the WWTF. As such, source reduction/pollution prevention efforts were focused on the Butterball facility.

One alternative evaluated is discontinued use Butterballs existing freeze system, which uses a salt water solution. After evaluating, Butterball determined that it would cost approximately $18 million dollars to replace the current system with a blast system. However, based on calculations performed, it is estimated that TDS would be minimally reduced.

Butterball has implemented best management practices designed to find, capture, and eliminate where possible, drips and spills of water high in TDS and chloride. Examples of practices include:

- Daily system inspection is performed to find system leaks and spills.
- The Butterball maintenance program is continuous and designed to be preventative, e.g., to identify potential sources of leaks or spills prior to their occurrence.
- Butterball has also undertaken engineering studies to determine cost and feasibility for chloride and TDS reduction. Results to date suggest that only very minor reduction would be possible.

Source reduction and pollution prevention activities would not be sufficient to reduce average concentrations of chloride and TDS, although it is possible that maximum concentrations could be reduced by some, likely small, amount.

Reduction in sulfate levels could be achieved by a reduction in the amount of aluminum sulfate added in the wastewater treatment process. However, total phosphorus permit limits decreased even further in June 2012 so a reduction in usage of aluminum sulfate is not a potential occurrence because the reduction would not allow the City to remain compliant with the total phosphorus limit.

8.5 WQS Modifications

Amendment of the water quality standards is considered a viable option. The purpose of this study was to collect data sufficient to evaluate the merit of deriving site specific criteria, and to derive those criteria if warranted. Water quality standards amendment, pursuant to Regulation 2.306, was selected as the appropriate option.

9.0 USGS DISSOLVED MINERALS MODELING

The United States Geological Survey (USGS) completed a modeling study of the Beaver Lake watershed (USGS, 2012) to determine the potential effect on lake water quality of increasing dissolved minerals in the two primary drainages that carry treated wastewater from the cities of Fayetteville and Huntsville. Fayetteville discharges treated wastewater into the White River upstream of Beaver Lake and Huntsville discharges treated wastewater into Town Branch Creek which runs into Holman Creek to War Eagle Creek and then into Beaver Lake.

The USGS utilized the Corps of Engineers model CE-Qual-W2 to complete the modeling. The model was set-up to represent the lake and each main tributary as a series of interconnected longitudinal segments. The model also included vertical segmentation to allow water quality near the bottom of the lake and near the surface to be independently evaluated. Water quality monitoring data from multiple samples and sample locations in the main tributaries and the lake were collected between 2006 and 2010 and used to calibrate the model. Model calibration to actual measured water quality values helps ensure the models predictions are consistent with actual real world water quality in Beaver Lake and its tributaries.

Once calibrated the model was used to predict the effect in Beaver Lake of increasing dissolved mineral levels in each of the two primary tributaries (White River and War Eagle Creek) by a factor of 1.2, 1.5, 2.0, 5.0 and 10.0. This was accomplished by taking the average annual load from the nearest monitoring station to the lake in each respective tributary and calculating a daily average flow and concentration for that site. The daily average concentration could then be multiplied by each factor to increase the load of minerals entering the lake. For War Eagle Creek the monitoring station at Hindsville (Station S3) was used.

The result of these factorial increases, both in the main lake and in the arm of each tributary, was an increase in mineral levels with each factorial increase. However, the first three tiers of increases (1.2, 1.5 and 2.0) resulted in only minor increases in the lake arm. These increase factors are those most reasonable for use in evaluating the impact of mineral levels from the WWTPs in the watershed, as anything more than a two fold increase in loads from the WWTPs would be extraordinary. For War Eagle Creek, the baseline median TDS level in segment 48 (in the War Eagle Creek arm of the tributary) was 95 mg/L, and a doubling of the mineral levels in War Eagle Creek (at the Hindsville station) only increased this median level to 133 mg/L. Considering that the Huntsville WWTP effluent is only about 5% of the load of minerals in War Eagle Creek at Hindsville, the effect from a two fold increase in WWTP mineral loading would be less than 2 mg/L change, and therefore, negligible. The USGS study serves to prove that the requested change to the Arkansas WQS for TDS and chloride will have insignificant to no effect on the dissolved minerals concentration of Beaver Lake. A copy of the USGS Report is included in Appendix K.

10.0 SELECTED ALTERNATIVE

Based on the facility biomonitoring record, the results of the aquatic life field study, the mass balance modeling, toxicity modeling, the USGS modeling effort, and the assessment of alternatives presented previously, the selected alternative is to modify the WQS using site specific criteria for chloride, TDS and sulfate as presented in the Table 10.1.

Table 10.1. Site Specific Criteria Recommendations.

Town Branch from Point of Discharge of Huntsville WWTP downstream to the confluence with Holman Creek			**Holman Creek from the confluence with Town Branch downstream to the confluence with War Eagle Creek**			**War Eagle Creek from the confluence with Holman Creek downstream to Beaver Lake**		
Site Specific Criteria Proposed			**Site Specific Criteria Proposed**			**Site Specific Criteria Proposed**		
Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)
185	525	41	185	525	41	185	525	41

11.0 REFERENCES

ADEQ 1987. Physical, Chemical, and Biological Characteristics of Least Disturbed Reference streams in Arkansas Ecoregions.

ADEQ 2011. Regulation No. 2, As Amended: Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas, September 2011 (Regulation No. 2).

ADEQ 1995. State of Arkansas Continuing Planning Process, Update and Revisions, January 1995. ADEQ Water Division.

ADEQ 2000. State of Arkansas Continuing Planning Process, Update and Revisions, 2000. ADEQ Water Division.

ADEQ 2012. The 2012 Integrated Water Quality Monitoring and Assessment Report, December 2011. ADEQ Water Division.

Allan, J.D. 1995. Stream ecology: Structure and function of running waters. Kluwer Academic Publishers, Netherlands.

ANRC 2004. Upper White River Watershed – Watershed Management Strategy

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Gilbert 1987. Methods for Environmental Pollution Monitoring.

Pflieger, W. L., 1975. The Fishes of Missouri. Missouri Department of Conservation. 343 pp.

Merritt R. et. al. 2008. An Introduction to the Aquatic Insects of North America. Kendall Hunt, fourth edition.

MDNR 2011. Standard Operating Procedures, Taxonomic Levels for Macroinvertebrate Identification. MDNR-ESP-209.

Robison, H. W. and T. M. Buchanan, 1988. Fishes of Arkansas. University of Arkansas Press. 536 pp.

Sarver, et.al. 2002. Biological Criteria for Wadeable/Perennial Streams of Missouri. MDNR

Shackleford 1988. Rapid Bioassessments of Lotic Macroinvertebrate Communities: Biocriteria Development B. Shackleford, ADEQ Water Division, 1988. 45 p.

Tetra Tech 2009. Beaver Lake Watershed Protection Strategy. Tetra Tech, Research Triangle Park, NC.

USGS 2006. Land Use Land Cover Data. U.S. Geological Survey, United States Department of the Interior.

USGS 2010. Ambient Conditions of Dissolved Solids, Chloride, and Sulfate, and Fate and Transport Simulations in Beaver Lake, Arkansas, 2006-2010 (Draft)

Appendix A

DMR Data

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

Environmental Services Co., Inc.
1107 Century
Springdale, AR 72762

pproved
o. 2040-0004

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740
FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740
ATTN: LARRY GARRETT, DIRECTOR

7/2011

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

	MONITORING PERIOD		
	MM/DD/YYYY		MM/DD/YYYY
FROM	07/01/2011	TO	07/31/2011

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Oxygen, dissolved (DO)	SAMPLE MEASUREMENT	******	******	******	7.0	******	******		0	1/7	GRAB
00300 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6.6 INST MIN	******	******	mg/L		Weekly	GRAB
pH	SAMPLE MEASUREMENT	******	******	******	6.9	******	7.2		0	1/7	GRAB
00400 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6 MINIMUM	******	8 MAXIMUM	SU		Weekly	GRAB
Solids, total suspended	SAMPLE MEASUREMENT	40.9	******		******	4.5	7.0		0	1/7	COMP
00530 1 0 Effluent Gross	PERMIT REQUIREMENT	250 MO AVG	******	lb/d	******	15 MO AVG	22.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrogen, ammonia total (as N)	SAMPLE MEASUREMENT	<1.1	******		******	<0.2	0.4		0	1/7	COMP
00610 1 0 Effluent Gross	PERMIT REQUIREMENT	26.7 MO AVG	******	lb/d	******	1.6 MO AVG	3.9 7 DA AVG	mg/L		Weekly	COMPOS
Nitrite plus nitrate total 1 det. (as N)	SAMPLE MEASUREMENT	35.4	******		******	7.2	11.4		0	1/7	COMP
00630 1 0 Effluent Gross	PERMIT REQUIREMENT	168.8 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS
Phosphorus, total (as P)	SAMPLE MEASUREMENT	11.3	******		******	1.9	3.2		0	1/7	GRAB
00665 1 0 Effluent Gross	PERMIT REQUIREMENT	53.4 MO AVG	******	lb/d	******	5 MO AVG	7.5 7 DA AVG	mg/L		Weekly	GRAB
Flow, in conduit or thru treatment plant	SAMPLE MEASUREMENT	0.801129	1.372000		******	******	******	******	0	1/1	TOT
50050 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	Req. Mon. DAILY MX	Mgal/d	******	******	******	******		Daily	TOTALZ

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett	TELEPHONE	DATE
Larry D. Garrett Director			479-738-6629	08/11/2011
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

Form Approved
OMB No. 2040-0004

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

ATTN: LARRY GARRETT, DIRECTOR

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

	MONITORING PERIOD		
	MM/DD/YYYY		MM/DD/YYYY
FROM	07/01/2011	TO	07/31/2011

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Solids, total dissolved	SAMPLE MEASUREMENT	9388.6	******		******	1032	1548.0		0	1/7	COMP
70295 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	******	lb/d	******	Req. Mon. MO AVG	Req. Mon. 7 DA AVG	mg/L		Weekly	COMPOS
Coliform, fecal general	SAMPLE MEASUREMENT	******	******	******	******	<1	<1		0	1/7	GRAB
74055 1 1 Effluent Gross	PERMIT REQUIREMENT	******	******	******	******	1000 30DA GEO	2000 7 DA GEO	#/100mL		Weekly	GRAB
BOD, carbonaceous, 05 day, 20 C	SAMPLE MEASUREMENT	<18.4	******		******	<2.0	<2.0		0	1/7	COMP
80082 1 0 Effluent Gross	PERMIT REQUIREMENT	167 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett	479	738-~~2062~~ 6521	08/11/2011
TYPED OR PRINTED LARRY GARRETT, DIRECTOR		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00016

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

Environmental Services Co.
1107 Century
Sprindale AR 72764
479-750-1170

Approved
No. 2040-0004

ERMITTEE NAME/ADDRESS *(Include Facility Name/Location If Different)*

AME: HUNTSVILLE, CITY OF
DDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740
ACILITY: HUNTSVILLE, CITY OF
OCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740
TTN: LARRY GARRETT, DIRECTOR

8/2011

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

MONITORING PERIOD			
	MM/DD/YYYY		MM/DD/YYYY
FROM	08/01/2011	TO	08/31/2011

MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Oxygen, dissolved (DO)	SAMPLE MEASUREMENT	******	******	******	7.0	******	******		0	1/7	GRAB
00300 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	5.6 INST MIN	******	******	mg/L		Weekly	GRAB
pH	SAMPLE MEASUREMENT	******	******	******	7.0	******	7.4		0	1/7	GRAB
00400 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6 MINIMUM	******	9 MAXIMUM	SU		Weekly	GRAB
Solids, total suspended	SAMPLE MEASUREMENT	<25.3	******		******	<5.4	9.0		0	1/7	COMP
00530 1 0 Effluent Gross	PERMIT REQUIREMENT	250 MO AVG	******	lb/d	******	15 MO AVG	22.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrogen, ammonia total (as N)	SAMPLE MEASUREMENT	<1.2	******		******	<0.1	0.3		0	1/7	COMP
00610 1 0 Effluent Gross	PERMIT REQUIREMENT	28.7 MO AVG	******	lb/d	******	1.8 MO AVG	3.9 7 DA AVG	mg/L		Weekly	COMPOS
Nitrite plus nitrate total 1 det. (as N)	SAMPLE MEASUREMENT	36.0	******		******	5.0	5.9		0	1/7	COMP
00630 1 0 Effluent Gross	PERMIT REQUIREMENT	166.8 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS
Phosphorus, total (as P)	SAMPLE MEASUREMENT	3.1	******		******	0.3	0.6		0	1/7	GRAB
00665 1 0 Effluent Gross	PERMIT REQUIREMENT	83.4 MO AVG	******	lb/d	******	5 MO AVG	7.5 7 DA AVG	mg/L		Weekly	GRAB
Flow, in conduit or thru treatment plant	SAMPLE MEASUREMENT	0.800484	1.372000		******	******	******	******	0	1/1	TOT
50050 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	Req. Mon. DAILY MX	Mgal/d	******	******	******	******		Daily	TOTALZ

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	[illegible]	Larry D. Garrett	479-738-6955		09-16-2011
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS *(Reference all attachments here)*

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5, 44-00018

Form Approved
OMB No. 2040-0004

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

ATTN: LARRY GARRETT, DIRECTOR

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

	MONITORING PERIOD		
	MM/DD/YYYY		MM/DD/YYYY
FROM	08/01/2011	TO	08/31/2011

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Solids, total dissolved	SAMPLE MEASUREMENT	3089.4	******		******	639.0	671.4		0	1/7	COMP
70295 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	******	lb/d	******	Req. Mon. MO AVG	Req. Mon. 7 DA AVG	mg/L		Weekly	COMPOS
Coliform, fecal general	SAMPLE MEASUREMENT	******	******	******	******	2	4		0	1/7	GRAB
74055 1 1 Effluent Gross	PERMIT REQUIREMENT	******	******	******	******	1000 30DA GEO	2000 7 DA GEO	#/100mL		Weekly	GRAB
BOD, carbonaceous, 05 day, 20 C	SAMPLE MEASUREMENT	<9.7	******		******	<2.0	<2.0		0	1/7	COMP
80082 1 0 Effluent Gross	PERMIT REQUIREMENT	167 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	[illegible]	Larry D. Garrett		625 479-738-2061	09-16-2011
LARRY GARRETT, DIRECTOR TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 08/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

ENVIRONMENTAL SERVICES CO., INC.
1107 CENTURY
SPRINGDALE, AR 72762

Approved
No. 2040-0004

RMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

ME: HUNTSVILLE, CITY OF
DRESS: P.O. BOX 430
HUNTSVILLE, AR 72740
CILITY: HUNTSVILLE, CITY OF
CATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740
TN: LARRY GARRETT, DIRECTOR

9/2011

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

MONITORING PERIOD			
	MM/DD/YYYY		MM/DD/YYYY
FROM	09/01/2011	TO	09/30/2011

MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

[illegible]

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
ygen, dissolved (DO)	SAMPLE MEASUREMENT	------	------	------	~~6.5~~ [illegible]	------	------		0	1/7	GRAB
300 1 0 fluent Gross	PERMIT REQUIREMENT	------	------	------	[illegible] INST MIN	------	------	mg/L		Weekly	GRAB
	SAMPLE MEASUREMENT	------	------	------	6.9	------	7.3		0	1/7	GRAB
400 1 0 fluent Gross	PERMIT REQUIREMENT	------	------	------	6 MINIMUM	------	9 MAXIMUM	SU		Weekly	GRAB
lids, total suspended	SAMPLE MEASUREMENT	49.5	------		------	5.5	10.0		0	1/7	COMP
530 1 0 fluent Gross	PERMIT REQUIREMENT	250 MO AVG	------	lb/d	------	15 MO AVG	22.5 7 DA AVG	mg/L		Weekly	COMPOS
trogen, ammonia total (as N)	SAMPLE MEASUREMENT	<1.5	------		------	<0.2	0.4		0	1/7	COMP
610 1 0 fluent Gross	PERMIT REQUIREMENT	26.7 MO AVG	------	lb/d	------	1.8 MO AVG	3.9 7 DA AVG	mg/L		Weekly	COMPOS
trite plus nitrate total 1 det. (as N)	SAMPLE MEASUREMENT	49.0	------		------	2.6	[illegible]		0	1/7	COMP
630 1 0 fluent Gross	PERMIT REQUIREMENT	166.8 MO AVG	------	lb/d	------	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS
osphorus, total (as P)	SAMPLE MEASUREMENT	1.9	------		------	6.3	[illegible]		0	1/7	GRAB
665 1 0 fluent Gross	PERMIT REQUIREMENT	83.4 MO AVG	------	lb/d	------	5 MO AVG	7.6 7 DA AVG	mg/L		Weekly	GRAB
ow, in conduit or thru treatment plant	SAMPLE MEASUREMENT	1.0184737	1.542800		------	------	------	------	0	1/1	TOT
050 1 0 fluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	Req. Mon. DAILY MX	Mgal/d	------	------	------	------		Daily	TOTALZ

Larry D. Garrett
Director

Larry D. Garrett 479-738-6525 11-2-2011

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett	479	738-6525	10-17-2011
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code	NUMBER	MM/DD/YYYY

OMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

EPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE ART II, CONDITION #5. 44-00015

Form Approved
OMB No. 2040-0004

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

MITTEE NAME/ADDRESS *(Include Facility Name/Location If Different)*
ME: HUNTSVILLE, CITY OF
DRESS: P.O. BOX 430
HUNTSVILLE, AR 72740
CILITY: HUNTSVILLE, CITY OF
CATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740
TN: LARRY GARRETT, DIRECTOR

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

MONITORING PERIOD

	MM/DD/YYYY		MM/DD/YYYY
FROM	09/01/2011	TO	09/30/2011

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
lids, total dissolved	SAMPLE MEASUREMENT	5637.9	******		******	710	1095.0		3	1/7	COMP
295 1 0 luent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	******	lb/d	******	Req. Mon. MO AVG	Req. Mon. 7 DA AVG	mg/L		Weekly	COMPOS
liform, fecal general	SAMPLE MEASUREMENT	******	******	******	******	20	1.31		0	1/7	GRAB
055 1 1 luent Gross	PERMIT REQUIREMENT	******	******	******	******	1000 30DA GEO	2000 7 DA GEO	#/100mL		Weekly	GRAB
D, carbonaceous, 05 day, 20 C	SAMPLE MEASUREMENT	<16.9	******		******	<2.0	<2.0		0	1/7	COMP
082 1 0 luent Gross	PERMIT REQUIREMENT	167 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS

Larry D. Garrett
Director
NAME/TITLE PRINCIPAL EXECUTIVE OFFICER
Larry D. Garrett
Director
LARRY GREGOR PRINTED/CTOR

Larry D. Garrett 479-738-6929 11-02-2011
Larry D. Garrett

TELEPHONE		DATE
479-738-~~2921~~ 2929		10-17-2011
AREA Code	NUMBER	MM/DD/YYYY

SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT

OMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)
EPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE
ART II, CONDITION #5. 44-00019

Form 3320-1 (Rev.01/06) Previous editions may be used.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

ENVIRONMENTAL SERVICES CO., INC.
1107 CENTURY
SPRINGDALE, AR 72762

roved
2040-0004

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

ATTN: LARRY GARRETT, DIRECTOR

10/2011

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

MONITORING PERIOD

	MM/DD/YYYY		MM/DD/YYYY
FROM	10/01/2011	TO	10/31/2011

MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Oxygen, dissolved (DO)	SAMPLE MEASUREMENT	******	******	******	7.1	******	******		0		
00300 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6.6 INST MIN	******	******	mg/L		Weekly	GRAB
pH	SAMPLE MEASUREMENT	******	******	******	6.4	******	7.1		0		
00400 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6 MINIMUM	******	9 MAXIMUM	SU		Weekly	GRAB
Solids, total suspended	SAMPLE MEASUREMENT		******		******						
00530 1 0 Effluent Gross	PERMIT REQUIREMENT	250 MO AVG	******	lb/d	******	15 MO AVG	22.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrogen, ammonia total (as N)	SAMPLE MEASUREMENT		******		******						
00610 1 0 Effluent Gross	PERMIT REQUIREMENT	26.7 MO AVG	******	lb/d	******	1.8 MO AVG	3.9 7 DA AVG	mg/L		Weekly	COMPOS
Nitrite plus nitrate total 1 det. (as N)	SAMPLE MEASUREMENT		******		******	7.6					
00630 1 0 Effluent Gross	PERMIT REQUIREMENT	166.8 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS
Phosphorus, total (as P)	SAMPLE MEASUREMENT		******		******						
00665 1 0 Effluent Gross	PERMIT REQUIREMENT	83.4 MO AVG	******	lb/d	******	5 MO AVG	7.5 7 DA AVG	mg/L		Weekly	GRAB
Flow, in conduit or thru treatment plant	SAMPLE MEASUREMENT	1.015646	1.533000		******	******	******	******			
50050 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	Req. Mon. DAILY MX	Mgal/d	******	******	******	******		Daily	TOTALZ

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett	479	738-6929	11-28-2011
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

Form Approved
OMB No. 2040-0004

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

ATTN: LARRY GARRETT, DIRECTOR

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

	MONITORING PERIOD		
	MM/DD/YYYY		MM/DD/YYYY
FROM	10/01/2011	TO	10/31/2011

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Solids, total dissolved	SAMPLE MEASUREMENT		******		******	561.5					
70295 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	******	lb/d	******	Req. Mon. MO AVG	Req. Mon. 7 DA AVG	mg/L		Weekly	COMPOS
Coliform, fecal general	SAMPLE MEASUREMENT	******	******	******	******	2	6		0		
74055 1 1 Effluent Gross	PERMIT REQUIREMENT	******	******	******	******	1000 30DA GEO	2000 7 DA GEO	#/100mL		Weekly	GRAB
BOD, carbonaceous, 05 day, 20 C	SAMPLE MEASUREMENT		******		******						
80082 1 0 Effluent Gross	PERMIT REQUIREMENT	167 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett		6329	11-28-2011
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

ENVIRONMENTAL SERVICES CO., INC.
1107 CENTURY
SPRINGDALE, AR 72762

pproved
o. 2040-0004

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

ATTN: LARRY GARRETT, DIRECTOR

11/2011

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

MONITORING PERIOD

	MM/DD/YYYY		MM/DD/YYYY
FROM	11/01/2011	TO	11/30/2011

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Oxygen, dissolved (DO)	SAMPLE MEASUREMENT	------	------	------	6.9	------	------		0		
00300 1 0 Effluent Gross	PERMIT REQUIREMENT	------	------	------	6.8 INST MIN	------	------	mg/L		Weekly	GRAB
pH	SAMPLE MEASUREMENT	------	------	------	6.9	------	7.1		0		
00400 1 0 Effluent Gross	PERMIT REQUIREMENT	------	------	------	6 MINIMUM	------	9 MAXIMUM	SU		Weekly	GRAB
Solids, total suspended	SAMPLE MEASUREMENT		------		------	<4.0			0		
00530 1 0 Effluent Gross	PERMIT REQUIREMENT	250 MO AVG	------	lb/d	------	15 MO AVG	22.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrogen, ammonia total (as N)	SAMPLE MEASUREMENT		------		------	<0.3			0		
00610 1 1 Effluent Gross	PERMIT REQUIREMENT	50 MO AVG	------	lb/d	------	3 MO AVG	4.5 7 DA AVG	mg/L	0	Weekly	COMPOS
Nitrite plus nitrate total 1 det. (as N)	SAMPLE MEASUREMENT		------		------				0		
00630 1 0 Effluent Gross	PERMIT REQUIREMENT	166.8 MO AVG	------	lb/d	------	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS
Phosphorus, total (as P)	SAMPLE MEASUREMENT		------		------				0		
00665 1 0 Effluent Gross	PERMIT REQUIREMENT	83.4 MO AVG	------	lb/d	------	5 MO AVG	7.5 7 DA AVG	mg/L		Weekly	GRAB
Flow, in conduit or thru treatment plant	SAMPLE MEASUREMENT	1.034	3.495		------	------	------	------	0		
50050 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	Req. Mon. DAILY MX	Mgal/d	------	------	------	------		Daily	TOTALZ

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett	479-738-6951		12/14/2011
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00019

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

Form Approved
OMB No. 2040-0004

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

ATTN: LARRY GARRETT, DIRECTOR

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

MONITORING PERIOD			
	MM/DD/YYYY		MM/DD/YYYY
FROM	11/01/2011	TO	11/30/2011

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Solids, total dissolved	SAMPLE MEASUREMENT		******		******	400.6					
70295 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	******	lb/d	******	Req. Mon. MO AVG	Req. Mon. 7 DA AVG	mg/L		Weekly	COMPOS
Coliform, fecal general	SAMPLE MEASUREMENT	******	******	******	******	<2	0.35				
74055 1 1 Effluent Gross	PERMIT REQUIREMENT	******	******	******	******	1000 30DA GEO	2000 7 DA GEO	#/100mL		Weekly	GRAB
BOD, carbonaceous, 05 day, 20 C	SAMPLE MEASUREMENT		******		******						
80082 1 0 Effluent Gross	PERMIT REQUIREMENT	167 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett		6529	12/14/2011
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

ENVIRONMENTAL SERVICES CO., INC.
1107 CENTURY
SPRINGDALE, AR 72762

ad
10-0004

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740
FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

ATTN: LARRY GARRETT, DIRECTOR

12/2011

AR0022004
PERMIT NUMBER

001-A
DISCHARGE NUMBER

MONITORING PERIOD
FROM MM/DD/YYYY 12/01/2011 TO MM/DD/YYYY 12/31/2011

MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Oxygen, dissolved (DO)	SAMPLE MEASUREMENT	******	******	******	7.0	******	******		0	1/7	GRAB
00300 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6.5 INST MIN	******	******	mg/L		Weekly	GRAB
pH	SAMPLE MEASUREMENT	******	******	******	6.9	******	7.0		0	1/7	GRAB
00400 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6 MINIMUM	******	9 MAXIMUM	SU		Weekly	GRAB
Solids, total suspended	SAMPLE MEASUREMENT	<57.94	******		******	<4.3	6.0		0	1/7	COMP
00530 1 0 Effluent Gross	PERMIT REQUIREMENT	250 MO AVG	******	lb/d	******	15 MO AVG	22.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrogen, ammonia total (as N)	SAMPLE MEASUREMENT	<0.99	******		******	<0.1	<0.1		0	1/7	COMP
00610 1 1 Effluent Gross	PERMIT REQUIREMENT	50 MO AVG	******	lb/d	******	3 MO AVG	4.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrite plus nitrate total 1 det. (as N)	SAMPLE MEASUREMENT	58.5	******		******	6.3	6.9		0	1/7	COMP
00630 1 0 Effluent Gross	PERMIT REQUIREMENT	166.8 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS
Phosphorus, total (as P)	SAMPLE MEASUREMENT	2.0	******		******	0.2	0.3		0	1/7	GRAB
00665 1 0 Effluent Gross	PERMIT REQUIREMENT	83.4 MO AVG	******	lb/d	******	5 MO AVG	7.5 7 DA AVG	mg/L		Weekly	GRAB
Flow, in conduit or thru treatment plant	SAMPLE MEASUREMENT	1.322516	1.971000		******	******	******	******	0	1/1	TOT
50050 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	Req. Mon. DAILY MX	Mgal/d	******	******	******	******		Daily	TOTALZ

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER Larry D. Garrett Director TYPED OR PRINTED	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	TELEPHONE 479-738-6[illegible] AREA Code NUMBER	DATE 01-19-2012 MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

Form Approved
OMB No. 2040-0004

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

ATTN: LARRY GARRETT, DIRECTOR

PERMIT NUMBER	DISCHARGE NUMBER
AR0022004	001-A

MONITORING PERIOD

	MM/DD/YYYY		MM/DD/YYYY
FROM	12/01/2011	TO	12/31/2011

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Solids, total dissolved	SAMPLE MEASUREMENT	5153.2	******		******	398.5	515.0		0	1/7	COMP
70295 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	******	lb/d	******	Req. Mon. MO AVG	Req. Mon. 7 DA AVG	mg/L		Weekly	COMPOS
Coliform, fecal general	SAMPLE MEASUREMENT	******	******	******	******	0.66	5		0	1/7	GRAB
74055 1 1 Effluent Gross	PERMIT REQUIREMENT	******	******	******	******	1000 30DA GEO	2000 7 DA GEO	#/100mL		Weekly	GRAB
BOD, carbonaceous, 05 day, 20 C	SAMPLE MEASUREMENT	<32.10	******		******	<2.4	4.0		0	1/7	COMP
80082 1 0 Effluent Gross	PERMIT REQUIREMENT	167 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director LARRY GARRETT, DIRECTOR TYPED OR PRINTED	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	479	738-~~2081~~ 5727	01-19-2012
			AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR, SEE PART II, CONDITION #5. 44-00018

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

ENVIRONMENTAL SERVICES CO., INC.
1107 CENTURY
SPRINGDALE, AR 72762

ved
40-0004

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740
FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

ATTN: LARRY GARRETT, DIRECTOR

1/2012

AR0022004
PERMIT NUMBER

001-A
DISCHARGE NUMBER

MONITORING PERIOD
FROM MM/DD/YYYY 01/01/2012 TO MM/DD/YYYY 01/31/2012

MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Oxygen, dissolved (DO)	SAMPLE MEASUREMENT	******	******	******	7.1	******	******		0	1/7	Grab
00300 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6.5 INST MIN	******	******	mg/L		Weekly	GRAB
pH	SAMPLE MEASUREMENT	******	******	******	6.7	******	7.1		0	1/7	Grab
00400 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6 MINIMUM	******	9 MAXIMUM	SU		Weekly	GRAB
Solids, total suspended	SAMPLE MEASUREMENT	<59.1	******		******	<5.0	7.0		0	1/7	Comp
00530 1 0 Effluent Gross	PERMIT REQUIREMENT	250 MO AVG	******	lb/d	******	15 MO AVG	22.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrogen, ammonia total (as N)	SAMPLE MEASUREMENT	<0.7	******		******	<0.1	<0.1		0	1/7	Comp
00610 1 1 Effluent Gross	PERMIT REQUIREMENT	50 MO AVG	******	lb/d	******	3 MO AVG	4.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrite plus nitrate total 1 det. (as N)	SAMPLE MEASUREMENT	36.4	******		******	5.0	7.4		0	1/7	Comp
00630 1 0 Effluent Gross	PERMIT REQUIREMENT	166.8 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS
Phosphorus, total (as P)	SAMPLE MEASUREMENT	3.6	******		******	0.4	0.3		0	1/7	Grab
00665 1 0 Effluent Gross	PERMIT REQUIREMENT	83.4 MO AVG	******	lb/d	******	5 MO AVG	7.5 7 DA AVG	mg/L		Weekly	GRAB
Flow, in conduit or thru treatment plant	SAMPLE MEASUREMENT	1.119065	2.52000		******	******	******	******	0	1/1	TOT
50050 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	Req. Mon. DAILY MX	Mgal/d	******	******	******	******		Daily	TOTALZ

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett	479	738-69[illegible]	02/16/2012
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

Form Approved
OMB No. 2040-0004

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

ATTN: LARRY GARRETT, DIRECTOR

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

	MONITORING PERIOD		
	MM/DD/YYYY		MM/DD/YYYY
FROM	01/01/2012	TO	01/31/2012

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Solids, total dissolved	SAMPLE MEASUREMENT	5256.0	******		******	464.3	505		0	1/7	Comp
70295 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	******	lb/d	******	Req. Mon. MO AVG	Req. Mon. 7 DA AVG	mg/L		Weekly	COMPOS
Coliform, fecal general	SAMPLE MEASUREMENT	******	******	******	******	0.44	3		0	1/7	Comp
74055 1 1 Effluent Gross	PERMIT REQUIREMENT	******	******	******	******	1000 30DA GEO	2000 7 DA GEO	#/100mL		Weekly	GRAB
BOD, carbonaceous, 05 day, 20 C	SAMPLE MEASUREMENT	<22.4	******		******	<2.0	2.0		0	1/7	Comp
80082 1 0 Effluent Gross	PERMIT REQUIREMENT	167 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER
Larry D. Garrett
Director
TYPED OR PRINTED

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Larry D. Garrett
SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT

TELEPHONE		DATE
479	738-6929	2/16/2012
AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

Environmental Services Co.
1107 Century
Sprindale AR 72764
479-750-1170

ad
15-0004

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740
FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

2/2012

ATTN: LARRY GARRETT, DIRECTOR

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

MONITORING PERIOD

	MM/DD/YYYY		MM/DD/YYYY
FROM	02/01/2012	TO	02/29/2012

MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Oxygen, dissolved (DO)	SAMPLE MEASUREMENT	------	------	------	7.0	------	------		0	1/7	Grab
00300 1 0 Effluent Gross	PERMIT REQUIREMENT	------	------	------	6.6 INST MIN	------	------	mg/L		Weekly	GRAB
pH	SAMPLE MEASUREMENT	------	------	------	7.0	------	7.3		0	1/7	Grab
00400 1 0 Effluent Gross	PERMIT REQUIREMENT	------	------	------	6 MINIMUM	------	9 MAXIMUM	SU		Weekly	GRAB
Solids, total suspended	SAMPLE MEASUREMENT	<46.8	------		------	<4.0	6.0		0	1/7	Comp
00530 1 0 Effluent Gross	PERMIT REQUIREMENT	250 MO AVG	------	lb/d	------	15 MO AVG	22.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrogen, ammonia total (as N)	SAMPLE MEASUREMENT	<2.4	------		------	<0.2	0.6		0	1/7	Comp
00610 1 1 Effluent Gross	PERMIT REQUIREMENT	50 MO AVG	------	lb/d	------	3 MO AVG	4.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrite plus nitrate total 1 det. (as N)	SAMPLE MEASUREMENT	65.6	------		------	7.2	8.2		0	1/7	Comp
00630 1 0 Effluent Gross	PERMIT REQUIREMENT	168.8 MO AVG	------	lb/d	------	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS
Phosphorus, total (as P)	SAMPLE MEASUREMENT	<0.9	------		------	<0.1	1.2		0	1/7	Grab
00665 1 0 Effluent Gross	PERMIT REQUIREMENT	83.4 MO AVG	------	lb/d	------	5 MO AVG	7.5 7 DA AVG	mg/L		Weekly	GRAB
Flow, in conduit or thru treatment plant	SAMPLE MEASUREMENT	1.315828	2.144000		------	------	------	------	0	1/1	Tot
50050 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	Req. Mon. DAILY MX	Mgal/d	------	------	------	------		Daily	TOTALZ

