USE ATTAINABILITY ANALYSIS REPORT FOR BOGGY CREEK

UNION COUNTY, ARKANSAS

JANUARY 9, 2007

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FOR BOGGY CREEK

UNION COUNTY, ARKANSAS

Prepared for

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1.0 SUMMARY AND CONCLUSIONS

1.1 Summary

A Use Attainability Analysis (UAA) was completed to determine existing and attainable uses for Boggy Creek. The UAA also evaluated alternative for meeting NPDES permit limits for the Clean Harbor, Inc. Outfall 009, including modifications of Arkansas Water Quality Criteria (WQC) for total dissolved solids (TDS), chloride and selenium (Se) in Boggy Creek.

Clean Harbors, Inc. (formerly Teris LLC) operates a hazardous waste treatment and incineration facility in El Dorado, Union County, AR. In August 2006 Clean Harbors, Inc. purchased the Teris facility which had been operated since 1978. The location was a former petroleum refining site with documented contamination of surface water runoff and groundwater.

The current National Pollutants Discharge Elimination System (NPDES) permit for Clean Harbors (AR0037800) became effective October 1, 2004 and contained new requirements for TDS and Se. These permit requirements included monitoring and reporting TDS and Se for the first 3 years (through October of 2007). On November 1, 2007, numeric limitations for these parameters become enforceable. Analytical data for both TDS and Se indicate the discharge will not meet the permit limitations. Teris, LLC and subsequently Clean Harbors, enlisted the assistance of FTN Associates, Ltd. (FTN) to study the sources of TDS and Se and to provide recommendations for possible methods to manage the new limitations. This UAA Report provides an analysis of alternatives for meeting effluent limitations including treatment, modified plant operations and site specific WQC for Se, chloride, sulfate and TDS that are protective of existing and attainable designated uses in Boggy Creek.

1.2 Objectives

The objectives of this UAA study are as follows:

1. Define existing and attainable uses in Boggy Creek and Bayou de Loutre;
2. Identify factors (if any) limiting attainment of designated uses in Boggy Creek and Bayou de Loutre; and
3. Evaluate alternatives for meeting permit limits including treatment, modified plant operations and site specific WQC for Se, chloride, and TDS.

1.3 Approach

To demonstrate that the discharge of the plant effluent supports existing and attainable uses in Boggy Creek requires demonstrating that existing concentrations of chloride, TDS and Se will not limit aquatic life and will not impair existing or attainable uses. Boggy Creek is impacted by historical petroleum extraction and/or refining operations. Therefore it is necessary to distinguish between aquatic life limitation due to TDS, chlorides and Se vs. that due to petroleum contamination.

1.4 Conclusions

Chemical, habitat and biological data from the May and July 2006 field survey supports the following significant conclusions regarding factors limiting the aquatic life in Boggy Creek:

1.4.1 Field Survey

<u>Water Chemistry and Flows</u>

1. Lower TDS and chloride concentrations in Boggy Creek below Outfall 009 suggest dilution by upstream flow and/or wet weather seeps.
2. Boggy Creek is not the source of the elevated TDS/chloride concentrations in Bayou de Loutre measured during both sampling events.
3. The majority of total Se measured in the samples collected in May and July 2006 was likely present in the dissolved form.
4. Boggy Creek is not the source of elevated Se concentrations in Bayou de Loutre measured during both sampling events.
5. Petroleum residues are present in the upper Boggy Creek sampling reaches.

<u>Toxicity</u>

1. Sub-lethal toxicity observed in the BC-1 sample collected in May 2006 is not attributable to elevated forms of TDS such as chloride.
2. Worst case TDS due to chloride and other ions in Outfall 009 should not be toxic to aquatic life based on actual test data.
3. Effluent concentrations of 1360 mg/L TDS and 631 mg/L chlorides should not cause the Clean Harbors effluent to be toxic to aquatic life.

Habitat

1. Physical habitat in all sampling locations is generally adequate for the maintenance and propagation of aquatic life.
2. Flat Creek habitat may be limited due to sandy substrate.
3. Impacts due to petroleum contamination were a striking feature of the Boggy Creek reaches upstream of Highway 82 and downstream of the Clean Harbors facility.

Biological Communities

1. Benthic macroinvertebrate communities in upper Boggy Creek (i.e., upstream of Highway 82) have low taxonomic richness dominated by 1 or 2 functional groups with low predator abundance.
2. The benthic macroinvertebrate community in the upper Boggy Creek reaches is attributable to petroleum contamination rather than TDS/chloride.
3. Some degree of recovery of the benthic community has occurred in lower Boggy Creek.
4. Given the impacts to the benthic macroinvertebrate community due to petroleum contamination it is likely that there are similar impacts and impairments to the fish community in upper Boggy Creek.
5. Existing water quality in the upper reaches Boggy Creek partially supports a typical Gulf Coastal Ecoregion fishery. Impairments to the fishery are attributable to petroleum contamination.
6. Lower Boggy Creek supports a typical Gulf Coastal fishery within the constraints of habitat limitation due to low flows.
7. Se toxicity is not a cause of impairments to the fish community in Boggy Creek as evidenced by low levels of Se accumulation in sediments and fish tissues.

1.4.2 Mass Budget Modeling

1. The modeling results that conservatively assume no loss of Se show that under both high and low flow conditions, the Boggy Creek contribution to downstream Se concentrations Bayou de Loutre is minimal.

2. Although TDS/chloride/sulfate concentrations appear to be exceeding ecoregion WQC TDS/chloride/sulfate concentrations in Bayou de Loutre, the Clean Harbors discharge should not cause an increase in TDS/chloride/sulfate concentrations in Bayou de Loutre downstream of the Boggy Creek confluence.

1.4.3 Use Analysis

The Arkansas Department of Environmental Quality (ADEQ) classified Boggy Creek as a Typical Gulf Coast Ecoregion stream. The evaluation of existing uses in Boggy Creek indicates the following:

1. It is possible, though unlikely, that primary and secondary contact recreation occurs in Boggy Creek.
2. Much of the surrounding watershed, especially the riparian zone, is low lying, swampy and heavily wooded. These factors, in addition to low summertime flows, inhibit domestic/agricultural/industrial uses.
3. The existing aquatic life use for upper Boggy Creek can be characterized as a Typical Gulf Coastal Ecoregion perennial fishery impaired by petroleum contamination of the sediments.
4. Lower Boggy Creek supports a Typical Gulf Coastal Ecoregion perennial fishery within the constraints of habitat limitation due to low flows.

The evaluation of attainable uses in Boggy Creek indicates the following:

1. Toxicity data indicate that the Clean Harbors facility does not discharge toxic materials (i.e., TDS/chloride or Se) in toxic amounts.
2. The aquatic life use (benthic invertebrate communities and a Typical Gulf Coastal Ecoregion perennial fishery) in upper Boggy Creek is not fully attained due to the presence of petroleum contamination of the sediments.
3. The aquatic life use (benthic invertebrate communities and a Typical Gulf Coastal Ecoregion perennial fishery) in lower Boggy Creek is attained within the constraints imposed by limited habitat due to low flows.
4. Primary/secondary contact, industrial or agricultural water supply (livestock watering/irrigation) and public water supply uses in Boggy Creek are limited by physical factors such as lack of consistent flow, mud/silt bottom, the low lying, swampy and heavily wooded riparian zone, and in upper Boggy Creek, petroleum contamination of the sediments.
5. Attainability of the primary/secondary contact, industrial or agricultural water supply (livestock watering/irrigation) and public water supply uses in Boggy

Creek, to the extent that they occur, is not limited by existing TDS/chloride concentrations due to the Clean Harbors discharge.

6. Predicted "worst case" TDS/chloride concentrations due to the Clean Harbors discharge will support the existing and attainable uses in the Boggy Creek and Bayou de Loutre systems.
7. Existing Se concentrations in Boggy Creek do not limit aquatic life in Boggy Creek.
8. Downstream effects of existing Se concentrations in Boggy Creek are not apparent in Bayou de Loutre.

1.4.4 Alternative Evaluations

1.4.4.1 TDS/chlorides

Three alternatives were considered for the management of the discharge from the facility to achieve compliance with the new TDS limitations:

1. Source Control,
2. Installation of a reverse osmosis treatment system, and
3. Installation of a pipeline to the Ouachita River.

Table 1.1 provides a summary of the estimated costs associated with each option. The expected costs associated with providing a change to the WQC has been included for comparison purposes.

A rating has also been provided to evaluate the technical considerations with each option and the potential for success. The rating is based on a 1 to 10 scale with 10 representing a high degree of confidence for success and minimal technical difficulties. This rating is basically a professional judgment by the reviewing engineer.

Table 1.1. Summary of capital, operating and implementation costs – TDS/chlorides.

Option Description	Estimated Capital Cost	Estimated Annual Operating Cost	Technical Rating
Source Control	-	$650,000	4
Reverse Osmosis treatment	$6,400,000	$1,020,000	6
Pipeline to Ouachita River	$16,000,000	$40,000	9
Regulatory changes	$200,000	-	9

1.4.4.2 Selenium

Three alternatives were considered for the management of the discharge from the facility to achieve compliance with the new Se limitations:

1. Source Control,
2. Installation of a treatment system, and
3. Installation of a pipeline to the Ouachita River.

Table 1.2 provides a summary of the estimated costs associated with each option. The expected costs associated with providing a change to the WQC has been included for comparison purposes.

A rating has also been provided to evaluate the technical considerations with each option and the potential for success. The rating is based on a 1-10 scale with 10 representing a high degree of confidence for success and minimal technical difficulties. This rating is basically a professional judgment by the reviewing engineer.

Table 1.2. Summary of capital, operating and implementation costs – Se.

Option Description	Estimated Capital Cost	Estimated Annual Operating Cost	Technical Rating
Source Control	-	$290,000	4
Treatment	$5,300,000	$475,000	4
Pipeline to Ouachita River	$16,000,000	$40,000	9
Regulatory changes	$200,000	-	9

1.5 Recommendations

In accordance with Arkansas Pollution Control & Ecology Commission (APCEC) Regulation No. 2 (Section 2.306), 40 CFR 131.10 and the ADEQ CPP, the following recommendations are made for modifications to WQC found in APCEC Regulation No. 2 for Boggy Creek:

1. Revise the following WQC for Boggy Creek:
   a. TDS – from 138 mg/L to 1360 mg/L,
   b. Chloride – from 19 mg/L to 631 mg/L,
   c. Sulfate – from 41 mg/L to 63 mg/L, and
   d. Se – from 5 ug/L to 15.6 ug/L.
2. Remove the designated Domestic Water Supply use from Boggy Creek.

2.0 INTRODUCTION

2.1 Overview

Clean Harbors, Inc. (formerly Teris LLC) operates a hazardous waste treatment and incineration facility in El Dorado, Union County, AR (Figure 2.1). In August 2006 Clean Harbors, Inc. purchased the Teris facility which had operated since 1978. The location was a former petroleum-refining site with documented petroleum-related contamination of surface water runoff and groundwater.

At the time of the purchase by Clean Harbors, Inc., Teris LLC provided environmental remediation of existing contamination caused by petroleum operations. In addition to the removal and disposal of contaminated soil and equipment, Clean Harbors continues to operate a water treatment facility that collects groundwater and surface runoff (contaminated by the previous operations) containing elevated levels of TDS and Se. Water that passes through the treatment system is discharged to Boggy Creek under authority of a NPDES Permit (No. AR0037800).

The current NPDES permit for Clean Harbors became effective October 1, 2004 and contained new requirements for TDS and Se. These permit requirements included monitoring and reporting TDS and Se for the first 3 years (through October of 2007). On November 1, 2007, numeric limitations for these parameters become enforceable. Analytical data for both TDS and Se indicate the discharge will not meet the permit limitations. Teris LLC, and subsequently Clean Harbors, enlisted the assistance of FTN Associates, Ltd. (FTN) to study the sources of TDS and Se and to provide recommendations for alternatives to manage the new limitations. A draft summary report initial source evaluation study is included in Appendix A of this document.

This UAA Report provides an analysis of alternatives for meeting effluent limitations including treatment, modified plant operations and site specific WQC for Se, chloride, and TDS that are protective of existing and attainable designated uses in Boggy Creek and Bayou de Loutre.

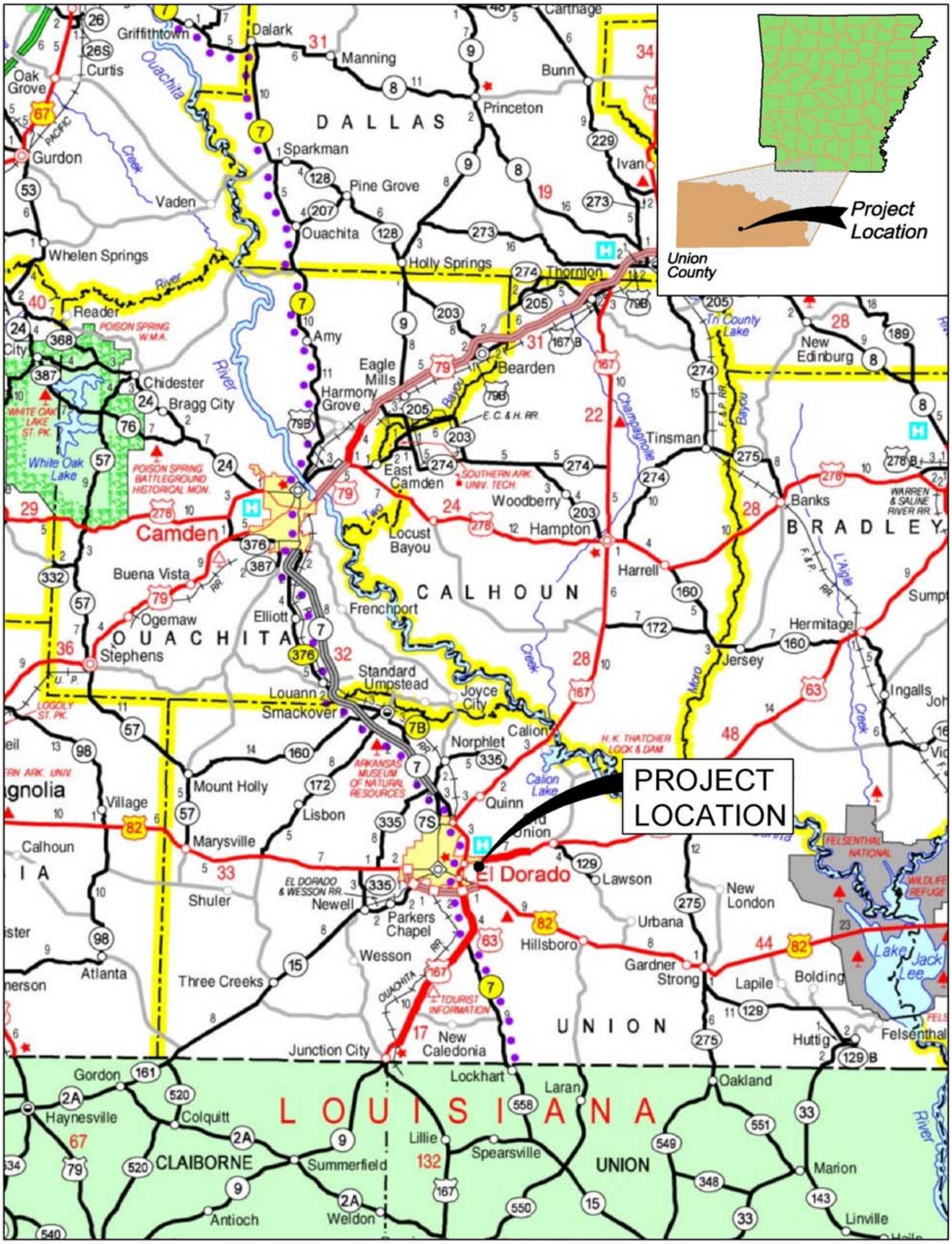


Figure 2.1. Project location map.

2.2 Objectives

The objectives of this UAA study are as follows:

1. Define existing and attainable uses in Boggy Creek and Bayou de Loutre;
2. Identify factors (if any) limiting attainment of designated uses in Boggy Creek and Bayou de Loutre; and
3. Evaluate alternatives for meeting permit limits including treatment, modified plant operations and site specific WQC for Se, chloride, and TDS.

2.3 Approach

For a UAA to justify less stringent chloride, TDS and Se WQC, it is necessary to determine whether the less stringent site-specific criteria will protect existing and attainable uses of the waterbodies in question. To demonstrate that the discharge of the plant effluent protects existing and attainable uses in Boggy Creek requires demonstrating that existing concentrations of chloride, TDS and Se will not limit aquatic life and will not impair existing or attainable uses.

Boggy Creek is impacted by historical petroleum extraction and/or refining operations. Therefore it is necessary to distinguish among Se, TDS, chlorides, and as causes of aquatic life limitation. To distinguish among these potential limiting factors this study sought to evaluate reference streams that showed elevated TDS/chloride levels but were not impacted by petroleum contamination. Comparing aquatic life in these reference streams to aquatic life in Boggy Creek should allow an evaluation of limiting factors in Boggy Creek. For example, greater diversity and abundance of aquatic life in high TDS/chloride reference streams as compared to Boggy Creek would suggest that existing TDS/chloride levels do not limit aquatic life in Boggy Creek. This result would support site-specific TDS and chloride criteria in Boggy Creek consistent with existing conditions.

Reference streams chosen for this purpose were Flat Creek and Curtis Creek. Both watersheds include forest and pasture land use in addition to sources of TDS. Based on previous FTN experience, Flat Creek was known to contain elevated levels of TDS. Curtis Creek (Figure 2.2) was found to have elevated levels of TDS during the April reconnaissance.

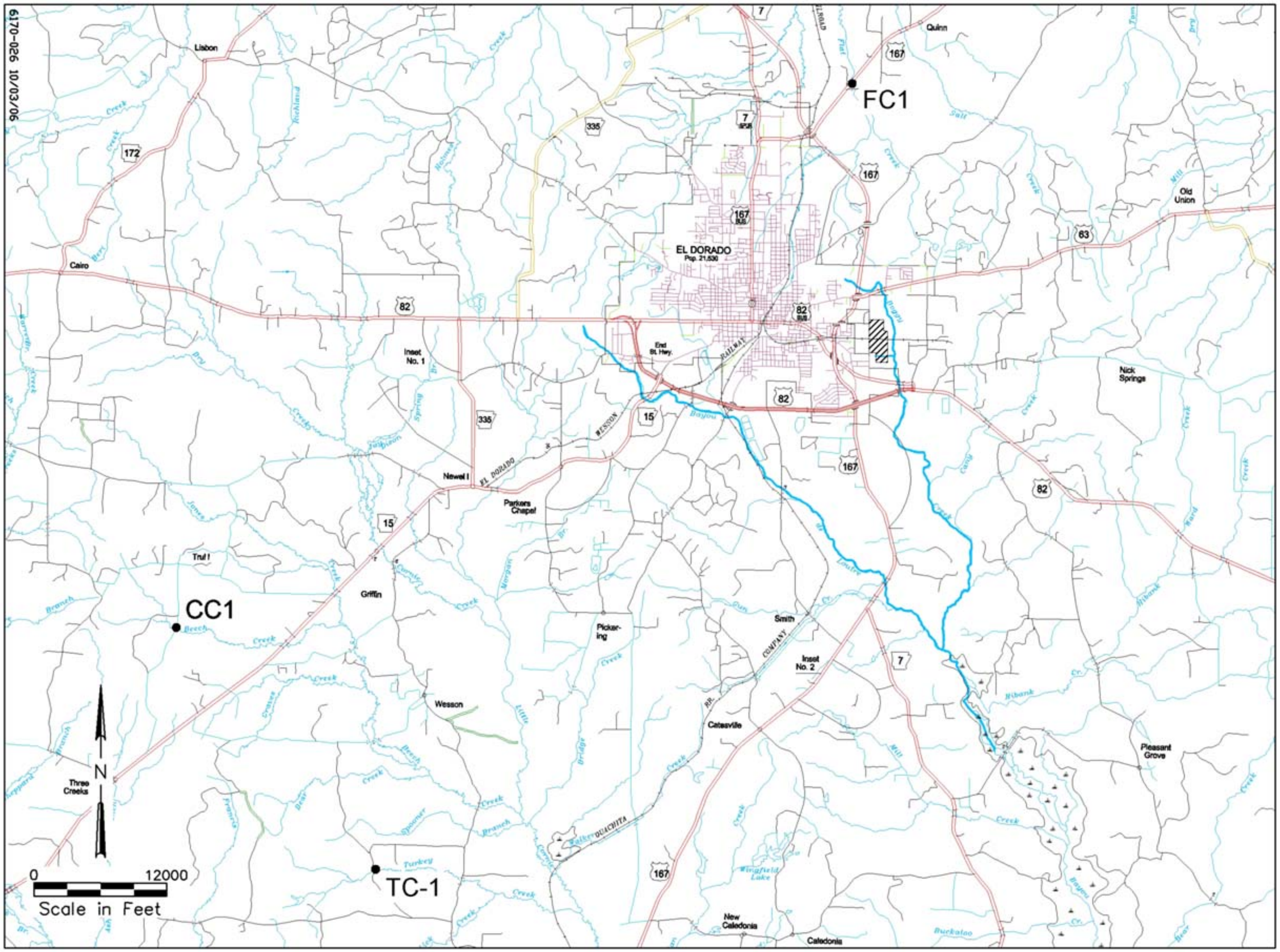


Figure 2.2. Map of El Dorado area showing locations of reference streams. Flat Creek (FC-1), Curtis Creek (CC-1), and Turkey Creek (TC-1).

Turkey Creek (Figure 2.2) was chosen as an additional reference site to represent least disturbed conditions. The Turkey Creek watershed is virtually 100% forested based on site reconnaissance and examination of USGS 1:25,000 scale quadrangle maps.

An additional line of evidence is toxicity information from the literature and the results of toxicity tests designed to evaluate in-steam toxicity and "worst case" TDS and chloride levels in the effluent.

Se impacts aquatic systems by causing reproductive impairment through bioaccumulation in the tissues of fish. Therefore, impacts to the fishery due to Se contamination can be evaluated separately from impacts due to petroleum contamination or elevated TDS/chloride by assessing fish tissue Se concentrations and comparing those levels with established benchmark values. This study sought to assess fish tissue Se concentrations in a wide variety of fish taxa, particularly sunfish (Centrarchidae) which are generally regarded to be highly susceptible to Se toxicity (Lemly 2002). EPA has proposed a whole-body tissue criterion of 7.91 µg/g in its draft Se criterion document (USEPA 2002). WQC are intended to represent levels at which adverse effects *begin to occur in sensitive species.* Therefore, low tissue levels of Se (i.e., below benchmark values such as draft criterion limits) provide strong support for a site-specific criterion consistent with existing conditions because it is presumed that do not limit Se tissue concentrations are below benchmark levels.

Specifically, this study addresses the following questions:

1. Can site-specific controls for TDS, chloride, and Se result in NPDES discharges from Clean Harbors that will meet existing WQC?
2. Will implementing these controls (if they exist) be economically feasible and result in significantly increased protection for the receiving streams?
3. Do existing TDS and Se concentrations in discharges from Clean Harbors' NPDES outfalls impair the fishery uses or other designated uses in Boggy Creek or Bayou de Loutre?
4. Can existing and attainable uses (as defined in APCEC 2005) in Boggy Creek be attained with less stringent criteria for Se, TDS, and chloride?

5. Are site-specific criteria for TDS, chlorides, and Se in Boggy Creek (and possibly Bayou de Loutre) that are consistent with existing Clean Harbors Inc. effluent concentrations protective of designated uses in Boggy Creek and Bayou de Loutre?

To address these questions, a comprehensive waterbody assessment was performed to determine:

1. The existing and attainable uses of Boggy Creek from its headwaters to its confluence with Bayou de Loutre.
2. Impacts of TDS, chlorides and Se in Boggy Creek on the existing and attainable uses of Boggy Creek.
3. Impacts of TDS, chlorides and Se in Boggy Creek on the existing and attainable uses of Bayou de Loutre.

Development of the UAA approach was in accordance with:

1. The USEPA Water Quality Standards Handbook (USEPA 1994) Second Edition,
2. The USEPA Technical Support Document for Waterbody Surveys and Assessments for Conducting UAAs (USEPA 1983),
3. The Water Environment Research Foundation's (WERF) reports "Suggested Framework for Conducting UAAs and Interpreting Results" (WERF 1997a) and "A Comprehensive UAA Technical Reference" (WERF 1997b),
4. The State of AR Continuing Planning Process document (ADEQ 2000),
5. APCEC Regulation No. 2 (2004, including Section Reg. 2.306), and
6. 40 CFR 131.10(a) through (k).

The proposal for changes to APCEC Regulation No. 2 is in accordance with Regulation No. 2, Section 2.306, "Procedures for Removal of Any Designated use Except Fishable/ Swimmable, and Modifications of WQC not Related to Fishable/Swimmable uses" (APCEC 2004). The proposal for changes to APCEC Regulation No. 2 is also in accordance with the applicable sections of 40 CFR 131.10 including:

1. 40 CFR 131.10(b): In designating uses of a water body and the appropriate criteria for those uses, the State shall take into consideration the WQC of downstream waters and shall ensure that its WQC provide for the attainment and maintenance of the WQC of downstream waters.
2. 40 CFR 131.10(e): Prior to adding or removing any use, or establishing sub-categories of a use, the State shall provide notice and an opportunity for a public hearing under Sec. 131.20(b) of this regulation.
3. 40 CFR 131.10(g): States may remove a designated use which is not an existing use, as defined in Sec. 131.3, or establish sub-categories of a use if the State can demonstrate that attaining the designated use is not feasible because:
    a. Naturally occurring pollutant concentrations prevent the attainment of the use;
    b. Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met;
    c. Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place;
    d. Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use;
    e. Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
    f. Controls more stringent than those required by Sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

(Note: Italics indicate applicable 40CFR131.10(g) criteria)

The UAA process included development of a UAA Study Plan (Provided in Appendix A) prior to the field studies in order to document for ADEQ and USEPA review the various strategies and planned tasks. As part of this process, both ADEQ and USEPA indicated conceptual agreement with the UAA approach that was proposed.

3.0 BACKGROUND

3.1 NPDES Outfalls

3.1.1 Outfalls 007 and 009

The Clean Harbors wastewater treatment plant (WWTP) is designed to provide treatment for process wastewater and surface water sources. Water from an onsite well is currently used to provide makeup water to the cooling tower (CT), which is associated with a new air pollution control system. The makeup well water also contains elevated concentrations of Se and TDS that are likely due to the previous refinery operations. Blowdown from the CT, which is the majority of the process wastewater, is a concentrated blend of the makeup well water.

Figure 3.1 provides a schematic drawing that shows the sources of water to the NPDES outfalls at the Clean Harbors facility. Outfall 009 is located at the mouth of a ditch (South Ditch) that traverses the Clean Harbors property along the south side of the main production area. Flow in the South Ditch is to the east towards Boggy Creek (Figure 3.2). The South Ditch receives water from several sources including stormwater runoff from private property along the western property line as well as runoff from areas of the plant property. The discharge from the WWTP for the facility also passes through this outfall. This WWTP treats water that is derived from three primary sources:

1. Recovered groundwater from groundwater recovery wells and the French drains that are part of the remediation efforts associated with past refinery operations;
2. Stormwater runoff from the plant site that is collected in Retention Areas (RA) 4, 7 and 10; and
3. Process wastewater which primarily consists of blowdown from the CT.

The stormwater from RA10 is continuously pumped through the WWTP at a controlled rate of about 50 to 70 gpm. The water is dosed with a polymer to encourage flocculation, settled in a clarifier and then pumped through a sand filter. The filtered water is then pumped through a bed of activated carbon. This treatment system effectively treats suspended solids and soluble organic constituents. The water is then mixed with other treated streams from the WWTP (i.e., groundwater, RA7).

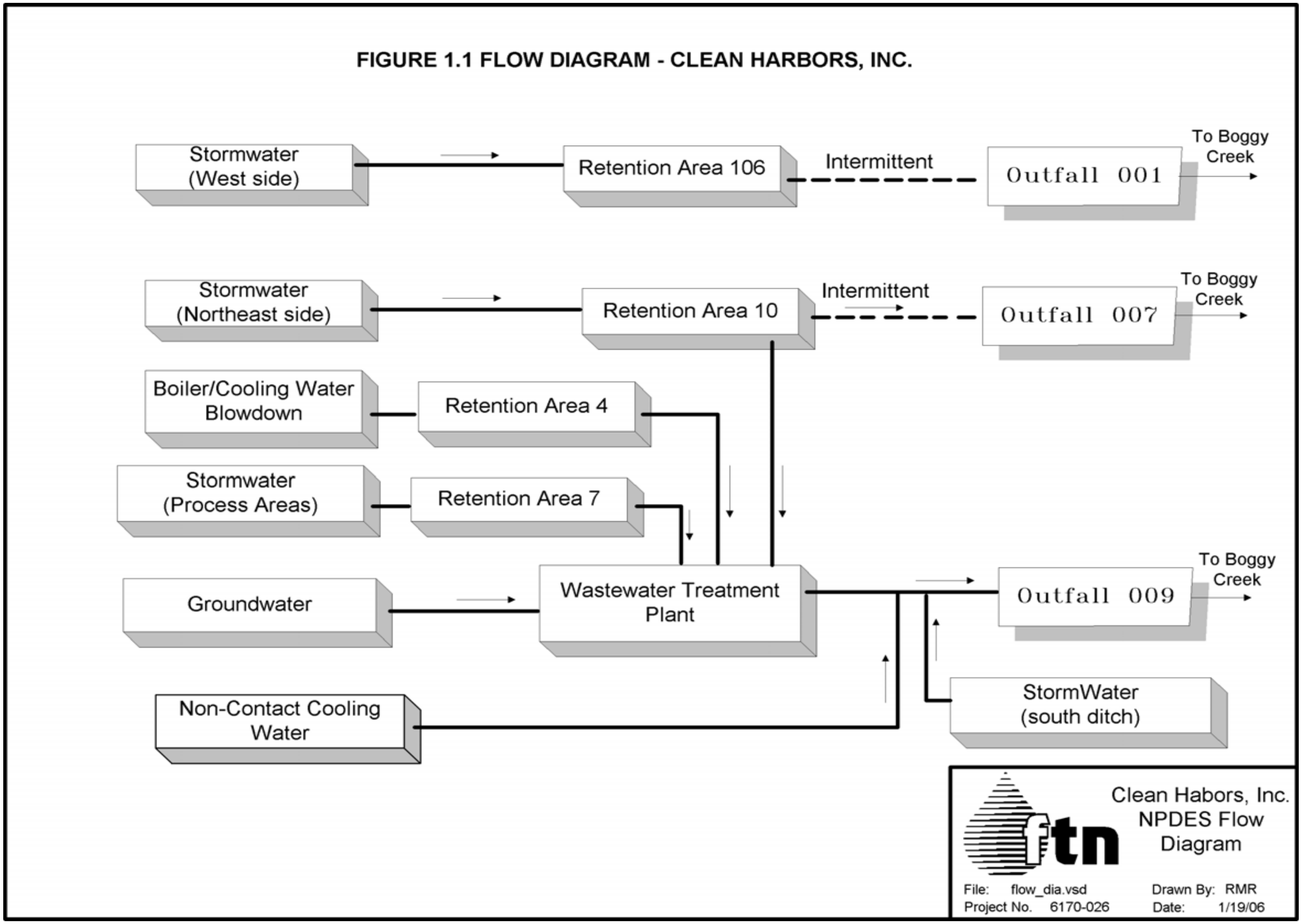


Figure 3.1. Clean Harbors flow diagram.

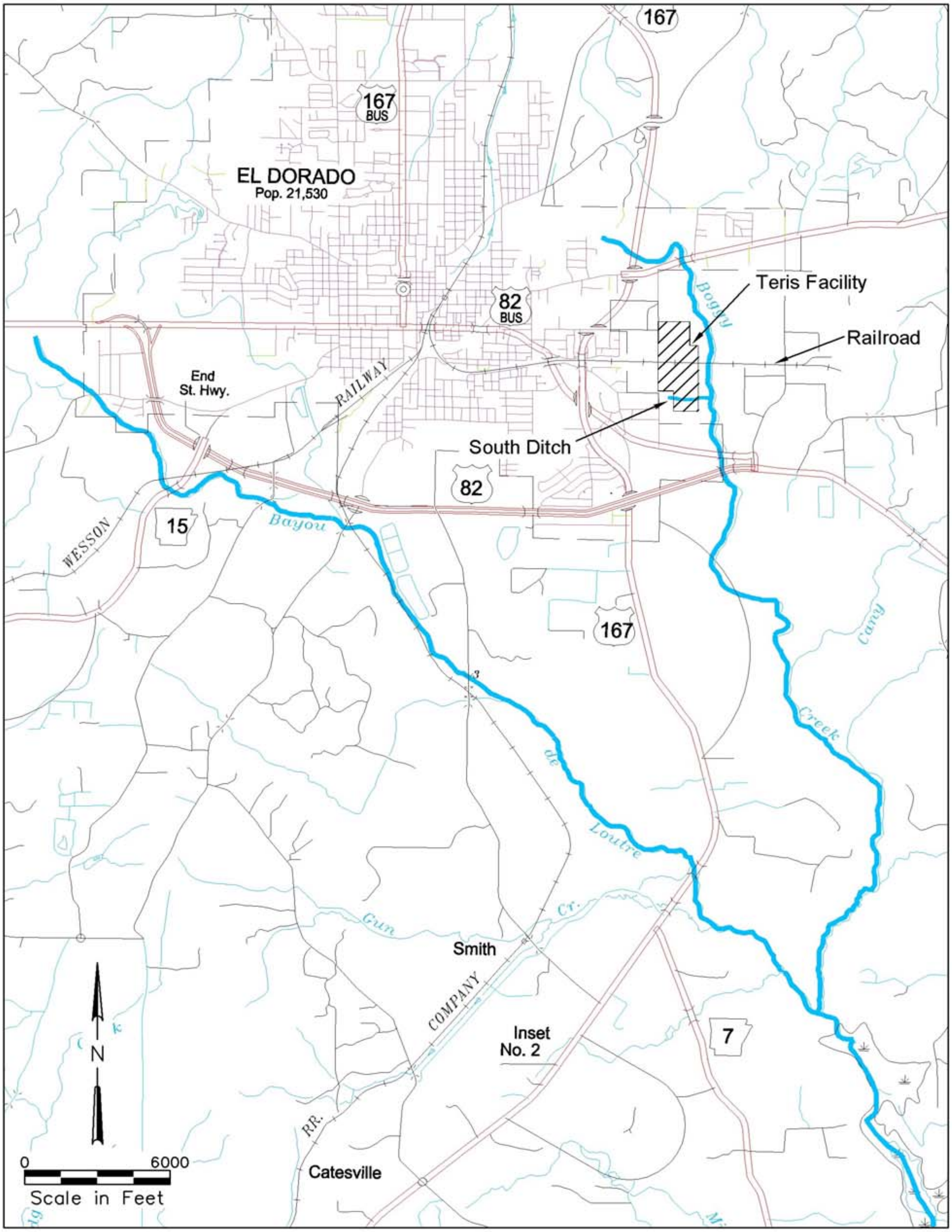


Figure 3.2. Project vicinity map.

These combined streams are discharged through Internal Outfall 009 and subsequently combined with South Ditch stormwater and discharged through Outfall 009. Stormwater that is collected in RA10 is normally treated through the WWTP that is associated with Outfall 009 as described above. However, during some storm events and high flows in Boggy Creek, the water can be discharged directly through Outfall 007 without further treatment. The rate of discharge is controlled by a set of values at Outfall 007 and is limited and proportional to the rate of flow in Boggy Creek. Boggy Creek is the ultimate receiving stream for Outfalls 007 and 009. Flow from Outfall 007 enters Boggy Creek via a small ditch at a railroad crossing approximately 600 ft upstream of the Outfall 009 discharge point.

3.1.2 Outfall 001

NPDES Outfall 001, which receives stormwater runoff from the west portion of the Clean Harbors plant, discharges one to two times per year on average. Water from this outfall enters the same small ditch that receives discharges from Outfall 007. Boggy Creek is the ultimate receiving stream for Outfall 001.

3.2 Se and TDS Sources

In preparation for the UAA Study, FTN completed a study of various streams that contribute water to Outfall 009 to identify sources of Se and TDS. A summary report from this ongoing source evaluation study is included as Appendix B to this document. Based on data collected during the source evaluation study, TDS is present in the groundwater and CT blowdown at relatively high concentrations. Data from the source evaluation study also indicate that Se occurs in groundwater under the site, in surface runoff from the site as well as in Boggy Creek upstream from the Clean Harbors point sources. Given the site’s history and the widespread distribution of Se at the site, it is believed that the source of Se is primarily connected to residues from the previous refinery operations. Permit limits for the existing NPDES permit (AR0037800) are provided in Table 3.1. The permit limits that will become effective on September 30, 2007 are summarized in Table 3.2.

Table 3.1 Current NPDES permit discharge limits for Outfall 009.

Effluent Characteristic	Discharge Limitations				Measurement Frequency
	Mass (lbs/day)		Concentration (mg/L)		
	Monthly Ave	Daily Max.	Monthly Ave	Daily Max.	
Total Organic Carbon	N/A	N/A	N/A	55	1x/Week
Oil and Grease	74	110	10	15	1x/Week
Temperature (Instantaneous maximum)	N/A	N/A	N/A	86°F	2x/Week
Total Chromium	N/A	N/A	Report	50 ug/L	1x/Quarter
Total Lead	0.03	0.06	3.8 ug/L	7.6 ug/L	1x/Quarter
Chlorides	N/A	N/A	Report	Report	1x/Week
Endrin	0.00002	0.00004	0.0026 ug/L	0.0052 ug/L	1x/Quarter
Dieldrin	0.0001	0.0002	0.0012 ug/L	0.0020 ug/L	1x/Quarter
Total Dissolved Solids	Report	Report	Report	Report	1x/Week
1,2-dichloroehtane	N/A	N/A	Report	100 ug/L	1x/Quarter
Dichloromethane	N/A	N/A	Report	50 ug/L	1x/Quarter
Total Se	Report	Report	Report	Report	1x/Quarter
Bis (2-ethylhexyl) phthalate	N/A	N/A	Report	Report	1x/Quarter
pH	N/A	N/A	Min 6 s.u.	Max 9 s.u.	1x/day

Table 3.2. TDS and Se limits that become effective on September 30, 2007 for the Clean Harbors Outfall 009.

Parameter	Monthly Average	Daily Maximum
TDS	343 mg/L	515 mg/L
Se	5.58 ug/L	11.20 ug/L

3.3 Discharge Characteristics

Discharge Monitoring Report (DMR) data for TDS, chloride and Se from Outfall 009 are presented in Table 3.3. The DMR data indicate frequent exceedances of the TDS and Se limits that will come into effect on 9/30/07. Monthly average discharge flows range from 0.075 to 0.653 mgd. Monitoring data also indicated that the Gulf Coastal Ecoregion WQC for chloride (19 mg/L) is exceeded in Boggy Creek.

Table 3.3. DMR data from Outfall 009 from November 2004 - June 2006.

DMR Date	TDS		Chlorides		Total Se	
	Monthly Avg mg/L	**Daily Max mg/L**	**Monthly Avg mg/L**	**Daily Max mg/L**	**Monthly Avg ug/L**	**Daily Max ug/L**
11/30/2004	194	1300	46	370		
12/31/2004	387	510	141	220	7.5	7.5
1/31/2005	233	460	81	170		
2/28/2005	371	720	135	330		
3/31/2005	621	710	279	330	29	29
4/30/2005	653	950	279	440		
5/31/2005	547	890	257	450		
6/30/2005	657	960	290	450	9.1	9.1
7/31/2005	833	920	383	490		
8/31/2005	392	450	159	200		
9/30/2005	997	1400	456	580	11	11
10/31/2005	753	1400	347	630		
11/30/2005	780	1400	321	560		
12/31/2005	486	530	212	230	< 5	< 5
1/31/2006	158	510	53	250		
2/28/2006	533	770	275	370		
3/31/2006	278	660	108.4	280	21	21
4/30/2006	607	780	284	350		
5/31/2006	495	850	217	390		
6/30/2006	552	1300	135	160	10	10

3.3.1 Biomonitoring

A summary of quarterly biomonitoring results for 2004 through 2006 is provided in Table 3.4. The Outfall 009 effluent does not typically show lethal to sub-lethal toxicity in routine biomonitoring. The summary indicates that toxic episodes occurred with samples collected 1/16 through 21/05, 4/17 through 22/05, 1/11 through 16/04, 2/15through 20/04 and 10/10 through 15/04. Follow-up testing was conducted as a result of some of these episodes. For other episodes follow-up evaluation of the test data or plant operations provided indications of the cause(s) of toxicity. The results and conclusions of these follow-up tests and evaluations are provided in Table 3.5 In no case was toxicity attributable to the ionic strength of the effluent. This conclusion is based on the following:

1. Toxicity was seen with *P. promelas* but not *C. dubia* (*C. dubia* is more sensitive to TDS related toxicity than *P. promelas*), or
2. Toxicity to *C. dubia* occurred at sample dilutions at which TDS is clearly not elevated.

Table 3.4 Summary of routine biomonitoring results and associated water chemistry measurements.