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett	TELEPHONE	DATE
Larry D. Garrett Director			479-738-6558	03-14-2012
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

Form Approved
OMB No. 2040-0004

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740
FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

ATTN: LARRY GARRETT, DIRECTOR

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

	MONITORING PERIOD		
	MM/DD/YYYY		MM/DD/YYYY
FROM	02/01/2012	TO	02/29/2012

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Solids, total dissolved	SAMPLE MEASUREMENT	5549.0	------		------	483.8	445		0	1/7	Comp
70295 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	------	lb/d	------	Req. Mon. MO AVG	Req. Mon. 7 DA AVG	mg/L		Weekly	COMPOS
Coliform, fecal general	SAMPLE MEASUREMENT	------	------	------	------	0.4	4		0	1/7	Grab
74055 1 1 Effluent Gross	PERMIT REQUIREMENT	------	------	------	------	1000 30DA GEO	2000 7 DA GEO	#/100mL		Weekly	GRAB
BOD, carbonaceous, 05 day, 20 C	SAMPLE MEASUREMENT	<23.4	------		------	<2.0	<2.0		0	1/7	Comp
80082 1 0 Effluent Gross	PERMIT REQUIREMENT	167 MO AVG	------	lb/d	------	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry Garrett, Director	[illegible]		479-738-~~2[illegible]~~ [illegible]		03/14/2012
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 05/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

Environmental Services Co.
1107 Century
Sprindale AR 72764
479-750-1170

n Approved
B No. 2040-0004

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740
FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740
ATTN: LARRY GARRETT, DIRECTOR

3/2012

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

MONITORING PERIOD			
	MM/DD/YYYY		MM/DD/YYYY
FROM	03/01/2012	TO	03/31/2012

I0

MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Oxygen, dissolved (DO)	SAMPLE MEASUREMENT	******	******	******	7.3	******	******		0	1/7	Grab
00300 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6.6 INST MIN	******	******	mg/L		Weekly	GRAB
pH	SAMPLE MEASUREMENT	******	******	******	7.1	******	7.2		0	1/7	Grab
00400 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6 MINIMUM	******	9 MAXIMUM	SU		Weekly	GRAB
Solids, total suspended	SAMPLE MEASUREMENT	<73.0	******		******	<4.0	6.0		0	1/7	Comp
00530 1 0 Effluent Gross	PERMIT REQUIREMENT	250 MO AVG	******	lb/d	******	15 MO AVG	22.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrogen, ammonia total (as N)	SAMPLE MEASUREMENT	<1.0	******		******	<1.0	0.2		0	1/7	Comp
00610 1 1 Effluent Gross	PERMIT REQUIREMENT	50 MO AVG	******	lb/d	******	3 MO AVG	4.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrite plus nitrate total 1 det. (as N)	SAMPLE MEASUREMENT	41.9	******		******	6.2	9.7		0	1/7	Comp
00630 1 0 Effluent Gross	PERMIT REQUIREMENT	166.8 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS
Phosphorus, total (as P)	SAMPLE MEASUREMENT	2.3	******		******	0.3	0.8		0	1/7	Grab
00665 1 0 Effluent Gross	PERMIT REQUIREMENT	83.4 MO AVG	******	lb/d	******	5 MO AVG	7.5 7 DA AVG	mg/L		Weekly	GRAB
Flow, in conduit or thru treatment plant	SAMPLE MEASUREMENT	1.460806	3.630000		******	******	******	******	0	1/1	Tot
50050 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	Req. Mon. DAILY MX	Mgal/d	******	******	******	******		Daily	TOTALZ

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett	479	738-6989	04/12/2012
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTR WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

Form Approved
OMB No. 2040-0004

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740
FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

ATTN: LARRY GARRETT, DIRECTOR

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

MONITORING PERIOD

	MM/DD/YYYY		MM/DD/YYYY
FROM	03/01/2012	TO	03/31/2012

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Solids, total dissolved	SAMPLE MEASUREMENT	6646.1	******		******	494.3	795		0	1/7	Comp
70295 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	******	lb/d	******	Req. Mon. MO AVG	Req. Mon. 7 DA AVG	mg/L		Weekly	COMPOS
Coliform, fecal general	SAMPLE MEASUREMENT	******	******	******	******	<1	1		0	1/7	Grab
74055 1 1 Effluent Gross	PERMIT REQUIREMENT	******	******	******	******	1000 30DA GEO	2000 7 DA GEO	#/100mL		Weekly	GRAB
BOD, carbonaceous, 05 day, 20 C	SAMPLE MEASUREMENT	<39.9	******		******	<2.3	3		0	1/7	Comp
80082 1 0 Effluent Gross	PERMIT REQUIREMENT	167 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett	TELEPHONE	DATE
Larry D. Garrett Director			479·738·6539	04/12/2012
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

PERMITTEE NAME/ADDRESS (include Facility Name/Location if Different)
NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740
ATTN: LARRY GARRETT DIRECTOR

4/2012

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

PERMIT NUMBER	DISCHARGE NUMBER
AR0022004	001-A

MONITORING PERIOD	
MM/DD/YYYY	MM/DD/YYYY
4/1/2012	4/30/2012

Environmental Services Co.
1107 Century
Springdale AR 72764
479-750-1170

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Oxygen, dissolved (DO)	SAMPLE MEASUREMENT	******	******	******	7.0	******	******		0	1/7	Grab
00300 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6.6 INST MIN	******	******	mg/L		Weekly	GRAB
pH	SAMPLE MEASUREMENT	******	******	******	7.0	******	7.3		0	1/7	Grab
00400 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6 MINIMUM	******	9 MAXIMUM	SU		Weekly	GRAB
Solids, total suspended	SAMPLE MEASUREMENT	<25.3	******		******	<2.5	4.0		0	1/7	Comp
00530 1 0 Effluent Gross	PERMIT REQUIREMENT	250 MO AVG	******	lb/d	******	15 MO AVG	22.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrogen, ammonia total (as N)	SAMPLE MEASUREMENT	<1.3	******		******	<0.2	0.4		0	1/7	Comp
00610 1 0 Effluent Gross	PERMIT REQUIREMENT	26.7 MO AVG	******	lb/d	******	1.6 MO AVG	3.9 7 DA AVG	mg/L		Weekly	COMPOS
Nitrite plus nitrate total 1 det. (as N)	SAMPLE MEASUREMENT	53.3	******		******	6.5	10.4		0	1/7	Comp
00630 1 0 Effluent Gross	PERMIT REQUIREMENT	166.8 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS
Phosphorus, total (as P)	SAMPLE MEASUREMENT	1.6	******		******	0.2	0.3		0	1/7	Grab
00665 1 0 Effluent Gross	PERMIT REQUIREMENT	83.4 MO AVG	******	lb/d	******	5 MO AVG	7.5 7 DA AVG	mg/L		Weekly	GRAB
Flow, in conduit or thru treatment plant	SAMPLE MEASUREMENT	1.057433	1.529000		******	******	******	******	0	1/1	Tot
50050 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	Req. Mon. DAILY MX	MGD	******	******	******	******		Daily	TOTALZ

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.		479	738-[illegible]	05/18/2012
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*

NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740

ATTN: LARRY GARRETT, DIRECTOR

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

MONITORING PERIOD	
MM/DD/YYYY	MM/DD/YYYY
4/1/2012	4/30/2012

Form Approved
OMB No. 2040-0004

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Solids, total dissolved	SAMPLE MEASUREMENT	6624.3	******		******	631	799		0	1/7	Comp
70295 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	******	lb/d	******	Req. Mon. MO AVG	Req. Mon. 7 DA AVG	mg/L		Weekly	COMPOS
Coliform, fecal general	SAMPLE MEASUREMENT	******	******	******	******	0.19	2		0	1/7	Grab
74055 1 1 Effluent Gross	PERMIT REQUIREMENT	******	******	******	******	1000 30DA GEO	2000 7 DA GEO	#/100mL		Weekly	GRAB
BOD, carbonaceous, 05 day, 20 C	SAMPLE MEASUREMENT	<21.2	******		******	<2.0	<2.0		0	1/7	Comp
80082 1 0 Effluent Gross	PERMIT REQUIREMENT	167 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations		479-738-6531		05/15/2012
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*
NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740
ATTN: LARRY GARRETT, DIRECTOR

5/2012

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

MONITORING PERIOD	
MM/DD/YYYY	MM/DD/YYYY
5/1/2012	5/31/2012

Environmental Services Co.
1107 Century
Springdale AR 72764
479-750-1170

MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Oxygen, dissolved (DO)	SAMPLE MEASUREMENT	******	******	******	6.8	******	******		0	1/7	Grab
00300 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6.6 INST MIN	******	******	mg/L		Weekly	GRAB
pH	SAMPLE MEASUREMENT	******	******	******	7.0	******	7.4		0	1/7	Grab
00400 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6 MINIMUM	******	9 MAXIMUM	SU		Weekly	GRAB
Solids, total suspended	SAMPLE MEASUREMENT	<40.3	******		******	<4.2	5.0		0	1/7	Comp
00530 1 0 Effluent Gross	PERMIT REQUIREMENT	250 MO AVG	******	lb/d	******	15 MO AVG	22.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrogen, ammonia total (as N)	SAMPLE MEASUREMENT	<0.6	******		******	<0.1	0.1		0	1/7	Comp
00610 1 0 Effluent Gross	PERMIT REQUIREMENT	26.7 MO AVG	******	lb/d	******	1.6 MO AVG	3.9 7 DA AVG	mg/L		Weekly	COMPOS
Nitrite plus nitrate total 1 det. (as N)	SAMPLE MEASUREMENT	69.9	******		******	11.2	12.9		1	1/7	Comp
00630 1 0 Effluent Gross	PERMIT REQUIREMENT	169.8 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS
Phosphorus, total (as P)	SAMPLE MEASUREMENT	3.6	******		******	0.7	0.6		0	1/7	Grab
00665 1 0 Effluent Gross	PERMIT REQUIREMENT	83.4 MO AVG	******	lb/d	******	5 MO AVG	7.5 7 DA AVG	mg/L		Weekly	GRAB
Flow, in conduit or thru treatment plant	SAMPLE MEASUREMENT	1.020903	1.497000		******	******	******	******	0	1/7	TOT
50050 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	Req. Mon. DAILY MX	MGD	******	******	******	******		Daily	TOTALZ

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	479	738-6929	06/14/2012
TYPED OR PRINTED			AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

PERMITTEE NAME/ADDRESS *(Include Facility Name/Location if Different)*
NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740
ATTN: LARRY GARRETT, DIRECTOR

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

PERMIT NUMBER	DISCHARGE NUMBER
AR0022004	001-A

MONITORING PERIOD

MM/DD/YYYY	MM/DD/YYYY
5/1/2012	5/31/2012

Form Approved
OMB No. 2040-0004

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Solids, total dissolved	SAMPLE MEASUREMENT	7241.9	******		******	758.2	852.0		0	1/7	Comp
70295 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	******	lb/d	******	Req. Mon. MO AVG	Req. Mon. 7 DA AVG	mg/L		Weekly	COMPOS
Coliform, fecal general	SAMPLE MEASUREMENT	******	******	******	******	<1	3		0	1/7	Grab
74055 1 1 Effluent Gross	PERMIT REQUIREMENT	******	******	******	******	1000 30DA GEO	2000 7 DA GEO	#/100mL		Weekly	GRAB
BOD, carbonaceous, 05 day, 20 C	SAMPLE MEASUREMENT	<19.1	******		******	<2.0	<2.0		0	1/7	Comp
80082 1 0 Effluent Gross	PERMIT REQUIREMENT	167 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER			TELEPHONE		DATE
Larry D. Garrett Director	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	479	738-6989	06/14/2012
TYPED OR PRINTED			AREA Code	NUMBER	MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR, SEE PART II, CONDITION #5. 44-00018

Environmental Services Co.
1107 Century
Springdale AR 72764
479-750-1170

ed
10-0004

PERMITTEE NAME/ADDRESS (Include Facility Name/Location if Different)
NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740
ATTN: LARRY GARRETT, DIRECTOR

6/2012

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

MONITORING PERIOD

MM/DD/YYYY	MM/DD/YYYY
6/1/2012	6/30/2012

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
Oxygen, dissolved (DO)	SAMPLE MEASUREMENT	******	******	******	6.6	******	******		0	1/7	GRAB
00300 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6.6 INST MIN	******	******	mg/L		Weekly	GRAB
pH	SAMPLE MEASUREMENT	******	******	******	7.1	******	7.3		0	1/7	GRAB
00400 1 0 Effluent Gross	PERMIT REQUIREMENT	******	******	******	6 MINIMUM	******	9 MAXIMUM	SU		Weekly	GRAB
Solids, total suspended	SAMPLE MEASUREMENT	<37.8	******	#/day	******	<4.5	8.0	mg/L	0	1/7	COMP
00530 1 0 Effluent Gross	PERMIT REQUIREMENT	250 MO AVG	******	lb/d	******	15 MO AVG	22.5 7 DA AVG	mg/L		Weekly	COMPOS
Nitrogen, ammonia total (as N)	SAMPLE MEASUREMENT	<1.3	******	#/day	******	<0.2	0.6	mg/L	0	1/7	COMP
00610 1 0 Effluent Gross	PERMIT REQUIREMENT	26.7 MO AVG	******	lb/d	******	1.6 MO AVG	6.9 7 DA AVG	mg/L		Weekly	COMPOS
Nitrite plus nitrate total 1 det. (as N)	SAMPLE MEASUREMENT	24.6	******	#/day	******	3.7	9.3	mg/L	0	1/7	COMP
00630 1 0 Effluent Gross	PERMIT REQUIREMENT	166.8 MO AVG	******	lb/d	******	10 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS
Phosphorus, total (as P)	SAMPLE MEASUREMENT	3.7	******	#/day	******	0.7	1.4	mg/L	0	1/7	GRAB
00665 1 0 Effluent Gross	PERMIT REQUIREMENT	33.1 MO AVG	******	lb/d	******	2 MO AVG	3 7 DA AVG	mg/L		Weekly	GRAB
Flow, in conduit or thru treatment plant	SAMPLE MEASUREMENT	0.907567	1.278000	MGD	******	******	******	******	0	1/1	TOT
50050 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	Req. Mon. DAILY MX	MGD	******	******	******	******		Daily	TOTALZ

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER
Larry D. Garrett
Director
TYPED OR PRINTED

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment for knowing violations.

Larry D. Garrett
SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT

TELEPHONE: 479-738-6519 (AREA Code / NUMBER)
DATE: 07/09/2012 (MM/DD/YYYY)

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

PERMITTEE NAME/ADDRESS (*Include Facility Name/Location If Different*)
NAME: HUNTSVILLE, CITY OF
ADDRESS: P.O. BOX 430
HUNTSVILLE, AR 72740

FACILITY: HUNTSVILLE, CITY OF
LOCATION: 30187 MADISON HWY 23
HUNTSVILLE, AR 72740
ATTN: LARRY GARRETT, DIRECTOR

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

AR0022004	001-A
PERMIT NUMBER	DISCHARGE NUMBER

MONITORING PERIOD

MM/DD/YYYY	MM/DD/YYYY
6/1/2012	6/30/2012

Form Approved
OMB No. 2040-0004

DMR Mailing ZIP CODE: 72740
MAJOR

001-MONTHLY-TRTD MUNICIPAL WW
External Outfall

No Discharge ☐

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		5453.1 VALUE	VALUE	#/day UNITS	VALUE	650.5 VALUE	830.0 VALUE	mg/L UNITS	0	1/7	COMP
Solids, total dissolved	SAMPLE MEASUREMENT	5453.1	******	#/day	******	650.5	830.0	mg/L	0	1/7	COMP
70295 1 0 Effluent Gross	PERMIT REQUIREMENT	Req. Mon. MO AVG	******	lb/d	******	Req. Mon. MO AVG	Req. Mon. 7 DA AVG	mg/L		Weekly	COMPOS
Coliform, fecal general	SAMPLE MEASUREMENT	******	******	******	******	1	1		0	1/7	GRAB
74055 1 1 Effluent Gross	PERMIT REQUIREMENT	<16.8	******	#/day	******	1000 <2.0 30DA GEO	2000 <2.0 7 DA GEO	#/100mL mg/L	0	Weekly	GRAB COMP
BOD, carbonaceous, 05 day, 20 C	SAMPLE MEASUREMENT	<16.8	******	#/day	******	<2.0	<2.0	mg/L	0	1/7	COMP
80082 1 0 Effluent Gross	PERMIT REQUIREMENT	167 MO AVG	******	lb/d	******	16 MO AVG	15 7 DA AVG	mg/L		Weekly	COMPOS.

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER LARRY GARRETT, DIRECTOR TYPED OR PRINTED LARRY GARRETT, DIRECTOR	I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	Larry D. Garrett SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	TELEPHONE 479-738-2001 479-738-~~2001~~ 6924 AREA Code / NUMBER	DATE 07/09/2012 MM/DD/YYYY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

REPORT FLOW AS MONTHLY AVERAGE & DAILY MAXIMUM IN MILLION GALLONS PER DAY. FINAL LIMITS FOR TOTAL PHOSPHORUS BEGIN 06/01/2012. SUBMIT TABULAR SSO REPORT EACH MONTH WITH THIS DMR. SEE PART II, CONDITION #5. 44-00018

Appendix B

WQ Data

AMERICAN INTERPLEX
CORPORATION
LABORATORIES

September 21, 2011
Control No. 151099

GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
219 Brown Lane
Bryant, AR 72022

This report contains the analytical results and supporting information for samples submitted on September 15, 2011. Attached please find a copy of the Chain of Custody and/or other documents received. Note that any remaining sample will be discarded two weeks from the original report date unless other arrangements are made.

This report is intended for the sole use of the client listed above. Assessment of the data requires access to the entire document.

This report has been reviewed by the Laboratory Director or a qualified designee.

John Overbey
Laboratory Director

This document has been distributed to the following:

PDF cc: GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
gphillips@gbmcassoc.com

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

SAMPLE INFORMATION

Project Description:
Eight (8) water sample(s) received on September 15, 2011

Receipt Details:
A Chain of Custody was provided. The samples were delivered in one (1) ice chest.

Each sample container was checked for proper labeling, including date and time sampled. Sample containers were reviewed for proper type, adequate volume, integrity, temperature, preservation, and holding times. Any exceptions are noted below:

Sample Identification:

Laboratory ID	Client Sample ID	Sampled Date/Time	Notes
151099-1	WEC-2 9-14-11 1032	14-Sep-2011 1032	
151099-2	WEC-2 D 9-14-11 1033	14-Sep-2011 1033	
151099-3	WEC-1 9-14-11 1140	14-Sep-2011 1140	
151099-4	HC-2 9/14/11 1240	14-Sep-2011 1240	
151099-5	HC-1 9-14-11 1305	14-Sep-2011 1305	
151099-6	TB-2 9-14-11 1330	14-Sep-2011 1330	
151099-7	TB-1 9-14-11 1345	14-Sep-2011 1345	
151099-8	001 9-14-11 1400	14-Sep-2011 1400	

Qualifiers:
D Result is from a secondary dilution factor

References:
"Methods for Chemical Analysis of Water and Wastes", EPA/600/4-79-020 (Mar 1983) with updates and supplements EPA/600/5-91-010 (Jun 1991), EPA/600/R-92-129 (Aug 1992) and EPA/600/R-93-100 (Aug 1993).
"Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW846)", Third Edition.
"Standard Methods for the Examination of Water and Wastewaters", 20th edition, 1998.
"American Society for Testing and Materials" (ASTM).
"Association of Analytical Chemists" (AOAC).

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 151099-1
Sample Identification: WEC-2 9-14-11 1032

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**230**	10	**mg/l**	
SM 2540C	Prep: 19-Sep-2011 1459 by 290	Analyzed: 20-Sep-2011 1314 by 290		Batch: W37449	
Chloride		**42**	0.2	**mg/l**	
EPA 300.0	Prep: 15-Sep-2011 1115 by 07	Analyzed: 15-Sep-2011 2116 by 07		Batch: S30880	

AIC No. 151099-2
Sample Identification: WEC-2 D 9-14-11 1033

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**240**	10	**mg/l**	
SM 2540C	Prep: 19-Sep-2011 1459 by 290	Analyzed: 20-Sep-2011 1314 by 290		Batch: W37449	
Chloride		**43**	0.2	**mg/l**	
EPA 300.0	Prep: 15-Sep-2011 1115 by 07	Analyzed: 15-Sep-2011 2142 by 07		Batch: S30880	

AIC No. 151099-3
Sample Identification: WEC-1 9-14-11 1140

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**100**	10	**mg/l**	
SM 2540C	Prep: 19-Sep-2011 1459 by 290	Analyzed: 20-Sep-2011 1314 by 290		Batch: W37449	
Chloride		**3.6**	0.2	**mg/l**	
EPA 300.0	Prep: 15-Sep-2011 1115 by 07	Analyzed: 15-Sep-2011 2208 by 07		Batch: S30880	

AIC No. 151099-4
Sample Identification: HC-2 9/14/11 1240

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**610**	10	**mg/l**	
SM 2540C	Prep: 19-Sep-2011 1459 by 290	Analyzed: 20-Sep-2011 1314 by 290		Batch: W37449	
Chloride		**180**	2	**mg/l**	D
EPA 300.0	Prep: 15-Sep-2011 1115 by 07	Analyzed: 15-Sep-2011 1907 by 07		Batch: S30880	Dil: 10

AIC No. 151099-5
Sample Identification: HC-1 9-14-11 1305

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**210**	10	**mg/l**	
SM 2540C	Prep: 19-Sep-2011 1459 by 290	Analyzed: 20-Sep-2011 1314 by 290		Batch: W37449	
Chloride		**9.5**	0.2	**mg/l**	
EPA 300.0	Prep: 15-Sep-2011 1115 by 07	Analyzed: 15-Sep-2011 2300 by 07		Batch: S30880	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 151099-6
Sample Identification: TB-2 9-14-11 1330

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**680**	10	**mg/l**	
SM 2540C	Prep: 19-Sep-2011 1459 by 290	Analyzed: 20-Sep-2011 1314 by 290		Batch: W37449	
Chloride		**200**	2	**mg/l**	D
EPA 300.0	Prep: 15-Sep-2011 1115 by 07	Analyzed: 15-Sep-2011 1959 by 07		Batch: S30880	Dil: 10

AIC No. 151099-7
Sample Identification: TB-1 9-14-11 1345

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**220**	10	**mg/l**	
SM 2540C	Prep: 19-Sep-2011 1459 by 290	Analyzed: 20-Sep-2011 1314 by 290		Batch: W37449	
Chloride		**27**	0.2	**mg/l**	
EPA 300.0	Prep: 15-Sep-2011 1115 by 07	Analyzed: 16-Sep-2011 0109 by 07		Batch: S30880	

AIC No. 151099-8
Sample Identification: 001 9-14-11 1400

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**730**	10	**mg/l**	
SM 2540C	Prep: 19-Sep-2011 1459 by 290	Analyzed: 20-Sep-2011 1314 by 290		Batch: W37449	
Chloride		**230**	2	**mg/l**	D
EPA 300.0	Prep: 15-Sep-2011 1115 by 07	Analyzed: 15-Sep-2011 2050 by 07		Batch: S30880	Dil: 10

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

DUPLICATE RESULTS

Analyte		AIC No.	Result	RPD	RPD Limit	Preparation Date	Analysis Date	Dil	Qual
Total Dissolved Solids		151006-1	100 mg/l			19Sep11 1459 by 290	20Sep11 1314 by 290		
	Batch: W37449	Duplicate	92 mg/l	8.88	10.0	19Sep11 1500 by 290	20Sep11 1314 by 290		
Total Dissolved Solids		151070-1	1000 mg/l			19Sep11 1459 by 290	20Sep11 1314 by 290		
	Batch: W37449	Duplicate	1000 mg/l	1.45	10.0	19Sep11 1500 by 290	20Sep11 1314 by 290		

LABORATORY CONTROL SAMPLE RESULTS

Analyte	Spike Amount	%	Limits	RPD	Limit	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	20 mg/l	104	90.0-110			S30880	15Sep11 1116 by 07	15Sep11 1449 by 07		

MATRIX SPIKE SAMPLE RESULTS

Analyte	Sample	Spike Amount	%	Limits	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	151087-1	20 mg/l	102	80.0-120	S30880	15Sep11 1116 by 07	15Sep11 1514 by 07		
	151087-1	20 mg/l	103	80.0-120	S30880	15Sep11 1116 by 07	15Sep11 1540 by 07		
	Relative Percent Difference:		0.0488	10.0	S30880				

LABORATORY BLANK RESULTS

Analyte	Result	RL	PQL	QC Sample	Preparation Date	Analysis Date	Qual
Total Dissolved Solids	< 10 mg/l	10	10	W37449-1	19Sep11 1500 by 290	20Sep11 1314 by 290	
Chloride	< 0.2 mg/l	0.2	0.2	S30880-1	15Sep11 1116 by 07	15Sep11 1423 by 07	

GBMc & Associates
219 Brown Ln
Bryant, AR 72022
(501) 847-7077 Fax (501) 847-7943

Chain of Custody

151099

Client/BILLING Information		SPECIAL INSTRUCTIONS/PRECAUTIONS:
Client:		email results to Greg phillips @ gphillips@gbmcassoc.com
Company:	GBMC & Associates	
Address:	219 Brown Lane	
	Bryant, AR 72022	Project Name / Number:
Phone No.:	(501) 847-7077	
Fax No.:	(501) 847-7943	

	Sample ID	Sample Description	Date	Time	Matrix S=Sed/Soil W=Water	Number of Containers	Composite or Grab	Chloride & TDS									
1	WEC-2	War Eagle creek 2	9/14/11	1030	W	1	G	X									
2	WEC-2 D	War Eagle creek 2 D		1033		1	G	X									
3	WEC-1	War Eagle Creek 1		1140		1	G	X									
4	HC-2	Holman Creek 2		1240		1	G	X									
5	HC-1	Holman Creek 1		1305		1	G	X									
6	TB-2	Town Branch 2		1330		1	G	X									
7	TB-1	Town Branch 1		1345		1	G	X									
8	001	outfall 001		1400		1	G	X									
	Preservative	(Sulfuric acid =S, Nitric acid =N, NaOH =B, Ice =I)						I									

Parameters for Analysis/Methods

Sampler(s): RHW / GDS
Shipment Method: GBMc Delivery
Turnaround Time Required: Normal

COC Completed by: Date: 9/15/11 Time: 0810
COC Checked by: GD Smith Date: 09/15/2011 Time: 0920
Relinquished by: GD Smith Date: 09/15/2011 Time: 0925
Received by: Date: 9-15-11 Time: 0925
Relinquished by: ____ Date: ____ Time: ____
Received in lab by: ____ Date: ____ Time: ____

LABORATORY USE ONLY: Samples Received On Ice? [✓ YES] or NO Sample Temperature: 2°C

V1 2 03/31/11

AMERICAN INTERPLEX
CORPORATION
LABORATORIES

October 21, 2011
Control No. 151850

GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
219 Brown Lane
Bryant, AR 72022

This report contains the analytical results and supporting information for samples submitted on October 14, 2011. Attached please find a copy of the Chain of Custody and/or other documents received. Note that any remaining sample will be discarded two weeks from the original report date unless other arrangements are made.

This report is intended for the sole use of the client listed above. Assessment of the data requires access to the entire document.

This report has been reviewed by the Laboratory Director or a qualified designee.

John Overbey
Laboratory Director

This document has been distributed to the following:

PDF cc: GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
gphillips@gbmcassoc.com

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

SAMPLE INFORMATION

Project Description:
Eight (8) water sample(s) received on October 14, 2011

Receipt Details:
A Chain of Custody was provided. The samples were delivered in one (1) ice chest.

Each sample container was checked for proper labeling, including date and time sampled. Sample containers were reviewed for proper type, adequate volume, integrity, temperature, preservation, and holding times. Any exceptions are noted below:

Sample Identification:

Laboratory ID	Client Sample ID	Sampled Date/Time	Notes
151850-1	TB-1 10/12/11 1805	12-Oct-2011 1805	
151850-2	TB-2 10/12/11 1745	12-Oct-2011 1745	
151850-3	HC-1 10/12/11 1710	12-Oct-2011 1710	
151850-4	HC-2 10/12/11 1730	12-Oct-2011 1730	
151850-5	WEC-1 10/13/11 1625	13-Oct-2011 1625	
151850-6	WEC-2 10/13/11 1250	13-Oct-2011 1250	
151850-7	WEC-1D 10/13/11 1627	13-Oct-2011 1627	
151850-8	001 10/12/11 1755	12-Oct-2011 1755	

Qualifiers:

D	Result is from a secondary dilution factor

References:
"Methods for Chemical Analysis of Water and Wastes", EPA/600/4-79-020 (Mar 1983) with updates and supplements EPA/600/5-91-010 (Jun 1991), EPA/600/R-92-129 (Aug 1992) and EPA/600/R-93-100 (Aug 1993).
"Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW846)", Third Edition.
"Standard Methods for the Examination of Water and Wastewaters", 20th edition, 1998.
"American Society for Testing and Materials" (ASTM).
"Association of Analytical Chemists" (AOAC).

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 151850-1
Sample Identification: TB-1 10/12/11 1805

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3 SM 2320B		**110** Analyzed: 19-Oct-2011 0857 by 93	1	**mg/l** Batch: W37725	
Total Dissolved Solids SM 2540C	Prep: 18-Oct-2011 1501 by 290	**180** Analyzed: 20-Oct-2011 1450 by 290	10	**mg/l** Batch: W37719	
Calcium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**45** Analyzed: 20-Oct-2011 1522 by 297	0.1	**mg/l** Batch: S31066	
Magnesium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**4.5** Analyzed: 20-Oct-2011 1522 by 297	0.03	**mg/l** Batch: S31066	
Potassium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**2.8** Analyzed: 20-Oct-2011 1522 by 297	1	**mg/l** Batch: S31066	
Sodium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**9.4** Analyzed: 20-Oct-2011 1522 by 297	1	**mg/l** Batch: S31066	
Chloride EPA 300.0	Prep: 14-Oct-2011 1652 by 07	**18** Analyzed: 15-Oct-2011 1150 by 07	0.2	**mg/l** Batch: S31065	
Sulfate EPA 300.0	Prep: 14-Oct-2011 1652 by 07	**14** Analyzed: 15-Oct-2011 1150 by 07	0.2	**mg/l** Batch: S31065	

AIC No. 151850-2
Sample Identification: TB-2 10/12/11 1745

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3 SM 2320B		**130** Analyzed: 19-Oct-2011 0857 by 93	1	**mg/l** Batch: W37725	
Total Dissolved Solids SM 2540C	Prep: 18-Oct-2011 1501 by 290	**620** Analyzed: 20-Oct-2011 1450 by 290	10	**mg/l** Batch: W37719	
Calcium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**64** Analyzed: 20-Oct-2011 1526 by 297	0.1	**mg/l** Batch: S31066	
Magnesium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**3.6** Analyzed: 20-Oct-2011 1526 by 297	0.03	**mg/l** Batch: S31066	
Potassium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**17** Analyzed: 20-Oct-2011 1526 by 297	1	**mg/l** Batch: S31066	
Sodium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**79** Analyzed: 20-Oct-2011 1526 by 297	1	**mg/l** Batch: S31066	
Chloride EPA 300.0	Prep: 14-Oct-2011 1652 by 07	**130** Analyzed: 17-Oct-2011 2240 by 07	2	**mg/l** Batch: S31065	D Dil: 10
Sulfate EPA 300.0	Prep: 14-Oct-2011 1652 by 07	**50** Analyzed: 15-Oct-2011 1216 by 07	0.2	**mg/l** Batch: S31065	

AIC No. 151850-3
Sample Identification: HC-1 10/12/11 1710

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3 SM 2320B		**120** Analyzed: 19-Oct-2011 0857 by 93	1	**mg/l** Batch: W37725	

ANALYTICAL RESULTS

AIC No. 151850-3 (Continued)
Sample Identification: HC-1 10/12/11 1710

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**270**	10	**mg/l**	
SM 2540C	Prep: 18-Oct-2011 1501 by 290	Analyzed: 20-Oct-2011 1450 by 290		Batch: W37719	
Calcium		**50**	0.1	**mg/l**	
EPA 200.7	Prep: 17-Oct-2011 0828 by 271	Analyzed: 20-Oct-2011 1530 by 297		Batch: S31066	
Magnesium		**4.0**	0.03	**mg/l**	
EPA 200.7	Prep: 17-Oct-2011 0828 by 271	Analyzed: 20-Oct-2011 1530 by 297		Batch: S31066	
Potassium		**2.8**	1	**mg/l**	
EPA 200.7	Prep: 17-Oct-2011 0828 by 271	Analyzed: 20-Oct-2011 1530 by 297		Batch: S31066	
Sodium		**5.0**	1	**mg/l**	
EPA 200.7	Prep: 17-Oct-2011 0828 by 271	Analyzed: 20-Oct-2011 1530 by 297		Batch: S31066	
Chloride		**8.8**	0.2	**mg/l**	
EPA 300.0	Prep: 14-Oct-2011 1652 by 07	Analyzed: 15-Oct-2011 1242 by 07		Batch: S31065	
Sulfate		**16**	0.2	**mg/l**	
EPA 300.0	Prep: 14-Oct-2011 1652 by 07	Analyzed: 15-Oct-2011 1242 by 07		Batch: S31065	

AIC No. 151850-4
Sample Identification: HC-2 10/12/11 1730

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3		**120**	1	**mg/l**	
SM 2320B		Analyzed: 19-Oct-2011 0857 by 93		Batch: W37725	
Total Dissolved Solids		**620**	10	**mg/l**	
SM 2540C	Prep: 18-Oct-2011 1501 by 290	Analyzed: 20-Oct-2011 1450 by 290		Batch: W37719	
Calcium		**55**	0.1	**mg/l**	
EPA 200.7	Prep: 17-Oct-2011 0828 by 271	Analyzed: 20-Oct-2011 1555 by 297		Batch: S31066	
Magnesium		**3.6**	0.03	**mg/l**	
EPA 200.7	Prep: 17-Oct-2011 0828 by 271	Analyzed: 20-Oct-2011 1555 by 297		Batch: S31066	
Potassium		**12**	1	**mg/l**	
EPA 200.7	Prep: 17-Oct-2011 0828 by 271	Analyzed: 20-Oct-2011 1555 by 297		Batch: S31066	
Sodium		**50**	1	**mg/l**	
EPA 200.7	Prep: 17-Oct-2011 0828 by 271	Analyzed: 20-Oct-2011 1555 by 297		Batch: S31066	
Chloride		**87**	2	**mg/l**	D
EPA 300.0	Prep: 14-Oct-2011 1652 by 07	Analyzed: 17-Oct-2011 2306 by 07		Batch: S31065	Dil: 10
Sulfate		**44**	0.2	**mg/l**	
EPA 300.0	Prep: 14-Oct-2011 1652 by 07	Analyzed: 15-Oct-2011 1308 by 07		Batch: S31065	

AIC No. 151850-5
Sample Identification: WEC-1 10/13/11 1625

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3		**73**	1	**mg/l**	
SM 2320B		Analyzed: 19-Oct-2011 0857 by 93		Batch: W37725	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 151850-5 (Continued)
Sample Identification: WEC-1 10/13/11 1625

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 18-Oct-2011 1501 by 290	**270** Analyzed: 20-Oct-2011 1450 by 290	10	**mg/l** Batch: W37719	
Calcium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**26** Analyzed: 20-Oct-2011 1559 by 297	0.1	**mg/l** Batch: S31066	
Magnesium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**2.9** Analyzed: 20-Oct-2011 1559 by 297	0.03	**mg/l** Batch: S31066	
Potassium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**2.1** Analyzed: 20-Oct-2011 1559 by 297	1	**mg/l** Batch: S31066	
Sodium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**3.2** Analyzed: 20-Oct-2011 1559 by 297	1	**mg/l** Batch: S31066	
Chloride EPA 300.0	Prep: 14-Oct-2011 1652 by 07	**4.6** Analyzed: 15-Oct-2011 1124 by 07	0.2	**mg/l** Batch: S31065	
Sulfate EPA 300.0	Prep: 14-Oct-2011 1652 by 07	**9.4** Analyzed: 15-Oct-2011 1124 by 07	0.2	**mg/l** Batch: S31065	

AIC No. 151850-6
Sample Identification: WEC-2 10/13/11 1250

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3 SM 2320B		**100** Analyzed: 19-Oct-2011 0857 by 93	1	**mg/l** Batch: W37725	
Total Dissolved Solids SM 2540C	Prep: 18-Oct-2011 1501 by 290	**230** Analyzed: 20-Oct-2011 1450 by 290	10	**mg/l** Batch: W37719	
Calcium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**46** Analyzed: 20-Oct-2011 1603 by 297	0.1	**mg/l** Batch: S31066	
Magnesium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**2.9** Analyzed: 20-Oct-2011 1603 by 297	0.03	**mg/l** Batch: S31066	
Potassium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**4.1** Analyzed: 20-Oct-2011 1603 by 297	1	**mg/l** Batch: S31066	
Sodium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**16** Analyzed: 20-Oct-2011 1603 by 297	1	**mg/l** Batch: S31066	
Chloride EPA 300.0	Prep: 14-Oct-2011 1652 by 07	**35** Analyzed: 15-Oct-2011 1333 by 07	0.2	**mg/l** Batch: S31065	
Sulfate EPA 300.0	Prep: 14-Oct-2011 1652 by 07	**19** Analyzed: 15-Oct-2011 1333 by 07	0.2	**mg/l** Batch: S31065	

AIC No. 151850-7
Sample Identification: WEC-1D 10/13/11 1627

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3 SM 2320B		**72** Analyzed: 19-Oct-2011 0857 by 93	1	**mg/l** Batch: W37725	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 151850-7 (Continued)
Sample Identification: WEC-1D 10/13/11 1627

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 18-Oct-2011 1501 by 290	**100** Analyzed: 20-Oct-2011 1450 by 290	10	**mg/l** Batch: W37719	
Calcium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**27** Analyzed: 20-Oct-2011 1607 by 297	0.1	**mg/l** Batch: S31066	
Magnesium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**3.0** Analyzed: 20-Oct-2011 1607 by 297	0.03	**mg/l** Batch: S31066	
Potassium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**2.2** Analyzed: 20-Oct-2011 1607 by 297	1	**mg/l** Batch: S31066	
Sodium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**3.3** Analyzed: 20-Oct-2011 1607 by 297	1	**mg/l** Batch: S31066	
Chloride EPA 300.0	Prep: 14-Oct-2011 1652 by 07	**4.6** Analyzed: 15-Oct-2011 1451 by 07	0.2	**mg/l** Batch: S31065	
Sulfate EPA 300.0	Prep: 14-Oct-2011 1652 by 07	**9.4** Analyzed: 15-Oct-2011 1451 by 07	0.2	**mg/l** Batch: S31065	

AIC No. 151850-8
Sample Identification: 001 10/12/11 1755

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3 SM 2320B		**130** Analyzed: 19-Oct-2011 0857 by 93	1	**mg/l** Batch: W37725	
Total Dissolved Solids SM 2540C	Prep: 18-Oct-2011 1501 by 290	**710** Analyzed: 20-Oct-2011 1450 by 290	10	**mg/l** Batch: W37719	
Calcium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**73** Analyzed: 20-Oct-2011 1610 by 297	0.1	**mg/l** Batch: S31066	
Magnesium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**2.8** Analyzed: 20-Oct-2011 1610 by 297	0.03	**mg/l** Batch: S31066	
Potassium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**26** Analyzed: 20-Oct-2011 1610 by 297	1	**mg/l** Batch: S31066	
Sodium EPA 200.7	Prep: 17-Oct-2011 0828 by 271	**150** Analyzed: 21-Oct-2011 1106 by 297	10	**mg/l** Batch: S31066	D Dil: 10
Chloride EPA 300.0	Prep: 14-Oct-2011 1652 by 07	**22** Analyzed: 15-Oct-2011 1517 by 07	0.2	**mg/l** Batch: S31065	
Sulfate EPA 300.0	Prep: 14-Oct-2011 1652 by 07	**7.5** Analyzed: 15-Oct-2011 1517 by 07	0.2	**mg/l** Batch: S31065	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

DUPLICATE RESULTS

Analyte		AIC No.	Result	RPD	RPD Limit	Preparation Date	Analysis Date	Dil	Qual
Total Dissolved Solids		151850-1	180 mg/l			18Oct11 1501 by 290	20Oct11 1450 by 290		
	Batch: W37719	Duplicate	170 mg/l	6.27	10.0	18Oct11 1502 by 290	20Oct11 1450 by 290		
Total Dissolved Solids		151850-2	620 mg/l			18Oct11 1501 by 290	20Oct11 1450 by 290		
	Batch: W37719	Duplicate	660 mg/l	6.09	10.0	18Oct11 1502 by 290	20Oct11 1450 by 290		
Alkalinity as CaCO3		151922-4	3300 mg/l				19Oct11 0857 by 93		
	Batch: W37725	Duplicate	3200 mg/l	1.23	20.0		19Oct11 0859 by 93		

LABORATORY CONTROL SAMPLE RESULTS

Analyte	Spike Amount	%	Limits	RPD	Limit	Batch	Preparation Date	Analysis Date	Dil	Qual
Calcium	10 mg/l	105	85.0-115			S31066	17Oct11 0828 by 271	20Oct11 1508 by 297		
Magnesium	10 mg/l	103	85.0-115			S31066	17Oct11 0828 by 271	20Oct11 1508 by 297		
Potassium	10 mg/l	104	85.0-115			S31066	17Oct11 0828 by 271	20Oct11 1508 by 297		
Sodium	10 mg/l	106	85.0-115			S31066	17Oct11 0828 by 271	20Oct11 1508 by 297		
Chloride	20 mg/l	101	90.0-110			S31065	14Oct11 1653 by 07	15Oct11 1007 by 07		
Sulfate	20 mg/l	101	90.0-110			S31065	14Oct11 1653 by 07	15Oct11 1007 by 07		

MATRIX SPIKE SAMPLE RESULTS

Analyte	Sample	Spike Amount	%	Limits	Batch	Preparation Date	Analysis Date	Dil	Qual
Calcium	151851-1	10 mg/l	106	75.0-125	S31066	17Oct11 0828 by 271	20Oct11 1511 by 297		
	151851-1	10 mg/l	107	75.0-125	S31066	17Oct11 0828 by 271	20Oct11 1514 by 297		
	Relative Percent Difference:		0.538	20.0	S31066				
Magnesium	151851-1	10 mg/l	75.6	75.0-125	S31066	17Oct11 0828 by 271	20Oct11 1511 by 297		
	151851-1	10 mg/l	86.7	75.0-125	S31066	17Oct11 0828 by 271	20Oct11 1514 by 297		
	Relative Percent Difference:		1.34	20.0	S31066				
Potassium	151851-1	10 mg/l	84.6	75.0-125	S31066	17Oct11 0828 by 271	20Oct11 1511 by 297		
	151851-1	10 mg/l	97.9	75.0-125	S31066	17Oct11 0828 by 271	20Oct11 1514 by 297		
	Relative Percent Difference:		1.75	20.0	S31066				
Chloride	151850-5	20 mg/l	106	80.0-120	S31065	14Oct11 1653 by 07	15Oct11 1033 by 07		
	151850-5	20 mg/l	106	80.0-120	S31065	14Oct11 1653 by 07	15Oct11 1058 by 07		
	Relative Percent Difference:		0.190	10.0	S31065				
Sulfate	151850-5	20 mg/l	108	80.0-120	S31065	14Oct11 1653 by 07	15Oct11 1033 by 07		
	151850-5	20 mg/l	109	80.0-120	S31065	14Oct11 1653 by 07	15Oct11 1058 by 07		
	Relative Percent Difference:		0.920	10.0	S31065				

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

LABORATORY BLANK RESULTS

Analyte	Result	RL	PQL	QC Sample	Preparation Date	Analysis Date	Qual
Alkalinity as CaCO3	< 1 mg/l	1	1	W37725-1		19Oct11 0857 by 93	
Total Dissolved Solids	< 10 mg/l	10	10	W37719-1	18Oct11 1502 by 290	20Oct11 1450 by 290	
Calcium	< 0.1 mg/l	0.1	0.1	S31066-1	17Oct11 0828 by 271	20Oct11 1504 by 297	
Magnesium	< 0.03 mg/l	0.03	0.03	S31066-1	17Oct11 0828 by 271	20Oct11 1504 by 297	
Potassium	< 1 mg/l	1	1	S31066-1	17Oct11 0828 by 271	20Oct11 1504 by 297	
Sodium	< 1 mg/l	1	1	S31066-1	17Oct11 0828 by 271	20Oct11 1504 by 297	
Chloride	< 0.2 mg/l	0.2	0.2	S31065-1	14Oct11 1653 by 07	15Oct11 0941 by 07	
Sulfate	< 0.2 mg/l	0.2	0.2	S31065-1	14Oct11 1653 by 07	15Oct11 0941 by 07	

GBMc & Associates
Strategic Environmental Services
219 Brown Ln.
Bryant, AR 72022
(501) 847-7077 Fax (501) 847-7943

Chain of Custody

121850

CLIENT INFORMATION		BILLING INFORMATION		SPECIAL INSTRUCTIONS/PRECAUTIONS:
Company:	GBMc & Associates	Bill To:	SAME	
Project Name/No.:	4450-11-075	Company:		
Send Report To:	Greg Phillips	Address:		
Address:	219 Brown Ln.			Parameters for Analysis/Methods
	Bryant, AR 72022	Phone No.:		
Phone/Fax No.:	501-847-7077	Fax No.:		

	Sample ID	Sample Description	Date	Time	Matrix S=Sed/Soil W=Water	Number of Containers	Composite or Grab	Chloride Sulfate TDS	Alkalinity	Calcium Magnesium	Potassium Sodium						
1	TB-1		10/12/11	1805	W	2	G	X	X	X	X						
2	TB-2		10/12/11	1745	W	2	G	X	X	X	X						
3	HC-1		10/12/11	1710	W	2	G	X	X	X	X						
4	HC-2		10/12/11	1730	W	2	G	X	X	X	X						
5	WEC-1		10/13/11	1625	W	2	G	X	X	X	X						
6	WEC-2		10/13/11	1250	W	2	G	X	X	X	X						
7	WEC-1d		10/13/11	1627	W	2	G	X			X						
8	DO1		10/12/11	1755	W	2	G	X	X	X	X						
	Preservative	(Sulfuric acid =S, Nitric acid =N, NaOH =B, Ice =I)						I	I	IN	IN						

Sampler(s): GLP/GDS
Shipment Method: GBMc deliv.
Turnaround Time Required: NORMAL

COC Completed by: Date: 10/14/11 Time: 1030
COC Checked by: Date: 10/14/2011 ~~GDS~~ Time: 1031
Relinquished by: Date: 10/14/11 Time: 1040
Received by: Date: 10/14/2011 Time: 1041
Relinquished by: Date: 10/14/2011 Time: 1247
Received in lab by: Date: 10-14-11 Time: 1248

LABORATORY USE ONLY:
Samples Received On Ice?: [✓ YES] or NO
Sample Temperature: 2°C

V1.2 07/07/09

AMERICAN INTERPLEX
CORPORATION
LABORATORIES

GBMc & Associates, Inc.
ATTN: Mr. Russell McLaren
219 Brown Lane
Bryant, AR 72022

This report contains the analytical results and supporting information for samples submitted on November 18, 2011. Attached please find a copy of the Chain of Custody and/or other documents received. Note that any remaining sample will be discarded two weeks from the original report date unless other arrangements are made.

This report is intended for the sole use of the client listed above. Assessment of the data requires access to the entire document.

This report has been reviewed by the Laboratory Director or a qualified designee.

John Overbey
Laboratory Director

This document has been distributed to the following:

PDF cc: GBMc & Associates, Inc.
ATTN: Mr. Russell McLaren
rmclaren@gbmcassoc.com

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

SAMPLE INFORMATION

Project Description:
Eight (8) water sample(s) received on November 18, 2011

Receipt Details:
A Chain of Custody was provided. The samples were delivered in one (1) ice chest.

Each sample container was checked for proper labeling, including date and time sampled. Sample containers were reviewed for proper type, adequate volume, integrity, temperature, preservation, and holding times. Any exceptions are noted below:

Sample Identification:

Laboratory ID	Client Sample ID	Sampled Date/Time	Notes
152926-1	WEC-1 War Eagle Creek (u/s) 11/17/2011 1155	17-Nov-2011 1155	
152926-2	WEC-2 War Eagle Creek (d/s) 11/17/2011 1120	17-Nov-2011 1120	
152926-3	WEC-2 Dup War Eagle Creek (d/s) 11/17/2011 1125	17-Nov-2011 1125	
152926-4	HC-1 Holman Creek (u/s) 11/17/2011 1225	17-Nov-2011 1225	
152926-5	HC-2 Holman Creek (d/s) 11/17/2011 1250	17-Nov-2011 1250	
152926-6	TB-1 Town Branch (u/s) 11/17/2011 1310	17-Nov-2011 1310	
152926-7	TB-2 Town Branch (d/s) 11/17/2011 1330	17-Nov-2011 1330	
152926-8	001 Outfall 001 11/17/2011 1320	17-Nov-2011 1320	

Qualifiers:
D Result is from a secondary dilution factor

References:
"Methods for Chemical Analysis of Water and Wastes", EPA/600/4-79-020 (Mar 1983) with updates and supplements EPA/600/5-91-010 (Jun 1991), EPA/600/R-92-129 (Aug 1992) and EPA/600/R-93-100 (Aug 1993).
"Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW846)", Third Edition.
"Standard Methods for the Examination of Water and Wastewaters", 20th edition, 1998.
"American Society for Testing and Materials" (ASTM).
"Association of Analytical Chemists" (AOAC).

AMERICAN INTERPLEX
CORPORATION
LABORATORIES

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 152926-1
Sample Identification: WEC-1 War Eagle Creek (u/s) 11/17/2011 1155

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**110**	10	**mg/l**	
SM 2540C	Prep: 22-Nov-2011 1729 by 258	Analyzed: 23-Nov-2011 1537 by 258		Batch: W38148	
Chloride		**10**	0.2	**mg/l**	
EPA 300.0	Prep: 18-Nov-2011 1359 by 07	Analyzed: 18-Nov-2011 2007 by 07		Batch: S31262	

AIC No. 152926-2
Sample Identification: WEC-2 War Eagle Creek (d/s) 11/17/2011 1120

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**110**	10	**mg/l**	
SM 2540C	Prep: 22-Nov-2011 1729 by 258	Analyzed: 23-Nov-2011 1537 by 258		Batch: W38148	
Chloride		**7.0**	0.2	**mg/l**	
EPA 300.0	Prep: 18-Nov-2011 1359 by 07	Analyzed: 18-Nov-2011 2033 by 07		Batch: S31262	

AIC No. 152926-3
Sample Identification: WEC-2 Dup War Eagle Creek (d/s) 11/17/2011 1125

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**110**	10	**mg/l**	
SM 2540C	Prep: 22-Nov-2011 1729 by 258	Analyzed: 23-Nov-2011 1537 by 258		Batch: W38148	
Chloride		**7.0**	0.2	**mg/l**	
EPA 300.0	Prep: 18-Nov-2011 1359 by 07	Analyzed: 18-Nov-2011 2059 by 07		Batch: S31262	

AIC No. 152926-4
Sample Identification: HC-1 Holman Creek (u/s) 11/17/2011 1225

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**250**	10	**mg/l**	
SM 2540C	Prep: 22-Nov-2011 1729 by 258	Analyzed: 23-Nov-2011 1537 by 258		Batch: W38148	
Chloride		**7.7**	0.2	**mg/l**	
EPA 300.0	Prep: 18-Nov-2011 1359 by 07	Analyzed: 18-Nov-2011 2124 by 07		Batch: S31262	

AIC No. 152926-5
Sample Identification: HC-2 Holman Creek (d/s) 11/17/2011 1250

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**180**	10	**mg/l**	
SM 2540C	Prep: 22-Nov-2011 1729 by 258	Analyzed: 23-Nov-2011 1537 by 258		Batch: W38148	
Chloride		**27**	0.2	**mg/l**	
EPA 300.0	Prep: 18-Nov-2011 1359 by 07	Analyzed: 18-Nov-2011 2150 by 07		Batch: S31262	

AMERICAN INTERPLEX
CORPORATION
LABORATORIES

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 152926-6
Sample Identification: TB-1 Town Branch (u/s) 11/17/2011 1310

Analyte	Result	RL	Units	Qualifier
Total Dissolved Solids	**210**	10	**mg/l**	
SM 2540C Prep: 22-Nov-2011 1729 by 258	Analyzed: 23-Nov-2011 1537 by 258		Batch: W38148	
Chloride	**20**	0.2	**mg/l**	
EPA 300.0 Prep: 18-Nov-2011 1359 by 07	Analyzed: 18-Nov-2011 2216 by 07		Batch: S31262	

AIC No. 152926-7
Sample Identification: TB-2 Town Branch (d/s) 11/17/2011 1330

Analyte	Result	RL	Units	Qualifier
Total Dissolved Solids	**270**	10	**mg/l**	
SM 2540C Prep: 22-Nov-2011 1729 by 258	Analyzed: 23-Nov-2011 1537 by 258		Batch: W38148	
Chloride	**80**	2	**mg/l**	D
EPA 300.0 Prep: 18-Nov-2011 1359 by 07	Analyzed: 21-Nov-2011 1020 by 07		Batch: S31262	Dil: 10

AIC No. 152926-8
Sample Identification: 001 Outfall 001 11/17/2011 1320

Analyte	Result	RL	Units	Qualifier
Total Dissolved Solids	**430**	10	**mg/l**	
SM 2540C Prep: 22-Nov-2011 1729 by 258	Analyzed: 23-Nov-2011 1537 by 258		Batch: W38148	
Chloride	**130**	2	**mg/l**	D
EPA 300.0 Prep: 18-Nov-2011 1359 by 07	Analyzed: 18-Nov-2011 2308 by 07		Batch: S31262	Dil: 10

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

DUPLICATE RESULTS

Analyte	AIC No.	Result	RPD	RPD Limit	Preparation Date	Analysis Date	Dil	Qual
Total Dissolved Solids	152945-1	2000 mg/l			22Nov11 1729 by 258	23Nov11 1537 by 258		
Batch: W38148	Duplicate	2100 mg/l	1.55	10.0	22Nov11 1729 by 258	23Nov11 1537 by 258		
Total Dissolved Solids	153002-5	1900 mg/l			22Nov11 1729 by 258	23Nov11 1537 by 258		
Batch: W38148	Duplicate	1800 mg/l	6.51	10.0	22Nov11 1729 by 258	23Nov11 1537 by 258		

LABORATORY CONTROL SAMPLE RESULTS

Analyte	Spike Amount	%	Limits	RPD	Limit	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	20 mg/l	105	90.0-110			S31262	18Nov11 0906 by 07	18Nov11 1351 by 07		

MATRIX SPIKE SAMPLE RESULTS

Analyte	Sample	Spike Amount	%	Limits	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	152906-1	20 mg/l	102	80.0-120	S31262	18Nov11 0906 by 07	18Nov11 1541 by 07		
	152906-1	20 mg/l	102	80.0-120	S31262	18Nov11 0906 by 07	18Nov11 1609 by 07		
	Relative Percent Difference:		0.349	10.0	S31262				

LABORATORY BLANK RESULTS

Analyte	Result	RL	PQL	QC Sample	Preparation Date	Analysis Date	Qual
Total Dissolved Solids	< 10 mg/l	10	10	W38148-1	22Nov11 1729 by 258	23Nov11 1537 by 258	
Chloride	< 0.2 mg/l	0.2	0.2	S31262-1	18Nov11 0906 by 07	18Nov11 1325 by 07	

GBM^c & Associates
219 Brown Ln.
Bryant, AR 72022
(501) 847-7077 Fax (501) 847-7943

152926

Chain of Custody

Client/BILLING Information		SPECIAL INSTRUCTIONS/PRECAUTIONS:
Client:		
Company:	GBM^c & Associates	
Address:	219 Brown Lane	
	Bryant, AR 72022	Project Name / Number:
Phone No.:	501-847-7077	
Fax No.:	501-847-7943	

Parameters for Analysis/Methods

Sample ID	Sample Description	Date	Time	Matrix S=Sed/Soil W=Water	Number of Containers	Composite or Grab	Chloride, TDS									
1 WEC-1	War Eagle Creek (u/s)	11/17/2011	1155	W	1	Grab	X									
2 WEC-2	War Eagle Creek (d/s)	11/17/2011	1120	W	1	Grab	X									
3 WEC-2 Dup	War Eagle Creek (d/s)	11/17/2011	1125	W	1	Grab	X									
4 HC-1	Holman Creek (u/s)	11/17/2011	1225	W	1	Grab	X									
5 HC-2	Holman Creek (d/s)	11/17/2011	1250	W	1	Grab	X									
6 TB-1	Town Branch (u/s)	11/17/2011	1310	W	1	Grab	X									
7 TB-2	Town Branch (d/s)	11/17/2011	1330	W	1	Grab	X									
8 001	Outfall 001	11/17/2011	1320	W	1	Grab	X									
Preservative	(Sulfuric acid =S, Nitric acid =N, NaOH =B, Ice =I)						I									

Sampler(s): GDS/RHW

Shipment Method: GBM^c Delivery

Turnaround Time Required: Normal

COC Completed by: Date: 11/18/2011 Time: 0905

COC Checked by: Date: 11/18/11 Time: 0910

Relinquished by: Date: 11/18/2011 Time: 1005

Received by: Date: Time:

Relinquished by: Date: Time:

Received in lab by: Date: 11-18-11 Time: 1005

LABORATORY USE ONLY: Samples Received On Ice?: [✓ YES] or NO

Sample Temperature: 2 °C

V1.2 11/18/11

AMERICAN INTERPLEX
CORPORATION
LABORATORIES

December 14, 2011
Control No. 153425
Page 1 of 5

GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
219 Brown Lane
Bryant, AR 72022

This report contains the analytical results and supporting information for samples submitted on December 9, 2011. Attached please find a copy of the Chain of Custody and/or other documents received. Note that any remaining sample will be discarded two weeks from the original report date unless other arrangements are made.

This report is intended for the sole use of the client listed above. Assessment of the data requires access to the entire document.

This report has been reviewed by the Laboratory Director or a qualified designee.

Steve Bradford

Steve Bradford
Deputy Laboratory Director

This document has been distributed to the following:

PDF cc: GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
gphillips@gbmcassoc.com

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

SAMPLE INFORMATION

Project Description:
Eight (8) water sample(s) received on December 9, 2011
4450-11-075

Receipt Details:
A Chain of Custody was provided. The samples were delivered in one (1) ice chest.

Each sample container was checked for proper labeling, including date and time sampled. Sample containers were reviewed for proper type, adequate volume, integrity, temperature, preservation, and holding times. Any exceptions are noted below:

Sample Identification:

Laboratory ID	Client Sample ID	Sampled Date/Time	Notes
153425-1	TB-1 12/8/11 1205	08-Dec-2011 1205	
153425-2	TB-1 D 12/8/11 1210	08-Dec-2011 1210	
153425-3	001 12/8/11 1230	08-Dec-2011 1230	
153425-4	TB-2 12/8/11 1240	08-Dec-2011 1240	
153425-5	HC-2 12/8/11 1255	08-Dec-2011 1255	
153425-6	WEC-2 12/8/11 1315	08-Dec-2011 1315	
153425-7	WEC-1 12/8/11 1345	08-Dec-2011 1345	
153425-8	HC-1 12/8/11 1415	08-Dec-2011 1415	

Qualifiers:

D	Result is from a secondary dilution factor

References:
"Methods for Chemical Analysis of Water and Wastes", EPA/600/4-79-020 (Mar 1983) with updates and supplements EPA/600/5-91-010 (Jun 1991), EPA/600/R-92-129 (Aug 1992) and EPA/600/R-93-100 (Aug 1993).
"Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW846)", Third Edition.
"Standard Methods for the Examination of Water and Wastewaters", 20th edition, 1998.
"American Society for Testing and Materials" (ASTM).
"Association of Analytical Chemists" (AOAC).

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 153425-1
Sample Identification: TB-1 12/8/11 1205

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**170**	10	**mg/l**	
SM 2540C	Prep: 12-Dec-2011 1459 by 290	Analyzed: 13-Dec-2011 1537 by 290		Batch: W38318	
Chloride		**12**	0.2	**mg/l**	
EPA 300.0	Prep: 09-Dec-2011 1314 by 07	Analyzed: 09-Dec-2011 1542 by 07		Batch: S31373	

AIC No. 153425-2
Sample Identification: TB-1 D 12/8/11 1210

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**160**	10	**mg/l**	
SM 2540C	Prep: 12-Dec-2011 1459 by 290	Analyzed: 13-Dec-2011 1537 by 290		Batch: W38318	
Chloride		**12**	0.2	**mg/l**	
EPA 300.0	Prep: 09-Dec-2011 1314 by 07	Analyzed: 09-Dec-2011 1606 by 07		Batch: S31373	

AIC No. 153425-3
Sample Identification: 001 12/8/11 1230

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**430**	10	**mg/l**	
SM 2540C	Prep: 12-Dec-2011 1459 by 290	Analyzed: 13-Dec-2011 1537 by 290		Batch: W38318	
Chloride		**110**	2	**mg/l**	D
EPA 300.0	Prep: 09-Dec-2011 1314 by 07	Analyzed: 09-Dec-2011 1631 by 07		Batch: S31373	Dil: 10

AIC No. 153425-4
Sample Identification: TB-2 12/8/11 1240

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**250**	10	**mg/l**	
SM 2540C	Prep: 12-Dec-2011 1459 by 290	Analyzed: 13-Dec-2011 1537 by 290		Batch: W38318	
Chloride		**42**	0.2	**mg/l**	
EPA 300.0	Prep: 09-Dec-2011 1314 by 07	Analyzed: 09-Dec-2011 1640 by 07		Batch: S31373	

AIC No. 153425-5
Sample Identification: HC-2 12/8/11 1255

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**150**	10	**mg/l**	
SM 2540C	Prep: 12-Dec-2011 1459 by 290	Analyzed: 13-Dec-2011 1537 by 290		Batch: W38318	
Chloride		**16**	0.2	**mg/l**	
EPA 300.0	Prep: 09-Dec-2011 1314 by 07	Analyzed: 09-Dec-2011 1906 by 07		Batch: S31373	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 153425-6
Sample Identification: WEC-2 12/8/11 1315

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**80**	10	**mg/l**	
SM 2540C	Prep: 12-Dec-2011 1459 by 290	Analyzed: 13-Dec-2011 1537 by 290		Batch: W38318	
Chloride		**4.6**	0.2	**mg/l**	
EPA 300.0	Prep: 09-Dec-2011 1314 by 07	Analyzed: 09-Dec-2011 1932 by 07		Batch: S31373	

AIC No. 153425-7
Sample Identification: WEC-1 12/8/11 1345

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**70**	10	**mg/l**	
SM 2540C	Prep: 12-Dec-2011 1459 by 290	Analyzed: 13-Dec-2011 1537 by 290		Batch: W38318	
Chloride		**3.4**	0.2	**mg/l**	
EPA 300.0	Prep: 09-Dec-2011 1314 by 07	Analyzed: 09-Dec-2011 1958 by 07		Batch: S31373	

AIC No. 153425-8
Sample Identification: HC-1 12/8/11 1415

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**79**	10	**mg/l**	
SM 2540C	Prep: 12-Dec-2011 1459 by 290	Analyzed: 13-Dec-2011 1537 by 290		Batch: W38318	
Chloride		**5.7**	0.2	**mg/l**	
EPA 300.0	Prep: 09-Dec-2011 1314 by 07	Analyzed: 09-Dec-2011 2024 by 07		Batch: S31373	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

DUPLICATE RESULTS

Analyte		AIC No.	Result	RPD	RPD Limit	Preparation Date	Analysis Date	Dil	Qual
Total Dissolved Solids		153356-1	1300 mg/l			12Dec11 1459 by 290	13Dec11 1537 by 290		
	Batch: W38318	Duplicate	1300 mg/l	0.770	10.0	12Dec11 1459 by 290	13Dec11 1537 by 290		
Total Dissolved Solids		153429-4	170 mg/l			12Dec11 1459 by 290	13Dec11 1537 by 290		
	Batch: W38318	Duplicate	760 mg/l	0.784	10.0	12Dec11 1459 by 290	13Dec11 1537 by 290		

LABORATORY CONTROL SAMPLE RESULTS

Analyte	Spike Amount	%	Limits	RPD	Limit	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	20 mg/l	99.3	90.0-110			S31373	09Dec11 1315 by 07	09Dec11 1407 by 07		

MATRIX SPIKE SAMPLE RESULTS

Analyte	Sample	Spike Amount	%	Limits	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	153425-1	20 mg/l	96.3	80.0-120	S31373	09Dec11 1315 by 07	09Dec11 1431 by 07		
	153425-1	20 mg/l	98.2	80.0-120	S31373	09Dec11 1315 by 07	09Dec11 1455 by 07		
	Relative Percent Difference:		1.81	10.0	S31373				

LABORATORY BLANK RESULTS

Analyte	Result	RL	PQL	QC Sample	Preparation Date	Analysis Date	Qual
Total Dissolved Solids	< 10 mg/l	10	10	W38318-1	12Dec11 1459 by 290	13Dec11 1537 by 290	
Chloride	< 0.2 mg/l	0.2	0.2	S31373-1	09Dec11 1315 by 07	09Dec11 1343 by 07	

GBM^c & Associates
219 Brown Ln.
Bryant, AR 72022
(501) 847-7077 Fax (501) 847-7943

Chain of Custody

153425

Client/BILLING Information	
Client:	
Company:	GBM^c & Associates
Address:	219 Brown Lane
	Bryant, AR 72022
Phone No.:	501-847-7077
Fax No.:	501-847-7943

SPECIAL INSTRUCTIONS/PRECAUTIONS:

Email results to Greg phillips @ gphillips@gbmcassoc.com

Project Name / Number: 4450-11-015

Parameters for Analysis/Methods

	Sample ID	Sample Description	Date	Time	Matrix S=Sed/Soil W=Water	Number of Containers	Composite or Grab	TDS, Cl									
1	TB-1		12/8/11	1205	W	1	G	X									
2	TB-1 D			1210		1		X									
3	001			1230		1		x									
4	TB-2			1240		1		X									
5	HC-2			1255		1		X									
6	WEC-2			1315		1		X									
7	WEC-1			1345		1		X									
8	HC-1			1415		1		X									
	—	—	—	—	—	—	—	—									
	Preservative	(Sulfuric acid =S, Nitric acid =N, NaOH =B, Ice =I)						I									

Sampler(s): RHW / GDS

Shipment Method: GBMc Delivery

Turnaround Time Required: Normal

COC Completed by: Date: 12/9/11 Time: 0850

COC Checked by: Date: 12/09/2011 Time: 0855

Relinquished by: Date: 12/9/11 Time: 1011

Received by: ______ Date: ______ Time: ______

Relinquished by: ______ Date: ______ Time: ______

Received in lab by: Date: 12 9-11 Time: 1011

LABORATORY USE ONLY: Samples Received On Ice?: [✓ YES] or NO

Sample Temperature: 2°C

V1.2 12/09/11

AMERICAN INTERPLEX CORPORATION
LABORATORIES

January 23, 2012
Control No. 154499

GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
219 Brown Lane
Bryant, AR 72022

This report contains the analytical results and supporting information for samples submitted on January 19, 2012. Attached please find a copy of the Chain of Custody and/or other documents received. Note that any remaining sample will be discarded two weeks from the original report date unless other arrangements are made.