Sampling period		**NOEC (% Effluent)** *C. dubia*		***P. promelas***		**Chemical Measurements**			
Begin	End	S	R	S	G	Conductivity (uS)	Total Alkalinity (mg/L)	Hardness (mg/L)	PH (S.U)
1/15/06	1/20/06	100	100	100	100	830	75	120	7.7
						280	36	44	7.4
							98	140	7.8
4/2/06	4/7/06	100	100	100	100	1400	150	140	8
						1400	130	120	7.9
						1400	140	130	8.1
7/19/06	7/14/06	100	100	100	100	830	71	110	7.5
						730	65	120	7.6
						710	60	110	7.8
10/8/06	10/13/06	100	100	100	100	2000	200	150	8.1
						2100	200	150	8.1
						2200	230	150	8.1
1/16/05	1/21/05	<32	<32	42	<32	670	62	130	7.5
						670	64	120	7.4
						760	74	130	7.6
2/20/05	2/25/05	100	100	No test	No test	1200	78	190	7.8
						1300	80	210	7.8
						1000	66	160	7.5
3/20/05	3/24/05	100	100	No test	No test	1100	90	200	7.3
						520	50	95	7.2
						1000	75	190	7.6
4/17/05	4/22/05	100	100	42	<32	810	73	120	7.3
						760	72	110	7.2
						1000	86	130	7.5

S = Survival, R = Reproduction, and G= Growth Endpoints.

Table 3.4 Continued

Sampling period		NOEC (% Effluent)				Chemical Measurements			
		C. dubia		*C. dubia*					
Begin	End	S	R	S	G	Conductivity (uS)	Total Alkalinity (mg/L)	Hardness (mg/L)	PH (S.U)
7/17/05	7/22/05	100	100	100	100	1800	220	130	8.3
						1700	210	120	8.1
						1700	210	130	8
10/10/05	10/15/05	100	100	100	100	1100	70	140	7.7
						1200	78	140	7.3
						1200	78	150	7.6
1/11/04	1/16/04	<32	<32	100	100	1600	170	96	7.8
						1500	170	102	8
						1400	160	100	7.7
2/15/04	2/20/04	<32	<32	No test	No test	200	33	35	6.9
						520	52	54	6.8
						920	89	78	7.6
4/11/04	4/16/04	100	100	100	100	1200	69	98	7.5
						740	67	71	7.2
						1100	90	100	7.7
5/16/04	5/21/04	100	100	100	100	1100	72	130	7.6
						1200	70	140	7.7
						1600	67	180	7.7
7/11/04	7/16/04	100	100	100	75	600	71	71	7.1
						1300	73	130	7.7
						960	78	98	7.6
10/10/04	10/15/04	100	100	42	32	130	21	27	7.3
						590	49	84	7.3
						930	61	100	7.7

S = Survival, R = Reproduction, and G= Growth Endpoints.

Table 3.5 Summary of toxic episodes observed as part of Outfall 009 routine biomonitoring conducted 2004 through 2006.

Sample Collection Period	Organisms Affected	Cause of toxicity	Basis for Conclusion
1/16 - 21/05	*C. dubia*	Likely related to fire retardant use. Not related to TDS; No toxicity in subsequent monthly retests	Toxicity at Outfall 007 attributable to fire retardants; Conductivity at lowest toxic test concentration (32%) = 234 uS indicating insufficient ionic strength for TDS-related toxicity.
	P. promelas	Pathogen interference	Non-monotonic dose response, high intereplicate variability (See Table 3.6)
4/17 - 22/05	*P. promelas*	Pathogen interference	Non-monotonic dose response, high intereplicate variability (See Table 3.6) Follow-up test with UV treated sample1
1/11 - 16/04	*C. dubia*	Organic toxicant; Not related to TDS.	Phase I Toxicity identification evaluation; Conductivity at lowest toxic test concentration (32%) = 512 uS indicating insufficient ionic strength for TDS-related toxicity.
2/15/04	*C. dubiai*	Unknown: Associated with unusual upset in cooling tower; Not related to TDS.	Conductivity at lowest toxic test concentration (32%) = 294 uS indicating insufficient ionic strength for TDS-related toxicity.
10/10 - 15/04	*C. dubia*	Pathogen interference	Non-monotonic dose response, high intereplicate variability (See Table 3.6).

Episodes of toxicity to *C. dubia* that occurred in early 2005 were most likely associated with fire retardants used to control a fire the occurred at the facility in late 2004. The fire incident resulted in several toxicity events occurring at Outfall 007 during wet weather releases resulting in a Toxicity Reduction Evaluation (TRE) requirement for Outfall 007.

Characterization efforts as part of this TRE indicated that fire retardants that were washed into RA10 were the likely cause of toxicity at Outfall 007. Episodes of toxicity at Outfall 009 during this time period are also very likely due the same fire retardants because RA10 water is treated by the facility and discharge through Outfall 009.

Episodes of toxicity to *P. Promelas* are, in all cases, attributable to pathogen interference. This diagnosis was made based on the dose response shown in the tests and followup testing conducted on samples collected 4/17 through 22/05. In all cases evaluation of the dose response in tests showing toxicity to *P. promelas* showed a lack of a monotonic dose response and high variability among test replicates. These test characteristics are diagnostic of pathogen interference as described in USEPA (2004; Section 11.3). Results of these tests summarizing dose response and inter-replicate variability are summarized in Table 3.6.

3.4 WQC and Designated uses (APCEC Regulation No. 2)

Boggy Creek lies within the Gulf Coastal Ecoregion (Plate D-2 APCEC 2005). Applicable WQC (APCEC 2005) are as follows:

1. Dissolved minerals: Chloride 19 mg/L, Sulfate 41 mg/L, TDS 138 mg/L.
2. Se: 5 µg/L (chronic), 20 µg/L (acute).
3. Designated uses – (assumed by default):
   a. Primary Contact Recreation.
   b. Secondary Contact.
   c. Domestic, Industrial and Agricultural Supply.
   d. Perennial Gulf Coastal Fishery.

Bayou de Loutre (in Arkansas) also lies within the Gulf Coastal Ecoregion (Plate D-2 of APCEC 2005). Applicable WQC (APCEC 2005) are as follows:

1. Dissolved minerals: Chloride 19 mg/L; Sulfate 41 mg/L; TDS 138 mg/L.
2. Se: 5 µg/L (chronic), 20 µg/L (acute).
3. Designated uses – (assumed by default):
   a. Primary Contact Recreation.
   b. Secondary Contact.
   c. Domestic, Industrial and Agricultural Supply (a previous UAA was performed that removed the Domestic Drinking Water Supply use from Bayou de Loutre near the Arkansas – Louisiana State line).
   d. Perennial Gulf Coastal Fishery.

3.4.1 Other Point and Non-point Sources to Boggy Creek

A Permit Compliance System (PCS) query indicated that there are 2 NPDES discharges to Boggy Creek in addition to Clean Harbors. Cooper Standard has not discharged in the last 2 years. The average monthly discharge from Columbian Chemicals was 0.02 cubic feet per second (cfs).

3.5 Reference Streams

Three reference streams as described below were chosen per the approach described in Section 2. The presence of oil production wells was evaluated by consulting the "New Ownership and Oil Development Map No. 580W" for Union County compiled by EBY Engineering, El Dorado, AR, revised 1970. This map indicates the location of oil leases and oil, gas and brine wells.

Turkey Creek is a tributary of Cornie Bayou with a total watershed area of 8.8 mi^3. The watershed area of Turkey Creek at the sampling location is 3.0 mi^2. According to site reconnaissance and USGS 1:24,000 quadrangle maps, the watershed is largely forested. Little if any oil production is evident in this watershed. The sampling reach was located on the downstream side of a road crossing, which may impact the biotic community to some extent. The reach upstream of the road was unsuitable for sampling for a significant distance.

Curtis Creek is a tributary of Beech Creek with a watershed area of 5.96 mi^2. The watershed area of Curtis Creek at the sampling location is 2.2 mi^2. According to site reconnaissance and USGS 1:24,000 quadrangle maps the watershed is mainly composed of pasture and forest. The forested riparian zone along the sampling reach was > 300 ft in width on either side of the stream. An oil production area is present upstream of the sampling location. Field reconnaissance indicated elevated TDS concentrations.

Flat Creek is a tributary of the Ouachita River with a watershed area of 36.91 mi^2. The watershed area of Flat Creek at the sampling location is 9.7 mi^2. According to site reconnaissance and USGS 1:24,000 quadrangle maps the watershed is composed of pasture and forest with some urban and industrial areas. The forested riparian zone along the sampling reach was > 300 ft in width on either side of the stream. No oil production areas are present upstream of the sampling location however a tank farm is located in the watershed upstream of the sampling location. Field reconnaissance indicated elevated TDS concentrations and variable flows.

4.0 FIELD SURVEYS

The field survey included sampling during May 15 through 18 and July 17 through 19, 2006 as summarized in Tables 4.1 and 4.2. The purpose of the field surveys was to establish the range of chemical, physical, habitat and biological (fish and benthic macroinvertebrates) conditions and Se concentrations in fish present in Boggy Creek and in Gulf Coastal Plain Ecoregion streams in the vicinity of Boggy Creek.

Sampling reaches (Figures 2.2, 4.1, and 4.2) were chosen based on an area reconnaissance conducted on April 6 through 7, 2006. Sampling reaches on Boggy Creek were chosen to capture habit representative of that stream and to document stream conditions and fish tissue Se concentrations upstream and downstream of Clean Harbors Outfall 009. Upper sampling reaches on Boggy Creek BC-1, BC-2, BC-3 were located upstream of Highway 82. The lower Boggy Creek sampling reach (BC-0) was located approximately 2.7 km upstream from the confluence with Bayou de Loutre. Sampling reaches on Turkey Creek, Curtis Creek and Flat Creek were chosen to capture representative habitat on those streams and to document background fish tissue Se concentrations in ecoregion streams. The length of each reach sampled was approximately 40 stream widths per Barbour *et al.* (1999). Sampling locations on Bayou de Loutre were chosen to evaluate water quality conditions and Se in fish tissue above and below the confluence with Boggy Creek. Habitat and biological community (fish and benthic macroinvertebrate) sampling was not performed at the Bayou de Loutre locations.

4.1 Supplemental Se Analysis Methods

During 9/6/06 – 11/27/06, supplemental sampling for total Se was conducted at Outfall 009 BC-3-3 (Boggy Creek upstream of Outfall 009), BC-1 and BC-1-3 (both stations downstream of Outfall 009). Sampling included additional samples collected upstream of Outfall 009 (BC-2) as well as from Bayou de Loutre (BDL-1 and BDL-2). Grab samples for analysis of Se were collected using methods outlined in Section 4.1.1.

Detailed description of sampling locations and methods are provided in the following sections. Tables 4.1 and 4.2 provide a summary of sampling locations and the types of data collected from each. Except for Flat Creek all streams sampled were sluggish low-gradient streams with extensive wooded riparian zones, 100% canopy cover and organic stained water. Flat Creek has a slightly higher gradient than other streams and does not have organic stained water. Photographs of sampling and monitoring locations are provided in Appendix C.

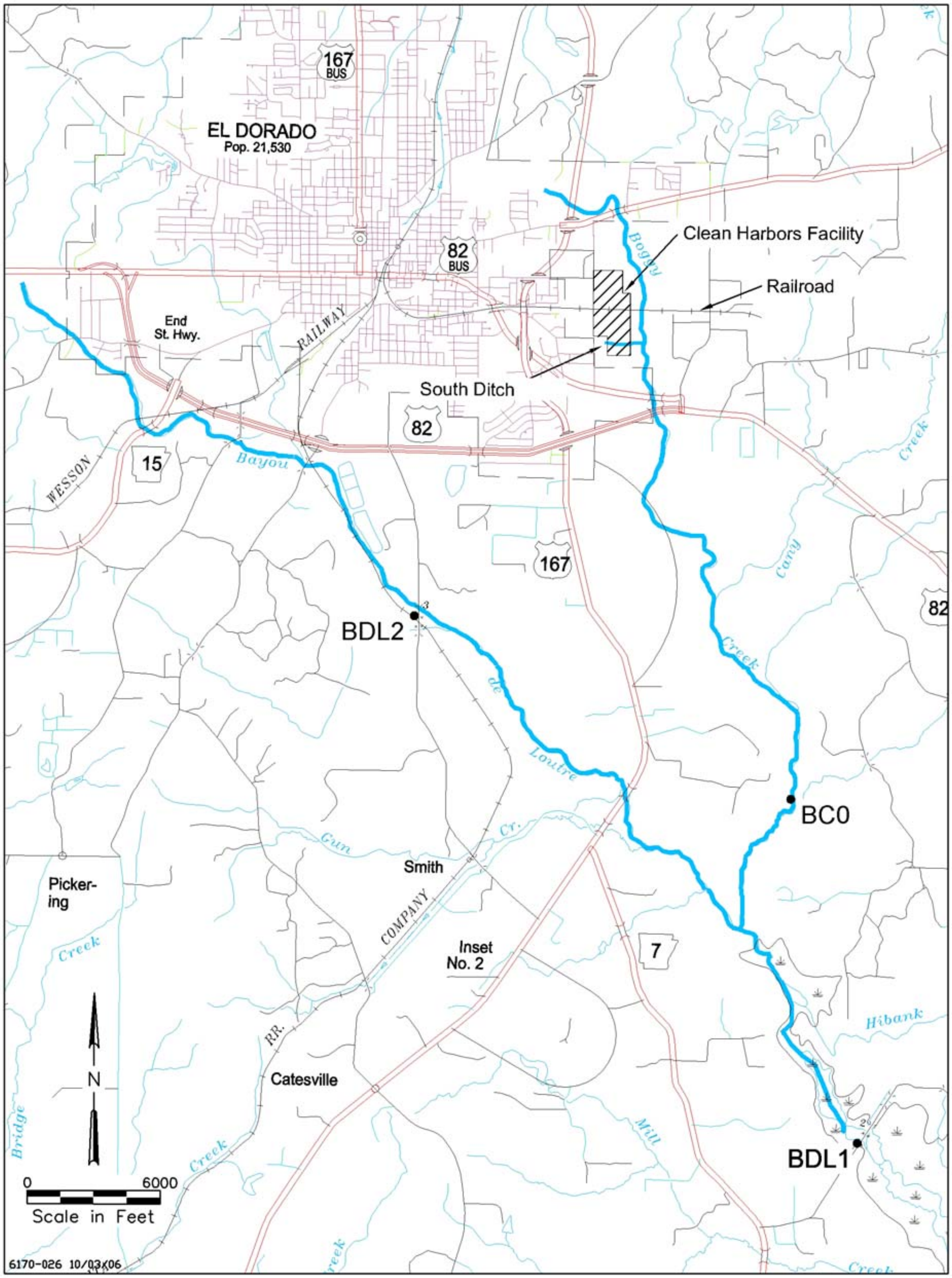


Figure 4.1. Map of El Dorado area showing sampling locations on lower Boggy Creek (BCO) and Bayou de Loutre (BDL1 and BDL2).

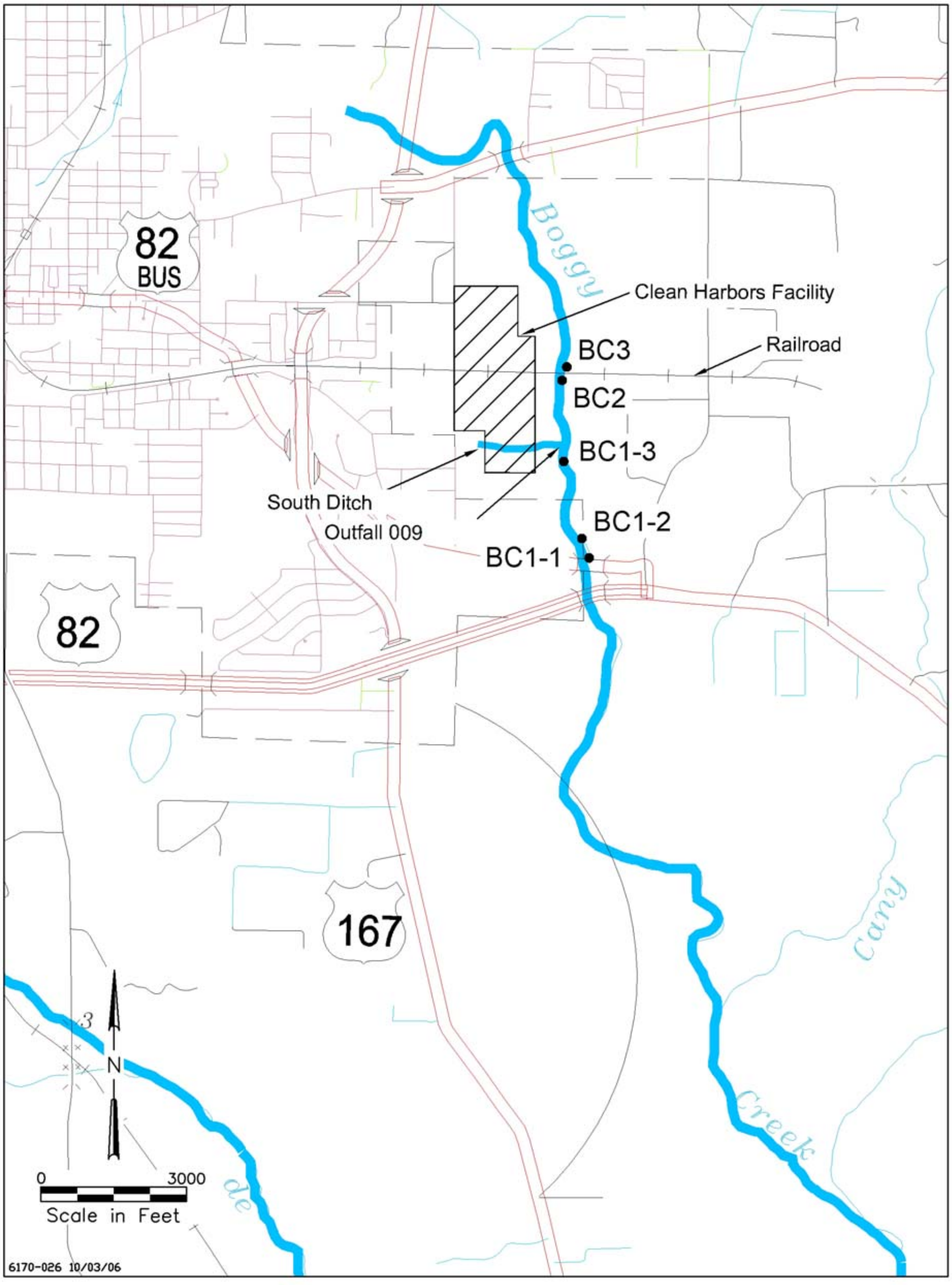


Figure 4.2. Map of El Dorado area showing sampling locations on upper Boggy Creek.

Table 4.1. Sampling reach/station descriptions.

Reach/Station	Description
BC-0-1	Lower Boggy Creek sampling reach; Located approximately 2.7 km. above the confluence with Bayou de Loutre. Sampled reach was primarily shallow flowing habitat and did not include any pool habitat.
BC-0-2	Lower Boggy Creek sampling reach; Located immediately downstream of B0-1. Reach was added to include pool habitat as part of the biological sampling for this location.
BC-1-1	Upper Boggy Creek sampling reach; Reach extended upstream from Highway 82 bridge.
BC-1-2	Upper Boggy Creek sampling reach; Additional sampling reach approximately 75 m upstream of BC-1-1. Sampling reach added to increase the number of sunfish for Se analysis.
BC-1-3	Upper Boggy Creek sampling reach; Sampling reach at Outfall 009 extending upstream and downstream of Outfall 009. Water quality samples collected from downstream end of reach approximately 20 m below Outfall 009.
BC-2	Upper Boggy Creek sampling reach; Mainly pool habitat at Outfall 007 and upstream of Outfall 009.
BC-3	Upper Boggy Creek sampling reach; Sampling reach upstream of Outfall 007.
BDL-1	Water quality sampling station located at the Pleasant Grove Road bridge, approximately 5.3 km downstream of the confluence with Boggy Creek.
BDL-2	Water quality sampling station located at the Jackson Street bridge, approximately 9.6 km upstream of the confluence with Boggy Creek. This station is downstream of the City of El Dorado wastewater treatment plant discharge.
FC-1	Sampling reach upstream of the Old Galion Highway bridge.
CC-1	Sampling reach upstream of bridge at Charlie Rogers Rd.
TC-1	Sampling reach downstream of bridge at Simmons Rd.

Table 4.2. Sampling stations and data collection summary for UAA sampling conducted May 15-18 and July 17-19, 2006.

Station	Chemistry, Flow, *In situ*	Continuous *in situ*	Fish Communities	Fish Tissue	Benthos	Toxicity
BC-0-1	X		X	X	X	
BC-0-2			X	X		
BC-1-1	X		X	X	X	X*
BC-1-2		X	X	X		
BC-1-3	X		X	X		
BC-2	X		X	X	X	
BC-3		X	X	X	X	
BDL-1	X	X		X		
BDL-2	X	X**		X		
FC-1	X	X*	X	X	X	
CC-1	X		X	X	X	
TC-1	X		X	X	X	

*sample collected during May sampling event only.
**sample collected during July sampling event only.

4.2 Chemical and *In Situ* Measurements

4.2.1 Chemical Measurement Methods

Grab samples for analysis of selected chemical parameters were collected from near the upstream end of each sampling reach and analyzed for the parameters indicated in Table 4.3. Grab samples were collected from the surface at each sampling location at mid current using a clean plastic bucket. Samples were placed in labeled sample bottles containing appropriate preservative and placed on ice immediately upon collection. Samples and chain of custody documents for chemical analyses and toxicity tests were delivered to American Interplex (AI) Laboratory (8600 Kanis Rd., Little Rock, AR 72204) for analysis within required holding times. Sampling parameters included total organic carbon (TOC), dissolved organic carbon (DOC) and oil and grease to assess the presence of petroleum contamination. Aliquots of sample were filtered in the field using 0.45 u pore size membrane filters for the analysis of DOC and dissolved Se. Field Quality Control (QC) samples included the collection of duplicates and field blanks at one station for both the May and July 2006sampling events. Field blanks were collected by placing American Society of Testing Material (ASTM) Type 1 laboratory water in the appropriate sample container in the field. Field blanks included filtration blanks, which were prepared by performing the field filtration procedure on laboratory water in the field.

Table 4.3 Analytical methods used for chemical analysis of water samples collected during the field survey.

Analyte	Method	Detection Limit (mg/L or mg/Kg)
Alkalinity as CaCO3	USEPA 310.1	1
Chloride	USEPA 300.0	0.2
Oil and Grease (Water)	AROG*	5
Oil and Grease (Sediment)	AROG*	40 mg/Kg
Total/Dissolved Se (Water)	USEPA 200.8	0.002
Total Se (Sediment)	USEPA 3051, 6010B	1 mg/Kg**
Sulfate	USEPA 300.0	0.2
Total Dissolved Solids	USEPA 160.1	10
Total/Dissolved Organic Carbon	USEPA 415.1	1

*Arkansas Oil and Grease Method.
**Detection limit for May sampling event = 2 mg/Kg.

Sediment samples were collected from depositional areas of each stream by dipping the sample container into the substrate. Sediment analysis included analysis for oil and grease to assess the presence of petroleum contamination and total Se measurements to assess Se accumulation in the sediments.

In situ measurements of temperature, dissolved oxygen (DO), pH and specific conductance were taken concurrently with each grab sample. All *in situ* measurements were taken using Hydrolab Minisonde Multiprobe water quality monitors. Prior to data collection sondes were calibrated according to FTN standard operating procedures based on manufacturer's recommended procedures. Calibration procedures involved air calibration of the DO function, 2-point calibration of the pH function using standard pH calibration solutions (pH 4 and 7 buffers), and a 1-point calibration of the specific conductance function using a standard calibration solution. At the end of each day's sampling instrument calibration was checked by documenting monitor readings in the appropriate standard calibration solution (or water saturated air in the case of DO).

4.2.2 NPDES Outfall 009 Measurements

Measurements of flow, TDS and chloride from NPDES Outfall 009 are provided for the weeks preceding and following each sampling period in Table 4.4.

4.2.3 Chemical Measurement Results

In situ and analytical data collected on May 15 through 18 and July 17 through 19, 2006 are presented in Tables 4.5 and 4.6, respectively. During both sampling events, field personnel noted distinct petroleum deposits on the sediments and a noticeable oil sheen on the surface of the water as personnel waded in the upstream Boggy Creek locations (BC-1, BC-1-3, BC-2, and BC-3). Photographs documenting the presence of oil sheens on the water surface and petroleum residue deposits on the substrate of Boggy Creek are presented in Figure 4.3.

Figure 4.3. Photographs illustrating the surface oil sheen and substrate oil deposits present at upper Boggy Creek sampling locations.

Petroleum odors and sheens were not noted at the downstream Boggy Creek location (BC-0), Turkey Creek or Flat Creek. A slight sheen but no odor was noted at Curtis Creek. Curtis Creek contained dense accumulations of decaying leaves and vegetation, which might in addition to potential petroleum impacts, account for the slight surface sheens observed. Spatial and temporal patterns in water and sediment chemistry for each parameter are described below.

Table 4.4. Measurements of flow, TDS and chloride from NPDES Outfall 009 for the weeks preceding and following each sampling period.

Sampling Date	Flow (cfs)	TDS (mg/L)	Chloride (mg/L)
5/1/2006	0.39	290	110
5/8/2006	0.35	660	310
5/15/2006	0.11	850	390
5/22/2006	0.08	400	160
5/30/2006	0.08	390	140
6/5/2006	0.05	1300	150
6/12/2006	0.08	450	160
6/19/2006	0.08	270	90
6/26/2006	0.05	410	150
7/5/2006	0.05	470	160
7/10/2006	0.06	490	210
7/17/2006	0.08	750	360
7/24/2006	0.01	520	240
7/31/2006	0.00	1700	740

Table 4.5. Summary of results of chemical analyses of grab samples and concurrent *in situ* measurements taken on May 15-18, 2006.

WATER CHEMISTRY	Sampling Reach/Station										
ANALYTE (mg/L unless otherwise noted)	BC-0	BC-1	BC-1 Dup	BC-1-3	BC-2	BDL-1	BDL-2	FC-1	FC-1 Blank	TC-1	CC-1
Date	5/16	5/15	NC	5/18	5/18	5/16	5/16	5/17	NA	5/17	5/17
Time	1545	1405	NC	0950	1015	1145	0811	0753	NA	1247	1:40
Flow (cfs)	0.8	0.8	0.8	ND	ND	2.7	11.1	1.1	ND	0.5	< 0.1
Temperature (^oC)	19.3	20.6	ND	ND	ND	19.6	21.2	18.1	ND	17.2	15.9
Dissolved Oxygen	5.1	3.1	ND	ND	ND	4.1	5.6	7.17	ND	8.05	0.5
pH (Standard Units)	6.0	7.4	ND	ND	ND	6.4	7.0	8.0	ND	8.0	7.9
Specific Conductance (US)	282	505	ND	ND	ND	1064	1705	1986	ND	74	475
Total Dissolved Solids	280	300	290	360	240	670	1100	1200	<10	95	410
Total Organic Carbon	18	8.4	8.5	5.5	5.7	16	6.7	5.3	<1	5.7	19
Dissolved Organic Carbon	15	6.4	6.3	4.5	4.4	13	5.1	3.7	<1	4.1	13
Total Se (ug/L)	3.3	4.1	5.2	7.1	4.0	7.5	8.0	23	< 2	< 2	7.2
Dissolved Se (ug/L)	3.8	4.7	6.4	6.3	3.0	7.9	8.1	24	< 2	< 2	6.0
Chloride	62	110	110	150	86	150	150	530	<0.2	9.3	130
Sulfate	66	4.7	4.7	4.4	4.2	220	420	76	<0.2	3.6	4.0
Oil and Grease	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
SEDIMENT CHEMISTRY											
ANALYTE (mg/Kg)											
Total Se	<2	<2	NC	<2	<2	NC	NC	<2	NA	<2	<2
Oil and Grease	2200	4600	NC	3100	6200	NC	NC	<40	NA	120	410

ND = No data; NA = Not applicable; NC – Not collected

Table 4.6. Summary of results of chemical analyses of grab samples and concurrent *in situ* measurements taken on July 17-19, 2006.

WATER CHEMISTRY	Sampling Reach/Station										
ANALYTE (mg/L unless otherwise noted)	**BC-0**	**BC-1**	**BC-1-3**	**BC-2**	**BDL-1**	**BDL-1 Dup**	**BDL-2**	**FC-1**	**TC-1**	**TC-1 blank**	**CC-1**
Date	07/18	07/18	07/18	07/17	07/18	NC	07/18	07/19	07/19	NA	07/19
Time	1615	1245	0825	1500	1705	NC	1850	1530	1018	NA	0805
Flow (cfs)	NMF	NMF	0.1	NMF	1.0	NC	13.0	<0.1	0.2	NA	NMF
Temperature (^{o}C)	30.4	26.9	24.8	27.6	29.6	NC	33.2	28.8	25.3	NA	23.5
Dissolved Oxygen	1.5	2.9	4.1	4.4	2.7	NC	9.9	7.0	5.4	NA	0.3
pH (Standard Units)	6.3	6.0	5.8	6.1	6.9	NC	7.5	6.9	6.4	NA	5.9
Specific Conductance (US)	67	455	428	451	1913	NC	2292	1017	93.4	NA	108
Total Dissolved Solids	180	300	300	330	1200	1200	1400	530	110	<10	92
Total Organic Carbon	9	5.4	4.9	5.2	15	15	9.4	6.8	3.9	<1	13
Dissolved Organic Carbon	5.9	3.1	2.8	2.9	12	12	6.4	4.7	1.8	<1	10
Total Se (ug/L)	2.8	4.6	2.8	3.3	5.8	6.2	8.9	5.7	1.5	< 1	1.5
Dissolved Se (ug/L)	2.2	3.8	2.9	3.2	6.0	6.3	8.5	4.8	1.1	< 1	1.2
Chloride	59	120	120	130	200	200	260	200	12	0.26	13
Sulfate	2.7	4.5	3.7	5.1	510	500	680	130	4.7	<0.2	1.6
Oil and Grease	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
SEDIMENT CHEMISTRY ANALYTE (mg/Kg)											
Total Se	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

NC = not collected; NA = Not applicable; NMF = No Measurable Flow

4.2.3.1 Water Chemistry

TDS – The ecoregion TDS criterion (138 mg/L) was exceeded in the May sampling at all locations except Turkey Creek and at all stations except Turkey Creek and Curtis Creek in the July 2006 sampling. In Boggy Creek, May 2006 concentrations increased between BC-2 (above Outfall 009) and BC-1-3 (below Outfall 009), and then decreased further down steam (Table 4.5). In July, Boggy Creek concentrations were highest at BC-2 (above Outfall 009) and decreased further downstream. Boggy Creek TDS concentrations were similar in May and July even though flows were lower in July. TDS concentrations were generally highest in Bayou de Loutre and Flat Creek. The TDS concentration in Curtis Creek Showed a 4-fold decrease between the May and July sampling. There was an unusual relationship between conductivity and TDS in both May and July data sets for BC-0, TC-1 and CC-1. In most waters, conductivity values are typically much higher than TDS values. At BC-0, TC-1 and CC-1, conductivity values were either similar to or lower than TDS values.

Chloride - The pattern of chloride variation among stations and between sampling events was very similar to the pattern described above for TDS. The sharp decrease in TDS noted between May and July in Curtis Creek was also reflected in a 10-fold decrease in chloride at that station. As with TDS, the ecoregion chloride criterion (19 mg/L) was exceeded in the May sampling at all locations except Turkey Creek and at all stations except Turkey Creek and Curtis Creek in the July sampling.

Sulfate – Sulfate concentrations exceeded the ecoregion criterion (41 mg/L) at both Bayou de Loutre stations and at Flat Creek in both May and July sampling events. Sulfate concentrations were uniformly low at all other locations except in the May sample at the downstream Boggy Creek location (BC-0) where the sulfate concentration exceeded the ecoregion criterion.

Organic Carbon – TOC concentrations were highest at BC-0, BDL-1, and CC-1 (range = 16 – 19 mg/L). TOC was similar (range 5.3 – 8.4 mg/L) at all other stations. Field personnel noted a distinct oil sheen and petroleum odor in many portions of upper Boggy Creek (upstream of Hwy 82). In addition, field personnel noted the presence of organic stain in all of the streams sampled except Flat Creek. Reconnaissance of additional streams in the area during April 2006 indicated that the presence of organic stain was a characteristic feature of streams in the area. Field personnel noted a slight sheen and no petroleum odor in Curtis Creek. Heavy deposits of decaying leaves and other vegetation were noted and might account for much of the TOC observed in Curtis Creek. The majority of the total organic carbon was present in the dissolved form at all stations.

Oil and Grease – Oil and grease concentrations were consistently < 5 mg/L at all stations for both sampling events.

Se – Total Se concentrations exceeded the state WQC (5 mg/L) in May and July at both Bayou de Loutre stations and Flat Creek. Concentrations at other stations, including Boggy Creek were below 0.005 mg/L in May and July. Measured dissolved Se concentrations frequently exceeded total concentrations in both the May and July samples. Se concentrations in the field filtration blanks were <2mg/L. In the July sampling, total Se was slightly higher (8.9 mg/L) at the Bayou de Loutre station upstream of the confluence with Boggy Creek than at the Bayou de Loutre station downstream of the confluence (6.3 mg/L). In May the Se concentrations at the 2 stations were similar (7.5 vs. 8.0 mg/L for the downstream and upstream stations, respectively).

Dissolved oxygen – DO concentrations in Curtis Creek were $\leq$ 0.5 mg/L on both sampling dates. Field personnel checked instrument operation and took several measurements in the Curtis Creek reach to verify the low readings. DO measurements at the remaining stations ranged from 3.1 to 8.1 in May and from 1.5 to 9.9 in July. The lowest DO values in Boggy Creek were observed at the station furthest downstream (BC-0) from the Clean Harbors facility. In general, DO concentrations were lower in July.

pH – pH values ranged from 6.0 to 8.0 across all stations in May. No values were less than 6.0 or greater than 9.0 (the Arkansas statewide water quality criteria for pH) in May. Measured pH values in July tended to be lower at all stations, ranging from 5.9 to 7.5. Measured pH values were below 6.0 at Curtis Creek and at the BC-1-3 station on Boggy Creek in July.

Specific Conductance - Spatial and temporal variation in specific conductance mirrored variation in TDS. Unusual or anomalous relationships between conductivity and TDS in both May and July data sets for BC-0, TC-1, CC-1 and especially FC-1 was described in the above description of TDS variation. The specific conductance reading taken in Flat Creek during reconnaissance on 5/16/06 was 1986 µS while the reading taken on the following morning was 850 µS. These differences were accompanied by marked differences in flow (higher on 5/16 and lower the following morning) as noted by field personnel. Field personnel also noted substantial flow variation in Flat Creek during the time of sample collection. These variations in flow may explain the anomalous relationship between TDS (530 mg/L) and specific conductance (1017 µS) on July 19, 2006 at FC-1. The grab sample was collected at 1530 while the *in situ* measurements were taken at 1345. Field personnel noted a significant change in flow during this time interval with higher flows at the beginning than at the end of the interval. These rapid changes in flow and conductivity, with higher conductivity at apparently higher flows, indicate the presence of an upstream point source.

4.2.3.2 Sediment Chemistry

Se – The analytical detection limit for the May sampling was 2 mg/Kg and 1 mg/Kg for the July sampling. Se concentrations were below detection limits (< 2 and < 1 mg/Kg for the May and July data, respectively) at all stations on both dates.

Oil and Grease – Oil and grease concentrations were highest in all samples collected in Boggy Creek. Concentrations in the Boggy Creek samples ranged from 2200 to 6200 mg/L. The highest value was obtained at BC-2 which is upstream of Outfall 009. Oil and grease analyses were not performed on sediment samples collected during the July sampling.

4.2.3.3 Supplemental Se Analysis Results

Se concentrations exceeded the state water quality criterion (5.0 ug/L) in September through November samples at several stations along Boggy Creek. Se concentrations also exceeded state water quality criterion at both Bayou de Loutre stations during September 2006 (Table 4.7).

Table 4.7 Total Se concentrations measured from September through November 2006.

Date	Selenium (ug/L) per Sampling Station									
	BC-0	**BC-1**	**BC-1-3**	**BC-1-3a**	**BC-2**	**BC-3**	**BC**	**BDL-1**	**BDL-2**	**Outfall 009**
9/6/2006		12	5.6			5				26
9/27/2006	4		5.3	9.3	4.3		<2	13	31	
10/2/2006		11	7.6			6.2				24
10/16/2006		24	13			18				4
10/30/2006		10	17			5.8				34
11/13/2006		4.4	6.9			3.8				13
11/27/2006		9.2	12			7.8				20

Se concentrations were highest at the Outfall 009 location (34 ug/L) and Bayou de Loutre downstream location (31 ug/L). During September Se concentrations were higher at Bayou de Loutre downstream (31 mg/L) than at Bayou de Loutre upstream (13 ug/L) of the Boggy Creek confluence. Data collected October 16, 2006 appears to be in error perhaps due to sample collection errors or flawed analysis. In all other sampling data outfall Se concentrations are higher at Outfall 009 than downstream concentrations. Similarly, in all other data measurements Se concentrations upstream of Outfall 009 (BC-3) are lower than concentrations immediately downstream of Outfall 009. This pattern is reversed in samples collected on October 16, 2006. Three samples collected during rainy weather with higher flows (Michael Karp, Clean Harbors, Inc. personal communication), which should reinforce upstream/downstream differences. Therefore data from this date have been deleted from the analysis.

4.3 Flow Measurements

4.3.1 Flow Measurement Methods

Stream flow was measured at the upstream end of each sampling reach indicated in Figure 4.2. Flows were measured by measuring stream width, depth and current velocity per the United States Geological Survey (USGS) (1982) using a calibrated wading rod and a Marsh-McBirney (Flow Mate Model 2000) flow meter. Flows were not measured at BC-1-3 or BC-2 during the May sampling.

4.3.2 Flow Measurement Results

Flow measurements are provided in Tables 4.5 and 4.6. Wet weather seeps were observed by field personnel in Boggy Creek in the BC-1-1 and BC-1-2 reaches during May sampling. Boggy Creek flow measured during the May sampling of the downstream station (BC-0) probably underestimates the actual flow. Boggy Creek at this location is somewhat braided with at least 1 minor side channel. Flow though the side channel was estimated by estimating the average depth, width and current velocity. Field personnel noted wide fluctuations in Flat Creek flows. For example field personnel noted an approximately 0.5 ft decrease in water level on the morning of May 17, 2006 as compared to the evening of May 16, 2006. This decrease in water level was accompanied by an increase in conductivity from 850 µS at 1630 on May 16 to 1986 µS at 0753 on May 17. Field personnel noted similar fluctuations in water level when Flat Creek was sampled again on July 19, 2006.

Measured flows were substantially lower at the downstream Bayou de Loutre (BDL-1) station than at the upstream station (BDL–2) on both sampling events.

Flows were lower at all locations during the July sampling event. No flow in Boggy Creek was noted upstream of Outfall 009 although water was pooled in the vicinity of the outfall. Given the depth of the water at BC-1, current velocity was too low to obtain flow measurements. There was no apparent flow at BC-0, the Boggy Creek station farthest downstream. No flow was present in Curtis Creek.

4.3.3 Chemical and Flow Measurement Conclusions

4.3.3.1 Water Chemistry and Flow Conclusions

Anomalous flow measurements showing lower flows at downstream locations, especially at the lowermost Boggy Creek station (BC-0) in July and the lowermost Bayou de Loutre station on both sampling dates may be due to flows through other side channels that were not apparent to field crews at the time of sampling. Field personnel noted side channels at BC-0 and USGS quadrangle maps indicate possible braiding of Bayou de Loutre in the vicinity of the downstream station (BDL-1).

1. These flow measurement results indicate that mass balance modeling based on measured flows may be less reliable than modeling based on flows estimated from annual rainfall and watershed area.

Chemical data collected in the May and July indicate elevated levels of chloride and TDS (with respect to ecoregion criteria) in Boggy Creek both above below Outfall 009. Table 4.8 further summarizes TDS, chloride and flow data (From Tables 4.5 and 4.6) in Boggy Creek and Outfall 009. TDS and chloride concentrations at Outfall 009 ranged from 290 to 850 mg/L for TDS and 110 to 390 mg/L for chloride (Table 4.5). Concentrations were highest on May 15, 2006 when Boggy Creek sampling occurred (Table 4.5).

2. Lower TDS and chloride concentrations below Outfall 009 suggest dilution by upstream flow and wet weather seeps although such dilution is not reflected in downstream flow measurements.

Outfall 009 TDS and chloride concentrations during July ranged from 470 to 1700 mg/L for TDS 160 to 740 mg/L for chloride. A similar pattern of reduced TDS and chloride concentrations is apparent at stations downstream of the Outfall during July although this dilution is again not reflected in flow measurements.

Table 4.8. Summary of TDS, chloride and flow data collected at Outfall 009 and Boggy Creek upstream and downstream of Outfall 009 on May 15 and July 17 2006.

Sampling Date		**BC-2**	**Outfall 009**	**BC-1-3**	**BC-1**	**BC-0**
	Distance from Outfall 009	**200 m Upstream**	**NA**	**100 m Downstream**	**1.9 km Downstream**	**8.2 km Downstream**
	Parameter					
5/16/06	Flow (cfs)	No data	0.11	No data	0.8	1.6*
	TDS	240	850	360	300	280
	Chloride	86	390	150	110	62
7/17/06	Flow (cfs)	No flow	0.08	0.1	Flow not measurable	No flow
	TDS	330	750	300	300	180
	Chloride	130	360	120	120	59

*Portion of the flow estimated as described in text.

3. Sampling data indicate that Boggy Creek does not cause the elevated TDS/chloride concentrations observed in Bayou de Loutre on both sampling events. This conclusion is based on the following observations:

   a. TDS/chloride concentrations were higher in Bayou de Loutre than in Boggy Creek, and

   b. TDS/chloride concentrations were higher upstream (BDL-2) than downstream (BDL-1) of the Boggy Creek confluence,

   c. Anomalous flow measurements reported for the upstream and downstream stations in Bayou de Loutre do not affect conclusions regarding relative values of water quality parameters at those stations,

   d. Total organic carbon concentrations in Boggy Creek are likely due to petroleum impacts and/or organic staining that is characteristic of streams in the area,

   e. Oil and grease measurements were all < 5 mg/L indicating that this measurement in water is probably not a good indicator of petroleum contamination in the streams sampled, and

   f. Highly variable flows and conductivity readings in Flat Creek indicate the presence of a point source upstream of the sampling location.

4. Measured dissolved Se concentrations were higher than total concentrations in 7 of 10 samples in the May data set and in 2 of 10 samples in the July data set. These results might indicate contamination during the field filtration process. However, conversations with the analytical laboratory (John Overbey, American Interplex Laboratory, 8/18/06) indicate that these differences are likely due to random analytical errors associated with measuring total and dissolved concentrations that are nearly equal.

5. Therefore the majority of total Se measured in the samples collected in May and July was likely present in the dissolved form.

   This conclusion is based on:

   a. Undetected Se in the filtration field blanks. Laboratory records indicate that the filtration field blanks contained no detectable Se at levels well below reported detection limits of 2 ug/L (May) and 1 ug/L; and

   b. In contrast to metals such as copper or lead, Se is not typically a problematic analyte with respect to contamination from filters, laboratory water or other sources encountered in the field (John Overbey, American Interplex Laboratory, personal communication).

6. Sampling data indicate that inflows from Boggy Creek do not cause the elevated Se concentrations observed in Bayou de Loutre on both sampling events. This conclusion is based on the following observations:
    a. Total Se concentrations were higher in Bayou de Loutre than in Boggy Creek, and
    b. Se concentrations were slightly higher upstream (BDL-2) than downstream (BDL-1) of the Boggy Creek confluence.

7. Low DO levels in Boggy Creek observed during the July sampling event probably reflect the combined effects of high temperatures, shading, low flows and organic content characteristic of Boggy Creek. Extremely low DO concentrations were present in Curtis Creek. Therefore biological data from Curtis Creek might not be useful to evaluate the effects of elevated TDS/chloride on aquatic life using the approach described in Section 2.3 because of the confounding effects of extremely low DO as an additional factor limiting aquatic life.

4.3.3.2 Sediment Chemistry Conclusions

Sediment concentrations of oil and grease in samples collected in May from Boggy Creek reflect the presence of petroleum contamination. Although no petroleum odor or surface sheen was noted on either the May or July sampling, the elevated oil and grease concentrations noted at BC-0 suggest the presence of petroleum hydrocarbons at that downstream site also. The much lower oil and grease concentrations at Turkey Creek, is consistent with the lack of oil production areas in that watershed. Despite the presence of a tank farm upstream there was no evidence in either the chemical data or direct observation of petroleum residues in Flat Creek. Turkey Creek had very silty sediments with significant amounts of leaf litter and detritus. Oil and grease concentrations in Turkey Creek may represent background values for low gradient stained waters of the area. Oil and grease concentrations in Curtis Creek were somewhat elevated in comparison to Turkey Creek and probably reflect the presence of oil production areas in that watershed. The following conclusions can be drawn regarding relative petroleum influences at the various sampling locations.

1. The highest levels of petroleum influences are present at the upper Boggy Creek sampling reaches BC-1, BC-2 and BC-3 (High oil and grease concentrations,

odors and sheens, historical and ongoing oil production activities indicated in the area).

2. Intermediate levels of petroleum influences are present at the lower Boggy Creek sampling reach BC-0 (intermediate oil and grease concentration, no odors or sheens, historical and ongoing oil production activities indicated in the area).
3. Low to moderate levels of petroleum influences are present at Curtis Creek (CC-1) (elevated oil and grease concentration, no odors, some sheens, and historical and ongoing oil production activities indicated in the area).
4. Little or no petroleum influences are present at Turkey Creek (low oil and grease concentration, no odors or sheens, no historical or ongoing oil production activities indicated in the area). The Turkey Creek oil and grease concentration probably represents background concentrations for low gradient streams with stained water and heavy organic detritus deposits.
5. Little or no petroleum influences are present at Flat Creek (low oil and grease concentration, no odors or sheens).
6. Sediment data indicate very low sediment concentrations (<1 mg/Kg) Se at all locations. Sediment Se concentrations from the May sampling were all < 2 mg/Kg. A lower detection limit was requested for the July samples which showed total Se concentrations < 1 mg/Kg at all stations.

4.4 Toxicity Analyses

Toxicity tests were conducted to assess in stream toxicity in Boggy Creek and the toxicity of the effluent from Outfall 009 under “worst case” conditions of TDS.

4.4.1 In Stream Toxicity

4.4.1.1 In stream Toxicity Analyses Methods

During the May sampling event a single grab sample was collected from BC-1-1 and shipped overnight to the laboratory for chronic toxicity testing using *Ceriodaphnia dubia* and *Pimephales promelas* per USEPA (2002). Toxicity tests were conducted using 3 sample concentrations (100%, 75%, 50%) with moderately hard water as diluent.

4.4.1.2 Instream Toxicity Analyses Results

Results of the toxicity tests conducted on sample collected from BC-1 on May 15, 2006 are provided in Table 4.9. Results showed no lethal or sub-lethal effects to *P. promelas*. No lethal effects to *C. dubia* were observed, however sub-lethal effects (reduced reproduction) were observed at all sample concentrations (i.e., 50, 75, 100% sample).

Table 4.9. Results of toxicity test on Boggy Creek sample (BC-1) collected on May 15, 2006.

Toxicity Test Exposure (% Sample)	***P. promelas***		***C. dubia***	
	% Survival	**Average Dry Weight per Fish**	**% Survival**	**Average Neonate Production per Female**
Control	100	0.366	100	33.7
50	97.5	0.358	100	27.1 *
75	90	0.317	90	22.8 *
100	92.5	0.338	100	24.7 *

* = Significantly less than control ($P < 0.05$)

4.4.1.3 Instream Toxicity Analyses Conclusions

The cause of sub-lethal toxicity to *C. dubia* cannot be determined from the toxicity data alone. However, the potential for TDS related toxicity, particularly toxicity due to chloride, can be addressed with the available data. The measured chloride value at BC-1 at the time of the biomonitoring sample collection was 110 mg/L (Table 4.6). The No Observed Effect Concentration (NOEC) for the toxicity test using BC-1 sample was <50%. Therefore the NOEC in terms of chloride concentration was <50% of 110 mg/L or <55 mg/L Cl. This value can be compared with chronic reference toxicant testing using sodium chloride (NaCl) conducted as part of routine quality assurance by the biomonitoring laboratory. Routine reference testing by the laboratory includes calculation of the IC25 (the concentration inhibiting reproduction by 25%), which estimates the reproduction NOEC. The average IC25 for *C. dubia* was 452 mg/L chloride for testing performed monthly during 11/2/05 through 5/2/06. IC25 values for the monthly reference tests bracketing the actual toxicity test period (5/16/23/06) were 378 and 480 mg/L chloride for reference tests beginning on 5/2/06 and 6/6/06, respectively. It is recognized that the toxicity of a particular ion may depend on other coexisting ions in the sample. However, NOEC for chloride concentration in the toxicity test from the Boggy Creek sample is well below IC25 values in laboratory reference testing.

1. Therefore the sublethal toxicity observed in the toxicity test is not attributable to elevated forms of TDS such as chloride.
2. A likely cause of the sub-lethal toxicity observed in the BC-1 sample collected in May is petroleum contamination in the sampled reach. Significant oil petroleum residues were documented in the sediments (Table 4.5) and field crews documented oil sheens and petroleum odors during sampling.

4.4.2 "Worst Case" Effluent Toxicity Analysis

Additional toxicity analysis was conducted to evaluate the toxicity of the Outfall 009 effluent under worst case conditions of TDS. It was determined that treated water collected from the 4th lagoon represents worst case conditions at Outfall 009. It should be noted that this worst case condition requires that the 4th lagoon comprise the entire discharge from Outfall 009. Toxicity testing focused on the water flea (*C. dubia)* because this organism is known to be more sensitive than fathead minnows (*P. promelas*) to TDS related toxicity.

4.4.2.1 "Worst Case" Effluent Toxicity Analysis Methods

On 2/23/06 a single grab sample was collected from the 4th lagoon and shipped overnight to the laboratory for chronic toxicity testing using *C. dubia* per USEPA (2002). Toxicity tests were conducted using 5 sample concentrations (100%, 80%, 60%, 40% and 20%) with moderately hard water as diluent. To aid in data interpretation the sample was also analyzed for total dissolved solids, calcium, magnesium, potassium, chloride and sulfate.

4.4.2.2 "Worst Case" Effluent Toxicity Analysis Results

Results of the toxicity test and chemical analysis are presented in Table 4.10. The sample was not lethally or sub-lethally toxic to *C. dubia.* Analytical results indicate that TDS and chloride concentrations of 1700 and 810 mg/L, respectively, were not toxic to *C. dubia.*

4.4.2.3 "Worst Case" Effluent Toxicity Analysis Conclusions

Results of the toxicity tests and chemical analyses summarized in Table 4.10 indicate that the worst case TDS due to chloride and other ions in Outfall 009 should not be toxic to aquatic life.

Table 4.10. Results of toxicity test and chemical analysis of 4th lagoon sample collected on February 23, 2006.

***C. dubia* Chronic Toxicity Test Results**			**Analytical Results**	
Toxicity Test Exposure (% Sample)	**% Survival**	**Average Neonate Production per Female**	**Parameter**	**Concentration (mg/L unless noted otherwise)**
Control	100	28.6	Total dissolved solids	1700
20	100	33.2	Calcium	65
40	90	32.6	Magnesium	6.3
60	100	34.3	Hardness	150
80	100	31.6	Alkalinity	300
100	80	21.2	pH (S.U.)	8.7
			Conductivity (US)	3200
			Potassium	33
			Sodium	590
			Chloride	810
			Sulfate	63

4.4.3 Evaluation of Toxicity of Clean Harbors Effluent

The “worst-case” toxicity evaluation indicates that TDS values up to 1700 mg/L and chloride values up to 810 mg/L are not lethally or sublethally toxic in standard aquatic toxicity tests in the Clean Harbors effluent matrix. These values can be compared to IC25 values from routine reference tests using NaCl in laboratory culture water conducted by American Interplex Laboratory as part of its routine QA/QC program. The IC25 (concentration producing 25% inhibition of survival and reproduction combined) estimates the reproduction NOEC in chronic tests using *C. dubia* per USEPA (2002). The mean IC25 value for reference testing by American Interplex Laboratory (AI) was 498 mg/L chloride in 6 routine reference tests conducted during July through December 2006. This concentration corresponds to 1,019 mg/L TDS in “moderately hard” laboratory water. This comparison indicates that chloride and TDS concentrations in the non-toxic “worst-case” effluent sample exceed threshold toxic levels as indicated by routine reference testing.

The toxicity of the “worst-case” effluent sample was also evaluated using the predictive model developed by Mount et al (1997). This salinity toxicity relationship (STR) model predicts survival in acute toxicity tests based on the ionic composition of a sample. The STR model predicted 51% survival in acute (48 h) *C. dubia* toxicity tests using the ion concentrations given in Table 4.10 as input. The results of the "worst-case" effluent test indicate that the STR model, in this case, is over-predicting toxicity.

Disagreement between the STR model prediction and the routine reference tests vs. the actual toxicity test suggests that there are matrix effects that ameliorate the toxicity of the "worst-case" effluent sample. While this single "worst-case" test does not indicate a threshold for TDS and chloride in the matrix discharged by Clean Harbors, it does indicate that chloride and TDS concentrations intermediate between the IC25 from routine reference testing and the NOCE from the "worst case" test might be consistently non-toxic to standard aquatic bioassay test organisms exposed to 009 effluent.

Support for this conclusion is found in literature studies of ion toxicity and from routine reference toxicant testing performed by AI. Mount et al (1997) examined interactions of various ions in acutely toxic aqueous solutions. Although their study focused on acute toxicity, their results showed that the toxicity of particular ions depended on the other ions in solution. For example their Table 2 shows that the 48 hour LC50 (*C. dubia*) of NaCl was 1182 mg/L as Cl. In contrast, the LC50 of an equal mixture of NaCl and CaCl2 shows an LC50 of 1928 mg/L Cl (Table 2 in Mount et al, 1997). This result indicates that the presence of calcium ameliorates Chloride ion toxicity. Soucek and Kennedy (2005) reported a similar effect of calcium on sulfate toxicity. This may explain the low level of toxicity observed in the toxicity test conducted on the "worst case" effluent sample described above in which calcium was present at 65 mg/L (measured hardness = 150 mg/L as CaCO3, Table 4.10). An intermediate value between the NaCl and NaCl + $CaCl_2$ toxicity values reported in Mount et al (1997) provides an estimate of the expected chloride toxicity in a solution with less influence from Ca such as the case in the "worst-case" effluent sample. Accordingly, an estimate of the expected acute toxicity of this "calcium influenced" chloride solution is given by (1182 + 1928)/2 = 1555 mg/L Cl.

An estimate of the expected *chronic* toxicity of this "calcium influenced" chloride solution can be obtained using an estimate of the acute to chronic ratio (ACR) for chloride. This ACR can be obtained using routine acute and chronic *C. dubia* reference testing preformed by AI. The average (arithmetic) acute (48 h) LC50 from 6 routine reference tests conducted by AI during December through July 2006 was 1880 mg/L NaCl (1028 mg/L Cl). The average (arithmetic) chronic IC25 (which estimates the reproduction NOEC) from 6 routine reference tests conducted during December through July 2006 was 498 mg/L Cl. Therefore an estimated ACR for NaCl using *C. dubia* is 1028/498 = 2.06. This ACR can be applied to the intermediate acute toxicity value of 1555 mg/L to obtain an estimated IC25 of 1555/2.06 = 755 mg/L Cl. This value estimates the chronic threshold for a "calcium influenced" solution containing chloride primarily as NaCl. This value is in approximate agreement with the results of the toxicity test using the "worst-case" effluent (NOEC = 810 mg/L Cl).

Based on the preceding analysis chloride and TDS concentrations intermediate between thresholds indicated by routine toxicity testing and the test result using the "worst-case" effluent sample can be expected to provide protection for Boggy Creek aquatic life. Therefore:

1. An intermediate (geometric mean) concentration of 631 mg/L chloride ((452 + 810)/2 = 631 mg/L) is proposed as a chloride concentration in the Clean Harbors effluent that will not result in a toxic discharge. This value is well below the estimated chronic threshold (755 mg/L Cl) for a "calcium influenced" solution containing chloride primarily as NaCl.
2. An intermediate (geometric mean) value of TDS concentration of (1,019 + 1,700)/2 = 1360 mg/L is proposed as TDS concentration that will not cause toxicity in the Clean Harbors discharge.
3. A sulfate concentration of a 63 mg/L (Based on Table 4.9) is also proposed as a sulfate concentration that will not cause toxicity in the Clean Harbors effluent.

It should be noted that if the ion concentrations shown in Table 4.10 are reduced by a factor of 631/810 (i.e., if the "worst case" effluent were diluted to a concentration consistent with the intermediate chloride concentration indicated above) and again used as input into the STR model, the STR model, which over-predicts toxicity in this case, predicts a very low acute effect (86.8% *C. dubia* survival). This comparison supports the conservatism of the proposed site-specific WCQ.

4.4.4 Site Specific Mineral Criteria

The toxicity evaluation presented in the preceding section indicates that the following site-specific minerals criteria will not be toxic to aquatic life.

1. TDS – 1360 mg/L
2. Chloride – 631 mg/L
3. Sulfate – 63 mg/L

4.5 Physical Habitat Characteristics

4.5.1 Physical Habitat Characteristics Methods

Physical and habitat characteristics based on the entire length of each sampling reach were documented by visual assessment using the approach outlined in Barbour *et al.* (1999). Field forms (Appendix D) used for this assessment of physical characteristics were taken directly from Barbour *et al.* (1999).

Physical variables assessed included:

1. Canopy Cover,
2. Substrate Type,
3. Sediment Characteristics,
4. Dominant Aquatic Vegetation,
5. Proportion of reach with aquatic vegetation,
6. Pool/Riffle Ratio,
7. Pool Depths,
8. Pool Widths,
9. Dominant Riparian Vegetation, and
10. Watershed Features.

Habitat characterization followed low gradient stream habitat assessment procedures per Barbour *et al.* (1999). Field forms (Appendix D) used for the habitat assessment were taken directly from Barbour *et al.* (1999). In contrast to the evaluation of physical variables, the habitat characterization per Barbour *et al.* (1999) provides a scoring methodology that allows a rough comparison of habitat quality among sites.

Scored habitat variables included:

1. Epifaunal Substrate/Available Cover,
2. Pool Substrate Characterization,
3. Pool Variability,

4. Sediment,
5. Channel Flow Status Deposition,
6. Channel Alteration,
7. Channel Sinuosity,
8. Bank Stability,
9. Vegetative Protection, and
10. Riparian Vegetative Zone Width.

4.5.2 Physical Habitat Characteristics Results

Results of the assessment of physical characteristics of each site are presented in Table 4.11. Results of the scoring assessment of habitat variables are presented in Table 4.12. Habitat comparisons between sampling periods were not an intended objective of this study. Therefore the habitat assessment was conducted only during the May sampling event.

Table 4.11. Physical habitat characteristics summary, May 15-18, 2006.

Physical Characterization	Parameter	BC-0	BC-1-1	BC-1-2	BC-1-3
Watershed features	Predominant land use	Forest	Forest, commercial, industrial	Forest, commercial, industrial	Forest
	Sources of pollution	Oil production	Upstream industry	Upstream industry	Industry
	Watershed erosion	None	None	None	None
Riparian Vegetation		Trees (Cypress, tupelo)	Trees, shrubs, herbaceous	Trees, shrubs, herbaceous	Trees, herbaceous
Instream features	Average Depth (m)	0.2	0.5	0.5	NR
	Average Width (m)	3-4	3-5	3-5	2.5-3
	Average current Velocity (m/sec)	0.1	<0.05	<0.05	-
	Canopy Cover	Shaded	Shaded	Shaded	Shaded
	% Riffle	10	0	0	0
	% Run	20	0	0	0
	% Pool	70	100	100	100
Large woody debris (m2)		10	5	5	5
% of reach with aquatic vegetation		10	0	0	5
Water odors		None	Heavy petroleum	Heavy petroleum	Petroleum
Surface oils		None	Heavy surface oils	Heavy surface oils	Sheen
Turbidity		Stained	Stained, turbid	Stained, turbid	Slightly turbid
Sediment Odors		None	Petroleum	Petroleum	NR
Sediment Oils		None	Heavy	Heavy	NR
Sediment Deposits		None	Oil sludge	Oil sludge	NR
Inorganic substrate (%)	Bedrock	0	0	0	0
	Silt	90	90	90	20
	Clay	10	10	10	80
Organic Substrate	Detritis	70	40	40	20
	Mud-muck	30	30	30	50
	Marl	0	0	0	0

Table 4.11 Continued. Physical habitat characteristics summary, May 15-18, 2006.

Physical Characterization	Parameter	BC-2	BC-3	FC-1	TC-1	CC-1
Watershed features	Predominant land use	Forest, commercial	Forest, industrial	Forest, field, pasture	Forest	Forest
	Sources of pollution	Industry	Industry	Upstream discharger	Gravel road	Oil field
	Watershed erosion	Moderate	NR	Moderate	Moderate	Moderate
Riparian Vegetation		Forest	Trees, shrubs, herbaceous	Trees, shrubs	Trees	Trees, shrubs
Instream features	Average Depth (m)	2	0.3	0.2	0.8	0.5
	Average Width (m)	3-15	3-6	3-5	3-4	3
	Average current Velocity (m/sec)	No visible current	No visible current	0.1	<0.05	No visible current
	Canopy Cover	Partly open	Partly open	Shaded	Shaded	Shaded
	% Riffle	0	0	5	10	0
	% Run	10	0	50	90	0
	% Pool	90	100	45	0	100
Large woody debris (m2)		<1	NR	5	5	5
% of reach with aquatic vegetation		1	2	0	0	0
Water odors		Petroleum	Petroleum	None	None	None
Surface oils		Sheen	Sheen	None	None	None
Turbidity		Stained, turbid	Turbid	Clear	Stained	Stained
Sediment Odors		Petroleum	NR	None	None	None
Sediment Oils		Heavy	NR	None	None	None
Sediment Deposits		Oil sludge	NR	None	None	None
Inorganic substrate (%)	Sand (gritty)	25	0	90	60	0
	Silt (fine, not gritty)	25	30	10	40	100
	Clay (slick)	50	70	0	0	0
Organic Substrate	Detritis	5	0	60	50	90
	Mud-muck	15	100	10	50	10
	Marl	0	0	0	0	0

Table 4.12. Summary of habitat evaluations performed during May 15-18, 2006.

Habitat Parameter	BC-0	BC-0 dup	BC-1-1	BC-1-2	BC-1-3	BC-2	BC-3	FC-1	TC-1	CC-1
1. Epifaunal Substrate/ Available Cover	16	16	16	17	13	12	14	6	11	15
2. Pool Substrate Characterization	13	14	8	8	13	10	13	10	14	11
3. Pool Variability	8	2	13	13	14	16	12	7	15	15
4. Sediment Deposition	18	11	16	8	15	18	14	4	8	18
5. Channel Flow Status	18	12	16	18	16	15	17	8	13	18
6. Channel Alteration	20	19	19	20	12	16	14	20	20	19
7. Channel Sinuosity	18	19	8	6	11	6	12	8	19	13
8. Bank Stability	20	20	20	20	16	18	18	16	20	20
9. Vegetative Protection (score each bank)	20	20	20	20	18	18	20	18	20	20
10. Riparian Vegetative Zone Width (score each bank riparian zone)	20	20	20	20	20	8	20	20	20	20
Total Score	171	153	156	150	148	137	154	117	160	169

Score interpretation: 1-5 Poor; 6-10 marginal; 11-15 sub-optimal; 16-20 optimal.

Physical and habitat assessments indicate habitat characteristics typical of low gradient streams with primarily pool habitats with silty substrates, low current velocities and abundant cover in the form of woody debris. All waters sampled except for Flat Creek showed noticeable organic staining. With the exception of Flat Creek there was relatively uniform habitat quality across all locations with respect to channel morphology, riparian vegetation and substrate characteristics (Table 4.12). The substrate of Flat Creek was comprised of loosely compacted sand that was generally unsuitable for colonization by benthic macroinvertebrates. As a result, woody debris provided most of the colonizable habitat in this stream reach. Although physical habitat characteristics in Curtis Creek were not unlike other locations (except Flat Creek), field personnel observed very low DO (<0.5 mg/L) and extremely heavy deposits of leafy debris. Field personnel also observed and documented (Figure 4.3) substantial surface oil sheen and petroleum deposits on the substrate of upper Boggy Creek reaches. Flow at BC-0 (the lower most location on Boggy Creek) was non-existent in the July sampling. All sites had well forested riparian zones with significant canopy cover. Most habitat scores (Table 4.12) were in the optimal or sub-optimal ranges. There was more industrial land use in the upper reaches of Boggy

Creek. Reduced flows during the July event, as noted above, probably decreased the amount of available habitat during July 2006.

4.5.3 Physical Habitat Characteristics Conclusions

1. There was generally adequate physical habitat for the maintenance and propagation of aquatic life at all locations,
2. The lowest habitat score was observed in Flat Creek where woody debris provided the majority of colonizable substrate,
3. Lower Boggy Creek habitat may be flow-limited, and
4. Impacts due to petroleum contamination were a striking feature of the Boggy Creek reaches upstream of Highway 82 and downstream of the Clean Harbors facility.

4.6 Biological Characteristics

Biological assessment procedures followed rapid bioassessment protocols for fish and invertebrates given in Barbour *et al.* (1999). Representative stream reaches were identified in selected stream reaches as described above.

4.6.1 Benthic Macroinvertebrate Sampling Methods

Prior to sampling each reach, the upper and lower ends of the reach were cordoned off using block nets. Invertebrate sampling was conducted before fish sampling. Invertebrates were sampled using D-frame kick nets with 0.5 mm mesh net.

A total of 12 individual samples were collected from all available habitat including woody debris, emergent vegetation, snags, undercut banks, open substrate, and riffles (if present). The sampling effort was distributed among habitat types in proportion to the availability of habitats as assessed by visual inspection. After removal and washing of large debris the entire contents of the net was washed into wide-mouth glass jars and immediately preserved with 70% ethanol.

Samples were sorted in the laboratory by dispensing the entire sample onto a Caton grid. All organisms were sorted from randomly selected grids until a minimum of 300 ± 20 organisms were collected. Sorted organisms were transferred to 70% ethanol in glass vials. To assure thorough removal of specimens from the sample, the sorted residue was retained and examined by a second biological technician. If the second sorting produced fewer than 10% of the number of organisms found in the initial sorting the sorting of that sample was considered complete. If the second sorting produced more than 10% of the number of organisms found in the initial sorting, the sample was resorted until the 10% goal was reached.

Taxonomic identifications were carried out to the lowest practical taxon according to Merritt and Cummins (1996), Thorp and Covich (2001) and Houston (1980). In general, macroinvertebrates were identified to genus except for bivalue mollusks, gastropods, dipteran larvae, and decapod shrimp which were identified to family. A voucher collection of invertebrate taxa collected at the sites was retained for further reference. All invertebrate taxa were classified into functional feeding groups (Predator, Shredder, Omnivore, Gatherer/collector, Scraper, and filterer/collector) per Barbour *et al.* (1999). Benthic invertebrate data were evaluated by visually examining changes and/or differences in taxa richness and relative abundance of functional feeding groups.

4.6.2 Benthic Macroinvertebrate Sampling Results

Benthic invertebrate taxa and counts for each sampling location are presented in Tables 4.13 and 4.14 for May and July, respectively. Relative abundance of functional feeding groups for each sampling location presented in Figures 4.4 and 4.5 for May and July, respectively. For purposes of summarization, and because of their close proximity to one another BC-0-1 data were combined with BC-0-2 as was BC-1-1 with BC-1-2 and BC-2-1 with BC-2-2.

4.6.2.1 May Benthic Macroinvertebrate Sampling Results

Palaemonid decapods dominated Boggy Creek downstream of Outfall 009 to Highway 82 in the May collection. There were far fewer palaemonid decapods present at the Boggy Creek station upstream of Outfall 009 and none at all other stations. Oligochaetes were relatively numerous at other Boggy Creek locations. Curtis Creek showed the highest number of taxa followed by Turkey Creek, the lowermost station of Boggy Creek and Flat Creek. The lowest numbers of taxa were collected from the upstream Boggy Creek locations (BC-1-2, BC-2-1, BC-2-2, BC-3; Table 4.13). Shredders and/or gatherers were the dominant functional feeding groups in the upstream Boggy Creek locations with few predators or filter feeders present (Figure 4.4). The downstream Boggy Creek location (BC-0) near the mouth of Boggy Creek showed both greater numbers of taxa and relatively more predators and filter feeders (Figure 4.4). The Turkey Creek location showed the greatest variety of functional feeding groups.

Table 4.13. Results of benthic invertebrate collections made during field survey conducted during May 15-18, 2006.

ORDER	FAMILY	GENUS	Location						
			BC-0	**BC-1**	**BC-2**	**BC-3**	**CC-1**	**FC-1**	**TC-1**
Amphipoda	Gammaridae	*Gammarus*	3		4		1		
Bivalva	Unionidea								2
Bivalva	Sphaeriidae		1		2		4		12
Bivalva	Corbiculida							12	1
Coleoptera	Dytiscidae	*Hydroporus*					1		
Coleoptera	Dytiscidae	*Oreodytes*					1		
Coleoptera	Gyrinidae	*Dineutus*	1						
Coleoptera	Hydrophilidden		1						
Coleoptera							1		
Decapoda							1		
Decapoda	Cambaridae		3	1	10	2	1		3
Decapoda	Mineribsachium								4
Decapoda	Palaemonidae	*Macrobrachium*		31	54	2			
Diptera	Ceratopogonidae						1		
Diptera	Chironomidae		3		3	5	2	1	2
Diptera	Culicidae						1		
Diptera	Pelecorhynchidae	*Glutops*				1			
Diptera	Tabanidae				1	1		1	
Diptera	Tipulidae	*Limnophilia*					1		
Diptera	Tipulidae	*Tipula*						4	
Ephemeroptera	Epheinerdae	*Hexogenia*							3
Euhirardea	Glossiphoniidae				1				
Gastropoda	Physidae	*Physella*							1
Gastropoda	Viviparidae	*Viviparus*							12
Gastropoda	Planorbidae				1		1		
Gastropoda					1				
Hemiptera	Corixidae	*Trichocorixa*	1				1		1
Isoptera	Assellidae	*Lisceus*							1
Odonata	Aeshnidae		1						
Odonata	Coenagrioidae	*Argia*			1			1	
Odonata	Gomphidae	*Dromogormphus*	1						
Odonata	Gomphidae	*Gomphis*							3
Odonata	Gomphidae	*Progomphus*						1	
Odonata	Libellulidae	*Sympetrum*					1		
Odonata	Libellylidae	*Simetrum*	1						
Oligochaeta			**2**				5	49	
Trichoptera	Hydropsychidae	*Cheumatopsyche*	1				1	4	1
	Elmidael	*Stenelmis*						3	
	Hirudinea							1	
	Oligochaeta				17	13			
		TOTAL TAXA	12	2	11	6	16	10	13

Table 4.14. Results of benthic invertebrate collections made during field survey conducted during July 17-19, 2006.

ORDER	FAMILY	GENUS	Location							
			BC-0	**BC-1**	**BC-2**	**BC-1-3**	**BC-3**	**CC-1**	**FC-1**	**TC-1**
Amphipoda	Gammaridae	*Gammarus*	4		3					3
Bivalva	Unionidea									
Bivalva	Sphaeriidae					9		1	19	65
Bivalva	Corbiculida	*Corbicula*					1		42	1
Coleoptera	Dytiscidae	*Laccophilus*					1			
Coleoptera	Dytiscidae							1		
Coleoptera	Gyrinidae	*Dineutus*	1							
Coleoptera	Haliplidae	*Peltodytes*			1					
Coleoptera	Elmidae	*Stenelmis*							4	8
Coleoptera	Hydrophilidae	*Berosus*				1				
Decapoda	Cambaridae		8			7	6	2	1	7
Decapoda	Palaemonidae	*Macrobrachium*			56	5	2			
Diptera	Ceratopogonidae	*Bezzia*								1
Diptera	Chironomidae		5		7	10	8	7	3	5
Diptera	Culicidae									
Diptera	Tabanidae							1		3
Diptera	Tabanidae	*Tabanus*					2			
Diptera								1		
Ephemeroptera	Caenidae	*Caenis*								1
Ephemeroptera	Ephemeride	*Hexogenia*								2
Ephemeroptera	Heptageniidae					1				
Gastropoda	Physidae								1	
Gastropoda	Physidae	*Physella*			1			7		1
Gastropoda	Viviparidae	*Viviparus*								20
Gastropoda	Planorbidae	*Planorbella*			2	2				
Gastropoda										
Hemiptera	Corixidae	*Trichocorixa*						4		
Hemiptera	Notonectidae	*Notonecta*						1		
Isoptera	Assellidae	*Lirceus*								1
Megaloptera	Sialidae	*Sialis*						2		7
Odonata	Aeshnidae									
Odonata	Cordulidae	*Epitheca*			1					
Odonata	Gomphidae	*Dromogormphus*								
Odonata	Gomphidae	*Gomphus*	1							2
Odonata	Gomphidae	*Progomphus*							2	
Odonata	Libellulidae	*Plathemis*				1				
Odonata	Libellulidae	*Pachydiplax*						1		
Odonata	Libellulidae						1			
Oligochaeta							1	1	1	1
Trichoptera	Hydropsychidae	*Cheumatopsyche*				1				2
	Oligochaeta									
		TOTAL TAXA	5	0	7	9	8	12	8	17

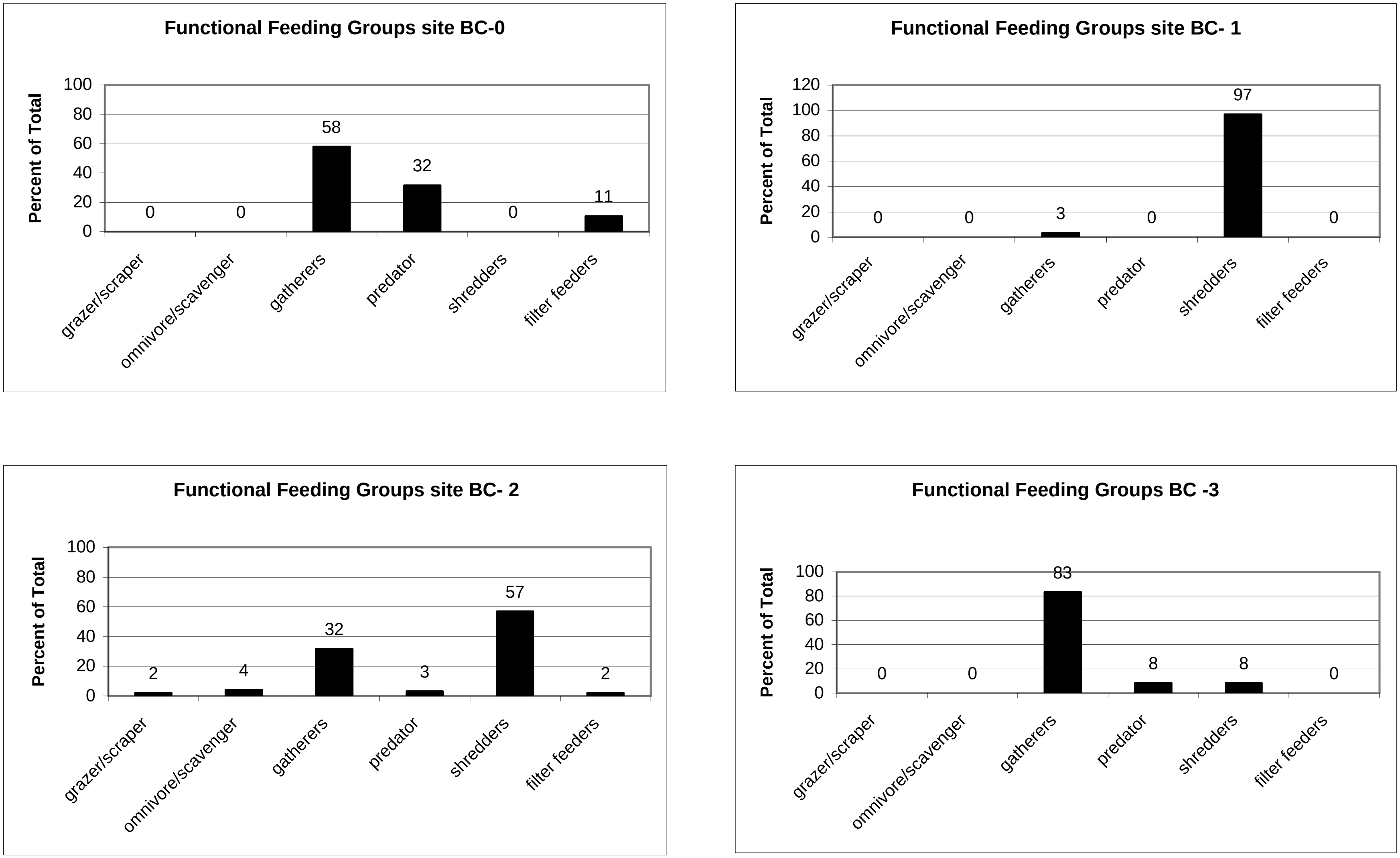
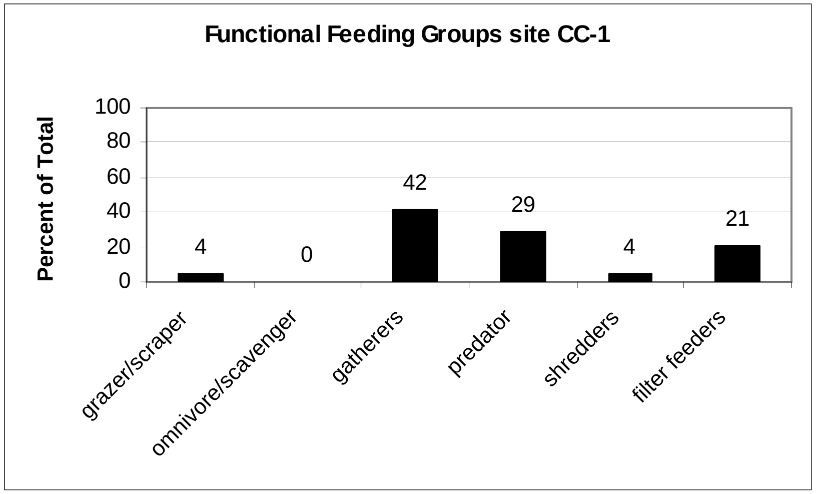
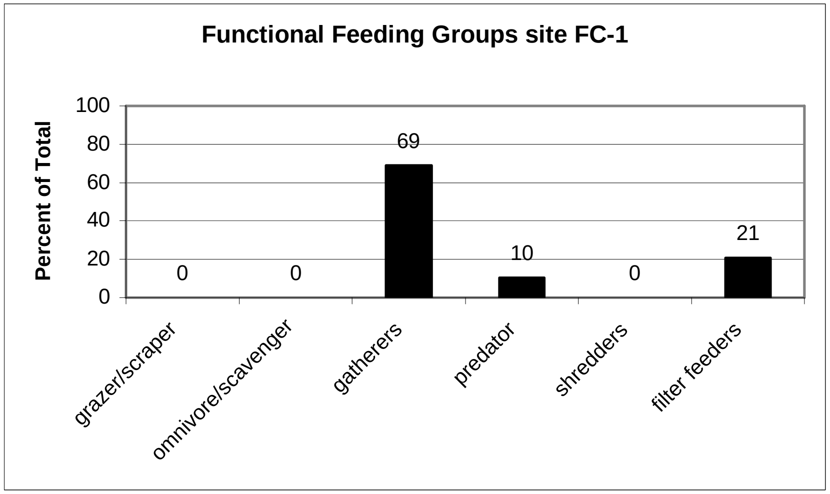


Figure 4.4. Distribution of functional feeding groups in benthic macroinvertebrate communities sampled in May 2006.





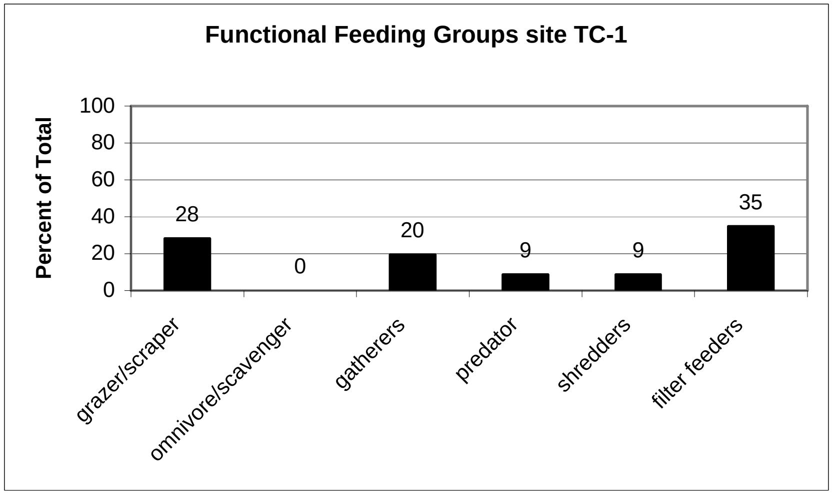


Figure 4.4. Continued.