This report is intended for the sole use of the client listed above. Assessment of the data requires access to the entire document.

This report has been reviewed by the Laboratory Director or a qualified designee.

John Overbey
Laboratory Director

This document has been distributed to the following:

PDF cc: GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
gphillips@gbmcassoc.com

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

SAMPLE INFORMATION

Project Description:

Eight (8) water sample(s) received on January 19, 2012
4450-11-075

Receipt Details:

A Chain of Custody was provided. The samples were delivered in one (1) ice chest.

Each sample container was checked for proper labeling, including date and time sampled. Sample containers were reviewed for proper type, adequate volume, integrity, temperature, preservation, and holding times. Any exceptions are noted below:

Sample Identification:

Laboratory ID	Client Sample ID	Sampled Date/Time	Notes
154499-1	001 1/18/12 1345	18-Jan-2012 1345	
154499-2	WEC-2 1/18/12 1125	18-Jan-2012 1125	
154499-3	WEC-1 1/18/12 1205	18-Jan-2012 1205	
154499-4	WEC-1 Dup 1/18/12 1210	18-Jan-2012 1210	
154499-5	TB-1 1/18/12 1350	18-Jan-2012 1350	
154499-6	TB-2 1/18/12 1330	18-Jan-2012 1330	
154499-7	HC-1 1/18/12 1310	18-Jan-2012 1310	
154499-8	HC-2 1/18/12 1245	18-Jan-2012 1245	

Qualifiers:

D	Result is from a secondary dilution factor

References:

"Methods for Chemical Analysis of Water and Wastes", EPA/600/4-79-020 (Mar 1983) with updates and supplements EPA/600/5-91-010 (Jun 1991), EPA/600/R-92-129 (Aug 1992) and EPA/600/R-93-100 (Aug 1993).
"Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW846)", Third Edition.
"Standard Methods for the Examination of Water and Wastewaters", 20th edition, 1998.
"American Society for Testing and Materials" (ASTM).
"Association of Analytical Chemists" (AOAC).

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 154499-1
Sample Identification: 001 1/18/12 1345

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**550**	10	**mg/l**	
SM 2540C	Prep: 20-Jan-2012 1401 by 285	Analyzed: 22-Jan-2012 1637 by 285		Batch: W38715	
Chloride		**170**	2	**mg/l**	D
EPA 300.0	Prep: 19-Jan-2012 1456 by 07	Analyzed: 19-Jan-2012 1901 by 07		Batch: S31630	Dil: 10

AIC No. 154499-2
Sample Identification: WEC-2 1/18/12 1125

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**94**	10	**mg/l**	
SM 2540C	Prep: 20-Jan-2012 1401 by 285	Analyzed: 22-Jan-2012 1637 by 285		Batch: W38715	
Chloride		**6.6**	0.2	**mg/l**	
EPA 300.0	Prep: 19-Jan-2012 1456 by 07	Analyzed: 19-Jan-2012 1948 by 07		Batch: S31630	

AIC No. 154499-3
Sample Identification: WEC-1 1/18/12 1205

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**58**	10	**mg/l**	
SM 2540C	Prep: 20-Jan-2012 1401 by 285	Analyzed: 23-Jan-2012 1313 by 258		Batch: W38715	
Chloride		**3.7**	0.2	**mg/l**	
EPA 300.0	Prep: 19-Jan-2012 1456 by 07	Analyzed: 19-Jan-2012 2012 by 07		Batch: S31630	

AIC No. 154499-4
Sample Identification: WEC-1 Dup 1/18/12 1210

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**56**	10	**mg/l**	
SM 2540C	Prep: 20-Jan-2012 1401 by 285	Analyzed: 22-Jan-2012 1637 by 285		Batch: W38715	
Chloride		**3.8**	0.2	**mg/l**	
EPA 300.0	Prep: 19-Jan-2012 1456 by 07	Analyzed: 19-Jan-2012 2036 by 07		Batch: S31630	

AIC No. 154499-5
Sample Identification: TB-1 1/18/12 1350

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**170**	10	**mg/l**	
SM 2540C	Prep: 20-Jan-2012 1401 by 285	Analyzed: 22-Jan-2012 1637 by 285		Batch: W38715	
Chloride		**17**	0.2	**mg/l**	
EPA 300.0	Prep: 19-Jan-2012 1456 by 07	Analyzed: 19-Jan-2012 2147 by 07		Batch: S31630	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 154499-6
Sample Identification: TB-2 1/18/12 1330

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**380**	10	**mg/l**	
SM 2540C	Prep: 20-Jan-2012 1401 by 285	Analyzed: 22-Jan-2012 1637 by 285		Batch: W38715	
Chloride		**100**	2	**mg/l**	D
EPA 300.0	Prep: 19-Jan-2012 1456 by 07	Analyzed: 20-Jan-2012 0910 by 07		Batch: S31630	Dil: 10

AIC No. 154499-7
Sample Identification: HC-1 1/18/12 1310

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**100**	10	**mg/l**	
SM 2540C	Prep: 20-Jan-2012 1401 by 285	Analyzed: 22-Jan-2012 1637 by 285		Batch: W38715	
Chloride		**6.6**	0.2	**mg/l**	
EPA 300.0	Prep: 19-Jan-2012 1456 by 07	Analyzed: 19-Jan-2012 2235 by 07		Batch: S31630	

AIC No. 154499-8
Sample Identification: HC-2 1/18/12 1245

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**210**	10	**mg/l**	
SM 2540C	Prep: 20-Jan-2012 1401 by 285	Analyzed: 22-Jan-2012 1637 by 285		Batch: W38715	
Chloride		**38**	0.2	**mg/l**	
EPA 300.0	Prep: 19-Jan-2012 1456 by 07	Analyzed: 19-Jan-2012 2259 by 07		Batch: S31630	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

DUPLICATE RESULTS

Analyte		AIC No.	Result	RPD	RPD Limit	Preparation Date	Analysis Date	Dil	Qual
Total Dissolved Solids		154494-1	160 mg/l			20Jan12 1401 by 285	22Jan12 1637 by 285		
	Batch: W38715	Duplicate	150 mg/l	3.87	10.0	20Jan12 1401 by 285	22Jan12 1637 by 285		
Total Dissolved Solids		154499-1	550 mg/l			20Jan12 1401 by 285	22Jan12 1637 by 285		
	Batch: W38715	Duplicate	540 mg/l	1.09	10.0	20Jan12 1401 by 285	22Jan12 1637 by 285		

LABORATORY CONTROL SAMPLE RESULTS

Analyte	Spike Amount	%	Limits	RPD	Limit	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	20 mg/l	108	90.0-110			S31630	19Jan12 1420 by 07	19Jan12 1442 by 07		

MATRIX SPIKE SAMPLE RESULTS

Analyte	Sample	Spike Amount	%	Limits	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	154516-8	20 mg/l	110	80.0-120	S31630	19Jan12 1420 by 07	19Jan12 1506 by 07		
	154516-8	20 mg/l	105	80.0-120	S31630	19Jan12 1420 by 07	19Jan12 1530 by 07		
	Relative Percent Difference:		2.89	10.0	S31630				

LABORATORY BLANK RESULTS

Analyte	Result	RL	PQL	QC Sample	Preparation Date	Analysis Date	Qual
Total Dissolved Solids	< 10 mg/l	10	10	W38715-1	20Jan12 1401 by 285	22Jan12 1637 by 285	
Chloride	< 0.2 mg/l	0.2	0.2	S31630-1	19Jan12 1417 by 07	19Jan12 1418 by 07	

154499

GBM^c & Associates

219 Brown Ln.
Bryant, AR 72022
(501) 847-7077 Fax (501) 847-7943

Chain of Custody

Client/BILLING Information

Client:
Company: GBM^c & Associates
Address: 219 Brown Lane
Bryant, AR 72022
Phone No.: 501-847-7077
Fax No.: 501-847-7943

SPECIAL INSTRUCTIONS/PRECAUTIONS:

Email results to Greg phillips @ gphillips@gbmcassoc.com

Project Name / Number: 4450-11-075

Parameters for Analysis/Methods

	Sample ID	Sample Description	Date	Time	Matrix S=Sed/Soil W=Water	Number of Containers	Composite or Grab	CL, TDS									
1	001		1/18/12	1345	W	1	G	x									
2	WEC-2			1125	W	1		x									
3	WEC-1			1205	W	1		x									
4	WEC-1 dup			1210	W	1		x									
5	TB-1			1350	W	1		x									
6	TB-2			1330	W	1		x									
7	HC-1			1310	W	1		x									
8	HC-2			1245	W	1		x									
	Preservative	(Sulfuric acid =S, Nitric acid =N, NaOH =B, Ice =I)						I									

Sampler(s): RHW/GLP
Shipment Method: GBMc Delivery
Turnaround Time Required: Normal

COC Completed by: Peter Walr Date: 1/19/12 Time: 0836
COC Checked by: Date: 1/19/12 Time: 0840

Relinquished by: Date: 1/19/12 Time: 0915
Received by: ______ Date: ______ Time: ______

Relinquished by: ______ Date: ______ Time: ______
Received in lab by: Date: 1-19-12 Time: 0915

LABORATORY USE ONLY: Samples Received On Ice?: [✓ YES] or NO
Sample Temperature: 2°C

V1.2 10/21/11

AMERICAN INTERPLEX CORPORATION
LABORATORIES

GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
219 Brown Lane
Bryant, AR 72022

This report contains the analytical results and supporting information for samples submitted on February 17, 2012. Attached please find a copy of the Chain of Custody and/or other documents received. Note that any remaining sample will be discarded two weeks from the original report date unless other arrangements are made.

This report is intended for the sole use of the client listed above. Assessment of the data requires access to the entire document.

This report has been reviewed by the Laboratory Director or a qualified designee.

John Overbey
Laboratory Director

This document has been distributed to the following:

PDF cc: GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
gphillips@gbmcassoc.com

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

SAMPLE INFORMATION

Project Description:
Eight (8) water sample(s) received on February 17, 2012

Receipt Details:
A Chain of Custody was provided. The samples were delivered in one (1) ice chest.

Each sample container was checked for proper labeling, including date and time sampled. Sample containers were reviewed for proper type, adequate volume, integrity, temperature, preservation, and holding times. Any exceptions are noted below:

Sample Identification:

Laboratory ID	Client Sample ID	Sampled Date/Time	Notes
155373-1	WEC-2 2/16/12 1040	16-Feb-2012 1040	
155373-2	WEC-1 2/16/12 1120	16-Feb-2012 1120	
155373-3	HC-1 2/16/12 1155	16-Feb-2012 1155	
155373-4	HC-2 2/16/12 1220	16-Feb-2012 1220	
155373-5	TB-2 2/16/12 1240	16-Feb-2012 1240	
155373-6	TB-1 2/16/12 1255	16-Feb-2012 1255	
155373-7	001 2/16/12 1305	16-Feb-2012 1305	
155373-8	WEC-1D 2/16/12 1120	16-Feb-2012 1120	

Notes:
155373-8: Not listed on chain of custody

Qualifiers:

D	Result is from a secondary dilution factor

References:
"Methods for Chemical Analysis of Water and Wastes", EPA/600/4-79-020 (Mar 1983) with updates and supplements EPA/600/5-91-010 (Jun 1991), EPA/600/R-92-129 (Aug 1992) and EPA/600/R-93-100 (Aug 1993).
"Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW846)", Third Edition.
"Standard Methods for the Examination of Water and Wastewaters", 20th edition, 1998.
"American Society for Testing and Materials" (ASTM).
"Association of Analytical Chemists" (AOAC).

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 155373-1
Sample Identification: WEC-2 2/16/12 1040

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**72**	10	**mg/l**	
SM 2540C	Prep: 20-Feb-2012 0924 by 285	Analyzed: 22-Feb-2012 0841 by 285		Batch: W38995	
Chloride		**3.5**	0.2	**mg/l**	
EPA 300.0	Prep: 17-Feb-2012 1416 by 07	Analyzed: 17-Feb-2012 1757 by 07		Batch: S31839	

AIC No. 155373-2
Sample Identification: WEC-1 2/16/12 1120

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**88**	10	**mg/l**	
SM 2540C	Prep: 20-Feb-2012 0924 by 285	Analyzed: 22-Feb-2012 0841 by 285		Batch: W38995	
Chloride		**3.4**	0.2	**mg/l**	
EPA 300.0	Prep: 17-Feb-2012 1416 by 07	Analyzed: 20-Feb-2012 0958 by 07		Batch: S31839	

AIC No. 155373-3
Sample Identification: HC-1 2/16/12 1155

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**100**	10	**mg/l**	
SM 2540C	Prep: 20-Feb-2012 0924 by 285	Analyzed: 22-Feb-2012 0841 by 285		Batch: W38995	
Chloride		**15**	0.2	**mg/l**	
EPA 300.0	Prep: 17-Feb-2012 1416 by 07	Analyzed: 17-Feb-2012 1844 by 07		Batch: S31839	

AIC No. 155373-4
Sample Identification: HC-2 2/16/12 1220

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**140**	10	**mg/l**	
SM 2540C	Prep: 20-Feb-2012 0924 by 285	Analyzed: 22-Feb-2012 0841 by 285		Batch: W38995	
Chloride		**4.9**	0.2	**mg/l**	
EPA 300.0	Prep: 17-Feb-2012 1416 by 07	Analyzed: 17-Feb-2012 1908 by 07		Batch: S31839	

AIC No. 155373-5
Sample Identification: TB-2 2/16/12 1240

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**240**	10	**mg/l**	
SM 2540C	Prep: 20-Feb-2012 0924 by 285	Analyzed: 22-Feb-2012 0841 by 285		Batch: W38995	
Chloride		**41**	0.2	**mg/l**	
EPA 300.0	Prep: 17-Feb-2012 1416 by 07	Analyzed: 20-Feb-2012 1046 by 07		Batch: S31839	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 155373-6
Sample Identification: TB-1 2/16/12 1255

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**150**	10	**mg/l**	
SM 2540C	Prep: 20-Feb-2012 0924 by 285	Analyzed: 22-Feb-2012 0841 by 285		Batch: W38995	
Chloride		**12**	0.2	**mg/l**	
EPA 300.0	Prep: 17-Feb-2012 1416 by 07	Analyzed: 17-Feb-2012 2107 by 07		Batch: S31839	

AIC No. 155373-7
Sample Identification: 001 2/16/12 1305

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**480**	10	**mg/l**	
SM 2540C	Prep: 20-Feb-2012 0924 by 285	Analyzed: 22-Feb-2012 0841 by 285		Batch: W38995	
Chloride		**140**	2	**mg/l**	D
EPA 300.0	Prep: 17-Feb-2012 1416 by 07	Analyzed: 17-Feb-2012 2131 by 07		Batch: S31839	Dil: 10

AIC No. 155373-8
Sample Identification: WEC-1D 2/16/12 1120

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**82**	10	**mg/l**	
SM 2540C	Prep: 20-Feb-2012 0924 by 285	Analyzed: 22-Feb-2012 0841 by 285		Batch: W38995	
Chloride		**3.5**	0.2	**mg/l**	
EPA 300.0	Prep: 17-Feb-2012 1416 by 07	Analyzed: 20-Feb-2012 1022 by 07		Batch: S31839	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

DUPLICATE RESULTS

Analyte		AIC No.	Result	RPD	RPD Limit	Preparation Date	Analysis Date	Dil	Qual
Total Dissolved Solids		155367-1	150 mg/l			20Feb12 0924 by 285	22Feb12 0841 by 285		
	Batch: W38995	Duplicate	150 mg/l	1.97	10.0	20Feb12 0924 by 285	22Feb12 0841 by 285		

LABORATORY CONTROL SAMPLE RESULTS

Analyte	Spike Amount	%	Limits	RPD	Limit	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	20 mg/l	106	90.0-110			S31839	17Feb12 1416 by 07	17Feb12 1450 by 07		

MATRIX SPIKE SAMPLE RESULTS

Analyte	Sample	Spike Amount	%	Limits	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	155353-1	20 mg/l	106	80.0-120	S31839	17Feb12 1416 by 07	17Feb12 1621 by 07		
	155353-1	20 mg/l	103	80.0-120	S31839	17Feb12 1416 by 07	17Feb12 1645 by 07		
	Relative Percent Difference:		3.14	10.0	S31839				

LABORATORY BLANK RESULTS

Analyte	Result	RL	PQL	QC Sample	Preparation Date	Analysis Date	Qual
Total Dissolved Solids	< 10 mg/l	10	10	W38995-1	20Feb12 0924 by 285	22Feb12 0841 by 285	
Chloride	< 0.2 mg/l	0.2	0.2	S31839-1	17Feb12 1416 by 07	17Feb12 1426 by 07	

GBM^c & Associates
219 Brown Ln.
Bryant, AR 72022
(501) 847-7077 Fax (501) 847-7943

Chain of Custody

155373

Client/BILLING Information		SPECIAL INSTRUCTIONS/PRECAUTIONS:
Client:		Email results to Greg Phillips @
Company:	GBM^c & Associates	gphillips@gbmcassoc.com
Address:	219 Brown Lane	
	Bryant, AR 72022	**Project Name / Number:**
Phone No.:	501-847-7077	
Fax No.:	501-847-7943	

Parameters for Analysis/Methods

	Sample ID	Sample Description	Date	Time	Matrix S=Sed/Soil W=Water	Number of Containers	Composite or Grab	CL, TDS									
1	WEC-2		2/16/12	1040	W	1	G	X									
2	WEC-1		|	1120	W	1	G	X									
3	HC-1		|	1155	W	1	G	X									
4	HC-2		|	1222	W	1	G	X									
5	TB-2		|	1240	W	1	G	X									
6	TB-1		|	1255	W	1	G	X									
7	001		|	1306	W	1	G	X									
8	—		—	—	—	—	—										
	—		—	—	—	—	—										

Preservative (Sulfuric acid =S, Nitric acid =N, NaOH =B, Ice =I)

Sampler(s): RHW/JBB
Shipment Method: GBMc Delivery
Turnaround Time Required: Normal

COC Completed by: Richard Waly Date: 2/17/12 Time: 0800
COC Checked by: [illegible] Date: 2-17-12 Time: 0800

Relinquished by: Richard Walch Date: 2/17/12 Time: 0930
Received by: ______ Date: ______ Time: ______

Relinquished by: ______ Date: ______ Time: ______
Received in lab by: [illegible] Date: 2.17-12 Time: 0930

LABORATORY USE ONLY: Samples Received On Ice?: [✓ YES] or NO Sample Temperature: 2°C

V1.2 12/09/11

AMERICAN
INTERPLEX
CORPORATION
LABORATORIES

GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
219 Brown Lane
Bryant, AR 72022

This report contains the analytical results and supporting information for samples submitted on March 29, 2012. Attached please find a copy of the Chain of Custody and/or other documents received. Note that any remaining sample will be discarded two weeks from the original report date unless other arrangements are made.

This report is intended for the sole use of the client listed above. Assessment of the data requires access to the entire document.

This report has been reviewed by the Laboratory Director or a qualified designee.

John Overbey
Laboratory Director

This document has been distributed to the following:

PDF cc: GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
gphillips@gbmcassoc.com

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

SAMPLE INFORMATION

Project Description:

Eight (8) water sample(s) received on March 29, 2012
City of Huntsville
4450-11-075

Receipt Details:

A Chain of Custody was provided. The samples were delivered in one (1) ice chest.

Each sample container was checked for proper labeling, including date and time sampled. Sample containers were reviewed for proper type, adequate volume, integrity, temperature, preservation, and holding times. Any exceptions are noted below:

Sample Identification:

Laboratory ID	Client Sample ID	Sampled Date/Time	Notes
156533-1	TB-1 27MAR12 1300	27-Mar-2012 1300	
156533-2	HC-2 27MAR12 1410	27-Mar-2012 1410	
156533-3	WEC-1 27MAR12 1605	27-Mar-2012 1605	
156533-4	001 27MAR12 1245	27-Mar-2012 1245	
156533-5	WEC-2 27MAR12 1530	27-Mar-2012 1530	
156533-6	HC-1 27MAR12 1435	27-Mar-2012 1435	
156533-7	TB-2D 27MAR12 1346	27-Mar-2012 1346	
156533-8	TB-2 27MAR12 1345	27-Mar-2012 1345	

Qualifiers:

D Result is from a secondary dilution factor

References:

"Methods for Chemical Analysis of Water and Wastes", EPA/600/4-79-020 (Mar 1983) with updates and supplements EPA/600/5-91-010 (Jun 1991), EPA/600/R-92-129 (Aug 1992) and EPA/600/R-93-100 (Aug 1993).
"Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW846)", Third Edition.
"Standard Methods for the Examination of Water and Wastewaters", 20th edition, 1998.
"American Society for Testing and Materials" (ASTM).
"Association of Analytical Chemists" (AOAC).

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 156533-1
Sample Identification: TB-1 27MAR12 1300

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 02-Apr-2012 1155 by 285	**160** Analyzed: 03-Apr-2012 1433 by 285	10	**mg/l** Batch: W39416	
Chloride EPA 300.0	Prep: 29-Mar-2012 1316 by 07	**7.6** Analyzed: 29-Mar-2012 2040 by 07	0.2	**mg/l** Batch: S32133	

AIC No. 156533-2
Sample Identification: HC-2 27MAR12 1410

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 02-Apr-2012 1155 by 285	**130** Analyzed: 03-Apr-2012 1433 by 285	10	**mg/l** Batch: W39416	
Chloride EPA 300.0	Prep: 29-Mar-2012 1316 by 07	**10** Analyzed: 29-Mar-2012 2106 by 07	0.2	**mg/l** Batch: S32133	

AIC No. 156533-3
Sample Identification: WEC-1 27MAR12 1605

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 02-Apr-2012 1155 by 285	**64** Analyzed: 03-Apr-2012 1433 by 285	10	**mg/l** Batch: W39416	
Chloride EPA 300.0	Prep: 29-Mar-2012 1316 by 07	**1.9** Analyzed: 29-Mar-2012 2132 by 07	0.2	**mg/l** Batch: S32133	

AIC No. 156533-4
Sample Identification: 001 27MAR12 1245

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 02-Apr-2012 1155 by 285	**400** Analyzed: 03-Apr-2012 1433 by 285	10	**mg/l** Batch: W39416	
Chloride EPA 300.0	Prep: 29-Mar-2012 1316 by 07	**82** Analyzed: 29-Mar-2012 2158 by 07	2	**mg/l** Batch: S32133	D Dil: 10

AIC No. 156533-5
Sample Identification: WEC-2 27MAR12 1530

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 02-Apr-2012 1155 by 285	**82** Analyzed: 03-Apr-2012 1433 by 285	10	**mg/l** Batch: W39416	
Chloride EPA 300.0	Prep: 29-Mar-2012 1316 by 07	**2.9** Analyzed: 29-Mar-2012 2223 by 07	0.2	**mg/l** Batch: S32133	

AMERICAN INTERPLEX
CORPORATION
LABORATORIES

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 156533-6
Sample Identification: HC-1 27MAR12 1435

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**90**	10	**mg/l**	
SM 2540C	Prep: 02-Apr-2012 1155 by 285	Analyzed: 03-Apr-2012 1433 by 285		Batch: W39416	
Chloride		**3.4**	0.2	**mg/l**	
EPA 300.0	Prep: 29-Mar-2012 1316 by 07	Analyzed: 29-Mar-2012 2249 by 07		Batch: S32133	

AIC No. 156533-7
Sample Identification: TB-2D 27MAR12 1346

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**220**	10	**mg/l**	
SM 2540C	Prep: 02-Apr-2012 1155 by 285	Analyzed: 03-Apr-2012 1433 by 285		Batch: W39416	
Chloride		**30**	0.2	**mg/l**	
EPA 300.0	Prep: 29-Mar-2012 1316 by 07	Analyzed: 29-Mar-2012 2315 by 07		Batch: S32133	

AIC No. 156533-8
Sample Identification: TB-2 27MAR12 1345

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**220**	10	**mg/l**	
SM 2540C	Prep: 02-Apr-2012 1155 by 285	Analyzed: 03-Apr-2012 1433 by 285		Batch: W39416	
Chloride		**30**	0.2	**mg/l**	
EPA 300.0	Prep: 29-Mar-2012 1316 by 07	Analyzed: 30-Mar-2012 0033 by 07		Batch: S32133	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

DUPLICATE RESULTS

Analyte		AIC No.	Result	RPD	RPD Limit	Preparation Date	Analysis Date	Dil	Qual
Total Dissolved Solids		156533-1	160 mg/l			02Apr12 1155 by 285	03Apr12 1433 by 285		
	Batch: W39416	Duplicate	160 mg/l	2.77	10.0	02Apr12 1155 by 285	03Apr12 1433 by 285		

LABORATORY CONTROL SAMPLE RESULTS

Analyte	Spike Amount	%	Limits	RPD	Limit	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	20 mg/l	94.5	90.0-110			S32133	29Mar12 0848 by 07	29Mar12 1439 by 07		

MATRIX SPIKE SAMPLE RESULTS

Analyte	Sample	Spike Amount	%	Limits	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	156517-1	20 mg/l	101	80.0-120	S32133	29Mar12 0848 by 07	29Mar12 1504 by 07		
	156517-1	20 mg/l	98.5	80.0-120	S32133	29Mar12 0848 by 07	29Mar12 1530 by 07		
	Relative Percent Difference:		2.57	10.0	S32133				

LABORATORY BLANK RESULTS

Analyte	Result	RL	PQL	QC Sample	Preparation Date	Analysis Date	Qual
Total Dissolved Solids	< 10 mg/l	10	10	W39416-1	02Apr12 1155 by 285	03Apr12 1433 by 285	
Chloride	< 0.2 mg/l	0.2	0.2	S32133-1	29Mar12 0848 by 07	29Mar12 1413 by 07	

156533

GBMc & Associates
Strategic Environmental Services
219 Brown Ln.
Bryant, AR 72022
(501) 847-7077 Fax (501) 847-7943

Chain of Custody

CLIENT INFORMATION		BILLING INFORMATION		SPECIAL INSTRUCTIONS/PRECAUTIONS:
Company:	GBMC + Associates	Bill To:		E-mail results to Greg Phillips at
Project Name/No.:	City of Huntsville 4450-11-075	Company:	GBMC + Associates	GBMC + Associates gphillips@gbmcassoc.com
Send Report To:	GBMC + Associates	Address:	219 Brown Lane	
Address:	219 Brown Lane		Bryant, AR 72022	Parameters for Analysis/Methods
	Bryant, AR 72022	Phone No.:	501-847-7077	
Phone/Fax No.:	501-847-7077	Fax No.:	501-847-7943	

	Sample ID	Sample Description	Date	Time	Matrix S=Sed/Soil W=Water	Number of Containers	Composite or Grab	Cl TDS
1	TR-1		27Mar12	1300	W	1	Grab	X
2	HC-2		27Mar12	1410	W	1	Grab	X
3	WEC-1		27Mar12	1605	W	1	Grab	X
4	001		27Mar12	1245	W	1	Grab	X
5	WEC-2		27Mar12	1530	W	1	Grab	X
6	HC-1		27Mar12	1435	W	1	Grab	X
7	TR-2D		27Mar12	1345	W	1	Grab	X
8	TR-2		27Mar12	1345	W	1	Grab	X
	Preservative	(Sulfuric acid =S, Nitric acid =N, NaOH =B, Ice =I)						I

Sampler(s): GLP/ENJ
Shipment Method: GBMC Delivery
Turnaround Time Required: Normal

COC Completed by: Nicki Jensen Date: 29Mar12 Time: 900
COC Checked by: Date: 3/29/12 Time: 0905

Relinquished by: Nicki Jensen Date: 29Mar12 Time: 945
Received by: Date: 3-29-12 Time: 0945

Relinquished by: ________ Date: ________ Time: ________
Received in lab by: ________ Date: ________ Time: ________

LABORATORY USE ONLY: Samples Received On Ice?: [✓ YES] or NO
Sample Temperature: [illegible]

V1.2 07/07/09

AMERICAN INTERPLEX CORPORATION
LABORATORIES

GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
219 Brown Lane
Bryant, AR 72022

This report contains the analytical results and supporting information for samples submitted on April 13, 2012. Attached please find a copy of the Chain of Custody and/or other documents received. Note that any remaining sample will be discarded two weeks from the original report date unless other arrangements are made.

This report is intended for the sole use of the client listed above. Assessment of the data requires access to the entire document.

This report has been reviewed by the Laboratory Director or a qualified designee.

John Overbey
Laboratory Director

This document has been distributed to the following:

PDF cc: GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
gphillips@gbmcassoc.com

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

SAMPLE INFORMATION

Project Description:

Eight (8) water sample(s) received on April 13, 2012
4450-11-075
Huntsville

Receipt Details:

A Chain of Custody was provided. The samples were delivered in one (1) ice chest.

Each sample container was checked for proper labeling, including date and time sampled. Sample containers were reviewed for proper type, adequate volume, integrity, temperature, preservation, and holding times. Any exceptions are noted below:

Sample Identification:

Laboratory ID	Client Sample ID	Sampled Date/Time	Notes
156934-1	HC-2 4/10/12 0930	10-Apr-2012 0930	
156934-2	HC-1 4/10/12 1115	10-Apr-2012 1115	
156934-3	TB-1 4/10/12 1355	10-Apr-2012 1355	
156934-4	001 4/10/12 1430	10-Apr-2012 1430	
156934-5	TB-2 4/10/12 1555	10-Apr-2012 1555	
156934-6	WEC-2 4/10/12 1730	10-Apr-2012 1730	
156934-7	WEC-1 4/10/12 1705	10-Apr-2012 1705	
156934-8	WEC-2d 4/10/12 1735	10-Apr-2012 1735	

Qualifiers:

D	Result is from a secondary dilution factor
X	Spiking level is invalid due to the high concentration of analyte in the spiked sample

References:

"Methods for Chemical Analysis of Water and Wastes", EPA/600/4-79-020 (Mar 1983) with updates and supplements EPA/600/5-91-010 (Jun 1991), EPA/600/R-92-129 (Aug 1992) and EPA/600/R-93-100 (Aug 1993).
"Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW846)", Third Edition.
"Standard Methods for the Examination of Water and Wastewaters", 20th edition, 1998.
"American Society for Testing and Materials" (ASTM).
"Association of Analytical Chemists" (AOAC).