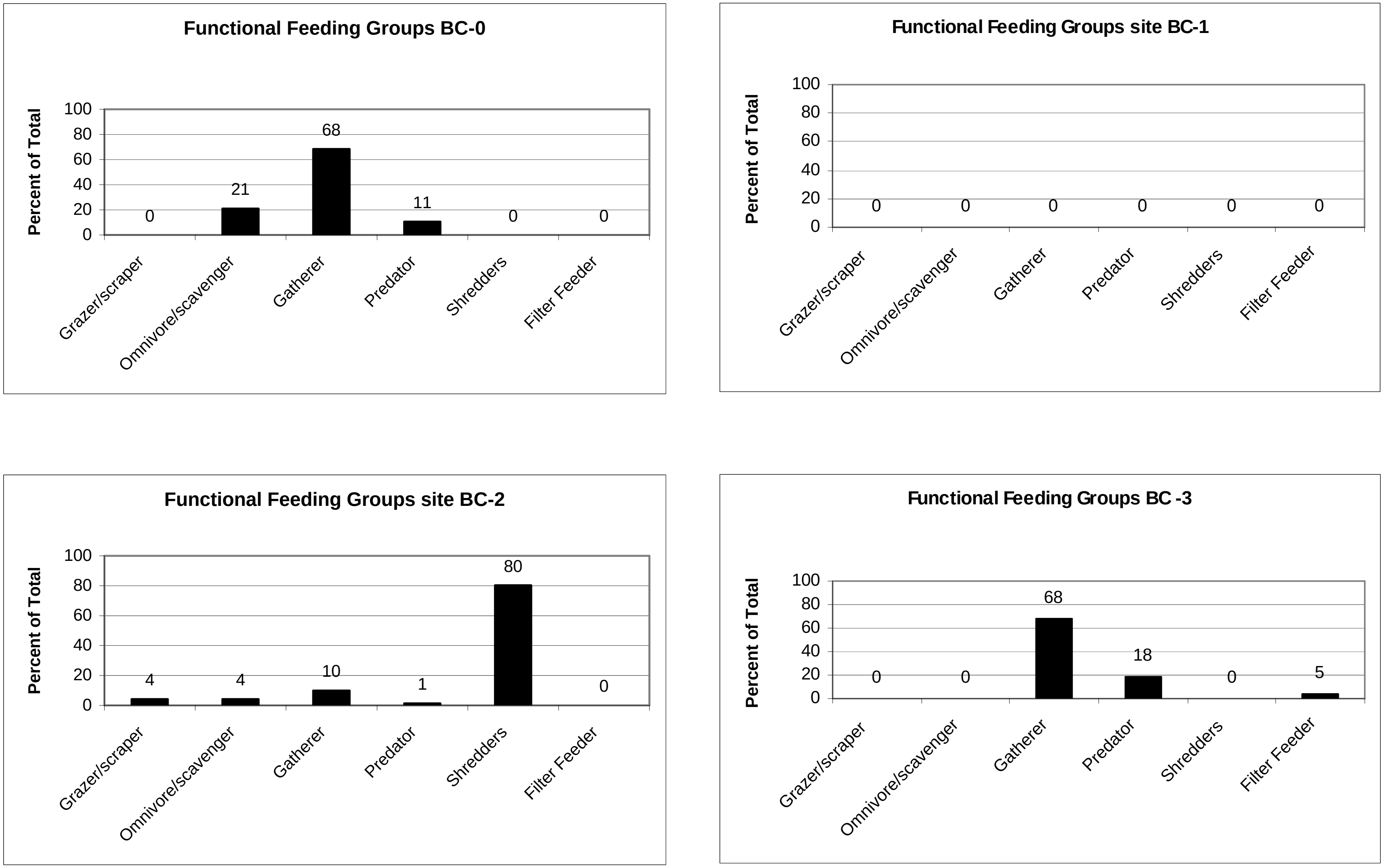
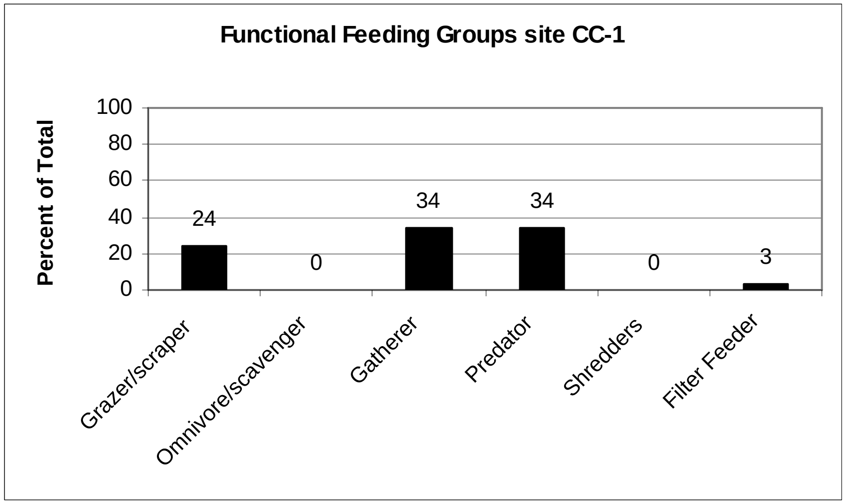
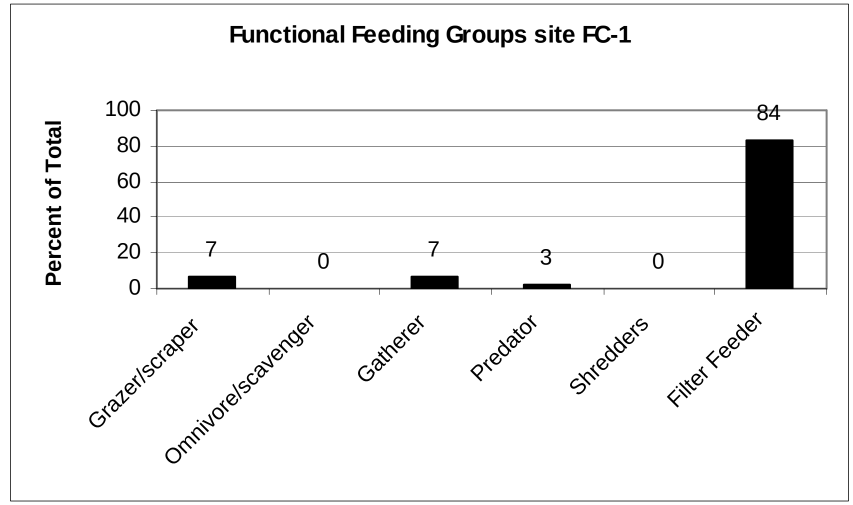


Figure 4.5. Distribution of functional feeding groups in benthic macroinvertebrate communities sampled in July 2006.





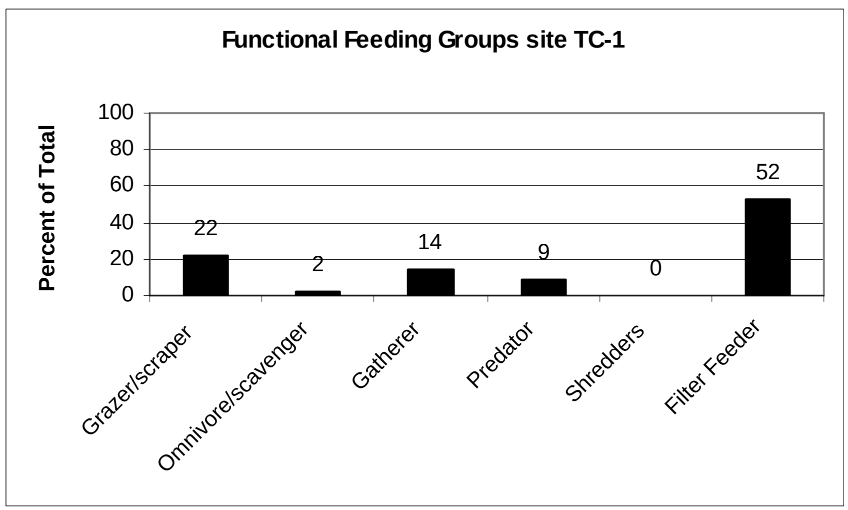


Figure 4.5. Continued.

4.6.2.2 July Benthic Macroinvertebrate Sampling Results

Palaemonid decapods were less dominant at the upstream Boggy Creek locations than in the May sampling but were still numerous at the BC-2 location. As in the May collection, the greatest number of taxa were collected at the Curtis Creek and Turkey Creek locations. The downstream Boggy Creek location (BC-0) showed a reduction in taxa relative to the May collections. Differences in the distribution of functional feeding groups between upstream Boggy Creek locations and other locations was less pronounced than in the May sampling.

4.6.3 Fish Community Sampling Methods

Fish sampling at Boggy Creek, Flat Creek, Turkey Creek and Curtis Creek was conducted using a Smith-Root LR-24 DC current backpack electroshocker. Sampling of each reach was conducted by probing all available habitat beginning at the downstream end of the reach and proceeding upstream. Two sampling passes were performed on each reach. Stunned fish were collected in a plastic bucket and maintained with aeration until processed. Each individual captured was identified in the field to species according to Robison and Buchanan (1984). Individuals that could not be positively identified in the field were killed, preserved in formalin and identified in the laboratory. All individuals of each species were weighed to the nearest 0.1 g and measured (total length) to the nearest mm. All fish were examined in the field for the presence physical deformities (e.g., crooked spines, malformed mouth parts).

Fish community data were evaluated by visually examining differences in species richness and species composition among locations in relation to habitat.

4.6.4 Fish Community Sampling Results

Fish taxa and counts for each sampling location are presented in Tables 4.15 and 4.16 for the May and July collections, respectively. Table 4.16 presents taxa and counts at each station for the 2 collections combined.

Table 4.15. Summary of fish collections obtained during May 15 - 18, 2006. RA% = percent relative abundance.

Species	Location															
	BC-0		BC-1		BC-1-3		BC-2		BC-3		FC-1		CC-1		TC-1	
	RA%	Count	RA%	Count	RA%	Count	RA%	Count	RA%	Count	RA%	Count	RA%	Count	RA%	Count
Aphredoderus sayanus	15.1	14	5.2	17			5.0	3	5.9	2			2.1	1	12.5	3
Centrarchus macropterus											0.7	1				
Elassoma zonatum			0.6	2									2.1	1		
Erimyzon oblongus											1.4	2			4.2	1
Esox americanus	5.4	5	1.8	6					2.9	1	0.7	1	2.1	1	4.2	1
Etheostoma chlorosomum															12.5	3
Etheostoma collettei															8.3	2
Etheostoma proeliare	2.2	2	1.2	4	0.3	2	1.7	1					2.1	1	12.5	3
Fundulus olivaceus													20.8	10	8.3	2
Gambusia affinis	21.5	20	73.2	240	94.3	626	30.0	18	44.1	15	5.7	8	27.1	13	8.3	2
Ictalurus melas													2.1	1		
Ictalurus natalis							1.7	1			0.7	1				
Lepomis cyanellus					0.3	2	5.0	3	5.9	2	5.7	8	2.1	1		
Lepomis gulosus	4.3	4	1.8	6	0.5	3	18.3	11	23.5	8			2.1	1		
Lepomis macrochirus					0.2	1	3.3	2			1.4	2	10.4	5		
Lepomis marginatus									5.9	2						
Lepomis megalotis	19.4	18	5.5	18	1.2	8	21.7	13	8.8	3	81.6	115	12.5	6	8.3	2
Lepomis punctatus	25.8	24	7.6	25	0.3	2	5.0	3	2.9	1						
Lepomis spp.			0.6	2	0.2	1					0.7	1			4.2	1
Micropterus salmoides					0.3	2	1.7	1								
Notemigonus crysoleucas			0.3	1	0.5	3	5.0	3					12.5	6		
Notropis emiliae	1.1	1	0.6	2												
Lythrurus umbratilis	4.3	4	1.2	4	2.1	14					0.7	1	2.1	1	16.7	4
Noturus gyrinus	1.1	1	0.3	1												
Pomoxis annularis							1.7	1								
Semotilus atromaculatus											0.7	1				
Total Taxa		10		13		11		12		8		11		13		11

Bold underlined and underlined species names indicate typical Gulf Coastal ecoregion indicator and key species, respectively (APCEC 2005)

Table 4.16 Summary of fish collections obtained July 2006

Species	Location															
	BC-0		BC-1		BC-1-3		BC-2		BC-3		FC-1		CC-1		TC-1	
	RA %	Count	RA %	Count	RA %	Count	RA %	Count	RA %	Count	RA %	Count	RA %	Count	RA %	Count
Aphredoderus sayanus	3.6	1	2.7	3											15.4	2
Centrarchus macropterus																
Elassoma zonatum									7.7	1						
Erimyzon oblongus					2.0	2					2.7	2				
Erimyzon succetta					0.2	1	7.1	1								
Esox americanus	3.6	1	0.9	1												
Etheostoma chlorosomum																
Etheostoma collettei																
Etheostoma proeliare	3.6	1	0.9	1	1.9	9										
Fundulus olivaceus															15.4	2
Gambusia affinis	89.3	25	81.1	90	86.8	402	35.7	5	69.2	9	58.9	43	33.3	1	46.2	6
Ictalurus melas			0.9	1												
Ictalurus natalis			0.9	1	0.2	1					8.2	6			15.4	2
Lepomis cyanellus					0.6	3	14.3	2			1.4	1	33.3	1		
Lepomis gulosus			5.4	6	1.7	8	7.1	1	23.1	3			33.3	1	7.7	1
Lepomis macrochirus																
Lepomis marginatus																
Lepomis megalotis			4.5	5	2.8	13					15.1	11				
Lepomis punctatus			2.7	3	2.2	10	28.6	4			1.4	1				
Lepomis spp.																
Micropterus salmoides																
Notemigonus crysoleucas					1.1	5										
Notropis emiliae					0.2	1										
Lythrurus umbratilis					0.6	3					2.7	2				
Notropis spp.											1.4	1				
Pomoxis annularis							7.1	1								
Semotilus atromaculatus											8.2	6				
Total Taxa		4		9		12		6		3		8		3		5

Bold underlined and underlined species names indicate typical Gulf Coastal ecoregion indicator and key species, respectively (APCEC 2005)

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Table 4.17 Summary of fish obtained May 15-18 and July 17-19, 2006.

Species	Location															
	BC-0		**BC-1**		**BC-1-3**		**BC-2**		**BC-3**		**FC-1**		**CC-1**		**TC-1**	
	RA %	**Count**	**RA %**	**Count**	**RA %**	**Count**	**RA %**	**Count**	**RA %**	**Count**	**RA %**	**Count**	**RA %**	**Count**	**RA %**	**Count**
Aphredoderus sayanus	12.4	15	4.6	20			4.1	3	4.3	2			2.0	1	13.5	5
Centrarchus macropterus											0.5	1				
Elassoma zonatum			0.5	2					2.1	1			2.0	1		
Erimyzon oblongus					0.2	2					1.9	4			2.7	1
Erimyzon succetta					0.1	1	1.4	1								
Esox americanus	5.0	6	1.6	7					2.1	1	0.5	1	2.0	1	2.7	1
Etheostoma chlorosomum															8.1	3
Etheostoma collettei															5.4	2
Etheostoma proeliare	2.5	3	1.1	5	1.0	11	1.4	1					2.0	1	8.1	3
Fundulus olivaceus													19.6	10	10.8	4
Gambusia affinis	37.2	45	75.2	330	91.6	1028	31.1	23	51.1	24	23.8	51	27.5	14	21.6	8
Ictalurus melas			0.2	1									2.0	1		
Ictalurus natalis			0.2	1	0.1	1	1.4	1			3.3	7			5.4	2
Lepomis cyanellus					0.4	5	6.8	5	4.3	2	4.2	9	3.9	2		
Lepomis gulosus	3.3	4	2.7	12	1.0	11	16.2	12	23.4	11			3.9	2	2.7	1
Lepomis macrochirus					0.1	1	2.7	2			0.9	2	9.8	5		
Lepomis marginatus									4.3	2						
Lepomis megalotis	14.9	18	5.2	23	1.9	21	17.6	13	6.4	3	58.9	126	11.8	6	5.4	2
Lepomis punctatus	19.8	24	6.4	28	1.1	12	9.5	7	2.1	1	0.5	1				
Lepomis spp.			0.5	2	0.1	1					0.5	1			2.7	1
Micropterus salmoides					0.2	2	1.4	1								
Notemigonus crysoleucas			0.2	1	0.7	8	4.1	3					11.8	6		
Notropis emiliae	0.8	1	0.5	2	0.1	1										
Lythrurus umbratilis	3.3	4	0.9	4	1.5	17					1.4	3	2.0	1	10.8	4
Notropis spp.											0.5	1				
Noturus gyrinus	0.8	1	0.2	1												
Pomoxis annularis							2.7	2								
Semotilus atromaculatus											3.3	7				
TOTAL TAXA		10		14		14		13		9		11		13		12

Bold underlined and underlined species names indicate typical Gulf Coastal ecoregion indicator and key species, respectively (APCEC 2005)

Table 4.18. Typical Gulf Coastal Ecoregion key and indicator species.

Typical Gulf Coastal Plain Ecoregion Key and Indicator Fish Species			
Key Species		Indicator Species	
Redfin shiner	*Lythrurus Umbratilus*	Pirate perch	*Aphredoderus sayanus*
Spotted sucker	*Minytrema melanops*	Flier	*Centrarchus macropterus*
Yellow bullhead	*Ictalurus Melas*	Spotted sunfish	*Lepomis Punctatus*
Warmouth	*Lepomis Gulosus*	Dusky darter	*Percina Sciera*
Slough darter	*Etheostoma Gracile*	Creek chubsucker	*Semotilus atromaculatus*
Grass pickerel	*Esox Americanus*	Banded pygmy sunfish	*Elassoma zonatum*
Ecoregion Key and Indicator Fish Species Collected in Boggy Creek			
Key Species		Indicator Species	
Warmouth	*Lepomis Gulosus*	Pirate perch	*Aphredoderus sayanus*
Grass pickerel	*Esox Americanus*	Spotted sunfish	*Lepomis Punctatus*
Redfin shiner	*Lythrurus Umbratilus*		
Ecoregion Key and Indicator Fish Species Collected in Curtis Creek, Flat creek and Turkey Creek			
Key Species		Indicator Species	
Warmouth	*Lepomis Gulosus*	Pirate perch	*Aphredoderus sayanus*
Grass pickerel	*Esox Americanus*	Flier	*Centrarchus macropterus*
Redfin shiner	*Lythrurus Umbratilus*	Spotted sunfish	*Lepomis Punctatus*
Yellow bullhead	*Ictalurus Melas*	Creek chubsucker	*Semotilus atromaculatus*
		Banded pygmy sunfish	*Elassoma zonatum*

A total 18 taxa were collected from Boggy Creek in May while 17 taxa were collected in July. *Gambusia affinis* were abundant at nearly all locations. Next in abundance were sunfish (*Centrarchidae*). If *G. affinis* is eliminated from the analysis sunfishes, minnows (*Cyprinidae*) and darters (*Esocidae*) comprised 12.7, 1.1 and 2.3 percent, respectively of the fish community in Boggy Creek. These groups comprised on the average 35.3, 9.6 and 7.9 percent, respectively of the fish communities in Curtis Creek, Flat Creek and Turkey Creek as a group. Four of the 6 sunfish species present in the May collection in Boggy Creek were also present in the July collection. The 4 sunfish species present in July included *Lepomis cyanellus, L. gulosus, L. megalotis* and *L. punctatus* which were the most common sunfish encountered. The remaining 2 sunfish species, *L. macrochirus* and *L. marginatus* comprised only 0.2% of the total sunfish present. Fewer numbers of individuals were captured during the July collection. 73% of all sunfish individuals were captured during the May collection.

Although the number of sunfish taxa in Boggy Creek was similar to other locations, the number of individuals did not appear to be consistent with the amount of habitat that appeared suitable for sunfish. Field personnel noted that the extensive pool-like habitat containing abundant overhanging vegetation and woody structure in Boggy Creek did not contain the numbers of sunfish that experience suggested should occur.

Overall taxa richness was similar across locations. Fish species not collected in Boggy Creek but collected at other locations included the darters *Etheostoma chlorosonum* and *E. collettei* and the creek chub *Semotilus atromaculatus.*

Key and indicator Gulf Coastal Ecoregion species collected during May and July 2006 are indicated in Tables 4.15, 4.16 and 4.17 and summarized in Table 4.18. Five of the 12 key and indicator ecoregion species were collected in Boggy Creek and 9 of the 12 species were collected in Curtis Creek, Flat Creek and Turkey Creek.

APCEC (2005) Describes the Typical Gulf Coastal Ecoregion fishery as "Streams supporting diverse communities of indigenous or adapted species of fish and other forms of aquatic life. The fish community is characterized by a limited proportion of sensitive species; sunfishes are distinctly dominant followed by darters and minnows." The fish community in Boggy Creek was distinctly dominated by sunfish, but darters were uncommon, especially in the upper reaches. The presences of darters at the lower sampling location suggests recovery of Boggy Creek such that the lower reaches support a Typical Gulf Coastal Ecorgion within the constraints of habitat limitations due to low flow.

4.6.5 Fish Tissue Sampling Methods

Selected fish captured during the May fish community sampling (above) were retained for whole-body Se analysis. Fish collected on May 16 and 17, 2006 using hook and line from the Bayou de Loutre stations (BDL-1 and BDL-2) were also included in the collections. Additional results of analyses of fish captured at BC-3-1 on April 7, 2005 using hook and line are also included herein. After field processing, all sunfish (*Cetrarchidae*), large predators (e.g., *Grass pickerel*) and other larger fish (e.g., catfish) were placed on ice in labeled plastic bags and retained for analysis of whole body total Se concentration. At the Bayou de Loutre stations

(BDL1 and BDL2) fish were captured using hook and line and placed on ice in labeled plastic bags immediately upon capture. Fish were frozen upon arrival to FTN associates 1 to 3 days after collection. As part of processing for submittal to AI, all fish were again examined for lesions and physical deformities, weighed to the nearest 0.1 gram and measured (total length) to the nearest mm. Scale samples were collected from below the lateral line at the posterior edge of the pectoral fin when laid flat against the fish's body. Fish samples were submitted to AI as individual fish for analysis of whole body total Se using EPA methods 3051 and 6010B. All fish, excluding minnows and darters, collected from Boggy Creek, Bayou de Loutre, Curtis Creek and Turkey Creek were submitted for whole body Se analysis. A subsample of fish from Flat Creek representing the range of sizes captured was retained and submitted for analysis.

4.6.5.1 Supplemental Biological Sampling

During September 27 through 29, 2006 FTN performed supplemental sampling of fish communities per EPA guidance. Fish were collected specifically for Se testing; therefore rapid bioassessments protocols were not strictly adhered to at all sampling locations.

Fish sampling at Boggy Creek and Bayou de Loutre consisted of several sampling methods. Fish at stations BC-0, BC-1-3, and BC-3 were collected using a Smith-Root LR-24 DC current backpack electroshocker. Sampling methods at these stations were similar to methods outlined in Section 4.6.3. However, because fish were collected specifically for Se testing, only fish such as catfish and sunfish were collected and processed. Smaller fish such as darters and minnows were not collected. Fish collected at remaining stations, i.e., BC-2 (Boggy Creek), BDL-1, and BDL-2 (Bayou de Loutre), were collected using a combination of hook and line angling, trotline, and gill net. In addition, fish were also collected at BDL-1 using an electroshocker along the banks. All fish collected in the field were identified and then immediately wrapped in plastic bags and placed on ice.

Fish captured during the September fish sampling event were retained for whole body Se analysis and processed per the method outlined in Section 4.6.5. Upon completion of the processing fish were submitted to AI as individual fish for analysis of whole body Se using EPA methods 3051 and 6010B.

4.6.6 Fish Tissue Sampling Results

Results of fish tissue analyses from the May survey are provided Table 4.19 and results of supplemental sampling are provided in Table 4.20. Table 4.21 includes results of analyses of fish captured at BC-3-1 on April 7, 2005 using hook and line as well as during supplemental sampling. Se measurements were obtained from a total of 94 fish from Boggy Creek and 63 fish from other locations. Collections from Boggy Creek included 8 centrarchid species (*Lepomis megalotis, L macrochirus, L. gulosus, L. punctatus, L. cyanellus, L. marginatus, Pomoxis nigromaculatus, and Micropterus salmoides*) and included a range of sizes. The collection did not include young-of-the–year (YOY) fish because YOY fish at the time of sampling would not have been vulnerable to the sampling technique due to their very small size. Examination of scales of selected specimens indicated that a distinct annulus does not form, precluding aging of the individual fish using scales.

Table 4.19. Results of whole body Se analysis on fish captured in Boggy Creek and Bayou de Loutre during May 15 - 18, 2006.

Station	Species	Length (mm)	Weight (g)	Se Concentration (mg/Kg)
BC 0-1	*Esox americanus*	165	30	<2
	Lepomis megalotis	85	11	<2
		92	17	<2
		93	14	<2
	Lepomis punctatus	96	25	<2
		112	37	<2
BC 1-1	*Lepomis gulosus*	50	2	<2
		140	61	<2
	L. punctatus	133	58	<2
	Lepomis spp.	45	2	<2
BC 1-2	*L. gulosus*	153	81	<2
	Lepomis macrochirus	87	14	<2
	L. megalotis	123	43	<2
BC 1-3	*Lepomis cyanellus*	135	42	<2
	L. gulosus	107	24	<2
		132	58	<2
		145	59	<2
	L. macrochirus	103	18	<2
	L. megalotis	76	8	<2
		85	12	<2
		90	16	<2
		92	18	<2
		112	29	<2
	Micropterus salmoides	185	89	<2
		204	126	<2
	Pomoxis nigricans	200	120	1.23 *
	L. machrochirus	139	44	1.00 *
		176	128	3.38 *
	Lepomis marginatus	91	18	3.31 *
		119	41	1.16 *
	L. megalotis	113	35	1.17 *
		122	45	1.13 *
	L. punctatus	103	27	1.73 *
		117	42	1.74 *
	L. gulosus	146	89	0.871 *

*Asterisk indicates fish collected on April 7, 2005.

Table 4.19 Continued. Results of whole body Se analysis on fish captured in Boggy Creek and Bayou de Loutre during May 15 - 18, 2006

Station	Species	Length (mm)	Weight (g)	Se Concentration (mg/Kg)
BC-0	*Aphredoderus saynaus*	76	6	<2
	Esox americanus	86	4	<2
		107	8	<2
		123	13	<2
	L. gulosus	99	19	<2
		110	24	<2
	L. megalotis	53	3	<2
		66	6	<2
		66	5	<2
		68	6	<2
		108	22	<2
	L. punctatus	53	3	<2
		55	3	<2
		63	4	<2
		65	5	<2
		71	7	<2
		79	9	<2
		83	11	<2
		84	11	<2
		96	19	<2
		115	33	<2
	Lepomis spp.	55	3	<2
BC-2	*Ictalurus natalis*	165	46	<2
	L. cyanellus	40	1	<2
		48	2	<2
		94	14	<2
	L. gulosus	93	14	<2
		134	46	<2
		140	57	<2
	L. macrochirus	76	9	<2
	L. megalotis	47	1	<2
		50	3	<2
		51	2	<2
		69	7	<2
		77	9	<2
		86	13	<2
		113	28	<2
	L. punctatus	110	28	<2
		117	34	<2
	M. salmoides	192	97	<2

Table 4.19 Continued. Results of whole body Se analysis on fish captured in Boggy Creek and Bayou de Loutre during May 15 - 18, 2006

Station	Species	Length (mm)	Weight (g)	Se Concentration (mg/Kg)
BC-2	*P. annularis*	159	34	<2
BC-3	*L. cyanellus*	76	7	<2
		134	46	<2
	L. gulosus	44	1	<2
		67	5	<2
		82	9	<2
		91	13	<2
		95	15	<2
		109	22	<2
		109	22	<2
	L. megalotis	49	2	<2
		50	2	<2
		51	2	<2
		103	18	<2
	L. punctatus	51	3	<2
		134	52	<2
BDL-1	*L. macrochirus*	111	23	<2
	L. megalotis	93	18	<2
		100	25	<2
		115	31	<2
		144	68	<2
	L. punctatus	81	11	<2
		84	12	<2
		85	13	<2
		96	18	<2
BDL-2	*L. cyanellus*	103	22	<2
		117	29	<2
		132	49	<2
	L. megalotis	114	29	<2
		120	40	<2
		135	54	<2
		137	65	<2
	L. punctatus	95	21	<2
		100	25	<2
		106	33	<2
		110	36	<2
		116	44	<2
		119	48	<2
		120	45	<2

Table 4.19 Continued. Results of whole body Se analysis on fish captured in Boggy Creek and Bayou de Loutre during May 15 - 18, 2006

Station	Species	Length (mm)	Weight (g)	Se Concentration (mg/Kg)
CC-1	*I. melas*	185	98	<2
	L. gulosus	59	4	<2
	Lepomis macrochirus	100	15	<2
		112	28	<2
		134	46	<2
		163	96	<2
	Lepomis megalotis	49	2	<2
		56	4	<2
		63	5	<2
		64	5	<2
		65	6	<2
		70	7	<2
FC-1	*Ictalurus natalis*	189	87	<2
	Lepomis cyanellus	64	3	<2
		81	9	<2
		81	8	<2
		99	15	<2
		106	25	<2
		120	31	<2
		156	75	<2
	Lepomis macrochirus	128	40	<2
	Lepomis megalotis	62	5	<2
		67	6	<2
		70	6	<2
		72	6	<2
		75	7	<2
		78	8	<2
		80	8	<2
		83	11	<2
		85	11	<2
		86	10	<2
		132	53	<2
		134	48	<2
		136	59	<2
		137	45	<2
TC-1	*Esox americanus*	191	42	<2
	Lepomis megalotis	90	16	<2
		107	24	<2
	Lepomis spp.	43	1	<2

Table 4.20 Whole body Se residues (dry weight) in fish collected from Boggy Creek and Bayou de Loutre during supplemental sampling 9/27/06 - 9/29/06.

Location	Species	Length (mm)	Weight (g)	Selenium (mg/Kg)
BC1 BC-1-1 BC1-2	*Aphredoderus sayanus*	41	2	<2
		50	3	<2
		52	3	<2
		51	3	<2
		53	3	<2
		54	3	<2
		51	3	<2
		58	3	<2
		63	5	<2
		64	4	<2
		66	5	<2
		80	8	<2
	Ictalurus natalis	136	31	<2
	L. gulosus	37	2	<2
		63	5	<2
		107	26	<2
		114	29	<2
		119	32	<2
		121	35	<2
		125	38	<2
		145	63	<2
		51	3	<2
		55	4	<2
		71	7	<2
		91	15	<2
	L. megalotis	65	6	<2
		66	7	<2
		71	7	<2
		78	9	<2
		84	12	<2
		60	5	<2
		60	4	<2
		66	6	<2
		66	6	<2
		100	19	<2
	L. punctatus	89	18	<2
		105	23	<2
		104	24	<2
		130	55	<2
		58	4	<2
		83	12	<2
		95	19	<2
		105	21	<2
		105	26	<2

Table 4.20 Continued. Whole body Se residues (dry weight) in fish collected from Boggy Creek and Bayou de Loutre during supplemental sampling 9/27/06 - 9/29/06.

Location	Species	Length (mm)	Weight (g)	Selenium (mg/Kg)
BC-0	*A. sayanus*	74	6	<2
	Esox americanus	105	8	<2
	I. natalis	111	14	<2
		137	24	<2
		142	27	<2
		149	28	<2
	L. megalotis	64	5	<2
		68	6	<2
		58	12	<2
		103	16	<2
	L. punctatus	58	4	<2
		65	5	<2
		80	10	<2
		79	10	<2
		82	10	<2
		112	22	<2
BDL-0	*Amia calva*	520	1361	<2
	I. natalis	119	19	<2
		145	41	<2
	L. megalotis	135	50	<2
		100	20	<2
	L. punctatus	110	35	<2
BDL-1	*A calva*	590	2112	<2
		530	1389	<2
	A. sayanus	42	1	<2
		43	1	<2
	E. americanus	148	19	<2
	L. punctatus	33	<1	<2
		43	1	<2
		51	3	<2
		56	3	<2
		64	5	<2
	Lepomis spp.	27	<1	<2

4.6.7 Biological Characteristics Conclusions

4.6.7.1 Benthic Invertebrates

Benthic invertebrate data collected in May and July indicate habitats in upper Boggy Creek that are, in general, dominated by gatherers (primarily Chironomidae, cambarid decapods and gammarid amphipods) and decapod shredders (primarily palaemonid shrimp). Table 4.21 compares benthic community characteristic between the habitats sampled in this study and the least disturbed habitats reported in ADPCE (1987). The benthic communities of the aquatic environments in Boggy Creek contrast sharply with the least disturbed streams identified in ADPCE (1987) in having far lower taxa richness as well as a higher proportion of shedders and a lower proportion of predators. Lower Boggy Creek as well as the Curtis Creek, Flat Creek and Turkey Creek locations more closely resemble the least disturbed benthic communities with respect to the distribution of functional groups. All locations in the present study had much lower taxa richness than the least disturbed streams in ADPCE (1987).

1. The benthic macroinvertebrate communities in upper Boggy Creek have low taxonomic richness dominated by 1 or 2 functional groups with low predator abundance.
2. The relatively high taxa richness in Curtis Creek is unexpected given the extremely low DO concentrations in the sampling reach.

Table 4.21 Comparison of benthic communities in the aquatic habitats of the present study with least disturbed streams reported in ADPCE (1987).

Benthic Community Parameter	Upper Boggy Creek (Locations BC-1, BC-2, BC-1-3, BC-3)	Lower Boggy Creek (BC-0)	Curtis Creek, Turkey Creek, Flat Creek	Least Disturbed Gulf Coastal Plain (Average Values form ADPCE, 1987)
Number of Taxa	0-11	5-12	8-17	59
% Gatherers *	3-83	58-68	7-69	51
% Predators	0-8	11-32	3-34	40
% Shredders	8-97	0	0-9	2
% Scrapers	0-2	0	7-24	4

*Identified as "collectors" in ADPCE (1987)

Low taxa richness in upper Boggy Creek might be due to either elevated TDS/chlorides or petroleum contamination or to a combination of both. A comparison with Flat Creek biological and chemical data offers a potential approach to distinguish between petroleum and TDS/chloride effects because Flat Creek has elevated TDS/chloride and no detectable petroleum contamination. However, as noted above, Flat Creek also has poor habitat for benthic invertebrate colonization and the lowest habitat score of all stream reaches sampled (Table 4.12). Although comparisons with Flat Creek are hampered by this confounding factor, the data provide some insights regarding the relative roles of TDS and petroleum contamination in limiting aquatic life in Boggy Creek.

Benthic macroinvertebrate abundance was lowest at the BC-1 reaches (BC-1-1 and BC-1-2) where significant petroleum contamination was noted by field personnel and documented by sediment chemistry results (Table 4.5). TDS and chloride data presented in Tables 4.5 and 4.6 indicate that TDS and chloride concentrations are substantially higher in Flat Creek than in Boggy Creek. Higher taxa richness in Flat Creek indicates that the higher TDS/chloride levels found in Flat Creek support a greater number of taxa than is present in the BC-1 reaches. If TDS/chloride limited the benthic macroinvertebrate community in Boggy Creek, then Flat Creek, with its substantially higher TDS/chloride concentrations, should have a benthic macroinvertebrate community comparable to that found in the BC-1 reaches.

1. The benthic macroinvertebrate community in the BC-1 reaches is more likely limited by petroleum contamination than TDS/chloride.
2. This conclusion should be valid for the other upper Boggy Creek locations as well although the confounding effect of poor habitat in Flat Creek precludes comparisons in these locations.
3. Although there is an intermediate level of petroleum contamination at BC-0, the May benthic data showing taxa richness comparable to Turkey Creek (Tables 4.13 and 4.14) indicate that some degree of recovery has occurred in lower Boggy Creek.
4. Lower taxa richness during the July collection at BC-0 (Table 4.14) is likely due to the extremely low flows present at the time of the July sampling (Table 4.6).

4.6.7.2 Fish Communities

Although the total number of taxa collected was similar, the number of individuals from the July collection was substantially less than in the May collection (Table 4.15 and 4.16). This difference is likely due to fish movement out shallow areas and into deeper habitats that were less accessible to sampling crews. Aside from *G. affinis,* the dominant group of fish in Boggy creek was sunfish. Pflieger (1975) states "Individuals of most species (of *Centrarchids*) show a definite attachment to a particular pool or reach of shoreline to which they will return after being displaced….Often the same fish…may spend its entire life within a rather restricted area."

1. Differences between May and July collections in the numbers of sunfish captured are likely due to localized movements of resident populations into habitats where they are less vulnerable to sampling efforts.
2. Key and Indicator species in Curtis, Flat and Turkey Creeks represent a subset of the Key and Indicator species given in ADPCE (1987). This result is expected based on the size of the creeks in this study as compared to the size of the creeks sampled in ADPCE (1987).
3. The lower number of Key and Indicator species captured in Boggy Creek is likely due also to its smaller size plus impairments due to petroleum contamination (see below).
4. Existing water quality in the upper reaches Boggy Creek partially supports a Typical Gulf Coastal Ecoregion fishery.

As with the benthic macroinvertebrate community, elevated TDS and petroleum contamination may limit the fish community in Boggy Creek. However taxa richness in Boggy Creek was comparable to the relatively unimpacted Turkey Creek in both May and July collections.

5. This finding suggests that levels of TDS/chloride in Boggy Creek do not limit the fish community in Boggy Creek because fish taxa richness is similar in the 2 creeks even though Turkey Creek has much lower levels of TDS and chloride.

Although the taxa abundance of Boggy Creek is similar to Turkey Creek, darters are notably absent in Boggy Creek and sunfish are less numerous than expected based on the type of habitat present, especially in the upper reaches of Boggy Creek. Darter abundance is highly dependent on substrate (Page 1983) and significant fouling of the sediments was observed in Boggy Creek, especially in the upper sampling reaches.

6. Given the impacts to the benthic macroinvertebrate community due to petroleum contamination it is likely that there are similar impacts and impairments to the fish community in upper Boggy Creek especially to those fish species, such as darters, that are highly dependent on substrate.

The fish community of lower Boggy Creek contains darters which indicates that sediment impairments due to petroleum contamination are less apparent in this reach. With the presence of more darters, the fish community in lower Boggy Creek is more representative of a Typical Gulf Coastal Ecoregion perennial fishery. The July sampling data indicate that the fishery in this reach may be limited by low flows, with fish populations occupying enduring pool refugia during low flow periods.

7. Lower Boggy Creek, with the presence of darters, supports a Typical Gulf Coastal Ecoregion fishery within constraints imposed by habitat due to low flows.
8. An additional potential source of impairment to the Boggy Creek fish community, particularly to resident sunfish populations, is reproductive impairment due to elevated Se concentration in the water. This possibility is examined in the following section.

4.6.7.3 Fish Tissue Analysis

EPA has issued a draft national criterion (USEPA 2004), which recognizes that the adverse effect of Se on aquatic life is to impair reproduction in fish by accumulating in the tissues of fish. As a result, fish tissue measurements are the most appropriate means to assess the effect of Se on aquatic life. Accordingly, the EPA draft criterion (USEPA 2004) is not given as a water concentration, but rather, as a fish tissue concentration (7.9 ug/g) representing a level of Se accumulation in fish tissue that results in impaired reproductive capability in fish. Lemly (2002) and others (Hamilton 2003) have criticized this value as too low to protect reproductive impairment through fry teratogenicity and have recommended a maximum whole body residue of 4 ug/g (dry weight) as being protective of reproduction in sensitive species such as sunfish.

All fish collected during April 2005, May 2006 and September 2006 showed whole body residues well below both the EPA draft criterion and other, more conservative, recommended threshold values for reproductive impairment. Only 2 of the fish collected (1 bluegill and 1 dollar sunfish) showed whole body concentrations > 2 ug/g. These values (3.38 and 3.31 ug/g;

Table 4.19) were still below the more conservative threshold level of 4 ug/g. Additional data collected by FTN indicates that whole body residues from composite fish samples from the Saline River (Arkansas), Extraordinary Resource Water (ERW) averaged 1.59 ug/g (range = 0.75 – 2.69 µg/g). Other data collected by FTN shows an average whole body Se residue of 1.2 µg/g (Range = 0.91 – 2.0 µg/g) from 5 hatchery reared bluegill sunfish.

Sediment concentrations of Se provide additional information relevant to the bioaccumulation potential of Se in Boggy Creek. Se is thought to enter the aquatic food web primarily through sediments (Lemly 2002). Analytical results provided in Tables 4.4 and 4.5 indicate that Se concentrations in sediment samples collected from Boggy Creek are < 2 ug/g and likely < 1 ug/g. Lemly (2002, pg. 31) recommends a toxic threshold of 2 ug/g for Se in sediments. [1] Since all measured Se concentrations in Boggy Creek were < 2 ug/g (and more likely < 1 ug/g) the potential for toxic effects due to exposure of the food web to Se via the benthic pathway is minimal.

These results indicate that:

1. Se is not bioaccumulating in the tissues of fish to harmful levels,
2. Whole body residues in Boggy Creek are comparable to background levels as indicated by fish from an ERW and a commercial hatchery,
3. Sediment concentrations of Se indicate a low potential for exposure of the food web to Se via the benthic pathway, and
4. Se toxicity is not a likely cause of any impairments to the fish community in Boggy Creek.

As indicated in the previous section on fish communities it is likely that the sunfish populations sampled represent a resident population. Also, Se concentrations in fish were low in fish collected both in the spring and late summer. Therefore, the low Se residues observed in the fish of Boggy Creek are not likely due to the seasonal influx of fish from unimpacted habitats.

[1] A threshold is a level at which "toxic effects *begin to occur in sensitive species* of fish and aquatic birds." (Lemly 2002, emphasis added).

4.7 Field Survey Conclusions

Chemical, habitat and biological data from the May and July 2006 field survey supports the following significant conclusions regarding factors limiting the aquatic life in Boggy Creek:

Water Chemistry and Flows

1. Flow measurement results indicate that mass balance modeling based on measured flows may be less reliable than modeling based on flows estimated from annual rainfall and watershed area.
2. Lower TDS and chloride concentrations below Outfall 009 suggest dilution by upstream flow and wet weather seeps.
3. Boggy Creek inflows do not cause the elevated TDS/chloride concentrations observed in Bayou de Loutre on both sampling events.
4. The majority of total Se measured in the samples collected in May and July was present in the dissolved form.
5. Inflows from Boggy Creek do not cause the elevated Se concentrations observed in Bayou de Loutre on both sampling events.
6. Highly variable flows and conductivity readings in Flat Creek indicate the presence of a point source upstream of the sampling location.
7. Substantial petroleum residues are present in the upper Boggy Creek sampling reaches.

Toxicity

1. A likely cause of the sub-lethal toxicity observed in the BC-1 sample collected in May is petroleum contamination in the sampled reach rather than elevated forms of TDS such as chloride.
2. Worst case TDS due to chloride and other ions in Outfall 009 should not be toxic to aquatic life. This finding is supported by the analysis of biological communities that existing TDS and chloride levels do not limit aquatic life in Boggy Creek.

Habitat

1. Physical habitat in all sampling locations is generally adequate for the maintenance and propagation of aquatic life.
2. Curtis Creek habitat might be limited due to low DO.
3. Flat Creek habitat might be limited due to sandy substrate.

4. Impacts due to petroleum contamination were a striking feature of the Boggy Creek reaches upstream of Highway 82 and downstream of the Clean Harbors facility.

Biological Communities

1. Benthic macroinvertebrate communities in upper Boggy Creek have low taxonomic richness dominated by 1 or 2 functional groups with low predator abundance.
2. Based on a analysis of instream toxicity and comparisons of biological communities in other TDS impacted habitats, the benthic macroinvertebrate community in the upper Boggy Creek reaches is likely limited by petroleum contamination rather than existing TDS/chloride.
3. Some degree of recovery of the benthic has occurred in lower Boggy Creek.
4. Given the likely impacts to the benthic macroinvertebrate community due to petroleum contamination it is likely that there are similar impacts and impairments to the fish community in upper Boggy Creek.
5. Existing water quality in the upper reaches Boggy Creek partially supports a Typical Gulf Coastal Ecoregion fishery.
6. Lower Boggy Creek supports a Typical Gulf Coastal Ecoregion fishery within the constraints of habitat limitation due to low flows.
7. Se toxicity is not the cause of impairments to the fish community in Boggy Creek as evidenced by low levels of Se accumulation in sediments and fish tissues.

5.0 MASS BALANCE MODEL

5.1 Selenium Modeling

A mass balance model was used to predict the average annual concentrations of Se in Bayou de Loutre downstream of the confluence of Boggy Creek and Bayou de Loutre. The model consisted of a simple mass balance using flow data based on DMRs downloaded from ADEQ's permit confluence system (PCS) and average runoff data computed by USGS. Several different scenarios were evaluated to see how the concentration of Se changed with different flow scenarios. Although Se might not be a conservative parameter, the mass balance models used herein assumed Se to be conservative (i.e., no Se loss due to chemical, physical, or biological processes). This assumption will lead to an over-predicted worst case scenario for Se. Additional assumptions used for these models are documented below.

5.1.1 Ambient Flow Assumptions

The natural flows for Bayou de Loutre upstream of Boggy Creek and Boggy Creek were calculated based on runoff estimated from 3 nearby flow gages and the drainage areas. The drainage area for Bayou de Loutre was found in "Drainage areas of Streams in Arkansas Ouachita River Basin" published by USGS in 1979. The drainage area for Boggy Creek was delineated based on 7.5-minute USGS topos with the 335 acres of stormwater drainage area removed. The 335 acres removed from the Boggy Creek drainage area was included in the stormwater drainage area to calculate stormwater flows through Outfall 009. These areas were multiplied by 13.5 inches of runoff to estimate flow. Inflow or outflow to or from groundwater was assumed to be negligible. The calculated ambient high flows were 29.84 and 22.75 cfs for Bayou de Loutre and Boggy Creek respectively.

5.1.2 Point Source Flow Assumptions

Point source data were obtained online from PCS by searching for point sources based on 2-12 digit HUC (0804021 and 08040202) and the Arkansas 305(B) ADEQ (2004) report. For point sources discharging to Bayou de Loutre or Boggy Creek, DMRs were obtained to provide information on the discharges into Bayou de Loutre and Boggy Creek for the mass balance model. When flows were computed from DMRs, the average of the monthly average flow values reported on the DMR for the period of record (6/31/04 to 6/31/06) was computed. In some cases outfalls had not discharged in that time and were set equal to zero. There were a total of 7 point sources located in PCS but only 4-point sources that had actual measured discharge into Bayou de Loutre. These discharges totaled 16.96 cfs during this time. In Boggy Creek there were 2-point sources, Cooper Standard and Columbian Chemicals in addition to Clean Harbors. Cooper Standard did not have any discharge in the last 2 years. The average of monthly average discharges from Columbian Chemicals was 0.02 cfs. All point source flows were assumed to be process flows.

5.1.2.1 Clean Harbors Outfalls

Clean Harbors has 3 external outfalls: 001, 007, and 009. Outfall 001 is a stormwater outfall and rarely discharges. Outfall 007 is also a stormwater outfall draining 35 acres. The flow for Outfall 007 was calculated assuming 13.5 inches of runoff. Outfall 009 discharges process water and stormwater runoff. DMRs were used to calculate the process water component of this outfall and the stormwater flow was based on a drainage are of 300 acres with 13.5 inches of runoff. The total Clean Harbors point source flow was therefore calculated to be 0.86 cfs. The contributions of these different components to the Clean Harbors discharge is illustrated in Figure 5.1.

5.1.3 Scenarios

A total of 6 Se scenarios are described below and summarized in Table 5.1. In each scenario the assumptions documented above were held constant and the Se concentration just downstream of the Boggy Creek/Bayou de Loutre confluence was calculated. Scenarios 1 – 4 are high flow scenarios while Scenarios 5 and 6 assumed low flow conditions.

Scenario 1

The only point source operating is Clean Harbors. All other point sources are shut down so the only flows into the system are surface runoff and the Clean Harbors effluent (which includes stormwater and process water). Also the only Se in the system comes solely from the Clean Harbors outfalls, which have a Se concentration of 20 ug/L. In this scenario the Se concentration below the confluence is 0.32 ug/L.

Scenario 2

In this scenario all the point sources are discharging but like scenario 1 the sole source of Se is Clean Harbors which discharges to Boggy Creek at concentration of 20 ug/L. In this scenario the Se concentration below the confluence is 0.23 ug/L.

Table 5.1 Conditions and results of Se modeling scenarios.

Condition	Scenario					
	1	2	3	4	5	6
Clean Harbor Outfall 007 and 009 flow (cfs)	0.86	0.86	0.86	0.86	0.27	0.27
Clean Harbor Outfall 007 and 009 Se concentration (ug/L)	20	20	30	30	30	40
Boggy Creek ambient flow (cfs)	22.75	22.75	22.75	22.75	0.0	0.0
Boggy Creek point source flow (cfs)	0.0	0.02	0.0	0.02	0.02	0.02
Bayou de Loutre ambient flow (cfs)	29.84	29.84	29.84	29.84	0.0	0.0
Bayou de Loutre point source flows (cfs)	0.0	16.96	0.0	16.96	16.96	16.96
Se concentration (ug/L) below Boggy Creek/Bayou de Loutre confluence	0.32	0.24	0.48	0.37	0.47	0.63

Scenario 3

This is identical to scenario 1 but assumes a Se concentration of 30 ug/L which leads to a concentration of 0.48 ug/L in Bayou De Loutre just downstream of the confluence with Boggy Creek.

Scenario 4

This is identical to scenario 1 but assumes a Se concentration of 30 ug/L which leads to a concentration of 0.35 ug/L in Bayou de Loutre just downstream of the confluence with Boggy Creek.

Scenarios 5 and 6

Both scenarios simulate conditions were there is no flow in either Boggy Creek or Bayou de Loutre except for the point sources, which are all discharging. Therefore the Clean Harbors effluent includes only process water. In scenario 5 the effluent Se concentration is 30 ug/L (with a resulting concentration of 0.47 ug/L in Bayou de Loutre downstream of Boggy Creek) while in scenario 6 the effluent Se concentration is 40 ug/L (with a resulting concentration of 0.63 ug/L in Bayou de Loutre downstream of Boggy Creek).

5.1.4 Selenium Modeling Conclusions

The modeling results provide an estimate of the Se concentration in the mixed streams (Boggy Creek + Bayou de Loutre) that is attributable to Boggy Creek (or, more precisely, to the Clean Harbors Outfall 009). The added Se due to Boggy Creek will not cause an exceedance of the Se WQC in Bayou de Loutre (5ug/L).

1. The modeling results show that under both high and low flow condition; the Boggy Creek contribution to downstream Se concentrations will not impact downstream systems or cause a WQC exceedance.

5.2 TDS, Chloride, and Sulfate Modeling

The objective of the mass balance modeling for TDS, sulfate, and chlorides was to calculate the concentrations of TDS/chloride/sulfate in Bayou de Loutre downstream of the confluence of Boggy Creek and Bayou de Loutre. The evaluation of TDS and chloride focused on downstream impacts of the Clean Harbors discharge under near worst-case existing conditions in the Clean Harbors Outfall 009 effluent and Boggy Creek. The calculations included estimates of sulfate loading and concentrations to evaluate potential impacts to compliance with the ecoregion sulfate WQC in Boggy Creek and Bayou de Loutre.

5.2.1 TDS/Chloride/Sulfate Model Assumptions

Based on available monitoring data (November 2004 through September 2006) the 95^{th} percentile value for TDS at Outfall 009 is 1400 mg/L. Based on the TDS/chloride relationship presented in Figure 5.1, a chloride concentration of 653 mg/L corresponds to the

95th percentile TDS effluent value of 1400 mg/L. [2] Therefore TDS and chloride concentrations of 1400 and 653 mg/L, respectively, represent near worst-case existing conditions in the Clean Harbors Outfall 009 effluent.

Boggy Creek point sources are Clean Harbors (0.27 cfs monthly average) and Columbian Chemicals (0.02 cfs monthly average). Both point sources were assumed to discharge the same concentration of TDS/chloride/sulfate.

Point source loadings and concentrations of TDS, chlorides and sulfates in Bayou de Loutre were calculated based on 90th percentile values from DMR data submitted by Lion Oil Company, Great Lakes Chemical Corporation and El Dorado South wastewater treatment plant. Point source flows were assumed to be equal to the highest monthly average flow for June 30, 2004 through June 30, 2006. The calculations included sulfate to evaluate potential impacts to compliance with the ecoregion sulfate WQC in Boggy Creek and Bayou de Loutre. Details of these calculations are presented in Appendix F (Table F.2).

Based on this approach the Bayou de Loutre TDS/chloride/sulfate concentrations upstream of the Boggy Creek confluence were calculated to be 394/24/153 mg/L, respectively. However, these values are well below concentrations measured during the field survey (Tables 4.5 and 4.6). Although there are a total of 7 outfalls from Lion Oil Company, TDS, chloride and sulfate monitoring is required only for Outfall 001 of that facility.

[2] Figure 5.1 was prepared after deleting 2 outlier data points corresponding to 1300/150 and 1300/260 mg/L TDS/chloride. The chloride concentration corresponding to the 95th percentile TDS concentration with the 2 outliers included was 670 mg/L.

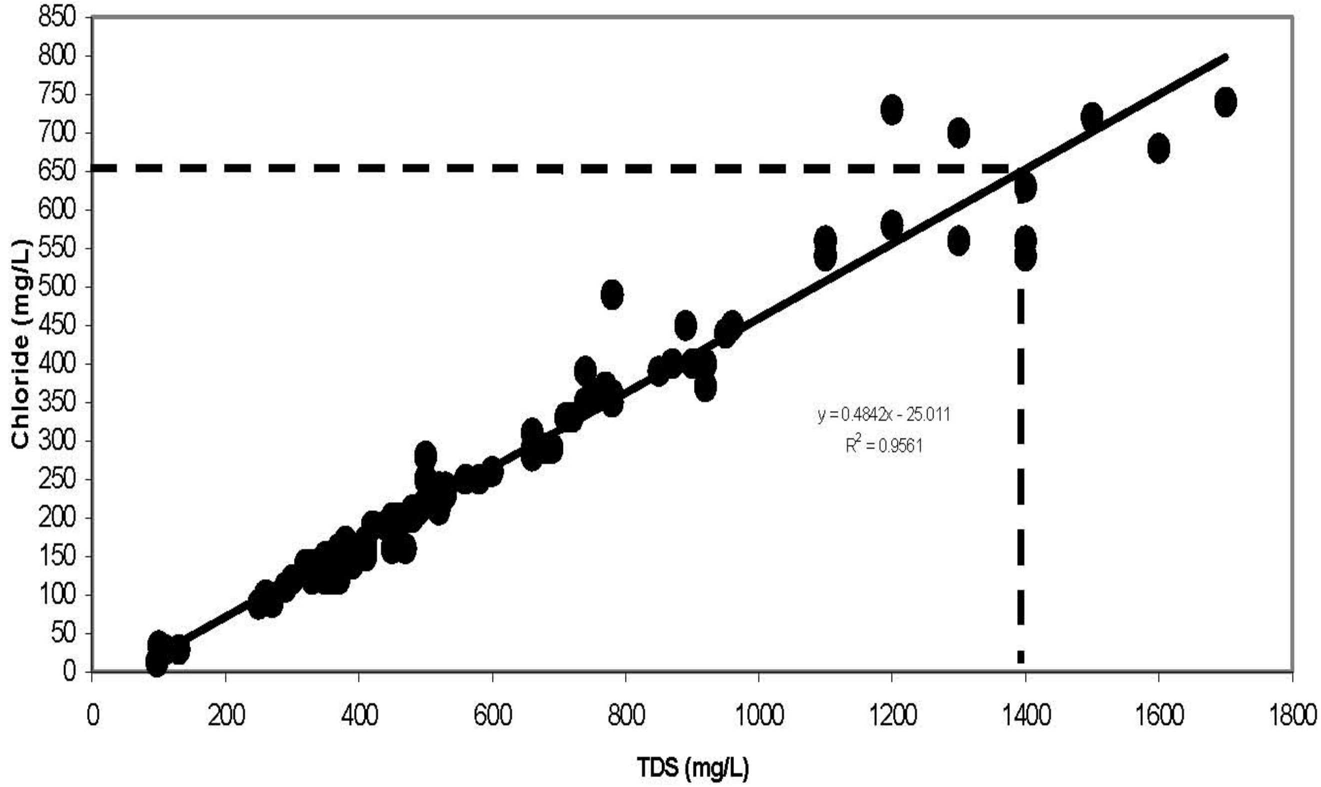

Figure 5.1. Scatter plot showing relationship between TDS and chloride at Clean Harbors Outfall 009, November 2004 through September 2006.

Therefore, the TDS/chloride/sulfate loadings and concentration from the point sources are likely biased downward using this procedure (Appendix F, Table F.2). Accordingly, additional mass loading calculations were made using the highest concentrations (1705/150/420 mg/L TDS/chloride/sulfate, respectively, from July monitoring, Table 4.6) for the upstream Bayou de Loutre location (BDL-2) from the field survey. Low flow conditions assumed that the only flow in Boggy Creek and Bayou de Loutre was from point sources. High flow conditions assumed additional runoff flows as calculated in Section 5.1. Runoff TDS/chloride/sulfate concentrations (240/86/4.2 mg/L, respectively) were assumed to equal the concentrations measured in Boggy Creek upstream of the Clean Harbors Outfall 001 (BC-2) during the field survey on May 18, 2006 (Table 4.5).

Clean Harbors DMR monitoring does not include sulfate. Therefore sulfate concentration in the Clean Harbors discharge was estimated as follows. The sulfate concentration in the Retention Pond #4 sample used in the “worst-case” toxicity evaluation (Table 4.9) was 63 mg/L and was associated with 1700 mg/L TDS. The sulfate concentration associated with the 95th percentile Outfall 009 effluent TDS value of 1400 mg/L was therefore estimated as 63 x 1400/1700 = 52 mg/L.

5.2.2 TDS/Chloride/Sulfate Model Scenarios

TDS/chloride/sulfate concentrations downstream of the Boggy Creek Bayou de Loutre confluence were evaluated under 4 scenarios. The scenarios were intended to evaluate downstream Bayou de Loutre TDS/chloride/sulfate concentrations with near worst case TDS/chloride/sulfate conditions in Boggy Creek under high and low flow conditions and 2 different approaches to calculating inputs from Bayou de Loutre upstream of the Boggy Creek confluence. Input data and results from the 4 scenarios are summarized in Table 5.2. In all scenarios Boggy Creek TDS/chloride/sulfate concentrations were estimated based on 95th percentile TDS concentrations from DMR monitoring as described above. Also in all scenarios, flows from point sources were held constant. The only parameters that were varied were runoff flows to simulate high flow and low flow conditions and TDS/chloride/sulfate conditions in Bayou de Loutre upstream of the Boggy Creek confluence.

Scenario 1

The only source of flow in Boggy Creek and Bayou de Loutre is the point sources Bayou de Loutre flows and TDS/chloride/sulfate originate from 3 point sources as described above.

Scenario 2

Flows from point sources and runoff. Bayou de Loutre flows and TDS/chloride/sulfate from 3 point sources as described above.

Scenario 3

All flow from point sources. Bayou de Loutre TDS/chloride/sulfate concentrations based on field survey data.

Scenario 4

Flows from point sources and runoff. Bayou de Loutre concentrations based on field survey data.

5.2.3 TDS/Chloride/Sulfate Modeling Conclusions

The large disparity between TDS/chloride/sulfate calculated in Bayou de Loutre upstream of the Boggy Creek confluence in scenarios 1 and 2 vs. the measured concentrations in scenarios 3 and 4 indicates that the upstream concentration used in scenarios 1 and 2 are probably unrealistically low. Mass balance modeling summarized in Table 5.2 indicates that ecoregion WQC for TDS/chloride/sulfate (138/19/41 mg/L, respectively) will be exceeded in Bayou de Loutre under all scenarios. In addition, WQC variations for TDS as supported by UAA in Bayou de Loutre (Bayou de Loutre from Gum Creek to state line; TDS 750 mg/L) will also be exceeded if measured TDS concentrations in Bayou de Loutre upstream of the Boggy Creek confluence are used (Scenarios 3 and 4). However, the mass balance modeling shows that, using measured upstream TDS/chloride/sulfate concentrations, Boggy Creek should not contribute to an increase in TDS/chloride/sulfate concentrations in Bayou de Loutre downstream of the Boggy Creek confluence.

1. Although TDS/chloride/sulfate concentrations appear to be exceeding ecoregion WQC TDS/chloride/sulfate concentrations, the Clean Harbors discharge should not cause an increase in TDS/chloride/sulfate concentrations in Bayou de Loutre downstream of the Boggy Creek confluence

Table 5.2. Summary of scenario conditions and results of TDS/chloride/sulfate mass balance modeling.

Condition		Scenario			
		1	2	3	4
Boggy Creek Point Sources	TDS	1400	1400	1400	1400
	Chloride	653	653	653	653
	Sulfate	52	52	52	52
	Flow	0.290	0.290	0.290	0.290
Runoff to Boggy Creek	TDS	240	240	240	240
	Chloride	86	86	86	86
	Sulfate	4.2	4.2	4.2	4.2
	Flow	0	22.750	0	22.750
Boggy Creek at Mouth	TDS	1400	255	1400	255
	Chloride	653	93	653	93
	Sulfate	52	5	52	5
	Flow	0.290	23.040	0.290	23.040
Point Sources for Bayou de Loutre Above Confluence with Boggy Creek	TDS	465	465	1705	1705
	Chloride	53	53	150	150
	Sulfate	157	157	420	420
	Flow	36.072	36.072	36.072	36.072
Runoff to Bayou de Loutre Above Confluence with Boggy Creek	TDS	240	240	240	240
	Chloride	86	86	86	86
	Sulfate	4.2	4.2	4.2	4.2
	Flow	0	29.840	0	29.840
Bayou de Loutre Above Confluence with Boggy Creek	TDS	465	363	1705	1042
	Chloride	53	68	150	121
	Sulfate	157	88	420	232
	Flow	36.072	65.912	36.072	65.912
Bayou de Loutre Below Confluence with Boggy Creek	TDS	402	306	1703	838
	Chloride	29	63	154	114
	Sulfate	152	65	417	173
	Flow	36.362	88.952	36.362	88.952

6.0 EXISTING USES IN BOGGY CREEK

The following sections provide an evaluation of existing uses in Boggy Creek as indicated by the results of the field survey and other observations. For virtually its entire length, Boggy Creek is a low lying, swampy and sometimes braided stream with low summer time flows. Much of its surrounding watershed, especially the riparian zone, is low lying, swampy and heavily wooded. These factors will tend to inhibit primary/secondary contact and domestic/agricultural/industrial uses.

6.1 Primary and Secondary Contact Recreation

These uses were assigned by default to Boggy Creek and are assumed to be existing uses because theoretically, people can come in contact with water in Boggy Creek. However, the field surveys did not find evidence that this is an existing use. The physical conditions (lack of consistent flow, mud/silt bottom, low lying, swampy and heavily wooded riparian zone) are not conducive to either primary or secondary contact recreation in this system. There was no evidence of these uses (e.g., litter, trails) during the field survey.

6.2 Industrial Water Supply

The Arkansas Natural Resources Commission (ANRC) has identified no registered agricultural, municipal, or industrial diversions from Boggy Creek and no evidence of such use was discovered during the field surveys (Letter from E.T. Smith, Chief, Water Resources Division, ANRC, December 11, 2006, Appendix G). Low flows observed during the July sampling would seem to preclude industrial uses.

6.3 Agricultural Water Supply

ANRC has determined contacted to document that the proposed changes to Boggy Creek will not conflict with the State Water Plan (Appendix G). Although only limited segments of Boggy Creek could be accessed during reconnaissance or sampling, no agricultural or livestock use was evident. Pastureland was noted within the Boggy Creek watershed. However, because of its low lying and swampy character, Boggy Creek does not appear to be well suited for livestock watering. Low flows observed during the July sampling would likely preclude other agricultural uses such as irrigation.

6.4 Domestic Water Supply

For reasons stated cited above, it is not likely that Boggy Creek has ever been used for domestic water supply. The field surveys did not find any evidence for this use and a review of the Arkansas Department of Health (ADH) public water supply database (http://www.healthyarkansas.com/eng/pwslist0.htm) verified that Boggy is not used for domestic water supply. The Arkansas Department of Health and Human Services (ADHHS) has no knowledge of any plans to use Boggy Creek as a public water system source (Letter from B. Maken, Assistant Director, Engineering Section, ADHHS, December 11, 2006, Appendix G). Low flows observed during the July sampling would also seem to preclude domestic water uses.

6.5 Aquatic Life

An aquatic life use presently exists in Boggy Creek. However, the aquatic life use is impaired in the upper reaches due to petroleum contamination. The aquatic life use in lower Boggy Creek is more comparable to Gulf Coastal Ecoregion characteristics and to the relatively unimpacted Turkey Creek. However, the fishery in this reach appears limited by low flows, with fish populations occupying enduring pool refugia during low flow periods.

6.6 Conclusions

This evaluation of existing uses in Boggy Creek indicates the following:

1. It is possible, though unlikely that primary and secondary contact recreation occurs in Boggy Creek.
2. Much of the surrounding watershed, especially the riparian zone, is low lying, swampy and heavily wooded. These factors in addition to low summertime flows appear to inhibit domestic/agricultural/industrial uses.
3. The ANRC identified no registered agricultural, municipal, or industrial diversions on Boggy Creek and the ADHHS has no knowledge of any plans to use Boggy Creek as a public water supply source.

4. The existing aquatic life use for upper Boggy Creek can be characterized as a Typical Gulf Coastal Ecoregion perennial fishery impaired by petroleum contamination of the sediments.

5. Lower Boggy Creek appears to support a Typical Gulf Coastal Ecoregion perennial fishery within the constraints of habitat limitation due to low flows.

7.0 ATTAINABLE USES IN BOGGY CREEK

This section evaluates attainable uses in Boggy Creek in the presence of the plant discharge. This evaluation is based on water quality and biological communities information presented in Section 4 and focuses on TDS/chlorides and Se in Boggy Creek. Since Se exerts it's adverse environmental effects by impairing reproductive success in fish and aquatic birds (Lemly 2002), it will be assumed that existing concentrations of Se in the Clean Harbors discharge will have potential effects only on aquatic life uses and will not have the potential to impair other uses such as primary/secondary contact or domestic/agricultural/industrial water supply. Because the aquatic life hazard posed by TDS/chloride is distinctly different from that of Se, these two issues will be considered separately in evaluating attainability of aquatic life uses.

7.1 Primary and Secondary Contact Recreation

These uses were assigned by default to Boggy Creek. Although these are assumed to be existing uses because theoretically people can come in contact with water in Boggy Creek, the field surveys did not find evidence that this is an existing use. Physical conditions such as lack of consistent flow, mud/silt bottom, low lying, swampy and heavily wooded riparian zone are not conducive to primary or secondary contact recreation in these ditch systems. In addition, existing petroleum contamination of the sediments in upper Boggy Creek would appear to pose an additional limitation on these uses. These physical and chemical factors would limit the primary/secondary contact use more than the existing TDS/chloride concentrations due to the Clean Harbors discharge. Therefore the existing water quality in Boggy Creek due to the Clean Harbors discharge does not affect the attainability of this use.

7.2 Industrial Water Supply

Although low flows, particularly in lower Boggy Creek during the summer, limit this use, existing water quality due to the Clean Harbors discharge should not affect the attainability of an industrial water supply use for this waterbody.

7.3 Agricultural Water Supply

The suitability of Boggy Creek as an irrigation supply may be questionable due to TDS. However, according to information provided by the University of Arkansas Agricultural Extension Service[3], a water supply suitable for irrigation should provide minimum flows of 5, 10, or 15 gpm per acre for center pivot, furrow and levee irrigation, respectively, of soybeans. Dry weather (July 2006) flows in upper and lower Boggy Creek (Table 4.6) were less than 0.2 cfs (90 gpm). These data indicate that agricultural supply (irrigation) is clearly not an attainable use in Boggy Creek. Because of its low lying and swampy character, Boggy Creek does not appear to be well suited for livestock watering. Therefore this agricultural use would also seem to be limited by the physical nature of Boggy Creek.

7.4 Public Water Supply

Public water supply is not an attainable use for Boggy Creek due to low flows that occur in summer.

7.5 Aquatic Life

7.5.1 TDS/Chlorides

The existing aquatic life use in Boggy Creek represents the attainable aquatic life use in Boggy Creek considering the presence petroleum contamination of the sediments in upper Boggy Creek and low flows in lower Boggy Creek. Existing TDS/chloride conditions in Boggy Creek do not limit the attainability of aquatic life uses in Boggy Creek. This conclusion is based on the following observations:

1. Results of a toxicity test on the “worst case” effluent indicate that maximum anticipated effluent concentrations of TDS and chloride will not be toxic to aquatic life (Section 4.4).
2. The combined results of the evaluation of instream and “worst case” effluent toxicity indicate that the instream toxicity observed to *C. dubia* is due to factors other than TDS/chloride (Section 4.4).

[3] http://www.uaex.edu/Other_Areas/publications/HTML/MP197/chapter8_irrigation_methods.asp

3. A comparison of water quality and benthic communities in Boggy Creek and Flat Creek (Section 4.6.7) indicates that TDS/chloride does not limit benthic communities in Boggy Creek.
4. Based on the toxicity evaluation presented in section 4.4.3, and suggested by the evaluation benthic macroinvertabrates in Section 4.6.7.1 the following site specific minerals criteria will support existing and attainable aquatic life uses:
    a. TDS – 1360 mg/L
    b. Chloride – 631 mg/L
    c. Sulfate – 63 mg/L

7.5.2 Se

This evaluation is based on water chemistry and biological data (particularly whole body fish tissue analyses) collected as part of this study plus information obtained from the literature. There is a considerable body of literature pertaining to the ecological effects of Se. This evaluation will draw heavily on Lemly (2002) who provides a comprehensive review and evaluation of the environmental effects of Se. In addition, based on FTN’s review of published literature, Lemly’s approach to evaluating the ecological hazard of Se is among the more environmentally conservative (i.e. more stringent) approaches.

Se bioaccumulates in aquatic food webs resulting in elevated tissue concentrations in food web organisms relative to the water concentrations. Fish and aquatic birds are the most susceptible components of the aquatic food web to Se bioaccumulation. Bioaccumulation can result in direct mortality in fish and aquatic birds, but its most insidious effect is to cause teratogenicity in developing embryos. Embryo teratogenicity can be caused by adult body burdens that are well below levels that cause signs of toxicity in the adult. Embryo teratogenicity results in poor survival of fish larvae and fry so that the ultimate ecological effect of excess Se in aquatic habitats is to impair reproductive success in fish and piscivorous birds.

Salmonids and centrarchids are known to be particularly susceptible to tissue concentrations of Se while many forage fish species such as *Gambusi affinis* (abundant at the locations sampled in this study), *Pimephales promelas*, and *Notropis lutrensis* (not present at the locations sampled in this study) can tolerate high body burdens without indications of reproductive impairment (Lemly 2002). Accordingly, this evaluation focuses on Se tissue concentration in centrarchid populations found in Boggy Creek and Bayou de Loutre.This evaluation included Bayou de Loutre as well as Boggy Creek because, in contrast to other metals that tend to become less bioavailable in downstream habitats, Se is likely to bioaccumulate in more productive, low gradient, depositional downstream habitats (Lemly 2002).

Recognizing that the environmental hazard of Se occurs as a result of bioaccumulation, EPA has proposed a draft tissue-based water quality criterion for Se (USEPA 2004). The draft criterion document sets the chronic exposure criterion at 7.91 µg/g dry weight (dw) in whole body fish tissue. If whole-body fish tissue concentrations exceed 5.85 µg/g dw during summer or fall, additional monitoring during the winter is needed to determine if the Se concentration exceeds 7.91 µg/g dw. At the time of this writing, this criterion had not yet been promulgated.

Lemly (2002) and others (e.g., Hamilton 2003) have argued that the draft EPA tissue-based criterion is not protective of teratogenic effects on developing fish embryos and that lower tissue concentrations are justified. Lemly (2002) has proposed threshold concentrations in water, sediments, food-web organisms and fish tissues that represent levels at which "…toxic effects begin to occur in sensitive species of fish and aquatic birds." (Lemly 2002, page. 31). The proposed toxic effects thresholds are 4 ug/g for whole-body fish tissues and 2 ug/g for sediments (Lemly 2002, Table 2.4). These proposed thresholds are among the more conservative thresholds in the published literature.

Whole-body fish tissue analyses performed on 154 fish including 7 centrarchid genera (Table 4.18) indicate that whole body Se residues are typically < 2 ug/g. Two of the fish collected (1 bluegill and 1 dollar sunfish) showed whole body concentrations > 2 ug/g (3.38 and 3.31 ug/g; Table 4.17) that were still below the threshold level of 4 ug/g proposed by Lemly 2002. No fish showed residues > 4 ug/g. These whole-body residues are comparable to data collected by FTN from the Saline River (Arkansas), an Extraordinary Resource Water (ERW) that showed an average whole-body residue of 1.59 ug/g (range = 0.75 – 2.69 ug/L). Other data collected by FTN showed an average whole body Se residue of 1.2 ug/g (Range = 0.91 – 2.0) from 5 hatchery reared bluegill sunfish.

Lemly (2002) cautions that fish populations can be mobile and that samples of fish from a point in time may not reflect exposure of resident individuals. However, this situation probably does not to apply to centrarchids, particularly the genus *Lepomis*. Pflieger (1975) states

"Individuals of most species (of centrarchids) show a definite attachment to a particular pool or reach of shoreline to which they will return after being displaced….Often the same fish…may spend its entire life within a rather restricted area." Therefore, fish collected in Boggy Creek were likely part of the resident sunfish population of Boggy Creek and were not recent emigrants from uncontaminated habitat.

Lemly (2002) also cautions that fish populations in downstream habitats may be more likely to bioaccumulate Se than upstream habitats because of differences in Se cycling in downstream habitats. However, sunfish collected in Bayou de Loutre downstream of the Boggy Creek/Bayou de Loutre confluence also showed whole-body Se residues well below threshold levels (Tables 4.18 and 4.19).

Analytical results provided in Tables 4.5 and 4.6 indicate that Se concentrations in sediment samples collected from Boggy Creek are < 2 ug/g and likely < 1 ug/g. These concentrations are below the thresholds proposed by Lemly (2002) that result in bioaccumulation in the food web via the sediment exposure pathway. This result indicates that Se in Boggy Creek sediments has a low potential to bioaccumulate in the Boggy Creek food web.

Finally, low Se levels in fish and sediment indicate a low potential for bioaccumulation in other sensitive compounds of the Boggy Creek ecosystem, such as piscivorous aquatic birds.The information provided above indicates that Se in Boggy Creek does not limit aquatic life in Boggy Creek of Bayou de Loutre. This conclusion is based on the following observations:

1. Se residues in fish are well below conservative harmful threshold levels,
2. Whole body residues in Boggy Creek fish are comparable to background levels as indicated by fish from an ERW and a commercial hatchery, and
3. Sediment concentrations of Se indicate a low potential for exposure of the food web to Se via the benthic pathway.

7.6 Conclusions: Attainable uses

This evaluation of attainable uses in Boggy Creek indicates the following:

1. Toxicity data indicate that the Clean Harbors facility will not discharge toxic materials (i.e., TDS/chloride) in toxic amounts.
2. The aquatic life use (benthic invertebrate communities and a Typical Gulf Coastal Ecoregion perennial fishery) in upper Boggy Creek is not fully attained due to the presence of petroleum contamination of the sediments.
3. The aquatic life use (benthic invertebrate communities and a Typical Gulf Coastal Ecoregion perennial fishery) in lower Boggy Creek is fully attained within the constraints imposed by habitat limited due to low flows.
4. Primary/secondary contact, industrial or agricultural water supply (livestock watering/irrigation) and public water supply uses in Boggy Creek are limited by physical factors such as lack of consistent flow, mud/silt bottom, the low lying, swampy and heavily wooded riparian zone, and, in upper Boggy Creek, petroleum contamination of the sediments.
5. Attainability of the primary/secondary contact, industrial or agricultural water supply (livestock watering/irrigation) and public water supply uses, to the extent that they occur, is not limited by existing TDS/chloride concentrations due to the Clean Harbors discharge.
6. Predicted “worst case” TDS/chloride concentrations in the Clean Harbor effluent will support the existing and attainable uses in these systems.
7. Existing Se concentrations in Boggy Creek do not limit aquatic life in Boggy Creek.
8. Downstream effects of existing Se concentrations in Boggy Creek are not apparent in Bayou de Loutre fish tissue.

8.0 ALTERNATIVES EVALUATION

8.1 Total Dissolved Solids – Alternatives Analysis

The discharge from Outfall 009 of the Clean Harbors facility contains elevated concentrations of dissolved minerals, or TDS. The direct discharge of this wastewater has been, and would continue to be the most direct and least expensive method for managing this wastewater. However, as previously discussed, the continued use of direct discharge will require modifications to the stream standards that are listed in ADPCE (2004).

UAA guidance requires that an evaluation be made of other alternatives to achieve compliance with the stream standards rather than the modification of the standard itself. These alternatives should be evaluated for technical and economic considerations. Based on a number of similar evaluations in previous UAAs, the alternatives for management of effluents with elevated dissolved minerals are limited. Three alternatives that previously have been considered in other similar evaluations for controlling TDS are: 1) Source Control, 2) Treatment using reverse osmosis, and 3) Pumping the wastewater to a larger stream that holds the potential for dilution of the minerals. The following section evaluates these three alternatives for meeting the existing stream standards at the Clean Harbors facility.

8.1.1 Source Control

A review of the options for source control was included in a preliminary study that FTN conducted in 2005. Compliance with the WQC for Boggy Creek would require the elimination of a significant portion of the TDS found in the effluent. FTN reviewed the different sources of TDS and possible alternatives to eliminating these sources.

There are several sources that contribute water to Outfall 009. Because each of the major sources can potentially be the primary flow on any given day, source control would require efforts for each waste stream that demonstrated effluent concentrations above the new limitation.

For the recovered groundwater, Clean Harbors is required by permit to treat a minimum flow rate of groundwater. Since the concentrations in the groundwater are also set, source control is not an option for this stream. The existing treatment system for this groundwater is not effective for the removal of TDS and cannot be modified to be effective.

For stormwater runoff, Clean Harbors has an ongoing program of Best Management Practices (BMPs) and storm controls. While some of the concentration values during low flows were elevated, the overall mass contribution from storm water is relatively low. Expanded efforts to improve BMPs, while potentially helpful, will not eliminate the problem of TDS in Outfall 009.

For process wastewater, the analytical data indicated that the CT blowdown represents the most significant source of TDS at the Clean Harbors facility. Groundwater is cycled several times within the CT and the concentrations of dissolved solids increases with each cycle. Maintaining the level of dissolved solids in the CT water is a major factor in determining the rate of blowdown. Using makeup water with higher purity would reduce the rate of blowdown but would require the use of City Water with a lower dissolved solids content than the groundwater currently being used.

The use of City Water for this source would add a considerable expense to the operations cost. Since the City Water itself has a TDS concentration of about 250 mg/L, compliance with TDS limitations of 343 mg/L in the existing permit would require about 850 gpm of City Water in the CT at an additional cost of approximately $584,000 per year.

For comparison purposes, maintaining a value of about 1000 mg/L of TDS in the outfall is estimated to require an additional 61 MG per year of City Water at a cost of approximately $75,000 to $100,000 over the present costs. While Clean Harbors could be forced to pay this additional cost, the standards would still have to be changed to allow the discharge of water with the higher TDS concentrations. With the 1000 mg/L concentrations, there would not be any additional environmental safeguards relative to the proposed limits. Water conservation of the Sparta aquifer is an additional consideration for this option.

An alternative to the use of City Water for supply would be for the City Utility to accept the CT blowdown for disposal in the sanitary sewer system. The City Utility has been approached about this subject in the past. While agreeing to accept the sanitary wastewater from the plant, the Utility declined to accept the CT blowdown. Further attempts to approach the City about this subject have not met with success. Even if the City had agreed to accept the blowdown, the facility would not be able to meet the effluent limits for TDS required by the new permit. This is due to the other contributing sources of TDS such as groundwater, runoff into the South Ditch, and Retention Area 10.

8.1.2 TDS Treatment Through Reverse Osmosis

Wastewater technologies, such as conventional precipitation, can efficiently remove the heavy metals from wastewater to meet the effluent requirements. However, these systems do not remove the dissolved compounds like sulfates and chlorides. As a result, the effluent flow from the treatment plant is limited by the dilution of the flow in the receiving stream to reduce these contaminants to acceptable concentrations.

Reverse Osmosis (RO) is an advanced water/wastewater treatment process capable of removing dissolved contaminants such as sulfates and chlorides. It is essentially an extension of a filtration process in which highly pressurized feed water flows across a membrane, with a portion of the flow, identified as "permeate", going through the membrane. The rest of the feed is called "concentrate" because it carries off the concentrated contaminants rejected by the membrane. The concentrate amount depends on many factors and can vary between 10 to 30% of the feed. Depending on the size of the pores in the membrane, the process results in different classes of separation. For the removal of dissolved solids, a membrane capable of rejecting elemental particles must be utilized.

Since TDS levels are elevated in the runoff into the South Ditch as well as the treatment plant outfall, the treatment system would be required to treat the water in the South Ditch. This would require the installation of a storage basin to reduce flow rates to the treatment system.

8.1.2.1 Technical Considerations

Based on the preliminary information available from equipment manufacturers, RO is a possible alternative treatment to meet the limits for dissolved minerals. The RO permeate would be of high quality and meet downstream WQC in this process.

The most common problems with RO involve the tendency for fouling problems when applied to concentrated waste streams and the cost of operation (i.e., electricity, membrane cleaning, etc.).

The controlling factor in the selection of RO for many applications is the cost of disposal of the concentrated brine. RO separates the contaminants from water but it does not chemically change them to other non-polluting compounds. The concentrate would require disposal by other methods. The brine solution may be solidified and disposed on site, transported off site for stabilization prior to landfilling, or transported off site to a municipal or industrial wastewater treatment system. The waste brine solution is not a hazardous waste in Arkansas, but due to the source of the brine, disposal may be restricted to industrial or hazardous waste facilities. Transportation will be a critical factor for two of the three options.

On Site Stabilization - The concentrate could be stabilized on site, using a cementitious element such as Portland cement or fly ash. This would require the construction of a mixing facility, purchase of the cementitious agent, crews and equipment to mix the waste solution, regulatory authority to dispose of the waste on site, and engineering support for selection and operation of a disposal area. The critical and unknown costs for this option are the mixing ratio for the waste solution/stabilization agent, and any required environmental protection controls for the disposal area. The mixing ratio determines the tonnage necessary for purchase of the stabilizing agent, and the environmental protection controls could range from open disposal on land adjacent to the facility or the installation of a landfill with liners and caps.

Off Site Treatment - The wastewater could be transported off site by truck to an industrial or municipal wastewater treatment facility. It would be necessary to provide waste profile information to each facility to obtain cost information. For treatment and discharge, the treatment facility would need to be located at a site with capabilities for discharging to a large water body. The critical cost component would be the cost of transportation and the cost per disposal on a per gallon basis.

Off Site Stabilization - The wastewater could be transported to an industrial or municipal landfill for stabilization and disposal. Offsite disposal offers several advantages. Primarily, there are minimal of regulatory approvals required when the waste is removed to an offsite facility. For local landfills, the costs may be lower than for landfills dedicated to industrial or hazardous waste, but the environmental controls can differ from cell to cell, requiring more oversight of disposal operations.

8.1.2.2 Economic Considerations

The water analysis and the design flow requirements are primary considerations in the sizing and cost of the equipment. Pumps and piping that are associated with the RO process would be required along with controls, building, utilities etc.