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 156934-1
Sample Identification: HC-2 4/10/12 0930

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3 SM 2320B		**100** Analyzed: 17-Apr-2012 0920 by 93	1	**mg/l** Batch: W39559	
Total Dissolved Solids SM 2540C	Prep: 17-Apr-2012 0806 by 285	**220** Analyzed: 18-Apr-2012 1340 by 285	10	**mg/l** Batch: W39557	
Calcium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**27** Analyzed: 13-Apr-2012 2009 by 270	0.1	**mg/l** Batch: S32235	
Magnesium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**2.7** Analyzed: 13-Apr-2012 2009 by 270	0.03	**mg/l** Batch: S32235	
Potassium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**1.9** Analyzed: 13-Apr-2012 2009 by 270	1	**mg/l** Batch: S32235	
Sodium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**3.4** Analyzed: 13-Apr-2012 2009 by 270	1	**mg/l** Batch: S32235	
Chloride EPA 300.0	Prep: 12-Apr-2012 1629 by 07	**32** Analyzed: 17-Apr-2012 0533 by 07	0.2	**mg/l** Batch: S32231	
Sulfate EPA 300.0	Prep: 12-Apr-2012 1629 by 07	**28** Analyzed: 17-Apr-2012 0533 by 07	0.2	**mg/l** Batch: S32231	

AIC No. 156934-2
Sample Identification: HC-1 4/10/12 1115

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3 SM 2320B		**70** Analyzed: 17-Apr-2012 0920 by 93	1	**mg/l** Batch: W39559	
Total Dissolved Solids SM 2540C	Prep: 17-Apr-2012 0806 by 285	**98** Analyzed: 18-Apr-2012 1340 by 285	10	**mg/l** Batch: W39557	
Calcium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**42** Analyzed: 13-Apr-2012 2012 by 270	0.1	**mg/l** Batch: S32235	
Magnesium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**3.6** Analyzed: 13-Apr-2012 2012 by 270	0.03	**mg/l** Batch: S32235	
Potassium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**5.3** Analyzed: 13-Apr-2012 2012 by 270	1	**mg/l** Batch: S32235	
Sodium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**20** Analyzed: 13-Apr-2012 2012 by 270	1	**mg/l** Batch: S32235	
Chloride EPA 300.0	Prep: 12-Apr-2012 1629 by 07	**4.7** Analyzed: 17-Apr-2012 0559 by 07	0.2	**mg/l** Batch: S32231	
Sulfate EPA 300.0	Prep: 12-Apr-2012 1629 by 07	**11** Analyzed: 17-Apr-2012 0559 by 07	0.2	**mg/l** Batch: S32231	

AIC No. 156934-3
Sample Identification: TB-1 4/10/12 1355

Analyte	Result	RL	Units	Qualifier
Alkalinity as CaCO3 SM 2320B	**130** Analyzed: 17-Apr-2012 0920 by 93	1	**mg/l** Batch: W39559	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 156934-3 (Continued)
Sample Identification: TB-1 4/10/12 1355

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**190**	10	**mg/l**	
SM 2540C	Prep: 17-Apr-2012 0806 by 285	Analyzed: 18-Apr-2012 1340 by 285		Batch: W39557	
Calcium		**49**	0.1	**mg/l**	
EPA 200.7	Prep: 12-Apr-2012 1447 by 297	Analyzed: 13-Apr-2012 2015 by 270		Batch: S32235	
Magnesium		**4.3**	0.03	**mg/l**	
EPA 200.7	Prep: 12-Apr-2012 1447 by 297	Analyzed: 13-Apr-2012 2015 by 270		Batch: S32235	
Potassium		**2.0**	1	**mg/l**	
EPA 200.7	Prep: 12-Apr-2012 1447 by 297	Analyzed: 13-Apr-2012 2015 by 270		Batch: S32235	
Sodium		**7.2**	1	**mg/l**	
EPA 200.7	Prep: 12-Apr-2012 1447 by 297	Analyzed: 13-Apr-2012 2015 by 270		Batch: S32235	
Chloride		**13**	0.2	**mg/l**	
EPA 300.0	Prep: 12-Apr-2012 1629 by 07	Analyzed: 17-Apr-2012 0624 by 07		Batch: S32231	
Sulfate		**15**	0.2	**mg/l**	
EPA 300.0	Prep: 12-Apr-2012 1629 by 07	Analyzed: 17-Apr-2012 0624 by 07		Batch: S32231	

AIC No. 156934-4
Sample Identification: 001 4/10/12 1430

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3		**100**	1	**mg/l**	
SM 2320B		Analyzed: 17-Apr-2012 0920 by 93		Batch: W39559	
Total Dissolved Solids		**500**	10	**mg/l**	
SM 2540C	Prep: 17-Apr-2012 0806 by 285	Analyzed: 18-Apr-2012 1340 by 285		Batch: W39557	
Calcium		**61**	0.1	**mg/l**	
EPA 200.7	Prep: 12-Apr-2012 1447 by 297	Analyzed: 13-Apr-2012 2019 by 270		Batch: S32235	
Magnesium		**3.8**	0.03	**mg/l**	
EPA 200.7	Prep: 12-Apr-2012 1447 by 297	Analyzed: 13-Apr-2012 2019 by 270		Batch: S32235	
Potassium		**23**	1	**mg/l**	
EPA 200.7	Prep: 12-Apr-2012 1447 by 297	Analyzed: 13-Apr-2012 2019 by 270		Batch: S32235	
Sodium		**110**	1	**mg/l**	
EPA 200.7	Prep: 12-Apr-2012 1447 by 297	Analyzed: 16-Apr-2012 1123 by 270		Batch: S32235	
Chloride		**140**	2	**mg/l**	D
EPA 300.0	Prep: 12-Apr-2012 1629 by 07	Analyzed: 17-Apr-2012 0650 by 07		Batch: S32231	Dil: 10
Sulfate		**83**	2	**mg/l**	D
EPA 300.0	Prep: 12-Apr-2012 1629 by 07	Analyzed: 17-Apr-2012 0650 by 07		Batch: S32231	Dil: 10

AIC No. 156934-5
Sample Identification: TB-2 4/10/12 1555

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3		**110**	1	**mg/l**	
SM 2320B		Analyzed: 17-Apr-2012 0920 by 93		Batch: W39559	

ANALYTICAL RESULTS

AIC No. 156934-5 (Continued)
Sample Identification: TB-2 4/10/12 1555

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 17-Apr-2012 0806 by 285	**420** Analyzed: 18-Apr-2012 1340 by 285	10	**mg/l** Batch: W39557	
Calcium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**56** Analyzed: 13-Apr-2012 2023 by 270	0.1	**mg/l** Batch: S32235	
Magnesium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**4.1** Analyzed: 13-Apr-2012 2023 by 270	0.03	**mg/l** Batch: S32235	
Potassium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**13** Analyzed: 13-Apr-2012 2023 by 270	1	**mg/l** Batch: S32235	
Sodium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**54** Analyzed: 13-Apr-2012 2023 by 270	1	**mg/l** Batch: S32235	
Chloride EPA 300.0	Prep: 12-Apr-2012 1629 by 07	**79** Analyzed: 17-Apr-2012 0948 by 07	2	**mg/l** Batch: S32231	D Dil: 10
Sulfate EPA 300.0	Prep: 12-Apr-2012 1629 by 07	**52** Analyzed: 17-Apr-2012 0948 by 07	2	**mg/l** Batch: S32231	D Dil: 10

AIC No. 156934-6
Sample Identification: WEC-2 4/10/12 1730

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3 SM 2320B		**64** Analyzed: 17-Apr-2012 0920 by 93	1	**mg/l** Batch: W39559	
Total Dissolved Solids SM 2540C	Prep: 17-Apr-2012 0806 by 285	**110** Analyzed: 18-Apr-2012 1340 by 285	10	**mg/l** Batch: W39557	
Calcium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**24** Analyzed: 13-Apr-2012 2026 by 270	0.1	**mg/l** Batch: S32235	
Magnesium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**2.0** Analyzed: 13-Apr-2012 2026 by 270	0.03	**mg/l** Batch: S32235	
Potassium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**1.9** Analyzed: 13-Apr-2012 2026 by 270	1	**mg/l** Batch: S32235	
Sodium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**4.1** Analyzed: 13-Apr-2012 2026 by 270	1	**mg/l** Batch: S32235	
Chloride EPA 300.0	Prep: 12-Apr-2012 1629 by 07	**6.0** Analyzed: 17-Apr-2012 0742 by 07	0.2	**mg/l** Batch: S32231	
Sulfate EPA 300.0	Prep: 12-Apr-2012 1629 by 07	**8.2** Analyzed: 17-Apr-2012 0742 by 07	0.2	**mg/l** Batch: S32231	

AIC No. 156934-7
Sample Identification: WEC-1 4/10/12 1705

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3 SM 2320B		**47** Analyzed: 17-Apr-2012 0920 by 93	1	**mg/l** Batch: W39559	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 156934-7 (Continued)
Sample Identification: WEC-1 4/10/12 1705

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 17-Apr-2012 0806 by 285	**72** Analyzed: 18-Apr-2012 1340 by 285	10	**mg/l** Batch: W39557	
Calcium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**17** Analyzed: 13-Apr-2012 2030 by 270	0.1	**mg/l** Batch: S32235	
Magnesium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**2.0** Analyzed: 13-Apr-2012 2030 by 270	0.03	**mg/l** Batch: S32235	
Potassium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**1.5** Analyzed: 13-Apr-2012 2030 by 270	1	**mg/l** Batch: S32235	
Sodium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**2.1** Analyzed: 13-Apr-2012 2030 by 270	1	**mg/l** Batch: S32235	
Chloride EPA 300.0	Prep: 12-Apr-2012 1629 by 07	**2.5** Analyzed: 17-Apr-2012 0808 by 07	0.2	**mg/l** Batch: S32231	
Sulfate EPA 300.0	Prep: 12-Apr-2012 1629 by 07	**6.3** Analyzed: 17-Apr-2012 0808 by 07	0.2	**mg/l** Batch: S32231	

AIC No. 156934-8
Sample Identification: WEC-2d 4/10/12 1735

Analyte		Result	RL	Units	Qualifier
Alkalinity as CaCO3 SM 2320B		**63** Analyzed: 17-Apr-2012 0920 by 93	1	**mg/l** Batch: W39559	
Total Dissolved Solids SM 2540C	Prep: 17-Apr-2012 0806 by 285	**100** Analyzed: 18-Apr-2012 1340 by 285	10	**mg/l** Batch: W39557	
Calcium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**24** Analyzed: 13-Apr-2012 2033 by 270	0.1	**mg/l** Batch: S32235	
Magnesium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**2.1** Analyzed: 13-Apr-2012 2033 by 270	0.03	**mg/l** Batch: S32235	
Potassium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**1.9** Analyzed: 13-Apr-2012 2033 by 270	1	**mg/l** Batch: S32235	
Sodium EPA 200.7	Prep: 12-Apr-2012 1447 by 297	**4.2** Analyzed: 13-Apr-2012 2033 by 270	1	**mg/l** Batch: S32235	
Chloride EPA 300.0	Prep: 12-Apr-2012 1629 by 07	**6.2** Analyzed: 17-Apr-2012 0834 by 07	0.2	**mg/l** Batch: S32231	
Sulfate EPA 300.0	Prep: 12-Apr-2012 1629 by 07	**8.8** Analyzed: 17-Apr-2012 0834 by 07	0.2	**mg/l** Batch: S32231	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

DUPLICATE RESULTS

Analyte		AIC No.	Result	RPD	RPD Limit	Preparation Date	Analysis Date	Dil	Qual
Total Dissolved Solids		156905-1	480 mg/l			17Apr12 0806 by 285	18Apr12 1340 by 285		
	Batch: W39557	Duplicate	480 mg/l	0.105	10.0	17Apr12 0806 by 285	18Apr12 1340 by 285		
Alkalinity as CaCO3		156880-1	350 mg/l				17Apr12 0920 by 93		
	Batch: W39559	Duplicate	350 mg/l	0.462	20.0		17Apr12 0920 by 93		

LABORATORY CONTROL SAMPLE RESULTS

Analyte	Spike Amount	%	Limits	RPD	Limit	Batch	Preparation Date	Analysis Date	Dil	Qual
Calcium	10 mg/l	106	85.0-115			S32235	12Apr12 1448 by 297	13Apr12 1937 by 270		
Magnesium	10 mg/l	105	85.0-115			S32235	12Apr12 1448 by 297	13Apr12 1937 by 270		
Potassium	10 mg/l	104	85.0-115			S32235	12Apr12 1448 by 297	13Apr12 1937 by 270		
Sodium	10 mg/l	102	85.0-115			S32235	12Apr12 1448 by 297	13Apr12 1937 by 270		
Chloride	20 mg/l	94.4	90.0-110			S32231	12Apr12 0915 by 07	12Apr12 1511 by 07		
Sulfate	20 mg/l	94.1	90.0-110			S32231	12Apr12 0915 by 07	12Apr12 1511 by 07		

MATRIX SPIKE SAMPLE RESULTS

Analyte	Sample	Spike Amount	%	Limits	Batch	Preparation Date	Analysis Date	Dil	Qual
Calcium	156879-1	10 mg/l	103	75.0-125	S32235	12Apr12 1448 by 297	13Apr12 1939 by 270		
	156879-1	10 mg/l	104	75.0-125	S32235	12Apr12 1448 by 297	13Apr12 1942 by 270		
	Relative Percent Difference:		0.706	20.0	S32235				
Magnesium	156879-1	10 mg/l	-	75.0-125	S32235	12Apr12 1448 by 297	16Apr12 1058 by 270	10	X
	156879-1	10 mg/l	-	75.0-125	S32235	12Apr12 1448 by 297	16Apr12 1103 by 270	10	X
	Relative Percent Difference:		0.570	20.0	S32235				D
Potassium	156879-1	10 mg/l	99.0	75.0-125	S32235	12Apr12 1448 by 297	13Apr12 1939 by 270		
	156879-1	10 mg/l	106	75.0-125	S32235	12Apr12 1448 by 297	13Apr12 1942 by 270		
	Relative Percent Difference:		1.11	20.0	S32235				
Sodium	156879-1	10 mg/l	-	75.0-125	S32235	12Apr12 1448 by 297	16Apr12 1058 by 270	10	X
	156879-1	10 mg/l	-	75.0-125	S32235	12Apr12 1448 by 297	16Apr12 1103 by 270	10	X
	Relative Percent Difference:		1.73	20.0	S32235				D
Chloride	156893-1	20 mg/l	94.1	80.0-120	S32231	12Apr12 0915 by 07	12Apr12 1536 by 07		
	156893-1	20 mg/l	96.6	80.0-120	S32231	12Apr12 0915 by 07	12Apr12 1602 by 07		
	Relative Percent Difference:		2.22	10.0	S32231				
Sulfate	156893-1	20 mg/l	88.0	80.0-120	S32231	12Apr12 0915 by 07	12Apr12 1536 by 07		
	156893-1	20 mg/l	94.6	80.0-120	S32231	12Apr12 0915 by 07	12Apr12 1602 by 07		
	Relative Percent Difference:		4.14	10.0	S32231				

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

LABORATORY BLANK RESULTS

Analyte	Result	RL	PQL	QC Sample	Preparation Date	Analysis Date	Qual
Alkalinity as CaCO3	< 1 mg/l	1	1	W39559-1		17Apr12 0920 by 93	
Total Dissolved Solids	< 10 mg/l	10	10	W39557-1	17Apr12 0806 by 285	18Apr12 1340 by 285	
Calcium	< 0.1 mg/l	0.1	0.1	S32235-1	12Apr12 1448 by 297	13Apr12 1933 by 270	
Magnesium	< 0.03 mg/l	0.03	0.03	S32235-1	12Apr12 1448 by 297	13Apr12 1933 by 270	
Potassium	< 1 mg/l	1	1	S32235-1	12Apr12 1448 by 297	13Apr12 1933 by 270	
Sodium	< 1 mg/l	1	1	S32235-1	12Apr12 1448 by 297	13Apr12 1933 by 270	
Chloride	< 0.2 mg/l	0.2	0.2	S32231-1	12Apr12 0915 by 07	12Apr12 1445 by 07	
Sulfate	< 0.2 mg/l	0.2	0.2	S32231-1	12Apr12 0915 by 07	12Apr12 1445 by 07	

156934

GBMc & Associates
Strategic Environmental Services
219 Brown Ln.
Bryant, AR 72022
(501) 847-7077 Fax (501) 847-7943

Chain of Custody

~~156918~~ GEH177 4-13-12

CLIENT INFORMATION		BILLING INFORMATION		SPECIAL INSTRUCTIONS/PRECAUTIONS:
Company:	GBMc & Assoc.	Bill To:	SAME	
Project Name/No.:	Huntsville - 4450-11-075	Company:		
Send Report To:	Greg Phillips	Address:		
Address:	219 Brown Ln.			Parameters for Analysis/Methods
	Bryant, AR 72022	Phone No.:		
Phone/Fax No.:	501-847-7077/7943	Fax No.:		

	Sample ID	Sample Description	Date	Time	Matrix S=Sed/Soil W=Water	Number of Containers	Composite or Grab	CL, TDS, SO4, total Alk.	CA, MG, NA, K								
1	HC-2		4/10/12	0930	W	2	G	X	X								
2	HC-1		4/10/12	115	W	2		X	X								
3	TB-1		4/10/12	1355	W	2		X	X								
4	001		4/10/12	1430	W	2		X	X								
5	TB-2		4/10/12	1555	W	2		X	X								
6	WFC-2		4/10/12	1730	W	2		X	X								
7	WFC-1		4/10/12	1705	W	2		X	X								
8	WFC-2d		4/10/12	1735	W	2	G	X	X								
	Preservative	(Sulfuric acid =S, Nitric acid =N, NaOH =B, Ice =I)						I	I,N								

Sampler(s): GLP/RHW/ENJ
Shipment Method: GBMc delivery
Turnaround Time Required: NORMAL

COC Completed by: Date: 4/12/12 Time: 1055
COC Checked by: Allyn Tuell Date: 4.12.12 Time: 1134

Relinquished by: Date: 4/12/12 Time: 1335
Received by: Date: Time:

Relinquished by: Date: Time:
Received in lab by: Date: 4-12-12 Time: 1335

LABORATORY USE ONLY: Samples Received On Ice?: [✓ YES] or NO
Sample Temperature: 2°C

V1.2 07/07/09

AMERICAN
INTERPLEX
CORPORATION
LABORATORIES

40
1972 2012

May 17, 2012
Control No. 157683

GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
219 Brown Lane
Bryant, AR 72022

This report contains the analytical results and supporting information for samples submitted on May 10, 2012. Attached please find a copy of the Chain of Custody and/or other documents received. Note that any remaining sample will be discarded two weeks from the original report date unless other arrangements are made.

This report is intended for the sole use of the client listed above. Assessment of the data requires access to the entire document.

This report has been reviewed by the Laboratory Director or a qualified designee.

Steve Bradford

Steve Bradford
Deputy Laboratory Director

This document has been distributed to the following:

PDF cc: GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
gphillips@gbmcassoc.com

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

SAMPLE INFORMATION

Project Description:
Eight (8) water sample(s) received on May 10, 2012

Receipt Details:
A Chain of Custody was provided. The samples were delivered in one (1) ice chest.

Each sample container was checked for proper labeling, including date and time sampled. Sample containers were reviewed for proper type, adequate volume, integrity, temperature, preservation, and holding times. Any exceptions are noted below:

Sample Identification:

Laboratory ID	Client Sample ID	Sampled Date/Time	Notes
157683-1	WEC-2 5/9/12 1135	09-May-2012 1135	
157683-2	WEC-2D 5/9/12 1140	09-May-2012 1140	
157683-3	WEC-1 5/9/12 1215	09-May-2012 1215	
157683-4	HC-1 5/9/12 1240	09-May-2012 1240	
157683-5	HC-2 5/9/12 1315	09-May-2012 1315	
157683-6	TB-2 5/9/12 1330	09-May-2012 1330	
157683-7	001 5/9/12 1345	09-May-2012 1345	
157683-8	TB-1 5/9/12 1450	09-May-2012 1450	

Qualifiers:

D	Result is from a secondary dilution factor

References:
"Methods for Chemical Analysis of Water and Wastes", EPA/600/4-79-020 (Mar 1983) with updates and supplements EPA/600/5-91-010 (Jun 1991), EPA/600/R-92-129 (Aug 1992) and EPA/600/R-93-100 (Aug 1993).
"Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW846)", Third Edition.
"Standard Methods for the Examination of Water and Wastewaters", 20th edition, 1998.
"American Society for Testing and Materials" (ASTM).
"Association of Analytical Chemists" (AOAC).

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 157683-1
Sample Identification: WEC-2 5/9/12 1135

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**160**	10	**mg/l**	
SM 2540C	Prep: 15-May-2012 1111 by 285	Analyzed: 16-May-2012 1053 by 285		Batch: W39844	
Chloride		**15**	0.2	**mg/l**	
EPA 300.0	Prep: 10-May-2012 1906 by 270	Analyzed: 15-May-2012 2021 by 07		Batch: S32411	

AIC No. 157683-2
Sample Identification: WEC-2D 5/9/12 1140

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**150**	10	**mg/l**	
SM 2540C	Prep: 15-May-2012 1111 by 285	Analyzed: 16-May-2012 1053 by 285		Batch: W39844	
Chloride		**15**	0.2	**mg/l**	
EPA 300.0	Prep: 10-May-2012 1906 by 270	Analyzed: 15-May-2012 2047 by 07		Batch: S32411	

AIC No. 157683-3
Sample Identification: WEC-1 5/9/12 1215

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**93**	10	**mg/l**	
SM 2540C	Prep: 15-May-2012 1111 by 285	Analyzed: 16-May-2012 1053 by 285		Batch: W39844	
Chloride		**3.1**	0.2	**mg/l**	
EPA 300.0	Prep: 10-May-2012 1906 by 270	Analyzed: 15-May-2012 2113 by 07		Batch: S32411	

AIC No. 157683-4
Sample Identification: HC-1 5/9/12 1240

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**140**	10	**mg/l**	
SM 2540C	Prep: 15-May-2012 1111 by 285	Analyzed: 16-May-2012 1053 by 285		Batch: W39844	
Chloride		**5.9**	0.2	**mg/l**	
EPA 300.0	Prep: 10-May-2012 1906 by 270	Analyzed: 15-May-2012 2139 by 07		Batch: S32411	

AIC No. 157683-5
Sample Identification: HC-2 5/9/12 1315

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**370**	10	**mg/l**	
SM 2540C	Prep: 15-May-2012 1111 by 285	Analyzed: 16-May-2012 1053 by 285		Batch: W39844	
Chloride		**92**	2	**mg/l**	D
EPA 300.0	Prep: 10-May-2012 1906 by 270	Analyzed: 11-May-2012 1819 by 07		Batch: S32411	Dil: 10

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 157683-6
Sample Identification: TB-2 5/9/12 1330

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**540**	10	**mg/l**	
SM 2540C	Prep: 15-May-2012 1111 by 285	Analyzed: 16-May-2012 1053 by 285		Batch: W39844	
Chloride		**150**	2	**mg/l**	D
EPA 300.0	Prep: 10-May-2012 1906 by 270	Analyzed: 11-May-2012 1844 by 07		Batch: S32411	Dil: 10

AIC No. 157683-7
Sample Identification: 001 5/9/12 1345

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**710**	10	**mg/l**	
SM 2540C	Prep: 15-May-2012 1111 by 285	Analyzed: 16-May-2012 1053 by 285		Batch: W39844	
Chloride		**230**	20	**mg/l**	D
EPA 300.0	Prep: 10-May-2012 1906 by 270	Analyzed: 11-May-2012 1910 by 07		Batch: S32411	Dil: 100

AIC No. 157683-8
Sample Identification: TB-1 5/9/12 1450

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids		**210**	10	**mg/l**	
SM 2540C	Prep: 15-May-2012 1111 by 285	Analyzed: 16-May-2012 1053 by 285		Batch: W39844	
Chloride		**19**	2	**mg/l**	D
EPA 300.0	Prep: 10-May-2012 1906 by 270	Analyzed: 11-May-2012 1936 by 07		Batch: S32411	Dil: 10

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

DUPLICATE RESULTS

Analyte		AIC No.	Result	RPD	RPD Limit	Preparation Date	Analysis Date	Dil	Qual
Total Dissolved Solids		157683-1	160 mg/l			15May12 1111 by 285	16May12 1053 by 285		
	Batch: W39844	Duplicate	140 mg/l	8.05	10.0	15May12 1111 by 285	16May12 1053 by 285		

LABORATORY CONTROL SAMPLE RESULTS

Analyte	Spike Amount	%	Limits	RPD	Limit	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	20 mg/l	95.3	90.0-110			S32411	10May12 1906 by 270	11May12 1426 by 07		

MATRIX SPIKE SAMPLE RESULTS

Analyte	Sample	Spike Amount	%	Limits	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	157683-1	20 mg/l	97.0	80.0-120	S32411	10May12 1906 by 270	11May12 1452 by 07		
	157683-1	20 mg/l	97.7	80.0-120	S32411	10May12 1906 by 270	11May12 1518 by 07		
	Relative Percent Difference:		0.646	10.0	S32411				

LABORATORY BLANK RESULTS

Analyte	Result	RL	PQL	QC Sample	Preparation Date	Analysis Date	Qual
Total Dissolved Solids	< 10 mg/l	10	10	W39844-1	15May12 1111 by 285	16May12 1053 by 285	
Chloride	< 0.2 mg/l	0.2	0.2	S32411-1	10May12 1906 by 270	11May12 1400 by 07	

157683

GBMc & Associates
Strategic Environmental Services
219 Brown Ln.
Bryant, AR 72022
(501) 847-7077 Fax (501) 847-7943

Chain of Custody

CLIENT INFORMATION

Company: GBMc & Associates
Project Name/No.:
Send Report To: Greg Phillips
Address: 219 Brown Lane
Bryant, AR 72022
Phone/Fax No.:

BILLING INFORMATION

Bill To:
Company: Same
Address:
Phone No:
Fax No.:

SPECIAL INSTRUCTIONS/PRECAUTIONS:

Email results to Greg phillips @ gbmcassoc.com

Parameters for Analysis/Methods

	Sample ID	Sample Description	Date	Time	Matrix S=Sed/Soil W=Water	Number of Containers	Composite or Grab	Chloride	TDS
1	WEC-2		5/9/12	1135	W	1	G	x	x
2	WEC-2D			1140		1		x	x
3	WEC-1			1215		1		x	x
4	HC-1			1240		1		x	x
5	HC-2			1315		1		x	x
6	TB-2			1330		1		x	x
7	001			1345		1		x	x
8	TB-1			1450		1		x	x

Preservative (Sulfuric acid =S, Nitric acid =N, NaOH =B, Ice =I)

Sampler(s): RHW / ENJ
Shipment Method: Delivery
Turnaround Time Required: Normal

COC Completed by: Date: 5/10/12 Time: 0825
COC Checked by: Date: 5/10/12 Time: 0920

Relinquished by: Date: 5/10/12 Time: 1100
Received by: Date: Time:

Relinquished by: Date: Time:
Received in lab by: Date: 5.10.12 Time: 1100

LABORATORY USE ONLY: Samples Received On Ice?: [✓ YES] or NO
Sample Temperature: 2 C

V1.2 04/26/12

AMERICAN INTERPLEX
CORPORATION
LABORATORIES

40
1972 2012

GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
219 Brown Lane
Bryant, AR 72022

This report contains the analytical results and supporting information for samples submitted on June 22, 2012. Attached please find a copy of the Chain of Custody and/or other documents received. Note that any remaining sample will be discarded two weeks from the original report date unless other arrangements are made.

This report is intended for the sole use of the client listed above. Assessment of the data requires access to the entire document.

This report has been reviewed by the Laboratory Director or a qualified designee.

Steve Bradford

Steve Bradford
Deputy Laboratory Director

This document has been distributed to the following:

PDF cc: GBMc & Associates, Inc.
ATTN: Mr. Greg Phillips
gphillips@gbmcassoc.com

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

SAMPLE INFORMATION

Project Description:
Nine (9) water sample(s) received on June 22, 2012
City of Huntsville

Receipt Details:
A Chain of Custody was provided. The samples were delivered in one (1) ice chest.

Each sample container was checked for proper labeling, including date and time sampled. Sample containers were reviewed for proper type, adequate volume, integrity, temperature, preservation, and holding times. Any exceptions are noted below:

Sample Identification:

Laboratory ID	Client Sample ID	Sampled Date/Time	Notes
158819-1	HC-1 21JUN12 1320	21-Jun-2012 1320	
158819-2	HC-1-2 21JUN12 1325	21-Jun-2012 1325	
158819-3	HC-2 21JUN12 1305	21-Jun-2012 1305	
158819-4	WEC-1 21JUN12 1150	21-Jun-2012 1150	
158819-5	WEC-2 21JUN12 1045	21-Jun-2012 1045	
158819-6	001 21JUN12 1210	21-Jun-2012 1210	
158819-7	TB-1 21JUN12 1220	21-Jun-2012 1220	
158819-8	TB-2 21JUN12 1230	21-Jun-2012 1230	
158819-9	Field Blank		1

Notes:
1. Sample label was incomplete in regard to date/time of sampling

Qualifiers:
D Result is from a secondary dilution factor

References:
"Methods for Chemical Analysis of Water and Wastes", EPA/600/4-79-020 (Mar 1983) with updates and supplements EPA/600/5-91-010 (Jun 1991), EPA/600/R-92-129 (Aug 1992) and EPA/600/R-93-100 (Aug 1993).
"Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW846)", Third Edition.
"Standard Methods for the Examination of Water and Wastewaters", 20th edition, 1998.
"American Society for Testing and Materials" (ASTM).
"Association of Analytical Chemists" (AOAC).

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 158819-1
Sample Identification: HC-1 21JUN12 1320

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 25-Jun-2012 1410 by 302	**190** Analyzed: 27-Jun-2012 0812 by 302	10	**mg/l** Batch: W40236	
Chloride EPA 300.0	Prep: 22-Jun-2012 1012 by 07	**10** Analyzed: 22-Jun-2012 1253 by 07	0.2	**mg/l** Batch: S32629	

AIC No. 158819-2
Sample Identification: HC-1-2 21JUN12 1325

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 25-Jun-2012 1410 by 302	**180** Analyzed: 27-Jun-2012 0812 by 302	10	**mg/l** Batch: W40236	
Chloride EPA 300.0	Prep: 22-Jun-2012 1012 by 07	**11** Analyzed: 22-Jun-2012 1318 by 07	0.2	**mg/l** Batch: S32629	

AIC No. 158819-3
Sample Identification: HC-2 21JUN12 1305

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 25-Jun-2012 1410 by 302	**510** Analyzed: 27-Jun-2012 0812 by 302	10	**mg/l** Batch: W40236	
Chloride EPA 300.0	Prep: 22-Jun-2012 1012 by 07	**180** Analyzed: 22-Jun-2012 1343 by 07	2	**mg/l** Batch: S32629	D Dil: 10

AIC No. 158819-4
Sample Identification: WEC-1 21JUN12 1150

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 25-Jun-2012 1410 by 302	**110** Analyzed: 27-Jun-2012 0812 by 302	10	**mg/l** Batch: W40236	
Chloride EPA 300.0	Prep: 22-Jun-2012 1012 by 07	**4.1** Analyzed: 22-Jun-2012 1407 by 07	0.2	**mg/l** Batch: S32629	

AIC No. 158819-5
Sample Identification: WEC-2 21JUN12 1045

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 25-Jun-2012 1410 by 302	**200** Analyzed: 27-Jun-2012 0812 by 302	10	**mg/l** Batch: W40236	
Chloride EPA 300.0	Prep: 22-Jun-2012 1012 by 07	**36** Analyzed: 22-Jun-2012 1432 by 07	0.2	**mg/l** Batch: S32629	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

ANALYTICAL RESULTS

AIC No. 158819-6
Sample Identification: 001 21JUN12 1210

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 27-Jun-2012 1100 by 302	**650** Analyzed: 28-Jun-2012 1354 by 302	10	**mg/l** Batch: W40266	
Chloride EPA 300.0	Prep: 22-Jun-2012 1012 by 07	**210** Analyzed: 22-Jun-2012 1457 by 07	2	**mg/l** Batch: S32629	D Dil: 10

AIC No. 158819-7
Sample Identification: TB-1 21JUN12 1220

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 27-Jun-2012 1100 by 302	**220** Analyzed: 28-Jun-2012 1354 by 302	10	**mg/l** Batch: W40266	
Chloride EPA 300.0	Prep: 22-Jun-2012 1012 by 07	**24** Analyzed: 22-Jun-2012 1612 by 07	0.2	**mg/l** Batch: S32629	

AIC No. 158819-8
Sample Identification: TB-2 21JUN12 1230

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 27-Jun-2012 1100 by 302	**570** Analyzed: 28-Jun-2012 1354 by 302	10	**mg/l** Batch: W40266	
Chloride EPA 300.0	Prep: 22-Jun-2012 1012 by 07	**190** Analyzed: 22-Jun-2012 1636 by 07	2	**mg/l** Batch: S32629	D Dil: 10

AIC No. 158819-9
Sample Identification: Field Blank

Analyte		Result	RL	Units	Qualifier
Total Dissolved Solids SM 2540C	Prep: 27-Jun-2012 1100 by 302	**< 10** Analyzed: 28-Jun-2012 1354 by 302	10	**mg/l** Batch: W40266	
Chloride EPA 300.0	Prep: 22-Jun-2012 1012 by 07	**< 0.2** Analyzed: 22-Jun-2012 1753 by 07	0.2	**mg/l** Batch: S32629	

GBMc & Associates, Inc.
219 Brown Lane
Bryant, AR 72022

DUPLICATE RESULTS

Analyte		AIC No.	Result	RPD	RPD Limit	Preparation Date	Analysis Date	Dil	Qual
Total Dissolved Solids		158760-1	900 mg/l			25Jun12 1410 by 302	27Jun12 0812 by 302		
	Batch: W40236	Duplicate	890 mg/l	0.560	10.0	25Jun12 1410 by 302	27Jun12 0812 by 302		
Total Dissolved Solids		158772-1	63000 mg/l			25Jun12 1410 by 302	27Jun12 0812 by 302		
	Batch: W40236	Duplicate	62000 mg/l	0.958	10.0	25Jun12 1410 by 302	27Jun12 0812 by 302		
Total Dissolved Solids		158819-6	650 mg/l			27Jun12 1100 by 302	28Jun12 1354 by 302		
	Batch: W40266	Duplicate	630 mg/l	3.99	10.0	27Jun12 1100 by 302	28Jun12 1354 by 302		

LABORATORY CONTROL SAMPLE RESULTS

Analyte	Spike Amount	%	Limits	RPD	Limit	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	20 mg/l	104	90.0-110			S32629	22Jun12 1013 by 07	22Jun12 1138 by 07		

MATRIX SPIKE SAMPLE RESULTS

Analyte	Sample	Spike Amount	%	Limits	Batch	Preparation Date	Analysis Date	Dil	Qual
Chloride	158819-1	20 mg/l	113	80.0-120	S32629	22Jun12 1013 by 07	22Jun12 1203 by 07		
	158819-1	20 mg/l	111	80.0-120	S32629	22Jun12 1013 by 07	22Jun12 1228 by 07		
	Relative Percent Difference:		1.39	10.0	S32629				

LABORATORY BLANK RESULTS

Analyte	Result	RL	PQL	QC Sample	Preparation Date	Analysis Date	Qual
Total Dissolved Solids	< 10 mg/l	10	10	W40236-1	25Jun12 1410 by 302	27Jun12 0812 by 302	
Total Dissolved Solids	< 10 mg/l	10	10	W40266-1	27Jun12 1100 by 302	28Jun12 1354 by 302	
Chloride	< 0.2 mg/l	0.2	0.2	S32629-1	22Jun12 1013 by 07	22Jun12 1114 by 07	

GBM^c & Associates
219 Brown Ln.
Bryant, AR 72022
(501) 847-7077 Fax (501) 847-7943

Chain of Custody

15 8819

Client/BILLING Information	
Client:	
Company:	GBM^c & Associates
Address:	219 Brown Lane
	Bryant, AR 72022
Phone No.:	501-847-7077
Fax No.:	501-847-7943

SPECIAL INSTRUCTIONS/PRECAUTIONS: Please e-mail Greg Phillips gphillips@gbmcassoc.com with results

Project Name / Number: City of Huntsville

	Sample ID	Sample Description	Date	Time	Matrix S=Sed/Soil W=Water	Number of Containers	Composite or Grab	Cl, TDS									
1	HC-1	Holman Creek	21Jun12	1320	W	1	G	X									
2	HC-1-Z	Holman Creek	21Jun12	1325	W	1	G	X									
3	HC-2	Holman Creek	21Jun12	1305	W	1	G	X									
4	WEC-1	War Eagle Creek	21Jun12	1150	W	1	G	X									
5	WEC-2	War Eagle Creek	21Jun12	1045	W	1	G	X									
6	001	Outfall 001	21Jun12	1210	W	1	G	X									
7	TB-1	Town Branch	21Jun12	1220	W	1	G	X									
8	TB-2	Town Branch	21Jun12	1230	W	1	G	X									
9																	

Preservative (Sulfuric acid =S, Nitric acid =N, NaOH =B, Ice =I)

Sampler(s): ENJ/KMB

Shipment Method: Delivered

Turnaround Time Required: Normal

COC Completed by: Nicki Jensen Date: 22Jun12 Time: 830

COC Checked by: Kevin Batchelder Date: 6-22-12 Time: 0835

Relinquished by: Kevin Batchelder Date: 6-22-12 Time: 0924

Received by: ______ Date: ______ Time: ______

Relinquished by: ______ Date: ______ Time: ______

Received in lab by: Date 6-22-12 Time: 0924

LABORATORY USE ONLY: Samples Received On Ice?: YES or NO Sample Temperature: ______

Appendix C

Mineral Statistics

All data were examined for normality using Analyse-it® for Microsoft Excel ® prior to calculated site specific criteria. We generated normal quantile (Q-Q) plots for raw data from Huntsville WWTF Outfall 001, which discharges into Town Branch Creek. Figures 1-3 show the normal quantile plots for each data set.