The basic assumptions used in the analysis of costs are shown below:

1. The average flow of the treatment system would be 0.24 million gallons per day (mgd). The system must be sized to handle storm flow with a peak of 5.7 mgd. A storage system would be required to allow a continuous flow rate through the treatment systems. For purposes of this economic evaluation, a holding basin capable of one hour of peak storm flow will be provided to match with a peak design treatment flow of 1.0 mgd.
2. Approximately 0.88 million gallons/year will be generated as brine solution reject from the RO treatment system and will require disposal.
3. The system will consist of a minimum of three RO units in series, and a holding tank to facilitate disposal of the concentrate.
4. The treated effluent will be discharged through the existing Outfall 009.
5. The waste brine solution will be 20% solids, 80% water.
6. The solution will be concentrated 100 times from the blowdown concentration expected for 8 cycles of concentration.
7. RO costs are estimated based on data calculated by the CORPS and reported in the Source Book of Alternative Technologies for Freshwater Augmentation.

The following cost information is based upon a three stage RO system, able to sequentially concentrate the pit water approximately 100 times. The concentrate could then be stored in an onsite holding tank.

The capital costs of installing RO treatment have been estimated by the CORPS to range from $1.44 to $2.13 per gpd. This is for a single stage RO unit. For a three-stage RO unit, it is estimated that the costs would be a factor of 2.0 higher. Given these factors, the costs for installing a RO system are estimated at \$3.58 per gpd. Providing for storage of stormwater, a total estimated capital cost of the treatment system of approximately \$6.4 MM.

The CORPS further estimated the operating costs of a RO system (less the costs of brine disposal) at about \$0.001/gallon for a large scale treatment system. This cost would translate to an annual operating cost of about \$140,000.

For both the capital and operating costs, the factors provided by the CORPS may be low due to the relative size of this application. However, the cost estimates should provide a method for comparison. Also, as stated above, the costs of disposal of the concentrate actually becomes the controlling factor with this application.

For the disposal of the concentrate, the critical cost components for offsite treatment or disposal are the cost of transportation and the per ton disposal fee for the waste. Safety Kleen provided a preliminary cost quote for a similar project of \$1.00/gallon for transport and disposal at an Oklahoma facility. The annual costs associated with disposal would be about \$880,000.

Therefore, based on these preliminary calculations, RO treatment would have a capital cost of about \$6,400,000 and an annual operating cost of about \$1,020,000.

8.1.3 Pipeline to Ouachita River

The possibility exists that a pipeline could be installed to route the effluent from the Internal Outfall 009 to the Ouachita River. The Ouachita is the only river/stream in the area that carries sufficient flow to potentially dilute the TDS to below water quality standards.

Discharging to the Ouachita River would require the construction of a pipeline of about 15 miles in length. This alternative would require that all of the wastewater from the onsite water treatment plant be pumped through the pipeline. It would require the construction of a 6-inch diameter force main and a pump station with adequate capacity for the operation.

For this size pipeline, a polyethylene line could be routed underground. The estimated costs for this project would be about \$100,000 for the pump station and about \$20/linear foot for the installed pipe. This includes an allowance for the purchase of right of way. However, it is not assured that the right of way could be purchased at this cost. Based on these preliminary estimates, the capital costs associated with the pipeline alternative would be about \$16,000,000.

The primary operating costs for this option would result from the electrical costs associated with pumping and the maintenance of the pumping station and pipeline. This is estimated at about $40,000 annually.

8.1.4 Regulatory Changes - Site Specific Criteria

Effluent characteristics discussed in previous sections indicate that 1360 mg/L TDS and 631 mg/L chlorides represent existing near worst-case TDS and chloride concentrations in the Clean Harbors effluent. The field survey documented a lack of flow upstream of the Clean Harbors effluent during the July sampling event. Therefore, during dry periods the Clean Harbor effluent can be expected to make up most if no all of the flow in upper Boggy Creek. Accordingly, an instream TDS/chloride concentration that reflects conditions in the Clean Harbors discharge is appropriate as a site specific WQC. The analysis of toxicity presented Section 4.4.3 indicate that these TDS, chloride and sulfate concentrations of 1360 mg/L, 631 mg/L, and 63 mg/L respectively will not result in a toxic discharge and are appropriate as site specific WQC.

8.1.5 Summary of Costs

There are three alternatives that were considered for the management of the discharge from the facility to achieve compliance with the new TDS limitations:

1. Source Control,
2. Installation of a reverse osmosis treatment system, and
3. Installation of a pipeline to the Ouachita River.

Table 8.1 provides a summary of the estimated costs associated with each option. The expected costs associated with providing a change to the WQC has been included for comparison purposes.

A rating has also been provided to evaluate the technical considerations with each option and the potential for success. The rating is based on a 1 to 10 scale with 10 representing a high degree of confidence for success and minimal technical difficulties. This rating is basically a professional judgment by the reviewing engineer.

Table 8.1. Summary of capital, operating and implementation costs.

Option Description	Estimated Capital Cost	Estimated Annual Operating Cost	Technical Rating
Source Control	-	$650,000	4
Reverse Osmosis treatment	$6,400,000	$1,020,000	6
Pipeline to Ouachita River	$16,000,000	$40,000	9
Regulatory changes	$200,000	-	9

8.2 Selenium – Alternatives Analysis

The discharge from Outfall 009 of the Clean Harbors facility contains elevated concentrations of Se. As part of the justification for modifying the stream standards, any other alternatives to achieve compliance must be fully evaluated. These alternatives should be reviewed for technical and economic considerations. Three alternatives that previously have been described for controlling TDS, and which apply equally to the situation for Se, are: 1) Source Control, 2) Treatment and 3) Pumping the wastewater to a larger stream that holds the potential for dilution of the minerals. The following section evaluates these three alternatives for meeting the existing stream standards at the Clean Harbors facility. The evaluation of these alternatives is documented in the following discussion. Much of this information is repeated from the options for managing the TDS. However, options for treating Se are fully explored as part of this section.

8.2.1 Source Control

There are several sources that contribute water to Outfall 009. Each of the major sources can potentially be the primary flow on any given day. Each of these sources has also been demonstrated to contain Se at concentrations above the monthly permit limits. Since the ongoing operations at the plant are not the source of the Se, the only option for control would be to substitute City Water for the use of well water as a means of diluting the Se. To achieve the monthly average of 5 ug/L it has been calculated that the flow of City Water would have to be about 400 gpm. This translates to a cost of about $240,000 per year.

An alternative would be for the City to accept this wastewater for disposal in the sanitary sewer system. The City has been approached about this subject. While agreeing to accept the sanitary wastewater from the plant, the City declined to accept the CT blowdown. If the City would accept the blowdown, the Clean Harbors facility would still have difficulty meeting the effluent limits for Se required by the new permit. This is due to the intermittent nature of these wastewater streams (i.e., no consistent dilution source) and the other contributing sources of Se such as groundwater and Retention Area 10.

8.2.2 Treatment Methods

Several methods have been evaluated over the past few years for reducing Se concentrations to acceptable levels in aqueous solutions. These methods generally fall into one of the following categories:

1. Physical separation using reverse osmosis (RO), ion exchange, distillation etc.;
2. Chemical separation;
3. Adsorption/absorption techniques;
4. Biological; and
5. Constructed wetlands.

8.2.2.1 Physical Separation

Treatment methods that employ physical separation mechanics can be effective in removing Se. Se ions in the selenate oxidation state can be removed by ion exchange or RO. Distillation is another method that would be applicable to an inorganic pollutant with low volatility such as Se. These methods are prohibitively expensive when significant volumes of an aqueous solution must be treated. For instance, as discussed in section 8.1.2.2, the costs of RO for a waste stream of this concentration would require a capital expenditure of about $6.4 MM. The operating costs for this system is estimated to be over $1 MM per year, mainly due to the costs of reject disposal. Distillation and ion exchange would present similar operating costs. Further, all of these methods produce a contaminated regeneration effluent that requires further treatment for Se fixation or removal before disposal. Dewatering this solution would to be a difficult task, because the solids still exist as extremely fine particles.

8.2.2.2 Chemical Separation

One method employed to remove or substantially reduce the concentration of soluble inorganic pollutants, such as heavy metals in water, is chemical precipitation of the metals as their oxides or their hydroxides. This precipitation generally is effected by the addition of lime, alum or an iron salt to the water at an appropriate pH.

It is known that Se ions can be removed from aqueous systems employing chemical precipitation if the Se is present in the selenite (SeO_3^{-2}) form. Generally, such precipitation methods comprise treating the Se-containing aqueous system with an iron salt, such as ferric or ferrous sulfate, chloride or hydroxide, or with aluminum or zinc in some appropriate form such as powder or granules. However, such chemical precipitation methods provide only very limited removal of Se when it is present in the selenate (SeO_4^{-2}) form. Therefore, when Se is present in the selenate oxidation state (Se^{+6}), other methods generally must be considered for treatment.

Laboratory tests and pilot plant studies have shown that chemical precipitation, employing alum, lime, ferrous sulfate or ferric sulfate, is substantially ineffective for removing Se in the selenate oxidation state from water. Studies on water having a Se concentration of 0.03 to 10 mg per liter have shown that the conventional chemical precipitation methods remove less than 10% of the Se from the water according to the United States Environmental Protection Agency (US EPA), “Manual of Treatment Techniques for Meeting the Interim Primary Drinking Water Regulations,” (May 1977, pages 29-31).

An alternative treatment process that precipitates the Se as metal selenate or metal selenite has been recently patented and demonstrated. This technology is effective due to its co-precipitation with a soluble sulfate, which encapsulates the metal selenate or metal selenite. The process can be carried out in a batch or continuous manner. While any metal salt and any soluble sulfate could theoretically be used, the process has been demonstrated with the use of barium chloride and ferrous sulfate. The company holding the patent for this process claims to have the capability to apply this treatment to wastewater received at their treatment facility in Oklahoma. A large scale, onsite application of this process has not been demonstrated. At this time, the process would have to be considered experimental, at least in terms of the subject application.

8.2.2.3 Adsorption

Literature published to date by US EPA and others reports removal efficiency of greater than 98% of Se with ALCOA™ F-1 alumina. F-1 alumina has an inherently low chemisorptions capacity, which means that a large amount of this material would be required per volume of water treated. The literature does not describe other successful applications of adsorption techniques for treating Se-contaminated water. In addition, many problems (e.g., algae buildup and used adsorbent disposal) could be anticipated with pumping high flows of the Alcoa water through adsorption columns. The costs appear to be comparable to those associated with ion exchange as described in Section 2.1.

8.2.2.4 Biological Systems

Variations of treatment systems based on biological methods have been demonstrated for the treatment of Se. Two of these systems could be described as:

1. Constructed wetlands, and
2. Bioreactor.

Constructed Wetlands - It has been found that flow-through wetland areas populated with certain plant species, such as cattail and bulrush, provide treatment for Se. Even wetland cells with no plant species, colonized by naturally occurring algae and other microbes, can be effective. As a wetland system matures and organic debris and microbial biomass builds up, the wetland's ability to remove Se improves. Se is incorporated into plant tissue and volatilized into the atmosphere, but the majority is tied up with the sediment particles of the wetland.

Although constructed wetlands are applicable in certain situations, it would be difficult to apply this technology given the situation at Clean Harbors. For Clean Harbors flow rate, a rock-reed type wetland system would require the construction of about 8 acres of lined cells. Given the special soil conditions and ground contamination in the area, the cost of construction could be expected to cost at least $8 million.

Bioreactor - Other biological methods for treating wastewater contaminated with Se have been studied for many years in California. One particular method was developed as a result of the attention focused on treatment of agricultural drainage water in the San Joaquin Valley. This Valley has about 1.1 million acres of extremely productive land, which is under irrigation. The land is generally low-lying and requires drainage in order to avoid high salinity in crop root zones. A major scheme to drain off subsurface water after use for irrigation has been frustrated by discovery of high levels of contaminants. The drainage water is brackish, and has a relatively high concentration of salts and potentially toxic elements, with Se representing a particular problem.

The bioreactor involves treating the water in a reactor containing a microbial biomass in which reducing activity can occur. The method causes the Se to be converted to insoluble forms of Se, including elemental Se, which can be captured or entrained by larger particles. The discharge from the reactor can then be processed to remove along particles with the captured Se. Conversion of the Se to filterable form is accompanied by conversion to volatile Se compounds, typically including hydrogen selenide and methyl selenide. Such compounds can also be eliminated from the discharge of the reactor.

The water to be treated by this process is normally spiked with a nutrient for the biomass, especially an assimilable carbon source. Free oxygen must be eliminated from the reactor so that the biological conversion proceeds in an anaerobic or anoxic state. The reactor can take the form of a single or multi-stage reactor, with suitable reactor types including fixed-bed reactors, fluidized-bed reactors, sludge-blanket reactors, and stirred reactors.

After carrying out the biological conversion, the Se is in different forms, including:

1. Organically bound (probably in the form of a soluble complex compound),
2. Captured by larger particles,
3. Captured by the biomass retained in the reactor,
4. Volatile organic, and
5. Inorganic Se compounds.

Se captured by larger particles can be removed, by filtration. Volatile Se compounds are allowed to escape as gas from the water. Biological methods are especially suited for removing the selenate form of Se from water that contains a high concentration of sulfate. Although the reaction mechanism is not known, it is possible that during fermentation extra-cellular amino acids form organic complexes with the Se and these are subsequently assimilated by the microorganisms in the biomass. Precipitation or co-precipitation may also occur. The particles might contain one or more organic complexes, some of which may be in suspension or some in solution. The Se compounds may also absorb or adsorb on the surface of microbial cells, which subsequently can be removed by precipitation.

Selenate is a known competitive inhibitor of sulfate reduction, having a 40-fold greater affinity for the enzyme uptake system than the sulfate ions. Generally, the growth of the biomass needs to be promoted by supplementing the Se-containing water with a nutrient. The nutrient feed can be incorporated in the water to be treated, or can be applied in a separate feed to the reactor. The nutrient can include a readily biodegradable organic compound, for example methanol, ethanol, or a mixture of organic wastes. Nitrogen and phosphorous may have to be added in order to generate and sustain the necessary biochemical activity, if they are not already sufficiently present in the water to be treated. The system must be operated so that there is only a small residual of nitrate-nitrogen left in the reactor at the outlet (less than 1 mg/L). Residual nitrate-nitrogen in the reactor will interfere with the selenate reduction process.

The bacterial biomass will be heterotrophic but will not be of a specific strain and is unlikely to be a pure culture. The biomass may initially be composed of organisms growing from natural contamination. Suitable bacteria are likely to include strains belonging to the genera *Hyphomicrobium*, *Corynebacterium*, *Salmonella*, *Pseudomonas*, and *Bacillus*. There is no need for special seeding of the reactor unless the water is sterile, but in practice it is possible to save time by seeding with sludge from a sewage treatment plant, preferably from an anoxic nitrate-removing reactor or an ordinary activated sludge reactor.

Setting up a biological reactor to treat 1.0 mgd (maximum) would require an anoxic reactor followed by filtration. Chemical feed systems to inject nutrients and a carbon source would be required. The capital costs for such a system are estimated to be about $5.3 million. The operating costs would be about $475,000 annually. While this cost is high, it represents the most cost effective treatment available. Given the low permit limits and the lack of operating history, this type of approach would not be guaranteed to consistently achieve the permit requirements.

8.2.2.5 Pipeline

The possibility exists that a pipeline could be installed to route the effluent from the Internal Outfall 009 to the Ouachita River. The Ouachita is the only river/stream in the area that carries sufficient flow to potentially dilute the Se to below water quality standards. Discharging to the Ouachita River would require the construction of a pipeline of about 15 miles in length. This alternative would require that all of the wastewater from the onsite water treatment plant be pumped through the pipeline. It would require the construction of a 6-inch diameter force main and a pump station with adequate capacity for the operation. For this size pipeline, a polyethylene line could be routed underground. The estimated costs for this project would be about $100,000 for the pump station and about $20/linear foot for the installed pipe. This includes an allowance for the purchase of right of way. However, it is not assured that the right of way could be purchased at this cost. Based on these preliminary estimates, the capital costs associated with the pipeline alternative would be about $16 MM. The primary operating costs for this option would result from the electrical costs associated with pumping and the maintenance of the pumping station and pipeline. This is estimated at about $40,000 annually.

8.2.3 Regulatory Changes – Site Specific Criterion

Results of the fish tissue analyses indicate that existing Se concentrations in Boggy Creek do not impair the fish populations of Boggy Creek. Therefore, a site-specific criterion for Se that does not increase existing Se concentrations in Boggy Creek will protect aquatic life in Boggy Creek.

Table 8.3 provides instream Se concentrations in Boggy Creek at 2 locations downstream of Outfall 009 (BC-1 and BC1-3) on 5 sampling dates from the supplemental sampling conducted 9/6/06 through 11/27/06. These data plus those from the May and July 2006 sampling data (Tables 4.5 and 4.6) provide 17 measurements of total Se concentrations in Boggy Creek downstream of Outfall 009. However, as described previously, data collected on 10/16/06 should be discarded due to a likely sampling error. Therefore, a total of 15 Se measurements were available for this analysis.

A value equivalent to the 95th percentile of the instream concentrations was selected as a value representative of the upper bound of instream Se concentrations. Because a calculated 95th percentile using interpolation based on 15 observations is not reliable, the upper 95th percentile was estimated using the value of the normal deviate, Z, assuming a normal distribution (Sokal and Rohlf, 1995)[4]. The mean and standard deviation of the downstream Se data were 7.967 mg/L and 3.875 mg/L, respectively. The value corresponding to the upper 95th percentile in a normal distribution is given by X in $Z = (X - u)/s$ where $u = 7.967$ mg/L, $s = 3.875$ mg/L and $Z = 1.96$ (the normal deviate corresponding to 95% of the area under the normal curve; Table A in Rohlf and Sokal, 1995). From this calculation a 95th percentile value of 15.6 ug/L is obtained. This value represents an upper bound of total Se concentrations in Boggy Creek below Outfall 009 based on measured concentrations. Therefore a value of 15.6 ug/L total Se is proposed as an instream criterion representing the upper bound of existing concentrations and a value below which adverse effects on sensitive species due to Se should not be observed.

Table 8.2. Outfall and downstream Total Se concentration measured during supplemental sampling conducted 9/6/06 through 11/27/06. .

Sampling Date	Station					
	BC-1	BC-1-3	BC-1-3a	BC-2	BC-3	Outfall 009
5/17/06	4.0	7.1				
7/18/06	4.6	2.8				
9/6/06	12	5.6			5	26
9/27/06		5.3	9.3	4.3		
10/2/06	11	7.6			6.2	24
10/16/06	24	13			18	4.0
10/30/06	10	17			5.8	34
11/13/06	4.4	6.9			3.8	13
11/27/06	9.2	12			7.8	20

[4] The Kolmogorov-Smirnov test for normality (Sokal and Rohlf, 1995) on untransformed data indicated non-significant skewness (skewness coefficient = 0.8337; $P = 0.14$) and a non-significant Kolmogorov-Smirnov coefficient (0.5621; $P > 0.15$). Therefore, the normal approximation procedure using untransformed data is valid.

8.2.4 Site Specific Criteria

The information provided in this section and summarized in Tables 8.1 and 8.2 indicate that alternatives to regulatory changes are either unlikely to result in permit compliance, costly to implement, or both.

Fish tissue and sediment data presented in preceding sections indicate that whole body Se residues in fish in Boggy Creek and Bayou de Loutre are well below levels at which adverse effects begin to occur in sensitive fish species. In addition, Se concentrations in Boggy Creek sediments are below levels indicated in the literature as having the potential to bioaccumulate in the food web. Therefore existing Se concentrations in the Boggy Creek resulting from the Clean Harbors discharge are not accumulating to toxic levels in fish in Boggy Creek or downstream habitats (i.e., Bayou de Loutre) and show a low potential to accumulate in the food wed via the sediments. Section 4.4.3 provides support for proposed support values that will not cause toxicity in the Clean Harbor 009 discharge. Accordingly, the following site specific WQC consistent with existing conditions in the Clean Harbors discharge will be protective of the aquatic life uses in Boggy Creek and downstream habitats.

1. TDS – 1360 mg/L
2. Chloride – 631 mg/L
3. Sulfate – 63 mg/L
4. Total Se – 15.6 mg/L

8.2.5 Summary of Costs

Three alternatives were considered for the management of the discharge from the facility to achieve compliance with the new Se limitations:

1. Source Control,
2. Installation of a treatment system, and
3. Installation of a pipeline to the Ouachita River.

Table 8.3 provides a summary of the estimated costs associated with each option. The expected costs associated with providing a change to the WQC has been included for comparison purposes. A rating has also been provided to evaluate the technical considerations with each option and the potential for success. The rating is based on a 1 to 10 scale with 10 representing a high degree of confidence for success and minimal technical difficulties. This rating is basically a professional judgment by the reviewing engineer.

Table 8.3. Summary of capital, operating and implementation costs.

Option Description	Estimated Capital Cost	Estimated Annual Operating Cost	Technical Rating
Source Control	-	$290,000	4
Treatment	$5,300,000	$475,000	4
Pipeline to Ouachita River	$16,000,000	$40,000	9
Regulatory changes	$200,000	-	9

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APPENDIX A

Draft Teris LLC Selenium and Dissolved Solids Sources and Source Control Report

TERIS LLC

(NPDES PERMIT NO. AR0037800)

SELENIUM AND DISSOLVED SOLIDS SOURCES AND SOURCE CONTROL

DRAFT
March 16, 2006

TERIS LLC

(NPDES PERMIT NO. AR0037800)

SELENIUM AND DISSOLVED SOLIDS
SOURCES AND SOURCE CONTROL

Prepared for

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DRAFT
March 16, 2006

EXECUTIVE SUMMARY

Teris LLC (Teris) owns and operates an incinerator facility at El Dorado, AR (Union County). Prior to Teris' acquisition of the property, the site was a former petroleum refinery operation with documented soil and groundwater impacts. The current National Pollutant Discharge Elimination System (NPDES) permit for Teris, which became effective October 1, 2004, contains provisions for new effluent limitations for Total Dissolved Solids (TDS) and Total Selenium (Se). These new limitations, which are required to be monitored and reported for 3 years, will become enforceable after November 1, 2007.

The available analytical data for both TDS and Se indicate it will not be possible for Teris to meet these new limitations. Teris enlisted the assistance of FTN Associates, Ltd. (FTN) to study the sources of TDS and Se and to provide recommendations for possible methods to address manage the new limitations.

FTN began a study that included, among other tasks, data collection of various streams that contribute water to Outfall 009 to identify the sources of Se and TDS. Based on the data collected during this study, TDS is present in the groundwater under the site at relatively high concentrations. The blowdown from the cooling tower (CT) is another significant source of TDS. However, converting from the use of well water to City of El Dorado water to reduce TDS would add significantly to the cost of operations and still not allow Teris to consistently meet impending NPDES permit limitations. The widespread distribution of Se at the site and the nature of the historical refinery operations strongly suggest that the source of Se is primarily connected to residues from previous refinery operations.

Based on the concentration values and the characteristics of the different sources, it does not appear that the application of source control or waste minimization techniques alone will achieve compliance with the new effluent limitations. The study is ongoing regarding the feasibility and potential costs associated with treatment for the constituents. Data and information related to these issues will be incorporated into the final document.

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1.0 INTRODUCTION

The current National Pollutant Discharge Elimination System (NPDES) permit for Teris LLC (Teris) which became effective October 1, 2004, contains provisions for new effluent limitations for Total Dissolved Solids (TDS) and Total Selenium (Se). These new limitations, which are required to be monitored and reported for 3 years, will become enforceable after November 1, 2007.

The available analytical data for both TDS and Se indicate problems in achieving effluent concentrations associated with these new limitations. Teris enlisted the assistance of FTN Associates, Ltd. (FTN) to study the sources of TDS and Se and to provide recommendations for possible methods to manage the new limitations.

FTN proposed a study that included data collection of various streams that contribute water to Outfall 009 in an effort to identify the sources of Se and TDS. Figure 1.1 shows a simplified schematic that shows the sources of water to the outfalls at the Teris facility.

1.1 Background

Outfall 009 is located at the mouth of a ditch (South Ditch) that traverses the Teris property along the south side of the main production area (Figure 1.2). The South Ditch receives water from several sources including stormwater runoff from private property along the western property line as well as runoff from areas of the plant property. The discharge from the waste water treatment plant (WWTP) for the facility also passes through this outfall. This WWTP treats water that is derived from three primary sources:

1. Groundwater from the French drains that are part of the remediation efforts associated with past refinery operations;
2. Stormwater runoff from the plant site that is collected in Retention Areas (RA) 4 and 10; and
3. Process wastewater which primarily consists of blowdown from the cooling tower (CT).

The receiving stream for Outfall 009 is Boggy Creek.

Outfall 007 is located downstream from Retention Area 10 which collects stormwater runoff from the west side of the Teris property. The outfall rarely discharges however, during some storm events and high flows in Boggy Creek, stormwater can be discharged directly through Outfall 007. If the outfall is utilized, the rate of discharge is limited and proportional to the rate of flow in Boggy Creek. The rate of flow is controlled by a set of valves at Outfall 007. The receiving stream for Outfall 007 is also Boggy Creek at a point approximately 600 ft upstream from Outfall 009.

Outfall 001 is located downstream from Retention Area 106 which collects stormwater runoff from the northeast side of the Teris property. Discharges from this outfall are also rare (similar to Outfall 007). In the event Outfall 001 discharges, the discharge enters a small ditch that also receives Outfall 007 discharge and that empties into Boggy Creek at a point approximately 600 ft upstream from Outfall 009.

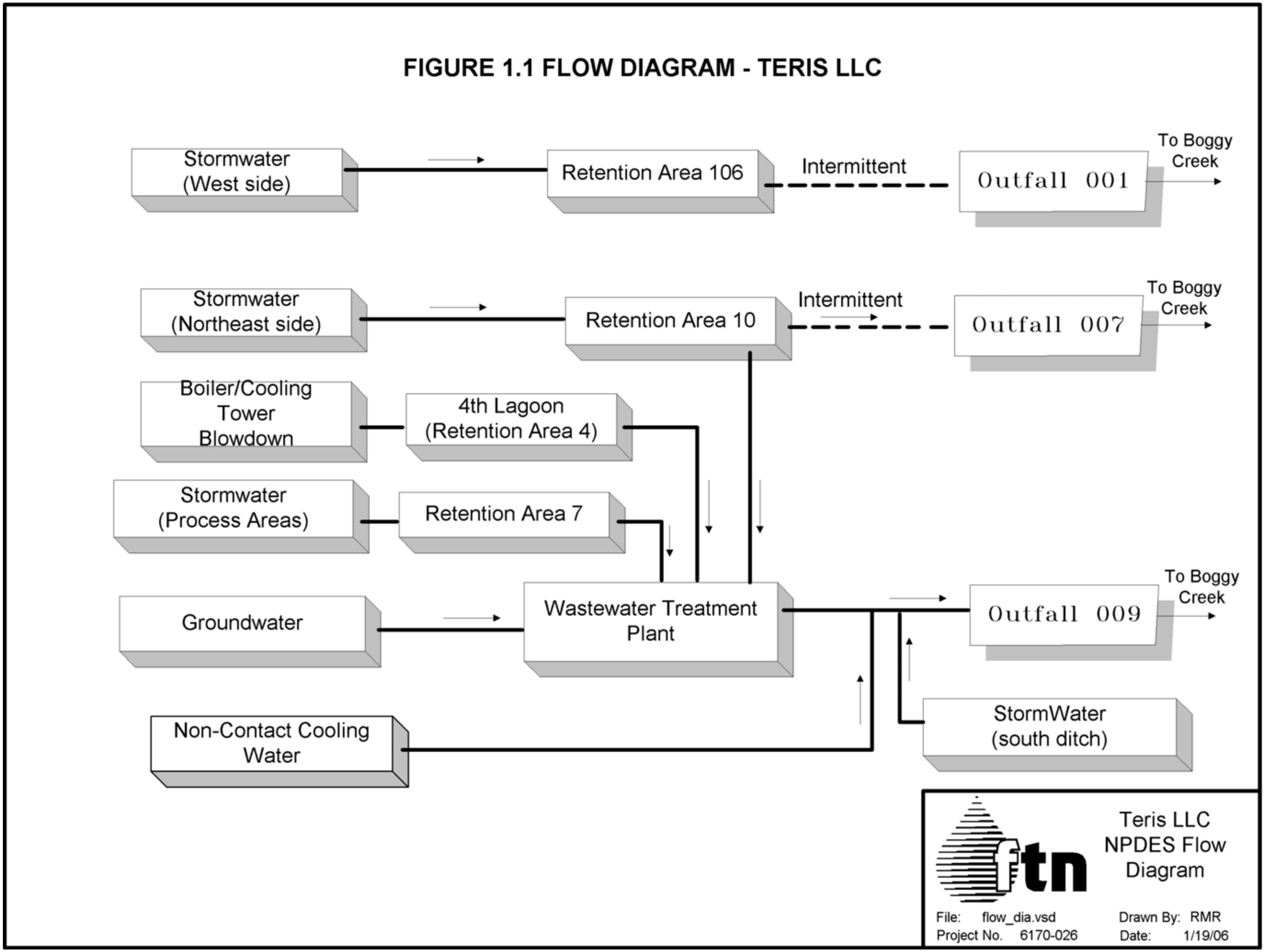

Figure 1.1. Flow diagram.

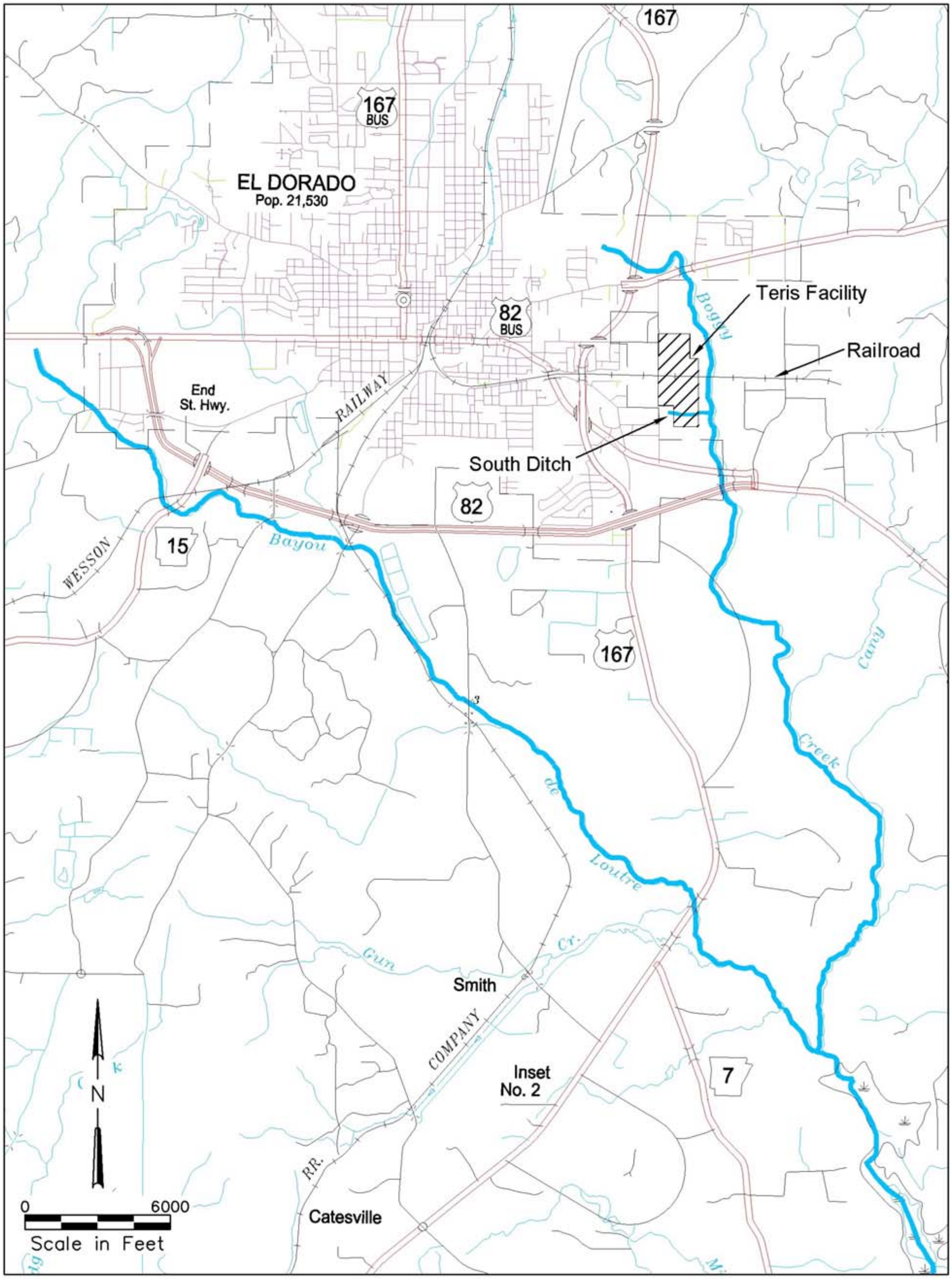

Figure 1.2. Project vicinity map.

2.0 SAMPLING METHODS

2.1 Sampling Stations

The following sampling stations were selected in order to characterize the primary components of the Teris discharges as well as Boggy Creek in the vicinity of the plant.

1. BC–1: Boggy Creek at the Hwy. 82 bridge located approximately 4,000 ft downstream from Outfall 009.
2. BC-2: Boggy Creek approximately 300 ft downstream from Outfall 009.
3. BC-3: Boggy Creek approximately 300 ft upstream of inflows from the Teris NPDES outfalls 001 and 007,
4. SD-1: South Ditch approximately 1,000 ft upstream from Outfall 009 Internal.
5. SD-2: South Ditch approximately 100 ft upstream from Outfall 009 Internal.
6. 009 Upstream: South Ditch immediately upstream from Outfall 009.
7. 009 Internal: The 009 internal outfall upstream from the South Ditch.
8. RA10: Retention Area 10. Stormwater from the northeast part of the site collected in Retention Area 10, which typically is pumped to the WWWTP but could discharge through Outfall 007 during a large storm event.
9. RA10 Treated: Treated water from Retention Area 10 prior to mixing with other water.
10. Treated GW: Recovered groundwater that has been treated, prior to mixing with other water.
11. RA4: Retention Area 4. CT and Boiler blowdown water.
12. CT: Cooling Tower blowdown.
13. RA7: Retention Area 7. Stormwater runoff from process areas collected in Retention Area 7.
14. Makeup to CT: Water from the on-site well that provides water to the CT.
15. Culvert: Surface flow from seepage in drainages downstream from Outfalls 001 and 007 as well as other areas impacted by previous refinery operations. There were no discharges through the 001 or 007 outfalls during the study.

2.2 Wet Weather Sampling

To obtain data regarding the potential sources of Se and TDS in the water from Outfall 009, a sampling program was developed and initiated with a round of wet weather samples taken at various areas around the plant as well as in the receiving stream. These samples were collected on April 7, 2005 by FTN staff using clean sampling techniques. The areas sampled included Boggy Creek, the South Ditch and various water sources that contribute flow to Outfall 009 described in Section 2.1.

2.3 Dry Weather Sampling

Additional rounds of sampling were taken under dry weather conditions. In general, the sampling locations were the same as for the wet weather sampling described above.

Ultimately five rounds of dry weather samples were collected. A total of 15 stations were sampled with a subset of eight stations sampled repeatedly. These samples occurred over a span of 4 months during the Summer and early Fall of 2005.

2.4 Analytical Techniques

In all cases, analytical services were provided by American Interplex (AI) Corporation of Little Rock, AR (an Arkansas Department of Environmental Quality (ADEQ) certified laboratory). Water samples were analyzed using the United States Environmental Protection Agency (USEPA) Method 200.8 for Se, USEPA Method 160.1 for TDS and USEPA 300.0 for sulfate and chloride. The laboratory data sheets are included with this report as Appendix A (with the final version).

3.0 RESULTS AND ANALYSIS

3.1 Sampling data

Sampling data are shown in Tables 3.1 through 3.4 for Se, TDS, chloride, and sulfate, respectively. The chloride and sulfate, which form a portion of the TDS, were analyzed to provide information about sources of the TDS.

Wet weather samples showed no exceedences of future NPDES limitations or acute or chronic Arkansas Water Quality Standards (AR WQS) for Se (0.020 mg/L and 0.005 mg/L, respectively) at any station sampled. Dry weather water samples indicated low levels of Se at various locations across the Teris plant site that exceeded the chronic AR WQS (see Table 3.1 for the Se data):

1. BC-3,
2. SD-1,
3. 009 Upstream,
4. 009 Internal,
5. RA10,
6. RA10 Treated,
7. Makeup to CT,
8. Treated GW,
9. CT,
10. RA4,
11. RA7, and
12. Culvert.

Selenium concentrations in samples from the "Culvert," the groundwater makeup to the CT, treated recovered groundwater, Retention Area 10 and Outfall 009 Internal averaged approximately three times higher than the Arkansas chronic WQS. Selenium in the samples of the CT and water from Retention Area 4 (the CT Blowdown) were significantly higher than the Arkansas chronic and acute WQS.

The data in Table 3.1 indicate that Se appears in several samples of groundwater and surface runoff from the site as well as Boggy Creek upstream from the Teris' point sources (sampling location BC-3). It has been documented (Barbour 1999, EPRI 2001, and Hamilton 2004) that contamination of Se in groundwater and stormwater is generally associated with mining activities, petroleum or metal refining, or natural erosion of Se bearing strata. Given the widespread distribution of the Se at this site, in the groundwater as well as the surface runoff, and given the history of soil contamination with petroleum and oil residues, it appears that the previous refinery operations are the primary sources of the Se contamination in the water at this site.

The data in Table 3.2 indicates that the CT blowdown is a primary source of TDS. This is shown in the samples taken from the blowdown and from water in Retention Pond 4 which primarily consists of this blowdown. As with the dry weather Se data, however, several sources showed elevated levels of TDS. The treated water from Retention Area 10, which averages approximately 70 gpm, has concentrations of TDS over 800 mg/L. The treated groundwater has TDS concentrations over 300 mg/L.

3.2 Discharge Monitoring Reports

Teris has been monitoring TDS on a monthly basis at 009 since the latest NPDES permit became effective in November 2004. From the Discharge Monitoring Reports (DMRs), the average value for TDS is approximately 550 mg/L over that time period. The highest daily maximum value reported over that period of time was 1,400 mg/L.

For Se, quarterly sampling at 009 is required. For the samples collected in the 4th quarter of 2004 through the 3rd quarter of 2005, the concentration of Se has ranged from a low of 7.5 µg/L up to a maximum value of 29 µg/L. All of the samples would have exceeded the chronic AR WQS (5 µg/L). The maximum value exceeded the acute AR WQS (20 µg/L).

Table 3.1. Selenium data.

Station	Location Description	Wet	Dry 1	Dry 2	Dry 3	Dry 4	Dry 5	n	Avg.
BC-1	Boggy Creek at Hwy 82 Bridge approximately 4,000 ft downstream from Outfall 009	<0.002	0.0033					2	0.0022
BC-2	Boggy Creek approximately 300 ft downstream from Outfall 009	<0.002	0.0036					2	0.0023
BC-3	Boggy Creek approximately 300 ft upstream from Outfall 007)	<0.002	0.0059					2	0.0035
SD-1	South Ditch approximately 1,000 ft upstream from Outfall 009 Internal	<0.002	N/A	0.0092	0.037	0.019	0.018	5	0.0168
SD-2	South Ditch approximately 100 ft upstream from Outfall 009 Internal)	<0.002	<0.002					2	0.0010
009 Upstream	South Ditch, immediately upstream from Outfall 009	<0.002	0.0079					2	0.0045
009 Internal	Internal outfall	<0.002	0.0076	0.0082	0.031	0.021	0.018	6	0.0143
RA10	Retention Area 10	<0.002	N/A	0.015	0.013	0.016	0.017	1	0.0124
RA10 Treated	Treated water from Retention 10	<0.002	0.0099					2	0.0055
Treated GW	Treated groundwater	<0.002	0.0074	0.018	0.018	0.015	0.017	6	0.0127
RA4	Retention Area 4	<0.004[7]	0.036	0.035	0.029	0.049	0.057	6	0.0347
CT	Blowdown from CT	<0.01[7]	N/A	0.084	0.028	0.029	0.046	5	0.0384
RA7	Retention Area 7			0.0062	0.0046	0.0082	0.021	4	0.0100
Makeup to CT	Makeup to CT (from well)			0.020	0.018	0.012	0.0096	4	0.0149
Culvert	Water from culvert, downstream from Outfalls 007, 001		0.017					1	0.017

Notes: 1) All values are shown as mg/L
2) Wet-Sample taken under wet weather conditions
3) Dry 1-Sample taken on 6-29-05
4) Dry 2-Sample taken on 8-29-05
5) Dry 3-Sample taken on 9-6-05
6) Dry 4-Sample taken on 9-12-05
7) Elevated detection level due to interference.
8) N/A=Not Applicable

Table 3.2. TDS data.