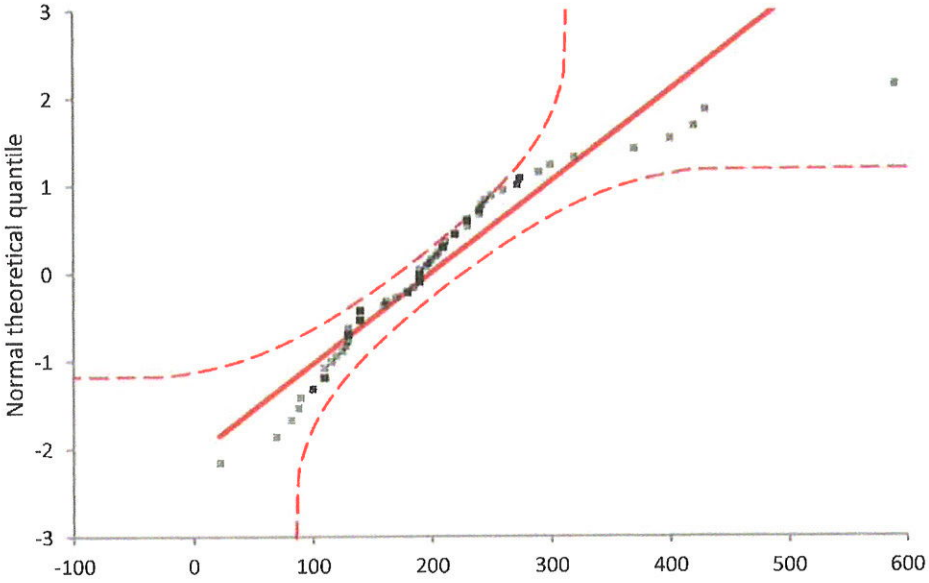


Figure 1. Normal quantile plot for chloride data from the City of Huntsville WWTF discharge into Town Branch Creek.

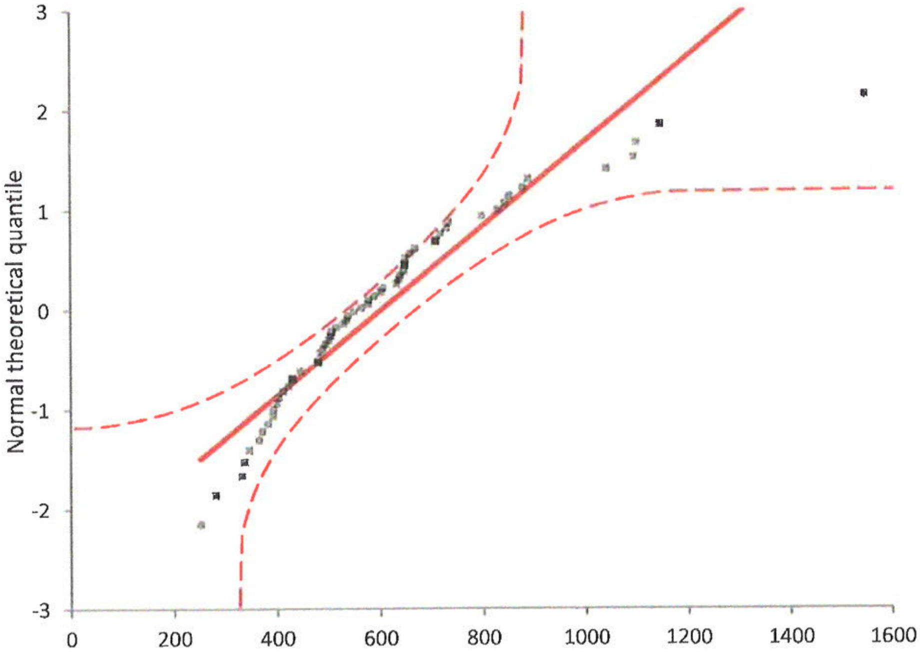


Figure 2. Normal quantile plot for TDS data from the City of Huntsville WWTF discharge into Town Branch Creek.

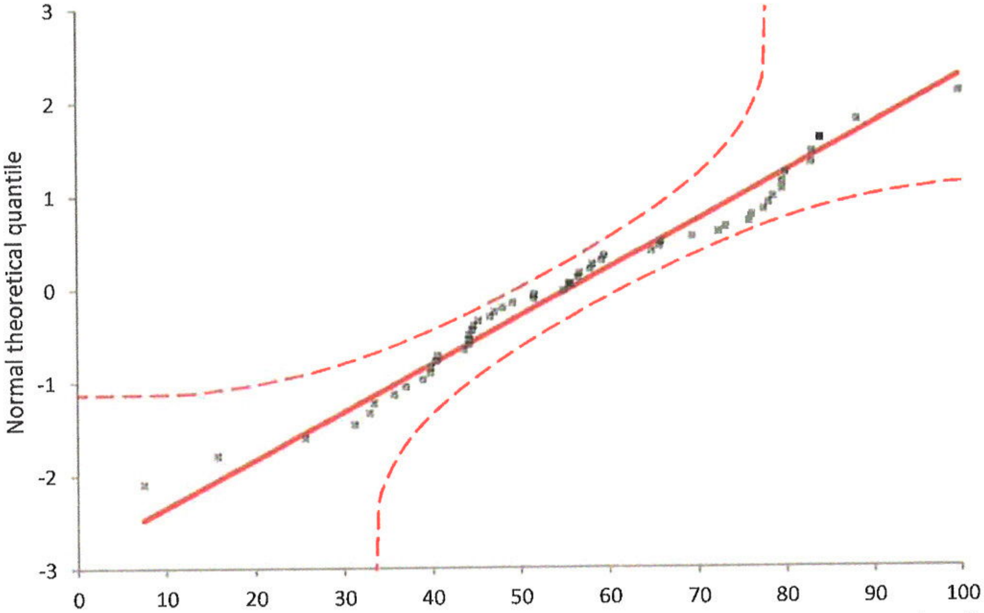


Figure 3. Normal quantile plot for sulfate data from the City of Huntsville WWTF discharge into Town Branch Creek.

Sulfate was found to fit a normal distribution. Chloride and TDS raw data were not normally distributed and required log transformation. Normality plots for transformed data are shown in figures 4 and 5.

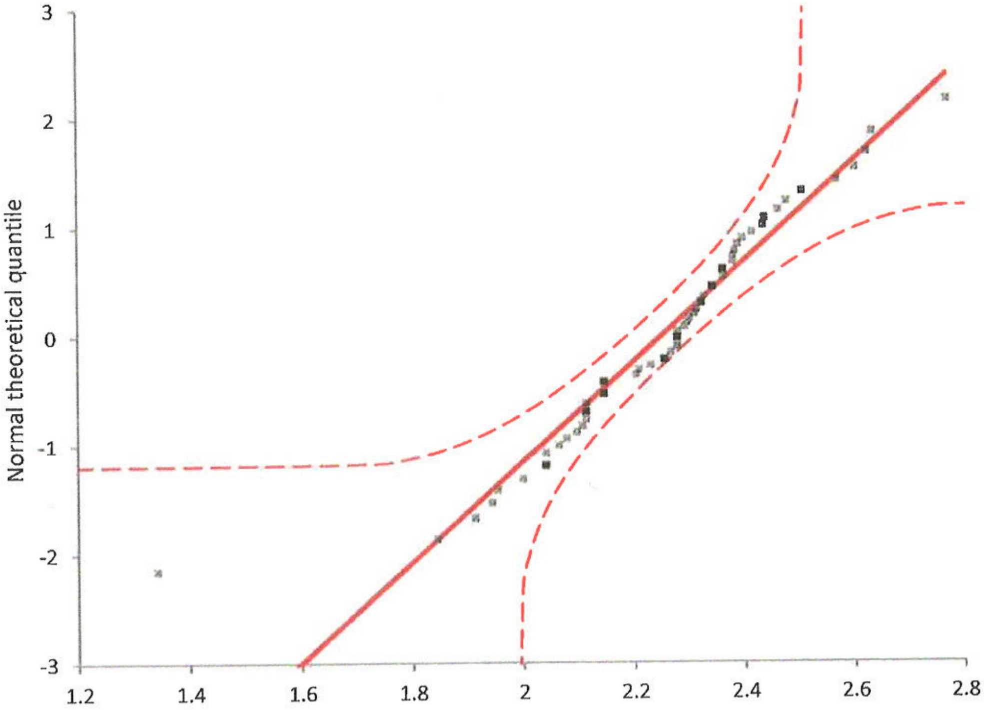


Figure 4. Normal quantile plot for chloride data after log transformation.

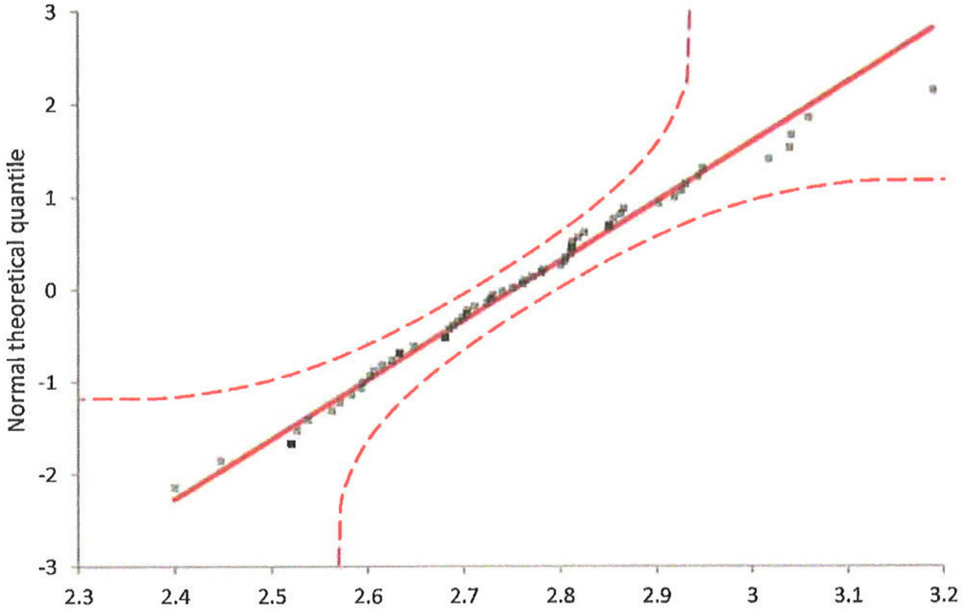


Figure 5. Normal quantile plot for TDS data after log transformation.

Chloride data were not normally distributed even after applying a log transformation. Additionally, we conducted Shapiro-Wilks Goodness-of-Fit tests to confirm hypotheses of normality. A *p*-value greater than 0.05 indicates data that are normally distributed. Data sets with *p*-values less than 0.05 are not normally distributed, though some data sets can be normalized by applying a log transformation, as in the case of Outfall 001 TDS data. Results of Shapiro-Wilk tests are shown below.

Table 1. Results of Shapiro-Wilk tests.

	***p*-value**		
Data set	**TDS**	**Chloride**	**Sulfate**
Outfall 001 (raw)	<0.0001	<0.0001	0.41
Outfall 001 (transformed)	0.88	0.003	N/A

We calculated the 99th and 95th percentile values for raw sulfate data and log transformed TDS data using the following equation for determining percentiles of normally distributed data (Gilbert 1987):

$$x_p = \overline{X} + Z_p s$$

where $\overline{X}$ denotes the sample mean, s is the standard deviation, and Z_p is a coefficient that corresponds to the 99th or 95th quantile of the standard normal distribution.

When applied to the raw sulfate data, the formula above, though appropriate for determining quantiles for normally distributed data sets, rendered a 99th percentile value greater than the maximum sulfate concentration in the data series. Thus, the 99th percentile for sulfate was determined using a distribution-free method provided by Microsoft Excel ®, while the 95th percentile was calculated using the equation in Gilbert (1987).

Given that the log transformed chloride data rendered a normal quantile plot with several values deviating from the $y = x$ line as well as a Shapiro-Wilks p-value less than 0.05, we concluded that the chloride data were not normally distributed under any circumstance. We utilized nonparametric measures to obtain the 99th percentile, using the following equation from Gilbert (1987) to assign ranks:

$$k = p(n+1)$$

where n is the number of data points, p corresponds to the percentile of interest, and k is an integer that denotes the rank that is the best nonparametric estimate of the pth percentile.

The table below lists the 99th and 95th percentile for total dissolved solids, chloride, and sulfate for Huntsville WWTF Outfall 001.

Table 2. Percentile values for TDS and chloride for Outfall 001.

	Percentile Value		
Percentile	**TDS (mg/L)**	**Chloride (mg/L)**	**Sulfate (mg/L)**
99th	1300	590	93
95th	1019	416	87

Values corresponding to the 95th percentile were used in the calculation of site specific criteria. Additionally, background concentrations of total dissolved solids and chloride for the Ozark Highlands ecoregion were used in these calculations. These concentrations are 143 mg/L, 6 mg/L, and 6 mg/L, respectively.

Flow values utilized for the calculation of site specific criteria were 4.0 cfs upstream flow and 3.1 cfs for City of Huntsville WWTF Outfall 001, which corresponds to the design flow for the outfall.

The site specific criteria for each parameter were calculated for Outfall 001 as shown below.

$SSC_{chloride}=$
[(4 cfs x 6 mg/L) + (3.1 cfs x 416 mg/L) /(4 cfs + 3.1 cfs)] = 185 mg/L

$SSC_{TDS}=$
[(4 cfs x 143 mg/L) + (3.1 cfs x 1019 mg/L) /(4 cfs + 3.1 cfs)] = 525 mg/L

$SSC_{sulfate}=$
[(4 cfs x 6 mg/L) + (3.1 cfs x 87 mg/L) /(4 cfs + 3.1 cfs)] = 41 mg/L

Appendix D

Whole Effluent Toxicity

Outfall 001 City of Huntsville Toxicity Summary (7-day chronic toxicity test)

	Ceriodaphnia dubia (Water Flea)							Pimephales promelas (Fathead Minnow)							WET Chemistry (Maximum values)					
Date Test initated	Survival CNTL	Survival 100%	Survival NOEC	Repro. CNTL	Repro. 100%	Repro. NOEC	Pass/Fail (Lethal/ Sublethal)	Survival CNTL	Survival 100%	Survival NOEC	Growth CNTL	Growth 100%	Growth NOEC	Pass/Fail (Lethal/ Sublethal)	Residual Chlorine	Hardness (Max)	Alkalinity	Sp. Cond. (us/cm)	NH3-N	pH (Max)
2/3/2009	100	100	100	23.5	25.7	100.0	Pass	97.5	100	100	0.535	0.552	100	Pass	*0.025*	78	36	580	0.63	7.3
4/28/2009	100	100	100	20.1	8.2	75.0	Fail (Subleth)	97.5	92.5	100	0.413	0.411	100	Pass	0.06	200	96	1000	*0.05*	7.9
8/18/2009	100	100	100	15.7	11.7	100.0	Pass								*0.025*	180	77	890	1.70	7.8
10/27/2009	100	100	100	16.9	23.2	100.0	Pass	100	95	100	0.432	0.496	100	Pass	*0.025*	120	42	460	0.16	7.8
2/2/2010								100	100	100	0.585	0.576	100	Pass	0.07	140	52	660	2.80	7.5
3/16/2010	100	100	100	17.5	16.9	100.0	Pass								0.07	110	100	690	0.35	8.2
4/20/2010	100	100	100	20.7	13.0	42.0	Fail (Subleth)	97.5	97.5	100	0.665	0.663	100	Pass	*0.025*	180	110	900	3.10	7.8
7/27/2010	100	100	100	21.0	21.3	100.0	Pass	100	100	100	0.61	0.662	100	Pass	*0.025*	240	72	1000	1.50	7.6
10/26/2010	100	100	100	21.7	18.9	100.0	Pass	100	97.5	100	0.451	0.495	100	Pass	0.05	170	72	700	3.90	7.5
3/1/2011	100	90	100	20.6	23.8	100.0	Pass	100	90	100	0.616	0.546	100	Pass	0.06	220	89	640	0.23	8.0
5/17/2011	90	100	100	14.9	15.2	100.0	Pass	95	92.5	100	0.409	0.568	100	Pass	*0.05*	180	68	860	0.10	8.0
8/16/2011	80	100	100	14.0	17.1	100.0	Pass	100	97.5	100	0.467	0.424	100	Pass	*0.025*	220	130	720	2.20	8.4
11/15/2011	100	100	100	24.4	19.7	100.0	Pass	95	97.5	100	0.528	0.647	100	Pass	*0.05*	170	45	660	0.39	7.4
1/31/2012								97.5	77.5	100	0.459	0.378	100	Pass	*0.05*	160	90	560	3.80	8.0
2/28/2012	100	100	100	18.6	18.5	100.0	Pass								*0.05*	220	110	1300	0.80	8.0
5/1/2012	100	90	100	22.4	18.2	100.0	Pass	100	92.5	100	0.363	0.295	100	Pass	*0.05*	250	110	1100	0.38	8.0
N	14	14	14	14	14	14	--	13	13	13	13	13	13	--	16	16	16	16	16	16
AVE	97.9	98.6	100.0	19.4	18.0	94.1	--	98.5	94.6	100.0	0.5	0.5	100.0	--	0.0	177.4	81.2	795.0	1.4	7.8
MIN	80	90	100	14	8.2	42	--	95	77.5	100	0.363	0.295	100	--	0.025	78	36	460	0.05	7.3
MAX	100	100	100	24.4	25.7	100	--	100	100	100	0.665	0.663	100	--	0.07	250	130	1300	3.9	8.4
STD DEV	5.8	3.6	0.0	3.2	4.8	16.4	--	1.9	6.1	0.0	0.1	0.1	0.0	--	0.0	48.1	27.9	224.5	1.4	0.3
90%TILE	100	100	100	23.17	23.62	100	--	100	100	100	0.6148	0.659	100	--	0.065	230	110	1050	3.45	8.1

Appendix E

Habitat Data

Habitat Characterization Summary Table - City of Huntsville, AR (Holman Ck, Town Branch, & War Eagle Ck)

Observation	Study Locations					
	HC-1	**HC-2**	**TB-1**	**TB-2**	**WEC-1**	**WEC-2**
Date	4/10/2012	4/10/2012	4/10/2012	4/10/2012	4/11/2012	4/11/2012
Location:	**Upstream/Downstream**	**Upstream/Downstream**	**Upstream/Downstream**	**Upstream/Downstream**	**Upstream/Downstream**	**Upstream/Downstream**
General Stream Characteristics:						
Total Habitat Reach Length, ft	1564	1196	600	850	1300	1900
Average Bankfull Width, ft	78.2	59.8	30	40	71	93.4
Average Bankfull Depth, ft	2.05	3.2	1.6	1.8	2.7	1.85
Average Velocity, fps	0.09	0.60	0.50	0.20	0.76	0.7
Flow, cfs	3.74	7.70	1.88	2.68	61.4	72.3
Morphology Regime						
% Riffle	40	27	47	51	8	13
% Run	33	26	25	17	15	16
% Pool	28	47	28	32	77	72
Depth and Width Regime						
Average Riffle Thalwag Depth, ft.	0.7	0.6	0.7	0.7	1.5	1.4
Average Riffle Overall Depth, ft	0.4	0.4	0.4	0.5	1.0	0.9
Average Riffle Wetted Width, ft	15.6	20.7	15.0	14.8	25.3	35.6
Average Run Thalwag Depth, ft.	1.0	1.1	1.2	0.7	1.9	1.9
Average Run Overall Depth, ft.	0.5	0.7	0.7	0.4	1.4	1.1
Average Run Wetted Width, ft	19.0	23.9	13.4	21.3	47.0	39.4
Average Pool Thalwag Depth, ft	2.7	3.0	1.5	1.9	4.7	4.7
Average Pool Overall Depth, ft.	1.4	1.8	1.0	1.1	3.5	2.9
Average Pool Wetted Width, ft	26.0	26.6	18.6	19.6	74.4	50.9
In-Stream Habitat (Percent Stable Habitat)						
Epifaunal Substrate, Macroinvertebrates	69	64	50	55	33	34.5
In-Stream Cover, Fish	62	59	52	57	46	48
Substrate Characterization (Dominate Substrate)						
Riffle	Cobble	Coarse Gravel	Boulder	Cobble	Coarse Gravel	Coarse Gravel
Run	Cobble	Coarse Gravel	Cobble	Fine Gravel	Coarse Gravel	Coarse Gravel
Pool	Coarse Gravel	Coarse Gravel	Boulder	Cobble	Coarse Gravel/Silt,Clay	Coarse Gravel/Sand
Embeddedness						
% Embeddedness	13	11	18	25	13	10
Sediment Deposition						
Average Percent of Bottom Affected	5	10	19	10	26	25
Aquatic Macrophytes and Periphyton (Percent Coverage)						
Average Riffle Macrophytes	0	0	0	0	10	3
Average Riffle Periphyton	58	62	56	65	65	47
Average Run Macrophytes	0	0	0	0	4	5
Average Run Periphyton	49	45	61	35	55	50
Average Pool Macrophytes	0	0	0	0	1	0
Average Pool Periphyton	43	24	43	30	10	6
Canopy Cover (Percent Stream Shading)						
Stream Shading	30	55	51	60	35	25
Bank Stability and Slope						
Average Left Bank Stability	8	7	7	9	6	7
Average Left Bank Slope (degrees)	37	54	54	45	68	72
Average Right Bank Stability	6	7	6	8	8	6
Average Right Bank Slope (degrees)	56	62	54	43	72	61
Bank Vegetative Protection						
Average Left Bank Protection (percent)	74	75	53	80	61	65
Average Right Bank Protection (percent)	53	74	54	71	73	71
Riparian Vegetative Zone Width						
Average Left Bank Riparian Width, meters	6	3	3	7	2	8
Average Right Bank Riparian Width, meters	3	10	3	2	2	5
Land-Use Stream Impacts						
Impacts	Cattle-moderate/Bridge-minor	Cattle-moderate	Industrial & Urban-moderate	Cattle-minor	Cattle-moderate/industrial-minor	Cattle-minor

Habitat Characterization Summary Table - City of Huntsville, AR (Holman Ck, Town Branch, & War Eagle Ck)

	Study Locations					
Observation	**HC-1**	**HC-2**	**TB-1**	**TB-2**	**WEC-1**	**WEC-2**
Date	10/12/2011	10/12/2011	10/11/2011	10/11/2011	10/13/2011	10/13/2011
Location:	**Upstream/Downstream**	**Upstream/Downstream**	**Upstream/Downstream**	**Upstream/Downstream**	**Upstream/Downstream**	**Upstream/Downstream**
General Stream Characteristics:						
Total Habitat Reach Length, ft	1224	1280	600	800	1300	1900
Average Bankfull Width, ft	61.2	64	30	40	71	93.4
Average Bankfull Depth, ft¹	0.9	2.5	1.6	1.8	2.7	1.85
Average Velocity, fps	--	--	--	--	--	--
Flow, cfs	--	--	--	--	--	--
Morphology Regime						
% Riffle	36	28	25	38	22	15
% Run	26	33	33	38	23	6
% Pool	39	38	43	23	54	79
Depth and Width Regime						
Average Riffle Thalwag Depth, ft	0.9	0.7	0.5	0.7	0.9	0.7
Average Riffle Overall Depth, ft	0.4	0.5	0.3	0.5	0.4	0.4
Average Riffle Wetted Width, ft	9.2	24.9	14.3	14.7	18.3	38.8
Average Run Thalwag Depth, ft	1.0	1.4	0.8	1.3	1.8	1.0
Average Run Overall Depth, ft.	0.6	0.9	0.5	0.7	1.4	0.6
Average Run Wetted Width, ft	13.0	43.4	10.0	28.7	30.0	37.5
Average Pool Thalwag Depth, ft.	2.7	2.7	1.3	2.8	2.0	3.8
Average Pool Overall Depth, ft.	1.8	1.8	0.8	1.7	1.4	2.5
Average Pool Wetted Width, ft	24.8	41.2	--	22.0	65.0	88.7
In-Stream Habitat (Percent Stable Habitat)						
Epifaunal Substrate, Macroinvertebrates	68	68	55	72	68	50.5
In-Stream Cover, Fish	71	72	59	76	72	67
Substrate Characterization (Dominate Substrate)						
Riffle	Coarse Gravel	Coarse Gravel	Boulder	Cobble	Coarse Gravel	Coarse Gravel
Run	Coarse Gravel	Coarse Gravel	Boulder	Cobble/Fine Gravel	Coarse Gravel	Coarse Gravel
Pool	Coarse Gravel	Coarse Gravel	Bedrock	Cobble	Coarse Gravel	Coarse Gravel
Embeddedness						
% Embeddedness	30	48	35	33	25	27
Sediment Deposition						
Average Percent of Bottom Affected	8	20	14	9	20	53
Aquatic Macrophytes and Periphyton (Percent Coverage)						
Average Riffle Macrophytes	0	3	2	1	15	10
Average Riffle Periphyton	81	75	70	70	75	66
Average Run Macrophytes	3	5	1	4	14	8
Average Run Periphyton	74	68	68	57	63	75
Average Pool Macrophytes	3	5	2	2	7	5
Average Pool Periphyton	70	53	75	72	41	32
Canopy Cover (Percent Stream Shading)						
Stream Shading	20	33	55	61	32	22
Bank Stability and Slope						
Average Left Bank Stability	8	5	5	7	6	5
Average Left Bank Slope (degrees)	42	70	59	49	75	76
Average Right Bank Stability	4	6	5	7	6	6
Average Right Bank Slope (degrees)	77	70	60	49	59	69
Bank Vegetative Protection						
Average Left Bank Protection (percent)	77	70	54	72	76	77
Average Right Bank Protection (percent)	50	79	53	75	72	74
Riparian Vegetative Zone Width						
Average Left Bank Riparian Width, meters	7	2	4	8	2	3
Average Right Bank Riparian Width, meters	2	7	3	3	9	7
Land-Use Stream Impacts						
Impacts	Pasture-minor	Pasture-minor	Industrial & Urban-moderate	Cattle-minor	Cattle-moderate/Urban-minor	Pasture-minor

Appendix F

Macroinvertebrate Data

Macroinvertebrates identified from WEC-1, WEC-2, TB-1, TB-2, HC-1, and HC-2 subsamples collected in War Eagle Creek in Madison County, AR during the fall of 2011.

Taxa/Station I.D.	Biotic Index*	Trophic Group	Station Sampled in Fall 2011					
			WEC-1	WEC-2	TB-1	TB-2	HC-1	HC-2
TURBELLARIA								
Planariidae	8	GC	0	0	0	0	0	0
COLLEMBOLA								
Isotomidae	-	GC	0	2	0	1	0	9
ANNELIDA								
Hirudinea	7.8	PR	1	0	0	0	1	0
Oligochaeta	9.2	GC	3	1	1	2	4	9
GASTROPODA								
Ancylidae	6	SC	0	2	0	0	0	0
Physa	9.1	SC	18	53	1	9	2	52
Planorbidae	---	SC	0	2	0	0	1	0
BIVALVIA								
Sphaeriidae	7.7	FC	8	37	1	5	0	7
CRUSTACEA								
Amphipoda	7.9	GC	6	2	0	1	29	2
Cambaridae	6	GC	0	1	1	1	2	0
Isopoda	7.7	GC	0	0	0	0	2	0
EPHEMEROPTERA								
Anthopotamus	3.6	FC	1	0	0	0	0	1
Baetis	6	GC	12	57	41	98	37	137
Americaenis	7.6	GC	0	2	0	0	0	0
Caenis	7.6	GC	216	325	77	13	60	17
Callibaetis	9.3	GC	0	4	0	4	0	0
Choroterpes	2	GC	0	0	0	0	6	0
Isonychia	3.8	FC	0	1	0	0	4	0
Stenacron	7.1	GC	0	0	0	0	1	0
Stenonema	3.4	SC	20	76	10	0	82	6
Tricorythodes	5.4	GC	5	50	0	0	4	26
ODONATA								
Aeshnidae	8	PR	0	0	0	1	0	0
Argia	8.7	PR	4	2	7	20	0	8
Arigomphus	6.4	PR	0	0	1	0	0	0
Basiaeschna	7.7	PR	0	1	0	0	0	0
Calopteryx	8.3	PR	0	0	1	0	0	1
Enallagma	9	PR	5	4	0	2	2	6

Taxa/Station I.D.	Biotic Index*	Trophic Group	Station Sampled in Fall 2011					
			WEC-1	WEC-2	TB-1	TB-2	HC-1	HC-2
Gomphus	6.2	PR	2	0	0	0	0	1
Hetaerina	6.2	PR	0	6	0	1	0	0
Ischnura	9.4	PR	0	0	0	3	0	0
Lanthus	2.7	PR	0	0	0	2	4	0
Macromia	6.7	PR	0	0	0	0	0	1
Progomphus	8.7	PR	1	0	6	4	0	1
PLECOPTERA								
Neoperla	1.6	PR	16	9	0	0	0	3
Perlidae	1	PR	0	0	0	0	9	0
Zealeuctra	0	SH	0	0	0	0	1	0
HEMIPTERA								
Corixidae	6	PR	0	0	0	1	0	0
Rheumatobates	6.4	PR	0	0	0	0	0	1
Saldidae	10	PR	0	0	0	1	0	0
MEGALOPTERA								
Corydalus	5.6	PR	2	3	0	0	1	1
TRICHOPTERA								
Branchycentrus	3.5	GC	1	0	0	0	0	1
Chematopsyche	6.6	FC	243	99	70	366	10	82
Chimarra	2.8	FC	2	6	26	152	3	7
Helicopsyche	0	SC	0	0	2	0	0	0
Hydropsyche	4	FC	0	0	6	6	1	0
Hydroptila	6.2	SC	0	0	1	0	0	0
Polycentropus	3.5	PR	0	0	0	0	3	0
COLEOPTERA								
Ancyronyx (larvae)	6.9	SC	1	0	0	0	0	0
Ancyronyx (adult)	6.9	SC	1	3	0	0	0	0
Dubiraphia (larvae)	6.4	GC	3	5	0	0	0	0
Dubiraphia (adult)	6.4	GC	1	1	0	0	0	0
Ectopria	4.3	SC	0	0	1	0	0	0
Helichus	5.4	SC	0	21	0	0	1	0
Macronychus (larvae)	4.7	SH	0	2	0	0	0	1
Macronychus (adult)	4.7	SH	0	0	0	0	0	3
Peltodytes	8.5	SH	1	0	0	0	0	0
Psephenus	2.5	SC	1	2	16	4	52	16
Stenelmis (larvae)	5.4	SC	22	29	17	22	5	61
Stenelmis (adult)	5.4	GC	4	4	1	12	0	4

Taxa/Station I.D.	Biotic Index*	Trophic Group	Station Sampled in Fall 2011					
			WEC-1	WEC-2	TB-1	TB-2	HC-1	HC-2
Tropisternus	9.8	PR	0	0	0	0	0	4
DIPTERA								
Ceratopogonidae	5.6	PR	0	0	1	0	4	3
Chironomini	8	GC	244	108	66	80	32	9
Ortholadiinae	8	GC	108	21	17	82	82	4
Tanypodinae	8	PR	12	10	11	43	15	1
Nemotelus	-	-	0	0	1	1	0	4
Diptera Sp.1	---	GC	0	0	0	0	1	0
Hemerodromia	6	PR	0	0	0	0	1	0
Forcipomyia	6	SC	0	0	0	0	4	0
Prosimulium	2.6	FC	0	0	1	4	0	2
Psychoda	9.9	GC	0	0	0	0	0	1
Simulium	4.4	FC	19	15	7	0	2	0
Tabanidae	8	PR	0	0	2	0	1	2
Tipula	7.7	SH	2	0	2	3	0	1
Total Abundance:			985	966	395	944	469	495

**All B.I. values are from Sarver 2001 (MDNR) or EPA RBA doc. (1999) and values are either family/genus/species specific or the highest value represented for that family/genus if specifics are unavailable.*

Macroinvertebrates identified from WEC-1, WEC-2, TB-1, TB-2, HC-1, and HC-2 subsamples collected in War Eagle Creek in Madison County, AR during the spring of 2012.

Taxa/Station I.D.	Biotic Index*	Trophic Group	Station Sampled in Spring 2012					
			WEC-1	WEC-2	TB-1	TB-2	HC-1	HC-2
COLLEMBOLA								
Isotomidae	-	GC	0	1	0	0	0	1
ANNELIDA								
Hirudinea	7.8	PR	0	1	0	29	0	0
Oligochaeta	9.2	GC	5	7	8	28	5	9
GASTROPODA								
Physa	9.1	SC	3	27	12	54	1	8
Planorbidae	---	SC	0	1	0	0	0	1
BIVALVIA								
Sphaeriidae	7.7	FC	3	3	0	0	0	0
CRUSTACEA								
Amphipoda	7.9	GC	1	2	0	0	0	0
Cambaridae	6	GC	3	2	7	0	4	2
Isopoda	7.7	GC	0	0	2	0	8	4
EPHEMEROPTERA								
Baetis	6	GC	47	26	86	18	238	178
Caenis	7.6	GC	18	42	77	42	30	43
Callibaetis	9.3	GC	7	6	2	0	0	1
Leptophlebia	6.4	GC	3	6	0	0	4	1
Stenonema	3.4	SC	15	15	2	0	8	14
Tricorythodes	5.4	GC	8	11	0	1	0	10
ODONATA								
Argia	8.7	PR	0	0	3	6	0	0
Calopteryx	8.3	PR	0	0	2	1	0	3
Enallagma	9	PR	3	4	8	8	1	9
Hagenius	4	PR	0	0	1	1	0	0
Hetaerina	6.2	PR	0	0	1	0	0	0
Ischnura	9.4	PR	2	2	0	4	0	0
Ladona	---	PR	0	0	0	2	0	0
Macromia	6.7	PR	0	0	1	0	0	0
Progomphus	8.7	PR	0	1	0	0	0	0
Stylogomphus	4.8	PR	0	0	1	1	0	0
PLECOPTERA								
Amphinemura	3.4	SH	0	0	0	0	4	0
Attaneuria	2.75	PR	10	4	0	0	3	2

Taxa/Station I.D.	Biotic Index*	Trophic Group	Station Sampled in Spring 2012					
			WEC-1	WEC-2	TB-1	TB-2	HC-1	HC-2
Haploperla	1.3	PR	0	0	0	0	2	2
Isoperla	2	PR	0	0	0	0	8	0
Neoperla	1.6	PR	2	5	0	0	21	1
Perlesta	0	PR	1	5	0	0	4	4
Zealeuctra	0	SH	0	0	1	0	0	1
MEGALOPTERA								
Corydalus	5.6	PR	4	0	0	0	0	0
Sialis	7.5	PR	0	0	0	0	1	1
TRICHOPTERA								
Chematopsyche	6.6	FC	38	25	208	82	29	244
Chimarra	2.8	FC	2	5	13	18	7	2
Helicopsyche	0	SC	0	0	2	0	0	0
Hydropsyche	4	FC	1	0	9	27	0	0
Hydroptila	6.2	SC	2	0	0	0	3	0
Orthotrichia	7.2	GC	0	0	1	0	0	0
Polycentropus	3.5	PR	0	0	0	0	1	0
COLEOPTERA								
Ancyronyx (larvae)	6.9	SC	0	3	0	0	0	0
Ancyronyx (adult)	6.9	SC	0	3	0	0	0	0
Dubiraphia (larvae)	6.4	GC	0	1	0	0	0	0
Dubiraphia (adult)	6.4	GC	0	2	0	0	0	0
Macronychus (larvae)	4.7	SH	1	0	0	0	0	2
Macronychus (adult)	4.7	SH	0	0	0	0	0	0
Psephenus	2.5	SC	1	0	11	2	24	6
Stenelmis (larvae)	5.4	SC	9	6	8	5	8	20
Stenelmis (adult)	5.4	GC	0	2	13	3	1	2
DIPTERA								
Ceratopogonidae	5.6	PR	1	1	0	0	5	0
Chironomini	8	GC	158	130	230	105	161	208
Ortholadiinae	8	GC	66	47	117	96	86	39
Tanypodinae	8	PR	3	13	41	8	23	7
Culicidae	---	GC	0	0	0	0	0	1
Prosimulium	2.6	FC	0	0	55	0	0	2
Psychoda	9.9	GC	0	0	0	0	4	1
Simulium	4.4	FC	36	48	10	22	56	77
Tipula	7.7	SH	1	0	2	1	2	1
Total Abundance:			454	457	934	564	752	907

**All B.I. values are from Sarver 2001 (MDNR) or EPA RBA doc. (1999) and values are either family/genus/species specific or the highest value represented for that family/genus if specifics are unavailable*

Appendix G

Fish Data

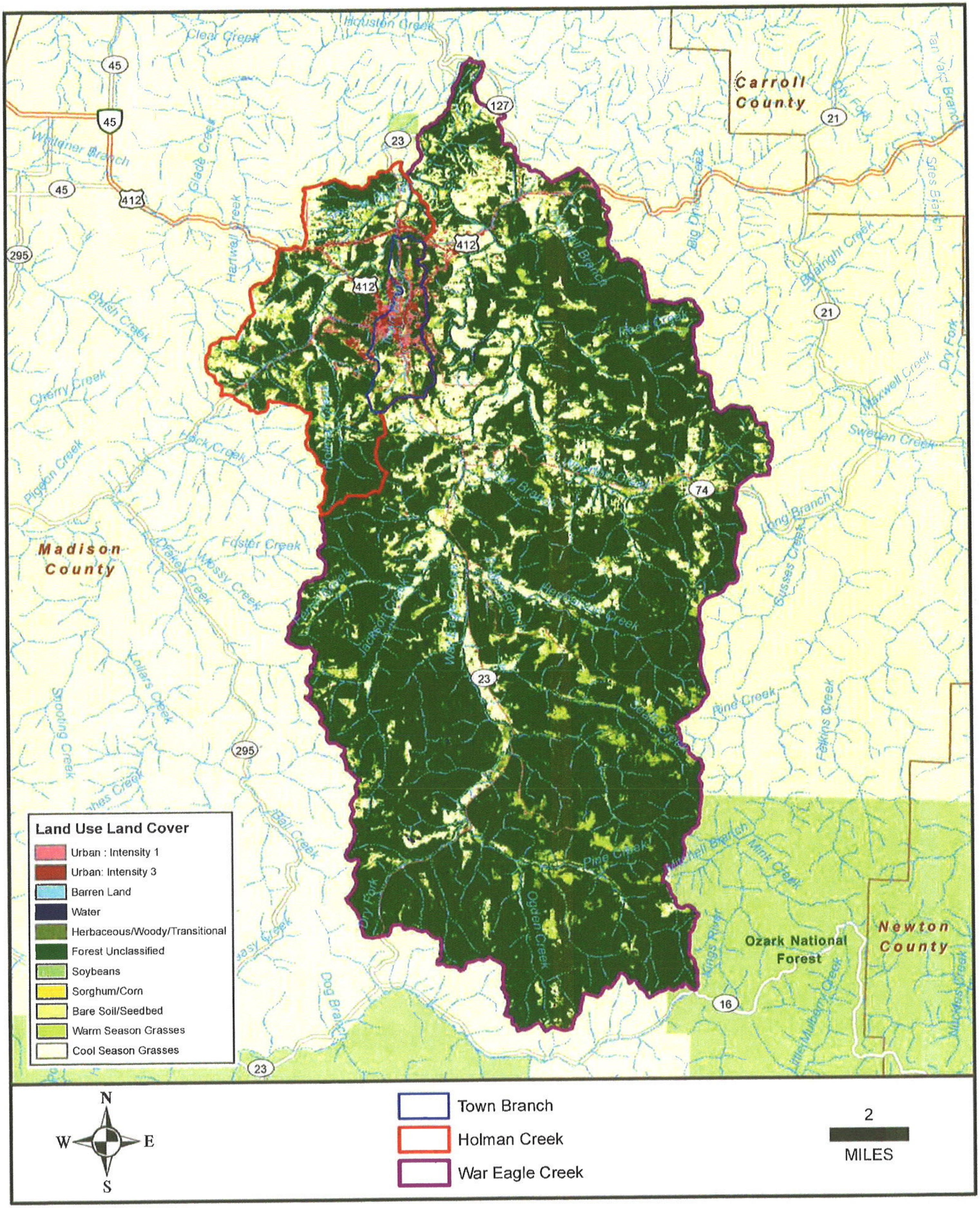
Raw fish numbers for stations of the Town Branch, Holman Creek, and War Eagle Creek in Fall 2011.

Scientific Name	Common Name	TB-1	TB-2	HC-1	HC-2	WEC-1	WEC-2
PETROMYZONTIDAE							
Ichthyomyzon spp.		0	0	0	0	1	0
CYPRINIDAE							
Campostoma anomalum	central stoneroller	237	219	176	49	47	12
Cyprinella whipplei	steelcolor shiner	0	1	0	17	25	5
Luxilus pilsbryi[1]	duskystripe shiner	35	39	39	87	16	5
Luxilus chrysocephalus	striped shiner	21	5	0	0	0	0
Notropis boops	bigeye shiner	0	0	0	2	4	0
Notropis atherinoides	emerald shiner	0	0	0	0	0	3
Notropis nubilis[2]	ozark minnow	251	138	20	65	20	5
Notropis telescopus	telescope shiner	0	0	0	1	0	0
Phoxinus erythrogster[2]	southern redbelly dace	0	0	9	0	0	0
Pimehpales notatus	bluntnose minnow	13	11	8	12	12	3
Semotilus atromaculatus	creek chub	5	0	9	0	0	0
CATOSTOMIDAE							
Hypentelium nigricans[1]	northern hog sucker	0	2	4	3	2	3
Moxostoma duquesnei	black redhorse	0	0	0	2	0	1
Moxostoma erythrurm	golden redhorse	0	0	0	0	0	2
FUNDULIDAE							
Fundulus olivaceus	blackspotted topminnow	0	0	2	2	4	1
Fundulus catenatus	northern studfish	16	6	18	0	0	0
POECILIIDAE							
Gambusia affinis	mosquitofish	0	0	0	0	1	0
ICTALURIDAE							
Noturus exilis[1]	slender madtom	8	10	12	7	1	0
Noturus albater[2]	ozark madtom	0	0	0	0	2	14
Ameiurus natalis	yellow bullhead	3	7	1	5	1	0
CENTRARCHIDAE							
Ambloplites constellatus[1]	ozark bass	0	0	0	1	3	4
Lepomis cyanellus	green sunfish	12	7	4	8	23	4
Lepomis gulosus	warmouth	0	0	0	0	0	2
Lepomis macrochirus	bluegill sunfish	1	3	0	1	1	3
Lepomis megalotis	longear sunfish	37	53	42	94	199	72
Micropterus salmoides	largemouth bass	0	0	1	0	0	1
Micropterus dolomieu[1]	smallmouth bass	1	1	0	0	0	0
Micropterus punctulatus	spotted bass	0	0	0	0	6	7

Scientific Name	**Common Name**	**TB-1**	**TB-2**	**HC-1**	**HC-2**	**WEC-1**	**WEC-2**
PERCIDAE							
Etheostoma blennioides	greenside darter	1	0	3	3	10	7
Etheostoma caeruleum[1]	rainbow darter	42	31	55	48	54	50
Etheostoma juliae	yoke darter	0	0	0	0	8	87
Etheostoma punctulatum	stippled darter	0	0	1	0	0	0
Etheostoma stigmaeum	speckled darter	0	0	0	0	3	2
Etheostoma zonale	banded darter	0	0	0	0	7	22
Percina caproides	Logperch	0	0	0	1	1	0
COTTIDAE							
Cottus carolinae[2]	banded sculpin	7	7	4	0	2	24
Total Fish Collected		690	540	408	408	453	339

Appendix H

Land-Use Analysis


Land Use Land Cover
Urban : Intensity 1
Urban: Intensity 3
Barren Land
Water
Herbaceous/Woody/Transitional
Forest Unclassified
Soybeans
Sorghum/Corn
Bare Soil/Seedbed
Warm Season Grasses
Cool Season Grasses
Town Branch
Holman Creek
War Eagle Creek
N
W
E
S
2
MILES
Carroll County
Madison County
Newton County
Ozark National Forest
Clear Creek
Houston Creek
Whitener Branch
Glade Creek
Hartwell Creek
Brush Creek
Cherry Creek
Pigeon Creek
Hock Creek
Foster Creek
Mossy Creek
Drakes Creek
Lollars Creek
Shooting Creek
Ball Creek
Dog Branch
Big Dry Creek
Dry Fork
Tan Vat Branch
Sites Branch
Boatright Creek
Maxwell Creek
Sweden Creek
Long Branch
Gusses Creek
Pine Creek
Felkins Creek
Mitchell Branch
Mink Creek
Kings River
Little Mulberry Creek
Mulberry Creek
Jackson Creek
Hargraves Creek
Ogden Creek
Dry Fork
45
45
45
412
412
412
295
295
127
23
23
23
21
21
74
16

Landuse Data analysis

WAR EAGLE

Value	Land Use	Count	Percentage
11	Urban: Intensity 1	5543	1.01%
13	Urban: Intensity 3	578	0.11%
31	Barren Land	713	0.13%
41	Water	651	0.12%
51	Herbaceous/Woody/Transitional	31167	5.68%
100	Forest Unclassified	404411	73.68%
201	Soybeans	1609	0.29%
205	Sorghum/Corn	2	0.00%
208	Bare Soil/Seedbed	69	0.01%
209	Warm Season Grasses	26955	4.91%
210	Cool Season Grasses	77148	14.06%
		Total 548846	100.00%

HOLMAN

Value	Land Use	Count	Percentage
11	Urban: Intensity 1	6253	7.14%
13	Urban: Intensity 3	2769	3.16%
31	Barren Land	265	0.30%
41	Water	93	0.11%
51	Herbaceous/Woody/Transitional	6677	7.62%
100	Forest Unclassified	44398	50.67%
201	Soybeans	1	0.00%
208	Bare Soil/Seedbed	6	0.01%
209	Warm Season Grasses	7697	8.78%
210	Cool Season Grasses	19466	22.22%
		Total 87625	100.00%

TOWN BRANCH

Value	Land Use	Count	Percentage
11	Urban: Intensity 1	2846	19.55%
13	Urban: Intensity 3	1277	8.77%
31	Barren Land	46	0.32%
41	Water	47	0.32%
51	Herbaceous/Woody/Transitional	1218	8.37%
100	Forest Unclassified	5136	35.27%
201	Soybeans	1	0.01%
208	Bare Soil/Seedbed	4	0.03%
209	Warm Season Grasses	1597	10.97%
210	Cool Season Grasses	2388	16.40%
		Total 14560	100.00%

Appendix I

7Q10 Calculation

7Q10 Calculation

The 7Q10 was calculated using a Pearson Log III type low flow statistical analysis (Riggs, 1968 & 1982). In this method the 7-day low flow for each year is calculated using a moving average. Then each year 7-day low flow is ranked in ascending order. The flow data is then log transformed and the average, the skew, and the standard deviation are calculated for the set of low flows. This data is used to develop a standard normal deviate and a frequency factor (Martin, 1999) which is utilized to determine the low flow at a given recurrence interval.

The Pearson Log III analysis returned a 7Q10 of 9.5 cfs for the data set. The results of the Pearson Log III analyses for War Eagle Creek are shown in Table 1. The raw annual low flow data are depicted graphically in Figure 1.

Table 1 - Low Flow Analysis of War Eagle Creek near Hindsville, Arkansas.

R.I.	Std. Norm. Dev.	K	Log 7QX	7QX
1.25	0.840	0.85116	1.131386	13.53274
2	0.000	0.054234	1.075575	11.90077
3	-0.429	-0.38231	1.045002	11.09181
4	-0.672	-0.63895	1.027029	10.64215
5	-0.840	-0.81914	1.01441	10.33738
10	-1.281	-1.31041	0.980006	9.55005
25	-1.753	-1.86071	0.941467	8.739097

R.I = recurrence interval
K= frequency factor for a given skewness coefficient (Cs) and R.I.
Avg. = 1.07178
Cs = -0.32637
SD = 0.07003

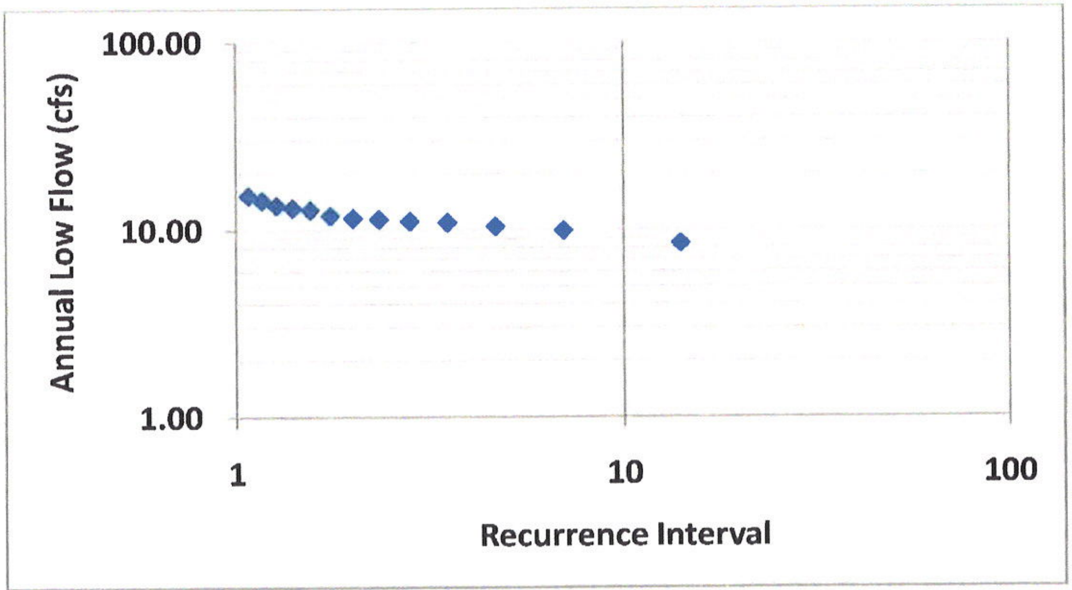


Figure 1. Plot of annual low flow versus recurrence interval for period of record.

Appendix J

Alternative Analysis

Butterball-Huntsville
Dissolved Minerals Treatment Cost Estimate

BASIS: 1.01 MGD Filtration/Reverse Osmosis/Concentrated Reject Crystallization
Ground storage tanks
Max/Avg Effluent TDS = 1300/922mg/l
Discharge limit TDS = 500 mg/l

Reject flow= 0.27 MGD

ITEM	
CAPITAL	TOTAL ($000)
UF+Carbon+RO	$13,764
Storage tanks	$1,250
Evaporative crystallization system	$15,833
TOTAL CAPITAL	**$30,847**

ANNUAL OPERATING	TOTAL ($000)
Filtration	$250
RO	$1,974
CRYSTALLIZATION	$824
EQUIP REPLACEMENT	$1,542
TOTAL OPERATING	**$4,590**

PROCESS FLOW: 24HR EMER STG+UF+8HR STORAGE+CARBON+24HR STORAGE+RO+REJECT STORAGE 40HR+(1)250GPM BRINE CONC+(1)20GPM CRYSTALLIZ

Appendix K

USGS Report

USGS
science for a changing world

Prepared in cooperation with the
City of Fayetteville, Arkansas and Beaver Water District

Ambient Conditions of Dissolved Solids, Chloride, and Sulfate, and Fate and Transport Simulations in Beaver Lake, Arkansas, 2006-2010

By W. Reed Green

Report Series SIR–XXXX

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 201x
Revised and reprinted: 201x

Suggested citation:
Green, W. Reed, 2012, Ambient Conditions of Dissolved Solids, Chloride, and Sulfate, and Fate and Transport Simulations in Beaver Lake, Arkansas, 2006-2010, U.S. Geological Survey Scientific Investigations Report, 2012-xxxx, xx p.

Contents

Figures

Tables

Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Area	
square kilometer (km^2)	247.1	acre
	Volume	
cubic meter (m^3)	6.290	barrel (petroleum, 1 barrel = 42 gal)
liter (L)	33.82	ounce, fluid (fl. oz)
liter (L)	2.113	pint (pt)
liter (L)	1.057	quart (qt)
liter (L)	0.2642	gallon (gal)
cubic meter (m^3)	0.0002642	million gallons (Mgal)
liter (L)	61.02	cubic inch (in^3)
cubic meter (m^3)	35.31	cubic foot (ft^3)
cubic meter (m^3)	1.308	cubic yard (yd^3)
	Flow rate	
cubic meter per second (m^3/s)	70.07	acre-foot per day (acre-ft/d)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F=(1.8×°C)+32

Vertical coordinate information is referenced to the insert datum name (and abbreviation) here, for instance, "North American Vertical Datum of 1988 (NAVD 88)"

Horizontal coordinate information is referenced to the insert datum name (and abbreviation) here, for instance, "North American Datum of 1983 (NAD 83)"

Altitude, as used in this report, refers to distance above the vertical datum.

*Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness $[(ft^3/d)/ft^2]ft$. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Ambient Conditions of Dissolved Solids, Chloride, and Sulfate, and Fate and Transport Simulations in Beaver Lake, Arkansas, 2006-2010

By W. Reed Green

Abstract

Beaver Lake, a deep-storage reservoir located in the upper White River Basin in northwestern Arkansas is the major water supply for the region. Beaver Lake is affected by both point and nonpoint sources of contamination. The city of Fayetteville discharges about one-half of its sewage effluent into the White River immediately upstream from the backwater of the reservoir and the city of West Fork discharges its sewage effluent further upstream in a tributary to the White River, the West Fork of the White River. The city of Huntsville discharges its effluent into a tributary of the War Eagle Creek, the second largest tributary to Beaver Lake.

A study was conducted, in cooperation with the City of Fayetteville and Beaver Water District, to describe ambient conditions of dissolved solids, chloride, and sulfate in Beaver Lake, and using a mathematical model of hydrodynamics and water quality previously prepared for Beaver Lake, examine fate and transport of increasing concentrations of these constituents, through time, at seven locations in the reservoir, from upstream to downstream. Dissolved solids, chloride, and sulfate loads from the

White River and War Eagle Creek were increased by factors of 1.2, 1.5, 2.0, 5.0, and 10.0 times ambient conditions individually for each tributary and together for the period January 2006 through December 2012, for a total of 15 different scenarios.

Concentrations of dissolved solids, chloride, and sulfate, two meters below the surface and two meters above the bottom at seven locations in the model grid (which also correspond to locations where water-quality samples were also collected) were measured daily in each of the 15 scenarios and examined against the baseline (calibrated) condition. Concentrations from the stepped-increase loading scenarios were greater in the reservoir at model segments closer to where the White River and War Eagle Creek enter. Concentrations resulting from the stepped increases in loading became more dilute further downstream from the source. Differences between the baseline condition and concentrations resulting from loading factors of 1.2, 1.5, and 2.0 times ambient concentrations were smaller than loading factors 5.0 and 10.0 times ambient concentrations. The same general pattern was observed between concentrations two meters below the surface and two meters above the bottom, with the exception of concentrations resulting from the higher loading factors (5.0 and 10.0 times), where concentrations two meters above the bottom were consistently greater than those two meters below the surface.

Introduction

Beaver Lake is a large, deep-storage reservoir located in the upper White River Basin in northwestern Arkansas. The reservoir was completed in 1963 for the purposes of flood control, hydroelectric power, and water supply. In addition, the reservoir is used for fish and wildlife habitat, recreation, and waste assimilation.

Beaver Lake is affected by both point and nonpoint sources of minerals, nutrients, and sediment. The city of Fayetteville discharges about one-half of its sewage effluent into the White River immediately upstream from the backwater of the reservoir. The city of West Fork discharges its sewage effluent into the West Fork of the White River and the city of Huntsville discharges its effluent into a tributary of War Eagle Creek. Dissolved solids (DS), chloride (Cl), and sulfate (SO_4), nutrients, sediment, pathogenic bacteria, and other constituents can enter Beaver Lake through its tributaries and around its shoreline.

In 2006, a study was conducted by Galloway and Green (2006), analyzing ambient water-quality conditions. In Galloway and Green (2006), a two-dimensional model of hydrodynamics and water-quality characteristics was developed and calibrated for the period 2001 through 2003. For the present study, this model was modified and recalibrated to examine ambient conditions of DS, Cl, and SO_4 and fate and transport of these compounds and elements in Beaver Lake from January 2006 through December 2010.

Purpose and Scope

The purpose of this report is to describe the ambient conditions and fate and transport of DS, Cl, and SO_4 concentrations in Beaver Lake. DS, Cl, and SO_4 are components of wastewater discharged into Beaver Lake and a major concern of the drinking water utilities that use Beaver Lake as their source. The Galloway and Green (2006) CE-QUAL-W2 two-dimensional model of hydrodynamics and water quality in Beaver Lake was modified and recalibrated to include DS, Cl, and SO_4 simulations for the period, January 2006 through December 2010. Estimated daily DS, Cl, and SO_4 loads were increased in the White River and War Eagle Creek tributaries by 1.2, 1.5, 2.0, 5.0, and 10.0 times, individually and together, to examine fate and transport of these constituents through time at various downstream locations in Beaver Lake.

Description of Study Area

Beaver Lake was impounded in 1963 on the White River, northeast of the city of Fayetteville, Arkansas, near Eureka Springs, Arkansas and in 1968 the reservoir reached conservation capacity (Haggard and Green, 2002). The conservation capacity of the reservoir is the storage capacity used for hydroelectric power, water supply, fish and wildlife, recreation, and water quality (U.S. Army Corps of Engineers, 1997). The main inflows into Beaver Lake are the White River, Richland Creek, and War Eagle Creek (fig. 1). Several smaller tributaries also flow into the reservoir. The basin has a drainage area of 3,087 km^2 at the Beaver Lake dam. Beaver Lake contains 2,040 million m^3 of water at the top of the current conservation pool (341.4 m above NGVD of 1929) and the surface area is 114 km^2 (Haggard and Green, 2002). The length of the reservoir is 80 km from the White River at the Highway 45 Bridge to the Beaver Lake dam. The depth of the reservoir at the dam at conservation pool elevation is 60 m, and the average depth through the reservoir is 18 m (Haggard and Green, 2002).

The U.S. Geological Survey (USGS) in cooperation with Beaver Water District (BWD) has monitored water quality in Beaver Lake since 2001. Currently, water-quality samples are collected at seven lake (L1 – L5, L9 and L10) and three tributary inflow sites (S1 – S3) (table 1, fig. 1). Continuous streamflow is also monitored at S1, S2, and S3 and used to calculate constituent loading into Beaver Lake.

Table 1. Streamflow and water-quality sites for Beaver Lake, Arkansas

Figure 1. Beaver Lake study area, with locations of water-quality sampling sites.

Ambient Conditions of Dissolved Solids, Chloride, and Sulfate in Beaver Lake

This section describes the ambient hydrologic and water-quality conditions for Beaver Lake from January 2006 through December 2010. Streamflow in the three major tributaries, outflow at Beaver Lake dam, and pool elevation for Beaver Lake are described for the period. In addition, water-quality conditions for the three major tributaries and for five sites on Beaver Lake are described for January 2006 through December 2010.

Hydrologic Conditions

Streamflow varied substantially during the period of January 2006 through December 2010 for the three major tributaries that provide inflow to Beaver Lake (fig. 2). The White River is the main inflow into Beaver Lake and approximately 34 percent of the drainage area at Beaver Lake dam is above the gaging station near Fayetteville (site S1; fig. 1). The daily mean streamflow for the White River ranged from 0.01 to 1,215 m^3/s for the period of January 2006 through December 2010. Mean daily streamflow for the period was 16.3 m^3/s. The drainage area of Richland Creek at the gaging station at Goshen (site S2; fig. 1) comprises 12 percent of the drainage area at Beaver Lake dam. The daily mean streamflow for Richland Creek ranged from 0.003 to 957 m^3/s for the period of January 2006 through December 2010, with a mean daily streamflow of 6.06 m^3/s for the period. War Eagle Creek at the gaging station near Hindsville (site S3; fig. 1) has a drainage area that comprises 22 percent of the drainage area at Beaver Lake dam. The daily mean streamflow for War Eagle Creek ranged from 0.312 to 767 m^3/s for the period of January 2006 through December 2010, with a mean daily streamflow of 9.90 m^3/s for the period.

Figure 2. Mean daily streamflow for White River (site S1), Richland Creek (site S2), and War Eagle Creek (site S3), and hourly outflow at Beaver Dam.

The outflow from Beaver Lake also varied substantially for the period of January 2006 through December 2010 (fig. 2). Outflow discharge at Beaver Dam ranged from 1.76 m^3/s to 2,254 m^3/s with a mean outflow discharge of 35.3 m^3/s for the period. Four public water-supply withdrawals also are located on Beaver Lake.

The pool elevation for Beaver Lake varied according to changes in the inflow and outflow for the reservoir (fig. 3). Water-surface elevation started off low in January 2006 reaching a minimum elevation March 7, 2006 at 336.9 m above NGVD of 1929, and remained below the top of conservation pool (341.4 m above NGVD of 1929) for most of 2006. Water-surface elevation reached a maximum elevation of 344.9 m above NGVD of 1929 on April 11, 2008.

Figure 3. Daily reservoir water-surface elevation near Beaver Lake Dam, January 2006 through December 2010.

Water-Quality Conditions

Inflow Water Quality

Water-quality samples were collected at the three main inflows to Beaver Lake: the White River near Fayetteville (site S1), Richland Creek at Goshen (site S2), and War Eagle Creek near Hindsville (site S3) (fig. 1). The inflows were sampled for many constituents, including DS, Cl, and SO_4. Annual loads were estimated for DS, Cl, and SO_4 using measured concentrations and daily streamflow at each station.

Measured DS, Cl, and SO_4 concentrations varied among the tributaries because of differences in land use and contributions from point sources. DS concentrations were greater at Richland Creek and War Eagle Creek than White River (fig. 4). The median DS concentrations at White River, Richland Creek, and War Eagle Creek were 72, 96, and 109 mg/L, respectively. Cl concentrations were greater at

War Eagle Creek than Richland Creek and White River. The median Cl concentrations at White River, Richland Creek, and War Eagle Creek were 3.1, 4.1, and 6.9 mg/L, respectively. The median SO_4 concentration at War Eagle Creek was lower than both White River and Richland Creek. The median SO_4 concentrations at White River, Richland Creek, and War Eagle Creek were 10.6, 9.5, and 5.8 mg/L, respectively.

Figure 4. Distribution of dissolved solids, chloride, and sulfate concentrations for White River (site S1), Richland Creek (site S2), and War Eagle Creek (site S3), 2006 – 2010.

Reservoir Water Quality

Water-quality samples were collected at the seven sites in Beaver Lake: White River near Goshen (site L1), Beaver Lake at Highway 412 Bridge near Sonora (site L2), Beaver Lake near Lowell (site L3), Beaver Lake at Highway 12 Bridge near Rogers (site L4), Beaver Lake near Eureka Springs (site L5), War Eagle Creek above White River near Lowell (site L9), and Beaver Lake downstream from Hickory Creek Landing near Springdale (site L10) (table 1, fig. 1). Concentrations of DS, Cl, and SO_4 were analyzed from samples collected 1 m beneath the surface at White River near Goshen (site L1) and 1 m above the bottom when the water column was thermally stratified. When the water column was isothermal, only sample 1 m beneath the surface was collected. Samples were collected 2 m beneath the surface and 2 m above the bottom at the other six sampling sites. When the water column was isothermal, only the sample 2 m beneath the surface was collected.

Measured DS, Cl, and SO4 concentrations varied among lake sites, relative to their downstream distance from the tributary point of entry to Beaver Lake (fig.8). DS, Cl, and SO_4 concentrations were most variable at the upper end of the reservoir, White River at Highway 45 (site L1). The City of Fayetteville discharges wastewater into the White River, upstream from the Highway 45 site (L1), and downstream from White River near Fayetteville (site S1). Although the variability in DS concentrations was greatest at White River near Goshen (site L1), the greatest median value (98 mg/L) occurred at War Eagle Creek above White River near Lowell (site L9), followed by Beaver Lake at Highway 412 Bridge near Sonora (site L2, 93 mg/L) and Beaver Lake downstream from Hickory Creek Landing near Springdale (site L10, 91 mg/L). Variability and median concentrations for both Cl (5.4 mg/L) and SO_4 (13.0 mg/L) were greatest at White River near Goshen (site L1) and generally decreased the further downstream the site was located.

Figure 5. Distribution of dissolved solids, chloride, and sulfate concentrations 2 meters beneath the surface at lake sites, 2006 – 2010.

Methods

This section describes the methods of data collection and analysis used to describe the ambient DS, Cl, and SO_4 conditions in Beaver Lake, Arkansas used in this report. Streamflow and water-quality data were collected at three tributaries to Beaver Lake from January 2006 through December 2010. Annual DS, Cl, and SO_4 loads were estimated from streamflow and water-quality data at these three sites.

Streamflow

Stream stage was measured continuously at White River near Fayetteville (site S1), Richland Creek at Goshen (site S2), and War Eagle Creek near Hindsville (site S3) (table 1 and fig. 1). Stage and instantaneous discharge were measured to compute the continuous streamflow from stage-discharge rating curves using methods described by Rantz and others (1982). Outflow data from Beaver Lake were provided by the U.S. Army Corps of Engineers, Little Rock District, for the period January 2006 through December 2010.

Water-Quality Sampling

Water-quality data were collected from January 2006 through December 2010 at five fixed sites along the downstream gradient of Beaver Lake. Sample sites in the lake were located along the original stream channel, the deepest location within the lake cross section. Samples were collected six times annually at White River near Goshen (site L1), at Beaver Lake at Highway 412 Bridge near Sonora (site L2), near Beaver Lake near Lowell (site L3), at Beaver Lake at Highway 12 Bridge near Rogers (site L4), and Beaver Lake near Eureka Springs (site L5) (table 1 and fig.1). Samples were collected six times annually at War Eagle Creek above White River near Lowell (site L9) from October 2007 through December 2010 and monthly (12 times annually) at Beaver Lake downstream from Hickory Creek Landing near Springdale (site L10) from August 2008 through December 2010.

Water-quality samples were collected at lake sites using a peristaltic pump and weighted hose to collect samples 2 m below the water surface when isothermal and well mixed conditions were present. During thermal stratification, samples were collected at 2 m below the water surface to represent the epilimnion (near surface), at various depths in the metalimnion depending on the depth of the thermocline (middle depth), and at 2 m above the reservoir bottom to represent the hypolimnion (near bottom). Water-quality samples were analyzed for concentrations of DS (analytically determined by weighing residue after drying at 180 degrees Celsius, not the sum of individual constituents), Cl, and SO_4. All samples analyses were conducted at the USGS National Water Quality Laboratory following USGS procedures (Fishman, 1993). Field measurements of water temperature were recorded at various depths at the time of sample collection.

Water-quality samples also were collected from three fixed inflow sites including White River near Fayetteville (site S1), Richland Creek at Goshen (site S2), and War Eagle Creek near Hindsville (site S3) (table 1, fig. 3). Water-quality samples were collected following equal-width increment methods using depth-integrated samplers and processed using protocols described in Wilde and Radke (1998), Wilde and others (1998a, 1998b, 1998c, 1999a, and 1999b), and Meyers and Wilde (1999). Water-quality samples were analyzed for concentrations of DS, Cl, and SO_4. Field measurements including water temperature were collected with each sample. Water-quality samples were collected six times annually and during selected surface runoff events.