Station	Location Description	Wet	Dry 1	Dry 2	Dry 3	Dry 4	Dry 5	n	Avg
BC-1	Boggy Creek at Hwy 82 Bridge approximately 4,000 ft downstream from Outfall 009	220	240					2	230
BC-2	Boggy Creek approximately 300 ft downstream from Outfall 009	220	300					2	260
BC-3	Boggy Creek approximately 300 ft upstream from Outfall 007)	140	200					2	170
SD-1	South Ditch approximately 1,000 ft upstream from Outfall 009 Internal	96	N/A	450	1,200	1,300	1,200	5	849
SD-2	South Ditch approximately 100 ft upstream from Outfall 009 Internal)	270	290					2	280
009 Upstream	South Ditch, immediately upstream from Outfall 009	750	550					2	650
009 Internal	Internal outfall	920	580	460	980	1,400	1,200	6	923
RA10	Retention Area 10	830	910					1	870
RA10 Treated	Treated water from Retention 10	1,100	N/A	850	880	1,200	1,100	2	1,026
Treated GW	Treated groundwater	420	350	450	580	660	560	6	503
RA4	Retention Area 4	790	2,400	1,800	2,500	2,600	2,300	6	2,065
CT	Blowdown from CT	2,300	N/A	4,700	2,700	2,900	3,100	5	3,140
RA7	Retention Area 7			130	140	310	730	4	328
Makeup to CT	Makeup to CT (from well)			990	790	890	760	4	858
Culvert	Water from culvert, downstream from Outfalls 007, 001		670						670

Notes: 1) All values are shown as mg/L
2) Wet-Sample taken under dry weather conditions
3) Dry 1-Sample taken on 6-29-05
4) Dry 2-Sample taken on 8-29-05
5) Dry 3-Sample taken on 9-6-05
6) Dry 4-Sample taken on 9-12-05
7) N/A=Not Applicable

Table 3.3. Chloride data.

Station	Location Description	Wet	Dry 1	Dry 2	n	Avg
BC-1	Boggy Creek at Hwy 82 Bridge approximately 4,000 ft downstream from Outfall 009	72	89		2	215
BC-2	Boggy Creek approximately 300 ft downstream from Outfall 009	79	120		2	100
BC-3	Boggy Creek approximately 300 ft upstream from Outfall 007)	36	100		2	68
SD-1	South Ditch approximately 1,000 ft upstream from Outfall 009 Internal	4.9	N/A	200	2	102
SD-2	South Ditch approximately 100 ft upstream from Outfall 009 Internal)	91	57		2	74
009 Upstream	South Ditch, immediately upstream from Outfall 009	340	260		2	300
009 Internal	Internal outfall	410	270	200	3	293
RA10	Retention Area 10	370	N/A		1	370
RA10 Treated	Treated water from Retention 10	360	520	420	3	433
Treated GW	Treated groundwater	160	140	170	3	157
RA4	Retention Area 4	340	990	750	3	693
CT	Blowdown from CT	1,000	N/A	2,200	2	1,600
RA7	Retention Area 7			25	1	25
Makeup to CT	Makeup to CT (from well)			470	1	470
Culvert	Water from culvert, downstream from Outfalls 007, 001	N/A	320		1	320

Notes: 1) All values are shown as mg/L
2) Wet-Sample taken under wet weather conditions
3) Dry 1-Sample taken under dry weather conditions
4) Dry 2-Sample taken under wet weather conditions
5) N/A=Not Applicable

3.3 Flow Data

For Outfall 009, flow data was obtained from the DMRs for the time period from November 2004 to October 2005. During this time, the average flow was approximately 0.24 mgd. The daily maximum flow recorded was 5.65 mgd which apparently included a significant amount of stormwater from the upstream drainage.

Significant sources of flow to Outfall 009 include the following:

- The CT blowdown and Retention Area 4 which can produce about 50 gpm with intermittent operation.
- Retention Area 10 at about 60-70 gpm.

- Recovered groundwater at about 70 gpm.
- Stormwater from the drainage in the South Ditch which can range from zero during dry periods to over 3,400 gpm during heavy storm events.

Table 3.4. Sulfate data.

Station	Location Description	Wet	Dry 1	n	Avg
BC-1	Boggy Creek at Hwy 82 Bridge approximately 4,000 ft downstream from Outfall 009	8.4	6.7	2	7.6
BC-2	Boggy Creek approximately 300 ft downstream from Outfall 009	8.2	6.6	2	7.4
BC-3	Boggy Creek approximately 300 ft upstream from Outfall 007)	4.1	4.8	2	4.4
SD-1	South Ditch approximately 1,000 ft upstream from Outfall 009 Internal	4.6	N/A	1	4.6
SD-2	South Ditch approximately 100 ft upstream from Outfall 009 Internal)	5.8	0.33	2	3.1
009 Upstream	South Ditch, immediately upstream from Outfall 009	36	12	2	24
009 Internal	Internal outfall	43	13	2	28
RA10	Retention Area 10	64	66	2	65
RA10 Treated	Treated water from Retention 10	64	N/A	1	64
Treated GW	Treated groundwater	9.4	6.0	2	7.7
RA4	Retention Area 4	39	36	2	37.5
CT	Blowdown from CT	38	N/A	1	38
Culvert	Water from culvert, downstream from Outfalls 007, 001	N/A	1.8	1	1.8

Notes: 1) All values are shown as mg/L
2) Wet-Sample taken under wet weather conditions
3) Dry 1-Sample taken under dry weather conditions
4) Dry 2-Sample taken under wet weather conditions
5) N/A=Not Applicable

Based on the chloride and sulfate data, a large portion of the TDS is associated with chloride. In some cases, as with the TDS in Retention Area 10, the source appears to be present operations. With the treated groundwater, the results reflect past refinery operations with possible contribution from the incineration process.

3.4 Source Control/Other Options

As shown in Figure 1.1, there are several sources that contribute water to Outfall 009. Because each of the major sources can potentially be the primary flow on any given day, source control would require efforts for each waste stream that demonstrated effluent concentrations above the new limitation.

For the recovered groundwater, ongoing remediation is required and source control cannot be applied. The existing treatment system for this groundwater is not effective for the removal of TDS and cannot be modified to be effective.

The CT blowdown represents the most significant source of TDS at the Teris facility. Groundwater is cycled several times within the CT and the concentrations of dissolved solids increase with each cycle. Maintaining the level of dissolved solids in the CT water is a major factor in determining the rate of blowdown. Using makeup water with higher purity would reduce the rate of blowdown but this would require identifying a source of water with lower dissolved solids than the groundwater currently being used.

The use of city water for this source would substantially increase operations costs at Teris where operating margin is an important issue. This statement considers costs associated with the well water conservation fee, additional wastewater treatment, etc. Analysis of this effect is ongoing at this time and will be included in the final version of this report.

An alternative would be to petition the City Utility to accept this wastewater for disposal in the sanitary sewer system. The City Utility has been approached about this subject. While agreeing to accept the sanitary wastewater from the plant, the Utility declined to accept the CT blowdown. If the City would accept the blowdown, the Teris facility would have difficulty meeting the effluent limits for TDS required by the new permit. This is due to the intermittent nature of these wastewater streams (i.e., no consistent dilution source) and the other contributing sources of TDS such as groundwater and Retention Area 10.

For stormwater, source control could be effective for the reduction of TDS. Teris has implemented measures to identify and cover or remove obvious sources. However, stormwater is an intermittent contribution to Outfall 009 and cannot be depended on for dilution, even if the concentration of TDS could be reduced to zero.

There are several source areas that contribute the Se to the NPDES outfalls, although the ultimate source appears to be the previous refinery operations. Ongoing remediation of the groundwater contamination from the refinery is critical for groundwater protection in this area of Arkansas. The same situation regarding source control would apply as described above for TDS. As with the TDS, the diversion of the CT blowdown would remove a primary source of the Se, but would not prove adequate to achieve compliance with the future permit conditions (see Table 3.1). Also, the existing treatment system is not effective for the treatment of Se.

A separate study is ongoing regarding the feasibility and potential costs associated with treatment for both Se and TDS. The preliminary conclusions of the study are that treatment would be expensive and would not guarantee removals down to the upcoming effluent limitations. This is particularly true for Se, the treatment of which is still regarded as experimental on a case-by-case basis according to the literature and FTN experience.

4.0 SUMMARY

Based on the data collected by this study, a significant source of TDS at the Teris plant is the recovered groundwater. The blowdown from the CT is another significant source of TDS. Significant Se concentrations were detected in samples throughout the plant site. The widespread distribution of Se at the site and the nature of former operations at the site prior to Teris strongly suggest the source of Se is primarily connected to residues from the previous refinery activities at this site.

Based on the widespread presence of these constituents (at significant concentrations relative to the upcoming permit limits) in various sources of water from the plant, the application of source control or waste minimization techniques will likely not achieve compliance with upcoming permit limitations. Converting from well water to city water to reduce TDS would add significantly to the annual cost of operations for Teris but still would not allow Teris to consistently meet permit limits. A separate study is ongoing regarding the feasibility and potential costs associated with treatment.

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APPENDIX B

TDS and Se Source Evaluation Study, March 15, 2006

TERIS LLC

(NPDES PERMIT NO. AR0037800)

SELENIUM AND DISSOLVED SOLIDS SOURCES AND SOURCE CONTROL

DRAFT
March 16, 2006

TERIS LLC

(NPDES PERMIT NO. AR0037800)

SELENIUM AND DISSOLVED SOLIDS SOURCES AND SOURCE CONTROL

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March 16, 2006

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FTN began a study that included, among other tasks, data collection of various streams that contribute water to Outfall 009 to identify the sources of Se and TDS. Based on the data collected during this study, TDS is present in the groundwater under the site at relatively high concentrations. The blowdown from the cooling tower (CT) is another significant source of TDS. However, converting from the use of well water to City of El Dorado water to reduce TDS would add significantly to the cost of operations and still not allow Teris to consistently meet impending NPDES permit limitations. The widespread distribution of Se at the site and the nature of the historical refinery operations strongly suggest that the source of Se is primarily connected to residues from previous refinery operations.

Based on the concentration values and the characteristics of the different sources, it does not appear that the application of source control or waste minimization techniques alone will achieve compliance with the new effluent limitations. The study is ongoing regarding the feasibility and potential costs associated with treatment for the constituents. Data and information related to these issues will be incorporated into the final document.

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1.0 INTRODUCTION

The current National Pollutant Discharge Elimination System (NPDES) permit for Teris LLC (Teris) which became effective October 1, 2004, contains provisions for new effluent limitations for Total Dissolved Solids (TDS) and Total Selenium (Se). These new limitations, which are required to be monitored and reported for 3 years, will become enforceable after November 1, 2007.

The available analytical data for both TDS and Se indicate problems in achieving effluent concentrations associated with these new limitations. Teris enlisted the assistance of FTN Associates, Ltd. (FTN) to study the sources of TDS and Se and to provide recommendations for possible methods to manage the new limitations.

FTN proposed a study that included data collection of various streams that contribute water to Outfall 009 in an effort to identify the sources of Se and TDS. Figure 1.1 shows a simplified schematic that shows the sources of water to the outfalls at the Teris facility.

1.1 Background

Outfall 009 is located at the mouth of a ditch (South Ditch) that traverses the Teris property along the south side of the main production area (Figure 1.2). The South Ditch receives water from several sources including stormwater runoff from private property along the western property line as well as runoff from areas of the plant property. The discharge from the waste water treatment plant (WWTP) for the facility also passes through this outfall. This WWTP treats water that is derived from three primary sources:

1. Groundwater from the French drains that are part of the remediation efforts associated with past refinery operations;
2. Stormwater runoff from the plant site that is collected in Retention Areas (RA) 4 and 10; and
3. Process wastewater which primarily consists of blowdown from the cooling tower (CT).

The receiving stream for Outfall 009 is Boggy Creek.

Outfall 007 is located downstream from Retention Area 10 which collects stormwater runoff from the west side of the Teris property. The outfall rarely discharges however, during some storm events and high flows in Boggy Creek, stormwater can be discharged directly through Outfall 007. If the outfall is utilized, the rate of discharge is limited and proportional to the rate of flow in Boggy Creek. The rate of flow is controlled by a set of valves at Outfall 007. The receiving stream for Outfall 007 is also Boggy Creek at a point approximately 600 ft upstream from Outfall 009.

Outfall 001 is located downstream from Retention Area 106 which collects stormwater runoff from the northeast side of the Teris property. Discharges from this outfall are also rare (similar to Outfall 007). In the event Outfall 001 discharges, the discharge enters a small ditch that also receives Outfall 007 discharge and that empties into Boggy Creek at a point approximately 600 ft upstream from Outfall 009.

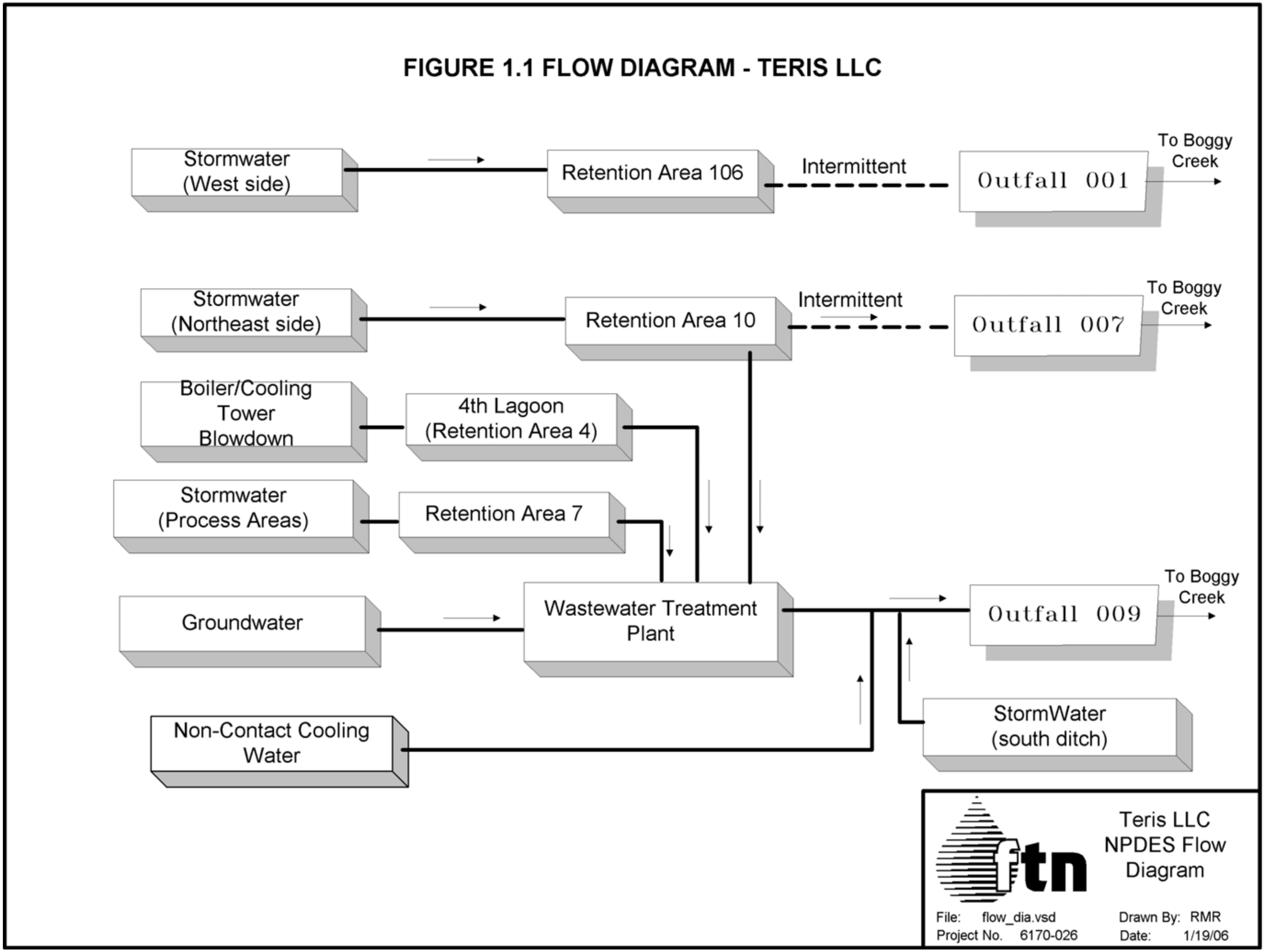

Figure 1.1. Flow diagram.

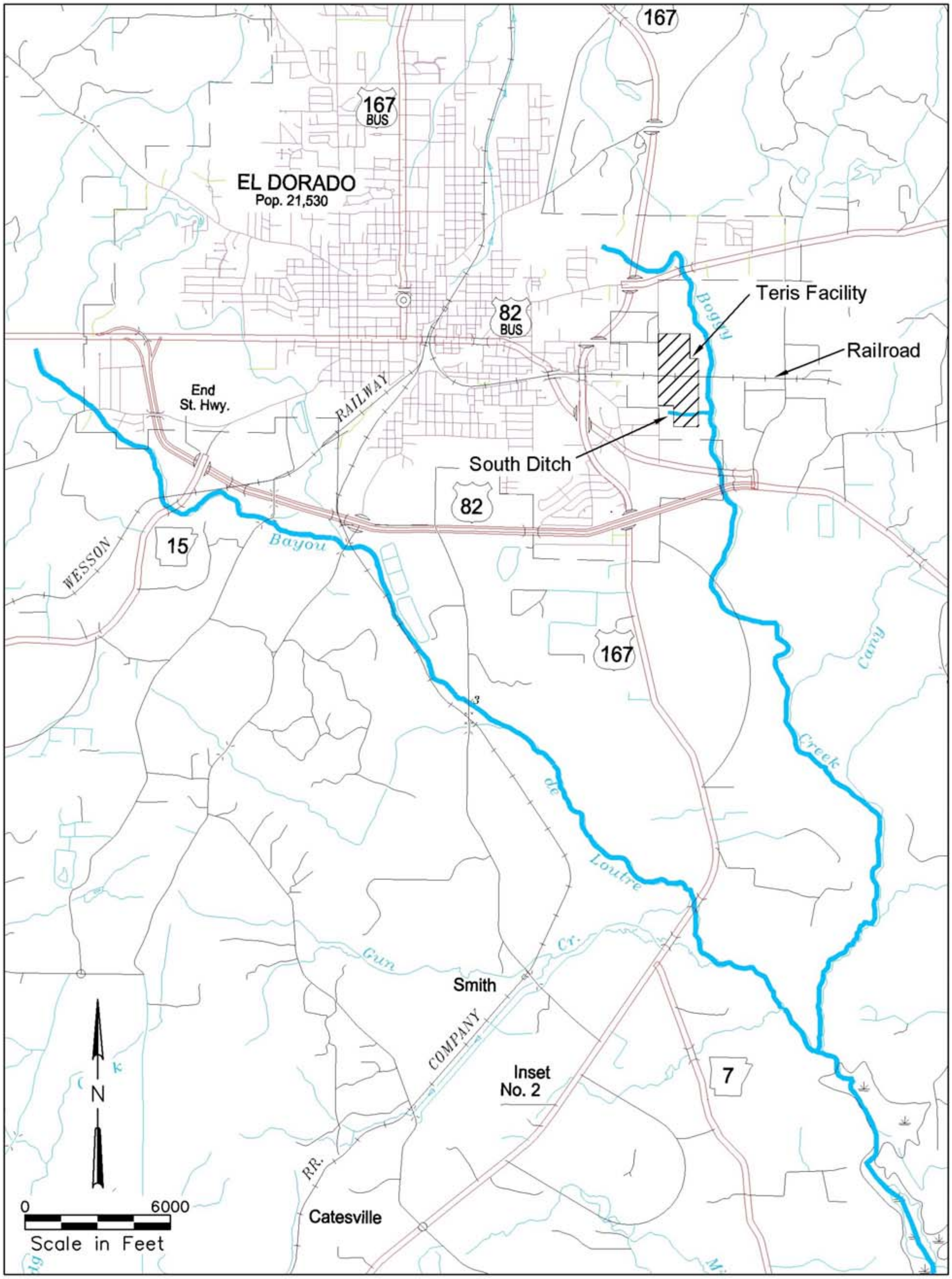

Figure 1.2. Project vicinity map.

2.0 SAMPLING METHODS

2.1 Sampling Stations

The following sampling stations were selected in order to characterize the primary components of the Teris discharges as well as Boggy Creek in the vicinity of the plant.

1. BC–1: Boggy Creek at the Hwy. 82 bridge located approximately 4,000 ft downstream from Outfall 009.
2. BC-2: Boggy Creek approximately 300 ft downstream from Outfall 009.
3. BC-3: Boggy Creek approximately 300 ft upstream of inflows from the Teris NPDES outfalls 001 and 007,
4. SD-1: South Ditch approximately 1,000 ft upstream from Outfall 009 Internal.
5. SD-2: South Ditch approximately 100 ft upstream from Outfall 009 Internal.
6. 009 Upstream: South Ditch immediately upstream from Outfall 009.
7. 009 Internal: The 009 internal outfall upstream from the South Ditch.
8. RA10: Retention Area 10. Stormwater from the northeast part of the site collected in Retention Area 10, which typically is pumped to the WWWTP but could discharge through Outfall 007 during a large storm event.
9. RA10 Treated: Treated water from Retention Area 10 prior to mixing with other water.
10. Treated GW: Recovered groundwater that has been treated, prior to mixing with other water.
11. RA4: Retention Area 4. CT and Boiler blowdown water.
12. CT: Cooling Tower blowdown.
13. RA7: Retention Area 7. Stormwater runoff from process areas collected in Retention Area 7.
14. Makeup to CT: Water from the on-site well that provides water to the CT.
15. Culvert: Surface flow from seepage in drainages downstream from Outfalls 001 and 007 as well as other areas impacted by previous refinery operations. There were no discharges through the 001 or 007 outfalls during the study.

2.2 Wet Weather Sampling

To obtain data regarding the potential sources of Se and TDS in the water from Outfall 009, a sampling program was developed and initiated with a round of wet weather samples taken at various areas around the plant as well as in the receiving stream. These samples were collected on April 7, 2005 by FTN staff using clean sampling techniques. The areas sampled included Boggy Creek, the South Ditch and various water sources that contribute flow to Outfall 009 described in Section 2.1.

2.3 Dry Weather Sampling

Additional rounds of sampling were taken under dry weather conditions. In general, the sampling locations were the same as for the wet weather sampling described above.

Ultimately five rounds of dry weather samples were collected. A total of 15 stations were sampled with a subset of eight stations sampled repeatedly. These samples occurred over a span of 4 months during the Summer and early Fall of 2005.

2.4 Analytical Techniques

In all cases, analytical services were provided by American Interplex (AI) Corporation of Little Rock, AR (an Arkansas Department of Environmental Quality (ADEQ) certified laboratory). Water samples were analyzed using the United States Environmental Protection Agency (USEPA) Method 200.8 for Se, USEPA Method 160.1 for TDS and USEPA 300.0 for sulfate and chloride. The laboratory data sheets are included with this report as Appendix A (with the final version).

3.0 RESULTS AND ANALYSIS

3.1 Sampling data

Sampling data are shown in Tables 3.1 through 3.4 for Se, TDS, chloride, and sulfate, respectively. The chloride and sulfate, which form a portion of the TDS, were analyzed to provide information about sources of the TDS.

Wet weather samples showed no exceedences of future NPDES limitations or acute or chronic Arkansas Water Quality Standards (AR WQS) for Se (0.020 mg/L and 0.005 mg/L, respectively) at any station sampled. Dry weather water samples indicated low levels of Se at various locations across the Teris plant site that exceeded the chronic AR WQS (see Table 3.1 for the Se data):

1. BC-3,
2. SD-1,
3. 009 Upstream,
4. 009 Internal,
5. RA10,
6. RA10 Treated,
7. Makeup to CT,
8. Treated GW,
9. CT,
10. RA4,
11. RA7, and
12. Culvert.

Selenium concentrations in samples from the “Culvert,” the groundwater makeup to the CT, treated recovered groundwater, Retention Area 10 and Outfall 009 Internal averaged approximately three times higher than the Arkansas chronic WQS. Selenium in the samples of the CT and water from Retention Area 4 (the CT Blowdown) were significantly higher than the Arkansas chronic and acute WQS.

The data in Table 3.1 indicate that Se appears in several samples of groundwater and surface runoff from the site as well as Boggy Creek upstream from the Teris' point sources (sampling location BC-3). It has been documented (Barbour 1999, EPRI 2001, and Hamilton 2004) that contamination of Se in groundwater and stormwater is generally associated with mining activities, petroleum or metal refining, or natural erosion of Se bearing strata. Given the widespread distribution of the Se at this site, in the groundwater as well as the surface runoff, and given the history of soil contamination with petroleum and oil residues, it appears that the previous refinery operations are the primary sources of the Se contamination in the water at this site.

The data in Table 3.2 indicates that the CT blowdown is a primary source of TDS. This is shown in the samples taken from the blowdown and from water in Retention Pond 4 which primarily consists of this blowdown. As with the dry weather Se data, however, several sources showed elevated levels of TDS. The treated water from Retention Area 10, which averages approximately 70 gpm, has concentrations of TDS over 800 mg/L. The treated groundwater has TDS concentrations over 300 mg/L.

3.2 Discharge Monitoring Reports

Teris has been monitoring TDS on a monthly basis at 009 since the latest NPDES permit became effective in November 2004. From the Discharge Monitoring Reports (DMRs), the average value for TDS is approximately 550 mg/L over that time period. The highest daily maximum value reported over that period of time was 1,400 mg/L.

For Se, quarterly sampling at 009 is required. For the samples collected in the 4th quarter of 2004 through the 3rd quarter of 2005, the concentration of Se has ranged from a low of 7.5 µg/L up to a maximum value of 29 µg/L. All of the samples would have exceeded the chronic AR WQS (5 µg/L). The maximum value exceeded the acute AR WQS (20 µg/L).

Table 3.1. Selenium data.

Station	Location Description	Wet	Dry 1	Dry 2	Dry 3	Dry 4	Dry 5	n	Avg.
BC-1	Boggy Creek at Hwy 82 Bridge approximately 4,000 ft downstream from Outfall 009	<0.002	0.0033					2	0.0022
BC-2	Boggy Creek approximately 300 ft downstream from Outfall 009	<0.002	0.0036					2	0.0023
BC-3	Boggy Creek approximately 300 ft upstream from Outfall 007)	<0.002	0.0059					2	0.0035
SD-1	South Ditch approximately 1,000 ft upstream from Outfall 009 Internal	<0.002	N/A	0.0092	0.037	0.019	0.018	5	0.0168
SD-2	South Ditch approximately 100 ft upstream from Outfall 009 Internal)	<0.002	<0.002					2	0.0010
009 Upstream	South Ditch, immediately upstream from Outfall 009	<0.002	0.0079					2	0.0045
009 Internal	Internal outfall	<0.002	0.0076	0.0082	0.031	0.021	0.018	6	0.0143
RA10	Retention Area 10	<0.002	N/A	0.015	0.013	0.016	0.017	1	0.0124
RA10 Treated	Treated water from Retention 10	<0.002	0.0099					2	0.0055
Treated GW	Treated groundwater	<0.002	0.0074	0.018	0.018	0.015	0.017	6	0.0127
RA4	Retention Area 4	<0.004[7]	0.036	0.035	0.029	0.049	0.057	6	0.0347
CT	Blowdown from CT	<0.01[7]	N/A	0.084	0.028	0.029	0.046	5	0.0384
RA7	Retention Area 7			0.0062	0.0046	0.0082	0.021	4	0.0100
Makeup to CT	Makeup to CT (from well)			0.020	0.018	0.012	0.0096	4	0.0149
Culvert	Water from culvert, downstream from Outfalls 007, 001		0.017					1	0.017

Notes: 1) All values are shown as mg/L
2) Wet-Sample taken under wet weather conditions
3) Dry 1-Sample taken on 6-29-05
4) Dry 2-Sample taken on 8-29-05
5) Dry 3-Sample taken on 9-6-05
6) Dry 4-Sample taken on 9-12-05
7) Elevated detection level due to interference.
8) N/A=Not Applicable

Table 3.2. TDS data.

Station	Location Description	Wet	Dry 1	Dry 2	Dry 3	Dry 4	Dry 5	n	Avg
BC-1	Boggy Creek at Hwy 82 Bridge approximately 4,000 ft downstream from Outfall 009	220	240					2	230
BC-2	Boggy Creek approximately 300 ft downstream from Outfall 009	220	300					2	260
BC-3	Boggy Creek approximately 300 ft upstream from Outfall 007)	140	200					2	170
SD-1	South Ditch approximately 1,000 ft upstream from Outfall 009 Internal	96	N/A	450	1,200	1,300	1,200	5	849
SD-2	South Ditch approximately 100 ft upstream from Outfall 009 Internal)	270	290					2	280
009 Upstream	South Ditch, immediately upstream from Outfall 009	750	550					2	650
009 Internal	Internal outfall	920	580	460	980	1,400	1,200	6	923
RA10	Retention Area 10	830	910					1	870
RA10 Treated	Treated water from Retention 10	1,100	N/A	850	880	1,200	1,100	2	1,026
Treated GW	Treated groundwater	420	350	450	580	660	560	6	503
RA4	Retention Area 4	790	2,400	1,800	2,500	2,600	2,300	6	2,065
CT	Blowdown from CT	2,300	N/A	4,700	2,700	2,900	3,100	5	3,140
RA7	Retention Area 7			130	140	310	730	4	328
Makeup to CT	Makeup to CT (from well)			990	790	890	760	4	858
Culvert	Water from culvert, downstream from Outfalls 007, 001		670						670

Notes:
1) All values are shown as mg/L
2) Wet-Sample taken under dry weather conditions
3) Dry 1-Sample taken on 6-29-05
4) Dry 2-Sample taken on 8-29-05
5) Dry 3-Sample taken on 9-6-05
6) Dry 4-Sample taken on 9-12-05
7) N/A=Not Applicable

Table 3.3. Chloride data.

Station	Location Description	Wet	Dry 1	Dry 2	n	Avg
BC-1	Boggy Creek at Hwy 82 Bridge approximately 4,000 ft downstream from Outfall 009	72	89		2	215
BC-2	Boggy Creek approximately 300 ft downstream from Outfall 009	79	120		2	100
BC-3	Boggy Creek approximately 300 ft upstream from Outfall 007)	36	100		2	68
SD-1	South Ditch approximately 1,000 ft upstream from Outfall 009 Internal	4.9	N/A	200	2	102
SD-2	South Ditch approximately 100 ft upstream from Outfall 009 Internal)	91	57		2	74
009 Upstream	South Ditch, immediately upstream from Outfall 009	340	260		2	300
009 Internal	Internal outfall	410	270	200	3	293
RA10	Retention Area 10	370	N/A		1	370
RA10 Treated	Treated water from Retention 10	360	520	420	3	433
Treated GW	Treated groundwater	160	140	170	3	157
RA4	Retention Area 4	340	990	750	3	693
CT	Blowdown from CT	1,000	N/A	2,200	2	1,600
RA7	Retention Area 7			25	1	25
Makeup to CT	Makeup to CT (from well)			470	1	470
Culvert	Water from culvert, downstream from Outfalls 007, 001	N/A	320		1	320

Notes: 1) All values are shown as mg/L
2) Wet-Sample taken under wet weather conditions
3) Dry 1-Sample taken under dry weather conditions
4) Dry 2-Sample taken under wet weather conditions
5) N/A=Not Applicable

3.3 Flow Data

For Outfall 009, flow data was obtained from the DMRs for the time period from November 2004 to October 2005. During this time, the average flow was approximately 0.24 mgd. The daily maximum flow recorded was 5.65 mgd which apparently included a significant amount of stormwater from the upstream drainage.

Significant sources of flow to Outfall 009 include the following:

- The CT blowdown and Retention Area 4 which can produce about 50 gpm with intermittent operation.
- Retention Area 10 at about 60-70 gpm.

- Recovered groundwater at about 70 gpm.
- Stormwater from the drainage in the South Ditch which can range from zero during dry periods to over 3,400 gpm during heavy storm events.

Table 3.4. Sulfate data.

Station	Location Description	Wet	Dry 1	n	Avg
BC-1	Boggy Creek at Hwy 82 Bridge approximately 4,000 ft downstream from Outfall 009	8.4	6.7	2	7.6
BC-2	Boggy Creek approximately 300 ft downstream from Outfall 009	8.2	6.6	2	7.4
BC-3	Boggy Creek approximately 300 ft upstream from Outfall 007)	4.1	4.8	2	4.4
SD-1	South Ditch approximately 1,000 ft upstream from Outfall 009 Internal	4.6	N/A	1	4.6
SD-2	South Ditch approximately 100 ft upstream from Outfall 009 Internal)	5.8	0.33	2	3.1
009 Upstream	South Ditch, immediately upstream from Outfall 009	36	12	2	24
009 Internal	Internal outfall	43	13	2	28
RA10	Retention Area 10	64	66	2	65
RA10 Treated	Treated water from Retention 10	64	N/A	1	64
Treated GW	Treated groundwater	9.4	6.0	2	7.7
RA4	Retention Area 4	39	36	2	37.5
CT	Blowdown from CT	38	N/A	1	38
Culvert	Water from culvert, downstream from Outfalls 007, 001	N/A	1.8	1	1.8

Notes: 1) All values are shown as mg/L
2) Wet-Sample taken under wet weather conditions
3) Dry 1-Sample taken under dry weather conditions
4) Dry 2-Sample taken under wet weather conditions
5) N/A=Not Applicable

Based on the chloride and sulfate data, a large portion of the TDS is associated with chloride. In some cases, as with the TDS in Retention Area 10, the source appears to be present operations. With the treated groundwater, the results reflect past refinery operations with possible contribution from the incineration process.

3.4 Source Control/Other Options

As shown in Figure 1.1, there are several sources that contribute water to Outfall 009. Because each of the major sources can potentially be the primary flow on any given day, source control would require efforts for each waste stream that demonstrated effluent concentrations above the new limitation.

For the recovered groundwater, ongoing remediation is required and source control cannot be applied. The existing treatment system for this groundwater is not effective for the removal of TDS and cannot be modified to be effective.

The CT blowdown represents the most significant source of TDS at the Teris facility. Groundwater is cycled several times within the CT and the concentrations of dissolved solids increase with each cycle. Maintaining the level of dissolved solids in the CT water is a major factor in determining the rate of blowdown. Using makeup water with higher purity would reduce the rate of blowdown but this would require identifying a source of water with lower dissolved solids than the groundwater currently being used.

The use of city water for this source would substantially increase operations costs at Teris where operating margin is an important issue. This statement considers costs associated with the well water conservation fee, additional wastewater treatment, etc. Analysis of this effect is ongoing at this time and will be included in the final version of this report.

An alternative would be to petition the City Utility to accept this wastewater for disposal in the sanitary sewer system. The City Utility has been approached about this subject. While agreeing to accept the sanitary wastewater from the plant, the Utility declined to accept the CT blowdown. If the City would accept the blowdown, the Teris facility would have difficulty meeting the effluent limits for TDS required by the new permit. This is due to the intermittent nature of these wastewater streams (i.e., no consistent dilution source) and the other contributing sources of TDS such as groundwater and Retention Area 10.

For stormwater, source control could be effective for the reduction of TDS. Teris has implemented measures to identify and cover or remove obvious sources. However, stormwater is an intermittent contribution to Outfall 009 and cannot be depended on for dilution, even if the concentration of TDS could be reduced to zero.

There are several source areas that contribute the Se to the NPDES outfalls, although the ultimate source appears to be the previous refinery operations. Ongoing remediation of the groundwater contamination from the refinery is critical for groundwater protection in this area of Arkansas. The same situation regarding source control would apply as described above for TDS. As with the TDS, the diversion of the CT blowdown would remove a primary source of the Se, but would not prove adequate to achieve compliance with the future permit conditions (see Table 3.1). Also, the existing treatment system is not effective for the treatment of Se.

A separate study is ongoing regarding the feasibility and potential costs associated with treatment for both Se and TDS. The preliminary conclusions of the study are that treatment would be expensive and would not guarantee removals down to the upcoming effluent limitations. This is particularly true for Se, the treatment of which is still regarded as experimental on a case-by-case basis according to the literature and FTN experience.

4.0 SUMMARY

Based on the data collected by this study, a significant source of TDS at the Teris plant is the recovered groundwater. The blowdown from the CT is another significant source of TDS. Significant Se concentrations were detected in samples throughout the plant site. The widespread distribution of Se at the site and the nature of former operations at the site prior to Teris strongly suggest the source of Se is primarily connected to residues from the previous refinery activities at this site.

Based on the widespread presence of these constituents (at significant concentrations relative to the upcoming permit limits) in various sources of water from the plant, the application of source control or waste minimization techniques will likely not achieve compliance with upcoming permit limitations. Converting from well water to city water to reduce TDS would add significantly to the annual cost of operations for Teris but still would not allow Teris to consistently meet permit limits. A separate study is ongoing regarding the feasibility and potential costs associated with treatment.

5.0 REFERENCES

Barbour, M.T., J. Gerritsen, B.D. Snyder, J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, benthic macroinvertebrates and fish, Second Edition. USEPA 841-B-99-002. USEPA; Office of Water; Washington, D.C.

EPRI. 2001. Se cycling and impact in aquatic ecosystems: Defining trophic transfer and water-borne exposure pathways. Electric Power Research Institute, Final Report No. 1005217, November 2001.

Hamilton, S. 2004. Review of Se toxicity in the aquatic food chain. Science of the Total Environmental 326:1-31

APPENDIX C

Photographs of Sampling Locations, May 15-18, 2006

Photo 1. Boggy Creek at the BC-0 station near the confluence with Bayou de Loutre.

Photo 2. Boggy Creek (BC-1) upstream of Hwy 82B.

Photo 3. Photo showing the upper portion of reach at Boggy Creek (BC1-3).

Photo 4. Boggy Creek (BC-3) looking upstream.

Photo 5. Fish sampling at Curtis Creek (CC-1).

Photo 6. Photo showing Outfall 007 entering Boggy Creek (BC-2).

Photo 7. Bowfin (Amia calva) collected at Bayou de Loutre during September 2006 sampling event.