Constituent Loads

DS, Cl, and SO_4 loads were estimated for the three main inflows to Beaver Lake; the White River near Fayetteville (site S1), Richland Creek at Goshen (site S2), and War Eagle Creek near Hindsville (site S3) (fig. 1). Constituent load (L) is a function of the volumetric rate of water passing a point in the stream (Q) and the constituent concentration within the water (C). Regression methods used to estimate constituent loads use the natural logarithm (ln) transformed relation between Q and C to estimate daily C (or L) of the constituent. The regression method can account for non-normal data distributions, seasonal and long-term cycles, censored data, biases associated with using logarithmic transformations, and serial correlations of the residuals (Cohn, 1995). The regression method uses discrete water-quality samples often collected over several years and a daily streamflow hydrograph. The relations between natural logarithmic-transformed L and Q were used:

$$\ln (L) = \beta_0 + \beta_1 \ln (Q) \tag{1}$$

Transformation of the results of the model from logarithmic space to real space was accomplished using two methods; an adjusted maximum likelihood estimator (AMLE) and a least absolute deviation (LAD) (Cohn and others, 1992). The AMLE method was used if the constituent had censored values and the LAD method was used to transform the results if no censored values were included in the data or if outliers in the residuals were present. The S-LOADEST computer program (Runkel and others, 2004) was used to estimate daily loads for calendar years 2006 through 2010.

Data Analysis

The resulting measured streamflow, water-quality (DS, Cl, and SO_4 concentrations -- inflow and lake samples), and S-LOADEST loading rates were analyzed and summarized using several graphical techniques for data collected from January 2006 and December 2010. Time-series plots were used to describe inflow and outflow. Boxplots and time-series plots were used to compare concentrations of DS, Cl, and SO_4 between sites. Boxplots, scatter plots, line plots, and bar charts were used to describe model simulation results.

Model Implementation

Implementation of the CE-QUAL-W2 model for Beaver Lake included development of the computational grid, specification of boundary and initial conditions, and preliminary selection of model parameter values. Model development and associated assumptions in the selection of boundary and initial conditions are described, and model parameters are listed in this section.

Computational Grid

The computational grid is the geometric scheme that numerically represents the space and volume of the reservoir. The model extends 80 km from the upstream boundary (White River at the Highway 45 bridge) to the Beaver Lake dam (figs. 1 and 9). The grid originally was developed by Haggard and Green (2002) to simulate the hydrodynamics and distribution of temperature and dissolved oxygen in Beaver Lake for calendar years 1994 and 1995. Thirty-five computational segments exist along the mainstem of the White River in Beaver Lake and 12 computational segments are in War Eagle Creek. In addition, four other downstream branches are modeled with three computational segments each. Volumes of the smaller embayments not included in the computational grid were added to associated mainstem segments so that reservoir volume was preserved. Each segment was divided vertically into 1-m layers. Tributaries are linked geometrically to the segment they enter and allow for the application of boundary conditions without affecting the geometry. Two tributaries were included in the model at the most upstream segment. One tributary was used to simulate the input from the Fayetteville wastewater-treatment plant (WWTP) discharge at the upstream segment, although WWTP discharge concentrations were not included for the purposes of this study; DS, Cl and SO_4 concentration data in WWTP discharge were limited and uncertain. A second tributary was used to simulate the inflow from Richland Creek, and a third to simulate the inflow from Prairie Creek (fig. 1). Model grid segments 2, 5, 14, 16, 23, 35, and 48 (fig. 9) relate to water-quality monitoring sites L1, L2, L10, L3, L4, L5, and L9, respectively (table 1).

Figure 6. Side view (A), top view (B), and face view from the dam (C) of the computational grid of Beaver Lake used in the CE-QUAL-W2 model.

Boundary and Initial Conditions

Hydraulic and Thermal Boundary Conditions

Daily reservoir inflows used in the model were obtained from streamflow-gaging station data on the three main inflows (White River, Richland Creek, and War Eagle Creek) and were estimated for the three smaller branches. The mean daily streamflow recorded for War Eagle Creek (site S3) was used to estimate the streamflow for the other three other branches and Prairie Creek, based on the reation between the drainage area for site S3 and the drainage areas of the other three branch drainage areas and Prairie Creek.

The downstream boundary for the Beaver Lake model consists of the outflow from Beaver Lake dam. Hourly outflow data was produced by the USACE using stage-discharge relations and hourly power generation records for the period of January 2006 through December 2010. The release structure (penstock) was simulated as a point release, and the middle of the structure was at an elevation of 302.2 m above NGVD of 1929, model layer 45 (fig.9).

Other hydraulic boundary conditions included water withdrawal by four public water-supply districts (Beaver Water District, Carroll-Boone County Water District, Madison County Water District, and Benton-Washington County Water District). Annualized mean daily withdrawal rates for each water-supply district were applied (Terrance W. Holland, U.S. Geological Survey, written commun., 2011).

Hydraulic boundary conditions at the water surface included evaporation, wind stress, and surface heat exchange. Meteorological data required for these computations were measured hourly at a weather station southwest of Rogers (fig. 1) (National Climatic Data Center, Asheville, North Carolina, written commun., 2011).

Hourly inflow water temperatures were estimated from the meteorological data and from periodic measurements at the three main inflow sites (White River, Richland Creek, and War Eagle Creek). Water temperatures for the smaller tributaries were estimated only from the meteorological data.

Dissolved Solids, Chloride, and Sulfate Boundary Conditions

Chemical boundary conditions were estimated daily, as described above, by dividing daily S-LOADEST loads (kg/d) by the daily mean streamflow (m^3/s) and converted to provide a daily mean concentration (mg/L) for each of the main inflow sites. Daily streamflow is used to calculate daily concentrations from daily loads because it probably more accurately reflects the variation in constituent concentrations compared to using discrete concentrations as input, where the model linearly interpolates daily concentrations between sample collection dates.

Initial Conditions

Initial water-surface elevation, water temperature, and DS, Cl, and SO_4 concentrations for each model segment are required at the start of a model simulation. Initial water-surface elevations were set to the measured value on January 1, 2006. At this time, Beaver Lake was assumed to be in isothermal conditions (6.0 °C) throughout the entire reservoir. Initial DS, Cl, and SO_4 concentrations also were assumed to be uniform and were set at 80, 4.0, and 9.0 mg/L, respectively.

Model Parameters

Parameters are used to describe the physical and chemical processes that are not explicitly modeled and to provide the chemical kinetic rate information. Many parameters cannot be measured directly and often are adjusted during the model calibration process until simulated values agree with measured observations. Most of the hydrodynamic and thermal processes are modeled in CE-QUAL-W2, which results in very few adjustable hydraulic and thermal parameters. There are many chemical and biological rate coefficients required for the application of CE-QUAL-W2, which are all temporally constant (table 3). Many of the coefficients were based on suggested values given as default values for CE-QUAL-W2 and others were based on other model applications (Haggard and Green, 2002; Galloway and Green, 2002 and 2003; Green and others, 2003; Bales and others, 2001; Sullivan and Rounds, 2005).

Table 2. Parameters and values used in the CE-QUAL-W2 model of Beaver Lake, January 2006 to December 2010.

Model Calibration and Testing

Successful model application requires model calibration that includes comparing simulated results with measured reservoir conditions. The Beaver Lake model calibration was completed by adjusting parameters for the 5-year period from January 2006 through December 2010. Calibration was achieved generally by first calibrating the water balance and then thermodynamics.

Two statistics were used to compare simulated and measured water temperature, DS, Cl, and SO_4. The absolute mean error (AME) indicates the average difference between simulated and measured values and is computed by equation 2.

$$AME = \frac{\Sigma|\text{simulated value - measured value}|}{\text{number of observations}} \qquad (2)$$

An AME of 1.5 °C means that the average difference between simulated temperatures and measured temperature is 1.5 °C.

The root mean square error (RMSE) indicates the spread of how far simulated values deviate from the measured values and is computed by equation 3:

$$RMSE = \sqrt{\frac{\Sigma(\text{simulated value - measured value})^2}{\text{number of observations}}} \qquad (3)$$

An RMSE of 1.5 °C means that the simulated temperatures are within 1.5 °C of the measured temperatures about 67 percent of the time.

Water Balance

Simulated water-surface elevations in Beaver Lake were adjusted to the measured water-surface elevation near the dam for the model period of January 2006 through December 2010 (fig. 10). The water-surface elevations were corrected to the measured values by adjusting the unmeasured inflow into the lake that was distributed to all the segments within a branch. Inflow was added or subtracted so that the simulated water-surface elevation reflected the measured water-surface elevation, therefore, accounting for unmeasured inflow and groundwater interaction in Beaver Lake. By correcting the distributed inflow, the temperature and water quality could be calibrated without the uncertainty incurred with having differences between simulated and measured water-surface elevations.

Figure 7. Simulated and measured water-surface elevations near Beaver Lake Dam, January 2006 through December 2010.

Sensitivity Analysis

Sensitivity analysis is the determination of the effects of small changes in calibrated model parameters and input on model results. A complete sensitivity analysis for the Beaver Lake model was not conducted. However, testing of how changes in different parameters affect the hydrodynamics, temperature, and water quality was conducted as part of the model development and calibration. Results from these simulations and information from previous model studies (Haggard and Green, 2002; Galloway and Green, 2002; 2003; Green and others, 2003; Bales and others, 2001; Sullivan and Rounds, 2005) were used to identify several parameters for evaluation in the sensitivity analysis.

The sensitivity of simulated water temperature and water quality was assessed with changes in the wind-sheltering coefficient, light-extinction coefficient for pure water. Simulated vertical profiles of water temperature, at 1 m depth intervals were compared with measured water temperature profiles.

Water temperature in the Beaver Lake model was the most sensitive to wind speed (wind-sheltering coefficient) and light extinction in the water column (table 3). The wind speed, adjusted using the wind-sheltering coefficient, affects the amount of mixing in the reservoir, which can change the depth of the thermocline and increase or decrease the evaporative cooling. Higher wind speeds result in more mixing, thus a deeper thermocline and lower surface temperatures, while lower wind speeds result in a shallower thermocline and higher surface temperatures. The changes in the thermocline depth resulted in the greatest differences at the thermocline between the calibrated model and the sensitivity test because of the rapid change in water temperature with depth that occurs at the thermocline.

Model Limitations

An understanding of model limitations is essential for effective use of reservoir models. The accuracy of the Beaver Lake model is limited by the simplification of complexities of the hydrodynamics within the reservoir, by spatial and temporal discretization effects, and by assumptions made in the formulation of the governing equations. Model accuracy also is limited by segment size, boundary conditions, accuracy of calibration, and parameter sensitivity. Model accuracy also is limited by the availability of data and by the interpolations and extrapolations that are inherent in using data in a model. Although a model might be calibrated, calibration parameter values are not necessarily unique in yielding acceptable values for the selected water-quality constituents, algal biomass, and reservoir water-surface elevation.

Another limitation of the Beaver Lake model is that it is a two-dimensional representation of a three-dimensional water body. The governing equations are laterally and vertically averaged within layers. Although the model may accurately represent vertical and longitudinal processes within the reservoir, processes that occur laterally, or from shoreline to shoreline perpendicular to the downstream axis, may not be properly represented.

Fate and Transport of Dissolved Solids, Chloride, and Sulfate in Beaver Lake

A two-dimensional, laterally averaged, hydrodynamic and water-quality model using CE-QUAL-W2 Version 3.1 (Cole and Wells, 2003) was developed for Beaver Lake and calibrated based on vertical profiles of temperature and dissolved oxygen, and water-quality constituent concentrations collected at various depths at four sites in the reservoir from April 2001 to April 2003 (Galloway and Green, 2006). The Beaver Lake CE-QUAL-W2 model simulates water-surface elevation and vertical and longitudinal gradients in water-quality constituents. The model includes routines for 18 state variables in addition to temperature, including any number of inorganic suspended solids groups, phytoplankton groups, nitrogen and phosphorus species, dissolved and particulate organic matter, total inorganic carbon, dissolved oxygen, and organic sediment. Additionally, over 60 derived variables can be computed from the state variables (Cole and Wells, 2003); however, for the purposes of this report, only water temperature, DS, Cl, and SO_4 were simulated.

Inflow Loads and Concentrations

Estimated daily DS, Cl, and SO_4 concentrations into the Beaver Lake model were determined by dividing daily S-LOADEST loads by daily discharge and converting to milligrams per liter. S-LOADEST daily concentrations were similar to measured instantaneous concentrations at all three inflow tributaries (figs. 8 - 10, table 3). In general, estimated mean daily concentrations followed the seasonal (high-flow / low-flow) cycles of instantaneous measured concentrations.

Figure 8. Time-series distributions of measured and LOADEST estimated dissolved solids, chloride, and sulfate concentrations at White River (site S1).

Figure 9. Time-series distributions of measured and LOADEST estimated dissolved solids, chloride, and sulfate concentrations at Richland Creek (site S2).

Figure 10. Time-series distributions of measured and LOADEST estimated dissolved solids, chloride, and sulfate concentrations at War Eagle Creek (site S3).

Table 3. Statistics measuring error between measured and S-LOADEST estimated dissolved solids, chloride, and sulfate concentrations at White River (S1), Richland Creek (S2), and War Eagle Creek (S3). [AME = absolute mean error, RMSE = root mean square error; DS = dissolved solid, Cl = chloride, SO4 = sulfate]

Reservoir Hydrodynamics

Simulated water temperatures in Beaver Lake were compared to 197 depth profiles of temperature measured at seven sites on Beaver Lake (fig. 1). Temperatures were adjusted to the measured values for the model period, January 2006 through December 2010.

Simulated temperatures compared reasonably well with measured temperatures and differences varied spatially in Beaver Lake for January 2006 through December 2010. Differences in temperature between simulated and measured values decreased from site L2 (segment 5) to site L5 (segment 35). The AME ranged from 1.75 °C at site L5 to 2.68 °C at L2 and the RMSE ranged from 2.22 °C at site L5 to 3.35 °C at site L2 from January 2006 through December 2010 (figs. 9-15; table 4). The greatest differences between measured and simulated data occurred in the upstream part of the reservoir, which is the most dynamic part of the reservoir. The upstream part of the reservoir is the shallowest section of Beaver Lake and has more riverine characteristics than the deep lacustrine-type characteristics of the downstream part of the reservoir. The upstream part also receives most of the inflow to the reservoir, which creates more dynamic conditions. The greatest differences between simulated and measured temperatures generally occurred in simulating the location of the thermocline (figs. 11 - 17).

Table 4. CE-QUAL-W2 model calibration evaluation statistics for water temperature, dissolved solids, chloride, and sulfate for Beaver Lake sites, January 2006 through December 2010.Dissolved Solids, Chloride, and Sulfate

Figure 11. Selected simulated and measured water-temperature profiles for White River near Goshen (site L1, segment 2).

Figure 12. Selected simulated and measured water-temperature profiles for Beaver Lake at Highway 412 Bridge near Sonora (site L2, segment 5).

Figure 13. Selected simulated and measured water-temperature profiles for War Eagle Creek above White River near Lowell (site L9, segment 48).

Figure 14. Selected simulated and measured water-temperature profiles for Beaver Lake downstream from Hickory Creek Landing near Springdale (site L10, segment 14).

Figure 15. Selected simulated and measured water-temperature profiles for Beaver Lake near Lowell (site L3, segment 16).

Figure 16. Selected simulated and measured water-temperature profiles for Beaver Lake at Highway 12 Bridge near Rogers (site L4, segment 23).

Figure 17. Selected simulated and measured water-temperature profiles for Beaver Lake near Eureka Springs (site L5, segment 35).

Dissolved Solids, Chloride and Sulfate Concentrations

Simulated DS, Cl, and SO_4 concentrations in model segments 2, 5, 48, 14, 16, 23, and 35 matched well with measured concentrations at lake sites L1, L2, L9, L10, L3, L4, and L5, respectively (figs. 18 - 23). The greatest differences between measured and simulated DS, Cl, and SO_4 concentrations occurred at the upstream sites on the White River in Beaver Lake: White River near Goshen, site L1, model segment 2; and Beaver Lake at Highway 412, site L2, model segment 5. The higher measured concentrations are a result of wastewater discharges upstream from station L1 that are not included in the model input. The AME for DS not including sites L1 and L2, ranged from 7.64 mg/L at site L10 to 11.5 mg/L at L9 and the RMSE ranged from 10.4 mg/L at site L5 to 15.2 mg/L at site L9 from January 2006 through December 2010 (figs. 18 and 19; table 4). The AME for CL not including sites L1 and L2, ranged from 0.224 mg/L at site L5 to 1.20 mg/L at L9 and the RMSE ranged from .286 mg/L at site L5 to 1.37 mg/L at site L9 from January 2006 through December 2010 (figs. 20 and 21; table 4). The AME for SO_4 not including sites L1 and L2, ranged from 1.27 mg/L at site L4 to 1.58 mg/L at L9 and the RMSE ranged from 1.51 mg/L at site L5 to 1.95 mg/L at site L9 from January 2006 through December 2010 (figs. 22 and 23; table 4).

Figure 18. Simulated and measured dissolved solids concentrations 2 meters beneath the surface in Beaver Lake.

Figure 19. Simulated and measured dissolved solids concentrations 2 meters above the bottom in Beaver Lake.

Figure 20. Simulated and measured chloride concentrations 2 meters beneath the surface in Beaver Lake.

Figure 21. Simulated and measured chloride concentrations 2 meters above the bottom in Beaver Lake.

Figure 22. Simulated and measured sulfate concentrations 2 meters beneath the surface in Beaver Lake.

Figure 23. Simulated and measured sulfate concentrations 2 meters above the bottom in Beaver Lake.

Dissolved Solids, Chloride, and Sulfate Fate and Transport

Fifteen DS, Cl, and SO_4 fate and transport scenarios were compared to the baseline (calibrated) simulation. Daily DS, Cl, and SO_4 concentrations in the baseline simulation from the White River near Fayetteville (site S1), and War Eagle Creek near Hindsville (site S3) (fig. 1) were increased by factors of 1.2, 1.5, 2.0, 5.0, and 10.0 times individually for each inflow and together; flow (discharge) remained unchanged. This resulted in increase inflow DS, Cl, and SO_4 loading in each tributary by a factor of 1.2, 1.5, 2.0, 5.0, and 10.0 times baseline. It should be noted again that contributions from the City of Fayetteville's WWTP were not included in either the baseline model or any of the loading scenarios. Daily DS, Cl, and SO_4 concentrations in the 15 scenarios were output at the seven model segments (2, 5, 48, 14, 16, 23, and 35) corresponding to lake sites L1, L2, L9, L10, L3, L4, and L5, respectively, 2 m below the surface and 2 m above the bottom, the same locations where water-quality samples were collected. Time-series plots of baseline and scenario results for each of the seven model segments, 2 m below the surface were prepared to visualize differences for the period January 2006 through December 2010 (figs. 24-26). For all three constituents (DS, Cl, and SO_4) and the three different tributary loading scenario series, the increased loads by factors of 1.2, 1.5, and 2.0 times baseline only produced slightly higher concentrations in the model segments than those in the baseline condition. Much greater separation in concentrations from the baseline condition, at model segments 2, 5, 48, 14, 16, 23, and 35, 2 m below the surface, occurred when loads were increased by a factor of 5.0 and 10.0 times baseline loads. Similar results occurred between baseline and scenario results for each of the seven model segments, 2 m above the bottom; however, individual time-series plots are not provided in this report.

Average daily DS, Cl, and SO_4 concentrations for each constituent for the baseline and each loading scenario at each of the seven model segments both 2 m below the surface and 2 m above the bottom are presented in tables 5-10 and figs. 27-44. Concentrations were greater in the reservoir at model segments closer to the source, sites L1 and L2 (segments 2 and 5) for increasing loads from White River near Fayetteville (site S1), and sites L9 and L10 (segments 48 and 14) for increasing loads from War Eagle Creek near Hindsville. Concentrations resulting from the stepped increase in loading became more dilute further downstream of the source. Differences between the baseline condition and concentrations resulting from loading factors of 1.2, 1.5, and 2.0 were smaller than loading factors 5.0 and 10.0. The same general pattern was observed between concentrations 2 m below the surface and 2 m above the bottom, with the exception of concentrations resulting from the higher loading factors (5.0 and 10.0), where concentrations two meters above the bottom were consistently greater than those two 2 m below the surface.

Figure 24. Dissolved solids, chloride, and sulfate concentrations 2 meters below the surface at model segments 2, 5, 48, 14, 16, 23 and 35 from baseline model and increased loading scenarios from White River near Fayetteville (site S1) only.

Figure 24. (continued) Dissolved solids, chloride, and sulfate concentrations 2 meters below the surface at model segments 2, 5, 48, 14, 16, 23 and 35 from baseline model and increased loading scenarios from White River near Fayetteville (site S1) only.

Figure 24. (continued) Dissolved solids, chloride, and sulfate concentrations 2 meters below the surface at model segments 2, 5, 48, 14, 16, 23 and 35 from baseline model and increased loading scenarios from White River near Fayetteville (site S1) only.

Figure 25. Dissolved solids, chloride, and sulfate concentrations 2 meters below the surface at model segments 2, 5, 48, 14, 16, 23 and 35 from baseline model and increased loading scenarios from War Eagle Creek near Hindsville (site S3) only.

Figure 25. (continued) Dissolved solids, chloride, and sulfate concentrations 2 meters below the surface at model segments 2, 5, 48, 14, 16, 23 and 35 from baseline model and increased loading scenarios from War Eagle Creek near Hindsville (site S3) only.

Figure 25. (continued) Dissolved solids, chloride, and sulfate concentrations 2 meters below the surface at model segments 2, 5, 48, 14, 16, 23 and 35 from baseline model and increased loading scenarios from War Eagle Creek near Hindsville (site S3) only.

Figure 26. Dissolved solids, chloride, and sulfate concentrations 2 meters below the surface at model segments 2, 5, 48, 14, 16, 23 and 35 from baseline model and increased loading scenarios from both White River near Fayetteville (site S1) and War Eagle Creek near Hindsville (site S3).

Figure 26. (continued) Dissolved solids, chloride, and sulfate concentrations 2 meters below the surface at model segments 2, 5, 48, 14, 16, 23 and 35 from baseline model and increased loading scenarios from both White River near Fayetteville (site S1) and War Eagle Creek near Hindsville (site S3).

Figure 26. (continued) Dissolved solids, chloride, and sulfate concentrations 2 meters below the surface at model segments 2, 5, 48, 14, 16, 23 and 35 from baseline model and increased loading scenarios from both White River near Fayetteville (site S1) and War Eagle Creek near Hindsville (site S3).

Table 5. Average daily dissolved solids, chloride, and sulfate concentrations for baseline condition and increasing loading factor scenarios from White River near Fayetteville (site S1) only, for the period January 2006 through December 2010, 2 meters below the surface at model segments 2, 5, 14, 16, 23, and 35.

Table 6. Average daily dissolved solids, chloride, and sulfate concentrations for baseline condition and increasing loading factor scenarios from War Eagle Creek (site S3) only, for the period January 2006 through December 2010, 2 meters below the surface at model segments 48, 5, 14, 16, 23, and 35.

Table 7. Average daily dissolved solids, chloride, and sulfate concentrations for baseline condition and increasing loading factor scenarios from White River near Fayetteville (site S1) and War Eagle Creek near Hindsville (site S3), for the period January 2006 through December 2010, 2 meters below the surface at model segments 2, 5, 14, 16, 23, and 35.

Table 8. Average daily dissolved solids, chloride, and sulfate concentrations for baseline condition and increasing loading factor scenarios from White River near Fayetteville (site S1) only, for the period January 2006 through December 2010, 2 meters above the bottom at model segments 2, 5, 14, 16, 23, and 35.

Table 9. Average daily dissolved solids, chloride, and sulfate concentrations for baseline condition and increasing loading factor scenarios from War Eagle Creek (site S3) only, for the period January 2006 through December 2010, 2 meters above the bottom at model segments 48, 5, 14, 16, 23, and 35.

Table 10. Average daily dissolved solids, chloride, and sulfate concentrations for baseline condition and increasing loading factor scenarios from White River near Fayetteville (site S1) and War Eagle Creek near Hindsville (site S3), for the period January 2006 through December 2010, 2 meters above the bottom at model segments 2, 5, 14, 16, 23, and 35.

Figure 27. Average daily dissolved solids for the period January 2006 through December 2010 2 meters below the surface at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from White River near Fayetteville (site S1) only. [* Fayetteville WWTP dissolved solids not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 28. Average daily dissolved solids for the period January 2006 through December 2010 2 meters below the surface at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from War Eagle Creek near Hindsville (site S3) only. [* Fayetteville WWTP dissolved solids not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 29. Average daily dissolved solids for the period January 2006 through December 2010 2 meters below the surface at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from both White River near Fayetteville (site S1) and War Eagle Creek near Hindsville (site S3). [* Fayetteville WWTP dissolved solids not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 30. Average daily chloride concentrations for the period January 2006 through December 2010 2 meters below the surface at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from White River near Fayetteville (site S1) only. [* Fayetteville WWTP chloride load not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 31. Average daily chloride concentrations for the period January 2006 through December 2010 2 meters below the surface at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from War Eagle Creek near Hindsville (site S3) only. [* Fayetteville WWTP chloride load not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 32. Average daily chloride concentrations for the period January 2006 through December 2010 2 meters below the surface at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from both White River near Fayetteville (site S1) and War Eagle Creek near Hindsville. [* Fayetteville WWTP chloride load not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 33. Average daily sulfate concentrations for the period January 2006 through December 2010 2 meters below the surface at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from White River near Fayetteville (site S1) only. [* Fayetteville WWTP sulfate load not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 34. Average daily sulfate concentrations for the period January 2006 through December 2010 2 meters below the surface at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from War Eagle Creek near Hindsville (site S3) only. [* Fayetteville WWTP sulfate load not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 35. Average daily sulfate concentrations for the period January 2006 through December 2010 2 meters below the surface at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from both White River near Fayetteville (site

S1) and War Eagle Creek near Hindsville. [* Fayetteville WWTP sulfate load not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 36. Average daily dissolved solids for the period January 2006 through December 2010 2 meters above the bottom at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from White River near Fayetteville (site S1) only. [* Fayetteville WWTP dissolved solids not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 37. Average daily dissolved solids for the period January 2006 through December 2010 2 meters above the bottom at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from War Eagle Creek near Hindsville (site S3) only. [* Fayetteville WWTP dissolved solids not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 38. Average daily dissolved solids for the period January 2006 through December 2010 2 meters above the bottom at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from both White River near Fayetteville (site S1) and War Eagle Creek near Hindsville (site S3). [* Fayetteville WWTP dissolved solids not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 39. Average daily chloride concentrations for the period January 2006 through December 2010 2 meters above the bottom at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and

increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from White River near Fayetteville (site S1) only. [* Fayetteville WWTP chloride load not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 40. Average daily chloride concentrations for the period January 2006 through December 2010 2 meters above the bottom at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from War Eagle Creek near Hindsville (site S3) only. [* Fayetteville WWTP chloride load not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 41. Average daily chloride concentrations for the period January 2006 through December 2010 2 meters above the bottom at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from both White River near Fayetteville (site S1) and War Eagle Creek near Hindsville. [* Fayetteville WWTP chloride load not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 42. Average daily sulfate concentrations for the period January 2006 through December 2010 2 meters above the bottom at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from White River near Fayetteville (site S1) only. [* Fayetteville WWTP sulfate load not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 43. Average daily sulfate concentrations for the period January 2006 through December 2010 2 meters above the bottom at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from War Eagle Creek near Hindsville (site S3) only. [* Fayetteville WWTP sulfate load not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Figure 44. Average daily sulfate concentrations for the period January 2006 through December 2010 2 meters above the bottom at model segments 2, 5, 14, 16, 23, and 35 from baseline model (loading factor 1.0) and increasing loading factor scenarios (1.2, 1.5, 2.0, 5.0, and 10.0) from both White River near Fayetteville (site S1) and War Eagle Creek near Hindsville. [* Fayetteville WWTP sulfate load not included in CE-QUAL-W2 baseline calibration or any scenario runs.]

Summary

Beaver Lake, a deep-storage reservoir located in the upper White River Basin in northwestern Arkansas is the major water supply for the region. Beaver Lake is affected by both point and nonpoint sources of contamination. The city of Fayetteville discharges about one-half of its sewage effluent into the White River immediately upstream from the backwater of the reservoir and the city of West Fork discharges its sewage effluent further upstream in a tributary to the White River, the West Fork of the White River. The city of Huntsville discharges its effluent into a tributary of the War Eagle Creek, the second largest tributary to Beaver Lake.

This study was conducted to describe ambient conditions of dissolved solids, chloride, and sulfate in Beaver Lake, and to examine fate and transport of increasing concentrations of these constituents, through time, at seven locations in the reservoir, from upstream to downstream using a mathematical model of hydrodynamics and water quality previously prepared for Beaver Lake. Dissolved solids, chloride, and sulfate loads from the White River and War Eagle Creek were increased by factors of 1.2, 1.5, 2.0, 5.0, and 10.0 times ambient conditions individually for each tributary and together for the period January 2006 through December 2012, for a total of 15 different increasing loading factor scenarios. Concentrations of dissolved solids, chloride, and sulfate, two meters below the surface and two meters above the bottom at seven locations in the model grid (which also correspond to locations where water-quality samples were also collected) were measured daily in each of the 15 scenarios and examined against the baseline (calibrated) condition.

Concentrations from the increasing loading factor scenarios were greater in the reservoir at model segments closer to where the White River and War Eagle Creek enter. Concentrations resulting from the stepped increases in loading became more dilute further downstream from the source. Differences between the baseline condition and concentrations resulting from loading factors of 1.2, 1.5, and 2.0 times ambient concentrations were smaller than loading factors 5.0 and 10.0 times ambient concentrations. The same general pattern was observed between concentrations 2 m below the surface and 2 m above the bottom, with the exception of concentrations resulting from the higher loading factors (5.0 and 10.0 times), where concentrations 2 m above the bottom were consistently greater than those 2 m below the surface.

References Cited

Bales, J.D., Sarver, K.M., and Giorgino, M.J., 2001, Mountain Island Lake, North Carolina: Analysis of ambient conditions and simulation of hydrodynamics, constituent transport, and water-quality characteristics, 1996-97: U.S. Geological Survey Water-Resources Investigations Report 01-4138, 85p.

Cohn, T.A., 1995, Recent advances in statistical methods for the estimation of sediment and nutrient transport in rivers, U.S. National Report to the International Union Geodesy and Geophysics, 1991-1994: Reviews of Geophysics, Supplement 33, p. 1117-1123.

Cohn, T.A., Caulder, D.L., Gilroy, E.J., Zynjuk, L.D., and Summers, R.M., 1992, The validity of a simple log-linear model for estimating fluvial constituent loads: An empirical study involving nutrient loads entering Chesapeake Bay: Water Resources Research, v. 28, no. 9, p. 2353-2363.

Cole, T.M. and Wells, S.A., 2003, CEQUAL-W2: A two dimensional, laterally averaged, hydrodynamic and water quality model, version 3.1: U.S. Army Corps of Engineers Instruction Report EL-03-1, variously paginated.

Galloway, J.M. and Green, W.R., 2002, Simulation of hydrodynamics, temperature, and dissolved oxygen in Norfork Lake, Arkansas, 1994-1995: U.S. Geological Survey Water-Resources Investigations Report 02-4250, 23 p.

Galloway, J.M. and Green, W.R., 2003, Simulation of hydrodynamics, temperature, and dissolved oxygen in Bull Shoals Lake, Arkansas, 1994-1995: U.S. Geological Survey Water-Resources Investigations Report 03-4077, 23 p.

Green, W.R., Galloway, J.M., Richards, J.M., and Wesolowski, E.A., 2003, Simulation of hydrodynamics, temperature, and dissolved oxygen in Table Rock Lake, Missouri, 1996-1997: U.S. Geological Survey Water-Resources Investigations Report 03-4237, 35 p.

Haggard, B.E. and Green, W.R., 2002, Simulation of hydrodynamics, temperature, and dissolved oxygen in Beaver Lake, Arkansas, 1994-1995: U.S. Geological Survey Water-Resources Investigations Report 02-4116, 21 p.

Helsel, D.R., and Hirsch, R.M., 1992, Statistical methods in water resources: Amsterdam, Netherlands, Elsevier, 522 p.

Meyers, D.N. and Wilde, F.D., 1999, Biological indicators: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A7, variously paginated.

Rantz, S.E, and others, 1982, Measurement and computation of streamflow: Volume 1. Measurement of stage and discharge and Volume 2. Computation of discharge: U.S. Geological Survey Water-Supply Paper 2175, 631 p.

Runkel, R.L., Crawford, C.G., and Cohn, T.A., 2004, Load estimator (LOADEST): A FORTRAN program for estimating constituent loads in streams and rivers: U.S. Geological Survey Techniques and Methods, book 4, chap. A5, 69 p.

Sullivan, A.B. and Rounds, S.A., 2005, Modeling hydrodynamics, temperature, and water quality in Henry Hagg Lake, Oregon, 2000-03: U.S. Geological Survey Scientific Investigations Report 2004-5261, 38 p.

U.S. Army Corps of Engineers, 1997, Hydrologic engineering requirements for reservoirs: U.S. Army Corps of Engineers Engineering Manual 1110-2-1420, variously paginated.

Wilde, F.D. and Radke, D.B., 1998, Field measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, variously paginated.

Wilde, F.D., Radke, D.B., Gibs, J., and Iwatsubo, R.T., 1998a, Preparations for water sampling: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A1, variously paginated.

Wilde, F.D., Radke, D.B., Gibs, J., and Iwatsubo, R.T.,1998b, Selection of equipment for water sampling: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A2, variously paginated.

Wilde, F.D., Radke, D.B., Gibs, J., and Iwatsubo, R.T.,1998c, Cleaning of equipment for water sampling: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A3, variously paginated.

Wilde, F.D., Radke, D.B., Gibs, J., and Iwatsubo, R.T.,1999a, Collection of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A4, variously paginated.

Wilde, F.D., Radke, D.B., Gibs, J., and Iwatsubo, R.T.,1999b, Processing of water samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A5, variously paginated.