APPENDIX D

Physical Characteristics and Habitat Evaluation Field Forms

ftn

Date	Project Name	Project No.	Project Manager (Print)	Page
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page 1 of 18

Report and Bill to:	Submitted by:
Teris Mohamed Abdulhafid, Director of Compliance 309 American Circle El Dorado, AR 71730 (870) 863-7173 • Fax (870) 864-3720	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time

☐ 24 Hours
☐ 48 Hours
☒ Normal
☐ Other:
Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
LESF-log no.260	5/16/06				X	1 Fish			X								
BGSF-log no.261	5/16/06				X	1 Fish			X								
GSF-log no.262	5/16/06				X	1 Fish			X								
GSF-log no.263	5/16/06				X	1 Fish			X								
GSF-log no.264	5/16/06				X	1 Fish			X								
GSF-log no.265	5/16/06				X	1 Fish			X								
GSF-log no.266	5/16/06				X	1 Fish			X								
LESF-log no.267	5/16/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					
Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

Date	Project Name	Project No.	Project Manager (Print)	Page
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __2__ of __18__

Report and Bill to:	Submitted by:
Teris Mohamed Abdulhafid, Director of Compliance 309 American Circle El Dorado, AR 71730 (870) 863-7173 • Fax (870) 864-3720	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
GSF-log no.268	5/16/06				X	1 Fish			X								
GSF-log no.269	5/16/06				X	1 Fish			X								
LESF-log no.270	5/16/06				X	1 Fish			X								
LESF-log no.271	5/16/06				X	1 Fish			X								
LESF-log no.272	5/16/06				X	1 Fish			X								
LESF-log no.273	5/16/06				X	1 Fish			X								
LESF-log no.274	5/16/06				X	1 Fish			X								
LESF-log no.275	5/16/06				X	1 Fish			X								
Container Type																	
Preservative																	

Parameters (Method Number)

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					
Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	Page
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __3__ of __18__

Report and Bill to:	Submitted by:
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Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Parameters (Method Number)

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
LESF-log no.276	5/16/06				X	1 Fish			X								
LESF-log no.277	5/16/06				X	1 Fish			X								
LESF-log no.278	5/16/06				X	1 Fish			X								
LESF-log no.279	5/16/06				X	1 Fish			X								
LESF-log no.280	5/16/06				X	1 Fish			X								
LESF-log no.281	5/16/06				X	1 Fish			X								
YELL BULL HEAD-log no.282	5/16/06				X	1 Fish			X								
BGSF-log no.283	5/16/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	Page
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __4__ of __18__

Report and Bill to:

Teris
Mohamed Abdulhafid, Director of Compliance
309 American Circle
El Dorado, AR 71730
(870) 863-7173 • Fax (870) 864-3720

Submitted by:

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, AR 72211
(501) 225-7779 • Fax (501) 225-6738

Sampler Signature(s)

Recorded By (Print)
Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	**Se--whole body analysis**								Laboratory Notes
LESF-log no.284	5/16/06				X	1 Fish			X								
LESF-log no.285	5/16/06				X	1 Fish			X								
LESF-log no.286	5/16/06				X	1 Fish			X								
LESF-log no.287	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.288	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.289	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.290	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.291	5/16/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	Page
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __5__ of __18__

Report and Bill to:	Submitted by:
Teris Mohamed Abdulhafid, Director of Compliance 309 American Circle El Dorado, AR 71730 (870) 863-7173 • Fax (870) 864-3720	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	S	O	No. of Containers	Comp	Grab	Parameters (Method Number): Se--whole body analysis								Laboratory Notes
LESF-log no.292	5/17/06				X	1 Fish			X								
LESF-log no.293	5/17/06				X	1 Fish			X								
LESF-log no.294	5/17/06				X	1 Fish			X								
LESF-log no.295	5/17/06				X	1 Fish			X								
LESF-log no.296	5/17/06				X	1 Fish			X								
BGSF-log no.297	5/17/06				X	1 Fish			X								
BGSF-log no.298	5/17/06				X	1 Fish			X								
BGSF-log no.299	5/17/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					
Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	Page
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __6__ of __18__

Report and Bill to:	Submitted by:
Teris Mohamed Abdulhafid, Director of Compliance 309 American Circle El Dorado, AR 71730 (870) 863-7173 • Fax (870) 864-3720	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	S	O	No. of Containers	Comp	Grab	Se--whole body analysis	Parameters (Method Number)							Laboratory Notes
BGSF-log no.300	5/17/06				X	1 Fish			X								
WARMOUTH-log no.301	5/17/06				X	1 Fish			X								
BLK BULL HEAD-log no.302	5/17/06				X	1 Fish			X								
LESF-log no.303	5/17/06				X	1 Fish			X								
LESF-log no.304	5/18/06				X	1 Fish			X								
LESF-log no.305	5/18/06				X	1 Fish			X								
Lepomis spp.-log no.306	5/18/06				X	1 Fish			X								
GRASS PICKEREL-log no.307	5/18/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					
Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	Page
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __7__ of __18__

Report and Bill to:

Teris
Mohamed Abdulhafid, Director of Compliance
309 American Circle
El Dorado, AR 71730
(870) 863-7173 • Fax (870) 864-3720

Submitted by:

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, AR 72211
(501) 225-7779 • Fax (501) 225-6738

Sampler Signature(s)

Recorded By (Print)
Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
WARMOUTH-log no.308	5/15/06				X	1 Fish			X								
WARMOUTH-log no.309	5/15/06				X	1 Fish			X								
SPOTTED SF-log no.310	5/15/06				X	1 Fish			X								
Lepomis spp.-log no.311	5/15/06				X	1 Fish			X								
LESF-log no.312	5/17/06				X	1 Fish			X								
LESF-log no.313	5/17/06				X	1 Fish			X								
LESF-log no.314	5/17/06				X	1 Fish			X								
SPOTTED SF-log no.315	5/17/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __8__ of __18__

Report and Bill to:

Teris
Mohamed Abdulhafid, Director of Compliance
309 American Circle
El Dorado, AR 71730
(870) 863-7173 • Fax (870) 864-3720

Submitted by:

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, AR 72211
(501) 225-7779 • Fax (501) 225-6738

Sampler Signature(s)

Recorded By (Print)
Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time

☐ 24 Hours
☐ 48 Hours
☒ Normal
☐ Other:
Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
SPOTTED SF-log no.316	5/17/06				X	1 Fish			X								
GRASS PICKEREL-log no.317	5/17/06				X	1 Fish			X								
Lepomis spp.-log no.318	5/17/06				X	1 Fish			X								
PIRATE PERCH-log no.319	5/17/06				X	1 Fish			X								
WARMOUTH-log no.320	5/17/06				X	1 Fish			X								
WARMOUTH-log no.321	5/17/06				X	1 Fish			X								
LESF-log no.322	5/17/06				X	1 Fish			X								
LESF-log no.323	5/17/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __9__ of __18__

Report and Bill to:	Submitted by:
Teris Mohamed Abdulhafid, Director of Compliance 309 American Circle El Dorado, AR 71730 (870) 863-7173 • Fax (870) 864-3720	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time
- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other:
  Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	S	O	No. of Containers	Comp	Grab	**Se--whole body analysis**								Laboratory Notes
LESF-log no.324	5/17/06				X	1 Fish			X								
LESF-log no.325	5/17/06				X	1 Fish			X								
LESF-log no.326	5/17/06				X	1 Fish			X								
SPOTTED SF-log no.327	5/17/06				X	1 Fish			X								
SPOTTED SF-log no.328	5/17/06				X	1 Fish			X								
SPOTTED SF-log no.329	5/17/06				X	1 Fish			X								
SPOTTED SF-log no.330	5/17/06				X	1 Fish			X								
SPOTTED SF-log no.331	5/17/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					
Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	Page
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __10__ of __18_

Report and Bill to:	Submitted by:
Teris Mohamed Abdulhafid, Director of Compliance 309 American Circle El Dorado, AR 71730 (870) 863-7173 • Fax (870) 864-3720	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Lab Turn-Around-Time:
- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	S	O	No. of Containers	Comp	Grab	**Se--whole body analysis**								Laboratory Notes
SPOTTED SF-log no.332	5/17/06				X	1 Fish			X								
SPOTTED SF-log no.333	5/17/06				X	1 Fish			X								
SPOTTED SF-log no.334	5/17/06				X	1 Fish			X								
SPOTTED SF-log no.335	5/17/06				X	1 Fish			X								
SPOTTED SF-log no.336	5/17/06				X	1 Fish			X								
GRASS PICKEREL-log no.337	5/17/06				X	1 Fish			X								
GRASS PICKEREL-log no.338	5/17/06				X	1 Fish			X								
GRASS PICKEREL-log no.339	5/17/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					
Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

Date	Project Name	Project No.	Project Manager (Print)	
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __11__ of __18_

Report and Bill to:

Teris
Mohamed Abdulhafid, Director of Compliance
309 American Circle
El Dorado, AR 71730
(870) 863-7173 • Fax (870) 864-3720

Submitted by:

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, AR 72211
(501) 225-7779 • Fax (501) 225-6738

Sampler Signature(s)

Recorded By (Print)
Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time

☐ 24 Hours
☐ 48 Hours
☒ Normal
☐ Other:
Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
LESF-log no.340	5/16/06				X	1 Fish			X								
LESF-log no.341	5/16/06				X	1 Fish			X								
LESF-log no.342	5/16/06				X	1 Fish			X								
LESF-log no.343	5/16/06				X	1 Fish			X								
WARMOUTH-log no.344	5/16/06				X	1 Fish			X								
WARMOUTH-log no.345	5/16/06				X	1 Fish			X								
WARMOUTH-log no.346	5/16/06				X	1 Fish			X								
WARMOUTH-log no.347	5/16/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					
Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __12__ of __18_

Report and Bill to:

Teris
Mohamed Abdulhafid, Director of Compliance
309 American Circle
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Submitted by:

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Little Rock, AR 72211
(501) 225-7779 • Fax (501) 225-6738

Sampler Signature(s)

Recorded By (Print)
Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	**Se--whole body analysis**								Laboratory Notes
WARMOUTH-log no.348	5/16/06				X	1 Fish			X								
WARMOUTH-log no.349	5/16/06				X	1 Fish			X								
WARMOUTH-log no.350	5/16/06				X	1 Fish			X								
GSF-log no.351	5/16/06				X	1 Fish			X								
GSF-log no.352	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.353	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.354	5/16/06				X	1 Fish			X								
WARMOUTH-log no.355	5/16/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __13__ of __18_

Report and Bill to:

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Mohamed Abdulhafid, Director of Compliance
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Submitted by:

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3 Innwood Circle, Suite 220
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(501) 225-7779 • Fax (501) 225-6738

Sampler Signature(s)

Recorded By (Print)
Jimmy Rogers

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Parameters (Method Number): **Se--whole body analysis**								Laboratory Notes
WARMOUTH-log no.356	5/16/06				X	1 Fish			X								
WARMOUTH-log no.357	5/16/06				X	1 Fish			X								
LESF-log no.358	5/16/06				X	1 Fish			X								
LESF-log no.359	5/16/06				X	1 Fish			X								
LESF-log no.360	5/16/06				X	1 Fish			X								
LESF-log no.361	5/16/06				X	1 Fish			X								
LESF-log no.362	5/16/06				X	1 Fish			X								
LESF-log no.363	5/16/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

Date	Project Name	Project No.	Project Manager (Print)	
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __14__ of __18_

Report and Bill to:

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Mohamed Abdulhafid, Director of Compliance
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El Dorado, AR 71730
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Sampler Signature(s)

Recorded By (Print)
Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	**Se--whole body analysis**								Laboratory Notes
LESF-log no.364	5/16/06				X	1 Fish			X								
BGSF-log no.365	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.366	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.367	5/16/06				X	1 Fish			X								
GSF-log no.368	5/16/06				X	1 Fish			X								
GSF-log no.369	5/16/06				X	1 Fish			X								
GSF-log no.370	5/16/06				X	1 Fish			X								
WHITE CRAPPIE-log no.371	5/16/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					
Relinquished By (Signature)	**Print Name**	**Date**	**Time**	**Received By Laboratory (Signature)**	**Print Name**	**Date**	**Time**

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __15__ of _18__

Report and Bill to:	Submitted by:
Teris Mohamed Abdulhafid, Director of Compliance 309 American Circle El Dorado, AR 71730 (870) 863-7173 • Fax (870) 864-3720	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Lab Turn-Around-Time: ☐ 24 Hours ☐ 48 Hours ☒ Normal ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Parameters (Method Number)

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
LM BASS-log no.372	5/16/06				X	1 Fish			X								
YELL. BULL HEAD-log no.373	5/16/06				X	1 Fish			X								
LESF-log no.374	5/16/06				X	1 Fish			X								
LESF-log no.375	5/16/06				X	1 Fish			X								
LESF-log no.376	5/16/06				X	1 Fish			X								
LESF-log no.377	5/16/06				X	1 Fish			X								
GSF-log no.378	5/16/06				X	1 Fish			X								
GSF-log no.379	5/16/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					
Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	Page
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __16__ of __18_

Report and Bill to:	Submitted by:
Teris Mohamed Abdulhafid, Director of Compliance 309 American Circle El Dorado, AR 71730 (870) 863-7173 • Fax (870) 864-3720	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Lab Turn-Around-Time:
- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
GSF-log no.380	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.381	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.382	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.383	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.384	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.385	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.386	5/16/06				X	1 Fish			X								
SPOTTED SF-log no.387	5/16/06				X	1 Fish			X								
Container Type																	
Preservative																	

Parameters (Method Number)

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					
Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

Date	Project Name	Project No.	Project Manager (Print)	
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __17__ of __18_

Report and Bill to:

Teris
Mohamed Abdulhafid, Director of Compliance
309 American Circle
El Dorado, AR 71730
(870) 863-7173 • Fax (870) 864-3720

Submitted by:

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, AR 72211
(501) 225-7779 • Fax (501) 225-6738

Sampler Signature(s)

Recorded By (Print)
Jimmy Rogers

Lab Turn-Around-Time

☐ 24 Hours
☐ 48 Hours
☒ Normal
☐ Other:
Due: ___/___/___

SAMPLE DESCRIPTION / Parameters (Method Number)

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	**Se--whole body analysis**								Laboratory Notes
BGSF-log no.388	5/15/06				X	1 Fish			X								
LESF-log no.389	5/15/06				X	1 Fish			X								
WARMOUTH-log no.390	5/15/06				X	1 Fish			X								
BGSF-log no.391	5/16/06				X	1 Fish			X								
LESF-log no.392	5/16/06				X	1 Fish			X								
LESF-log no.393	5/16/06				X	1 Fish			X								
LESF-log no.394	5/16/06				X	1 Fish			X								
LESF-log no.395	5/16/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

Date	Project Name	Project No.	Project Manager (Print)	
5/24/06	**Teris**	**6170-026**	**Jim Malcolm**	Page _18_ of _18_

Report and Bill to:	Submitted by:
Teris Mohamed Abdulhafid, Director of Compliance 309 American Circle El Dorado, AR 71730 (870) 863-7173 • Fax (870) 864-3720	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	S	O	No. of Containers	Comp	Grab	**Se--whole body analysis**								Laboratory Notes
LESF-log no.396	5/16/06				X	1 Fish			X								
GSF-log no.397	5/16/06				X	1 Fish			X								
WARMOUTH-log no.398	5/16/06				X	1 Fish			X								
WARMOUTH-log no.399	5/16/06				X	1 Fish			X								
WARMOUTH-log no.400	5/16/06				X	1 Fish			X								
LM BASS-log no.401	5/16/06				X	1 Fish			X								
LM BASS-log no.402	5/16/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	5/24/06					
Relinquished By (Signature)	**Print Name**	**Date**	**Time**	**Received By Laboratory (Signature)**	**Print Name**	**Date**	**Time**

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	Page
7/21//06	**Teris**	**6170-026**	**Jim Malcolm**	Page _1_ of _1_

Report and Bill to:

Teris
Mohamed Abdulhafid, Director of Compliance
309 American Circle
El Dorado, AR 71730
(870) 863-7173 • Fax (870) 864-3720

Submitted by:

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, AR 72211
(501) 225-7779 • Fax (501) 225-6738

Sampler Signature(s)

Recorded By (Print)
David Rupe

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Mercury-tissue smaples								Laboratory Notes
Composite 1	7/20/06				X	1			X								
Composite 2	7/20/06				X	1			X								
Composite 3	7/19/06				X	1			X								
Composite 4	7/19/06				X	1			X								
Composite 5	7/19/06				X	1			X								
Composite 6	7/19/06				X	1			X								
Composite 7	7/18/06				X	1			X								
Composite 8	7/18/06				X	1			X								
Container Type																	
Preservative																	

Parameters (Method Number)

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	David Rupe	7/21/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Mohamed Abdulhafid mabdulha@TerisNA.com
CC: jtm@ftn-assoc.com

Laboratory Remarks:

Detection limit of 0.1 PPM

ftn

Date	Project Name	Project No.	Project Manager (Print)	
7/20/06	**Teris**	**6170-026**	**Jim Malcom**	Page __1__ of __3__

Report / Bill to:

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, AR 72211
(501) 225-7779 • Fax (501) 225-6738

Submitted by:

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, AR 72211
(501) 225-7779 • Fax (501) 225-6738

Sampler Signature(s)

Recorded By (Print): Jimmy Rogers

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	SO4, CL, TDS	Oil and Grease	TOC, DOC	SE	SE-Diss	SE		
TC-1	7/19/06	1030	X			5		X	X	X	X	X	X			
TC-1	7/19/06	1030		X		1		X						X		
CC-1	7/19/06	0807	X			5		X	X	X	X	X	X			
CC-1	7/19/06	0823		X		1		X						X		
BDL-1D	7/18/06	1735	X			4		X	X	X	X	X				
BDL-1D	7/18/06	1735		X		1		X						X		
BDL-1	7/18/06	1710	X			4		X	X	X	X	X				
BDL-1	7/18/06	1710		X		1		X						X		
Container Type																
Preservative																

Detection Limits

Parameter	Detection Limit
Sediment SE	1 mg/Kg
Water SE	1 mcg/L
SE – Diss	1 mcg/L

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	7/20/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Jim Malcom and Pat Downey at:
jtm@ftn-assoc.com ; pjd@ftn-assoc.com
Note Detection Limits

Laboratory Remarks:

Date	Project Name	Project No.	Project Manager (Print)	
7/20/06	**Teris**	**6170-026**	**Jim Malcom**	Page __2__ of __3__

Report / Bill to:	Submitted by:
FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	**SO4, CL, TDS**	**Oil and Grease**	**TOC, DOC**	**SE**	**SE-Diss**	**SE**		
BDL-2	7/18/06	1845	X			4		X	X	X	X	X				
BDL-2	7/18/06	1845		X		1		X						X		
BC-2	7/17/06	1515	X			4		X	X	X	X	X				
BC-2	7/19/06	1622		X		1		X						X		
BC-2	7/19/06	1626	X			1							X			
BC 1-3	7/18/06	0810	X			4		X	X	X	X	X				
BC 1-3	7/19/06	1440		X		1		X						X		
BC 1-3	7/19/06	1440	X			1		X					X			
Container Type																
Preservative																

Parameters (Method Number)

Detection Limits

Parameter	Detection Limit
Sediment SE	1 mg/Kg
Water SE	1 mcg/L
SE – Diss	1 mcg/L

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date | Time	Received By (Signature)	Print Name	Date | Time
	Jimmy Rogers	7/20/06 |			|

Relinquished By (Signature)	Print Name	Date | Time	Received By Laboratory (Signature)	Print Name	Date | Time
		|			|

Sampler Remarks:
Please e-mail results to Jim Malcom and Pat Downey at:
jtm@ftn-assoc.com ; pjd@ftn-assoc.com
Note Detection Limits

Laboratory Remarks:

Date	Project Name	Project No.	Project Manager (Print)	
7/20/06	**Teris**	**6170-026**	**Jim Malcom**	Page __3__ of __3__

Report / Bill to:	Submitted by:
FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Parameters (Method Number)

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	SO4, CL, TDS	Oil and Grease	TOC, DOC	SE	SE-Diss	SE		
BC-1	7/18/06	1045	X			4		X	X	X	X	X				
BC-1	7/18/06	1300		X		1		X						X		
BC-0	7/18/06	1528	X			4		X	X	X	X	X				
BC-0	7/18/06	1545		X		1		X						X		
FC-1	7/19/06	1345	X			5		X	X	X	X	X	X			
FC-1	7/19/06	1345		X		1		X						X		
TC-1B	7/19/06	1100	X			5		X	X	X	X	X	X			
Container Type																
Preservative																

Detection Limits

Parameter	Detection Limit
Sediment SE	1 mg/Kg
Water SE	1 mcg/L
SE – Diss	1 mcg/L

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	7/20/06					
Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to Jim Malcom and Pat Downey at:
jtm@ftn-assoc.com ; pjd@ftn-assoc.com
Note Detection Limits

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	Page
10/03/06	**Teris**	**6170-026**	**Jim Malcolm**	Page 1 of 10

Report and Bill to:	Submitted by:
Clean Harbors (formerly Teris) Michael Karp, Compliance Manager 309 American Circle El Dorado, AR 71730 (870) 863-7173 • Fax (870) 864-3720	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time
- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	S	O	No. of Containers	Comp	Grab	**Se--whole body analysis**								Laboratory Notes
Pirate Perch-log no.419	9/28/06				X	1 Fish			X								
Pirate Perch -log no.420	9/28/06				X	1 Fish			X								
Lepomis spp.-log no.421	9/28/06				X	1 Fish			X								
Spotted SF-log no.422	9/28/06				X	1 Fish			X								
Spotted SF -log no.423	9/28/06				X	1 Fish			X								
Spotted SF -log no.424	9/28/06				X	1 Fish			X								
Spotted SF -log no.425	9/28/06				X	1 Fish			X								
Spotted SF -log no.426	9/28/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	10/3/06					
Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to karp.Michael@cleanharbors.com
CC: jtm@ftn-assoc.com , pjd@ftn-assoc.com

Laboratory Remarks:

Revision Date 11/22/02

ftn

Date	Project Name	Project No.	Project Manager (Print)	
10/03/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __2__ of __10__

Report and Bill to:	Submitted by:
Clean Harbors (formerly Teris) Michael Karp, Compliance Manager 309 American Circle El Dorado, AR 71730 (870) 863-7173 • Fax (870) 864-3720	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time

☐ 24 Hours
☐ 48 Hours
☒ Normal
☐ Other:
Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	S	O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
Grass Pickerel-log no.427	9/28/06				X	1 Fish			X								
Bowfin-log no.428	9/28/06				X	1 Fish			X								
Bowfin-log no.429	9/28/06				X	1 Fish			X								
Spotted SF-log no.430	9/28/06				X	1 Fish			X								
LESF-log no.431	9/28/06				X	1 Fish			X								
LESF-log no.432	9/29/06				X	1 Fish			X								
Yellow Bullhead-log no.433	9/29/06				X	1 Fish			X								
Yellow Bullhead -log no.434	9/29/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	10/3/06					
Relinquished By (Signature)	**Print Name**	**Date**	**Time**	**Received By Laboratory (Signature)**	**Print Name**	**Date**	**Time**

Sampler Remarks:
Please e-mail results to karp.Michael@cleanharbors.com
CC: jtm@ftn-assoc.com , pjd@ftn-assoc.com

Laboratory Remarks:

Date	Project Name	Project No.	Project Manager (Print)	Page
10/03/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __3__ of __10__

Report and Bill to:	Submitted by:
Clean Harbors (formerly Teris) Michael Karp, Compliance Manager 309 American Circle El Dorado, AR 71730 (870) 863-7173 • Fax (870) 864-3720	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
LESF-log no.435	9/27/06				X	1 Fish			X								
LESF-log no.436	9/27/06				X	1 Fish			X								
LESF-log no.437	9/27/06				X	1 Fish			X								
LESF-log no.438	9/27/06				X	1 Fish			X								
Spotted SF-log no.439	9/27/06				X	1 Fish			X								
Spotted SF -log no.440	9/27/06				X	1 Fish			X								
Spotted SF -log no.441	9/27/06				X	1 Fish			X								
Spotted SF -log no.442	9/27/06				X	1 Fish			X								
Container Type																	
Preservative																	

Parameters (Method Number)

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	10/3/06					
Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to karp.Michael@cleanharbors.com
CC: jtm@ftn-assoc.com , pjd@ftn-assoc.com

Laboratory Remarks:

Date	Project Name	Project No.	Project Manager (Print)	
10/03/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __4__ of __10__

Report and Bill to:	Submitted by:
Clean Harbors (formerly Teris) Michael Karp, Compliance Manager 309 American Circle El Dorado, AR 71730 (870) 863-7173 • Fax (870) 864-3720	FTN Associates, Ltd. 3 Innwood Circle, Suite 220 Little Rock, AR 72211 (501) 225-7779 • Fax (501) 225-6738
Sampler Signature(s)	Recorded By (Print) Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time

- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
Spotted SF -log no.443	9/27/06				X	1 Fish			X								
Spotted SF -log no.444	9/27/06				X	1 Fish			X								
Pirate Perch-log no.445	9/27/06				X	1 Fish			X								
Grass Pickerel-log no.446	9/27/06				X	1 Fish			X								
Yellow Bullhead-log no.447	9/27/06				X	1 Fish			X								
Yellow Bullhead -log no.448	9/27/06				X	1 Fish			X								
Yellow Bullhead -log no.449	9/27/06				X	1 Fish			X								
Yellow Bullhead -log no.450	9/27/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	10/3/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to karp.Michael@cleanharbors.com
CC: jtm@ftn-assoc.com , pjd@ftn-assoc.com

Laboratory Remarks:

Date	Project Name	Project No.	Project Manager (Print)	Page
10/03/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __5__ of __10__

Report and Bill to:
Clean Harbors
(formerly Teris)
Michael Karp, Compliance Manager
309 American Circle
El Dorado, AR 71730
(870) 863-7173 • Fax (870) 864-3720

Submitted by:
FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, AR 72211
(501) 225-7779 • Fax (501) 225-6738

Sampler Signature(s)

Recorded By (Print)
Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time
- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
LESF-log no.451	9/27/06				X	1 Fish			X								
LESF-log no.452	9/27/06				X	1 Fish			X								
LESF-log no.453	9/27/06				X	1 Fish			X								
LESF-log no.454	9/27/06				X	1 Fish			X								
LESF-log no.455	9/27/06				X	1 Fish			X								
Spotted SF-log no.456	9/27/06				X	1 Fish			X								
Spotted SF -log no.457	9/27/06				X	1 Fish			X								
Spotted SF -log no.458	9/27/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	10/3/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to karp.Michael@cleanharbors.com
CC: jtm@ftn-assoc.com , pjd@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	Page
10/03/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __6__ of __10__

Report and Bill to:
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Sampler Signature(s)

Recorded By (Print)
Jimmy Rogers

Lab Turn-Around-Time
☐ 24 Hours
☐ 48 Hours
☒ Normal
☐ Other:
Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	S	O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
Spotted SF -log no.459	9/27/06				X	1 Fish			X								
Warmouth-log no.460	9/27/06				X	1 Fish			X								
Warmouth -log no.461	9/27/06				X	1 Fish			X								
Warmouth -log no.462	9/27/06				X	1 Fish			X								
Warmouth -log no.463	9/27/06				X	1 Fish			X								
Warmouth -log no.464	9/27/06				X	1 Fish			X								
Warmouth.-log no.465	9/27/06				X	1 Fish			X								
Warmouth -log no.466	9/27/06				X	1 Fish			X								
Container Type																	
Preservative																	

Parameters (Method Number)

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	10/3/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to karp.Michael@cleanharbors.com
CC: jtm@ftn-assoc.com , pjd@ftn-assoc.com

Laboratory Remarks:

Date	Project Name	Project No.	Project Manager (Print)	
10/03/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __7__ of __10__

Report and Bill to:
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Little Rock, AR 72211
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Sampler Signature(s)

Recorded By (Print)
Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time
☐ 24 Hours
☐ 48 Hours
☒ Normal
☐ Other:
Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
Warmouth -log no.467	9/27/06				X	1 Fish			X								
Pirate Perch-log no.468	9/27/06				X	1 Fish			X								
Pirate Perch -log no.469	9/27/06				X	1 Fish			X								
Pirate Perch-log no.470	9/27/06				X	1 Fish			X								
Pirate Perch -log no.471	9/27/06				X	1 Fish			X								
Pirate Perch -log no.472	9/27/06				X	1 Fish			X								
Pirate Perch -log no.473	9/27/06				X	1 Fish			X								
Pirate Perch -log no.474	9/27/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	10/3/06					
Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to karp.Michael@cleanharbors.com
CC: jtm@ftn-assoc.com , pjd@ftn-assoc.com

Laboratory Remarks:

Date	Project Name	Project No.	Project Manager (Print)	
10/03/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __8__ of __10__

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Sampler Signature(s)

Recorded By (Print)
Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time
- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	**Se--whole body analysis**								Laboratory Notes
Pirate Perch -log no.475	9/27/06				X	1 Fish			X								
Pirate Perch -log no.476	9/27/06				X	1 Fish			X								
Pirate Perch.-log no.477	9/27/06				X	1 Fish			X								
Pirate Perch -log no.478	9/27/06				X	1 Fish			X								
Pirate Perch -log no.479	9/27/06				X	1 Fish			X								
Yellow Bullhead-log no.480	9/27/06				X	1 Fish			X								
Spotted SF-log no.481	9/27/06				X	1 Fish			X								
Spotted SF -log no.482	9/27/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	10/3/06					
Relinquished By (Signature)	**Print Name**	**Date**	**Time**	**Received By Laboratory (Signature)**	**Print Name**	**Date**	**Time**

Sampler Remarks:
Please e-mail results to karp.Michael@cleanharbors.com
CC: jtm@ftn-assoc.com , pjd@ftn-assoc.com

Laboratory Remarks:

ftn

Date	Project Name	Project No.	Project Manager (Print)	
10/03/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __9__ of __10__

Report and Bill to:
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Little Rock, AR 72211
(501) 225-7779 • Fax (501) 225-6738

Sampler Signature(s)

Recorded By (Print)
Jimmy Rogers

Lab Turn-Around-Time
- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
Spotted SF -log no.483	9/27/06				X	1 Fish			X								
Spotted SF -log no.484	9/27/06				X	1 Fish			X								
Spotted SF -log no.485	9/27/06				X	1 Fish			X								
LESF-log no.486	9/27/06				X	1 Fish			X								
LESF -log no.487	9/27/06				X	1 Fish			X								
LESF -log no.488	9/27/06				X	1 Fish			X								
LESF -log no.489	9/27/06				X	1 Fish			X								
LESF -log no.490	9/27/06				X	1 Fish			X								
Container Type																	
Preservative																	

Parameters (Method Number)

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	10/3/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to karp.Michael@cleanharbors.com
CC: jtm@ftn-assoc.com , pjd@ftn-assoc.com

Laboratory Remarks:

Date	Project Name	Project No.	Project Manager (Print)	
10/03/06	**Teris**	**6170-026**	**Jim Malcolm**	Page __10__ of __10_

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Sampler Signature(s)

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Jimmy Rogers

Parameters (Method Number)

Lab Turn-Around-Time
- ☐ 24 Hours
- ☐ 48 Hours
- ☒ Normal
- ☐ Other: Due: ___/___/___

SAMPLE DESCRIPTION

Sample Identification	Date	Time	Matrix* W	Matrix* S	Matrix* O	No. of Containers	Comp	Grab	Se--whole body analysis								Laboratory Notes
Warmouth-log no.491	9/27/06				X	1 Fish			X								
Warmouth -log no.492	9/27/06				X	1 Fish			X								
Warmouth -log no.493	9/27/06				X	1 Fish			X								
Warmouth -log no.494	9/27/06				X	1 Fish			X								
Bowfin-log no.495	9/29/06				X	1 Fish			X								
Container Type																	
Preservative																	

* Matrix: W = Water S = Soil O = Other

G = Glass P= Plastic V = VOA vials H = HCl to pH2 T = Sodium Thiosulfate
NO = None S = Sulfuric acid pH2 N = Nitric acid pH2 B = NaOH to pH12 Z = Zinc acetate

Relinquished By (Signature)	Print Name	Date	Time	Received By (Signature)	Print Name	Date	Time
	Jimmy Rogers	10/3/06					

Relinquished By (Signature)	Print Name	Date	Time	Received By Laboratory (Signature)	Print Name	Date	Time

Sampler Remarks:
Please e-mail results to karp.Michael@cleanharbors.com
CC: jtm@ftn-assoc.com , pjd@ftn-assoc.com

Laboratory Remarks:

HABITAT ASSESSMENT FIELD DATA SHEET – LOW GRADIENT STREAMS (FRONT)

STREAM NAME Boggy Creek	LOCATION Up Stream of Bayou Deloutre confluence	
STATION #________BC-0_____RIVERMILE _______	STREAM CLASS	
LAT ______________________ LONG ___________	RIVER BASIN	
STOREY #	AGENCY	
INVESTIGATORS DMR, RPG, JJR, CDP		
FORM COMPLETED BY DMR	DATE____5/?/06____ TIME ____10:00_____ AM PM	REASON FOR SURVEY UAA

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE 16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation
SCORE 14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent
SCORE 2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-27% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

HABITAT ASSESSMENT FIELD DATA SHEET – LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE__10__(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE__10__(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed or grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE__10__(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE__10__(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE__10__(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE__10__(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score ______153_____

HABITAT ASSESSMENT FIELD DATA SHEET – LOW GRADIENT STREAMS (FRONT)

STREAM NAME Boggy Creek	LOCATION	
STATION # BC 1-1 RIVERMILE _______	STREAM CLASS	
LAT ______________________ LONG ___________	RIVER BASIN	
STOREET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY PJD	DATE 5/15/06 TIME 1700 AM PM	REASON FOR SURVEY UAA

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE 16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent
SCORE 13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-27% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

HABITAT ASSESSMENT FIELD DATA SHEET – LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach	Habitat Parameter	Condition Category			
		Optimal	Suboptimal	Marginal	Poor
	6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	SCORE 19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
	7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
	SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
	8. Bank Stability (score each bank) **where culverts/ditches enter**	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	SCORE__10__(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE__10__(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
	9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed or grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	SCORE__10__(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE__10__(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
	10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
	SCORE__10__(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE__10__(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score ______156______

HABITAT ASSESSMENT FIELD DATA SHEET – LOW GRADIENT STREAMS (FRONT)

STREAM NAME Boggy Creek	LOCATION
STATION # BC 1-2 RIVERMILE _______	STREAM CLASS
LAT _______________ LONG ___________	RIVER BASIN
STORET #	AGENCY
INVESTIGATORS	
FORM COMPLETED BY PJD	DATE 5/15/06 TIME 1600 AM PM — REASON FOR SURVEY UAA

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE 17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent
SCORE 13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-27% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

HABITAT ASSESSMENT FIELD DATA SHEET – LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach	Habitat Parameter	Condition Category			
		Optimal	Suboptimal	Marginal	Poor
	6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	SCORE 20	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
	7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
	SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
	8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	SCORE__10__(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE__10__(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
	9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed or grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	SCORE__10__(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE__10__(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
	10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
	SCORE__10__(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE__10__(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score ______150_____

HABITAT ASSESSMENT FIELD DATA SHEET – LOW GRADIENT STREAMS (FRONT)

STREAM NAME Boggy Creek	LOCATION
STATION # Bc 1-3 RIVERMILE _______	STREAM CLASS
LAT ______________________ LONG ___________	RIVER BASIN
STORET #	AGENCY
INVESTIGATORS DMR, RPG, JJR, NJS	
FORM COMPLETED BY DMR	DATE 5/16/05 TIME 1630 AM PM
	REASON FOR SURVEY UAA

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE 13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation
SCORE 13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent
SCORE 14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-27% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

HABITAT ASSESSMENT FIELD DATA SHEET – LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	**Condition Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 8 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 8 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) trees mostly absent	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed or grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 9 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 9 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE 10 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 142

HABITAT ASSESSMENT FIELD DATA SHEET – LOW GRADIENT STREAMS (FRONT)

STREAM NAME Boggy Creek	LOCATION	
STATION # BC - 3 RIVERMILE ______	STREAM CLASS	
LAT ____________________ LONG __________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS DMR, JJR, RPG		
FORM COMPLETED BY DMR	DATE 5/16/05 TIME 0845 AM PM	REASON FOR SURVEY UAA

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE 14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation
SCORE 13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent
SCORE 12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-27% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

HABITAT ASSESSMENT FIELD DATA SHEET – LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach	Habitat Parameter	Condition Category			
		Optimal	Suboptimal	Marginal	Poor
	6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	SCORE 14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
	7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
	SCORE 12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
	8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	SCORE 9 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE 9 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
	9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed or grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	SCORE 10 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE 10 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
	10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
	SCORE 10 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE 10 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 154

HABITAT ASSESSMENT FIELD DATA SHEET – LOW GRADIENT STREAMS (FRONT)

STREAM NAME Boggy Creek	LOCATION Near RR Track at Teris Plant Site	
STATION #________Reach 2__RIVERMILE _______	STREAM CLASS	
LAT ______________________ LONG ___________	RIVER BASIN	
STORET #	AGENCY NA	
INVESTIGATORS FTN Associates		
FORM COMPLETED BY NJS	DATE____5/16/05____ TIME ____1040______ AM PM	REASON FOR SURVEY UAA

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE 12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation. Concrete box culvert	Hard-pan clay or bedrock; no root mat or vegetation
SCORE 10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent
SCORE 16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-27% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

HABITAT ASSESSMENT FIELD DATA SHEET – LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	**Condition Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; “raw” areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 9 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 9 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed or grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 9 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 9 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE 4 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 4 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 136

APPENDIX E

Analytical Laboratory Data Reports

APPENDIX F

Steady State Mass Budget Model Runs

Case 1 and 2 Bayou de Loutre Point Source Concentrations
The mass balance below is used to calculate concetrations in Bayou de Loutre upstream of Boggy Creek

1. Point Source Inflow and loads to Bayou de Loutre US of Boggy Creek
Period of Record: 6/30/2004 - 6/30/2006

					Concentration (mg/L)[2]			Load (lbs/day)		
Permit	Company	Outfall	Flow (mgd)[1]	Flow (cfs)	SO_4	Cl	TDS	SO_4	Cl	TDS
AR0000647	Lion Oil Company	1	2.566	3.970	1,385.4	0	2807.98	29,667	0	60,131
		2	1.521	2.353	0	0	0	0	0	0
		3	1.393	2.155	0	0	0	0	0	0
		4	2.683	4.151	0	0	0	0	0	0
		5	0.000	0.000	0	0	0	0	0	0
		6	2.216	3.429	0	0	0	0	0	0
		7	2.880	4.456	0	0	0	0	0	0
AR0001171	Great Lakes Chemical Corp	1	2.650	4.100	15.4	159.7	0	340	3,531	0
		2	0.154	0.238	65.5	1,761.0	3,407.0	84	2,263	4,379
		3	0.747	1.156	51.3	480.8	2,385.0	319	2,997	14,868
		4	0.414	0.641	50.5	462.1	1,748.3	174	1,596	6,040
AR0033723	El Dorado South WWTP[3]		6.090	9.423	0	0	100	0	0	5,082
		TOTAL =	23.314	36.072				30,585	10,388	90,500

Notes: 1. These flows are based of DMRs downloaded from PCS and found in "Flow Calcs-DMR data 2 years". The analysis assumed the the design flow to be the highest monthly average flow measured in the last 2 years (per PHM).
2. These are the 95th percentile concentrations, based of DMRs downloaded from PCS and found in individual files, using average monthly concentrations.
3. El Dorado WWTP plant had no DMR concentration data but its TDS was set to 100 mg/L.

2. Point Source Concentrations for Bayou de Loutre upstream of Boggy Creek

Total Flow = 36.072 cfs

	SO_4	Cl	TDS
Loads (lbs/day) =	30,585	10,388	90,500
Concentrations (mg/L) =	157	53	465

FILE: R:\PROJECTS\6170-026\TECH\DMRS & LOADS\BACK CAL BDL.XLS

Mass balance calculations in Bayou de Loutre and Boggy Creek RRB;December 4, 2006.

Case 1: No runoff, all flow from point sources

1. Bayou de Loutre Upstream of Confluence With Boggy Creek

	Concentrations (mg/L)[1]			Load (lbs/day)		
Flow (cfs)[1]	TDS	Cl	SO_4	TDS	Cl	SO_4
36.072	465	53	157	90,472	10,312	30,547

2. Boggy Creek at Mouth

	Concentrations (mg/L)			Load (lbs/day)		
Flow (cfs)[2]	TDS	Cl	SO_4	TDS	Cl	SO_4
0.290	1,400	653	52	2,190	1,021	81

3. Bayou de Loutre Downstream of Confluence With Boggy Creek

	Concentrations (mg/L)			Load (lbs/day)		
Flow (cfs)	TDS	Cl	SO_4	TDS	Cl	SO_4
36.362	**472**	**58**	**156**	**92,662**	**11,333**	**30,628**

Case 2: Point Source plus runoff

1. Bayou de Loutre Upstream of Confluence With Boggy Creek

Ambient (runoff)

	Concentrations (mg/L)			Load (lbs/da	
Flow (cfs)[3]	TDS	Cl	SO_4	TDS	Cl
29.840	240	86	4.2	38,628	13,842

Point Source

	Concentrations (mg/L)[1]			Load (lbs/da	
Flow (cfs)[1]	TDS	Cl	SO_4	TDS	Cl
36.072	465	53	157	90,472	10,312

Ambient (runoff) + Point Source

	Concentrations (mg/L)			Load (lbs/da	
Flow (cfs)	TDS	Cl	SO_4	TDS	Cl
65.912	363	68	88	129,100	24,154

2. Boggy Creek at Mouth

Case 3: No runoff, all flow from point sources (same as in case 1 in Bayou de Loutre during May and July Field Surveyes

1. Bayou de Loutre Upstream of Confluence With Boggy Creek

	Concentrations (mg/L)			Load (
Flow (cfs)[1]	TDS	Cl	SO_4	TDS
36.072	1705	150	420	331,732	29

2. Boggy Creek at Mouth

	Concentrations (mg/L)			Load (
Flow (cfs)[2]	TDS	Cl	SO_4	TDS
0.290	1,400	653	52	2,190	1,

3. Bayou de Loutre Downstream of Confluence With Boggy Creek

Case 4: Point Source plus runoff (same as case 2) but with
in Bayou de Loutre during May and July Field Surve

1. Bayou de Loutre Upstream of Confluence With Boggy Creek

Ambient (runoff)

	Concentrations (mg/L)			
Flow (cfs)[3]	TDS	Cl	SO_4	TDS
29.840	240	86	4.2	38,628

Point Source

	Concentrations (mg/L)			
Flow (cfs)[1]	TDS	Cl	SO_4	TDS
36.072	1705	150	420	331,732

APPENDIX G

Use Documentation from State Agencies

File: 6170-026
Correspondence

Arkansas Natural Resources Commission

J. Randy Young, PE
Executive Director

101 East Capitol, Suite 350
Little Rock, Arkansas 72201
http://www.anrc.arkansas.gov/

Phone: (501) 682-1611
Fax: (501) 682-3991
E-mail: anrc@arkansas.gov

Mike Huckabee
Governor

December 11, 2006

Mr. David Rupe, Project Scientist
FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, Arkansas 72211-2492

RE: Evaluation of Boggy Creek and the State Water Plan

Dear Mr. Rupe:

Thank you for this opportunity to evaluate Boggy Creek within the scope of your Use Attainability Analysis. The Arkansas Natural Resources Commission has responsibility for the regulation of the withdrawal of water from streams and reservoirs not within the jurisdiction of regulation by the Arkansas Department of Environmental Quality.

As you know, Boggy Creek - and all other waters of the State - are included within the State Water Plan. We have examined the water use data for Union County, Arkansas and have identified no registered agricultural, municipal or industrial diversions from Boggy Creek, a tributary of Bayou de Loutre. Therefore, the results of your use attainability analysis will not conflict with the Arkansas State Water Plan.

If you need any further assistance, or have any questions, please contact Steve Loop at (501)-682-3959.

Sincerely,

Earl T. Smith, P.E., Chief
Water Resources Division

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LITTLE ROCK OFFICE

FTN ... Correspondence

Arkansas Department of Health and Human Services

Division of Health

Paul K. Halverson, DrPH, Director

Engineering Section – Environmental Health Branch – Center for Local Public Health

Postal Address	P. O. Box 1437, Slot H-37	Little Rock, AR 72203-1437	1-501-661-2623	TDD: 1-800-234-4399
Physical Address for UPS or Fedex	4815 West Markham St., Slot H-37	Little Rock, AR 72205		Fax: 1-501-661-2032

December 11, 2006

David Rupe
FTN Associates Ltd.
3 Innwood Circle, Suite 220
Little Rock, AR 72211-2492

RE: Clean Harbors discharge to Boggy Creek, El Dorado, Union County, Arkansas, FTN No. 6170-026

Dear Mr. Rupe,

A staff review has been made of the information received on the referenced project. The Engineering Section has no knowledge of any consideration of utilizing Boggy Creek or Bayou de Loutre as public water system source.

If you have any questions or comments, please coordinate them through Gerry Conley, 501-661-2067.

Sincerely,

Bob Makin, P.E.
Assistant Director
Engineering Section

BM:RH:RM:gc

Cc: