LOUTRE CREEK – SECTION 2.303
USE ATTAINABILITY ANALYSIS

Prepared for:

Lion Oil Company
1000 McHenry
El Dorado, AR 71730

Prepared by:

GBMc & Associates
219 Brown Lane
Bryant, AR 72022

January 7, 2013

CONTENTS

CONTENTS (cont)

CONTENTS (cont)

CONTENTS (cont)

FIGURES

FIGURES (cont)

FIGURES (cont)

FIGURES (cont)

FIGURES (cont)

TABLES

TABLES (cont)

ATTACHEMENTS

1.0 INTRODUCTION

1.1 Overview

Pursuant to Arkansas Pollution Control and Ecology Commission Regulation 2.303 on Use Attainability Analysis (UAA), Lion Oil Company (Lion Oil) submits this UAA for Loutre Creek to define and characterize the appropriate fisheries use designation for this waterbody and, based on this designation, the appropriate selenium and dissolved minerals (chloride, sulfate, and total dissolved solids) criteria that support the use.

Loutre Creek maintains a healthy fishery, but due to the small size of the watershed, the effects of urbanization, and historical resource extraction, the fishery is not a Typical Gulf Coastal Fishery. Loutre Creek supports a subcategory of fishery, referred to as a Limited Gulf Coastal Fishery, which includes 12 species of fish identified in Loutre Creek as compared to the 24 or more species of fish that characterize a Typical Gulf Coastal Fishery.

Given these findings, it is recommended that the Commission exercise its authority under Regulation No. 2.303 and designate Loutre Creek as supporting a Limited Gulf Coastal Fishery, a new subcategory of use. When designating Loutre Creek as supporting a Limited Gulf Coastal Fishery, it is also recommended that the Commission:

1. adopt new selenium water quality criterion for Loutre Creek of 38 ug/l, which is protective of the Limited Fishery that is present in the creek; and
2. adopt new dissolved minerals criteria for Loutre Creek because these criteria are protective of the Limited Fishery and would also be protective of the Typical Fishery if it were present in the creek.

With respect to the dissolved minerals criteria, the Commission already approved less stringent criteria for Loutre Creek in 2007. These criteria remain codified in Regulation 2, but the U.S. Environmental Protection Agency (EPA) disapproved these criteria and requested additional information before it would approve them. This UAA includes this additional information for Loutre Creek and recommends adoption of revised dissolved minerals criteria that are more stringent than the criteria previously approved. Although the criteria previously approved by the Commission are scientifically justified, Lion Oil is proposing more stringent criteria because it believes it can comply with the more stringent criteria. Over the past seven years, Lion Oil has reduced the mass of TDS and sulfates in its wastewater effluent by 20% and 32%, respectively. Further, Lion Oil has developed a strategy to continue to significantly reduce TDS and sulfates in its wastewater by adding SO_2 reducing catalyst additives to its fluid catalytic cracking unit regenerator. Through this process, Lion Oil expects an additional 20% reduction in TDS and 30% reduction in sulfates in the final effluent.

Loutre Creek is a tributary to Bayou de Loutre. This UAA focuses on Loutre Creek and demonstrates that it is unnecessary to develop a site specific criterion for selenium for Bayou de Loutre, but that it is necessary to develop site specific criteria for dissolved minerals for Bayou de Loutre. Accordingly, Lion Oil has also prepared for the Commission a second document entitled: *Bayou de Loutre Section 2.306 Supplemental Site Specific Water Quality Study* (Bayou de Loutre SSC). Because Lion Oil does not propose to modify the fishery use designation for Bayou de Loutre , the Bayou de Loutre SSC provides the basis to adopt revised dissolved minerals criteria for Bayou de Loutre under Regulation No. 2.306.[1]

1.2 Background on Loutre Creek

Loutre Creek is a small sub-watershed (less than 5 mi^2) that drains the southwest portion of the City of El Dorado (Figure 1.1). Loutre Creek is a tributary to Bayou de Loutre, which is also a small watershed (less than 5 mi^2) above the mouth of Loutre Creek. Collectively Loutre Creek and Bayou de Loutre drain a combined watershed area of less than 10 square miles at the mouth of Loutre Creek. Both of these watersheds are in Union County Arkansas. Currently, the fishery for Loutre Creek is designated as a Typical Gulf Coastal Fishery in Regulation 2 with a selenium chronic water quality criterion of 5 micrograms per liter (ug/L), selenium acute criterion of 20 ug/L, and dissolved minerals criteria of 18.7 milligrams per liter (mg/L) for chloride, 41.3 mg/L for sulfate, and 138 mg/L for TDS. Previous UAAs and aquatic life field studies have been completed on Loutre Creek for dissolved oxygen demanding waste in 1986 (Brown and Caldwell, 1986) and for site specific dissolved minerals criteria and removal of drinking water use designation in 2006 (GBMc, 2006).

As discussed more fully in this UAA, the Loutre Creek watershed has been and continues to be affected by land-use practices that limit the type of fishery that can develop in the Creek. Figures 1.2 to 1.8 depict the historical urban development within the Loutre Creek watershed for the period from 1949 through 2011. This development has caused increased sedimentation and storm water runoff that has impacted the fishery. Loutre Creek is also largely affected by historical oil extraction activities that have existed for over 90 years. For instance, the oil well that triggered the great south

[1] If the Commission decides not to create a subcategory of the fishery for Loutre Creek, then it is recommended that the Commission amend the dissolved minerals criteria for Loutre Creek pursuant to Regulation 2.306 and based upon the information in the Loutre Creek UAA and the attachments thereto.

Arkansas Oil Boom (Busey No. 1 also known as the “Discovery Well”) was completed on January 10, 1921 and “….produced a gusher well that sprayed 3,000 to 10,000 barrels of oil up to a mile way.” http://www.unioncountysheriff.net/viewpage.php?page_id=19[2] The Busey No. 1 well was in the immediate watershed of Loutre Creek (Figure 1.9). During the early days of the oil boom, Loutre Creek, and the immediate riparian flood plain were flooded with crude oil which remains as legacy contaminates even today and are present in the stream banks and stream beds in Loutre Creek and Bayou de Loutre (Figures 1.10 - 1.13).

1.3 Background on Lion Oil

The Lion Oil refinery is located in El Dorado, Arkansas, Union County. An oil refinery has operated at the site since 1922 (Figure 1.2). Current refinery capacity is approximately 85,000 barrels per day (bpd).

Lion Oil discharges treated wastewater to Loutre Creek through NPDES Outfall 001 (NPDES No. AR000647). A copy of Lion Oil’s NPDES permit is provided at Attachment A. Lion Oil has also prepared and implements a Storm Water Pollution Prevention Plan (SWPPP) to reduce pollutant loadings from facility storm water runoff to the Creek. In addition to implementing measures under the SWPPP, Lion Oil recently completed a facility wide Stormwater Segregation Project at a cost of $14,000,000 with the goal of eliminating the potential for contaminated storm water to be discharged to the Creek. Lion Oil also maintains a Spill Prevention, Control, and Countermeasure (SPCC) Plan for oil spill prevention, preparedness, and response to prevent oil spills. Further, Lion Oil is contributing to the restoration of the Loutre Creek watershed by remediating two lagoons on its property.

Although there is extensive urban development in the watershed, Lion Oil is the only permitted discharger in the Loutre Creek watershed. During the 2004 NPDES permit renewal, permit limits for total selenium at Outfall 001 were established as 5.8 micrograms per liter (µg/L) monthly average and 11.65 µg/L daily maximum. Under the permit, these limits did not go into effect until 2007. Analyses completed during the interim period of the new permit indicated the discharge from Outfall 001 would exceed the final daily maximum concentration permit limit. This condition, in addition to other permit issues led to the development of a consent administrative order (CAO LIS No. 08-104). In accordance with Item 3 of the CAO, Lion Oil developed a Compliance Action Plan to remedy the selenium compliance issue. One of the major components of the Compliance Action

[2] Buckalew, A.R. and R.B. Buckalew. The Discovery of Oil in South Arkansas, 1920-1924. Union County Sheriff’s Office Web site.

Plan was to complete a UAA and develop site specific criteria (SSC) for selenium in Loutre Creek and, if necessary, in Bayou de Loutre.

In addition, the 2004 NPDES permit renewal established permit limits for sulfate (SO_4 at 68 mg/L, monthly average and 102 mg/L daily maximum) and for total dissolved solids (TDS at 207 mg/L monthly average and 310 mg/L daily maximum). Lion Oil completed a third party rulemaking in accordance with Regulation 2.306 (APCEC, 2007) and the ADEQ dissolved mineral implementation strategy as provided in ADEQ's Continuous Planning Process (ADEQ, 2000). The third party rulemaking resulted in revised dissolved minerals criteria approved by the Commission. However, the criteria were subsequently disapproved by EPA and cannot be used in establishing new NPDES permit limits for Lion Oil's discharge to Loutre Creek. In response to EPA's disapproval, additional data has been developed for Loutre Creek and is presented in Section 1.5 below in support of the dissolved minerals criteria now proposed for adoption.

1.4 UAA Organization and Associated Tasks

This UAA includes the information required to support the proposed amendments to Regulation 2 through third party rulemaking, including:

- Information to modify the fisheries use designation for Loutre Creek in accordance with Regulation 2.303;
- Documentation of the current discharge concentrations that support the fisheries use in Loutre Creek downstream of the discharge and the supporting biotic communities to maintain that use, and
- Documentation for the proposed site-specific water quality criterion for total selenium and criteria for dissolved minerals in accordance with Regulation 2.303.

As a precursor to this UAA, a Quality Assurance Plan (QAPP) was developed and submitted to ADEQ and EPA for their review and comment (Attachment B). The UAA was completed in accordance with the QAPP. The QAPP identified seven specific tasks to complete in the UAA. These tasks were initially focused on evaluating the fishery in Loutre Creek and Bayou de Loutre for the purpose of proposing a revised selenium criterion because, at the time the tasks were developed, the Commission had already approved in 2007 the revised dissolved minerals criteria for both Loutre Creek and Bayou de Loutre. Once it became clear that the designated fishery for Loutre Creek should be changed to a Limited Gulf Coastal Fishery, and once EPA rejected the dissolved minerals criteria previously approved by the Commission, Lion Oil determined this UAA should include information to support modification of both the selenium and dissolved mineral criteria for Loutre

Creek. Many of the QAPP tasks performed to develop the selenium criterion (e.g., characterization of the aquatic community) are equally relevant to development of the dissolved minerals criteria. Where appropriate, the text delineates information that is relevant only to selenium or dissolved minerals.

The UAA is organized in the following sections:

- **Section 2: Significant Findings and Recommendations:** This section summarizes key findings and recommendations to change the fishery use designation for Loutre Creek and the associated selenium and dissolved minerals criteria.
- **Section 3: Fishery Use Designation and Modification:** This section addresses two related topics. First, it identifies the designated uses of Loutre Creek, describes how Loutre Creek was designated as supporting a Typical Gulf Coastal Fishery, and describes the fishery that is actually found in Loutre Creek. Second, it discusses the Commission's authority to designate a subcategory of fishery for Loutre Creek and explains why it is appropriate to do so.
- **Section 4: Findings from Aquatic Life Field Study:** A biological assessment was completed to document the existing conditions of the aquatic communities and physical habitat of Loutre Creek and Bayou de Loutre. Fish and macroinvertebrate collections were completed during the spring of 2009 under steady state flows to assess the health of the biota and maintenance of biological integrity. Detailed habitat assessment was completed to document the available habitat, the existing condition of the channel and the condition of the riparian corridor. Fish community assemblages were characterized using electro fishing techniques, supplemented with seine hauls where appropriate. The macroinvertebrate community was characterized in collections made using multi-habitat rapid bioassessment protocols. Data generated during this project was compared to available historical data to evaluate long-term trends in biological communities. This Biological Assessment was Task 1 of the QAPP.
- **Section 5: Existing loadings, water quality, and calculated criteria:** A historical summary of the Lion Oil Outfall 001 effluent is presented to statistically characterize the parameters in question (selenium and dissolved minerals) in the discharge and in the receiving streams. In addition, various chemical parameters were monitored during the UAA study. The selenium concentration was measured in the Lion Oil effluent and in ambient waters throughout the UAA project, and includes data generated during: 1) the 2009-2010 aquatic life field study, 2) an assessment of sunfish community reproductive activity, 3) the monthly Outfall 001 effluent

monitoring (January 2005 to April 2, 2012), and 4) ambient water quality monitoring (April 2009 through October 2010). *In-situ* parameters included pH, temperature, dissolved oxygen, specific conductance, and turbidity. Samples delivered to the laboratory were analyzed for total selenium, dissolved selenium, total hardness, total suspended solids, total dissolved solids and volatile suspended solids. This water quality analysis was Task 3 of the QAPP.

- **Section 6: Analysis of Selenium in Food Web:** An evaluation of selenium loading was completed to determine the effect of selenium on resident biota from Loutre Creek and downstream in Bayou de Loutre. The assessment included efforts to determine possible effects on reproductive and/or embryological development to fishes in the Centrarchidae (sunfish) family. Selenium levels from the water column, sediment, within primary producer and primary consumer trophic levels and selenium body burden of target fish species were measured to develop a relationship between water column levels and those measured in the target sunfish species. This analysis of selenium in the food web was Task 2 of the QAPP.
- **Section 7: Fate and Transport Modeling:** A water quality model was developed to assess the field data and calibrate the fate of selenium in the aquatic environment in Loutre Creek and downstream in Bayou de Loutre. The modeling was designed to determine the transport and deposition of selenium in the aquatic environment and to identify where in the trophic structure the selenium is being assimilated, predict and project bioaccumulation over time, and at what concentrations impacts would be projected to occur to the resident biota. This fate and transport modeling was Task 4 of the QAPP.
- **Section 8: Alternative Analyses to Meet Criteria:** Alternatives were investigated to control/reduce selenium and dissolved minerals in the discharge to meet current water quality criteria. This alternatives analysis was Task 6 of the QAPP.
- **Section 9: Selected Alternative, Use Determination, and SSC Development:** Maintenance of the fisheries use in Loutre Creek and Bayou de Loutre was evaluated. Feasibility of designating Loutre Creek with a fisheries subcategory consistent with the historical land-uses was explored. Based on this analysis, a new use subcategory of fishery is proposed for Loutre Creek and supported by the existing resident aquatic biota, and site specific criteria for selenium and dissolved minerals are proposed for Loutre Creek. For selenium, the site specific criterion is based on historical selenium data from the monitoring of UAA stream study reaches. For dissolved minerals, the site specific criteria are based on historical instream concentrations of dissolved minerals and the projected reduction in

dissolved minerals in the Lion Oil discharge following implementation of the SO_2 reducing catalyst additives to Lion Oil's fluid catalytic cracking unit regenerator.

- **Section 10: References**

1.5 Documentation and Technical Basis in Support of Revised Dissolved Minerals Criteria

This UAA provides information to support modification of the fisheries use designation and associated selenium and dissolved minerals criteria for Loutre Creek. Because the UAA was initially focused on selenium, a significant amount of the documentation pertains to selenium. Although information in support of the proposed dissolved minerals criteria for Loutre Creek is included in other sections of this UAA, this subsection summarizes the documentation and technical basis that pertain to the proposed dissolved minerals criteria.

Enclosed is a timeline of the information submitted and regulatory actions taken to support the revisions to the dissolved minerals criteria for Loutre Creek (Attachment C). The submittals and actions demonstrate Lion Oil's significant efforts to support the development of appropriate water quality criteria for this waterbody. Below is a summary of the more significant actions and associated documents that concern the dissolved minerals rulemaking:

1. October 27, 2006. Lion Oil initiates third party rulemaking for dissolved minerals for Loutre Creek and Bayou de Loutre with submittal of the Loutre Creek - Section 2.306 Site Specific Water Quality Study, dated October 3, 2006 (GBMc, 2006 Study) (Attachment D). This documentation provides technical and aquatic life information to document that the historical concentrations of dissolved minerals in Lion Oil's discharge have maintained aquatic life communities (both invertebrate and fish communities) in Loutre Creek and downstream in Bayou de Loutre. The 2006 Study also includes mass balance modeling to determine appropriate dissolved mineral criteria for the reaches in Bayou de Loutre that are downstream of Lion Oil's discharge. The bulk of the documentation supporting the dissolved minerals criteria proposed in this UAA is included in the 2006 Study. This UAA encloses and relies on the 2006 Study to support the findings and recommendations herein.
2. June, 22 2007. Commission approves third party rulemaking. The original third party rulemaking to support revised dissolved minerals criteria for Loutre Creek and Bayou de Loutre was initiated during the October 27, 2006 Commission meeting and was approved by Minute Order No. 07-10, docket number 06-011-R, signed on June 22, 2007 (Attachment E).

3. August, 17 2007. The Commission-approved criteria sent to Region 6 EPA for review and approval.
4. January 2008. In a letter dated January 3, 2008, EPA approved the third party rulemaking in part by approving the removal of the domestic water supply use for Loutre Creek and Bayou de Loutre. EPA requested additional information related to the modification of the criteria for dissolved minerals. Attachment F provides the EPA request for additional information.
5. June 27, 2008. Lion Oil provides ADEQ with a response to EPA's additional information request (Attachment G). ADEQ later (July 29, 2008) forwarded the response to EPA on July 29, 2008. In the cover letter transmitting the response, ADEQ stated that Lion Oil had adequately addressed the EPA issues and that ADEQ was in agreement with the additional information.
6. April 2009. EPA provided notice that the additional information provided in Lion Oil's initial response (Attachment H) to the EPA's January 2008 letter was not adequate for their approval of the revised dissolved minerals criteria. EPA's Record of Decision disapproves the site specific criteria for Loutre Creek and Bayou de Loutre approved by the Commission in 2007.
7. June 15, 2009. To address EPA's concerns related to dissolved minerals, Lion Oil developed an Aquatic Life Justification Supplemental Information Study Plan The Study Plan was approved by ADEQ and submitted to EPA for review and comment (Attachment I).
8. January 7, 2011. Lion Oil completes the Aquatic Life Justification Supplemental Report and submits to ADEQ and EPA for review (Attachment J). The Report demonstrates that the 2007-Commission approved modifications to the dissolved minerals criteria for Loutre Creek and Bayou de Loutre would be protective of the attainable fisheries use for these waterbodies. This information was developed in accordance with the approved Study Plan and provides additional justification for the revised dissolved mineral criteria for Loutre Creek and Bayou de Loutre. The Supplemental Report includes:
   - A literature review of past rulemakings approved by EPA for other stream segments that demonstrate that the modifications approved in Lion Oil's third party rulemaking approximate and/or are more conservative as compared to other waterbodies.
   - Modeling of projected dissolved minerals concentrations to determine the potential for toxic instream effects of the approved dissolved minerals criteria using a GRI model. The model predicted no toxic effects associated with the dissolved minerals concentration levels of the approved criteria.

- Based on concurrent long term monitoring of instream dissolved minerals concentrations and whole effluent toxicity (WET) testing in segments below Lion Oil's discharge, the historical instream concentrations of dissolved minerals are supportive of the attainable fisheries use for Loutre Creek and Bayou de Loutre.
- Assessment of the potential for toxic effects of the 2007 approved dissolved minerals criteria using a laboratory developed water matrix to mimic the worst case conditions in the receiving stream indicated the potential for chronic effects in a lab setting, but no such effects have been observed in the field.
- Assessment of long term effluent dissolved mineral concentrations and WET test performance verified that the dissolved minerals discharged in the Lion Oil Outfall 001 effluent had no statistically significant relationship with the results of the WET tests.
- Two technical documents have been prepared in response to comments from the EPA on the Supplemental Report (Attachment K).

9. October 24, 2012. Lion Oil submitted to ADEQ and EPA the results of whole effluent toxicity (WET) tests that were completed to reflect the revised more stringent dissolved minerals criteria now proposed for adoption. These recent tests show that the criteria proposed for Loutre Creek passed the 7-day chronic WET tests, both lethal and sub-lethal endpoints, evidencing the fact that the proposed criteria for Loutre Creek do not result in either lethal or sub-lethal effects. The criteria proposed for Bayou de Loutre are more stringent (lower in concentration) than those proposed for Loutre Creek so the Bayou de Loutre criteria also do not have such effects. (Attachment L, Artificial Matrix WET with 4 tests).

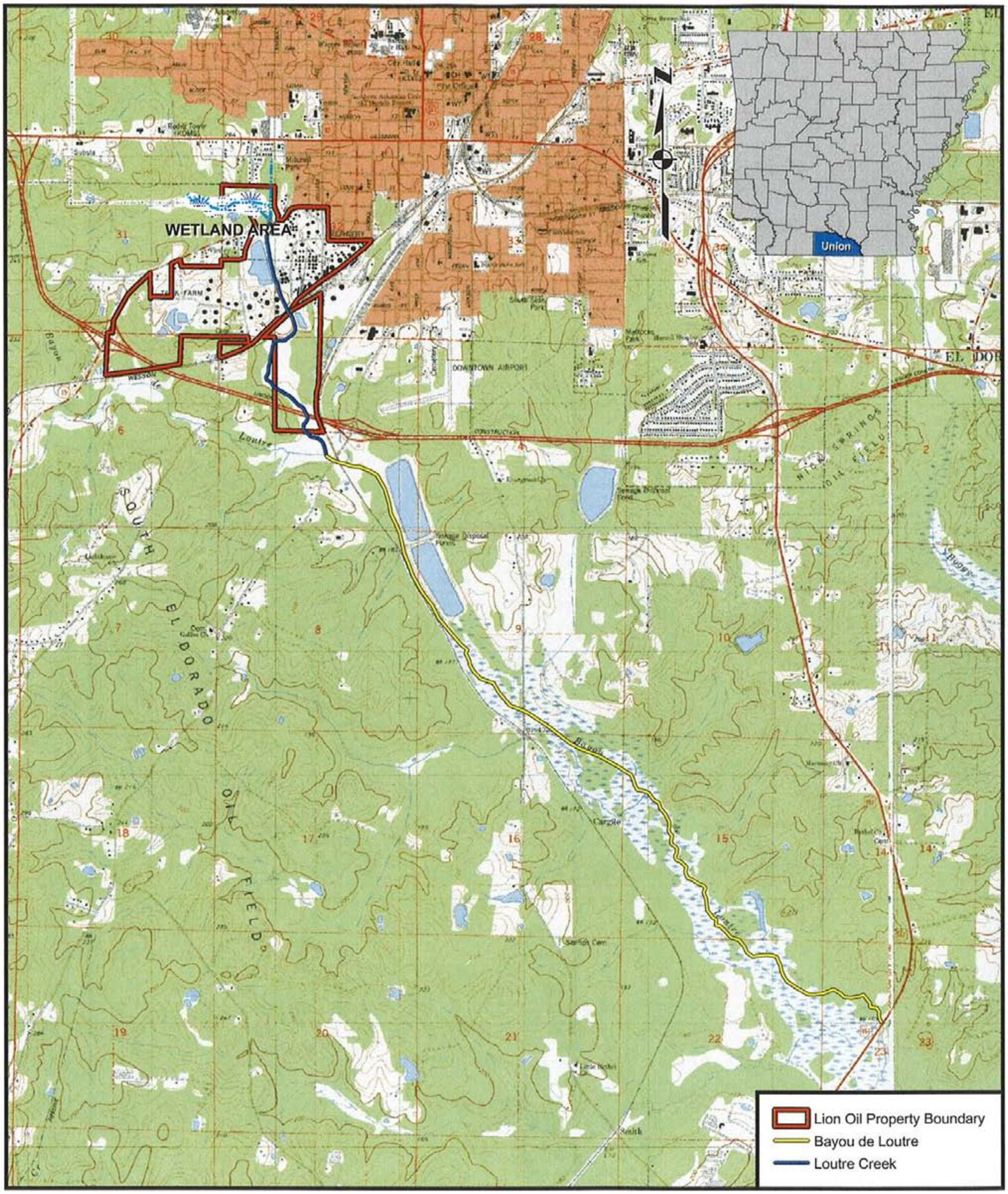
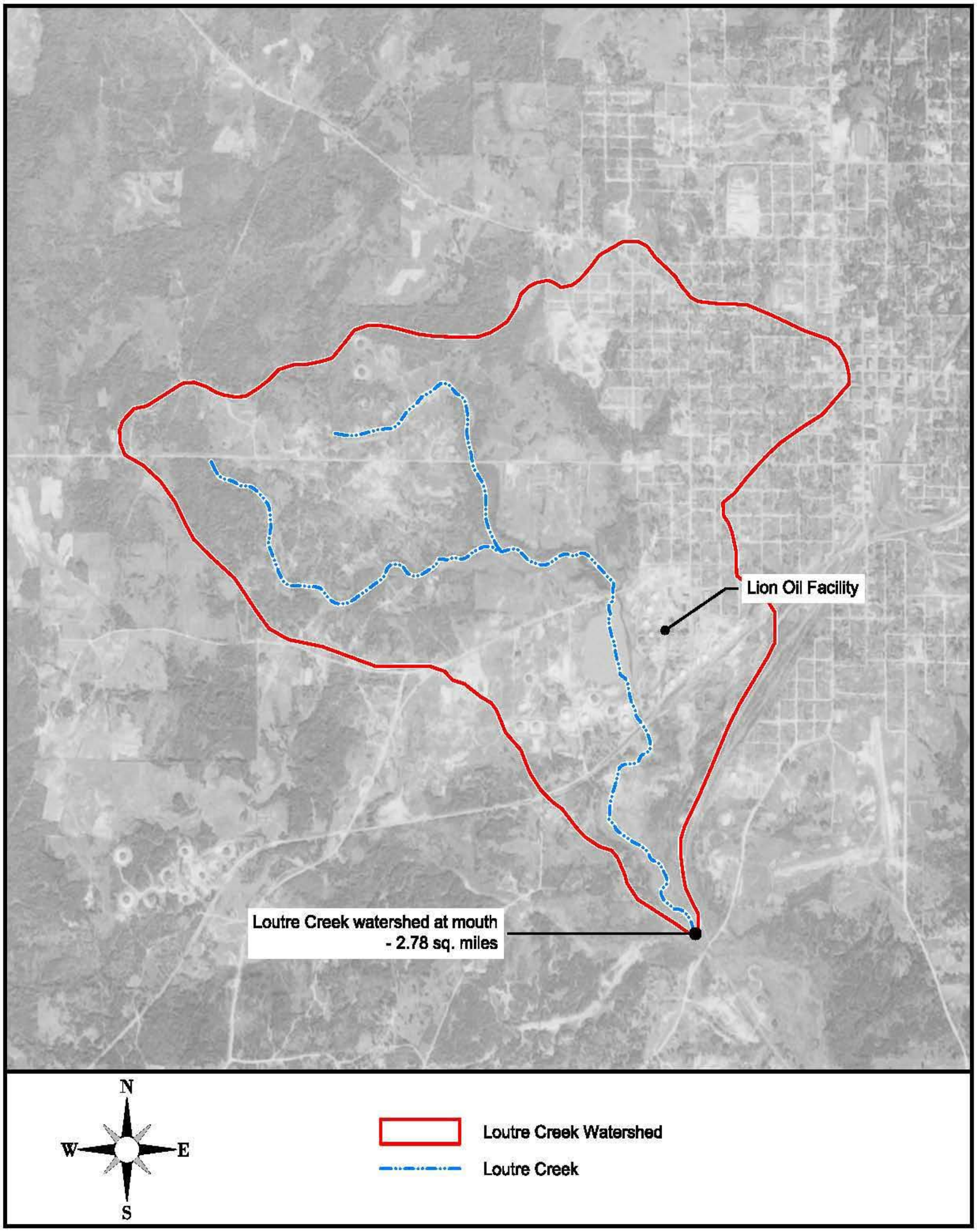


Figure 1.1. Location and spatial relationship of Lion Oil, Loutre Creek and Bayou de Loutre. UAA documentation. 2012.



1949 Aerial

Figure 1.2. Historical Aerial of Loutre Creek Watershed. Circa 1949.

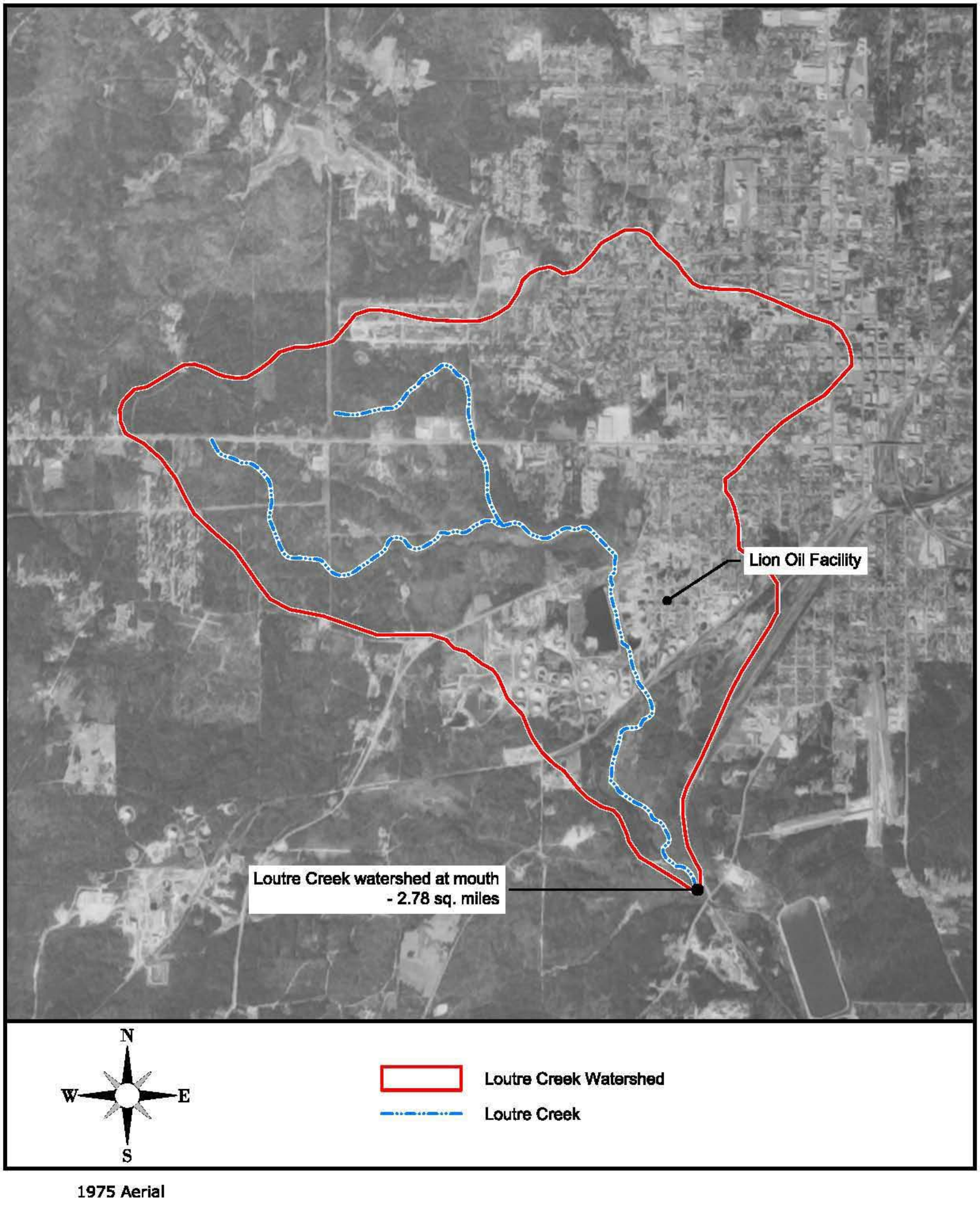
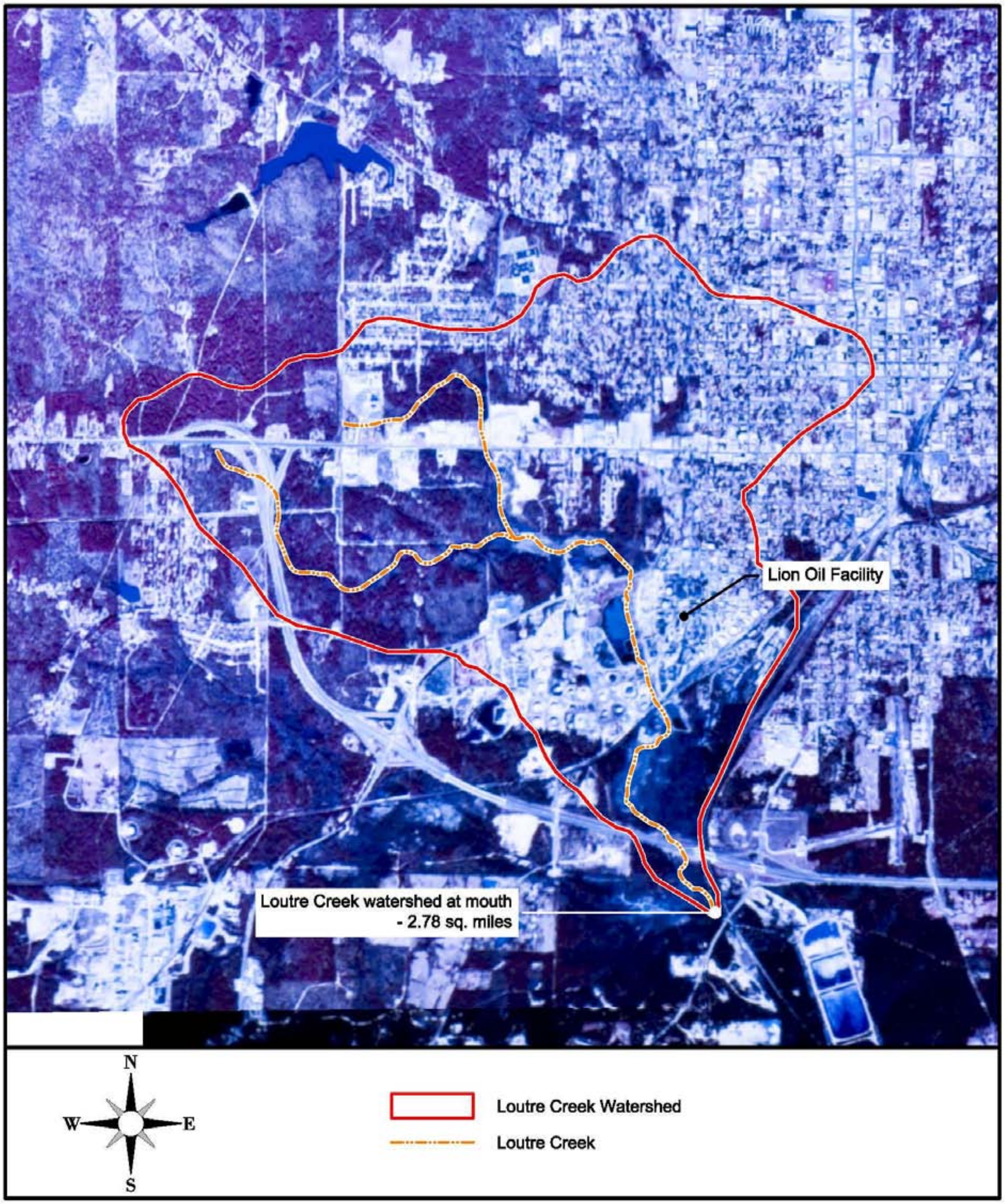
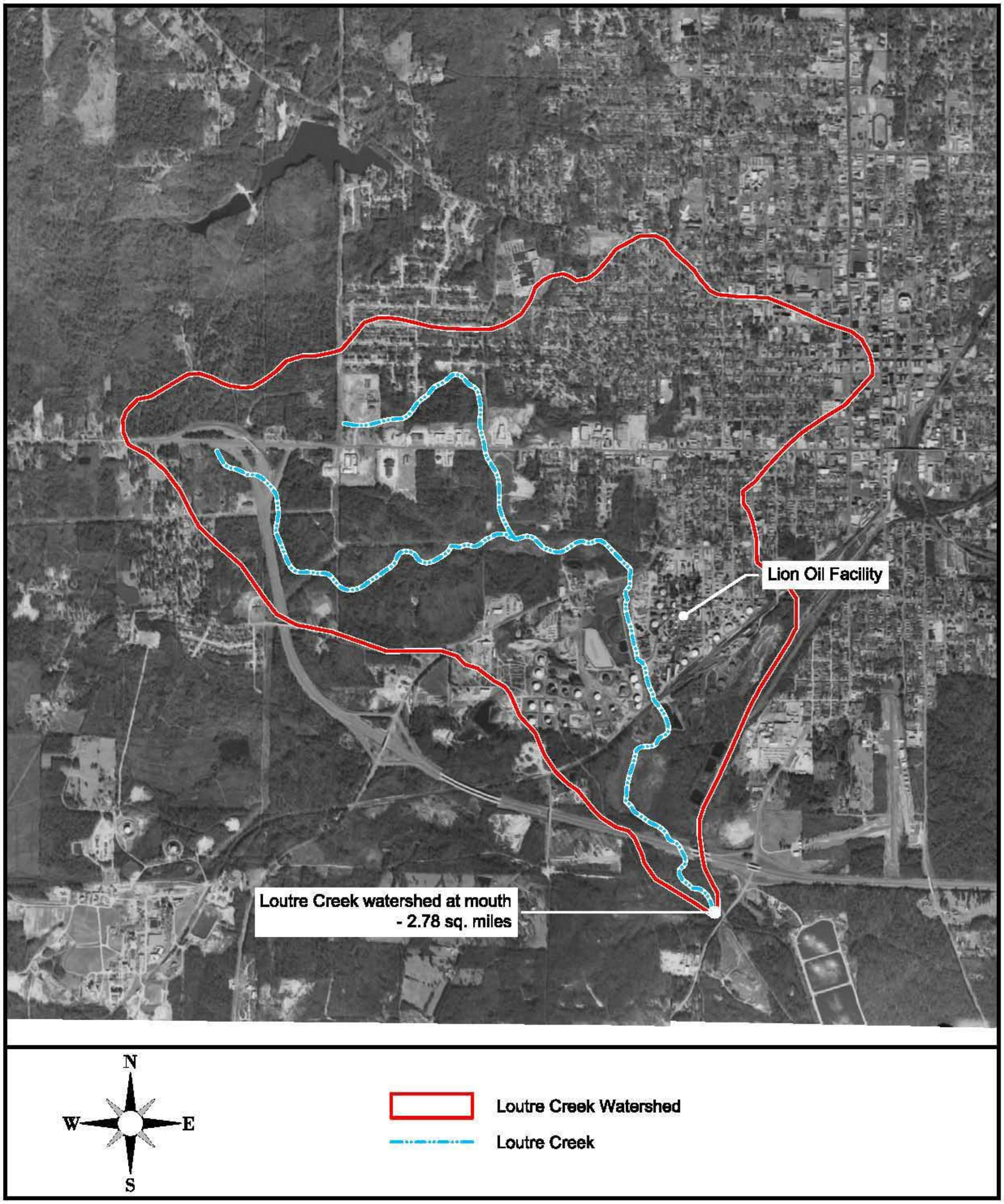


Figure 1.3. Historical Aerial of Loutre Creek Watershed. Circa 1975.



1989 Aerial

Figure 1.4. Historical Aerial of Loutre Creek Watershed. Circa 1989.



1994 Aerial

Figure 1.5. Historical Aerial of Loutre Creek Watershed. Circa 1994.

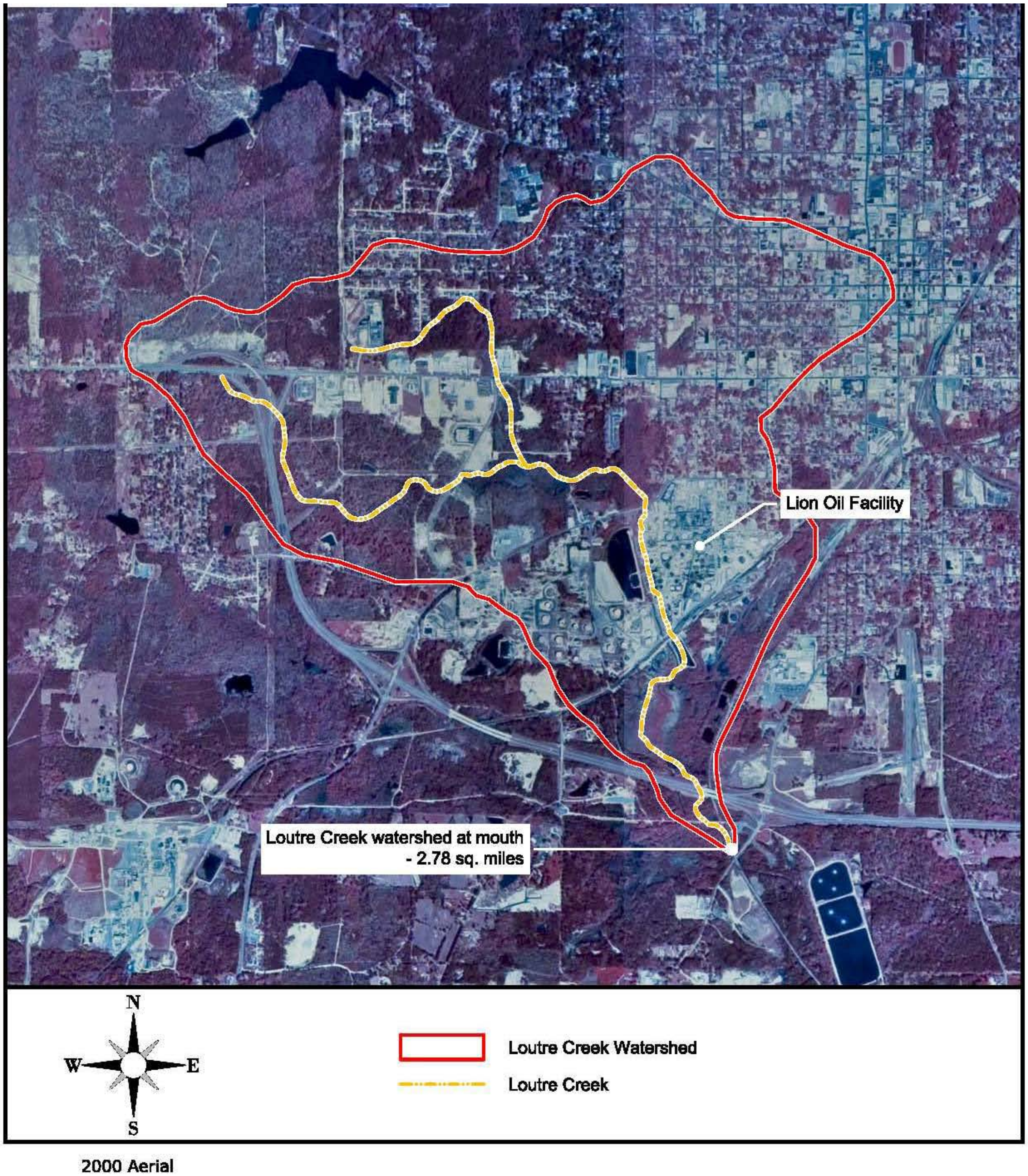


Figure 1.6. Historical Aerial of Loutre Creek Watershed. Circa 2000.

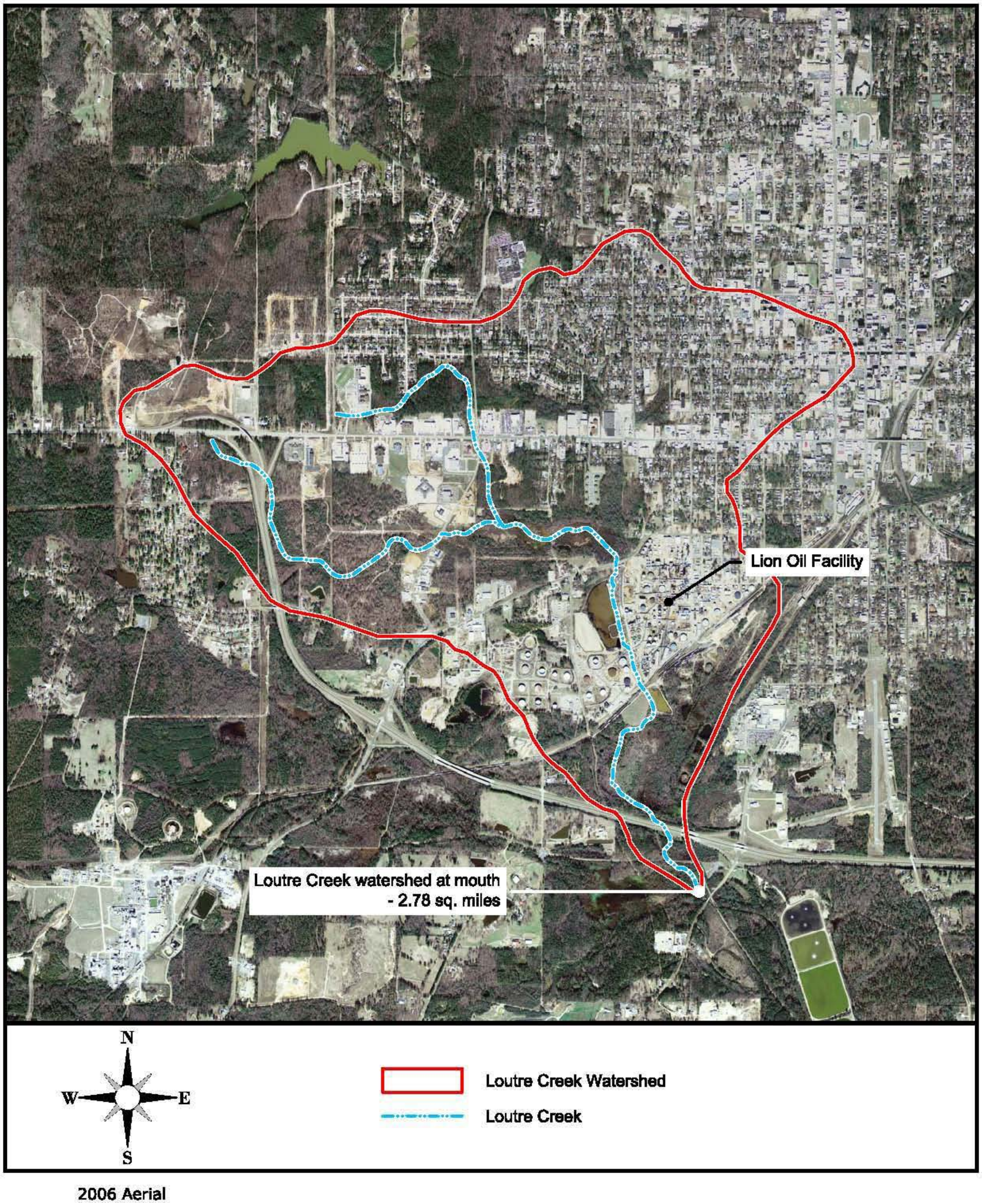


Figure 1.7. Historical Aerial of Loutre Creek Watershed. Circa 2006.

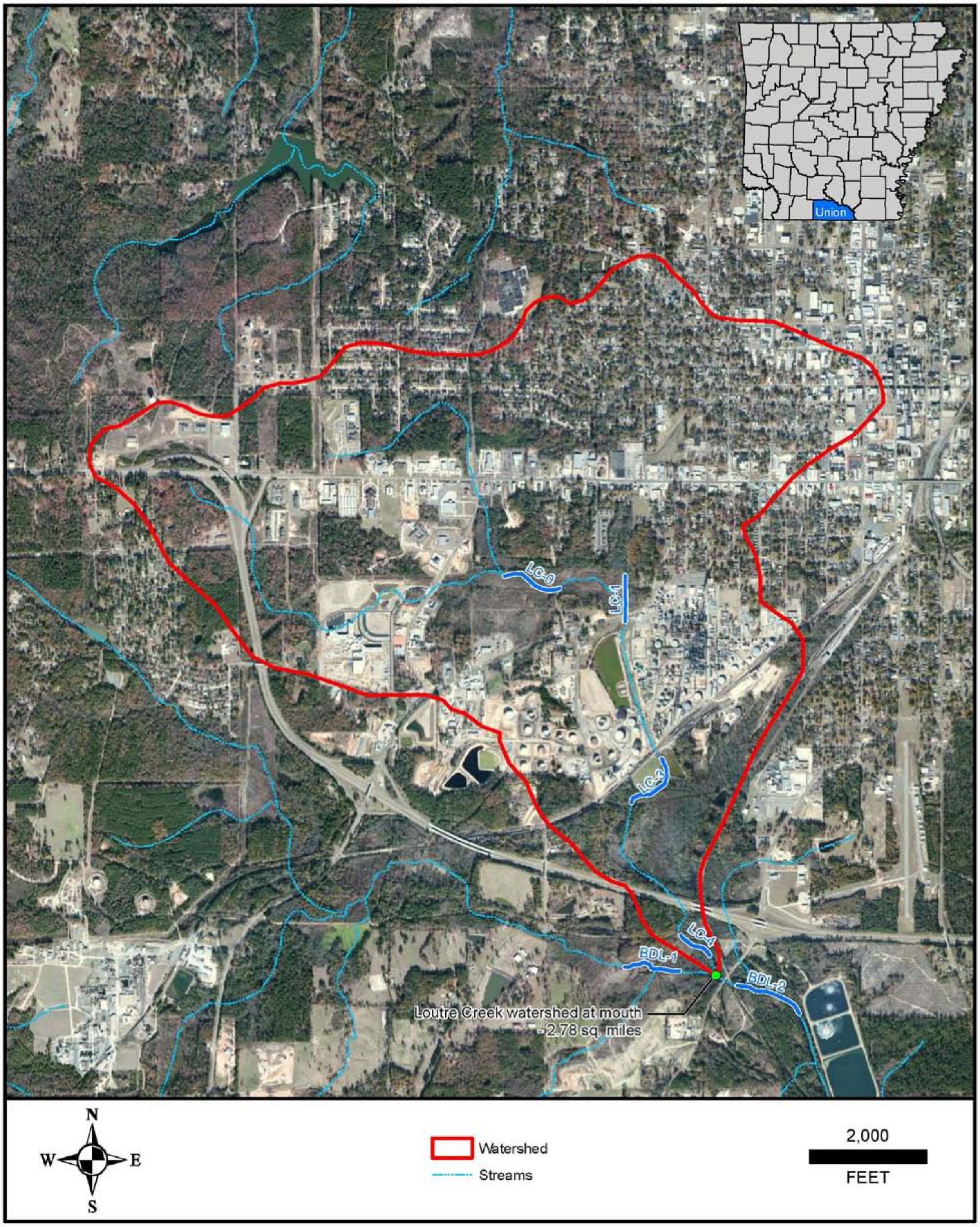
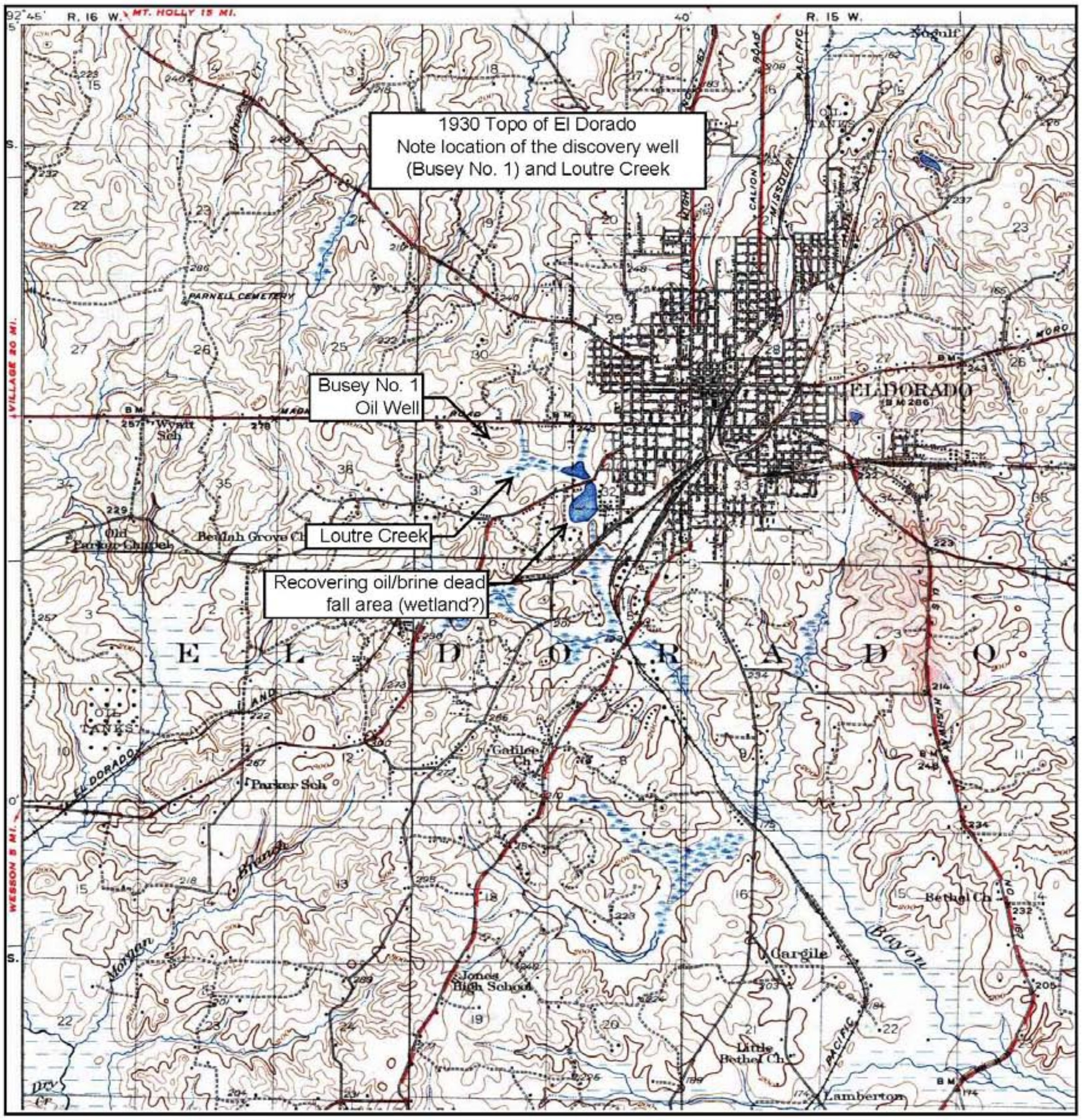


Figure 1.8. Historical Aerial of Loutre Creek Watershed. Circa 2011.

Historical Topographic Map



N ↑	TARGET QUAD NAME: EL DORADO MAP YEAR: 1930 SERIES: 15 SCALE: 1:62500	SITE NAME: Loutre Creek Watershed ADDRESS: Loutre Creek Watershed El Dorado, AR 71730 LAT/LONG: 33.2053 / -92.6841	CLIENT: GB Mc and Associates CONTACT: Jonathan Brown INQUIRY#: 3308154.2 RESEARCH DATE: 04/23/2012

Figure 1.9. Historical topographic map depicting the site of Busey No 1 (the discovery well) in relation to Loutre Creek.

Figure 1.10. Loutre Creek stream bank in Study Reach LC-0, upstream of Lion Oil. Note heavy oil sheen on water surface resulting from stream bed disturbances. 2009.

Figure 1.11. Loutre Creek stream bed along Study Reach LC-1. Note the petroleum deposits in stream bed and wetland areas. 2009.

Figure 1.12. Loutre Creek downstream in study Reach LC-3. Note the seams of petroleum residuals in stream banks (black deposits in lower left of picture), representing historical riparian oil field deposits currently exposed during low flow periods. 2009.

Figure 1.13. Loutre Creek in upper area of Reach LC-4. Note the clumps of petroleum residuals among the recently deposited sediments banks, representing historical riparian oil field deposits currently exposed during low flow periods during the Aquatic Life Field Study. 2009.

2.0 SIGNIFICANT FINDINGS AND RECOMMENDATIONS

2.1 Significant Findings

The following findings are based on the work performed for this UAA in conformance with the approved project QAPP. Additional details supporting the significant findings can be found in the documentation as follows: Sections 4.2.7 (habitat conclusions), 4.3.5 (benthic macroinvertebrates conclusions), 4.4.5 (fish community conclusions), 5.3.3 (summary of dissolved minerals WET tests), 5.4.4 and 5.5.3 (stream water chemistry conclusions), 6.8 (selenium in food web conclusions), and 7.9 (selenium fate and transport conclusions).

2.1.1 General Findings

1. The Lion Oil refinery is located in El Dorado, Arkansas, Union County. An oil refinery has operated at the site since 1922. Lion Oil (and the prior owners) has discharged treated wastewater to Loutre Creek for nearly 90 years.
2. Lion Oil discharges treated waste water to Loutre Creek under NPDES permit AR0000647. Lion Oil is the only NPDES permitted discharge to Loutre Creek. The facility's process wastewater discharge point to Loutre Creek is known as Outfall 001. The facility certifies that it maintains a Storm Water Pollution Prevention Plan and a Spill Prevention Control and Countermeasure Plan that limit non-point source contributions from the Lion Oil facility.
3. The watershed size at the mouth of Loutre Creek is less than 5 square miles.
4. The natural flow regime of Loutre Creek has been altered since the discovery of oil in 1921. The flow regime in Loutre Creek has also been affected by urbanization and associated deforestation in the watershed since at least the 1950s. There are no long term flow gauges on either Loutre Creek or Bayou de Loutre, so long term records of flow conditions do not exist for either waterbody.
5. The dominant land-use of the Loutre Creek watershed is urban, which includes development within the watershed resulting in continued deforestation. The continued urbanization of the Loutre Creek watershed has increased the impervious areas to greater than 55% of the watershed area (Section 3.4.2). The urban development has resulted in stream habitat limitations for fish community development, modified hydrologic characteristics (increased stream velocities and concentrated storm hydrographs that increase the magnitude and decrease the

duration of storm flows and increase sediment transport and deposition. This urbanization has degraded the habitat and modified the aquatic life communities that would otherwise inhabit Loutre Creek.

6. Sampling of stream reaches upstream of the discharge from Lion Oil has demonstrated low levels of selenium, which reflect the residual source from crude oil that flowed freely in streams (Loutre Creek and Bayou de Loutre) during the early years of exploration and well development, since oil was first discovered in the Loutre Creek watershed in 1921.
7. The 2009-2010 aquatic life field study involved an assessment of habitat potential used to characterize the potential for instream habitat to support the designated fisheries use referred to as a Typical Gulf Coastal Fishery. Those reaches scoring optimal would be expected to maintain the designated fisheries use. Scoring marginal or below would indicate that habitat limitations likely play a role in the use attainment. The qualitative assessment of habitat potential characterized three of the Loutre Creek and Bayou de Loutre study reaches as marginal (LC-3, BDL-1 and BDL-2) and two as sub-optimal (LC-1, LC-4), indicating that the habitat was less than typically expected for gulf coastal streams and that habitat, or lack thereof, likely restricts the fish community development. The assessment placed reaches LC-1 and LC-4 in the sub-optimal category with mean scores of 11.3 and 11.8, and reach LC-3, BDL-1, and BDL-2 in the marginal category with mean scores of 9.9, 9.7, and 8.7 (Table 4.3). This overall range of scores (8.7-11.8) indicates similar characteristics in habitat potential at each study reach. Differences in the scores between reaches were demonstrated most significantly by pool substrate, channel alteration, channel sinuosity, and bank vegetative protection.
8. The aquatic life field study demonstrated that the designated aquatic life use (Typical Gulf Coastal Fishery) is not maintained or attainable in Loutre Creek. The historical and existing watershed uses (urban runoff and oil field extraction activities), watershed size, and habitat limitations (sediment transport from deforestation and urban development) prevent the development of a fishery equivalent to that found in the least disturbed streams that are a reference condition for a Typical Gulf Coastal Fishery.
9. In addition to the habitat limitations to biotic community development, the fish community assemblages characterized at all study reaches in Loutre Creek were limited both in species diversity and numerical abundance when compared to the assemblages of species found in the least disturbed streams.

10. A more limited fishery is maintained and attainable in Loutre Creek compared to the fisheries found in the reference streams. This fishery is referred to as a Limited Gulf Coastal Fishery. As documented in the aquatic life field study, Lion Oil's discharge maintains this fishery, including during the low flow critical season, when this naturally intermittent stream would otherwise be dry.
11. There is no reasonably available treatment known that would reduce selenium, chloride, sulfate, and TDS sufficiently to comply with Lion Oil's NPDES permit limits. After construction of the joint pipeline, Lion Oil will be able to meet the permit limits that apply to its outfall to the Ouachita River, but not the limits that apply to its outfall on Loutre Creek.
12. Although future discharges through the current Outfall 001 will be greatly reduced once the Ouachita River pipeline is completed, there remains a need to maintain a permitted outfall to Loutre Creek.

2.1.2 Selenium Findings

Specific Findings

13. The total selenium criterion was developed in 1986 and was adopted in the 1996 revision of Arkansas Regulation No 2.
14. The existing discharge from Outfall 001 has exceeded the NPDES permit limit for total selenium.
15. The source of the selenium in the discharge is the crude oil processed at the refinery. The concentration of the selenium in the effluent is variable and is highly dependent on the source of the crude oil refined.
16. Since the waste water treatment process is not designed to remove selenium, and the source of the selenium is the crude oil, it is logical to assume that selenium has been present in the waste water and in Loutre Creek for almost 90 years.
17. The Aquatox modeling accurately predicted the fate and transport of selenium in the effluent in the Loutre Creek ecosystem and predicted limited downstream bioavailability for uptake of selenium by fish in Bayou de Loutre.
18. Selenium concentrations that exceed the current water quality criteria were measured in the upstream reference study reaches of Bayou de Loutre, the source of which is the residuals from historical oil extraction practices. (See Section 6.6 and Tables 6.5 -6.7).

19. No changes to the selenium criteria are proposed for Bayou de Loutre. Under existing discharge conditions, the long-term data recorded at the State's water quality monitoring station on Bayou de Loutre (OUA0005) demonstrate that the waterbody meets the selenium criteria. Further, increases in the instream selenium concentrations in Bayou de Loutre downstream of the mouth of Loutre Creek compared to the instream concentrations upstream of the mouth are less than an order of magnitude, so the influx of water from Loutre Creek does not appear to impact the existing fishery use attainment in Bayou de Loutre. The levels of selenium in fish tissue for fish collected in Bayou de Loutre above and below the confluence with Loutre Creek are nominally the same, so the contributions from Loutre Creek do not adversely affect the fishery in Bayou de Loutre.

20. The existing concentrations of selenium in Loutre Creek are protective of and maintain the existing fishery use in Loutre Creek and Bayou de Loutre. This is supported by the following data:

    - No deformities. During the 2005 and 2009-2010 aquatic studies, 859 fish were collected across seven study reaches: LC-0, LC-1, LC-2, LC-3, LC-4, BDL-1 and BDL-2. In addition, collections for embryonic development and tissue analyses harvested 252 specimens from the target study reaches. None of these fish (over 1,100 fish) evidenced any defects typically associated with selenium toxicity including but not limited to: (1) telangiectasia (swelling) of gill lamellae; (2) exopthalmus (popeye); (3) necrotic and ruptured mature egg follicles; and (4) teratogenic deformities of the spine, head, mouth, and fins. Further, as demonstrated by the historical record of fathead minnow chronic WET testing performed by the facility, selenium bioaccumulation in eggs larvae has not caused sub-lethal (growth) failures or post-hatch mortality.

      Population abundance with evidence of reproduction. The most abundant sunfish populations in Loutre Creek are Longear Sunfish and Green Sunfish. The 2009-2010 aquatic study confirmed that both species have healthy populations as evidenced by their population numbers and presence in all study reaches and the number of individuals present in multiple size classes. See Tables 6.5 – 6.7 and Figures 6.2 and 6.4. Further, the concentrations of selenium in the creek do not have adverse sub-lethal effects on these species as evidenced by the fact that the majority of fish collected in Loutre Creek were sunfish (fifty-one percent (151 of 293) in the 2009-2010 aquatic study and sixty-three percent (257 of 405) in the 2005 aquatic study). The lack of toxicity is also demonstrated by the fact that no deformities were identified on any of the fish and females were gravid with developed egg masses, and males were actively defending nest sites. See Figures 6.7 and 6.8 depicting Longear Sunfish nests at BDL-2 and LC-3. While the 2005 aquatic study did not collect bluegill sunfish in Loutre Creek, they were collected as part of the 2009 aquatic study downstream of the discharge, but not upstream of the discharge. See Table 4.9. The populations of bluegill in Loutre Creek are not large compared to Longear Sunfish and Green Sunfish, but this is likely due to the fact that Bluegill typically prefer areas in lentic and lentic-type environments such as ponds, lakes reservoirs and large low velocity streams. These conditions are not characteristic for Loutre Creek with its riffle/run reaches.

Summary Findings

21. The criterion proposed for approval is protective and will maintain the aquatic life of Loutre Creek (a Limited Gulf Coastal Fishery) and Bayou de Loutre (a Typical Gulf Coastal Fishery). This finding is based on the analysis of the habitat and composition of macroinvertebrate and fish communities evaluated in the 2005 and 2009-2010 aquatic studies, the comparative diversity of species across study reaches upstream and downstream of the discharge, the analysis of toxicity of selenium in the food web, and the fate and transport of selenium in Loutre Creek and Bayou de Loutre.
22. Modification of the total selenium criteria will not preclude the attainment of other designated and attainable uses for Loutre Creek (secondary contact recreation, industrial water supply, and agricultural water supply) or Bayou de Loutre (primary contact recreation, secondary contact recreation, industrial water supply, and agricultural water supply).
23. For other waterbodies besides Loutre Creek, the Commission and EPA have approved upward adjustments to selenium criteria to be consistent with historical effluent concentrations from dischargers in the waterbody. See for example Boggy Creek UAA (Clean Harbors LLC 3rd party rule making).

2.1.3 Dissolved Minerals Findings

The findings for dissolved minerals are based on: (1) this UAA, (2) the documentation relied on by the Commission to approve the revised dissolved minerals criteria for Loutre Creek and Bayou de Loutre in 2007; and (3) the documentation developed after that approval decision as requested by EPA, including the Aquatic Life Supplemental Report on Dissolved Minerals Rulemaking.

Specific Findings

24. Process and air emissions control equipment have been added to the Lion Oil facility in response to a Consent Decree jointly signed by ADEQ and EPA to control air emissions. The air emissions control equipment has been responsible for the recent increase in sulfates and TDS in the treated waste water discharged through Outfall 001.
25. The NPDES permit limitations for dissolved minerals are based on the water quality criteria for Loutre Creek, which are referred to as ecoregion reference criteria. These criteria were derived from a study of the water quality conditions in least-disturbed streams in the Gulf Coastal Ecoregion of Arkansas.
26. The discharge from Outfall 001 has exceeded the NPDES permit limitations for total sulfate and TDS.
27. The 2005 aquatic life field study of Loutre Creek and the 2009-2010 aquatic life field study of Loutre Creek and Bayou de Loutre demonstrate that the historical and current dissolved minerals loadings to Loutre Creek maintain and are protective of the existing fishery.
28. A review of existing scientific literature indicates that the dissolved minerals criteria proposed for approval are protective of the fishery and other instream aquatic life uses of Loutre Creek and Bayou de Loutre, and in fact, the proposed criteria are more stringent than those the Commission and EPA have approved for other stream segments in Arkansas and those that EPA has approved in other states.
29. Artificial matrix whole effluent toxicity (WET) testing completed in 2012 demonstrates that dissolved minerals concentrations consistent with the proposed criteria passed all WET testing endpoints. The concentrations of dissolved minerals did not elicit either lethal or sub-lethal effects. The criteria developed for Bayou de Loutre and discussed in the Bayou de Loutre SSC are more stringent (lower in concentration) than those developed for Loutre Creek, so the Bayou de Loutre Criteria also do not have such

effects. These WET tests indicate that the proposed dissolved minerals criteria will not result in lethal or sub-lethal effects in Loutre Creek or Bayou de Loutre and will maintain the designated uses of these receiving streams.

30. Past WET tests also demonstrate that Lion Oil's discharge is not toxic to fish. Additional statistical analyses of WET test results found no correlation between the level of dissolved minerals in the discharge and the WET test results.

Summary Findings

31. The criteria approved in 2007 are more stringent than the criteria the Commission and EPA approved for other stream segments in Arkansas and more stringent than criteria that have been approved in other states in EPA Region 6 and across the nation.

32. The criteria proposed for approval are more stringent than the criteria approved by the Commission in 2007. The proposed criteria are lower (more stringent) than the 2007 criteria by 6% for chloride, 33% for sulfate, and 30% for TDS.

33. The criteria proposed for approval are protective and will maintain the aquatic life of Loutre Creek (a Limited Gulf Coastal Fishery) and Bayou de Loutre (a Typical Gulf Coastal Fishery) as demonstrated by this UAA and the Bayou de Loutre SSC. These documents report the assemblage of fish species that reside in these water bodies without being adversely affected by historical dissolved minerals concentrations. For instance, as explained in Section 4.4, several fish species have healthy populations under historical dissolved minerals concentrations as evidenced by their population numbers, spatial distribution (presence in multiple study reaches), and individuals of the dominant species present in multiple size classes. The concentrations of dissolved minerals do not have adverse sub-lethal effects as evidenced by the fact that, during the 2005 and 2009-2010 aquatic studies, over 1,100 fish were collected, no deformities were observed in any of these fish, females were found to be gravid with developed egg sacs, and males were actively defending nest sites. See Sections 4.4 and 6.7. Further, based on the aquatic studies and the WET testing using the proposed criteria, the historical concentrations of dissolved minerals in Loutre Creek provide a reasonable basis to derive site specific criteria for this water body that are protective of these populations. Given the fact that the dissolved minerals criteria now proposed for approval for Loutre Creek and for the nine segments in Bayou de Loutre are lower (more stringent) than the historical levels of dissolved minerals in these water bodies,

the proposed dissolved minerals criteria are supportive of the aquatic life in both water bodies.

34. The proposed dissolved minerals criteria will not preclude the attainment of other designated and attainable uses for Loutre Creek (secondary contact recreation, industrial water supply, and agricultural water supply) or Bayou de Loutre (primary contact recreation, secondary contact recreation, industrial water supply, and agricultural water supply).

2.2 Recommendations

Based on the above findings, the following actions are recommended:

1. Designation of Limited Fishery: the designated Typical Gulf Coastal Fishery use for Loutre Creek should be changed to a new fishery subcategory to be known as a Limited Gulf Coastal Fishery because Loutre Creek is a small and urbanized watershed with historical resource extraction impacts. This modification should apply to all of Loutre Creek from its headwaters to its confluence with Bayou de Loutre (see Figure 2.1).
2. Adoption of Selenium Criterion: increase the water quality criteria for total selenium for Loutre Creek to 38 ug/L, which represents the average concentration as measured in Loutre Creek. This criterion would support the Limited Gulf Coastal Fishery proposed as the designated use for Loutre Creek. There is no need to revise the selenium criteria for Bayou de Loutre.
3. Adoption of Dissolved Minerals Criteria: increase the water quality criteria for dissolved minerals for Loutre Creek as shown below, which are calculated based on the historical instream concentrations of dissolved minerals in Loutre Creek and the projected reduction in dissolved minerals in the Lion Oil discharge following implementation of the SO_2 reducing catalyst additives to Lion Oil's fluid catalytic cracking unit regenerator. Because of these proposed revisions to the criteria for Loutre Creek, there is a need to revise the dissolved minerals criteria for Bayou de Loutre. The revision to the criteria for Bayou de Loutre is discussed in the Bayou de Loutre - Section 2.306 Supplemental Site Specific Water Quality Study.

The following table summarizes these recommendations for the individual stream segments evaluated in this UAA:

Table 2.1. Summary of Proposed WQS Modifications. Loutre Creek UAA. 2012.

Loutre Creek	**Bayou de Loutre – from Loutre Creek to the AR/LA State Line**
Modify fisheries use from Typical Gulf Coastal Fishery to a Limited Gulf Coastal Fishery (Small and Urbanized Watershed with Historical Resource Extraction).	No use change
Loutre Creek – from Hwy 15 South to the confluence of Bayou de Loutre **Instream Criteria:**	**Instream Criteria:**
Amend stream selenium criteria: From 5 ug/L (chronic) and 20 ug/L (acute) to 38 ug/L Amend stream dissolved minerals criteria. These changes are in relation to the criteria approved by the Commission in 2007, but not approved by EPA: Chloride from 256 mg/l to 241mg/L Sulfate from 997 mg/L to 645 mg/L TDS from 1756 mg/L to 1354 mg/L	Selenium: No change. Dissolved minerals: changes recommended. See Bayou de Loutre—Section 2.306 Supplemental Site Specific Water Quality Study.

3.0 FISHERY USE DESIGNATION AND MODIFICATION

3.1 Introduction

Section 3 addresses two related topics. First, it identifies the designated uses of Loutre Creek, describes how Loutre Creek was designated as supporting a Typical Gulf Coastal Fishery, and describes the fishery that is actually found in Loutre Creek. Second, it discusses the Commission's authority to designate a subcategory of fishery for Loutre Creek and explains why it is appropriate to do so. Additional details of the habitat, benthic macroinvertebrate community, and fish community in Loutre Creek is discussed in Section 4 of the UAA.

3.2 Designated Uses

The designated uses for Loutre Creek and Bayou de Loutre are listed in the water quality standards for Gulf Coastal Plain streams with watersheds less than 10 mi^2. These designated uses are:

- Secondary Contact Recreation,
- Typical Gulf Coastal Fishery,[3]
- Industrial Water Supply, and
- Agricultural Water Supply

3.3 Fisheries Use Designation and Characterization

3.3.1 Characterization of a Typical Gulf Coastal Fishery

Under Regulation 2.106, a fishery is "[t]he designated use of a waterbody determined by the fish community and other associated aquatic life". As noted, Loutre Creek is currently designated as supporting a Typical Gulf Coastal Fishery (Regulation 2, A-29 Designated Uses: Gulf Coastal Ecoregion). This type of ecoregion fishery includes:

[3] More specifically, Loutre Creek is designated as supporting a perennial fishery, except seasonal from railroad bridge (coordinates: 33°11'14.53" N, 92°40'37.79"W) to the mouth. *See* Regulation No. 2 at A-29. A "seasonal" fishery means: "[t]he designated fishery use that occurs in some waterbodies only during the period when stream flows increase substantially and water temperatures are cooler. This is normally during the months of December through May." Regulation 2.106.

> Streams supporting diverse communities of indigenous or adapted species of fish and other forms of aquatic life. Fish communities are characterized by a limited proportion of sensitive species; sunfishes are distinctly dominant followed by darters and minnows. Regulation 2.302(F)(3)(e)

The characterization of streams in the Gulf Coastal ecoregion identified certain species of fish that are typical inhabitants of fish community assemblages in least-disturbed streams in the region. Least disturbed streams were selected due to their lack of anthropogenic (human caused) impacts. The regulation lists 6 "key species" [4] and 6 "indicator species"[5] associated with the Typical Gulf Coastal Fishery. Regulation 2.302(F)(3)(e). Key species are "… normally the dominant species within the important groups such as fish families or trophic feeding levels…" and indicator species are "… readily associated with a specific ecoregion…." Regulation 2.106. The listed key and indicator species for a Typical Gulf Coastal Fishery are:

Key Species	**Indicator Species**
Redfin shiner	Pirate perch
Spotted sucker	Flier
Yellow bullhead	Spotted sunfish
Warmouth	Dusky darter
Slough darter	Creek chubsucker
Redfin pickerel	Banded pygmy sunfish

The Typical Gulf Coastal Fishery designation was applied to Loutre Creek without stream specific characterizations, site specific field work, or research to support the designation. Rather, this action was a blanket designation based on research conducted by ADEQ on least–disturbed streams in Arkansas's Gulf Coastal Ecoregion (ADEQ, 1987). In other words, at the time of designation, no field work had been conducted to determine whether these key or indicator species were present in Loutre Creek.

[4] "Key species" are defined in full as "[f]ishes which are normally the dominant species (except for some ubiquitous species) within the important groups such as fish families or trophic feeding levels. All specified key species need not be present to establish a normal or representative fishery." Regulation 2.106

[5] "Indicator species" are defined in full as "[s]pecies of fish which may not be dominant within a species group and may not be limited to one area of the state, but which, because of their presence, are readily associated with a specific ecoregion. All indicator species need not be present to establish a normal or representative fishery." Regulation 2.106.

3.3.2 Characterization of a Limited Gulf Coastal Fishery

Although Loutre Creek has some of the characteristics of a Typical Gulf Coastal Fishery, the fish community in Loutre Creek is limited both in diversity (e.g. limited number of species) and community development (population size) (See Section 4.4.3 for detailed discussion of fish community development).

A Typical Gulf Coastal Fishery is characterized by a relatively diverse community (24 species or greater in the ecoregion reference streams), including a majority of the key and indicator species described above (ADEQ, 1987). By contrast, during the fish collections that occurred in Loutre Creek in 2009, a total of 12 species of fish were found in the study reaches that spanned most of the Creek. Three of the six key species (Redfin (grass) pickerel, yellow bullhead, and warmouth) and three of the six indicator species (creek chubsucker, pirate perch, and spotted sunfish) were identified in the fish collections (See Table 4.9 in Section 4). Although the sunfish were found to dominate the fish community, subdominate trophic groups of fish in a Typical Gulf Coastal Fishery (minnows and darters) were not present in Loutre Creek, even in the upstream reference study reaches.

In addition to lower species diversity in Loutre Creek, this waterbody supports limited population abundance (i.e. community development) when compared to a Typical Gulf Coastal Fishery. The limitation to community development is directly related to habitat availability and the limited enduring pools for refugia during low flow summer periods. The numerical abundance of the fish communities was limited with the smallest numbers collected from the upstream reference study reach.

Thus, many of the key and indicator species of a Typical Gulf Coastal Fishery were not present in Loutre Creek and the population abundance of the fish community did not reflect a Typical Gulf Coastal Fishery. Loutre Creek supports a subcategory of fishery, referred to as a Limited Gulf Coastal Fishery, which includes the 12 species of fish identified in Loutre Creek as compared to the 24 or more species of fish that may characterize a Typical Gulf Coastal Fishery, and three of the key species and three of the indicator species.

3.4 Authority to Designate Subcategory of Fishery and Reason for the Subcategory

Loutre Creek differs significantly from the types of least-disturbed streams used to characterize the Typical Gulf Coastal Fishery because it has a small watershed (2.78 square miles), heavily urbanized, with historical resource extraction activities that collectively limit the type of fishery that can develop in Loutre Creek.

Under these circumstances, the Commission has authority under Regulation 2.303(A)(2) to rely on a UAA "to identify a subcategory of a fishable/swimmable use which requires less stringent criteria." One of the regulatory bases on which the Commission can identify a subcategory of a fishery is when the Commission finds that:

> human caused conditions or sources of pollution prevent attainment of the use [the Typical Gulf Coastal Fishery] and cannot be remedied or would cause more environmental damage to correct than leave in place. Regulation 2.303(B)(3).

Such "human caused conditions or sources of pollution" persist in the Loutre Creek watershed, so the Commission has authority to designate a subcategory of fishery for Loutre Creek with associated water quality criteria that are protective of that fishery. The data and analysis to support this subcategorization focus on two issues that limit the diversity and population size of the fishery: (1) historical oil field practices, and (2) the effects of urbanization on the small watershed (the City of El Dorado, which is expanding, lies in a significant portion of the Loutre Creek watershed).

3.4.1 Historical Oilfield Practices

The Loutre Creek watershed has an extensive history of resource extraction activities that have been important to economic development in Arkansas. Perhaps most significantly, Loutre Creek watershed was the heart of the state's oil boom in the 1920s. On January 10, 1921, the Union Oil field "discovery well" Busey No. 1 ushered in the South Arkansas oil boom (See Figures 3.1 and 3.2 for photographs of the "discovery well."). Observers described the event as follows:

> "….Oil and water rained to the earth, drenching the delirious crew and the spectators…. The wind caught the spray of oil and water and spread it all over the countryside. Sheep on Miles Murphy's farm a mile to the north turned black, while clothes on Monday's wash lines in El Dorado, also a mile away, dripped with oil…."

(Buckalew, A.R. and R.B. Buckalew in the Discovery of Oil in South Arkansas 1920-1924).

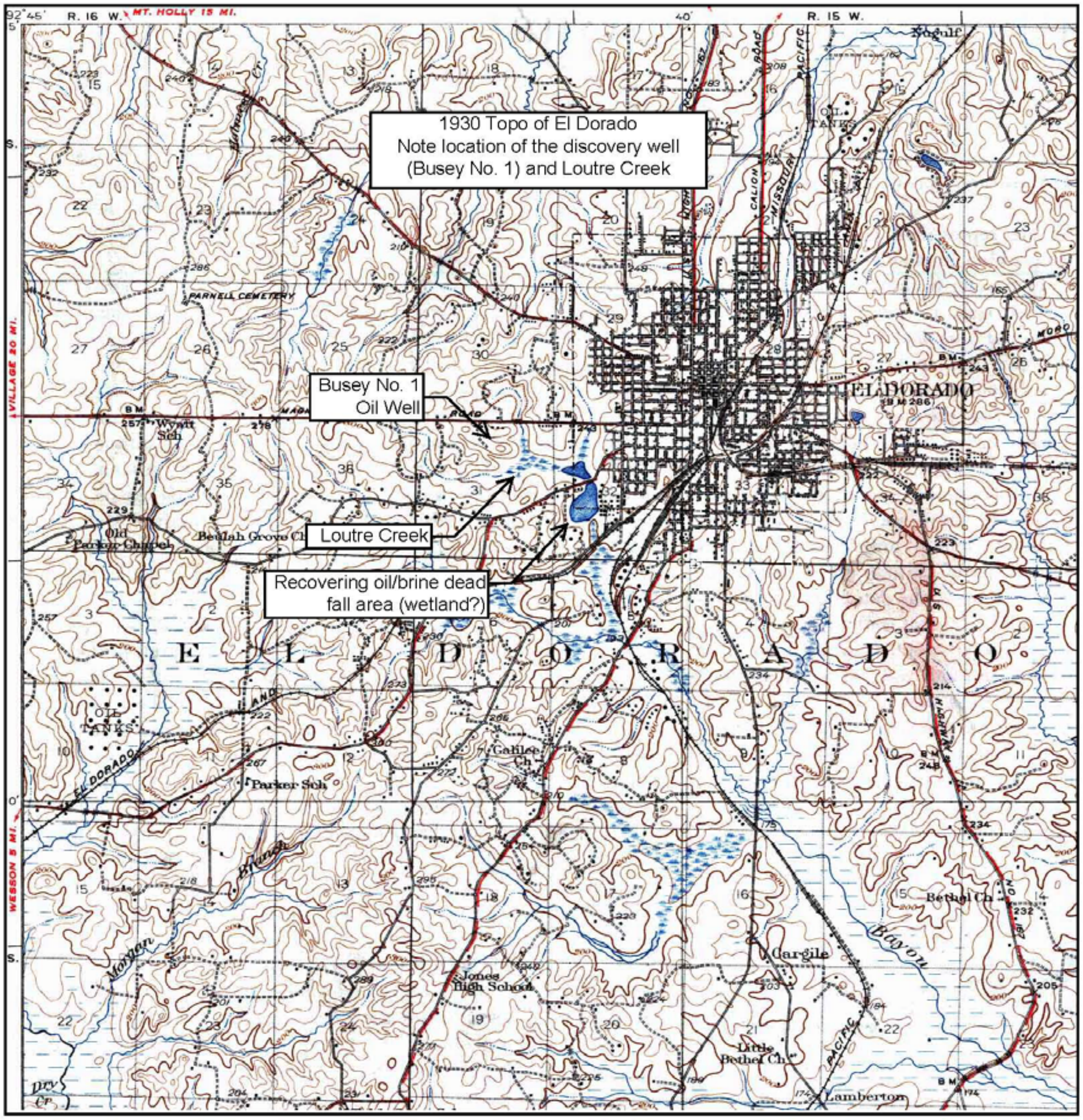
Significantly, Busey No.1 was located on a hillside a little over a mile southwest of the City of El Dorado.[6] The hillside drained directly to Loutre Creek (Figure 3.3). Therefore, it is highly likely that much of the oil that "rained to the earth" entered Loutre Creek.

[6] Specifically, Busey No. 1 was located in Section 31, Township 17 South, Range 15 West.

Figure 3.1 . Busey Well No. 1 January 10, 1921.

Figure 3.2. Busey Well No. 1 January 10, 1921. Initial blowout.

Historical Topographic Map



N	TARGET QUAD NAME: EL DORADO MAP YEAR: 1930 SERIES: 15 SCALE: 1:62500	SITE NAME: Loutre Creek Watershed ADDRESS: Loutre Creek Watershed El Dorado, AR 71730 LAT/LONG: 33.2053 / -92.6841	CLIENT: GB Mc and Associates CONTACT: Jonathan Brown INQUIRY#: 3308154.2 RESEARCH DATE: 04/23/2012

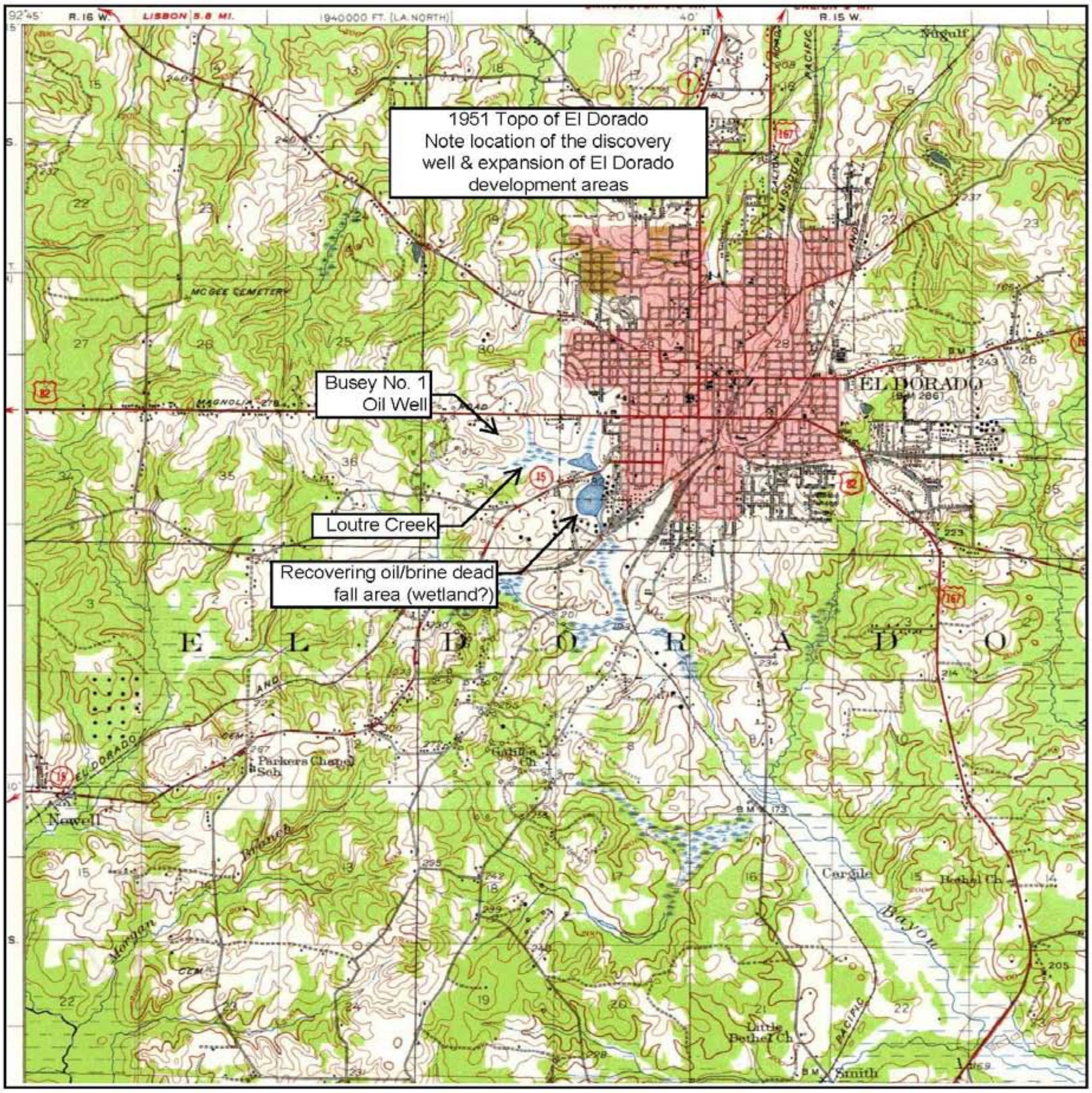
Figure 3.3. Historical Topographic El Dorado Quad dated 1930. Note the location of Busey No. 1 in relation to the Loutre Creek drainage.

Following this major event, the initial development of Busey No. 1 caused oil and salt water from the well to flow into Loutre Creek and then into Bayou de Loutre. Due to their location and the lack of controls over oil production practices, it is likely that Loutre Creek has not maintained a Typical Gulf Coastal Fishery and/or aquatic life (benthic) community since the initial crude oil and salt/water/brine flowed unrestricted throughout and over the Loutre Creek watershed, down Loutre Creek and into Bayou de Loutre. Current instream conditions related to these historical practices are still evident in the form of:

- Recovering brine areas, as depicted upstream of Lion Oil and indicated as a "wetland" area on topographic maps (see Figure 3.3 and 3.4 and as represented in Figures 4.7 and 4.8);
- Areas of petroleum laden sediment deposits that release oil when disturbed, in the upstream reference reach in Loutre Creek and Bayou de Loutre (See Figures 4.9-4.12);
- Legacy sludge deposits in the form of consolidated sediments and oil residuals in Loutre Creek (See Figures 4.17-4.20, 4.24 and 4.27); and
- Soil layers where petroleum seeps along the incised stream channel (See Figures 4.25 and 4.26).

As a result of these conditions, Loutre Creek has not likely supported a Typical Gulf Coastal Fishery since at least the time Busey No. 1 was developed in 1921. Today, given these historical resource impacts, Loutre Creek supports only a Limited Gulf Coastal Fishery. The longstanding and widespread hydrocarbon contamination in the watershed cannot be reasonably remedied in a way that would support a Typical Gulf Coast Fishery, and any attempt to remove the historic contamination would likely cause far more environmental damage than leaving it in place. Moreover, as discussed below, the small size and urbanized nature of the watershed would make it impossible for Loutre Creek to support a Typical Gulf Coastal Fishery even if the historic contamination could be addressed.

Historical Topographic Map



N	TARGET QUAD NAME: EL DORADO MAP YEAR: 1951 SERIES: 15 SCALE: 1:62500	SITE NAME: ADDRESS: LAT/LONG:	Loutre Creek Watershed Loutre Creek Watershed El Dorado, AR 71730 33.2053 / -92.6841	CLIENT: CONTACT: INQUIRY#: RESEARCH DATE: 04/23/2012	GB Mc and Associates Jonathan Brown 3308154.2

Figure 3.4 Historical Topographic El Dorado Quad dated 1951. Note location of the discovery well and expansion of El Dorado development areas.

3.4.2 Urbanization and Small Watershed

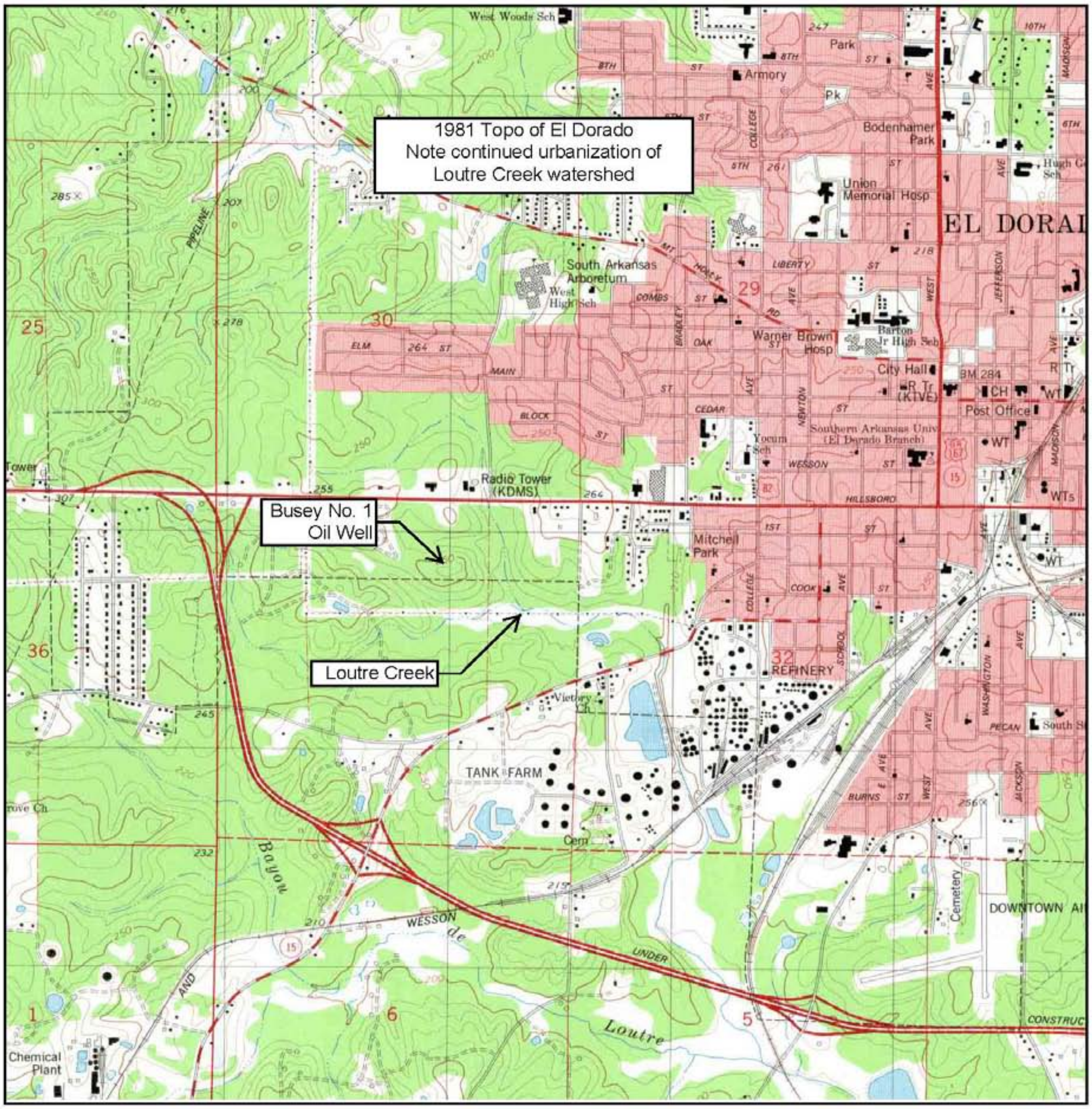
Since at least the 1940s, the City of El Dorado has expanded into the Loutre Creek watershed, converting it from a primarily rural and forested watershed to one dominated by urban land-use. This expansion is depicted in the historical topographic maps (See Figures 3.3 -3.5) and historical aerial photos (See Figures 1.3-1.6). These figures depict the growth and continued urbanization of the Loutre Creek watershed, which are human caused conditions or sources of pollution that have limited the development of the Loutre Creek fishery.

The current urbanized development within the watershed is illustrated by Figure 3.6, which depicts the impervious surfaces within the watershed account for over 55% of the surface area. As discussed below, the adverse impacts of this development on the Loutre Creek fishery are at least two-fold: (1) impacts from sedimentation; (2) impacts from increased urbanization of this small watershed.

According to the scientific literature, unless measures are implemented to remove the urbanized development from the riparian corridor and return the hydrogeology to the pre-development condition, the effects of urbanization can only continue to be modified (Simon, T.P, 2003)[7], but the watershed cannot return to its pre-development condition. Thus, the urbanized state of the Loutre Creek watershed and the effects of that urbanization cannot be remedied short of a decision to remove existing development and restore the area to its natural condition.

[7] Simon, Thomas P.2003. Biological response signatures; indicator patterns using aquatic communities.576pp.

Historical Topographic Map



N ↑	TARGET QUAD NAME: EL DORADO WEST MAP YEAR: 1981 SERIES: 7.5 SCALE: 1:24000	SITE NAME: Loutre Creek Watershed ADDRESS: Loutre Creek Watershed El Dorado, AR 71730 LAT/LONG: 33.2053 / -92.6841	CLIENT: GB Mc and Associates CONTACT: Jonathan Brown INQUIRY#: 3308154.2 RESEARCH DATE: 04/23/2012

Figure 3.5. Historical Topographic El Dorado Quad dated 1981. Note continued urbanization of Loutre Creek watershed.

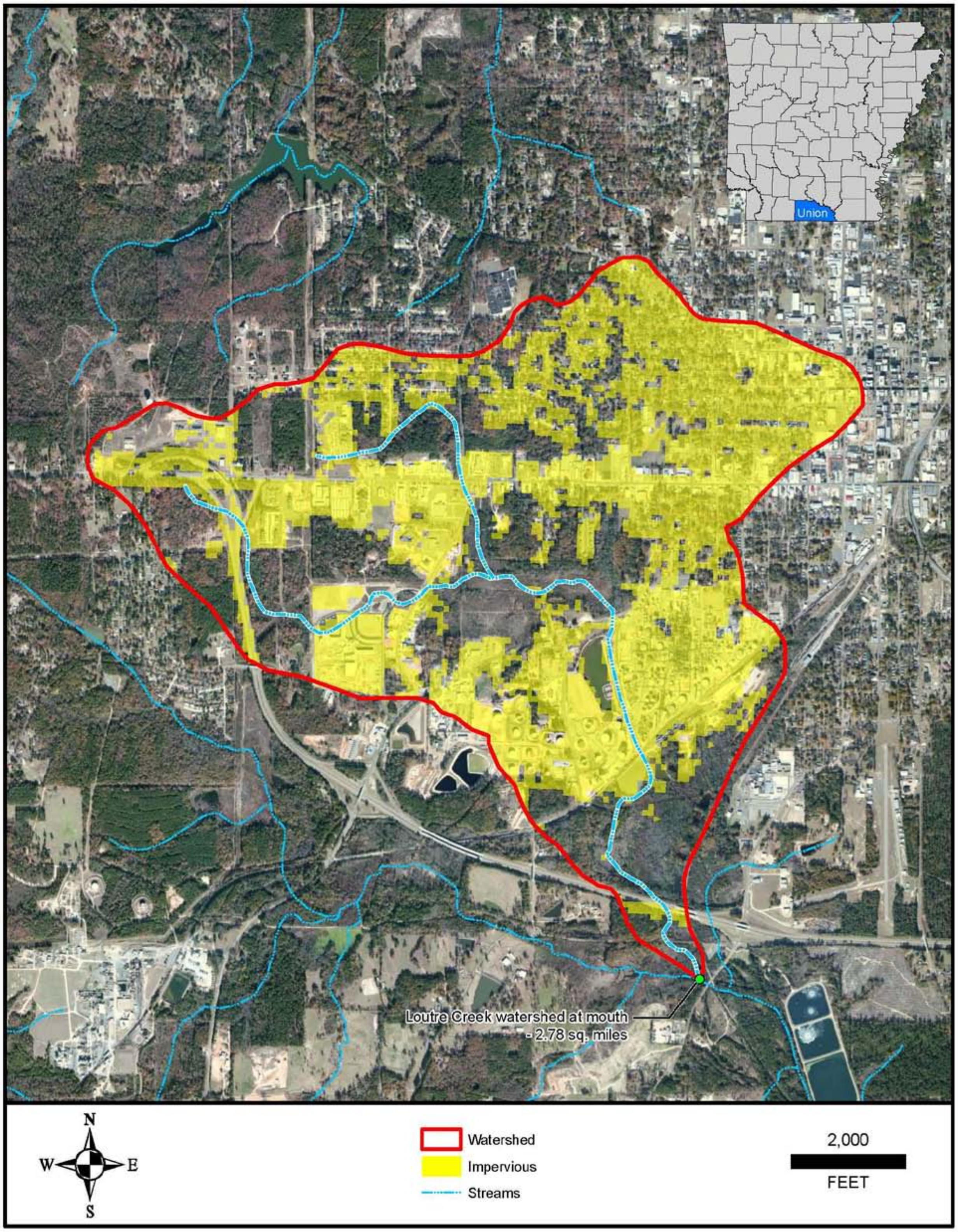


Figure 3.6. Aerial photograph depicting impervious development in Loutre Creek watershed.

3.4.2.1 Impacts from Sedimentation

Increased growth and urbanization in the Loutre Creek watershed has caused increased sediment loading through two primary mechanisms: (1) silt transport into and through Loutre Creek, and (2) increase of impervious surfaces within the watershed.

With respect to the first mechanism, evidence of heavy and excessive silt transport and turbidity (cloudiness) were documented during the UAA aquatic life field study. Figures 4.8, 4.13 to -4.18, 4.22, 4.24, and 4.28 and Figures 5.14-5.21 depict the effects of storm flow and increased silt transport and deposition in the Loutre Creek watershed. This increased silt transport and deposition in Loutre Creek has impaired the development of the biological communities and limited the development of a Typical Gulf Coastal Fishery. This is evident from the results of the aquatic life field study, which found study reaches LC-4 and LC-1 scored the lowest for sedimentation, adversely impacting habitat and sedimentation impacting the majority of each of the study reaches (See Tables 4.3 and 4.4 in Section 4.2 of the UAA). In addition, comparisons of the 2005 and 2009 field studies reflected the increased sediment deposition in study reach LC-3 (See Tables 4.3 and 4.4). The increased sedimentation impacted the benthic communities, reducing the species diversity of both LC-1 and LC-3 (from 18 to 4 taxa in LC-1 and 18 to 8 taxa in LC-3) (See Tables 4.8 (2005) and 4.5 (2009)).

These observations are consistent with the scientific literature documenting the effect of urbanization (and resulting increased sedimentation) on the development of aquatic life in small watersheds. For instance, urban development is known to substantially alter stream flow patterns, channel morphology, water quality and reduces biological community diversity and limits population structures, (Paul and Meyer, 2001)[8].

In addition to increasing silt transport, urbanization has caused more than 55 percent of the Loutre Creek watershed to be covered by impervious surface (Figure 3.6). As discussed in Section 3.4.2, this surface coverage has increased runoff velocities and enlarged hydrographs (duration of runoff from a given storm event) in Loutre Creek, resulting in scouring of the creek bed, greater erosion, and modification of the hydrologic characteristics of this small watershed. These conditions preclude the development of a Typical Gulf Coastal Fishery that requires a variety of habitats and stable substrates to support the characteristic food sources (e.g., invertebrates) and habitats (e.g., deep pools) in such a fishery (See UAA Section 4.2.5 and Tables 4.5 and 4.7).

[8] Paul, M.J. and J.L. Meyer, 2001. Streams in the Urban Landscape. Annual Review of Ecology and Systematics. 32:333-365.

These documented effects on the fishery in Loutre Creek due to urbanization are consistent with the scientific literature, which indicates that urbanization of a watershed greatly increases surface runoff changing both patterns and magnitude of stream flows (Booth and Jackson, 1997)[9]. More frequent and severe flooding can directly harm stream biota through loss of habitat, disruption of reproduction, reductions in feeding and growth, sediment transport and downstream deposition and displacement, and direct mortality of aquatic organisms leading to major shifts in biotic communities (Wang and Lyons, 2003)[10].

In particular, there is a growing body of scientific literature documenting the substantial changes in macroinvertebrate communities resulting from urban development (Wang and Kanehl, 2003)[11]. Wang and Kanehl, 2003, found that impervious areas above seven percent of a watershed are negatively correlated with macroinvertebrate diversity and consistently result in poor invertebrate community assemblages. More recently, Cuffney et. al, 2010 found that levels of impervious areas less than five percent of a watershed were associated with significant degradation to benthic assemblages and were not protective of biological communities.[12]

3.4.2.2 Impacts from Increased Urbanization of this Small Watershed

The Loutre Creek fishery is also limited because the watershed is very small and heavily urbanized—two conditions that distinguish it from the types of least disturbed streams used as a reference condition for a Typical Gulf Coastal Fishery. As provided in Attachment J (Aquatic Life Justification Supplemental Report), the specific reference streams in the Gulf Coastal Ecoregion included:

- Whitewater Creek (watershed of 23 mi^2),
- Big Creek (watershed of 59 mi^2),
- Derrieusseaux (watershed of 148 mi^2),
- Bayou Freeo (watershed of 156 mi^2),

[9] Booth, D. B. and C.R. Jackson, 1997. Urbanization of Aquatic systems, degradation threshold, stormwater detection and the limits of mitigation, Journal of the American Water Resources Association 33, 1077-1090.

[10] Wang , L and J. Lyons, 2003. Fish and Benthic Macroinvertebrate Assemblages as Indicators of Stream Degradation in Urbanizing Watersheds. Chapter 13 in Biological Response Signatures, Ed T.P.Simon.QH541.1515B562002.

[11] Wang, L and P Kanehl, 2003. Influences of Watershed Urbanization and Instream Habitat on Macroinvertebrates in Cold water Streams. Paper No. 02152 Journal of the American Water Resources Association. 1181-1196.

[12] Cuffney, T.F., R.A. Brightbill, J.T. May, and I.R. Waite, 2010. Responses of Benthic Macroinvertebrates to Environmental Changes Associated with Urbanization in Nine Metropolitan Areas. Ecological Applications, 20(5), 2010. Pp 138-1401.

- Hudgin Creek (watershed of 148 mi^2),
- L'Aigle Creek (watershed of 232 mi^2), and
- Moro Creek (watershed 451 mi^2).

None of these seven streams were similar to Loutre Creek at the time they were used as reference streams for a Typical Gulf Coastal Fishery.[13] For instance, the watersheds for each of these streams were dominated by forest land-use with more than 88% of the watersheds forested. This is in stark contrast to the Loutre Creek watershed, which is predominately urbanized (more than 55 percent (Figure 3.6) and has limited remaining forest land-use. In addition, the Loutre Creek watershed is only 2.78 square miles, which is less than 1/8th the size of the smallest watershed (Whitewater Creek) used as a reference stream (Figure 1.8).

In summary, the Loutre Creek watershed differs significantly from these reference streams and it is highly unlikely this small and urbanized watershed has or ever will support a Typical Gulf Coastal Fishery. Many of the characteristic species for this region are not present in Loutre Creek because the waterbody fails to provide adequate habitat such as undercut banks and root complexes (See UAA Section 4.2.5). This type of habitat is critical for many species and provides both fish spawning habitat and substrate for food source (e.g. invertebrate community development).

3.5 Existing Uses

When performing a UAA, it is necessary to identify "existing uses" of a waterbody because the Commission is not authorized to remove an "existing use." Regulation 2.303(B). Under Regulation 2.106, "existing uses" are:

> Those uses listed in Section 303(c)(2) of the Act [Clean Water Act] (i.e., public water supplies, propagation of fish and wildlife, recreational uses, agricultural and industrial water supplies and navigation) which were actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards.

[13] Details for the habitat characteristics of the ecoregion reference streams can be found in the Physical, Chemical and Biological Characteristics of Least Disturbed Reference Streams in Arkansas' Ecoregions. Volumes 1 (685pp) and II (187pp). (ADEQ, 1987). For comparison, the habitat conditions of Loutre Creek are provided in Section 4 of the UAA.

As explained in Section 3.4 above, the Typical Gulf Coastal Fishery is not an existing use and likely has not been since at least 1921. Rather, the existing fishery use in Loutre Creek is what has been described above as a Limited Gulf Coastal Fishery. The fish community is limited by Loutre Creek's small watershed size (2.78 sq. miles), the continued urbanization of the watershed, and the effects of historical resource extraction activities. These factors have combined to prevent the development of a Typical Gulf Coastal Fishery. Because Loutre Creek has never been verified as having a Typical Gulf Coastal fishery, the proposed modification of the fishery to a Limited Gulf Coastal Fishery would not represent removal of an existing use.

The secondary contact recreation use was not documented as an existing use. The uses of agricultural and industrial water supply were also not documented as an existing use and may be limited due to water volume, but are not precluded due to water quality.

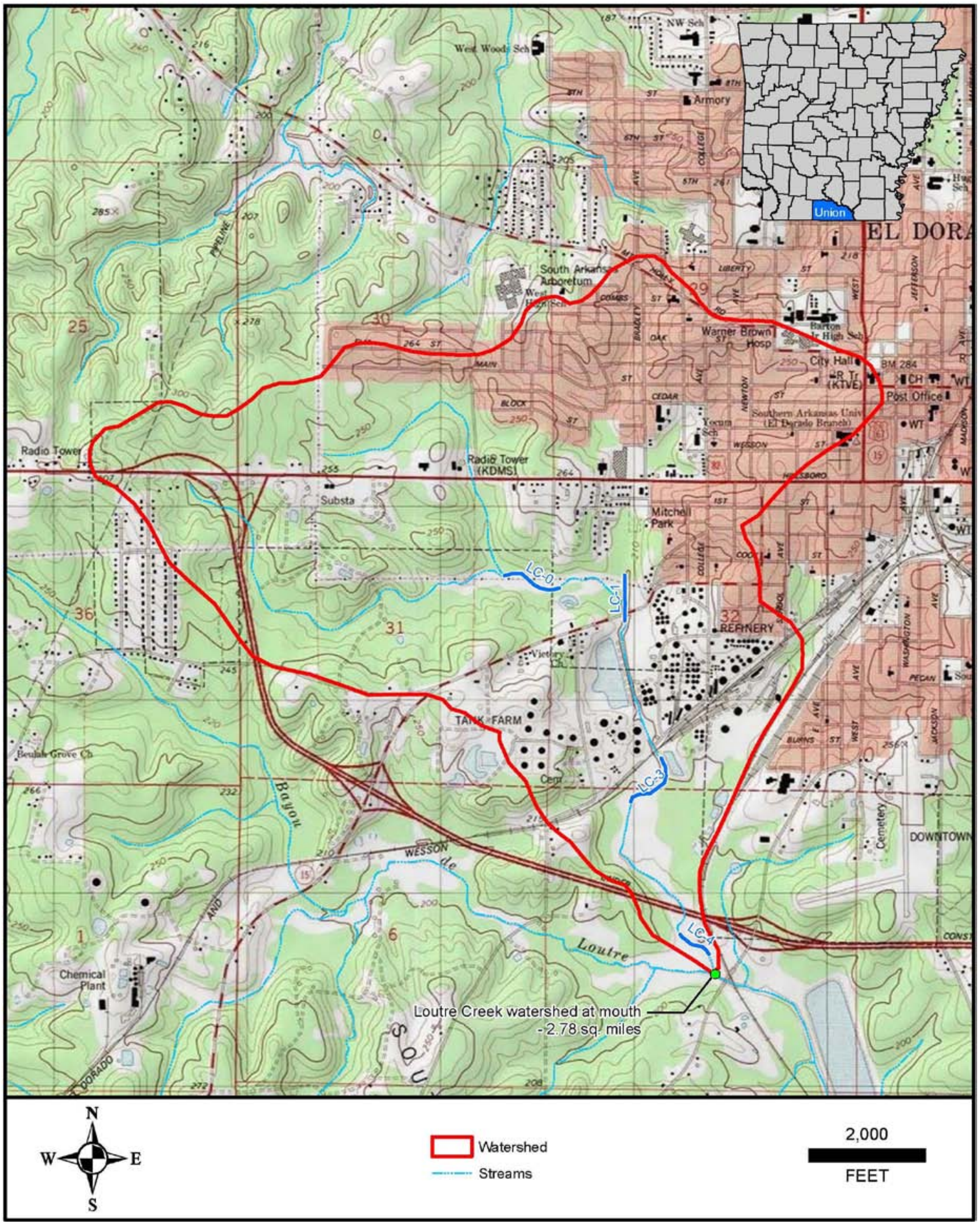


Figure 3.7. Study reaches, watershed boundaries, and sizes of Loutre Creek upstream of each UAA study reach.

4.0 AQUATIC LIFE FIELD STUDY

4.1 Introduction and Study Methodology

The goal of the 2009-2010 aquatic life field study was to document the existing condition of the designated aquatic life/fishery use in Loutre Creek. This section summarizes the findings of the 2009-2010 aquatic life field study on Loutre Creek and Bayou de Loutre and compares the 2009 condition to that characterized by the 2006 Section 2.306 Study (GBMc, 2007). The information includes:

- Summary of habitat characterization with results and discussion (4.2)
- Summary of benthic macroinvertebrate community with results and discussion (4.3)
- Summary of fish community with results and discussion (4.4)
- Conclusion from aquatic life field study (4.5)

The aquatic life field study was conducted in accordance with the Project QAPP (Attachment B) and to meet the information requirements for a Use Attainability Analysis. The aquatic life field study evaluated habitat, benthos, and fish community in five study reaches: three in Loutre Creek (one above and two below Lion Oil's Outfall 001 discharge) and two in Bayou de Loutre (one above and one below the mouth of Loutre Creek). The watershed size of Loutre Creek and Bayou de Loutre at each study reach is provided in Table 4.1. The geographic location of each study reach is shown on Figure 4.1. The information about the water quality in these study reaches is provided in Section 5 and 6.

Table 4.1. Watershed size of Loutre Creek at each study reach. Loutre Creek UAA.

Study Reach	Watershed Size
LC-1	2.0 sq. miles
LC-3	2.5 sq. miles
LC-4	2.8 sq. miles
BDL-1	3.4 sq miles
BDL-2	7.3 sq. miles

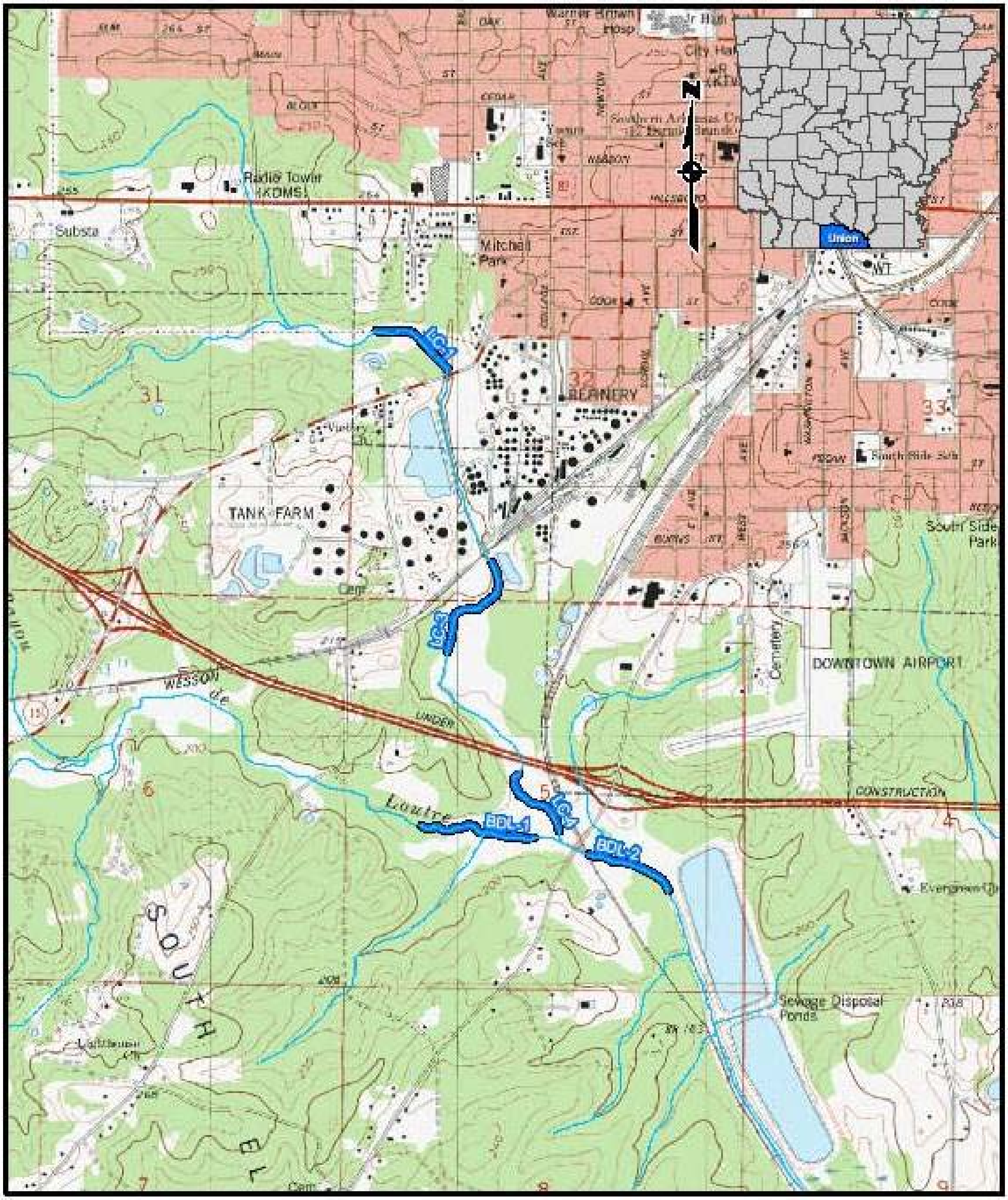


Figure 4.1. Loutre Creek UAA aquatic life field study reaches.

Field evaluations were conducted during June and August, 2009. Subsequent to the initial field characterizations and in response to comments from ADEQ and Region 6 EPA, Lion Oil implemented an extended monitoring program to characterize the instream dissolved mineral and selenium loadings monthly through October 2010 during the same period that effluent composites were collected for monthly whole effluent toxicity (WET) testing. During this extended monitoring period, instream loadings (e.g. water column concentrations) were documented through collections of Outfall 001 discharge and receiving stream water samples from the above-referenced study reaches during the same period that effluent composites were collected for monthly WET testing. Attachment N provides the field data sheets, *in-situ* field forms and data summaries, and analytical lab results for the 2009 - 2010 aquatic life field study.

Prior to the 2009-2010 aquatic life field study, an aquatic life field study was completed in 2005 in accordance with the ADEQ dissolved minerals implementation strategy procedures to address requirements to revise dissolved minerals criteria under Regulation 2.306. The results of the 2005 aquatic life field study were reported in the Loutre Creek-Section 2.306 Site Specific Water Quality Study dated October 3, 2006 (the 2006 report) (GBMC, 2006). Section 4 of this UAA focuses on the findings in the 2009-2010 aquatic study. In addition, the findings from the 2009-2010 study are also compared to that reported in the 2006 report.

4.2 Habitat Characterization

This sub-section highlights the results of the habitat characterization of Loutre Creek and Bayou de Loutre. The sub-section is divided into five parts including:

- Introduction to the objectives, habitat influences, and general methods of a habitat characterization;
- Summary of the specific methods for scoring and analyzing habitat assessment data;
- Summary of the results of the analysis for each study reach;
- Summary of the habitat potential;
- Comparison to the 2005 aquatic study; and
- Habitat conclusions.

4.2.1 Introduction

Stream habitat is the physical attributes that influence or sustain the flora (plant) and fauna (animal) communities in a stream. The objectives of this habitat characterization were to:

1) assess the availability and quality of habitat for the development and maintenance of benthic invertebrate and fish communities, and
2) evaluate the role of habitat quality in relation to the attainment of designated uses and biological integrity.

Physical habitat in streams includes all those physical attributes that influence or provide sustenance to biological attributes, both botanical and zoological, within the stream. Stream physical habitat varies naturally, as do biological characteristics; thus, habitat conditions differ even in the absence of point and anthropogenic non-point disturbance. Within a given ecoregion, stream drainage area, stream gradient and the geology are likely to be strong natural determinants of many aspects of stream habitat, because of their influence on discharge, flood stage, and stream energy (both static and kinetic).

Kaufmann (1993) identified seven general physical habitat attributes important in influencing stream ecology and the maintenance of biological integrity. These attributes include:

1) channel dimensions,
2) channel gradient,
3) channel substrate size and type,
4) habitat complexity and cover,
5) riparian vegetation cover and structure,
6) anthropogenic alterations, and
7) channel-riparian interaction.

As provided in Kaufmann (1993), land-use activities can directly or indirectly alter any and/or all of these attributes. Further, the trends for each attribute will naturally vary with stream size (drainage area) and overall gradient. The habitat characterization for Loutre Creek evaluated these and other factors that influence habitat such as the presence of aquatic macrophytes, riparian vegetation, and canopy cover, which can influence light inputs and associated habitat structure.

4.2.2 Methods for scoring and analyzing habitat assessment data

The general method to characterize habitat involves field physical habitat measurements used in conjunction with water chemistry, temperature, macroinvertebrate and vertebrate (typically fish) community analyses, and other data sources to determine the status of the target streams attainment of designated uses and the water quality required to maintain those uses.

The field procedures used to characterize habitat in Loutre Creek and Bayou de Loutre are intended for evaluating physical habitat in wadeable streams, but may be adapted for use in larger streams as necessary. These procedures are most efficiently applied during low flow conditions and during times when terrestrial vegetation is active, but can also be applied during spring seasonal conditions with higher base flows. The field procedures are expressly designed for monitoring applications where robust, quantitative or semi-quantitative descriptions of habitat are desired. To provide a more detailed view of the streams habitat condition, the semi-quantitative habitat procedure used to characterize the habitat of Loutre Creek and Bayou de Loutre was also used in conjunction with two other procedures, the *General Physical Habitat Characterization* and the *Qualitative Habitat Assessment as detailed in the GBMc Standard Operating Procedures (SOPs) for stream habitat assessments (GBMc, 2000).*

The field procedures used to characterize habitat for Loutre Creek and Bayou de Loutre differed from other rapid habitat assessment approaches (e.g., Plafkin et al., 1989, Rankin, 1995) because the procedures involved use of a systematic spatial sampling that minimizes bias in the placement and positioning of measurements. Measures were taken over defined channel areas and these sampling areas were placed systematically at spacing proportional to the length of the entire study reach. This systematic sampling design provides resolution appropriate to the length of the study reach. The habitat assessment protocol is more fully detailed in the GBMc SOP (GBMc, 2000) and is based on the USEPA's procedures in their Environmental Monitoring & Assessment Program and Rapid Bioassessments Protocols procedures (Lazorchak, 1998 and Barbour, 1999), as well as U.S. Geological Survey's North American Water Quality Assessment (NAWQA) program and Missouri Department of Natural Resources Environmental Sampling Protocols (ESP) (Sarver, 2000).

Field biologists conducted the habitat assessment within (or to the extent possible) the stream reach from which the benthic and fish communities were to be characterized. The physical habitat was characterized from measurements and observations of stream attributes made within 10 sub-reaches. The team assessing habitat moved along the stream channel (near the thalwag) observing habitat characteristics within each sub-reach. A description of and the rational for measuring each of the attributes is provided below. The details of how these attributes are recorded/evaluated are also described below.

Experienced field biologists followed the assessment procedures on a sampling reach of length equal to 20 times the bankfull width. The semi-quantitative habitat sampling reach length coincided as much as possible with that of the fish and macroinvertebrate collection reaches. Measurements were taken in each of the 10 sub-reaches, which were systematically placed at intervals equal to approximately one tenth (1/10) the length of the represented study reach. Measurements and observations for each habitat characteristic were made in each of the sub-reaches as the assessment team moved along the stream channel. An average or total of the scores for each of the 10 sub-reaches was then calculated resulting in a mean value for each characteristic for the entire reach.

The habitat characterization information is presented under three main categories: channel morphology, instream structure, and riparian characteristics. Each category is further divided into components (14 in total) that reflect the physical or habitat attributes of a study reach. For the 2009-2010 aquatic study, measurements for each of these components were recorded on a two-page field form entitled Stream Habitat Assessment (Semi-Quantitative). As discussed more fully below, the three categories and their component parts include:

1) Channel Morphology
   a) Reach Length Determination,
   b) Riffle-Pool Sequence, and
   c) Depth and Width Regime
2) Instream Structure
   a) Epifaunal substrate,
   b) Instream Habitat,
   c) Substrate Characterization,
   d) Sediment Deposition, and
   e) Aquatic Macrophytes and Periphyton
3) Riparian Characteristics
   a) Canopy Cover,
   b) Bank Stability and Slope,
   c) Vegetative Protection, and
   d) Riparian Vegetative Zone Width.

4.2.2.1 Channel Morphology

Channel morphology (or geomorphology) is a characterization of the shape of the stream channel including measurements and/or visual estimates of channel dimensions and riffle-pool sequences (i.e. a measure of the amount of riffles, runs and pools that occur in a given reach).

The channel observed includes that portion of the stream between the base flow wetted area and the top of the normal high water channel often referred to as the bankfull stage (Figure 4.2). The "bankfull" or "active" channel is defined as the channel that is filled by moderate-sized flood events that typically occur every one or two years. Such flow levels are on the verge of entering the flood plain and are believed to control channel dimensions in most streams.

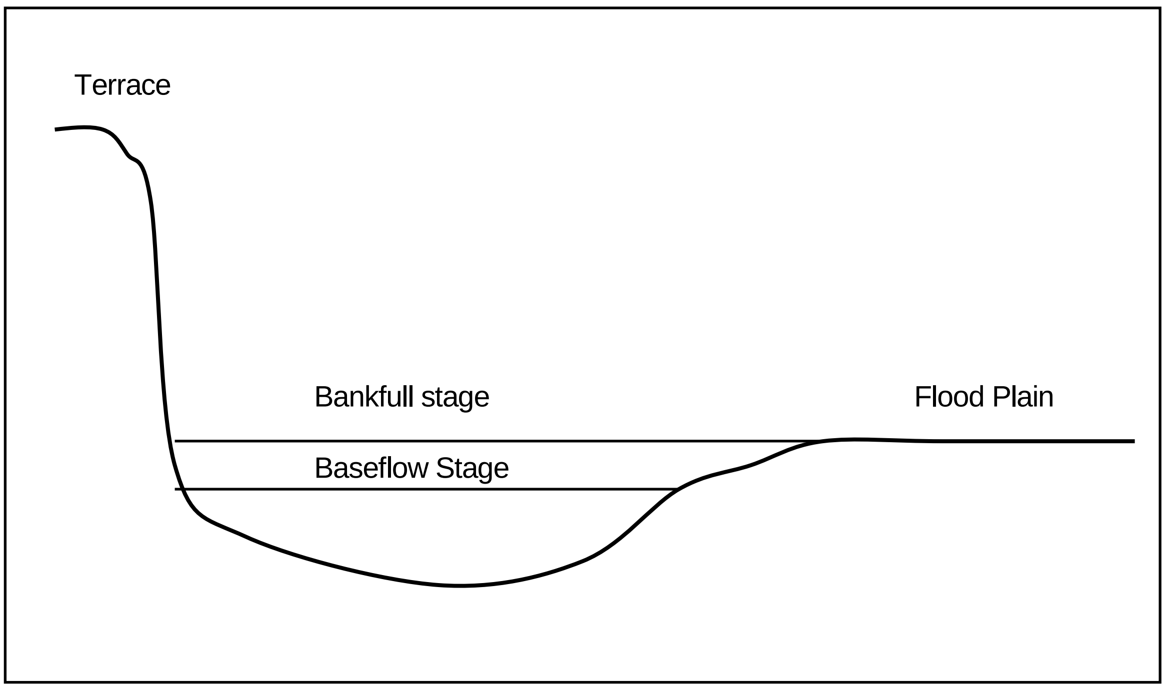


Figure 4.2. Stream channel depicting bankfull stage.

1) Reach Length Determination

First, bankfull depth (depth from stream bottom in thalwag to bankfull stage on the bank) was identified in at least two separate riffles (or alternatively runs in streams not exhibiting riffle morphology) in each study reach. Then bankfull depth and width was determined from 5 stream transects and recorded on the record sheet. Transect locations were selected to include each prominent morphology type represented in the stream. Bankfull depths were measured to the nearest 1/10 foot and bankfull widths were measured to the nearest foot using a wading rod and tape measure. An average of the 5 bankfull widths was then calculated and multiplied by 20 to arrive at the total reach length for assessment. This total length was then divided by ten to determine the length of each of the ten sub-reaches. Analysis of the first sub-reach began at the head of a given stream morphology (i.e. riffle, run, or pool).

2) Riffle-Pool Sequence

Stream morphology refers to the abundance and placement (sequencing) of riffles, runs, and pools in a stream system. This sequencing is an indicator of a streams hydrological regime and stability as well as a determinant of its potential to sustain diverse aquatic communities. Beginning at the head of a morphological type (riffle, run or pool) the length of each morphological type in the stream reach was measured using a tape measure and recorded on the record sheet. The sequence of each morphological type was depicted on the record sheet using the provided notations so as to create a map to the location of each riffle, run, or pool. The resulting measurements provided a quantitative measure of the percent of the study reach representing each stream morphological type (i.e. 40% riffle, 30% run, 30% pool, etc).

3) Depth and Width Regime

The average stream depth and width were estimated in riffles and pools in each sub-reach. Depths were measured along a transect, similar to that depicted in Figure 4.3, in a representative section of each riffle and pool in the sub-reach. Depths were generally taken in the thalwag (deepest area instream channel) and approximately half way between the thalwag and the left and right banks. An estimated average depth for riffles and pools occurring in a sub-reach was derived from the cross-sectional depth measurements and recorded on the record sheet to the nearest 1/10 foot. Once completed for all 10 sub-reaches this provided an accurate semi-quantitative measurements of riffle and pool average depth and depth variability across the entire stream reach.

Stream wetted widths were measured along a transect, in a representative section of each riffle and pool in the sub-reach. An estimated average width for each morphological type in a sub-reach was recorded on the record sheet to the nearest foot. Once completed for all 10 sub-reaches this provided accurate semi-quantitative measurements of riffle and pool widths across the entire stream reach.

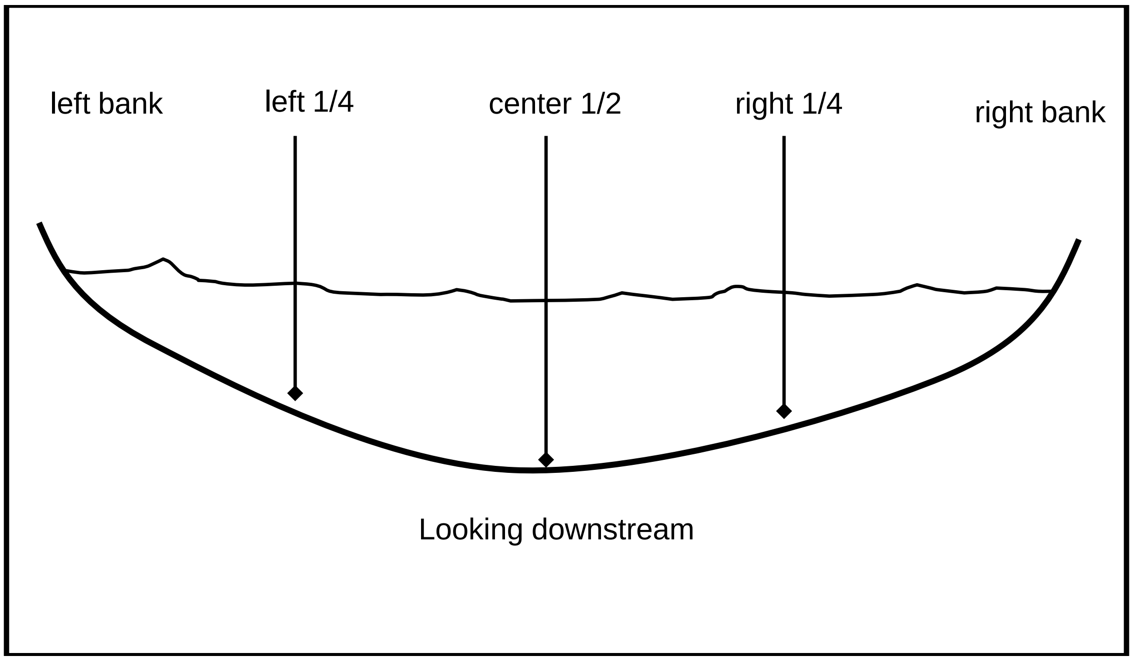


Figure 4.3. Approximate position of measurements across transect.

4.2.2.2 Instream Structure

Instream structure describes the characteristics of the stream within the wetted perimeter that makes up the habitat suitable for colonization of aquatic biota. This includes information about natural substrates (gravel, boulders, etc), aquatic plants and algae and debris that has been washed into or fallen into the stream, such as logs, leaves, etc. A stream capable of sustaining diverse aquatic communities will contain a variety of instream structure including some that is permanent and some that is mobile during high flow events.

1) Epifaunal Substrate (Macroinvertebrates)

   Epifaunal substrate refers to the area on the bottom of the stream (entire wetted perimeter) where macroinvertebrates inhabit. This attribute is scored as a percentage of the stream bottom in a sub-reach which contains substrates suitable for macroinvertebrate colonization. Scoring for this attribute should rely heavily on the stability of the substrate, the size of the interstitial spaces, and the cleanliness (not covered in thick algae or sediment deposits) of the substrate. Cobbles and coarse gravel will score higher percentages as they contain larger interstitial spaces for colonization, while sand and silt would score lower since they provide little spaces. In addition, root wads along the bank would score higher as they are more stable features than would depositional areas or small woody debris.

2) Instream Habitat (Fish)

Instream habitat refers to the habitat features within the wetted perimeter of the stream sub-reach which are available for fish colonization. This attribute is scored as the percentage of the stream bottom (wetted perimeter) in a sub-reach which is covered with fish habitat. As with the epifaunal substrate attribute, substrates composed of cobbles, coarse gravels, and boulders score higher for fish cover as they provide better spaces for colonization. Other habitats that score high are large woody debris (individual logs with diameter >4 inches or complex woody structures composed of rootwads, logs, or limbs with diameter of 1.5 ft. or greater) and undercut banks. Habitats that score lower are those such as depositional areas with leaf packs, fine sediments or sand.

3) Substrate Characterization

The dominant stream substrate size classification for riffles and pools within each sub-reach was recorded on the record sheet. Only substrates within the wetted perimeter were evaluated. This information was used to characterize the similarities and or differences in substrate structure and complexity in the riffles and pools of the study reach as it related to the development and maintenance of the system's biological integrity.

Particles were classified into one of the size classes listed on the Semi-Quantitative Habitat Assessment Field Form based on the size of the intermediate axis (median dimension) of its length, width, and depth. This "median" dimension is the sieve size through which the particle can pass.

• Bedrock	smooth or rough
• Boulder	>25 cm
• Cobble	6-25 cm
• Coarse Gravel	1.6 – 6 cm
• Fine Gravel	0.2 – 1.6 cm
• Sand	<0.2 cm
• Silt/Mud/Clay	fine, not gritty

Notations were made for unusual substrates such as concrete or asphalt. Field biologists denoted these artificial substrates as "other" and described them in the comments section of the field data form. They also coded and described other artificial substrates (such as large appliances, tires, car bodies, etc.) in the same manner.

4) Sediment Deposition

The sediment deposition attribute refers to the amount of stream bottom (in the wetted perimeter) that is covered by fine sediments and/or particulate organic matter. This attribute is scored as a percentage of the bottom in each sub-reach which is covered by such loose materials.

5) Aquatic Macrophytes and Periphyton Coverage

An estimate of the percentage of area covered by macrophytes and periphyton in a sub-reach is made and recorded both for riffles and pools. Macrophytes refers to aquatic plants that grow in the stream (both emergent and submerged), and periphyton refers to algae that grows on fixed surfaces. This attribute helps biologists determine stream productivity from a nutrient enrichment perspective and also for the availability of food sources for aquatic biota.

4.2.2.3 Riparian Characteristics

The riparian area includes the area from the stream bank in a direction away from the stream into the upland areas. It is these streamside riparian zones that ultimately help shape the stream and provide organic material as nutrients to the aquatic system. A well developed riparian area protects stream banks from erosion, provides shading, inputs nutrients, provides materials as habitat (instream structure) and filters runoff entering the stream. In the absence of well developed riparian zones the stream is more impacted by encroaching land-uses.

1) Canopy Cover

Canopy cover (percent stream shading) over the stream was determined for each of the sub-reaches. Estimates of cover are made by looking into the canopy over the stream channel. Estimates were made from mid-channel and each quarter channel to determine the average percent canopy cover for the width of the stream in the sub-reach. Percent canopy at each measurement point was estimated visually.

2) Bank Stability and Slope

Bank stability is an important attribute that is an indication of a stream reaches overall hydrologic equilibrium. A bank's stability also determines its ability to provide stable habitat for biota and its propensity to release large sediment yields to the stream, which ultimately cause high turbidity and deposition in downstream reaches. The right and left banks are classified according to the following categories:

- Score 9-10 = Stable, little evidence of erosion, < 5% bank eroding
- Score 6-8 = Moderately stable, some evidence of new erosion, 5-29% bank eroding
- Score 3-5 = Moderately unstable, obvious new erosion, 30-59% bank eroding
- Score 1-2 = Unstable, most of bank actively eroding, 60-100% bank eroding

Banks composed of sands and gravels are much less stable than banks composed of silt/mud/clay or cobbles. The density of well rooted (more permanent) vegetation and root structure also help to improve a banks stability.

Average bank slope (in degrees) in a sub-reach, was recorded for each bank (left and right). Bank slope affects the stability of a bank and is an indicator of past erosion. A gentle slope may average 30º while a steep or undercut bank may average 90º or 100º.

3) Vegetative Protection

Bank vegetative protection was measured as a percent of the bank surface area which is covered by stable riparian vegetation and their associated roots in a sub-reach. Each bank (right and left) was assessed separately and the value recorded on the record sheet. Banks were assessed from the edge of the water to the top of the first terrace or normal top of bank.

4) Riparian Vegetative Zone Width

Riparian zone encompasses the area from the top of the normal stream bank outwards into the upland area. A broader riparian vegetative zone width is more protective of stream banks from alteration, so fewer pollutants will enter the stream from runoff and more available food sources are deposited into the stream from the surrounding forest. Riparian zone width is scored for each bank in a sub-reach according to the following scale:

- Score 9-10 = Riparian Zone Width > 18 meters
- Score 6-8 = Riparian Zone Width 18 - 12 meters
- Score 3-5 = Riparian Zone Width 11 - 6 meters
- Score 1-2 = Riparian Zone Width < 6 meters

4.2.3 Scoring and Analysis of Habitat Assessment Data

Scores from the Semi-Quantitative Habitat Assessment was utilized in two different ways. First, data collected for each attribute (assessment category) was used independently to describe the study reach collectively. This method results in information such as: average riffle depth, average pool width, % riffle in entire reach, average bank stability, average (median) substrate size class in pools and riffles, mean % canopy cover, etc. Second, the data collected during the assessment was used in conjunction with the Qualitative Habitat Assessment procedure to score each of the ten “qualitative” indices with near quantitative accuracy (semi-quantitative). A combination of the two methodologies was incorporated into this intensive aquatic biota field study. The following sections outline the scoring of the qualitative habitat indices using the semi-quantitative data.

1) Epifaunal Substrate/Available Fish Cover

Average values from semi-quantitative categories 4 (Epifaunal Substrate) and 5 (Instream habitat) are combined into an overall average percent coverage used to score this metric.

The following table presents the scoring criteria:

Rank	Optimal	Sub-Optimal	Marginal	Poor
% Coverage	>70%	40%-70%	20%-39%	<20%
Score	20 -16	15 -11	10 - 6	5 - 1

2) Pool Substrate Characterization

Using the substrate characterization data from the semi-quantitative assessment (category 6) and the aquatic vegetation assessment (category 9) the following table may be used to score this metric.

Rank	Optimal		Sub-Optimal	Marginal	Poor
Substrate	Cobble or Gravel		Sand/Silt/Clay	Sand/Silt/Clay	Bedrock or Clay Only
Macrophytes Present	Yes	No	Yes	No	No
Score	20 - 18	17 - 16	15 - 11	10 - 6	5 - 1

3) Pool Variability

Semi-Quantitative categories 2 (Riffle-Pool Sequence) and 3 (Depth and Width regime) are used to help score this metric. The following table is used to determine pool variability.

Pool Characteristic	Large-Deep	Large-Shallow	Small-Deep	Small-Shallow
Size	Length ≥ Width	Length ≥ Width	Length < Width	Length < Width
Depth	≥3.2 feet	< 3.2 feet	≥3.2 feet	< 3.2 feet

An equal balance of all four pool types achieves higher scores. A prevalence of shallow pools scores lower.

4) Channel Alteration

Scored from visual assessment of entire reach. Not aided by semi-quantitative attributes.

5) Sediment Deposition

Reach average percent bottom affected by deposition (from category 8) is used directly to score this metric.

Rank	Optimal	Sub-Optimal	Marginal	Poor
% Bottom Affected	<5%	5%-30%	31%-50%	>50%
Score	20 -16	15 -11	10 - 6	5 - 1

The lower end of each scale was used to represent reaches where recent sediment bar formation is evident.

6) Channel Sinuosity (replacement for Frequency of Riffles)

This metric is assessed separately from the semi-quantitative data. It can be estimated in the field, measured during a longitudinal survey or calculated from current aerial photographs.

7) Channel Flow Status

Scored from visual assessment of entire reach. Not aided by semi-quantitative attributes.

8) Bank Stability

The average bank stability score for each represented bank from the semi-quantitative assessment (category 11) is directly applied to the qualitative assessment scoring for this metric (i.e. an average reach score of 8 for the right bank and 7 for the left bank gets transferred directly to the qualitative score sheet as such).

9) Vegetative Protection

Reach average percent bank protected (from category 12 of the semi-quantitative record sheet) is used directly to score this metric for the right and left bank.

Rank	Optimal	Sub-Optimal	Marginal	Poor
% Protected	>90%	70% - 90%	50% - 69%	<50%
Score	20 -16	15 -11	10 - 6	5 - 1

10) Riparian Vegetative Zone Width

The average riparian zone width score for each represented bank from the semi-quantitative assessment (category 13) is directly applied to the qualitative assessment scoring for this metric (i.e. an average reach score of 8 for the right bank and 7 for the left bank gets transferred directly to the qualitative score sheet as such).

4.2.4 Results and Discussion

4.2.4.1 Habitat Quality

Habitat assessment was completed on August 3-4, 2009. This field event was completed within 24 hours of a storm event resulting in elevated instream flows atypical of summer low flow conditions where the discharge from Outfall 001 typically dominates the instream flow. 2009 was the wettest year on record for the state of Arkansas with a total of 105 inches in precipitation. Several attempts at additional field activities were terminated due to elevated stream flow conditions. A summary of the attributes where physical data was collected is presented in Table 4.2. Field sheets and the raw habitat data are provided in Attachment N.

Table 4.2. Habitat characteristics of study reaches during seasonal flow conditions. Loutre Creek UAA. 2012.

Observation	Study Locations				
	LC-1	LC-3	LC-4	BDL-1	BDL-2
Date	8/4/2009	8/4/2009	8/3/2009	8/4/2009	8/3/2009
Location (upstream / downstream):	**Upstream**	**Downstream**	**Downstream**	**Upstream**	**Downstream**
Latitude:	33.201480	33.193762	33.186354	33.184628	33.183814
Longitude:	92.678635	92.677218	92.676333	92.674351	92.670905
General Stream Characteristics:					
Total Habitat Reach Length, ft	238	242	320	174	416
Average Bankfull Width, ft	11.9	12.1	16	8.7	20.8
Average Bankfull Depth, ft[1]	1.86	1.66	1.64	1.5	1.76
Average Velocity, fps	0.28	0.58	0.96	0.12	0.85
Flow, cfs	0.45	4.83	8.13	1.90	10.62
Morphology Regime					
% Riffle	10	28	16	5	15
% Run	10	42	15	20	25
% Pool	80	30	69	75	60
Depth and Width Regime					
Average Riffle Thalwag Depth, ft.	0.6	0.9	1.8	0.9	1.2
Average Riffle Overall Depth, ft.	0.2	0.5	1.0	0.6	0.6
Average Riffle Wetted Width, ft	4.0	9.0	12.0	6.0	15.5
Average Run Thalwag Depth, ft.	1.0	1.5	1.7	1.4	1.3
Average Run Overall Depth, ft.	0.6	1.0	1.4	0.9	0.9
Average Run Wetted Width, ft	12.0	11.9	14.5	6.5	16.7
Average Pool Thalwag Depth, ft.	2.2	2.1	3.1	1.8	2.2
Average Pool Overall Depth, ft.	1.5	1.3	2.4	1.4	1.7
Average Pool Wetted Width, ft	11.8	14.3	17.6	8.6	18.2
Instream Habitat (Percent Stable Habitat)					
Epifaunal Substrate, Macroinvertebrates	17	31	23	16	23
Instream Cover, Fish	26	36	35	26	23
Substrate Characterization (Dominate Substrate)					
Riffle	Sand	Gravel Fine	Cobble	Silt/Clay	Gravel Fine
Run	Sand	Silt/Clay/Small gravel	Silt/Clay	Silt/Clay	Gravel Fine/Coarse

Observation	Study Locations				
	LC-1	LC-3	LC-4	BDL-1	BDL-2
Pool	Sand	Silt/Clay	Silt/Clay	Silt/Clay	Silt/Clay
Embeddedness					
% Embeddedness	1	0	4	0	12
Sediment Deposition					
Average Percent of Bottom Affected	75	66	8	45	13
Aquatic Macrophytes and Periphyton (Percent Coverage)					
Average Riffle Macrophytes	0	17	0	0	3
Average Riffle Periphyton	0	7	45	0	5
Average Run Macrophytes	0	28	30	0	5
Average Run Periphyton	0	8	5	0	5
Average Pool Macrophytes	3	25	14	0	0
Average Pool Periphyton	0	8	3	0	0
Canopy Cover (Percent Stream Shading)					
Stream Shading	59	24	41	80	75
Bank Stability and Slope					
Average Left Bank Stability	Mod. Unstable	Mod. Unstable	Mod. Unstable	Mod. Unstable	Mod. Unstable
Average Left Bank Slope (degrees)	67	84	79	79	67
Average Right Bank Stability	Mod. Unstable	Mod. Unstable	Mod. Stable	Mod. Unstable	Mod. Unstable
Average Right Bank Slope (degrees)	67	70	70	72	78
Bank Vegetative Protection					
Average Left Bank Protection (percent)	73	62	60	24	32
Average Right Bank Protection (percent)	63	62	67	30	31
Riparian Vegetative Zone Width					
Average Left Bank Riparian Width, meters	>18	>18	>18	>18	>18
Average Right Bank Riparian Width, meters	>18	>18	>18	>18	>18

[1]Average bankfull depth is calculated on riffles only

4.2.4.2 Reach LC-0

Reach LC-0 was not selected for study during the aquatic life field study. This decision was made due to the transformation of this stream reach during the planning of the UAA field activities. As depicted in Figures 4.4 – 4.6, the watershed was modified to accommodate the construction of a new high school facility. These modifications immediately adjacent to and encroaching upon Loutre Creek rendered the use of the study reach impractical.

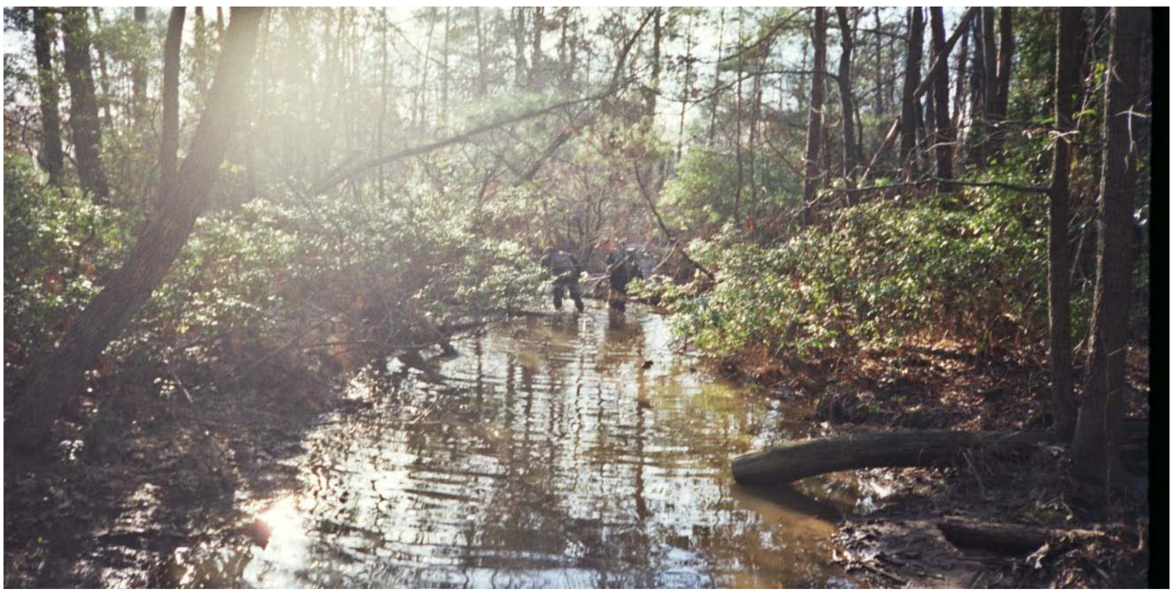


Figure 4.4. Reach LC-0 during study planning activities for Loutre Creek UAA. January 2008.

Figure 4.5. Loutre Creek headwaters. Uppermost stream channel development of Loutre Creek. January 2008.

Figure 4.6. Loutre Creek headwaters after clearing for high school site development. View to southwest. Note: the pooled water in depression. Remainder of the original stream channel. June 2009.

4.2.4.3 Reach LC-1

As identified in Section 3.4, Reach LC-1 was used to represent an upstream reference condition. This reach is located upstream of any discharge from Lion Oil. The watershed of this reach is approximately 2.0 mi^2. The upstream terminus of the reach LC-1 was a large wasteland area resulting from past oil field activities but had been maintained in a wetland form as a result of beaver activity and located between AR. Hwy 15 and Timberlane Drive (Figures 4.1 and 4.7-4.8). During low flow periods, the source flow, if any, in reach LC-1 was seepage from the beaver dam.

The reference reach was unique from the other study reaches in several characteristics including:

- **Flow:** the flow in LC-1 was much lower compared to the other reaches;
- **Stream Morphology:** LC-1 demonstrated a distinct pool/glide complex (80% pool); the highest percent compared to the other study reaches;

- **Instream Habitat**: availability and quality of instream habitat was lower than the downstream LC-3 and LC-4 reaches; however, was similar to both BDL-1 and BDL-2 percentages;
- **Sediments:** Historical petroleum residuals are presented upon disturbance of bottom sediments often resulting in surface oil sheens/slicks (Figures 4.9 - 4.12); and
- **Substrate**: Dominate substrate consisted of sand at 100% (resulting from the sediment transport during storm event from the construction activities and routine inflows from a developing urbanized watershed (Figures 4.13- 4.19).

Figure 4.7. Study Reach LC-1. Upstream of Lion Oil. Note remains of tree trunks, area indicated as wetland on maps but actually an old oil/brine waste area. Area just downstream of location of the Busey No. 1 Well (the Discovery Well). Feb 2008.

Figure 4.8. Study Reach LC-1. Above Lion Oil. Winter scene. View looking upstream towards dead timber area. Note the recently deposited sediments along both stream banks and in mid channel. January 2010.

Figure 4.9. Study Reach LC-1. Upstream most area. View from downstream to upstream. This area is immediately downstream (and to the east) of hillside upon which the Discovery Well was located. Note the oil sheen on water surface. January 2009.

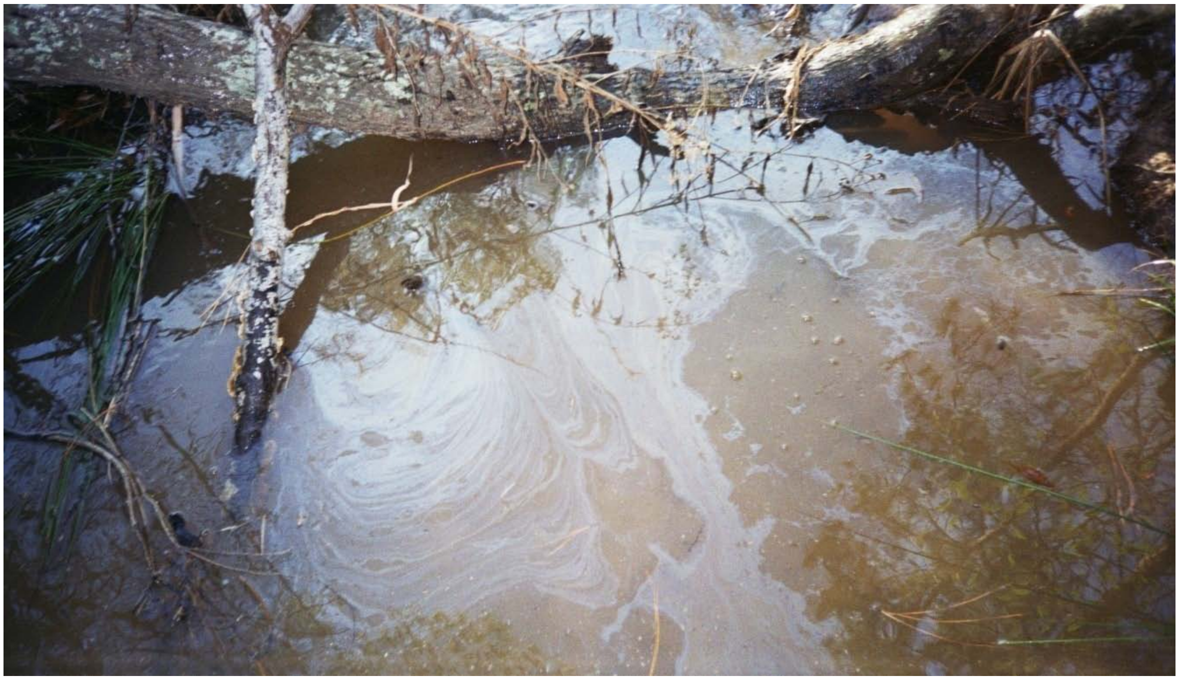


Figure 4.10. Study reach LC-1. Above Lion Oil. Note: Oil sheen on water surface after wading through area. January 2009.

Figure 4.11. Study reach LC-1. Above Lion Oil. Note: Oil sheen on water surface after wading through area. January 2009.


Figure 4.12. Study Reach LC-1. Upstream of Lion Oil. View from downstream to upstream. Note the oil sheen on water surface. February 2010.

During the course of the 2009-2010 aquatic life field study, the Loutre Creek watershed was undergoing extensive clearing and deforestation. The clearing was being developed for construction of a new high school complex. Before and during the study period, storm events transported excessive amounts of exposed sediments into Loutre Creek (Figures 4.13 - 4.18) and further downstream into Bayou de Loutre. In addition, during the 2010 summer low flow period, consolidated oil was present in the water column throughout Reach LC-1, there was no direct source identified and the apparent source was the disruption (e.g. construction) in the upper watershed (Figure 4.20).

Figure 4.13. Study Reach LC-1. Downstream terminus of study reach. Just upstream of AR Hwy 15 and Lion Oil facility. Spring scene. View looking upstream towards dead timber area. Note the recently deposited sediments and increased turbidity of inflow from right descending channel. March 2010.

Figure 4.14. Study Reach LC-1. Just upstream of AR Hwy 15 and Lion Oil facility. Spring scene. View looking upstream towards dead timber area. Note the increased turbidity of inflow from right descending channel. Residual flows from spring storm event. May 2010.

Figure 4.15. Electroshocking for fish community characterization. Note the recently deposited bed sediments and sand bar formation. April 2009.

Figure 4.16. Study Reach LC-1. View is upstream toward old oil/brine waste area. Electroshocking for fish community characterization. Note the recently accumulated sediments on the right descending bank. Also, water depth shin deep, less than 1 foot. April 2009.

Figure 4.17. Study Reach LC-1.View is upstream toward old oil/brine waste area. Electroshocking for fish community characterization during the spring seasonal steady state period. Water depth shin deep, less than 1 foot. Note the recently accumulated sediments on the right and left descending banks. April 2009.

Figure 4.18. Study Reach LC-1. View upstream to old oil/brine waste area during summer low flow period. Note low flow and exposed stream bed. August 2010.

Figure 4.19. Study Reach LC-1 during low flow conditions. Recently deposited stream bank sediments. Note dark globules in sediment. The dark spheres are oil/tar sediment masses. August 2010.

Figure 4.20. Study Reach LC-1 during summer low flow conditions. Note stagnant water with oil globules suspended in the water column. August 2010.

The LC-1 reach was approximately 238 feet in length with a bankfull width (the point at which the stream enters its active floodplain) of 11.9 feet, and was composed of approximately 80% shallow pools, 10% riffles, and 10% runs. The stream reach had an average wetted riffle depth and width of 0.2 ft and 4.0 ft. The average wetted pool depth and width was 1.5 ft and 11.8 ft. Average velocity was 0.28 fps, while the flow recorded at this study reach was 0.45 cfs (See field flow data sheets: Attachment N).

Instream habitat (fish cover) was composed of logs and woody debris, and covered approximately 26% of the reach. The epifaunal substrate (macroinvertebrate habitat) was available in approximately 16% of the reach. The stream substrate composed predominantly of sand in all habitat types. Sediment found in this reach was at about 75% of the bottom affected. Aquatic macrophytes were sparse at 3% and limited to pools only along this stream segment. Stream shading along the reach was at 59% canopy. Bank stability was characterized as moderately unstable. Bank vegetative protection covered approximately 63-73% of the reach, while riparian vegetative zone averaged >18 meters.

4.2.4.4 Reach LC-3

Reach LC-3 is located downstream of all Lion Oil discharges (Figure 4.1). This reach demonstrated a greater degree of stream morphologic development than any other reaches evaluated. The Study Reach LC-3 was dominated by the continuous 2 mgd plus flow from Outfall 001. In addition to the difference in flows, Reach LC-3 was unique from the other study reaches in several characteristics including:

- **Flow:** the flow in LC-3 was continuous even under summer low flow periods;
- **Stream Morphology:** the stream banks were deeply incised with limited flood plain development (Figure 4.21). LC-3 demonstrated a distinct run/glide dominated complex (80% run) the highest percent compared to the other study reaches (Figure 4.22);
- **Instream Habitat**: availability and quality of in-stream habitat was elevated when compared to LC-1 and the BDL reaches, due to the development of riffle and run habitats (Figure 4.23);
- **Sediments:** Historical petroleum residuals are presented primarily in two forms, consolidated bottom tars/sediment conglomerates and as seeps for layered soils in the deeply incised banks (Figures 4.24- 4.28); and

- **Substrate**: The substrate of the limited pool areas in Reach LC-3 were dominated by loose unconsolidated sands and silts (resulting from the sediment transport during storm event from the construction activities and routine inflows for a developing urbanized watershed). The run and glide areas were typically dominated by either clay or loose gravels.(Figure 4.26 and 4.27).

Although dominated by shallow runs with clay substrates, the study reach had developed pools of various depths and short riffle areas with shallow gravel substrates. The stream is steeply incised with a bank height typically exceeding 10 feet (Figure 4.21). In addition, average bank stability along LC-3 was moderately unstable and bank slope was very steep at 84% and 70%. This combination of physical attributes combined to promote bank sloughing during high flow events.

Reach LC-3 (242 feet) was composed of approximately 30% deep and shallow pools, 42% runs, and approximately 28% riffles (Attachment N). The average bankfull width was measured at 12.1 ft, while the bankfull depth was measured at approximately 1.7 ft. The average wetted riffle depth and width was 0.5 ft and 9.0 ft. The average wetted pool depth and width was 1.3 ft and 14.3 ft. Average velocity at LC-3 was 0.58 fps, while the flow recorded at this station was 4.83 cfs and included the discharge volume from Lion Oil, which was approximately 75% of the measured flow (Table 4.2 and Attachment N).

Within the study reach, the available fish cover and macroinvertebrate habitat covered approximately 36% and 31%, respectively. Stream shading within the reach was sparse with 24% canopy. The aquatic macrophytes within the reach were found in each morphology regime between 7% and 28%. Periphyton was also found in each regime and covered approximately 7% to 8% of available substrate. Bank vegetative protection was moderate and averaged 62% on each bank. The riparian vegetative zone average was >18 meters for both banks.

Figure 4.21. Study Reach LC-3. Below Lion Oil. Note shallow run with deeply incised banks. Notice Lion Oil cracking towers in upper left of figure. January 2009.

Figure 4.22. Study Reach LC-3. Downstream of Lion Oil. Run section. View downstream. Note substrate of rock and accumulated sediments along left descending bank. August 2010.

Figure 4.23. Study Reach LC-3 during summer low flow period. Vegetative habitat along stream margins. August 2010.

Figure 4.24. Study Reach LC-3. Run area. Note oil/tar residuals as “clumps” on the right descending bank and accumulated sediments along the inside stream meander. January 2008.

Figure 4.25. Study Reach LC-3. Outside meander bend. Note soil layering with oil /tar residuals seeping from layer about 3 feet above water surface. January 2009.

Figure 4.26. Study Reach LC-3. View to upstream. Electroshocking to characterize the fish community. Note the hydrocarbon laden soil layering on left and right banks about 3.5 feet above water surface. January 2009.

Figure 4.27. Study Reach LC-3. Run area during low flow. Note black substrate in left foreground is a tar sediment layer, common throughout reach. August 2010.

Figure 4.28. Study Reach LC-3. Pool area. Note accumulated sediments across entire stream section. June 2009.

4.2.4.5 Reach LC-4

Reach LC-4 is located downstream of LC-3 (Figure 4.1). This reach is classified as having a pool/glide complex with stream width and depth increasing compared to LC-1 and LC-3 reaches, providing ample habitat for fish community development (Figures 4.29-31). The primary physical factor at LC-4 is the pool complex that provides a sediment sink for the Loutre Creek system and limits the transport of sediments downstream into Bayou de Loutre.

- **Flow:** the flow in LC-4 was continuous even under summer low flow periods.
- **Stream Morphology:** the stream banks were deeply incised with limited flood plain development (Figure 4.29). LC-4 demonstrated a distinct pool dominated complex (80% pool), the highest percent compared to the other study reaches (Figure 4.30);
- **Instream Habitat**: availability and quality of instream habitat was reduced when compared to the LC-3 reach and limited primarily to marginal vegetative development during the spring and summer periods (Figure 4.30);
- **Sediments:** Historical petroleum residuals are not as obvious as at other reaches in Loutre Creek. This is due to the pool dominated habitats. In areas of exposed banks, the soil layering was also visible in this reach (Figure 4.31; and
- **Substrate**: The substrate of the pool areas in Reach LC-4 were dominated by loose unconsolidated sands and silts. The pool dominated reach also provided areas of sediment accumulation and served as sediment sinks limiting downstream transport into Bayou de Loutre.

Reach LC-4 (320 feet) was composed of approximately 79% shallow pools, 15% runs, and approximately 6% riffles (See field data sheets in Attachment N). The average bankfull width was measured at 16.0 ft, while the bankfull depth was measured at approximately 1.6 ft. The average wetted riffle depth and width was 1.0 ft and 12.0 ft. The average wetted pool depth and width was 2.4 ft and 17.6 ft. Average velocity at LC-4 was 0.96 fps, while the flow recorded at this station was 11.13 cfs (Table 4.2 and Attachment N).

Within the study reach, the available fish cover and macroinvertebrate habitat covered approximately 35% and 23%, respectively. Stream shading within the reach averaged 41% canopy. The aquatic macrophytes within the reach were found in pool and run morphology regimes at 14% and 30%. Periphyton was found in each regime and covered approximately 3% to 5% of available substrate in pools and runs and 45% in riffles. Average bank stability along

LC-4 was moderately unstable at left banks and moderately stable at the right banks. Bank slope was very steep at 79% and 70% for left bank and right bank. Bank vegetative protection was moderate and averaged 60% and 67% on each respective bank. The riparian vegetative zone average was >18 meters for both banks.

.

Figure 4.29. Study Reach LC-4. View from downstream to upstream. Note wide stream channel, with no apparent flow. August 2010.

Figure 4.30. Study Reach LC-4 just upstream of mouth of Loutre Creek. View to upstream. Note wide stream channel with no noticeable flow, but with extensive vegetative stream margin growth. June 2009

Figure 4.31. Study Reach LC-4. Stream channel wide with deep non- wade able pools. Note the soil layering in right descending bank with layer of petroleum laden soils at about 3 feet off water surface. June 2009.

4.2.4.6 Reach BDL-1

Reach BDL-1 (secondary upstream reference site) is located upstream of the confluence with Loutre Creek (Figure 4.1). This study reach is located in the upper Bayou de Loutre drainage basin. Stream characteristics of Bayou de Loutre are similar to Loutre Creek and represent a secondary reference condition. Reach BDL-1 demonstrated a comparable degree of stream morphology and general stream characteristics to reference site LC-1. Differences from the other study reaches include:

- **Bankfull width:** BDL-1 had the lowest bankfull widths compared to all study reaches (Figure 4.32);
- **Flow:** flows recorded were much lower than the LC-3, LC-4, and BDL-2 study reaches but four times that of the upstream location on Loutre Creek;
- **Canopy cover:** stream shading measured the highest at 80% coverage; and
- **Substrate type:** No dominant substrate, equally divided between clay, sand and silt, however, as at other study reaches, disturbance of the pool substrates resulted in oily surface sheens, indicating that petroleum residuals were retained in the pooled sediments (Figure 4.33).

Reach BDL-1 (174 feet) was composed of approximately 75% shallow pools, 20% runs, and approximately 5% riffles (Attachment N). The average bankfull width was measured at 8.7 ft, while the bankfull depth was measured at approximately 1.5 ft. (Figure 4.34). The average wetted riffle depth and width was 0.6 ft and 6.0 ft. The average wetted pool depth and width was 1.4 ft and 8.6 ft. Average velocity at BDL-1 was 0.12 fps, while the flow recorded at this station was 1.9 cfs (Table 4.2 and Attachment N).

The available fish cover and macroinvertebrate habitat were limited, covering approximately 26% and 16%, respectively (Figure 4.35). Stream shading within the reach was dense with 80% canopy. Aquatic macrophytes and periphyton were absent within this reach. Average bank stability along BDL-1 was moderately unstable at left and right banks. Bank slope was also similar to the other sites displaying a steep 79% and 72% for left bank and right bank. Bank vegetative protection was considered low at ≤30% on each bank and the riparian vegetative zone average was >18 meters for both banks.

Figure 4.32. Study Reach BDL-1. View to upstream. Electroshocking for spring seasonal fish community characterization April 2009.

Figure 4.33. Study Reach BDL-1. Note oil sheen developed after wading through shallow pool. August 2010.

Figure 4.34. Study Reach BDL -1. Above mouth of Loutre Creek. View upstream to downstream. Note narrow incised channel with flow. Spring seasonal steady state flow conditions. April 2009.

Figure 4.35. Study Reach BDL-1. Note narrow stream channel with root complex for habitat. Also, absence of accumulated sediments along the stream margins.

4.2.4.7 Reach BDL-2

Reach BDL-2 is located downstream of the confluence with Loutre Creek (Figure 4.1). Reach BDL-2 demonstrated a pool/glide complex throughout the reach. Morphology regime percentages were also similar to the other study reaches. Bankfull measurements were the widest in BDL-2 when compared to all other study reaches. In addition to the difference in flows, Reach BDL-2 was unique from the other study reaches in several characteristics including:

- **Flow:** the flow in BDL-2 was continuous even under summer low flow periods;
- **Stream Morphology:** the stream banks were deeply incised with limited flood plain development (Figure 4.36);
- **Instream Habitat**: availability and quality of instream habitat was reduced when compared to other study reaches, reflecting the effect of the historical channelization adjacent to the railroad right-of- way;
- **Sediments:** Historical petroleum residuals are not detected or evident in the study reach; however, the transport of suspended clays was evident during increased flow events (Figure 4.37); and
- **Substrate**: The substrate of the limited pool areas in Reach BDL-2 was dominated by hard-pack clay except in the immediate area of stream crossings by bridges and railroad crossings.

Reach BDL-2 (416 feet) was composed of approximately 60% shallow pools, 25% runs, and approximately 15% riffles. Width regimes were the highest along this reach, typical of downstream channel morphology. The average bankfull width was measured at 20.8 ft, while the bankfull depth was measured at approximately 1.8 ft. The average wetted riffle depth and width was 0.6 ft and 15.0 ft. The average wetted pool depth and width was 1.7 ft and 18.2 ft. Average velocity at BDL-2 was 0.85 fps, while the flow recorded at this station was 10.6 cfs (Table 4.2 and field data sheets in Attachment N).

Within the study reach, the available fish cover and macroinvertebrate habitat covered approximately 23% throughout the reach. Stream shading within the reach was dense with 75% canopy. The aquatic macrophytes and periphyton within the reach were found sparse in riffle and run morphology regimes at 3% to 5% coverage. Average bank stability along BDL-2 was moderately unstable at left and right banks. Bank slope was again steep at 67% and 78% for left bank and right bank. Bank vegetative protection was low and averaged 32% on the left bank and 31% on the right bank. The riparian vegetative zone average was >18 meters for both banks.

Figure 4.36. Study Reach BDL-2. Downstream of the mouth of Loutre Creek. Summer low flow conditions. Note the deeply incised channel and the exposed clay hard pan bottom sediments which dominated this study reach and the developed stream canopy. August 2010.

Figure 4.37. Study Reach BDL 2. Downstream mouth of Loutre Creek. Spring steady state conditions. Note increased turbidity. Heavy silt load being transported. April 2010.

4.2.5 Habitat Potential

The assessment of habitat potential is used to characterize the potential for instream habitat to support the designated fisheries use. Those reaches scoring optimal would be expected to maintain the designated fisheries use. Scoring marginal or below would indicate that habitat limitations likely play a role in the use attainment. The qualitative assessment of habitat potential characterized three of the study reaches as marginal (LC-3, BDL-1 and BDL-2) and two as sub-optimal (LC-1, LC-4), indicating that the habitat was less than typically expected for gulf coastal streams and that habitat, or lack thereof, likely restricts the fish community development. The assessment placed reaches LC-1 and LC-4 in the sub-optimal category with mean scores of 11.3 and 11.8, and reach LC-3, BDL-1, and BDL-2 in the marginal category with mean scores of 9.9, 9.7, and 8.7 (Table 4.3). This overall range of scores (8.7-11.8) indicates similar characteristics in habitat potential at each study reach. Differences in the scores between reaches were demonstrated most significantly by pool substrate, channel alteration, channel sinuosity, and bank vegetative protection.

The results of the qualitative habitat assessment indicate the presence of sub-optimal habitat for fish and macroinvertebrates at study reaches LC-1 and LC-4. Study reaches LC-3, BDL-1, and BDL-2 scored less favorably for fish and macroinvertebrate habitat due to disturbances both instream and alongside the stream, as well as alterations to the channel. The individual scoring forms are provided in Attachment N.

Table 4.3. Qualitative habitat potential summary of study reaches. August 2009.

Parameters	Reach				
	LC-1	**LC-3**	**LC-4**	**BDL-1**	**BDL-2**
1. Epifaunal Substrate	7	11	8	7	6
2. Pool Substrate	6	6	4	2	2
3. Pool Variability	7	7	16	6	6
4. Channel Alteration	14	3	10	7	6
5. Sediment Deposition	16	14	18	19	17
6. Channel Sinuosity	9	3	9	5	1
7. Channel Flow Status	15	18	16	19	18
8. Bank Stability					
Left Bank	5	5	4	5	4
Right Bank	5	6	5	5	4
9. Vegetative Protection					
Left Bank	6	4	5	1	2
Right Bank	5	4	5	1	1
10. Riparian Vegetative Zone Width					
Left Bank	9	9	9	10	10
Right Bank	9	9	9	10	10
Score (Total)	113	99	118	97	87
Score Average	11.3	9.9	11.8	9.7	8.7
Ranking	S	M	S	M	M

Ranking	Range
Optimal (O)	16-20
Sub-optimal (S)	11-15
Marginal (M)	6-10
Poor (P)	0-5

4.2.6 Comparison to 2005 Habitat Assessment

The procedures discussed above to perform the 2009-2010 aquatic study were also followed to perform the 2005 aquatic life field study. For ease of reference, Table 4.4 summarizes the physical attributes of all stations where physical data was collected in the 2005 aquatic study. The 2006 Study, which summarized the results of the 2005 aquatic study, provides a detailed description of the 2005 spring steady state habitat assessment (GBMc, 2006).

Table 4.4. Habitat characteristics of study reaches during seasonal flow conditions April 2005 (GBMc, 2006).

Observation	Study Locations LC-1	LC-2	LC-3
Date	4/28/2005	4/28/2005	4/28/2005
General Stream Characteristics:			
Upstream Watershed Size, mi^2	2.0	2.6	2.8
Total Habitat Reach Length, ft	254	424	338
Average Bankfull Width, ft	12.7	21.2	16.9
Average Bankfull Depth, ft[1]	1.4	2.2	1.95
Average Velocity, fps	0.25	0.78	0.86
Flow, cfs	0.48	4.19	4.45
Morphology Regime			
% Pool	74.7	100	65
% Riffle	25.3	--	8.8
% Run	--	--	27
Depth and Width Regime			
Average Riffle Depth, ft.	0.3	--	0.6
Average Riffle Wetted Width, ft	5	--	9
Average Pool Depth, ft.	1.7	1.0	1.5
Average Pool Wetted Width, ft	8.8	19.9	15.7
Instream Habitat (Percent Stable Habitat)			
Epifaunal Substrate, Macroinvertebrates	45	15	24
Instream Cover, Fish	48	14	29
Substrate Characterization (Dominate Substrate)			
Pool	sand	sand	clay/silt, sand
Riffle	sand	--	sand
Run	--	--	clay/silt, sand
Sediment Deposition			
Average Percent of Bottom Affected	38	55	27
Aquatic Macrophytes and Periphyton (Percent Coverage)			
Pool Macrophytes	2.9	4.5	4.4
Pool Periphyton	0	1	7.2
Riffle Macrophytes	0	--	2.5
Riffle Periphyton	0	--	22.5
Run Macrophytes	--	--	5
Run Periphyton	--	--	5
Canopy Cover (Percent Stream Shading)			
Stream Shading	85	0	13
Bank Stability and Slope			
Average Left Bank Stability	mod. stable	mod. unstable	unstable
Average Left Bank Slope (degrees)	79	76	87
Average Right Bank Stability	mod. unstable	mod. unstable	mod. unstable
Average Right Bank Slope (degrees)	70	67	77
Bank Vegetative Protection			
Average Left Bank Protection (percent)	54	54.5	40
Average Right Bank Protection (percent)	45	61	57
Riparian Vegetative Zone Width			
Left Bank Riparian Width, meters	12 - 18	0	12 – 18
Right Bank Riparian Width, meters	12 - >18	0	6 - 11

[1]Average bankfull depth is calculated on riffles only.

There are limited differences in the 2005 and 2009 habitat assessments. Data from the 2005 aquatic study and the 2009-2010 aquatic study demonstrate similar conditions at each of the individual study reaches, except for the substrate condition. This is predominantly reflected in the reduced pool depths in study reaches LC-1 and LC-3. Further, compared to the 2005 aquatic study, all reaches surveyed in Loutre Creek and Bayou de Loutre in the 2009-2010 aquatic study had significantly higher sand deposits in depositional areas and sand bars and sand points were more prominent in Loutre Creek (See Figures 4.15, 4.16, 4.18, 4.24 and 4.28).

These new sediment depositions and associated changes in habitat quality were the result of the deforestation and construction of a high school in the headwaters of Loutre Creek. As depicted in photographs, this construction caused a large influx of sediment into the Creek, which was transported downstream during storm events that occurred after the 2005 aquatic study and before or during the 2009 aquatic study. See photographs at Figures 5.13 through 5.21. The transport of this sediment was likely exacerbated by above normal storm flows in Loutre Creek given that 2008 was one of the wettest years on record and 2009 was the wettest year on record in Arkansas. As reported by the National Weather Service, the El Dorado reporting station received approximately 135 percent of its annual average rainfall in 2009. See http://www.srh.noaa.gov/lzk/?n=2009.htm.

As a result, compared to the 2005 aquatic study, more aquatic vegetation along the stream margins of downstream pools on the LC-3 reach was documented during the 2009 aquatic study. The increased emergent vegetation was in response to newly deposited sediments from the Creek's headwaters. The new nutrient laden topsoils provided the substrate for vegetation to root and develop. Once established, the vegetation increased sediment deposition in the margins of pools and at the head and toe of riffle/run areas in Reach LC-3. Likewise the sediment deposition also decreased variability in channel morphology and created sand and sediment bars at the head and toe of meander bends where they did not exist during the 2005 aquatic study. This new sedimentation negatively impacted the available habitat for the fishery in Loutre Creek by reducing the variability of bottom habitats, silting in of micro-habitats utilized by benthic invertebrates and by siltation of habitats used by sunfish for spawning.

4.2.7 Habitat Conclusions

The habitat characterization indicated that:

1. The habitat of Loutre Creek provides some minimum level of form and function to support a limited biotic (fish /insect) community, but the reduced habitat quality resulting from the urbanization of the watershed limits the development of the fishery community.
2. All study reaches, except the downstream most reach (BDL-2), exhibited residual contaminants from historical oil field activities.
3. All study reaches were dominated by pool complex systems with the exception of LC-3, where the run/glide community dominated. For the stream reaches dominated by pool communities, the pools are shallow with limited bank undercutting and developed fish habitat.
4. It is unknown what the natural flow regime is for Loutre Creek because it does not have a stream gauge and the regime has been affected by urbanization and associated deforestation in the watershed since at least the 1950s. (Section 3.4.2). The increased impervious surfaces from urbanization in this watershed affect the flow regime by causing increased runoff velocities and enlarged hydrographs. (Section 3.4.2.1).
5. Loutre Creek's current flow regime impacts available habitat as follows:
    - Under the current flow regime, flows in reach LC-1 above the Outfall 001 discharge are intermittent during the critical season (typically June through October in Loutre Creek). During this period, aquatic habitat is often limited to residual storm waters in pools. See Figures 4.6 and 4.18. This is similar to the flow regime in the upstream reference reach of BDL-1.
    - Relative to the upstream reaches, the current flow regimes in reach LC-3 and LC-4 and in reach BDL-2 are elevated because of the point source dischargers (Lion Oil to Loutre Creek and Bayou de Loutre and GLCC to Bayou de Loutre). The elevated and consistent flow from these discharges significantly modifies the hydrologic regime in these reaches when compared to the upstream reaches.

- In Loutre Creek, the discharge augments the flow in reach LC-3 and LC-4 during the summer low flow periods and the energy in the discharge creates riffle and run conditions that would otherwise be dry during the low-flow critical season. Without the discharge, this flow and associated habitats would recede and the flow regime would likely reflect an urban storm water dominated system like LC-1 with aquatic habitat in low flow periods limited to residual storm waters in pools. As discussed in the 2006 Study, the augmentation of flow from the discharge enhances the habitat availability and potential for community development in Loutre Creek because it adds water to the Creek. Although the discharge facilitates year-round aquatic habitat in Loutre Creek, these consistent flows also modify the natural habitat variability and associated aquatic communities in the Creek. In addition to providing consistent flows, the discharge increases the overall volume of flows (over 2 million gallons per day of water) to a 1st order stream segment that typically would have less water, particularly during dry periods. This additional volume of water modifies the natural habitat variability and associated aquatic communities.
- Loutre Creek's flow regime is not readily comparable to the least disturbed ecoregion reference streams discussed in Section 3.4.2.2 of the UAA because it is heavily deforested and urbanized with a large percentage of the watershed (approximately fifty-five percent) covered by impervious areas. By contrast, the least disturbed streams are in watersheds that are heavily forested with limited impervious areas. Further, unlike Loutre Creek, the least disturbed streams do not have dischargers, which is why none were documented to have flows during the critical low flow period. (ADEQ, 1987).

6. Compared to an eco-region reference stream, Loutre Creek has more limited habitat and, in turn, supports a more limited biotic community due to:

- Historical oil field deposits that although not directly impacting the habitat development, does contribute to the water quality that is not typical for Gulf Coastal ecosystems.
- Continued urbanization of the watershed that modifies the hydrology of the watershed, increasing the magnitude of storm hydrographs and shortening the duration of storm flows through the system. The increased storm hydrographs increase silt transport and results in increased sediment deposition in the stream channel. Sediment deposition reduces habitat variability and development of the pool/glide complex typical of small gulf coastal streams. The sedimentation also modifies the natural development of habitat variability. and
- It is a comparatively small watershed (2.78 square miles), which is not expected to maintain year round aquatic communities. Gulf Coastal streams are typically dry except for periods of storm events during the summer low flow periods. The dry stream bed does not provide sustainable wetted habitats for the development of complex biotic communities.

4.3 Benthic Macroinvertebrate Community

4.3.1 Introduction

The benthic macroinvertebrate community reflects the effects of habitat availability, and the long term exposure to physical and chemical properties of the water in which it develops and lives. The presence and diversity of the benthic macroinvertebrate community reflects a water body's biological integrity and the ability for the benthic community to support a diverse fish population.

4.3.2 Methods

An assessment of the benthic macroinvertebrate community was performed in June 2009 using rapid bioassessment (RBA) techniques as detailed by ADEQ (1988). The methods were modified to sample in pool habitats. As indicated in Section 4.1 five sampling stations were evaluated. Reach LC-1 was on Loutre Creek upstream of any contribution from the Lion Oil facility (treated process and storm water). Reaches LC-3, LC-4, and BDL-2 were sampled to characterize Loutre Creek and Bayou de Loutre downstream of Outfall 001 (Figure 4.1). Reach BDL-1, upstream of the mouth of Loutre Creek and not impacted by the Outfall 001 discharge, was sampled to characterize a secondary reference condition and to characterize where residual selenium from historical oil field activities may occur.

Macroinvertebrates were sampled using a Turtox Indestructible® dip net. Each station was sampled for three minutes according to the RBA protocol. The three minute sample period included time spent actively sampling the selected microhabitat and did not include time moving from microhabitat to microhabitat and/or sorting large debris particles from the sample to be processed.

Each sample was placed in a bucket and condensed using multiple washings into a standard #30 sieve. The samples were preserved in the field and transported to the lab for further processing, sub-sampling, identification, and enumeration. In the lab, each of the field preserved samples were sub-sampled at random, placed on a grid, white sorting tray from which the macroinvertebrates sub-sample was collected. The white tray, with a 10 X 10 grid, was used to randomly select a 100 organism sub-sample from the qualifiedly collected benthic sample. Numbered grids were selected at random, from which all insects were collected and ultimately identified. Collections from individual grids continued until 100 organisms were collected. The 100 organism sub-samples were preserved in Kaylee's solution or 70% ethanol as a voucher for verification. The remainder of the original sample was concentrated, large particles removed, preserved in Kaylee's solution, and retained as a voucher for the sample picking techniques used. These voucher samples will be held at GBM[c] for a period of 24 months or until the project is completed. After project completion the samples may be contributed to a university zoological collection.

The macroinvertebrate assemblages from each station were analyzed according to several benthic community biometrics. These include richness (number of different taxa), EPT richness (number of different taxa represented in the orders Ephemeroptera, Plecoptera, and Trichoptera), and species diversity as determined by the Shannon-Wiener Diversity Index. The analysis also included the seven biometrics used by the State of Arkansas (ADEQ, 1988) in its RBA scoring system. This scoring system places a value (1 to 4, 1=excessive differences, 4=no differences) on each of the seven biometrics to achieve a final mean score. The field data sheets and biometric score forms are provided in Attachment N.

4.3.3 Results and Discussion

4.3.3.1 Overview

BDL-1, the secondary reference reach upstream of the mouth of Loutre Creek , had the highest number of taxa (16) and the most diverse assemblage (diversity indices of 2.17) indicating that the benthic community was more developed both taxonomically and functionally when compared to other reaches in Loutre Creek and in Bayou de Loutre during the same period.

The species diversity was lowest (0.80) in LC-1 (the reference reach above the Lion Oil facility). This measure of invertebrate community development reflects the impact of the urban disturbances (the increased sedimentation for continued development in the watershed), the reduced water quality resulting from the urban non-point source contributions, residual petroleum deposits, and the limited watershed size of Loutre Creek in the upstream reference reach. A summary of the benthic macroinvertebrate community assemblages of Loutre Creek collected during the spring seasonal aquatic field study is presented in Table 4.5. The total number of taxa (i.e., community richness) increased at all downstream reaches of the Lion Oil facility (Table 4.6).

Table 4.5. Summary of benthic community taxa collected from Loutre Creek and Bayou de Loutre using the RBA techniques. June 2009.

Taxa/Station I.D.	Trophic Group	Study Reaches					
		LC-1	LC-1D	LC-3	LC-4	BDL-1	BDL-2
ANNELIDA							
Hirudinea	PR	--	--	1	--	1	--
Oligochaeta	GC	80	104	55	13	9	3
GASTROPODA							
Helisoma	SC	--	1	--	--	--	--
Physella	SC	1	--	--	--	--	--
PELECYPODA							
Sphaeridae	FC	--	2	--	--	--	--
CRUSTACEA							
Amphipoda	GC	--	--	--	--	1	--
Cambaridae	GC	--	2	--	1	1	1
Isopoda	GC	--	--	--	--	23	2
ODONATA							
Argia	PR	--	--	4	7	--	8
Enallagma	PR	--	--		4	--	
Ischnura	PR	--	1	2	3	3	3
Libellula	PR	--	--	--	--	1	--
Perithemis	PR	--	--	--	--	1	--
HEMIPTERA							
Corixidae	PR	--	--	--	--	5	--
Oravelia	PR	--	--	--	--	1	--
MEGALOPTERA							
Sialis	PR	--	--	--	--	3	--
TRICHOPTERA							
Chematopsyche	FC	--	--	--	--	6	1
Metrichia	GC	--	--	--	27	--	--
Ochrotrichia	GC	--	--	1	--	--	1
DIPTERA							
Chironominae	GC	50	68	98	61	29	44
Tanypodinae	PR	3	1	7	13	9	13
Tanytarsini	FC	--	2	--	1	14	9
Diptera Sp.1	GC	--	--	--	--	--	2
Hemerodromia	PR	--	--	3	3	1	3
Probezzia	PR	--	--	--	2	--	--
Sum of Percentages		100	100	100	100	100	100
Total Abundance:		134	181	171	135	108	90
Species Richness		4	8	8	11	16	12
Shannon-Wiener Index		0.80	0.92	1.09	1.69	2.17	1.73

Table 4.6. Summary of benthic community metrics from Loutre Creek and Bayou de Loutre as sampled June 2009.

Parameter	LC-1	LC-1D	LC-3	LC-4	BDL-1	BDL-2
COMMUNITY MEASURES						
Total number of Taxa (Richness)	4	8	8	11	16	12
EPT Richness	0	0	1	1	1	2
EPT % Abundance	0.0	0.0	0.6	20.0	5.6	2.2
Diversity Indices (Shannon-Wiener)	0.8	0.9	1.1	1.7	2.2	1.7
Total % of 5 Dominant Taxa	100.0	99.4	100.0	100.0	92.6	100.0
PERCENTAGE OF THE 4 DOMINANT ORDINAL GROUPS						
Ephemeroptera	0.0	0.0	0.0	0.0	0.0	0.0
Trichoptera	0.0	0.0	0.6	20.0	5.6	2.2
Odonata	0.0	0.6	3.5	10.4	4.6	12.2
Coleoptera	0.0	0.0	0.0	0.0	0.0	0.0
Diptera	39.6	39.2	63.2	59.3	49.1	78.9
Annelida	59.7	57.5	32.7	9.6	9.3	3.3
Crustacea	0.0	1.1	0.0	0.7	23.1	3.3
FUNCTIONAL FEEDING ASSEMBLAGES %						
Shredders	0.0	0.0	0.0	0.0	0.0	0.0
Scrapers	0.7	0.6	0.0	0.0	0.0	0.0
Filterers	0.0	2.2	0.0	0.7	18.5	11.1
Collectors	97.0	96.1	90.1	75.6	58.3	58.9
Predators	2.2	1.1	9.9	23.7	23.1	30.0
Biometric Index:	8.7	11.6	10.7	8.2	7.9	8.0

Diptera and/or Annelida communities dominated the benthic communities and were represented at each of the five study reaches. Trichoptera, Odonata, and/or Crustacea communities were also represented at downstream reaches. LC-1 had the least diverse community (i.e. Shannon-Wiener indices of 0.8).

The BDL-1 diversity was further demonstrated in that the five dominant taxa comprised 93 percent of the sample compared to 100 percent at the other study reaches and 99 percent of the duplicate sample (LC-1D) collected at LC-1.

The functional assemblage changed from LC-1 to BDL-2. The functional assemblage was dominated by collectors at LC-1 (nearly 50:1 ratio) and at LC-3 by approximately 10:1. This ratio moderated at LC-4 to 4:1 collectors to predators to approximately 2:1 at BDL-2. BDL-1 was also dominated by collectors at nearly 3:1. Collector functional groups are typically dominate in gulf coastal streams with watersheds of 10 square mile or less as is the case in these study reaches (Figure 4.38).

4.3.3.2 Reach LC-1

The upstream community (LC-1) was dominated by representatives from the orders Annelida (aquatic worms) and Diptera (true flies), and comprising of 99 percent of the LC-1 assemblage and 96 percent of the duplicate (LC-1D) sample assemblage. With a total richness of only 4 at LC-1 and 8 in the duplicate collection, LC-1 had the lowest Shannon-Wiener index and had a zero score of EPT richness or abundance.

4.3.3.3 Reach LC-3

The invertebrate community of Reach LC-3 was dominated by Diptera and Annelida, which comprised 96.7% of the assemblage. The trophic structure of community was dominated by collectors and a richness of 8 was collected during the reach study. Shannon –Wiener and EPT scores were higher than reach LC-1.

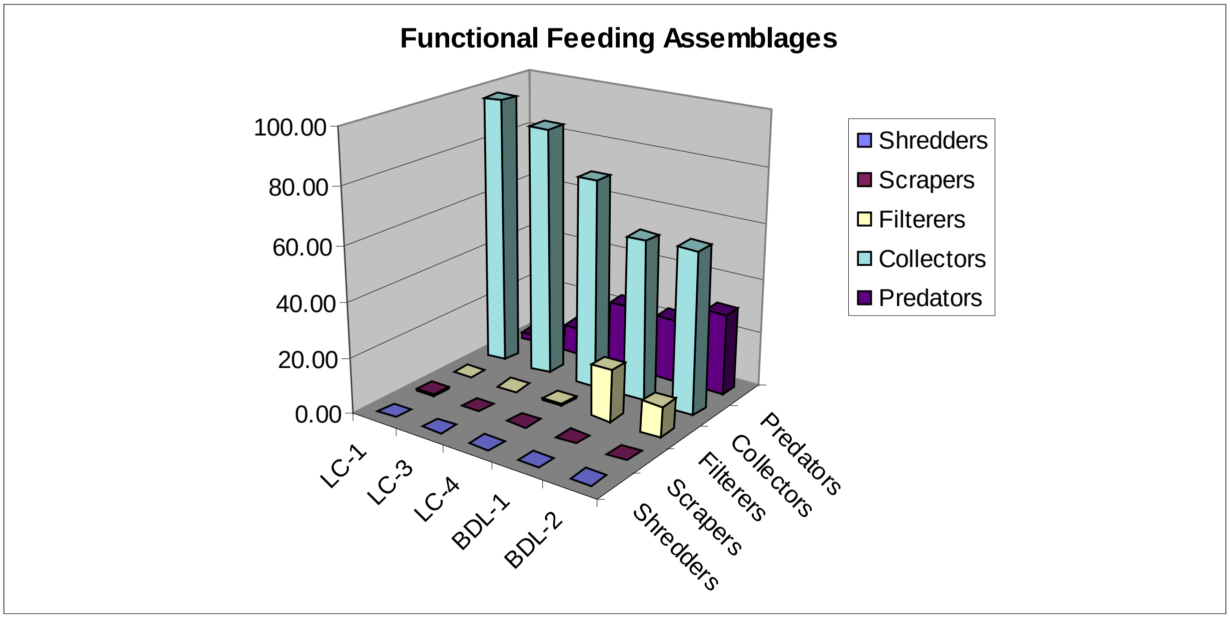


Figure 4.38. Comparison of trophic structure of benthic community at Loutre Creek and Bayou de Loutre study reaches.

4.3.3.4 Reach LC-4

The invertebrate community of reach LC-4 was dominated by Diptera and Trichoptera (caddisfly), which comprised 79.3% of the assemblage. Odonata (dragonflies and damselflies) and Annelida were also collected, making up 10.4% and 9.6% of the community. Species richness totaled 11 taxa and the Shannon-Wiener score of 1.7. Although LC-4 had the highest EPT percent abundance (20%), only one species of the order Trichoptera was collected, indicating an unbalanced distribution of the EPT indicator groups.

4.3.3.5 Reach BDL-1

The invertebrate community of reference reach BDL-1 was dominated by Diptera and Crustacea (arthropods), comprising 72.2% of the assemblage. BDL-1 had the highest number of species richness and diversity compared to all study reaches. Functional feeding groups included filterers (18.5%), collectors (58.3%), and predators (23.1%).

4.3.3.6 Reach BDL-2

The invertebrate community of BDL-2 was dominated by Diptera and Odonata, comprising 91.1% of the assemblage. However, species richness was the second highest, with

12 taxa collected and a Shannon-Wiener index of 1.7. Function feeding assemblage percentages were similar to BDL-1.

4.3.3.7 Biometric Comparisons

Although there were some specific taxonomic differences in the species collected, the biotic index calculated for the comparison of the assemblages collected at LC-1, LC-3, LC-4, BDL-1, and BDL-2 ranged from 7.9 to 11.6 indicating minimal differences between the benthic community assemblages. These high indices also demonstrate the dominant presence of tolerant species collected at each study reach. LC-1 and LC-3 resulted in the highest scores while reference site BDL-1 had the lowest. However, the downstream Loutre Creek reach was similar to both Bayou de Loutre reaches.

4.3.4 Comparison to 2005 Benthic Invertebrate Assessment

The 2005 aquatic Life Field Study was completed in May, 2005 during seasonal stream conditions. A summary of the benthic community assemblage is presented in Table 4.7. The 2006 Study, which summarized the results of the 2005 aquatic study, provides a detailed description of the 2005 spring benthic community assemblages (GBMc, 2006).

Compared to the 2005 aquatic study (Table 4.8), surveyors found a reduced benthic community (lower number of species) in the study reaches LC-1 and LC-3. Further, compared to the 2005 aquatic study, surveyors found the functional assemblages of macroinvertebrates were also modified; in 2009, the assemblage was almost completely dominated by gathering collectors and other feeding groups were mostly absent (Table 4.6).

These differences in the macroinvertebrate community between the studies was likely due to the massive sediment loading generated by the deforestation of a large section of the Loutre Creek watershed for the construction of the new El Dorado High School campus and parking areas, resulting in increased sediment transport into and through Loutre Creek. The sedimentation increased the percent of stream bed impacted by sediment deposition from 38% in 2006 to 75% in 2009. The increase in the percent of stream bed impacted by sedimentation in turn reduced the epifaunal substrate (the substrate used by aquatic invertebrates as habitat) which limited the development of the benthic community. The contributions of additional silt and sand to the waterbody limited habitat for other feeding groups. This increased sediment deposition is depicted in Figures 4.22 to 4.28.

Table 4.7. Summary of benthic community metrics from Loutre Creek as sampled May 2005.

Parameter	Reach Designation		
COMMUNITY MEASURES	**LC-1**	**LC-2**	**LC-3**
Total number of Taxa (Richness)	18	18	18
EPT Richness	0	0	1
EPT % Abundance	0	0	9.6
Diversity Indices (Shannon-Wiener)	3.0	3.4	3.9
Total % of 5 Dominant Taxa	89	72	58
Dominant Orders			
Ephemeroptera	0	0	9.6
Annelida	27.3	12.7	10.6
Odonata	5	11.8	9.6
Pelecypoda	12	0	0
Crustacea	3.6	6.9	10.6
Hemiptera	0	4.9	10.6
Diptera	48.	56	41.3
Functional Assemblage			
Shredders	9	11	10
Scrapers	0	1	0
Collectors, Filtering	26.4	29.4	14
Collectors, Gathering	28.2	14.7	23
Collectors, Total	54.6	44.1	37.5
Predators	35.5	44	52
Biometric Score:	**3.4**		**3.6**

Table 4.8. Summary of benthic community taxa collected from Loutre Creek using the RBA techniques. May 2005.

Taxa/Station I.D.	Trophic Group	STUDY REACHES		
		LC-1	LC-2	LC-3
COLLEMBOLA				
Podura	PR	---	---	2
ANNELIDA				
Oligochaeta	GC	29	13	11
Helobdella	PA	1	---	---
PELECYPODA				
Corbicula	FC	13	---	---
CRUSTACEA				
Cambarinae	SH	3	7	8
Amphipoda	GC	1	---	---
Isopoda	GC	---	---	3
Palaemonetes	FC	---	---	2
EPHEMEROPTERA				
Caenis	GC	---	---	10
ODONATA				
Argia	PR	1	3	4
Enallagma	PR	---	8	6
Libellula	PR	3	---	---
Perithemis	PR	1	1	---
HEMIPTERA				
Belostoma	PR	1	1	---
Corixidae	PR	---	4	11
MEGALOPTERA				
Sialis	PR	---	---	3
COLEOPTERA				
Curculionidae	PR	---	---	2
Dineutus (larvae)	PR	1	---	---
Dytiscus	SC	---	1	---
Hydrocanthus	SH	---	1	---
Hydrochus	SH	---	1	---
Peltodytes	SH	1	---	---
Uvarus	PR	---	3	3
DIPTERA				
Anopheles	FC	1	2	---
Bittacomorpha	SH	1	---	---
Probezzia	GC	1	2	---
Chironominae	FC	15	28	15
Tanypodinae	PR	25	14	11
Tanytarsini	PR	7	9	4
Hexatoma	PR	---	2	2
Psychoda	PR	---	---	8
Tipula	SH	5	2	3
Sum of Percentages		100	100	100
Total Abundance:		110	102	108
Species Richness:		18	18	18
Shannon-Wiener Diversity Index		3.1	3.4	3.86

4.3.5 Benthic Macroinvertebrate Conclusions

Based on the analysis of the macroinvertebrate collection from Loutre Creek and Bayou de Loutre, the following conclusions are provided:

1) The 2009 benthic community assemblage was decreased as compared to the 2005 aquatic study. Biometric comparisons indicate that the modifications in benthic community development were related to the decrease in habitat quality resulting from the continued urbanization of the watershed. In particular, the reduced benthic communities are in response to the recent increase in sediment transport and deposition resulting from development of a high school in the upper Loutre Creek watershed.
2) Despite the differences between the 2005 and 2009 aquatic studies, the 2009 aquatic study found that macroinvertebrate communities increased in taxonomic diversity proceeding downstream from the upstream most (reference) location (LC-1),
3) Biometric comparisons indicate that there are minimal differences in the benthic communities downstream of the Lion Oil Outfall 001 discharge in study reaches LC-3 and LC-4. The macroinvertebrate community is being maintained downstream of the Lion Oil Outfall 001 effluent.
4) The benthic macroinvertebrate communities observed in Loutre Creek and Bayou de Loutre (Tables 4.6 and 4.7) are similar in structure (dominated by collectors) to other small streams in the Gulf Coastal Plain region. (ADEQ ,1987) The benthic macroinvertebrate communities observed in Loutre Creek and Bayou de Loutre (Tables 4.5 and 4.8) is more limited when compared to an eco-region reference stream. (ADEQ, 1987).
5) Although there were changes to the benthic community structure from 2005 to 2009, the biological integrity of Loutre Creek is being supported by the existing discharge from Lion Oil.

4.4 Fish Community

4.4.1 Introduction

The fish community supported in a stream is in direct response to available habitat, food sources, and water quality in the stream. The presence of a certain level of species richness and diversity along with a community structure similar to that expected in typical streams of an ecoregion are indicators of aquatic ecosystem health.

The objective of the fish community characterization is to collect and identify a representative sample of all except very rare species in the assemblage reflective of the relative abundance within the community. Major factors that influence collecting include flows, water depth, instream obstructions, water turbidity, temperature, and conductivity.

4.4.2 Methods

An assessment of the fish community in Loutre Creek and Bayou de Loutre was performed as part of the UAA. Sampling fish species to determine their proportionate abundance was conducted after all water quality parameters and/or samples were collected, but prior to the collection of the macroinvertebrate sample and habitat data (discussed above).

During the summer low flow period of 2009 (June 16-18), each reach was sampled using a Smith-Root backpack electroshocker as the principal sampling gear supplemented by block netting and seining in habitats where flow, substrate, and structure affect the capture of fish species. The shocker includes an automated timing mechanism which records the amount of time that electricity is actually being applied, or “pedal down time” (PDT). Other methods of fish sampling were available if conditions were not adequate for backpack electrofishing or seining; these may include using boat electrofishing equipment and/or hook and line sampling equipment. Usually 2 - 4 team members made up the sampling team involved in collecting the aquatic vertebrates (Figures 4.39 and 4.40).

Shocked fish were captured with hand held dip nets and held in buckets while the sampling continued. The entire stream width within the sampling reach was sampled. PDT time continued for not less than 30 minutes unless the wetted habitat of any reach limited the PDT. In addition to the PDT, the total collection time was recorded. At the end of each sampling effort fish from all reaches were preserved in formalin for later identification in the lab. Fish identifications were made according to the Fishes of Arkansas (Robison, 1988) and The Fishes of Missouri (Pflieger, 1975) to species level where possible.

Figure 4.39. Collection of fish from Study Reach LC-3. Note shallow water run habitat. Also the ledge of consolidated petroleum materials on both bank profiles approximately 4 ft above stream bed. 2009.

Figure 4.40. Characterization of fish community from Study Reach LC-4 using backpack electroshock unit. June 2009.

A consistent level of effort was exerted at all stations to ensure comparable results. Sampling information was recorded on the Fish Community Collection Forms; general comments (perceived fishing efficiency, missed fish, and gear operation suggestions) were recorded on the lines provided on this form.

An effort to search for and collect fish was completed at all reaches, even if the stream was extremely small, and it appeared that sampling may not collect any specimens. If no specimens were collected, the "NONE COLLECTED" field on the Fish Collection Form was completed and an explanation was provided in the comments section of the form.

The fish collections at each reach were compared according to several biometrics including: species richness (number of taxa); sunfish richness; species diversity; abundance; dominant family groups; percent of tolerant species; trophic structure; percent of hybrids; percent of diseased fish; and key and indicator species as listed in Regulation 2. In addition, the fish community was assessed using a biocriteria method developed by ADEQ. This biocriteria uses a scoring system by which the assemblage collected is compared to a reference stream in the same ecoregion using eight different metrics. The metric scores are totaled and the resulting sum is used to assess if a stream reach is in support of its assigned designated uses.

4.4.3 Results and Discussion

4.4.3.1 Reach Comparisons

Table 4.9 provides a summary of the fish community sampled from each study reach. Although all reaches were found to contain fish populations, the communities of some reaches were more developed than others. Species richness and diversity demonstrated variation between the study reaches. Species richness and diversity were 8 and 2.03 for LC-1, 5 and 0.54 for LC-3, and 10 and 2.79 for LC-4, 17 and 3.49 for BDL-1, and 9 and 2.69 for BDL-2. Each study reach was dominated by sunfish with exception to LC-3. LC-1 was comprised of 59% sunfish, LC-3 was comprised of 51% mosquito fish, LC-4 was comprised of 81% sunfish, BDL-1 was comprised of 70% sunfish, and BDL-2 was comprised of 69% sunfish (Table 4.9). Mosquito fish were second dominant at each site with exception to BDL-1.

A summary of the fish collected from the five reaches is provided in Table 4.10. The fish assemblages collected from each study reach included a PDT ranging from 37.1 minutes at LC-1 to 74.6 minutes at LC-3. This equates to abundance of the fish observed during the collection and is expressed as fish caught per minute of shocking time or pedal down time (PDT). The number of fish caught per minute of PDT was 4.3 at LC-1, 0.9 at LC-3, 1.1 at LC-4, 2.3 at BDL-1, and 1.8 at BDL-2. The communities were dominated at all reaches by insectivores, which accounted for 84% to 100% of each community. The remaining community trophic structure was comprised of omnivores: 7.0% at LC-1, 1.5% at LC-4, and 2.2% at BDL-1 and piscivores: <1% at LC-1, 6.0% at LC-4, 12.1% at BDL-1, and 2.0 % at BDL-2. (Table 4.10) The field data sheets and biocriteria determination sheets are provided in Attachment N.

Table 4.9. Fish community from Loutre Creek and receiving stream Bayou de Loutre, El Dorado, Union County, AR.

Scientific Name	Common Name	LC-1	LC-3	LC-4	BDL-1	BDL-2
		6/18/2009	6/16/2009	6/17/2009	6/18/2009	6/17/2009
CYPRINIDAE						
Lythrurus umbratilis[1]	redfin shiner	--	--	--	--	1
Notemigonus crysoleucas	golden shiner	11	--	1	2	--
Notropis maculatus	taillight shiner	--	--	--	2	--
CATOSTOMIDAE						
Erimyzon oblongus[2]	creek chubsucker	--	2	--	3	--
POECILIIDAE						
Gambusia affinis	mosquitofish	48	35	6	3	10
CYPRINODONTIDAE						
Fundulus chrysotus	golden topminnow	--	--	--	--	1
ESOCIDAE						
Esox americanus[1]	grass pickerel	1	--	4	9	2
APHREDODERIDAE						
Aphredoderus sayanus[2]	pirate perch	--	--	1	2	--
ICTALURIDAE						
Noturus gyrinus	tadpol madtom	--	--	--	1	--
Ameiurus natalis[1]	yellow bullhead	4	2	1	2	8
Ameiurus nebulosus	brown bullhead	1	--	--	1	--
Ameiurus melas	black bullhead	--	--	--	1	--
CENTRARCHIDAE						
Lepomis cyanellus	green sunfish	24	9	17	13	12
Lepomis gulosus[1]	warmouth	2	--	4	12	3
Lepomis punctatus[2]	spotted sunfish	--	--	14	16	18
Lepomis macrochirus	bluegill sunfish	--	--	5	9	--
Lepomis megalotis	longear sunfish	67	20	14	12	15
Micropterus salmoides	largemouth bass	--	--	--	2	--
ELASSOMATIDAE						
Elassoma zonatum[2]	banded pigmy sunfish	--	--	--	1	--
Total No. Taxa Collected		8	5	10	17	9
Total Fish Collected		158	68	67	91	70
Level of Effort (Minutes) PDT[3]		37.1	74.6	60.2	38.8	39.3
Catch per Minute, PDT		4.3	0.9	1.1	2.3	1.8
Shannon-Wiever Diversity Index		2.03	0.54	2.79	3.49	2.69

[1] Typical Gulf Coastal Ecoregion Key Species

[2] Typical Gulf Coastal Ecoregion Indicator Species

[3] Pedal Down Time

4.4.3.2 Biometric Comparisons

The biometric scoring compared two things: (1) the fish community upstream and downstream of the discharge; and (2) the fish community in all study reaches to the community in the least disturbed streams used as a reference condition for a Typical Gulf Coastal Fishery. The results of the biometric scoring are summarized in Table 4.10.

The biometric assessment resulted in a total of 12 points at LC-1, a total of 10 points at LC-3, 12 points at LC-4, 14 points at BDL-1, and 14 points at BDL-2 out of 32 possible points. Variation among reach scoring was demonstrated at LC-3 which had the lowest biometric score compared to the upstream reference site (LC-1). A slight increase in scoring was then demonstrated downstream at reach LC-4 equal to that of LC-1. Bayou de Loutre reaches BDL-1 and BDL-2 scored higher then all Loutre Creek study reaches. Based on these biometric comparisons, the combined fish community downstream of Lion Oil's discharge (LC-3, LC-4, and BDL-2) is generally equivalent to the fish community in the upstream study reaches (LC-1, BDL-1). In other words, the Lion Oil discharges are not causing an adverse effect on downstream fish community development.

The biocriteria scoring matrix was developed for streams with watersheds of around 10 square miles and does not account for seasonal streams with very small (<3 mi^2) watersheds like Loutre Creek or the upper reaches of Bayou de Loutre. When the scoring matrix is applied to these study reaches, they all score in the "impaired" use support category compared to the least disturbed streams used as a reference condition for a Typical Gulf Coastal Fishery. The comparably low scores at all study reaches, including both references reaches (LC-1 and BDL-1), are a result of sensitive catfishes, darters, and key species rarity. While these stream reaches had more sunfish represented compared to the typical gulf coastal streams (ADEQ, 1987) they had lower overall species diversity.

Table 4.10. Fish community structural analysis for Loutre Creek and Bayou de Loutre. June 2009.

Parameter	LC-1	LC-3	LC-4	BDL-1	BDL-2
COMMUNITY MEASURES	6/18/2009	6/16/2009	6/17/2009	6/18/2009	6/17/2009
Richness (Total Number of Taxa)	8	5	10	17	9
Darter Richness (Number of Taxa)	0	0	0	0	0
Sunfish Richness (Number of Taxa)	3	2	5	6	4
% Pollution Tolerant Species	25.3	16.2	28.4	19.8	28.6
% Pollution Intermediate Species	74.7	84	71.6	78.0	70.0
% Pollution Intolerant Species	0.0	0.0	0.0	0.0	0.0
% Diseased	0.0	0.1	0.1	0.0	0.1
Number of Key & Indicator Species (Taxa)	3.0	2.0	5.0	7.0	5.0
Number of Key & Indicator Species (Individuals)	7.0	4.0	24.0	45.0	32.0
% Key & Indicator Species numbers of total fish	4.4	5.9	35.8	49.5	45.7
Diversity Indices (Shannon-Wiever)	2.03	0.54	2.79	3.49	2.69
Abundance, fish collected/minute	4.26	0.91	1.11	2.34	1.78
TROPHIC STRUCTURE					
% Herbivores	0.0	0.0	0.0	0.0	0.0
% Omnivores	6.96	0.0	1.5	2.20	0.0
% Insectivores	92.4	100	92.5	83.5	95.7
% Piscivores	0.63	0.0	6.0	12.1	2.9
PERCENT OF 5 DOMINANT FAMILY GROUPS					
Centrarchidae	58.9	42.6	80.6	70.3	68.6
Poeciliidae	30.4	51	9.0	3.3	14.3
Catostomidae	0.0	2.9	0.0	3.3	0.0
Aphredoderidae	0.0	0.0	1.5	2.2	0.0
Cyprinodontidae	0.0	0.0	0.0	0.0	1.4
Cyprinidae	7.0	0.0	1.5	4.4	1.4
Ictaluridae	3.2	2.9	1.5	5.5	11.4
Elassomatidae	0.0	0.0	0.0	1.1	0.0
Esocidae	0.6	0.0	6.0	9.9	2.9
Total % of 5 Dominant Groups	100.0	100.0	100.0	100.0	100.0

4.4.4 Comparison to 2005 Fish Community Assessment

The 2005 aquatic study was completed in May, 2005 during seasonal stream conditions. A summary of the fish community structural analyses is presented in assemblage is presented in Table 4.11 and the taxonomic assemblage is provided in Table 4.12. There were differences in the 2005 and 2009 fish community assemblages. The total number of species and total number of fish were decreased in 2009 when compared to 2005 collection. Despite the reduced community assemblages when comparing the 2005 and 2009 assessments, all study reaches were found to support a fish community that was dominated by sunfish species identified as key and indicator species for gulf coastal streams. As with the benthic community, the development of a diverse fish community is dependent on habitat variability. The decrease in habitat quality from 2005 to 2009 resulting from the continued urbanization of the watershed adversely impacted the fish community development. The large quantities of silt and sediment adversely impacted the fish community by limiting benthic food source covering spawning habitats, and impeding the successful spawning. The increased sediment deposition is depicted in Figures 4.22 to 4.28 The 2006 Study (GBMc, 2006) provides the detailed description of the 2005 fish community assemblages.

Table 4.11. Fish community structural analysis for Loutre Creek, El Dorado, AR, May 2005.

Parameter	LC-1	LC-2	LC-3
COMMUNITY MEASURES			
Richness (Total Number of Taxa)	8	8	6
Darter Richness (Number of Taxa)	--	--	--
Sunfish Richness (Number of Taxa)	5	5	5
% Pollution Tolerant Species	2.4	4.96	5.04
% Pollution Intermediate Species	96.8	95.04	94.96
% Pollution Intolerant Species	0.80	--	--
% Diseased	--	4.3	2.2
Number of Key & Indicator Species (Taxa)	2.0	2.0	3.0
Number of Key & Indicator Species (Individuals)	4.0	10.0	6.0
% Key & Indicator Species numbers of total fish	3.2	7.1	4.3
Diversity Indices (Shannon-Wiener)	1.53	1.64	1.43
Abundance, fish collected/minute	4.43	3.67	3.68
TROPHIC STRUCTURE			
% Herbivores	--	--	--
% Omnivores	1.60	0.71	--
% Insectivores	98.4	97.9	99.3
% Piscivores	--	1.42	0.72
PERCENT OF 5 DOMINANT FAMILY GROUPS			
Cyprinidae	2.4	0.7	--
Poeciliidae	36.8	24.8	25.2
Cyprinodontidae	2.4	--	--
Esocidae	--	--	0.7
Aphredoderidae	0.8	--	--
Ictaluridae	--	0.7	--
Centrarchidae	57.6	73.8	74.1
Total % of 5 Dominant Groups	100.0	100.0	100.0

* Total of 12 key and indicator species possible.

Table 4.12. Fish community assemblage for Loutre Creek, El Dorado, AR,

Scientific Name	Common Name	LC-1	LC-2	LC-3
		4/28/2005	4/28/2005	4/28/2005
CYPRINIDAE				
Notemigonus crysoleucas	golden shiner	2	1	0
Opsopoeodus emiliae	pugnose minnow	1	0	0
POECILIIDAE				
Gambusia affinis	mosquitofish	46	35	35
CYPRINODONTIDAE				
Fundulus chrysotus	golden topminnow	3	0	0
ESOCIDAE				
Esox americanus[1]	grass pickerel	0	0	1
APHREDODERIDAE				
Aphredoderus sayanus[2]	pirate perch	1	0	0
ICTALURIDAE				
Ameiurus melas	black bullhead	0	1	0
CENTRARCHIDAE				
Lepomis cyanellus	green sunfish	1	6	7
Lepomis gulosus[1]	warmouth	0	2	1
Lepomis punctatus[2]	spotted sunfish	3	8	6
Lepomis megalotis	longear sunfish	68	86	89
Micropterus salmoides	largemouth bass	0	2	0
Total No. Taxa Collected		8	8	6
Total Fish Collected		125	141	139
Level of Effort (Minutes) PDT[3]		28.2	38.4	37.8
Catch per Minute, PDT		4.43	3.67	3.68
Shannon-Wiener Diversity Index		1.53	1.64	1.43

[1] Typical Gulf Coastal Ecoregion Key Species
[2] Typical Gulf Coastal Ecoregion Indicator Species
[3] Pedal Down Time

4.4.5 Fish Community Conclusions

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

1) Loutre Creek maintains a fish community that is more diverse downstream of the discharge (LC-3 and LC-4 together) than upstream of the discharge (LC-1). For each of these study reaches, all of the species identified are considered to be pollution tolerant or of intermediate tolerance. See Table 4.10.
2) Study reach LC-3 (downstream of the Outfall 001 discharge) was studied in both the 2005 aquatic study and the 2009 aquatic study. The two studies found different, but a similarly diverse number of species in this study reach (6 in 2005 and 5 in 2009). It is unclear why these studies found a similar number, but a different composition of species.

One reason may be that recent habitat modifications in the headwaters of Loutre Creek (discussed above) modified the habitat downstream of the discharge and the species that live there. Another reason may be that field sampling methods can have an impact on the population sampled and these methods do not guarantee all fish species residing in a study reach will be collected during sampling. It is unlikely that the discharge changed the composition of this fishery in LC-3. As discussed more fully in Section 5 below, there is no indication that water quality had any effect on the composition of the fishery.

3) Study reach LC-4 (also downstream of the Outfall 001 discharge) had the highest population numbers and percentage of key and indicator fish species compared to the other Loutre Creek study reaches (LC-1 and LC-3). Three key and two indicator species were found in LC-4. The population numbers and percentage of key and indicator species in LC-4 was comparable to the Bayou de Loutre study reaches (BDL-1 and BDL-2).

4) The majority of fish collected in Loutre Creek were sunfish (fifty-one percent (151 of 293) in the 2009-2010 aquatic study and sixty-three percent (257 of 405) in the 2005 aquatic study). Based on the 2009-2010 aquatic study, the most abundant sunfish populations in Loutre Creek are Longear Sunfish and Green Sunfish. See Table 4.9. Both species have healthy populations as evidenced by their population numbers and presence in all study reaches and the number of individuals present in multiple size classes. See Tables 6.5 – 6.7 and Figures 6.2 and 6.4 of the UAA. While the 2005 aquatic study did not collect Bluegill in Loutre Creek, they were collected as part of the 2009-2010 aquatic study downstream of the discharge, but not upstream of the discharge. See Table 4.9. The populations of Bluegill in Loutre Creek are not large compared to Longear and Green Sunfish, but this is likely due to the fact that Bluegill typically prefer areas in lentic and lentic-type environments such as ponds, lakes reservoirs and large low velocity streams.[14] These conditions are not characteristic for Loutre Creek with its riffle/run reaches.[15]

5) The fish community assemblages collected at all study reaches in Loutre Creek are similar in structure and function (See Table 4.10). This indicates that the discharge does not adversely impact the biological integrity of the fishery in Loutre Creek.

---

[14] Stuber, R.J., G. Gebhart, and O.E. Maughan. 1982. Habitat suitability index models: Bluegill. U.S.D.A. Fish and Wildlife Service. FWS/OBS-82/10.8. 26pp. See also Whitmore, C.M., C.E. Warren, and P. Doudoroff. 1960. Avoidance reactions of salmonid and centrarchid fishes to low oxygen concentrations. Trans. Am, fish. Soc. 89:17-26.

[15] Populations of Bluegill Sunfish have been shown to be relatively low in streams with a high percent of riffle/run. Moyle, P.B, and R.D. Nichols. 1973. Ecology of some native and introduced fishes of the Sierra Nevada foothills in central California. Copeia 1973:478-490.

6) The fish community assemblages collected at all study reaches in Loutre Creek was limited both in species diversity and numerical abundance when compared to the assemblages of species found in the least disturbed streams used as a reference condition for a Typical Gulf Coastal Fishery. Hence, a more limited fishery is maintained and attainable in Loutre Creek compared to these reference streams.

4.5 Conclusions from Aquatic Life Field Study

Based on the aquatic life field study, the designated aquatic life use (Typical Gulf Coastal Fishery) is not maintained and is not attainable. However, Loutre Creek does maintain a more limited fishery, referred to as a Limited Gulf Coastal Fishery. Also, the attainable biological integrity of Loutre Creek is maintained downstream of the existing discharges from the Lion Oil facility.

5.0 EXISTING LOADINGS, WATER QUALITY, and CALCULATED CRITERIA

5.1 Introduction

This section summarizes the following information:

- Historical monitoring results from the Outfall 001 discharge;
- Results of toxicity analyses on dissolved minerals;
- Water quality in Loutre Creek and Bayou de Loutre;
- Additional information on water quality characteristics in Loutre Creek and Bayou de Loutre based on long-term water quality monitoring; and
- Method of developing the proposed selenium and dissolved minerals criteria.

5.2 Historical Monitoring Results from Outfall 001 Discharge

5.2.1 Outfall 001 Selenium Data

Currently Lion Oil is required under NPDES permit number AR0000647 to analyze for total recoverable selenium from NPDES Outfall 001. Established permit limits are 5.8 µg/L monthly average and 11.65 µg/L daily maximum. Tables 5.1 and 5.2 provide a summary of total recoverable selenium concentrations on a monthly basis. Figure 5.1 summarizes the Outfall 001 monthly discharge monitoring data during the period of record (POR) from January 2005 through April 2012. The monthly selenium information is provided in Attachment M.

Table 5.1. Lion Oil Outfall 001 Selenium Data Summary POR 1/4/2005 through 04/12/2012.[A]

Date Collected	**Concentration (ug/L)**
1/4/2005	12.0
2/1/2005	12.5
3/1/2005	9.99
3/28/2005	12.4
4/5/2005	25.1
5/3/2005	15.3
6/6/2005	23.5
7/4/2005	37.1
8/1/2005	21.3
9/5/2005	18.2
10/3/2005	15.5
11/7/2005	10.9
12/5/2005	11.2
1/2/2006	9.51
2/6/2006	9.55
3/6/2006	15.2
4/3/2006	14.8
5/1/2006	17.0
6/5/2006	39.2
7/10/2006	20.2
8/7/2006	28.6
9/4/2006	34.1
10/2/2006	27.7
11/6/2006	20.8
12/4/2006	22.4
1/1/2007	18.8
2/5/2007	21.4
3/5/2007	32.5
3/12/2007	38.9
3/19/2007	29.7
3/26/2007	36.4
4/2/2007	33.1
4/9/2007	30.2
4/16/2007	25.4
4/23/2007	28.3
4/29/2007	28.2

Date Collected	**Concentration (ug/L)**
5/7/2007	28.3
6/4/2007	23.4
7/2/2007	26.5
8/6/2007	12.6
9/3/2007	20.9
10/1/2007	17.4
11/5/2007	24.2
12/3/2007	20.9
12/3/2007	20.9
1/1/2008	20.7
2/4/2008	0.0
3/3/2008	22.3
4/7/2008	12.5
5/5/2008	20.6
6/2/2008	12.8
7/7/2008	24.6
8/4/2008	17.6
9/1/2008	9.72
10/6/2008	16.5
11/3/2008	17.4
12/1/2008	20.3
1/5/2009	18.8
2/2/2009	32.1
3/2/2009	34.4
4/6/2009	26.3
5/4/2009	30.9
6/1/2009	19.6
7/6/2009	32.1
11/5/2009	10.2
12/7/2009	25
1/5/2010	48
2/2/2010	80.6
3/2/2010	42.3
4/6/2010	34
5/4/2010	18
6/8/2010	35
7/6/2010	21
8/3/2010	23
9/7/2010	16.4

Date Collected	**Concentration (ug/L)**
10/5/2010	20.5
11/2/2010	16.2
12/7/2010	8.4
1/4/2011	17.1
2/8/2011	10.8
3/8/2011	18.3
4/5/11	18.0
5/3/11	9.4
6/7/11	12.4
7/5/11	37.9
8/2/11	33.6
9/6/11	40
10/4/11	37.2
11/8/11	25.8
12/6/11	14.4
1/3/12	33.7
2/7/12	23.5
3/5/2012	21.5
4/2/2012	21

A= Data set for POR with data during facility shut down 9 August – October 2009 extracted.

Table 5.2. Summary Statistics for Outfall 001 selenium concentrations.

Parameter	Summary Statistics
Count	94
Min	0.0
Max	80.6
Median	39.3
Average	39.5
St Dev	8.0
90th Percentile	34.1
95th Percentile	37.55
99th Percentile	45.15

During the current permit period the total recoverable selenium has ranged between zero and 80.6 ug/L (which appears to be a data outlier) and the mean concentration is 39.5 ug/L, with a standard deviation of 8.0.

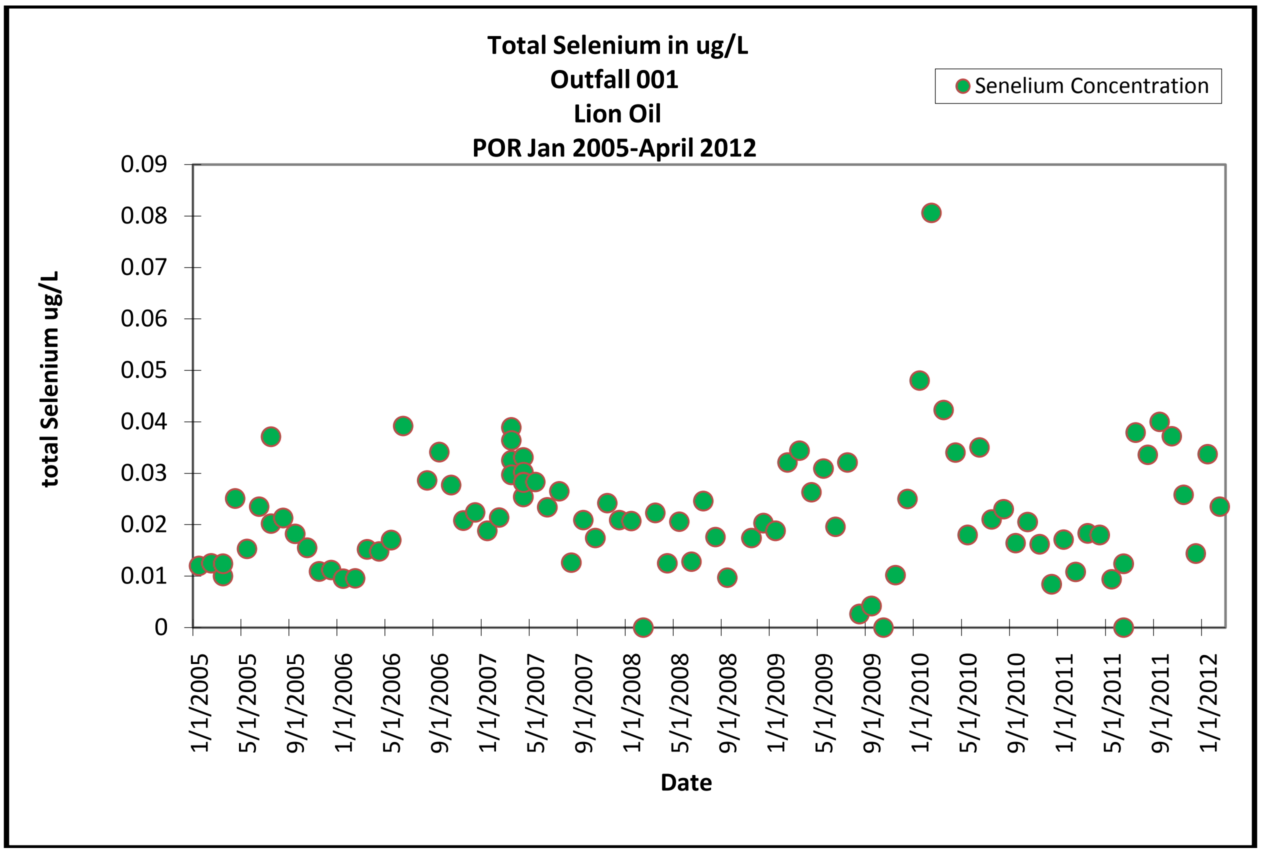


Figure 5.1. Total Selenium in Outfall 001 effluent, Lion Oil. POR January 2005 - April 2012.

5.2.2 Outfall 001 Dissolved Minerals Data

Dissolved minerals data from Outfall 001 (SO_4 and TDS) has been collected and reported monthly since January 2005, as required by the current NPDES permit. There are periods during the POR (January 2005 through April 2012) that the dissolved minerals were measured on a weekly basis, resulting in a total of 408 data points during the POR. Currently, there is no monitoring requirement for chloride in Lion Oil's NPDES permit, however chloride concentrations in the Outfall 001 effluent were measured periodically between February 2008 through May 2010. Prior to the 2004 permit renewal, there were no requirements to monitor and report dissolved minerals. Table 5.3 summarizes the dissolved minerals concentrations in Lion Oil's discharge from Outfall 001. The monthly chloride, sulfate, and TDS information is provided in Attachment M.

Table 5.3. Summary statistics for the dissolved mineral concentrations in Lion Oil Outfall 001. Period of Record January 2005 through April 2012.[A]

Parameter	Chlorides	Sulfate	TDS
Count	111	408	408
Min	19	147	318
Max	3,091	2,474	4,018
Median	250	847	1,972
Average	295	884	1,988
St Dev	313.56	272.24	457.7
90th Percentile	412.55	1,211.5	2,566
95th Percentile	492.6	1,319	2,726
99th Percentile	1,123.75	1,742	3,128

A= The POR for chloride ends April 2010 while the sulfate and TDS POR extends through April 2012.

The following figures (Figure 5.2 - 5.4) illustrate the historical record of dissolved minerals in the Outfall 001 discharge. The period of record for TDS and sulfate concentrations demonstrates a decrease in the effluent TDS and sulfate concentrations. This reduction over time reflects continued efforts by Lion Oil to reduce the dissolved minerals loadings in the effluent. The historical record of chloride concentrations reflect a uniform pattern of chloride concentrations.

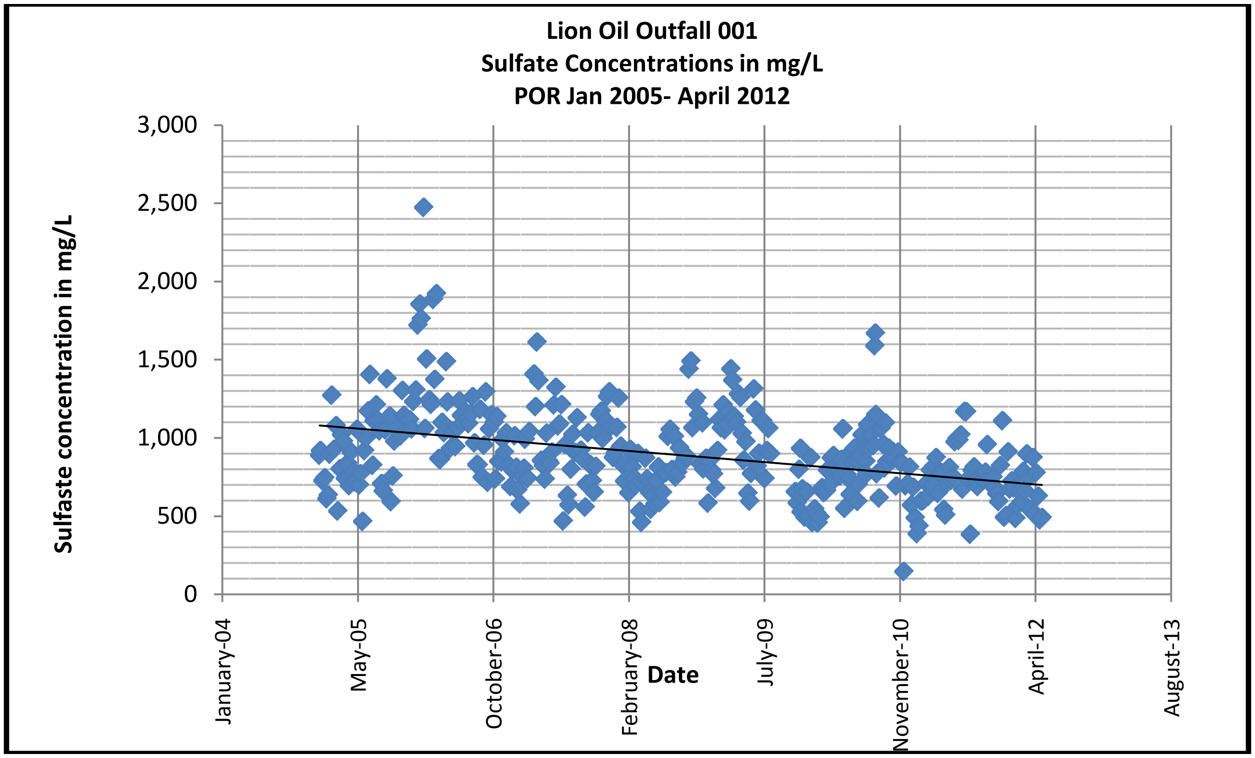


Figure 5.2. Sulfate Concentrations in Lion Oil Outfall 001. POR January 2005 – April 2012

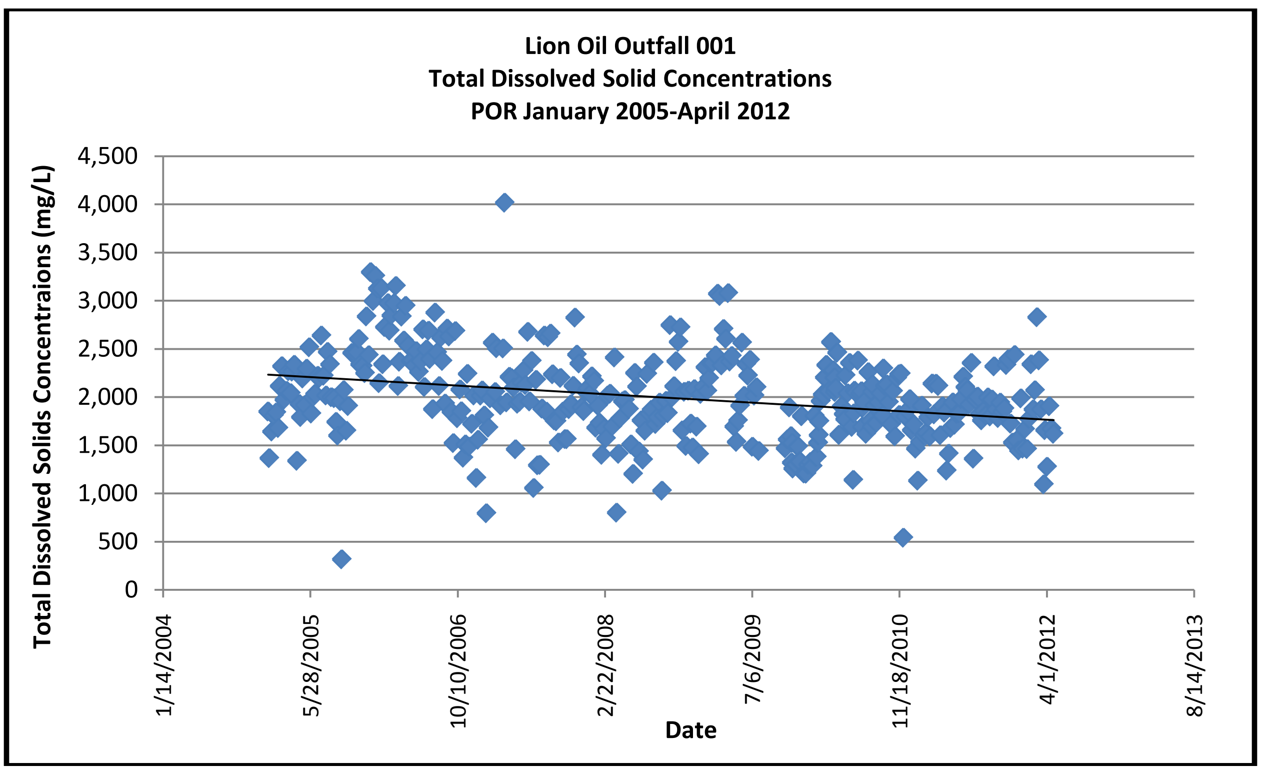


Figure 5.3. TDS Concentrations in Lion Oil Outfall 001. POR January 2005 - April 2012.

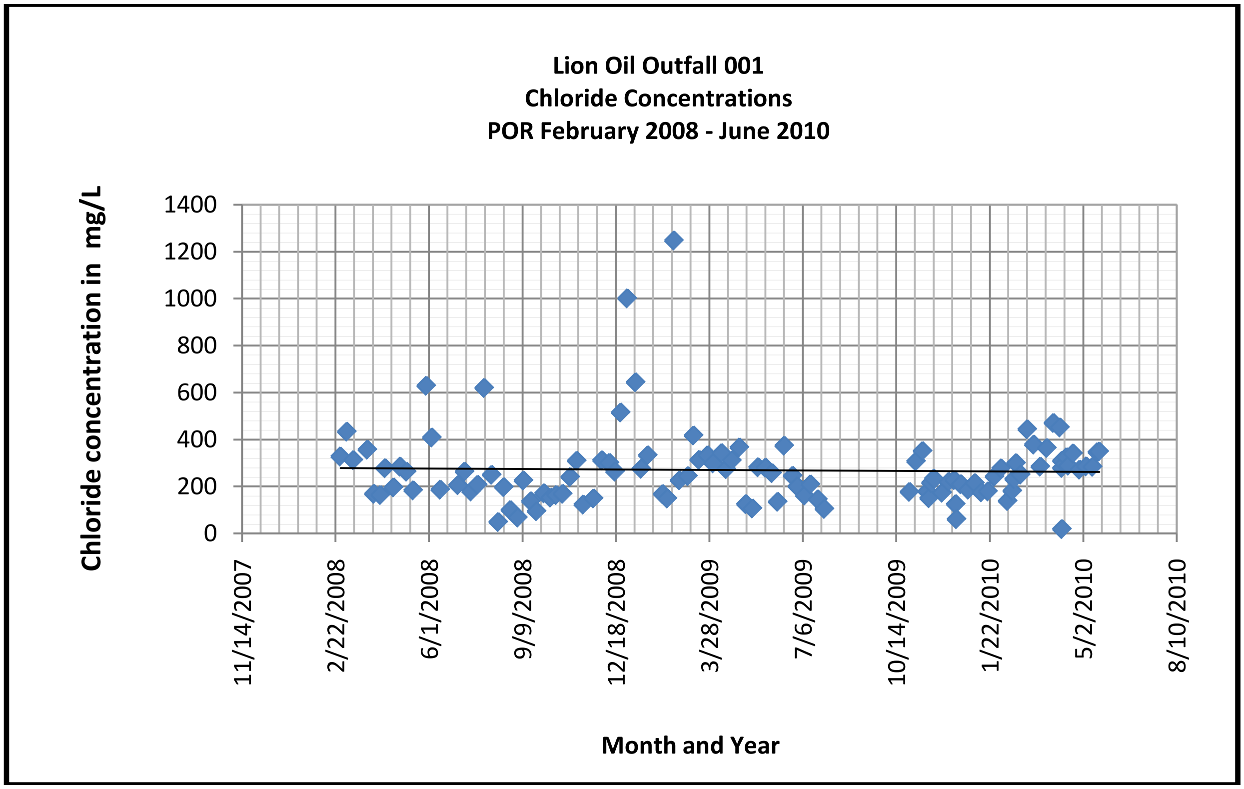


Figure 5.4. Chloride Concentrations in Lion Oil Outfall 001. POR February 2008 – June 2010

5.3 Results of Whole effluent toxicity (WET) testing and dissolved minerals

This sub-section provides information on the results of whole effluent toxicity (WET) testing and the relationship between dissolved minerals and those WET test results. Sections 6 and 7 provide additional information on the toxicity of selenium in the food web and the fate and transport of selenium in Loutre Creek and Bayou de Loutre.

This sub-section first summarizes the results of WET tests performed to evaluate the toxicity of the dissolved minerals criteria developed in this UAA and the Bayou de Loutre SSC. As noted above, these criteria are more stringent (lower in concentration) than Lion Oil's historic discharges of dissolved minerals.

Next, the results of historical routine WET tests completed as required by Lion Oil's NPDES permit are summarized. This summary was performed, in part, to assist EPA in its review of the dissolved minerals criteria approved by the Commission in 2007. Additional details of the WET testing and the analysis of the relationship between dissolved minerals and the WET test results is provided in Attachment K.

5.3.1 WET Tests on Proposed Dissolved Minerals Criteria

Attachment L includes the results of WET tests performed between September 6 and September 14, 2012 to evaluate whether the criteria developed in this UAA would maintain the biological integrity (e.g. aquatic life use) of the receiving stream. The biological integrity is determined using an EPA approved WET protocol to determine if the proposed criteria may result in toxic effects. These tests were performed on the water flea (*Ceriodaphnia dubia*) (as agreed to by ADEQ and EPA in the June 15, 2009 Study Plan developed by GBMc and approved by these agencies) because the EPA previously raised a concern that past WET tests performed on the water flea indicated lethal and sub-lethal effects at the criteria concentrations approved by the Commission in 2007.

As shown on the statistical reports, four sets of WET tests were performed to evaluate the potential effects of the proposed criteria. Because it is difficult for the laboratory to develop a precise mixture of dissolved minerals, the levels of dissolved minerals differ for each test.[16] Tests 01 and 04 most closely reflected the criteria developed in this UAA and demonstrate there are no lethal or sub-lethal effects on the water flea, even at concentrations of sulfates and TDS higher than the criteria developed. Although Tests 02 and 03 indicated reduced reproduction in the higher exposures of the WET tests, both of these tests (Test 02 and 03) had concentrations of sulfate and TDS that substantially exceeded the criteria developed.

As noted above, the dissolved minerals criteria analyzed in these WET tests and developed for adoption are more stringent than the criteria adopted in 2007. These WET tests indicate that the new criteria will not result in lethal or sub-lethal effects in the receiving streams and will maintain the designated uses of Loutre Creek and Bayou de Loutre. The criteria developed for Bayou de Loutre and discussed more fully in the Bayou de Loutre SSC are more stringent (lower in concentration) than those developed for Loutre Creek so the Bayou de Loutre criteria also do not have such effects.

5.3.2 WET tests on Historical Dissolved Minerals Concentrations

Toxicity testing has been routinely completed on Lion Oil's Outfall 001 for over 10 years. A summary of the WET testing history is provided in Attachment O. The summary demonstrates that Outfall 001 consistently passed the lethality endpoints at the applicable critical dilution (72% or 96% effluent depending on the test period) for both the water flea (*Ceriodaphnia dubia)* and the fathead minnow (*Pimephales promelas*). The Outfall 001 effluent has passed 98% of the WET tests lethality endpoint over the last 10 years.

---

[16] The laboratory mixtures to mimic the proposed instream dissolved minerals concentrations were also developed to reflect instream concentrations of anions and cations typical of Loutre Creek (i.e., nitrate, potassium, sodium, magnesium, and calcium).

Although there have been failures of the water flea sub-lethal endpoint (water flea reproduction in laboratory exposures), analyses of the WET test results (water flea reproduction No Observed Effect Concentrations, NOECs) and the dissolved minerals concentrations (chloride, sulfate, and TDS) demonstrated there is no correlation between the dissolved mineral concentrations in Lion Oil's discharge and the WET test results. A summary of the statistical analyses completed on the historical WET test results and concurrent dissolved solids in the Outfall 001 effluent is provided below. The details of this assessment are provided in two technical memoranda in Attachment K.

5.3.2.1 Review of Trend Lines Statistical Analysis

The statistical analysis previously submitted to ADEQ (in the 2006 report and again in the June 24, 2011 technical memorandum) shows there is no statistically significant relationship between the level of dissolved minerals in the discharge and the WET test results for the fathead minnow and the water flea. This conclusion is supported by the fact that sometimes dissolved mineral levels in the discharge were above average and the WET test passed and other times the dissolved minerals levels in the discharge were below average and the WET test failed. In other words, because there is no significant relationship (little to no predictability) between the dissolved minerals in the discharge and the WET test results, there is no measurable connection between the two.

A simple linear regression technique was utilized in this assessment because it demonstrates if a relationship (a correlation) exists in the data, the technique calculates a correlation coefficient to quantify the strength of the relationship and provides a quantitative measure if the relationship is significant statistically (has a significant slope line) or not. Simple linear regression analysis provides a visual representation of the relationship, depicted as a line of best fit to the plotted data. The slope of the line demonstrates the type of relationship, either negative (downward slope) or positive (upward slope) that the variables have to one another. The term "relationship" refers to the reaction of one variable value to the fluctuation of another variable value. When a strong relationship exists, one variable value can be predictive of another variable value.

In the case of this analysis, the key question is, are the dissolved minerals concentration(s) linked to WET test failures and can the dissolved minerals (TDS, chloride or sulfate) levels be used to predict the potential for WET test failures (e.g. reduced "No Observed Effect Concentration", NOEC), reduced number of young, etc.) due to the dissolved minerals in the discharge.

5.3.2.2 Review of Historical Data (2000-2012) to Supplement Statistical Analysis

An updated statistical analysis to determine if there is a relationship (at the α=0.05 level) between the level of dissolved minerals in the discharge and the WET tests was completed using WET test results and the analytical record over an approximately 12 year period (2000 - 2012). This analysis involved two steps: a statistical analysis of impacts of TDS in the discharge on the water flea, and a synoptic analysis of impacts of TDS on the fat heat minnow. A summary of the dissolved minerals data used in the analysis is presented in Table 5.4.

Table 5.4. Summary of minerals data used in the statistical analyses (based on 2000 to 2012 data).

Statistic	Calculated TDS (mg/L)[1]	Sulfate (mg/L)[2]	Chloride (mg/L)[2]	TDS-DMR (mg/L)[2]
Average	2118	746	264	1882
Minimum	1276	389	153	1134
Maximum	3110	1086	500	2462
St dev	447	180	91	298
Median	2130	745	255	1911
90%tile	2707	975	354	2162

[1]TDS values are calculated from conductivity measurements for 2000-2007. Values from 2008 forward are from actual measured values.
[2]Values are measured from effluent samples for years 2009-2012 for TDS and sulfate and 2009-2011 for chloride.

5.3.2.3 Analysis of TDS on Water Flea

The analysis of the impact of TDS on the water flea focused on a variable in the WET tests known as "No Observed Effect Concentration," or NOEC (a measure that tracks the number of young produced in the highest effluent dilution (96%)). The analysis focused primarily on the effects of TDS on the water flea because there have been more historical WET test failures involving these two variables when compared to the tests involving other dissolved minerals and the fathead minnow.

The distribution of TDS in the historical discharge and the WET test data was evaluated and determined to generally fit a normal curve. Regression analysis was then completed. Regression variables were varied to ensure that every possible combination was examined. Dependent variables included: water flea NOEC and number of young produced at 96% effluent. Independent variables included: all TDS values (calculated during each test from the measured conductivity values, period of record 2000-2008), TDS concentrations measured from samples collected during the course of the test (2009-2012), chloride values measured from samples collected during the course of the test (2009-2011), and sulfate values measured from samples collected during the course of the test (2009-2012). TDS, sulfate, and chloride results from actual samples only exist for toxicity tests completed since 2009. Linear regression analyses were completed for the following pairs of data:

- All NOEC results and all calculated TDS results (Figure 5.5)
- Water flea (*Ceriodaphnia dubia)* number of young produced at 96% effluent results and all calculated TDS results (Figure 5.6).
- Recent NOEC results and recent TDS DMR results (Figure 5.7).
- Recent NOEC results and recent sulfate DMR results (Figure 5.8).
- Recent NOEC results and recent chloride DMR results (Figure 5.9).

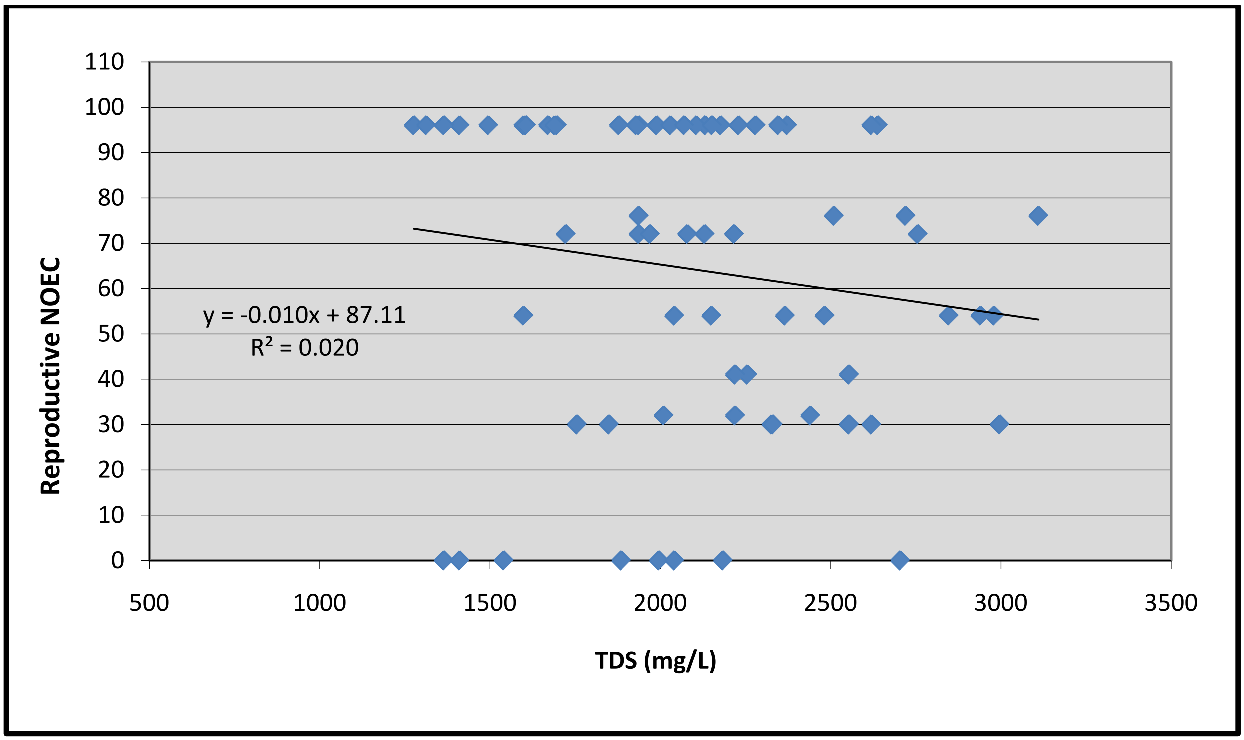


Figure 5.5. Water flea reproductive NOEC versus TDS values.

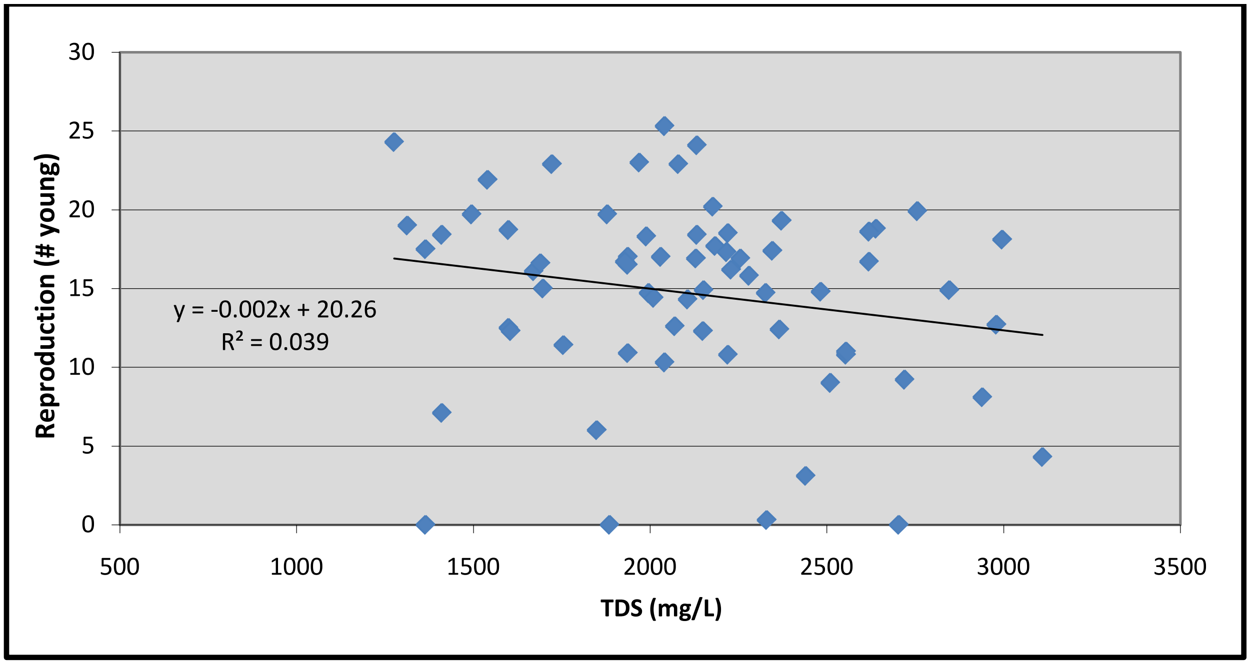


Figure 5.6. Water flea total young produced at 96% effluent versus TDS values.

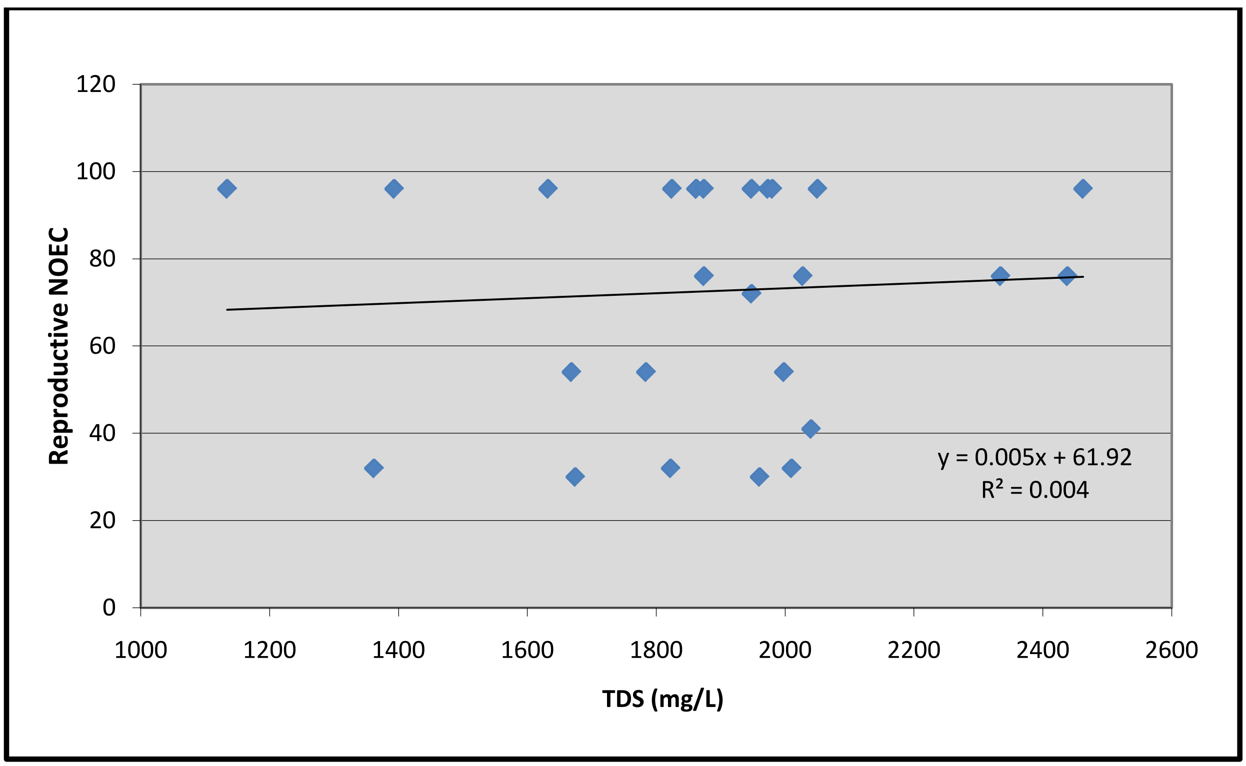


Figure 5.7. Water flea reproductive NOEC versus TDS values 2009-2012.

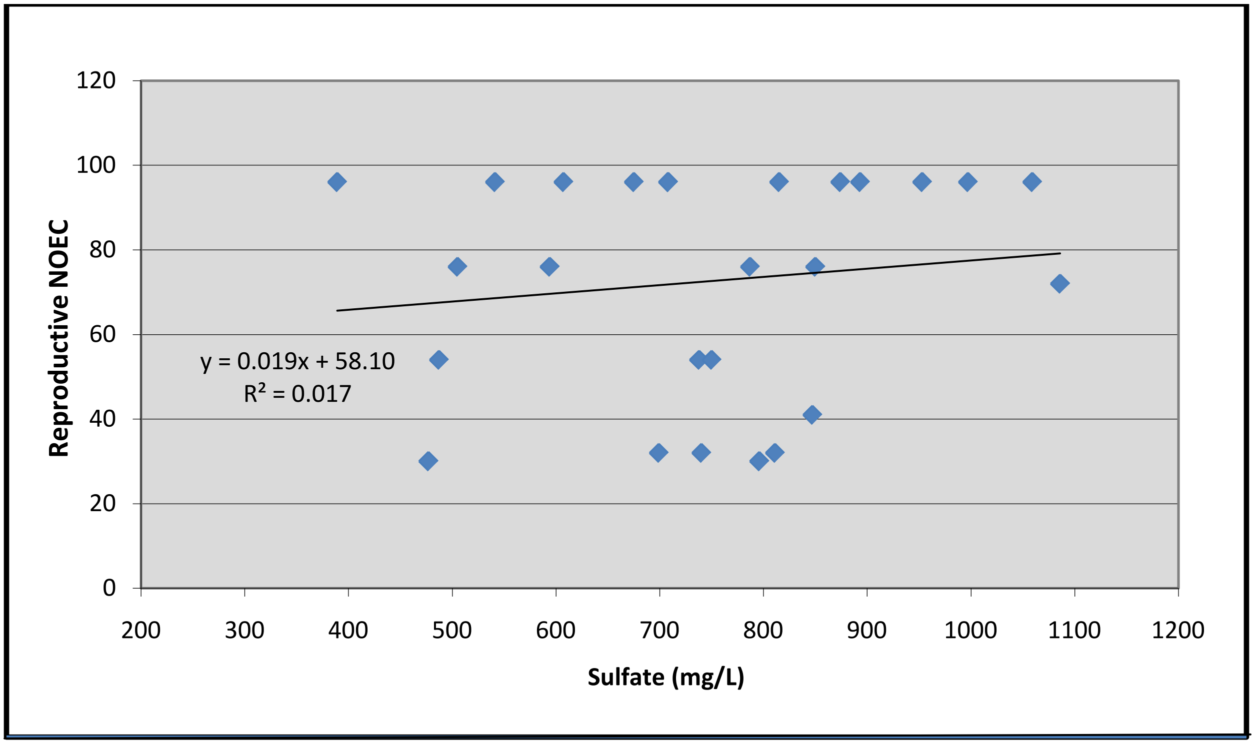


Figure 5.8. Water flea reproductive NOEC versus sulfate values 2009-2012.

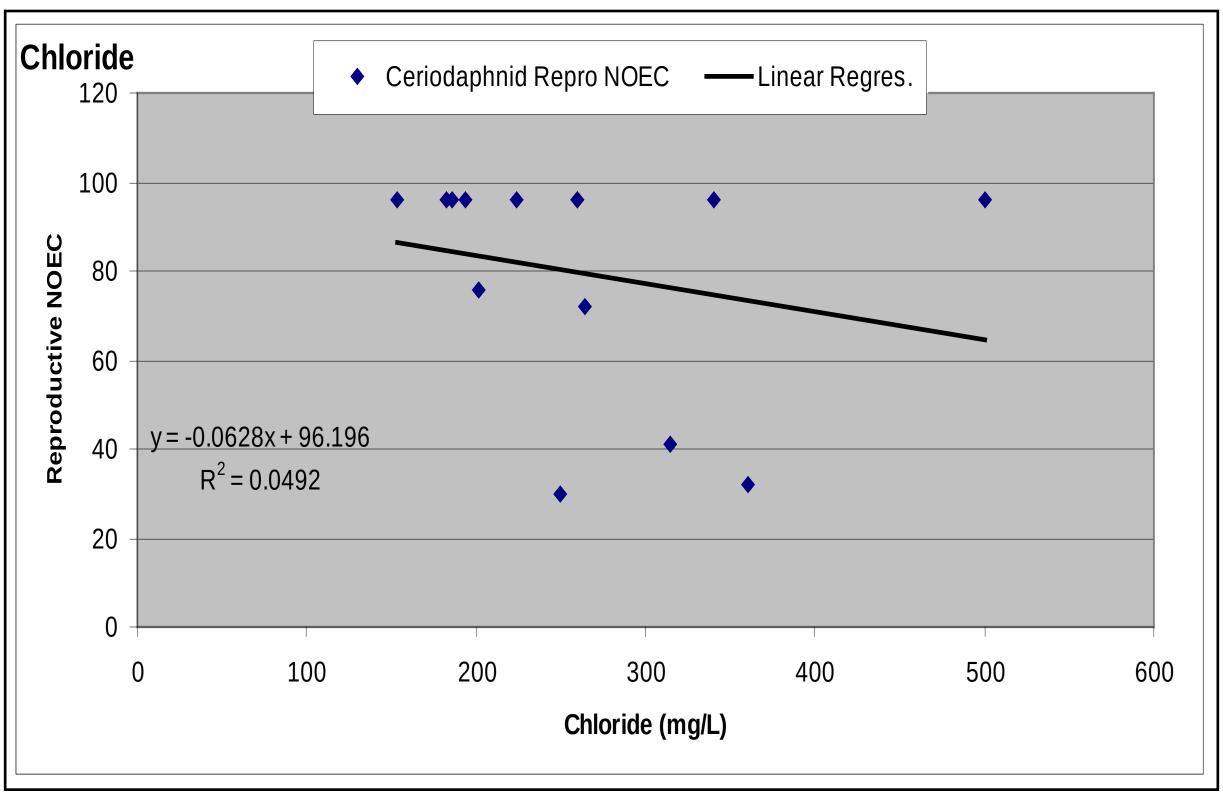


Figure 5.9. Water flea reproductive NOEC versus chloride values 2009-2011.

Table 5.5 presents the results of the regression analyses. The R^2 value relates the predictive ability of the independent variable, indicating what percent of the time the dependant variable can be accurately predicted by the independent variable. The R^2 values are very low, 0.05 or lower, for all paired variables, indicating that its predictive accuracy is no greater than 5% of the time. None of the paired variables displayed a statistically significant slope (relationship) at the α=0.05 level. Slopes were all close to flat indicating that **no significant relationship exists** for any pair of variables evaluated.

Therefore, the lack of a significant relationship indicates that the dissolved minerals concentrations observed in the discharge are **not related** to the WET test results demonstrated, regardless of the result, a pass or failure.

Table 5.5. Summary of linear regression analyses results.

Variables Compared	Correlation Coefficient	R^2 Value	Slope	p-value[1]
NOEC:TDS	0.01	0.02	-0.011	0.241
# Young:TDS	0.02	0.04	-0.003	0.105
NOEC:TDS DMR	0.04	<0.01	0.006	0.755
NOEC:Sulfate DMR	0.02	0.02	0.019	0.517
NOEC:Chloride DMR	0.22	0.05	-0.063	0.446

[1]P-value (probability that the line slope is significant) must be below 0.05 for a slope to be considered statistically significant.

To further evaluate whether these results show any significant correlation between TDS and the water flea WET test results, Kendall's Tau correlations were calculated. Kendall's Tau is a non-biased (in that it is unaffected by data distribution) estimator of correlation between two variables. The results of the Kendall's Tau correlations are provided in Table 5.6. Kendall's Tau results verify that no significant correlation exists between TDS and either water flea NOEC or the number of young produced by the water flea in the WET tests.

Table 5.6. Kendall's Tau results for the water flea.

Variables Compared	Correlation (Tau) Statistic	P-Value (2-tailed)
TDS:NOEC	-0.16	0.07
TDS :# Young	-0.13	0.11

5.3.2.4 Impacts of TDS on Fathead Minnow

A synoptic review of the impacts of TDS on WET tests involving the fathead minnow data was completed for the period of 2000 through April 2012. Linear regression analyses were performed on the fathead minnow growth NOEC versus TDS and the actual per larval growth versus TDS (Figures 5.10 and 5.11).

Although the slope of the line observed is positive indicating that the fathead minnow growth improves with increasing TDS concentrations, the R^2 value is not significant, indicating that there is no significant relationship between the dissolved minerals levels and the fathead minnow WET test results. This is the same finding with respect to the water flea WET test results. In summary, the dissolved mineral levels in the Lion Oil discharge do not have a measurable effect on the WET test results.

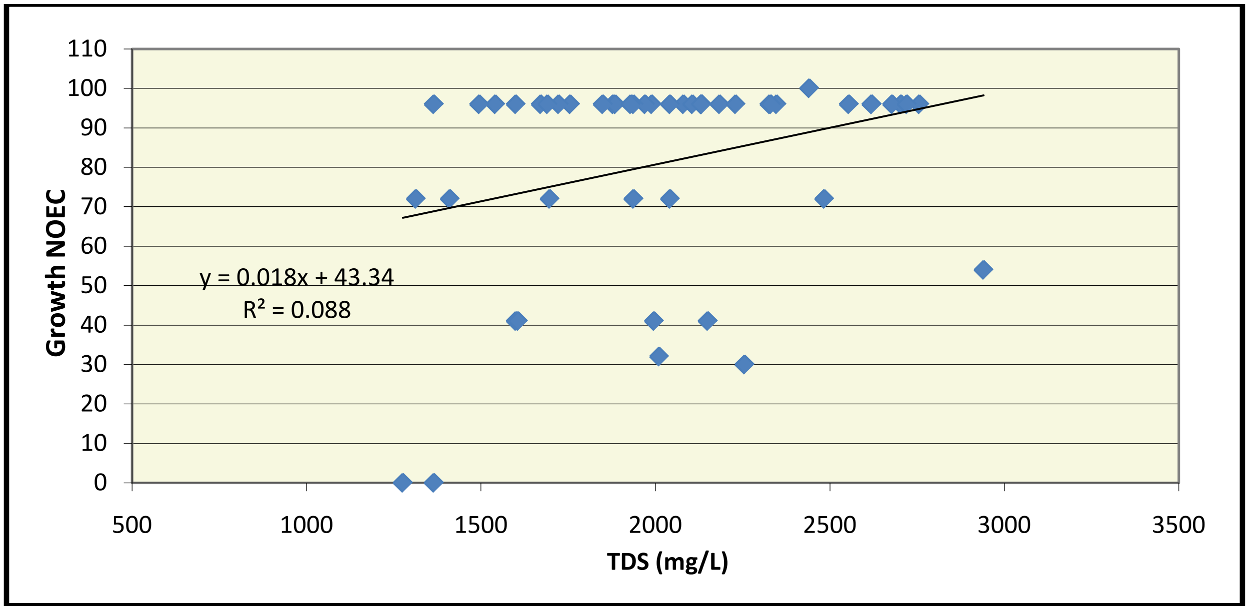


Figure 5.10. Chart displaying fathead minnow growth NOEC versus TDS values (calculated).

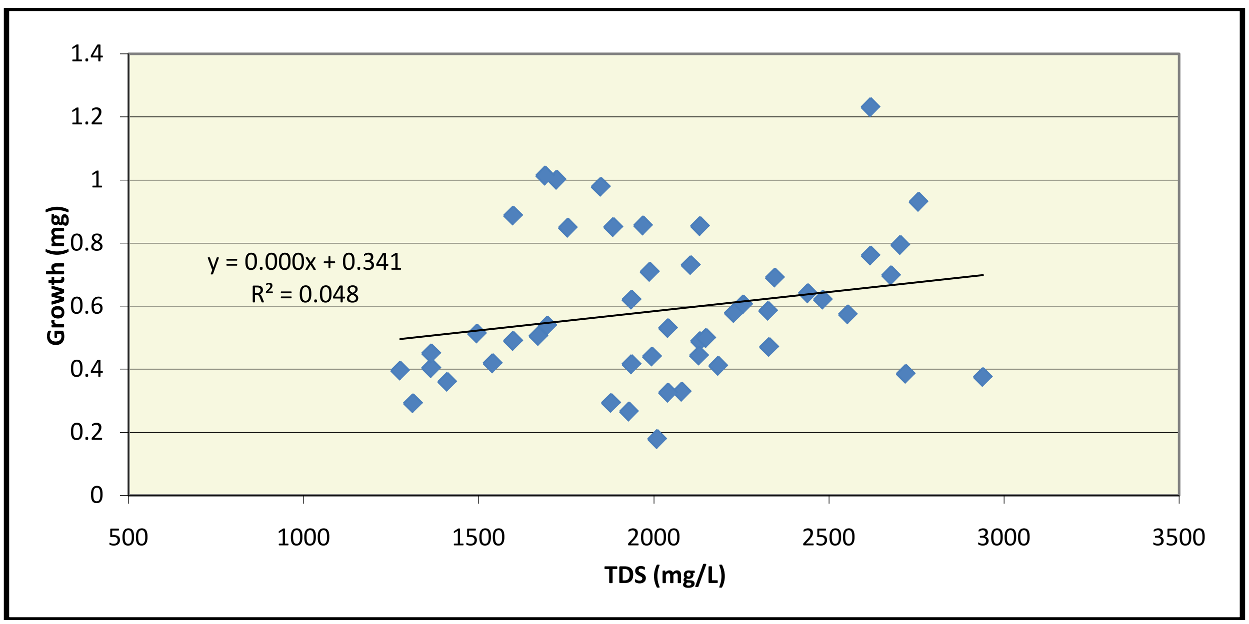


Figure 5.11. Fathead minnow growth at 96% effluent versus TDS values (measured).

5.3.2.5 Results of 2012 WET Tests (through April 2012) and Dissolved Minerals

The statistical analyses of the updated WET test (through April 2012) and effluent dissolved mineral data corroborates the previous analyses and verifies there is no correlation with the dissolved minerals concentrations and WET test performance, and verifies that the WET test sub-lethal reproduction failures of the water flea are not related to dissolved minerals levels in the discharge.

5.3.3 Summary of Dissolved Minerals WET Tests

Based on the statistical assessment of the WET tests results and concurrent dissolved mineral concentrations, the following conclusions are provided:

- WET tests verify that the dissolved minerals criteria developed in this UAA will not result in lethal or sub-lethal effects on the fisheries in Loutre Creek or Bayou de Loutre and will maintain the designated uses of these waterbodies.
- The criteria developed for Bayou de Loutre and discussed more fully in the Bayou de Loutre SSC are more stringent (lower in concentration) than those developed for Loutre Creek, so the Bayou de Loutre criteria also will not have lethal or sub-lethal effects on the fishery.
- With respect to historical concentrations of dissolved minerals:
    - The Outfall 001 effluent has consistently passed the lethality endpoints at the applicable critical dilution (72% or 96% effluent depending on the test period).
    - The Outfall 001 effluent has passed 98% of the biomonitoring tests lethality endpoint over the last 10 years. During the 10 year period, only a single water flea chronic test failed the lethality endpoint (February 2007) and only two fathead minnow tests (December 2001 and January 2012) failed the chronic lethality endpoint.
    - These results indicate that the historic dissolved minerals concentrations are not linked to WET test failures and cannot be used to predict the potential for WET test failures (e.g. reduced "No Observed Effect Concentration", NOEC, reduced number of young, etc.).
    - The analyses demonstrated that none of the paired variables displayed a statistically significant slope (relationship) at the α=0.05 level. Slopes were all close to flat indicating that no significant relationship exists for any pair of variables evaluated. Therefore, the lack of a significant relationship indicates that the dissolved minerals

concentrations observed in the discharge are not related to the WET test results demonstrated, regardless of the result, a pass or failure.

5.4 Loutre Creek Water Quality

The water quality of Loutre Creek was characterized in accordance with the Loutre Creek UAA QAPP and the ADEQ dissolved minerals implementation strategy requiring an assessment of the receiving stream above and below the subject discharge[17]. The goal of the water quality characterization was to document the instream water quality conditions, including levels of selenium and dissolved minerals, upstream and downstream of Lion Oil's discharge.

5.4.1 Receiving Stream Water Quality Characteristics

Physiochemical measurements and water quality samples were collected from each UAA study reach to characterize instream conditions during all seasonal periods. The water quality of Loutre Creek UAA study reaches was measured during multiple field activities during the UAA and aquatic life field studies. These included:

- Low flow fish and benthic community characterizations in June 2009,
- The seasonal habitat characterization in August 2009,
- Monitoring of fish traps for fish spawning condition (spring and summer 2009 and 2010),
- Collections of fish for use in tissue analyses, collection of fish eggs and milt for embryonic tetrogenesity testing (Summer 2009), and
- Monthly water quality sampling for effluent and instream selenium loadings (2009 and 2010).

Further, selenium and other analytical chemistry analyses were completed on samples collected during the following UAA tasks:

- Seasonal habitat characterizations,
- Low flow fish and benthic community characterizations, and
- Monthly water quality sampling of the Lion Oil effluent and UAA study reaches.

The following sections present the method and results of the water quality characterization for *in-situ* and specific parameter analyses in Loutre Creek. The analytical methods used followed procedures defined in the Project QAPP and outlined in Standard

[17] Administrative Guidance Document Pages IX-5 through IX-7 as approved on January 1994 by Director Randall Mathis and as provided in ADEQ CPP dated January 2000 (update and revisions).

Methods for the Examination of Water and Wastewater and appropriate EPA published methods.

5.4.2 Methods

Water quality analyses consisted of physiochemical measurements made *in-situ* and grab samples for laboratory analysis of selenium and dissolved selenium. *In-situ* measurements for water temperature, dissolved oxygen (DO), pH, and specific conductance were measured using a YSI Model 556 digital meter. Turbidity was measured using a Hach 2100P turbidimeter. Grab samples were collected and preserved on ice for laboratory analysis. All field meters were calibrated the morning prior to use in the field. Calibration records, analytical results and chain of custodies are provided in Attachment N. - Field Data Sheets.

5.4.3 Results and Discussion

The *in-situ* and water quality data collected during the fish and benthic community assessments on June 3, 2009 are presented in Table 5.7. Dissolved oxygen ranged from 4.7 mg/L to 8.5 mg/L in the sampling reaches. The pH ranged between 7.2 and 8.0 s.u. along the reaches evaluated. Specific conductivity reflected the discharge from Lion Oil at LC-3, LC-4, and at BDL-2 when compared to the reference sites LC-1 and BDL-1. Monitoring of on-site parameters was completed monthly with water quality sampling and analyses. A summary of the monthly *in-situ* monitoring is provided in Attachment N.

The Bayou de Loutre reference condition (BDL-1) had a selenium concentration almost three times (3X) that of the Loutre Creek reference site (LC-1) and exceeded the chronic water quality criteria on six of the 10 sample periods (Figure 5.12). The selenium concentrations in the upstream BDL-1 reach reflects the contributions from the historical land-use (oil and mineral extraction) and demonstrates the residual selenium concentration resulting from the historical land-use.

The maximum total selenium recorded from the downstream reach in Bayou de Loutre was 20 ug/L, representing a 68% increase from the upstream condition (less than an order of magnitude increase when compared to the upstream concentrations).

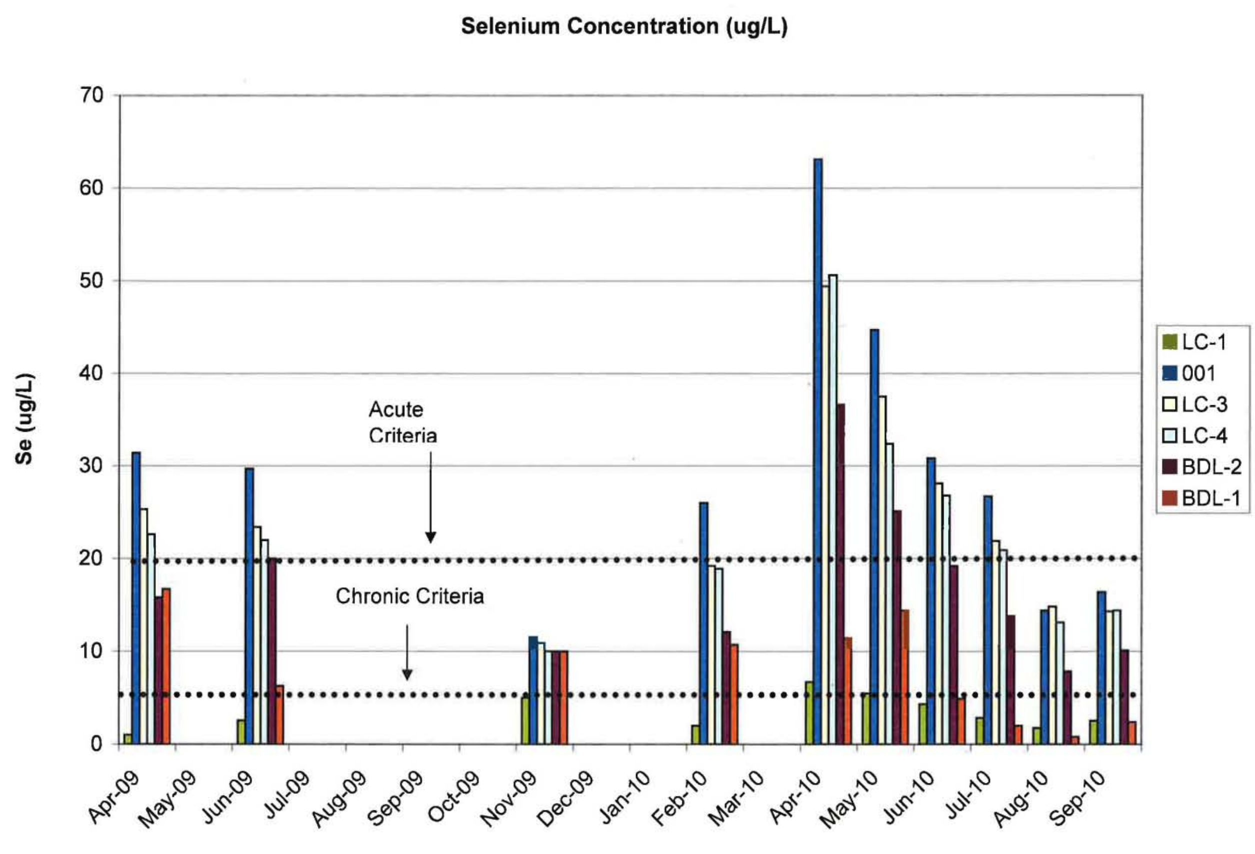


Figure 5.12. Summary of Total Selenium in water samples collected during the Loutre Creek UAA. POR April 2009 through September 2010.

Table 5.7. Water quality data of Loutre Creek and Bayou de Loutre measured/sampled in June 2009.

Parameter	LC-1	OF001	LC-3	LC--4	BDL-1	BDL-2
Date	6/3/2009	6/3/2009	6/3/2009	6/3/2009	6/3/2009	6/3/2009
Time	1715	--	0925	1250	1630	1500
Temperature, ^{oC}	24.7	--	27.2	27.4	29.4	27.9
Dissolved Oxygen, mg/L	7.0	--	8.5	8.1	4.7	7.8
Specific Conductance, µS	182	--	2994	3087	362	2483
pH, su	7.2	--	8.0	7.8	7.6	7.9
Turbidity, ntu	16.7	--	6.1	6.6	23.5	12.5
Total Selenium, µg/L	2.6	29.7	23.4	22.0	6.3	20.0
Dissolved Selenium, µg/L	2.4	29.7	21.6	21.5	4.6	17.3

5.4.4 Observations and Conclusions Regarding Water Quality Characteristics

The following observations and conclusions are based on the instream water quality monitoring completed in conjunction with the Loutre Creek QAPP.

1) There is a background concentration of selenium in the watersheds of Loutre Creek and Bayou de Loutre that is not due to the discharge from Lion Oil. The source of the selenium is likely the residual oil in soils and sediments deposited during the early years of oil exploration and production within the watersheds.
2) There is a limited increase in the selenium loadings from Loutre Creek when comparing the upstream and down-stream Bayou de Loutre sample results.
3) The *in-situ* parameters measured during the study indicate that water quality supports an aquatic life/fisheries use and the development and maintenance of the biotic community required to support that use.

5.5 Long Term Water Quality Monitoring

Selected analytical parameters and *In-situ* physicochemical water quality of the target streams (Loutre Creek and Bayou de Loutre) were monitored from November 2009 through September 2010 at LC-1, OF001 (Lion Oil NPDES Outfall 001), LC-3, LC-4, BDL-1, and BDL-2. Water samples and *In-situ* measurements were collected from the midchannel locations in each of the UAA study reaches on Loutre Creek and Bayou de Loutre and on Outfall 001 effluent. All water samples were collected as grab samples and analyzed for both total selenium and dissolved selenium. Analyses of water samples were performed by Ana Lab using USEPA approved methods and/or Standard Methods for the Examination of Water and Wastewater (latest edition). *In-situ* measurements were conducted by GBM^c & Associates following protocols outlined in the QAPP for this project and the GBM^c & Associates Quality Assurance Plan (GBM^c QAP, 2008) Attachment B.

Sample collection techniques were based on those recommended by EPA for specific media types in various guidance documents. The completeness criteria for this project resulted in 100% of the samples from each media providing usable results.

5.5.1 *In-situ* Measurements

The following parameters were monitored within each of the water quality samples:

1) Temperature, ºC
2) Dissolved oxygen, mg/L
3) Conductivity, µS
4) pH, su
5) Turbidity, ntu
6) Flow, cfs

Maintenance, calibration, and performance tests were performed following the QAPP for this project. All field meters were calibrated prior to each sampling event following GBM^c & Associates Standard Operating Procedures..

Temperature, dissolved oxygen, conductivity, and pH measurements were collected during each sampling event using a YSI 556 MPS (multi-probe system), YSI Pro MPS, and/or an Orion Star Series pH meter. Turbidity was measured using a HACH 2100P Turbidimeter, and instream velocity was measured using a Marsh-M^{c}Birney model 201 water current meter. A total of 10 monitoring events occurred between April 2009 and September 2010. Average and ranges of measurements from each monitoring site are summarized in Table 5.8 below. Also included are average and range concentrations for total selenium and dissolved selenium from each monitoring site. Refer to Attachment N for raw data sheets and additional summary spreadsheets.

Temperature ranges at LC-1 were similar to secondary reference site BDL-1 and downstream site BDL-2 but were different when compared to OF001, LC-3, and LC-4. Temperature ranges at these study reaches reflected the treated waste water discharge from Lion Oil.

Dissolved oxygen average measurements ranged from a low of 5.0 mg/L at LC-1 to 8.6 mg/L at LC-3. Specific conductivity was similar between both reference sites with averages of 446 microsiemens per centimeter (µS) and 545 µS, respectively. LC-3, LC-4, and BDL-2 demonstrated higher specific conductivity measurements. The pH measurements at each study site were similar and well within the 6 to 9 su range for natural streams. However, during the

November 18, 2009 field assessment, high pH measurements occurred at all study sites, including the upstream reference reaches. The cause for the elevated pH was not determined.

Turbidity from each site was recorded in nephelometric turbidity units (NTU). LC-1 and BDL-1 demonstrated the highest measurements compared to the other sites and LC-1 exceeded base flow standard values of 21 NTU on several occasions. The elevated turbidity at LC-1 was in direct response to construction and urbanization of the Loutre Creek watershed. During the UAA field studies, a large area of the Loutre Creek watershed was cleared for the construction of a new high school for the City of El Dorado (Figure 5.13- 5.17). The cleared site contributed large amounts of suspended solids to Loutre Creek. Figures 5.18 - 5.21 document the sediment loading into Loutre Creek during a summer storm event during the period of the construction and the loading from the urbanized area north of Loutre Creek (Figure 5.21).

Figure 5.13. Continued urban development in the Loutre Creek watershed. View to northwest storm drainage to the east and north to Loutre Creek (just to right out of picture frame) .Large area cleared for construction of new high school. Little to no construction BMPs to prevent erosion and heavy sediment transport to Loutre Creek. June 2009.

Figure 5.14. View to northeast toward Loutre Creek at tree line. Area cleared for business development along Timberlane Drive. 2009.

Figure 5.15. View along Timberlane Drive, looking to the south from Loutre Creek crossing. Note recently installed culvert, and check dam just upstream of Loutre Creek. BMPs placed as part of construction of high school in Loutre Creek watershed. September 2009.


Figure 5.16. Recent culvert instillation just upstream of Loutre Creek cement culvert on Timberlane Drive.


Figure 5.17. Loutre Creek Culvert on Timberlane Drive. View to the south west. Note turbidity resulting from construction within the watershed. Street view to south. Note recently deposited soils and sediments in Loutre Creek.

Figure 5.18. Drainage to Loutre Creek, View north along Timberlane Drive. Note runoff gulleys in recently deposited soils.

Figure 5.19. Loutre Creek upstream of study reach LC-1 during summer storm event. Note the culvert overflow. Storm runoff from construction area of new high school. July 2009.

Figure 5.20. Storm water runoff into Loutre Creek upstream of study reach LC-1. Storm flow from construction site for new high school. Loutre Creek in background. July 2009.

Figure 5.21. Urban storm water runoff into Loutre Creek during summer storm event. View looking south along Timberlane Drive toward Loutre Creek, Loutre Creek culverts approximately at location of car traveling north with headlights Site is upstream of LC-1. July 2009.

Table 5.8. Summary statistics for *In-situ* and selenium for each UAA study reach completed during the monthly routine monitoring from April 2009 to September 2010.

Site	Flow (cfs)		Temp (°C)		D.O. (mg/L)		Sp. Cond. (µS)		pH (su)		Turbidity (NTU)		Dissolved Selenium (µg/L)		Total Selenium (µg/L)	
	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range
LC-1	0.2	0.0 - 1.1	22	6 - 30	5.0	2.3 - 9.9	446	182 – 1,400	7.1	6.2 - 8.4	22	8 - 40	2.5	1.5 - 10.0	3.4	1.8 - 10.0
OF001	3.3	1.9 - 3.9	22	15 - 29	7.7	4.9 - 9.3	2652	381 – 3,880	7.8	7.0 - 8.7	8	2 - 33	24.2	10.1 - 33.8	29.5	11.5 - 63.1
LC-3	4.3	2.4 - 6.7	25	15 - 29	8.6	7.1 - 10.4	2609	1,900 – 3,570	7.9	7.5 - 9.1	9	3 - 27	20.1	10.0 - 28.7	27.2	10.9 - 49.4
LC-4	4.4	2.5 - 6.8	22	12 - 27	8.1	5.3 - 10.7	2363	1,683 – 3,250	7.7	7.3 - 9.4	10	6 - 14	18.6	13.6 - 27.8	22.2	13.1 - 50.6
BDL-1	2.1	1.0 - 4.4	22	6 - 29	6.3	4.3 - 11.8	545	362 - 707	7.6	7.1 - 9.2	18	7 - 25	4.2	0.8 - 10.7	7.5	0.8 - 16.7
BDL-2	6.4	4.1-10.9	22	9 - 28	6.6	1.2 - 11.1	2912	1,281 – 8,210	7.5	7.1 - 8.2	14	8 - 17	12.9	9.2 - 23.1	15.7	7.9 - 36.6

5.5.2 Water Chemistry Results: Extended Monitoring

Water quality samples were collected as grab samples from LC-1, OF001, LC-3, LC-4, BDL-1, and BDL-2 beginning in April 2009, then monthly November 2009 through September 2010. Results of the dissolved and total selenium analyses for each site are summarized in Table 5.8 above and in the Figures 5.22 and 5.23.

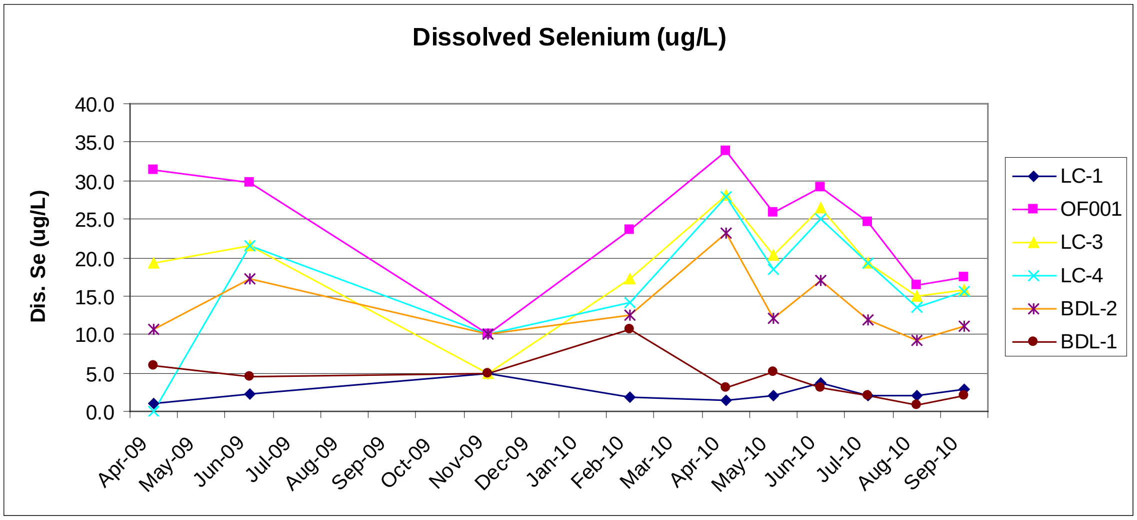


Figure 5.22. Linear description of dissolved selenium results collected at Loutre Creek, Bayou de Loutre, and Outfall 001 sample sites. April 2009 through September 2010.

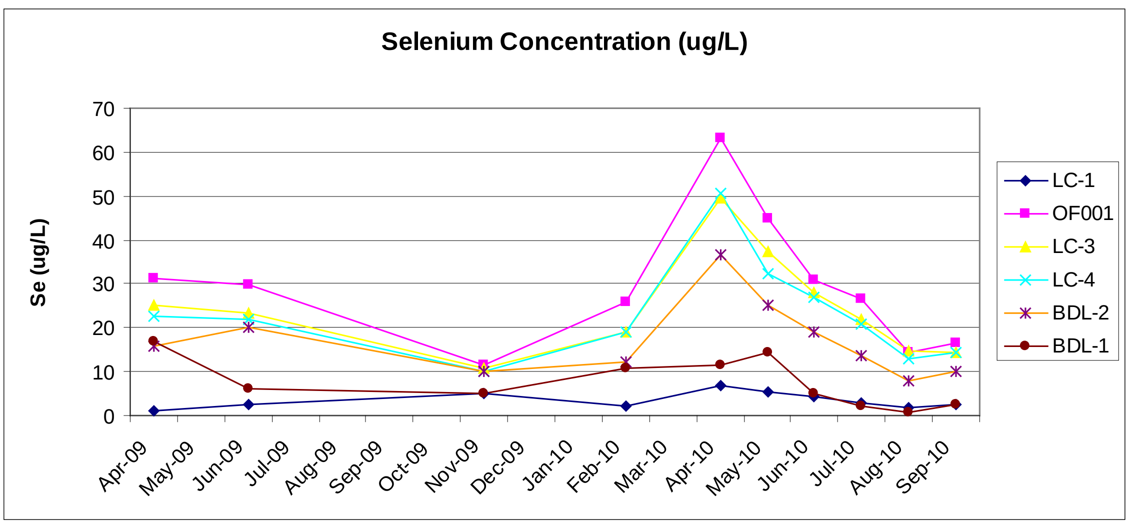


Figure 5.23. Linear description of total selenium concentrations results collected at Loutre Creek, Bayou de Loutre, and Outfall 001 sample sites. April 2009 through September 2010.

A total of 10 water quality monitoring events occurred from April 2009 through September 2010. Overall the dissolved selenium concentrations were lower than total selenium concentrations at all sites. Lion Oil Outfall 001 discharge (OF001) demonstrated the highest concentrations compared to other study locations with dissolved selenium concentrations ranging from 10.1 µg/L to 33.8 µg/L and total selenium ranging from 11.5 µg/L to 63.1 µg/L. OF001 lowest concentrations were recorded in November 2009 and highest concentrations were recorded in April 2010. Average concentrations at OF001 equaled 24.2 µg/L for dissolved selenium and 29.5 µg/L for total selenium. Lower concentrations were recorded downstream of the Lion Oil discharge and at both reference locations. LC-3 ranged from <10.0 µg/L to 28.7 µg/L for dissolved selenium and from 10.9 µg/L to 49.4 µg/L for total selenium. Monitoring site LC-4 ranged from 13.6 µg/L to 27.8 µg/L for dissolved selenium and 13.1 µg/L to 50.6 µg/L for total selenium.

Downstream site BDL-2 ranged from 9.2 µg/L to 23.1 µg/L for dissolved selenium and 7.9 µg/L to 36.6 µg/L for total selenium.

Upstream study reaches LC-1 concentrations ranged from 1.5 µg/L to 10.0µg/L for dissolved selenium and 1.8 µg/L to 10.0 µg/L for total selenium. Although LC-3, LC-4, and BDL-2 demonstrated selenium concentration levels exceeding the acute criteria for selenium (20 µg/L) on several occasions, a significant decrease at all locations occurred during August and September 2010.

Representative sampling was assured by collecting a field duplicate sample at a rate of 10% of samples collected (a minimum of one per day of sampling). Duplicates within +/- 20% of each other are considered to prove the representativeness of collection techniques. Results of representativeness are illustrated in Table 5.9 below as a relative percent difference between the samples and duplicate samples collected.

The QA/QC assessment of the long term selenium sampling is presented in the following table. The results were typically well within the relative percent difference for the analytical method, which suggests that sampling and sample handling did not impact the selenium results.

Table 5.9. Selenium QA/QC results of samples collected during the extended instream monitoring.

Site	Date	Dissolved Selenium*		Total Selenium*		Relative Percent Difference	
		Result	Duplicate	Result	Duplicate	Dissolved Selenium (%)	Total Selenium (%)
LC-1	6/3/09	2.4	4.3	2.6	4.3	59.1	49.9
LC-1	6/15/10	3.6	4.0	4.3	4.0	10.8	7.5
LC-3	4/16/09	19.3	24.4	25.3	25.4	23.3	0.4
LC-3	4/13/10	28.2	28.7	49.4	49.4	1.8	0.0
LC-3	5/18/10	20.4	20.5	37.5	34.1	0.5	9.5
LC-4	2/16/10	14.1	22.9	18.9	22.9	47.6	19.1
LC-4	7/13/10	19.3	19.5	20.9	20.0	1.0	4.4
LC-4	9/21/10	15.5	15.1	14.4	14.0	2.6	2.8
BDL-2	11/18/09	20.0	20.0	20.0	20.0	0.0	0.0
BDL-2	8/17/10	9.2	9.6	7.9	8.3	4.5	5.9

*= All results reported in micrograms per liter (ug/L).

5.5.3 Observations and Conclusions of Extended Receiving Stream Water Chemistry Monitoring

The following observations are based on the extended water quality monitoring of the receiving streams:

- Selenium was present at all locations including the upstream reference study sites and exceeded the current water quality criterion in the Bayou de Loutre reference reach.
- The minimum (lowest) dissolved oxygen level was recorded at the upstream reference reaches but recovered to above 5 mg/L in the downstream reaches of Loutre Creek.
- Turbidity was highest in the upstream reference reaches even during non-storm steady state conditions.
- Storm events transported large volumes of silt and sediments from the developed portion of the watershed upstream of the discharge from Lion Oil.
- The mean total selenium of Loutre Creek is 38 ug/L.

5.6 Selenium and Dissolved Minerals Criteria Development

This subsection explains how the proposed site specific selenium and dissolved minerals criteria were calculated.

5.6.1 Selenium Criterion Development

The historic Outfall 0001 selenium concentrations and instream selenium data were used to calculate the proposed water quality criterion for selenium. Specifically, the criterion is based on the 95th percentile of instream measures of selenium from study reaches LC-1, LC-3, LC-4, and from the Outfall 001 discharge over the period of the UAA field activities (April 2009 through September 2010). The 95th percentile of the data set is 38 ug/L.

5.6.2 Dissolved Minerals Criteria Development

The historic Outfall 001 dissolved minerals concentrations and the projected reductions in dissolved minerals from adding SO_2 reducing catalyst additives to Lion Oil's fluid catalytic cracking unit regenerator were used to calculate the proposed water quality criteria for chloride, sulfate and TDS. Thus, the dissolved minerals values used to derive these criteria are lower than the values in the historical discharge. This approach to derive site specific dissolved minerals criteria is consistent with the State's guidance in Appendix D (Pages D-12-D16) of the ADEQ's dissolved minerals implementation strategy.[18]

[18] The specific procedure for evaluating instream concentrations and developing permit limits for dissolved minerals can be found in *ADEQ Discharge Permit, Toxic Control Implementation Procedure* and in appendix D (Dissolved Minerals Implementation Policy in Arkansas' 2000 Continuing Planning Process (CPP) (ADEQ, 2000).

The following mass balance equation was used to calculate instream waste concentrations (IWC) for chloride, sulfate, and TDS. These IWCs are the numbers used for the criteria.

IWC = [(Ce x Qe) (Cb x Qb) +] / (Qe + Qb)

Where:

Qb = The background flow of the receiving stream

Cb = The background concentration of chloride, sulfate, or TDS in the receiving stream

Qe = The discharge flow of the effluent

Ce = The effluent concentration of chloride, sulfate, or TDS

The equation was populated as follows.

First, the value used for the background flow was 4 cfs, which is the critical flow for Loutre Creek for dissolved minerals under Regulation No 2.

Second, the value used for the background concentration in Loutre Creek and Bayou de Loutre of chloride (5 mg/L), sulfate (13 mg/L), and TDS (67 mg/L) was the mean concentration for the Gulf Coastal Plain Ecoregion. The background values are listed in the CPP in Attachment XII, *Mineral Permitting Strategy*, for streams in the Gulf Coastal Plain with a 7Q-10 of less than 100 cfs.

Third, the discharge flow of the effluent was based on Lion Oil's reported highest monthly average flow for Outfall 001 from January 2005 through April 2012, which was 2.422 mgd (3.75 cfs) (Attachment P). This flow value was used in the computations as the effluent flow at Outfall 001 as directed by Section D of *ADEQ Discharge Permit, Toxic Control Implementation Procedure* in the CPP.

Fourth, a concentration of 492 mg/L chloride, 1319 mg/L sulfate, and 2726 mg/L TDS were used as the effluent concentrations. Each of these values is the 95th percentile of its respective data set for the Outfall 001 discharge. Due to the limited number of data points, a clear normal distribution verses non-normal distribution determination was unable to be made. Therefore, the chloride, sulfate, and TDS 95th percentiles were calculated according to a non-parametric (the data set was analyzed using a non-normal distribution). The non-parametric statistical technique as outlined in *Statistical Methods for Environmental Pollution Monitoring* (Gilbert, 1987*)* was used for each data set. This method is summarized by the formula below:

k = p(n=1)

where: k = the ranked order number from the chloride data set (values of k that are not integers are interpolated for using the two values that k falls between).
p = desired percentile
n = number of data points

This method returns a k value of 32.3 for chloride and 25.65 for sulfate and TDS. The chloride data set has an n = 111, while the sulfate and TDS data sets have an n = 408. Therefore, the values ranked in the data for chloride, sulfate, and TDS were (492 mg/L, 1319 mg/L, and 2726 mg/L, respectively. These "ranked" values are equal to the 95th percentile.

Utilizing all the aforementioned data, the IWC for chloride, sulfate, and TDS are calculated below. The summary of the mass balance data inputs are provided in Table 5.10 for Loutre Creek.

$IWC_{chloride}$ =
[(4.0 cfs x 5.0 mg/L) + (3.75 cfs x 492 mg/L)] / (4.0 cfs + 3.75 cfs) = 241 mg/L

$IWC_{sulfate}$ =
[(4.0 cfs x 13 mg/L) + (3.75 cfs x 1319 mg/L)] / (4.0 cfs + 3.75 cfs) = 645 mg/L

IWC_{TDS} =
[(4.0 cfs x 67 mg/L) + (3.75 cfs x 2726 mg/L)] / (4.0 cfs + 3.75 cfs) = 1354 mg/L

Table 5.10. Instream Waste Concentration (IWC) Calculation for Loutre Creek.

Parameters	**Chloride**	**Sulfate**	**TDS**
Ce, mg/L	492	1319	2726
Cb, mg/L	5.0	13.0	67.0
Qe, cfs	3.75	3.75	3.75
Qb, cfs	4.0	4.0	4.0
Projected IWC (mg/L)	241	645	1354

6.0 SELENIUM IN THE FOOD WEB

The assessment of how selenium is processed in the food web of the receiving streams provides a measure of the potential for selenium in the Lion Oil effluent and in the water column from historic oil field practices to negatively impact the fish community and the designated use for Loutre Creek. Based on the research that formed the basis of the acute and chronic selenium criteria (Lemly, 2002), the primary pathway to the target community (fish) has been determined to be through the food web (e.g. dietary intake). This section provides details of how the selenium in the water column is transferred from the water, to the sediment, to the periphyton, to the benthic community and ultimately to the target group (fish). The primary impact is on the fish egg, which receives the selenium from the parental diet. When the eggs are hatched, the developing fish metabolize the selenium in the individual egg sac. Laboratory studies have indicated that some fish may be visibly deformed, but others grow into adult fish that appear healthy yet fail to reproduce. The level of selenium in the different components of the food web and how that translates to the concentrations in the individual fish provides an understanding of how the waterborne selenium may or may not support the fisheries use of the receiving stream.

6.1 Selenium in the Food Web

The current selenium water quality criterion is based on the sub-lethal endpoint of impairments to reproductive viability of fish. The basis for the criterion was research conducted primarily on bluegill sunfish (*Lepomis macrochirus*) (Lemly, 2002). Dissolved selenium in the water column is generally not in a form that is biologically available for uptake in higher trophic level organisms. Invertebrates and vertebrates bioaccumulate the majority of selenium from food sources or from solid material inadvertently ingested (Pressor and Luoma, 2006, Luoma and Pressor, 2009).

Selenium enters Loutre Creek and Bayou de Loutre from non-point sources such as historical oil deposits and from Lion Oil's discharge. According to the literature, selenium can then be expected to adhere to inorganic sediments (associated with elemental minerals) and to a lesser degree organic sediments and then settle into the sediment bed or be transported further downstream as suspended sediment load (Ralston, N.V.C., et al.).

Once in the sediment bed, the selenium will typically undergo various chemical transformations that ultimately determine the viability of the selenium to accumulate in the food web or to chemically bind to sediments where it is not biologically available. Selenium in the sediment bed is ingested by invertebrates while feeding and a portion of that selenium (dependant on form) becomes a part of their biomass. Some selenium may be adhered to phytoplankton or absorbed into their cells where it also becomes available for consumption by invertebrates. Selenium can then move up the food web to higher organisms that feed on the invertebrates or algae.

An effort to determine an instream effect of selenium loading and the potential for toxicity were completed on resident biota from Loutre Creek and downstream in Bayou de Loutre. The assessment included efforts to characterize the selenium from various segments of the food web, including:

1. Water quality of receiving stream study reaches during fish collection periods,
2. Tissue concentrations of resident fish populations,
3. Potential effects on embryonic development of the dominant sunfish species of the receiving streams (Longear Sunfish, *Lepomis megalotis*, Green Sunfish, *Lepomis cyanellus* and Spotted Sunfish, *Lepomis punctatus*), and
4. Measure effects on reproductive and/or embryological effects to fishes in the Centrarchidae (sunfish) family.

Samples from each media were collected at each study reach during the spring 2009 biological assessment events. Samples of fish tissue, sediment and within primary producer and primary consumer trophic levels were also collected during the 2009 summer field activities. Selenium levels from the water column, sediment, and within primary producer and primary consumer trophic levels were measured to develop a relationship between water column selenium concentrations and those affecting the test species, in this case Centrarchidae (sunfish) family. The Longear Sunfish is the dominant species of sunfish in Loutre Creek and therefore was selected, and identified in the QAPP, as the target species for efforts to identify potential embryological effects of the total selenium on fish in Loutre Creek.

As outlined in the QAPP, an attempt to assess the reproductive and embryological effects of fishes (sunfish) was performed to analyze test subjects eggs and embryo-larval fish. However, efforts to fertilize and hatch Longear Sunfish were not successful. Efforts to fertilize eggs collected from gravid Longear Sunfish in the field were completed for each of the study reaches in Loutre Creek and Bayou de Loutre, including the reach above the Lion Oil discharge. A total of six gravid females were stripped and the milt from as many adult males as available (n= 10-30 depending on the study reach) were mixed in the field and shipped to a hatching facility via overnight courier. However, none of the collections of eggs, including the samples from the study reach above Lion Oil were successful in providing fertilized eggs therefore preventing the reproductive and embryological assessment. An assessment of individual whole body fish tissue analysis was conducted at each of the study reaches. Results of this analysis as well as the selenium concentration in water, sediment, primary producer, and primary consumer tropic levels were determined and are discussed below.

6.2 Water Quality

This section presents the methods and results of the water quality characterization for *in-situ* and specific parameter analysis in Loutre Creek upstream (LC-1), from Lion Oil NPDES permitted Outfall 001 downstream sites (LC-3, LC-4, and BDL-2), and from the secondary reference site (BDL-1) during the initial fertilization effort. The analytical methods used followed procedures outlined in Standard Methods for the Examination of Water and Wastewater and appropriate EPA published methods.

6.2.1 Methods

Physiochemical measurements and water quality samples were collected from each reach location on June 3, 2009 to characterize instream conditions during summer seasonal period. Water quality analyses consisted of physiochemical measurements made *in-situ* and grab samples for laboratory analysis of selenium and dissolved selenium. *In-situ* measurements for water temperature, dissolved oxygen (DO), pH, and specific conductance were measured using a YSI Model 556 digital meter. Turbidity was measured using a Hach 2100P turbidimeter. Grab samples were collected and preserved on ice for laboratory analysis. All field meters were calibrated the morning prior to use in the field. Calibration records, analytical results and chain of custodies are provided in Attachment N - Field Data Sheets.

6.2.2 Water Quality Results

The *in-situ* water quality data is presented in Table 6.1. DO ranged from 4.7 mg/L to 8.5 mg/L in the sampling reaches (minimum value occurring at the upstream reference reach on Bayou de Loutre). The DO in Loutre Creek was lowest in the upstream reach and increased downstream of the Lion Oil discharge. The pH ranged between 7.2 and 8.0 s.u. along the reaches evaluated. Specific conductivity was a magnitude higher at LC-3 (2,994 ug/L), LC-4 (3,078 ug/L) and at BDL-2 (2,483 ug/L) verses the reference sites LC-1 (182 ug/L) and BDL-1 (362 ug/L). These increases reflect a result of residual storm water runoff, as well as the Outfall 001 discharge.

The selenium concentrations were also higher at LC-3, LC-4, and BDL-2 than at LC-1 and BDL-1. However, the water column selenium in the upstream reference reach of Bayou de Loutre (upstream of the Lion Oil discharge) was also in excess of the current water quality standard (5 µg/L), demonstrating contributions from historical land-uses within the watershed (oil exploration and production).

Table 6.1. Water quality data measured/sampled in June 2009 in conjunction with tissue and egg collections.

Parameter	**LC-1**	**OF001**	**LC-3**	**LC--4**	**BDL-1**	**BDL-2**
Date	6/3/2009	6/1/2009	6/3/2009	6/3/2009	6/3/2009	6/3/2009
Time	1715	--	0925	1250	1630	1500
Temperature, ^{oC}	24.7	--	27.2	27.4	29.4	27.9
Dissolved Oxygen, mg/L	7.0	--	8.5	8.1	4.7	7.8
Specific Conductance, uS	182	--	2994	3087	362	2483
pH, su	7.2	--	8.0	7.8	7.6	7.9
Turbidity, ntu	16.7	--	6.1	6.6	23.5	12.5
Total Selenium, µg/L	2.56	19.6*	23.4	22.0	6.3	20.0
Dissolved Selenium, µg/L	2.4	--	21.6	21.5	4.6	17.3

*provided by Lion Oil during routine permit sampling

6.3 Sediment Results

An evaluation of selenium sediment concentrations was completed for sediment samples on August 6, 2009 at each Loutre Creek and Bayou de Loutre study reach. Results indicate less than detection levels at reference reach LC-1 and the highest dry weight concentration recorded at LC-4 (Table 6.2). Total percent solids ranged from 43.5% to 74.9% as illustrated in the table below. Analytical data package for the sediment analyses is provided in Attachment N.

Table 6.2. Loutre Creek and Bayou de Loutre selenium sediment results from August 2009.

Location	**Total Solids (%)**	**Selenium Dry Weight (mg/kg)**
LC-1	69.5	<0.11
LC- 3	74.9	0.56
LC- 4	48.6	1.36
BDL-1	43.5	0.42
BDL- 2	71.2	0.36

Although the selenium in the sediment in the upstream study reach was less than the downstream study reaches, the recent increased sedimentation as depicted in Figures 4.8 and 4.15-4.18 could have buried the historical sediments.

The maximum concentration in the sediment samples were identified in the downstream most Loutre Creek study reach (LC-4). Study reach LC-4 has been characterized as having the lowest flows and deepest pools of Loutre Creek and therefore likely serves as a sediment sink as well as a depositional area for the historical oil/tar residuals.

The selenium in sediments from the upstream reference site on Bayou de Loutre was found to be higher than the selenium in the study reach downstream of the mouth of Loutre Creek. This condition illustrates the contributions from the historical residual.

6.4 Primary Producer Results

Selenium concentrations in primary producer (periphyton) samples collected on June 16, 2009 during the collection of fish for field fertilization efforts were determined for each Loutre Creek and Bayou de Loutre study reach. Table 6.3 summarizes the concentration of selenium in periphyton samples for each of the study reaches. Analytical data packages for the periphyton analyses are provided in Attachment N.

Table 6.3. Loutre Creek and Bayou de Loutre selenium periphyton results from June 2009.*

Location	Total Volume (mL)	Selenium (ug/cm2)
LC-1	115	0.0067
LC-3	162	0.019
LC-4	237	0.0222
BDL-2	200	0.0126
BDL-1	--	--

*Periphyton Samples from BDL-1 not analyzed due to lab error.

6.5 Primary Consumer Results - Macroinvertebrates

Selenium concentration in primary consumers (benthic macroinvertebrates) samples collected on August 8, 2009 during the collection of fish for field fertilization efforts were determined for each Loutre Creek and Bayou de Loutre study reach. Table 6.4 summarizes the concentration of selenium in primary consumer samples for each of the study reaches. Analytical data packages for the macroinvertebrate analyses is provided in Attachment N.

Table 6.4. Loutre Creek and Bayou de Loutre selenium benthic macroinvertebrate results from June 2009.

Location	Total Solids (%)	Selenium (dry weight) (mg/kg)
LC-1	17.4	<2.16
LC-3	19.1	14.3
LC-4	22.1	7.65
BDL-2	18.9	7.3
BDL-1	16.8	<2.23

6.6 Primary Consumer Results - Fish

Selenium concentration in primary consumers (whole body sunfish) samples were collected on January 10, 2007, June 3, 2009 and June 16-18, 2009 for each study reach during the collection of fish for field fertilization efforts. Tables 6.5 - 6.7 summarize the concentration of selenium in primary consumer samples for each of the study reaches for the three sample periods. Analytical data packages for the fish tissue analyses are provided in Attachment N.

Table 6.5. Whole body tissue results for fish collected on January 10, 2007.

Location	# Fish	Length (mm)	Total Solids (%)	Selenium ug/L
BDL-1	1	147	26.2	9.85
	2	147	19.7	13.5
	3	147	23.4	19.2
	4*	175	19.1	1.53
	5*	196	18.0	1.11
LC-0	1	120	22.2	3.14
	2	126	24.9	2.59
	3	126	27.3	3.05
	4*	147	19.5	1.95
	5*	238	18.7	2.01
	6*	238	17.8	2.30
LC-1	1	161	21.0	4.1
	2	168	28.0	2.32
	3	168	26.9	2.39
	4*	182	18.1	2.0
	5*	189	18.6	2.37
	6*	196	18.0	1.82
LC- 4	1	182	25.6	19.8
	2	189	23.7	20.1
	3	196	29.3	22.1
	4*	196	15.9	17.3
	5*	203	19.0	22.1
	6*	217	18.3	16.7
BDL- 2	1	147	23.1	9.78
	2	161	23.4	10.5
	3	168	25.1	8.84
	4*	168	20.8	12.6
	5*	175	17.8	8.88

* filet samples, all other whole fish.

Table 6.6. Whole body tissue results for fish collected on June 3, 2009.*

Location	# Fish	Length (mm)	Weight (g)	Total Solids (%)	Selenium ug/L	RL
LC- 3	1	102	21.2	31.9	19.8	0.784
	2	90	13.66	25.6	20.1	0.977
	3	86	11.3	26.2	22.1	0.954
	4	86	12.57	26.2	17.3	0.954
	5	91	13.07	25.4	22.1	0.984
LC- 4	1	111	27.07	32.1	8.75	0.779
	2	118	31.35	34.4	5.35	0.727
	3	92	11.9	29.9	13.1	0.836
	4	80	8.92	25.7	16.1	0.973
	5	113	24.94	29.5	13.2	0.847
BDL- 2	1	124	41.25	35.4	7.4	0.706
	2	112	30.57	39.9	6.27	0.627
	3	86	10.62	27.8	13.9	0.899
	4	94	14.57	28	9.21	0.893
	5	79	9.3	30.2	14.2	0.828

* All analyses were whole body Longear Sunfish (*Lepomis megalotis*)

Table 6.7. Whole body fish tissue results from June 16-18, 2009.*

Location	Fish Number	Total Solids (%)	Selenium ug/L
BDL-1	1	25.8	8.72
	2	27.7	8.59
	3	23.4	19.2
	4	19.1	11.35
	5	18	10.19
LC-1	1	26.2	2.17
	2	26.1	2.24
	3	27.2	1.81
	4	26.7	7.9
	5	24.6	4.88
LC- 3	1	24	14.5
	2	23	25.4
	3	25.4	19.8
	4	28	15.4
	5	25.9	19
LC- 4	1	28.5	9.68
	2	27.5	7.35
	3	28.2	9.57
	4	21.9	16
	5	25.4	4.84
BDL- 2	1	27.8	5.61
	2	28.9	4.36
	3	25.2	10.2
	4	22	17
	5	25.9	10.5

* All analyses were whole body Longear Sunfish (*Lepomis megalotis*)

6.7 Embryonic Development

An evaluation of selenium toxicity was to determine the effect of selenium on resident biota from Loutre Creek. The assessment target was reproductive and embryological effects to fishes in the Centrarchidae (sunfish) family. During the spring sampling season fertile females were stripped of eggs and field fertilized with milt from adult males. Eggs were sent to Great Lakes Environmental Center's laboratory for hatching and development to a 96-hour stage. Eggs were to be evaluated for fecundity and embryo-larval stage fish were to be evaluated for deformity to ascertain the potential impact of selenium. Selenium levels from the water column, eggs, fish tissue, sediment and within primary producer (periphyton, phytoplankton, etc.) and primary consumer (macroinvertebrates, fish, etc.) trophic levels were to be measured during the process to develop a relationship between water column levels and those in various tissue from the sunfish species.

An evaluation of selenium toxicity to determine the effect of selenium on resident biota from Loutre Creek was attempted. Samples from each media (water column, eggs, fish tissue, sediment and within primary producer (periphyton, phytoplankton, etc.) and primary consumer (macroinvertebrates, fish, etc.) trophic levels were collected at each study reach during the spring biological assessment event and analyzed for selenium and other constituents. Samples of fish tissue, sediment and primary producer and primary consumer trophic levels were also collected during the summer event. The targets of the reproductive and embryological effects were fishes in the Centrarchidae (sunfish) family. During the spring/summer sampling season fertile females were captured (Figure 6.1 and 6.2), striped and the eggs (Figure 6.3) field fertilized with milt extracted from males (Figure 6.4) collected from the same study reach. Once eggs and milt were combined and allowed a five minute contact time (Figure 6.5), the eggs were transferred to plastic minnow bags. The bags were then filled with oxygen and sealed (Figure 6.6); then placed in cooled ice chest and sent priority overnight via Federal Express to the hatching facility. Eggs were sent to Great Lakes Environmental Center's laboratory for hatching. This process was completed for each of the sample stations, including the LC-1 station which serves as a baseline for fecundity and deformity.

Fish cages were deployed during spawning seasons of 2008, 2009 and 2010. Despite weekly monitoring of the sites, the spawning season for 2008 and 2010 were interrupted by storm events and continuously elevated flows during the peak of the nesting season. Field conditions were favorable during 2009 and the field fertilization effort was completed on two occasions in June 2009, June 3-5 and June 14-17. However, none of the collections were successful in producing viable eggs resulting in a hatch, including the samples collected from the reference study reaches.

The cause for the hatch failures was not determined. The field conditions were determined to be optimum as females were gravid readily expressing mature ova when manipulated. Although the collection of milt was limited at all study reaches, it was determined that there was sufficient contact to facilitate fertilization. Also, the target sunfish were building nest and in some cases actively defending established nests (Figures 6.7 and 6.8).

Figure 6.1. Study Reach LC-3. Checking fish trap to determine the condition of sunfish for egg and milt harvesting. June 2009.

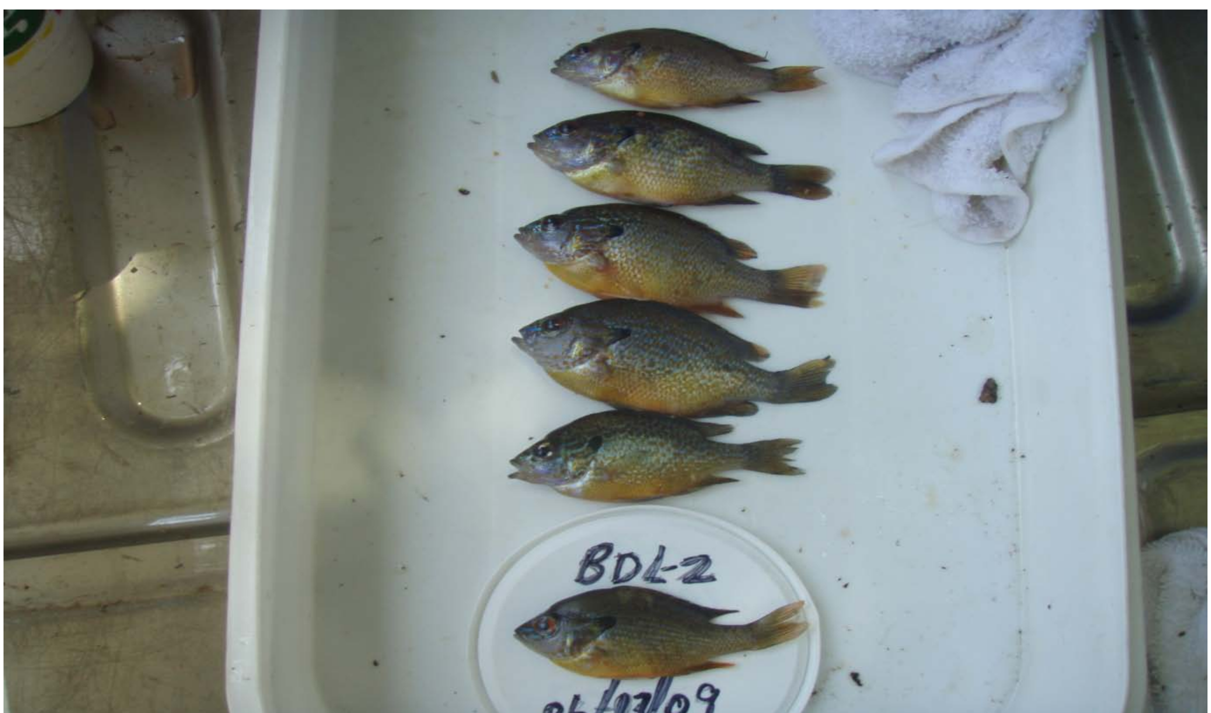


Figure 6.2. Sample of female long ear sunfish collected from BDL-2. Eggs used for fertilization effort.

Figure 6.3. Expressing eggs from female longear sunfish. Eggs used in fertilization effort. June 2009.

Figure 6.4. Effort to capture milt from male Longear Sunfish during 2009 fertilization effort. June 2009.


Figure 6.5. Vial of fish eggs and milt, exposure for five minutes under gentle agitation. June 2009.


Figure 6.6. Fish eggs after 5 minute exposure to milt, transferred to site water in prep for transport to hatching facility.

Figure 6.7. Study Reach BDL-2. Note long ear sunfish nest depressions being developed in preparations for spawn. June 2009.

Figure 6.8. Study Reach LC-3. Development of Longear Sunfish spawning nest. Note fish guarding nest in upper middle and right of pipe. June 2009.

6.8 Conclusions from Selenium Food Web Analyses

The following conclusions are based on the analyses of the selenium in the individual components of the Loutre Creek and Bayou de Loutre food web.

1) The waterborne selenium exceeds the chronic water quality criteria, even in the upstream reaches of Bayou de Loutre above the discharge from Lion Oil.
2) The *in-situ* parameters measured during the study indicate that water quality does not prevent the attainment of a fishery use and the development and maintenance of the biological integrity in the target stream reaches.
3) The selenium in sediments from the upstream reference site on Bayou de Loutre was found to be higher than the selenium in Bayou de Loutre downstream of the mouth of Loutre Creek. This condition illustrates the presence of a residual from historical oil field practices.
4) There is no increase in the selenium sediment loading of Bayou de Loutre downstream of the mouth of Loutre Creek.
5) The selenium sediment load in Bayou de Loutre upstream of the mouth of Loutre Creek was approximately the same as that in Loutre Creek just downstream of Lion Oil's Outfall 001.
6) Concentrations of selenium were found in fish collected from both of the upstream reference study reaches, again illustrating the continued release of historical contaminants into the food web.
7) There was no significant increase in the selenium concentration in fish in Bayou de Loutre when comparing the study reaches above and below the mouth of Loutre Creek.
8) The selenium concentrations in fish tissue were the largest in the study reach just downstream of the Outfall 001. However, the tissue concentrations were reduced in the downstream reach of Loutre Creek (LC-4) where the tissue concentrations were nominally the same as in both study reaches of Bayou de Loutre upstream and downstream of the mouth of Loutre Creek.
9) Efforts to fertilize and hatch sunfish eggs were not successful at any of the study reaches, including the reference reaches (Loutre Creek upstream of the Lion Oil discharge and Bayou de Loutre upstream of the mouth of Loutre Creek).

10) The 2009-2010 aquatic study and this food web analysis indicate that the historic levels of selenium in Loutre Creek are not toxic to fish, including sunfish. This is supported by the following findings:

- No deformities. During the 2005 and 2009-2010 aquatic studies, 859 fish were collected across seven study reaches: LC-0, LC-1, LC-2, LC-3, LC-4, BDL-1 and BDL-2. In addition, collections for embryonic development and tissue analyses harvested 252 specimens from the target study reaches. None of these fish (over 1,100 fish) evidenced any defects typically associated with selenium toxicity including but not limited to: (1) telangiectasia (swelling) of gill lamellae; (2) exopthalmus (popeye); (3) necrotic and ruptured mature egg follicles; and (4) teratogenic deformities of the spine, head, mouth, and fins. Further, as demonstrated by the historical record of fathead minnow chronic WET testing performed by the facility, selenium bioaccumulation in eggs larvae has not caused sub-lethal (growth) failures or post-hatch mortality.
- Population abundance with evidence of reproduction. The most abundant sunfish populations in Loutre Creek are Longear Sunfish, Green Sunfish and Spotted Sunfish. The 2005 and 2009-2010 aquatic study confirmed that both species have healthy populations as evidenced by their population numbers and presence in all study reaches and the number of individuals present in multiple size classes. See Tables 6.5 – 6.7 and Figures 6.2 and 6.4. Further, the concentrations of selenium in the Creek do not have adverse sub-lethal effects on these species as evidenced by the fact that the majority of fish collected in Loutre Creek were sunfish (fifty-one percent (151 of 293) in the 2009-2010 aquatic study and sixty-three percent (257 of 405) in the 2005 aquatic study). The lack of toxicity is also demonstrated by the fact that no deformities were identified on any of the fish and females were gravid with developed egg masses, and males were actively defending nest sites. See Figures 6.7 and 6.8 depicting Longear Sunfish nests at BDL-2 and LC-3. While the 2005 aquatic study did not collect Bluegill in Loutre Creek, they were collected as part of the 2009 aquatic study downstream of the discharge, but not upstream of the discharge. See Table 4.9. The populations of Bluegill in Loutre Creek are not large compared to Longear and Green Sunfish, but, as noted above, this is likely due to the fact that Bluegill typically prefer areas in lentic and lentic-type environments such as ponds, lakes

reservoirs and large low velocity streams.[19] These conditions are not characteristic for Loutre Creek with its riffle/run reaches.[20] . According to the Habitat Suitability index Model for the Bluegill sunfish,[21], the bluegill typically prefer areas in lentic and lentic-type environments such as ponds, lakes reservoirs and large low velocity streams (Whitmore, et.al, 1960)[22] typically prefer quieter waters where sluggish pools dominate the habitat. Bluegill are negatively correlated to a high percent of riffle/run (Moyle and Nichols, 1973)[23]. The Loutre Creek physical conditions, continuous flows with shallow pools, are not preferred habitat of bluegill sunfish. The dominate Loutre Creek sunfish species (Longear, Green and Spotted) are present in multiple size classes and have been documented to spawn in both downstream Loutre Creek study reaches. These sunfish species are not precluded from the fish community of Loutre Creek due to the exposure to selenium at the concentrations reported in the discharge from Lion Oil.

11) The literature on the toxicity of selenium has focused on impacts to sunfish populations. Findings from the literature are summarized below.

- The research to assess the toxicity of selenium on fish is based on lab exposures in a controlled environment. Researchers often caveat findings that indicate certain concentrations of selenium are toxic by calling for consideration of site specific conditions, such as speciation and bioavailability of the selenium in the receiving environment, in order to assess whether toxic effects observed in a lab have similar effects in the field.
- The lab-based research on the toxicity of selenium is often performed with lab-cultured organisms that have no previous exposure to selenium and have not had an opportunity to acclimate to exposure conditions. Thus, the lab-based results of these studies are not readily comparable to field settings such as Loutre Creek

[19] Stuber, R.J., G. Gebhart, and O.E. Maughan. 1982. Habitat suitability index models: Bluegill. U.S.D.A. Fish and Wildlife Service. FWS/OBS-82/10.8. 26pp. See also Whitmore, C.M., C.E. Warren, and P. Doudoroff. 1960. Avoidance reactions of salmonid and centrarchid fishes to low oxygen concentrations. Trans. Am, fish. Soc. 89:17-26.
[20] Populations of Bluegill Sunfish have been shown to be relatively low in streams with a high percent of riffle/run. Moyle, P.B, and R.D. Nichols. 1973. Ecology of some native and introduced fishes of the Sierra Nevada foothills in central California. Copeia 1973:478-490.
[21] Stuber, R.J., G. Gebhart, and O.E. Maughan. 1982. Habitat suitability index models: Bluegill. U.S.D.A. Fish and Wildlife Service. FWS/OBS-82/10.8. 26pp.
[22] Whitmore, C.M., C.E. Warren, and P. Doudoroff. 1960. Avoidance reactions of salmonid and centrarchid fishes to low oxygen concentrations. Trans. Am, fish. Soc. 89:17-26.
[23] Moyle, P.B, and R.D. Nichols. 1973. Ecology of some native and introduced fishes of the Serra Nevada foothills in central California. Copeia 1973:478-490.

and Bayou de Loutre where the fish community has evolved over multiple generations of exposure to selenium.

- Coyle et al. (1993)[24] reported that the Selenium toxicity threshold for mortality in larval fish (whole-body) is 16 ug/g (or 16 mg/L). Lemly (1993) showed toxicity effects to juvenile growth occurred at 7.91 ug/g or 7.91 mg/L. Both of these studies used laboratory created mixtures of selenium to evaluate the toxicity of selenium on bluegill sunfish in a lab as opposed to the field. The authors of both studies recognized the potential impact that site specific conditions could have on the uptake of selenium on fish through bioaccumulation. The 2009-2010 aquatic study was conducted to evaluate the site-specific effect of concentrations of selenium on fish in Loutre Creek. As discussed above, the study showed that the historic levels of selenium in Loutre Creek are not toxic to fish.
- The study reported in Coyle et al. (1993) involved exposing fish to selenium at higher concentrations and for a longer duration than fish would have been exposed to selenium in Loutre Creek and Bayou de Loutre. In the study, Coyle et.al. (1993) found that only the maximum exposures (33.3 ug/g or 33.3 ppm) were found to negatively impact the test organisms (33.3 ppm equals 33,300 ppb). This exposure is 1,000 times the average total selenium concentration of Lion Oil's Outfall 001 effluent. Thus, the lab-based conditions that influenced the results of this toxicity study are not readily comparable to the effects of selenium on fish in Loutre Creek or Bayou de Loutre.

12) Based on the aquatic life field studies and this food web analysis, the historic concentrations of selenium in Loutre Creek provide a reasonable basis to derive site specific criteria for this water body that are protective of the fishery in Loutre Creek.

[24] Coyle, J.J. Bucker, D.R., Ingersoll, C.G., Fairchild, J.F. and May, T.W. (1993), effect of dietary selenium on the reproductive success of bluegills (*Lepomis macrochirus*). Environmental Toxicology and Chemistry, 12:551-565.doi:10.1002/etc.5620120315.

7.0 SELENIUM FATE AND TRANSPORT MODELING USING AQUATOX

7.1 Fate and Transport Modeling

Evaluating the fate and transport of selenium as measured in the food web is done to determine the bioaccumulation of selenium in the target organism in this case the sunfish populations that dominate the Gulf Coastal fish communities. The bioaccumulation of selenium is dependent on site specific conditions. Therefore the fate of the selenium in fish tissue in Loutre Creek and Bayou de Loutre is specific to those streams and could be different than literature reported bioaccumulation factors.

AQUATOX, an ecological fate and transport model, was utilized to model the fate and transport of selenium in the Loutre Creek and Bayou de Loutre system. The most recent version of the model (version 3.1 Beta, build 42) was utilized in the modeling. AQUATOX was chosen because of its sediment and detritus transport capabilities and its ability to model chemical partitioning in the aquatic environment. Though selenium is not currently in the AQUATOX database it can be modeled by AQUATOX as a standalone chemical, using literature based partition coefficients and other reaction coefficients developed from the literature on selenium fate and transport. The focus of the AQUATOX modeling for this project was sediment transport including scour and deposition of sediments from and into the sediment bed. Sediment transport results provide insight into the mobility of the selenium from the Lion Oil discharge and prediction of where the selenium is being deposited in the Loutre Creek/Bayou de Loutre system.

The majority of inputs utilized in the AQUATOX model were based on field data collected over the 17 month study. Additionally, where field data was not available model specific defaults were utilized or literature values appropriate to the site conditions were used.

7.2 Aquatox Model Set-Up and Input Rationale

7.2.1 Model Site Characteristics

Initial conditions, including channel dimensions and morphology, and in-flow parameters were set to those observed during the field study. Remineralization rates were held at the AQUATOX default levels, which appeared to provide reasonable predictions to observed state variables. The model was then run to determine if its predictions matched up reasonably well to the observed water quality conditions for ammonia, TSS and dissolved oxygen. The resulting predictions provided a reasonable fit to the observed data. The model was then run for approximately a 17 month time period on a daily time step. Inflows and associated constituent loadings were varied on a time step to represent the conditions observed in the stream system from field study data collected during that time period.

Aquatox requires inputs in three basic areas to provide predictions of water quality and sediment transport, these are: Model Segmentation, Site Underlying Conditions and State/Driving Variables. Each of these categories is described below along with a summary of the values utilized. Data from Station LC-1, LC-3, LC-4, BDL-1, and BDL-2 were the basis for the majority of the inputs described.

Rates utilized in the model were generally the default rates provided in the AQUATOX 3.1 version of the model. Attachment Q provides a list of these key rates.

7.2.2 Model Segmentation

In order to represent the Bayou de Loutre stream system the Aquatox model was divided into three primary stream segments: one to represent Loutre Creek in the LC-3 stream reach, one to represent Loutre Creek in the LC-4 stream reach and one to represent the main stem of Bayou de Loutre, utilizing inputs based on BDL-2 reach data. Two stream segments were added to the model to represent tributary inflows (upstream Loutre Creek and upstream Bayou de Loutre) and a third stream segment was added to represent the Lion Oil outfall 001 point source discharge. The Aquatox model is designed to allow a "tributary-input" category to be utilized for boundary condition inflows and point sources. A generalized schematic of the model is provided in Figure 7.1.

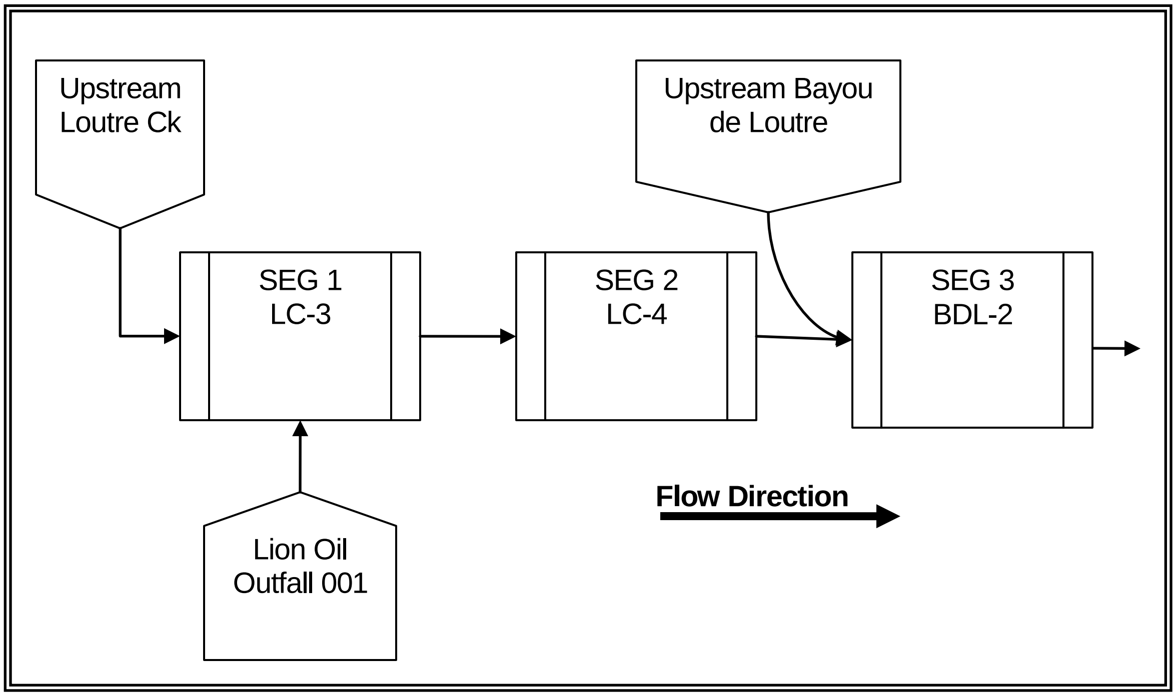


Figure 7.1. Fate and transport model development.

Flow in the Aquatox model segments is governed by linkages between stream segments. Linkages that contain flows are depicted in the flow chart as arrows, i.e. segment to segment. Flows are varied by season and day and are provided in Attachment R with all the model inputs.

7.3 Hydrology Inputs to AQUATOX

Flow data were entered into Aquatox on a daily time step that mimics the 17 month timeframe (May 2009 thru October 2010) that the study was on-going. There is no flow gauge on either Loutre Creek or Bayou de Loutre near El Dorado. Therefore, the gauge on Smackover Creek (USGS Gauge No. 07362100), just north of El Dorado, was used as the basis for calculating upstream (background) flow on Loutre Creek and Bayou de Loutre. Calculation of the background flow for each stream in the model was determined based on a ratio of watershed sizes (Table 7.1). The ratio that resulted for each watershed was then multiplied by Smackover Creek daily flows to estimate daily background flow in Loutre Creek and Bayou de Loutre. For example, if flow on October 10, 11 and 12 in Smackover Creek was 112 cfs, 144 cfs and 188 cfs, the resulting flow in Bayou de Loutre would be 1 cfs, 1.3 cfs and 1.7 cfs, respectively. In order for Aquatox to calculate channel volume and shear in a manner that varies with flow in the system additional flow values must be input into each segment for “Inflow of Water” and “Discharge of Water”. Inflow and discharge values entered into each segment must be proportional to the incoming background flows allowing the segment volume to adjust up or down with flow level. This method allowed the normal low flow pattern of these small streams to dominate, while also providing some large flow events during the study period that would cause fluxuation of channel shear, resulting in sediment scour and deposition as appropriate. Flows for the Lion Oil Outfall 001 were maintained at a steady rate of 3.3 cfs (2.13 mgd), which was the average flow measured during the entire study period.

Table 7.1. Stream watershed size and ratio for model development.

Stream	Watershed Size (mi^2)	Ratio	Value used if resulting flow<1 cfs
Smackover Creek	385	---	---
Loutre Creek	2.5	0.0065	---
Bayou de Loutre	3.4	0.0088	1.0

Channel morphology was input in the model as a Site Underlying Condition. Channel volume and water velocity was calibrated through adjustment of the inflow/discharge values and the segment slope in order to achieve volumes consistent with the geomorphic survey (baseflow dimensions versus top of bank dimensions) and velocities that compared well with those observed during the study. There were no velocity or flow measurements taken during high flow events, therefore, the velocity targets for the system during such events was predicted using Manning’s equation.

7.4 Site Underlying Conditions

The channel geometry, temperature and light parameters are largely controlled by the model through the Site Underlying Conditions. Site specific inputs provided to the model include reach length, reach volume, reach surface area, temperature range, mean and maximum (before flooding) depth, latitude, altitude and light range (Table 7.2). Bathymetry routines were utilized in the model in order that channel volumes/depths would vary from initial conditions as flow changed throughout the year. Mean evaporation was set to zero for each reach in the model to simplify water balance calibration. Extinction coefficients were maintained at the default levels.

Table 7.2. Summary of site underlying data utilized in the modeling.

Parameter	Units	Segment 1	Segment 2	Segment 3
Reach length	Km	1.53	0.46	2.41
Reach Volume	m3	1,458	1,487	4,688
Surface Area	m2	4,134	2,494	11,625
Mean Depth	m	0.37	0.61	0.40
Max Depth	m	1.6	2.0	2.25
Average Temperature	C	20	20	20
Temperature Range	C	12	12	12
Latitude	Degrees	33	33	33
Altitude	m	100	100	100
Average Light	Ly/d	450	450	450
Light Range	Ly/d	500	500	500
Slope	m/m	0.00033	0.0001	0.0002
Sediment Depth	M	0.5	0.5	0.5
Mannings N	Dimensionless	0.045	0.068	0.04
%Riffle	%	21	21	21
%Pool	%	66	66	66
%Run	%	13	13	13
Silt/Clay Scour Shear	Kg/m^2	0.083	0.083	0.083
Silt/Clay Depostion Shear	Kg/m^2	0.05	0.05	0.05
Silt Fall Velocity	m/s	0.002	0.002	0.002
Clay Fall Velocity	m/s	0.0015	0.0015	0.0015

7.5 State/Driving Variables

Initial conditions for water quality, water volume and sediment bed characteristics were based on field data collected during the 2009-2010 field study. Data from Station LC-1, LC-3, LC-4, BDL-1, and BDL-2 were the basis for the majority of the inputs (Table 7.2). The average of each parameter measured during the field study was utilized as the initial condition in the model (Table 7.3). That is, ammonia level is from the average ammonia recorded at each respective site, as is nitrate, total phosphorus, dissolved oxygen, etc. Carbon dioxide was estimated using standard CO_2 curves and based on alkalinity, temperature, and pH at each site. Suspended sand, silt, and clay were taken as a fraction of the remainder of TSS minus volatile suspended solids (VSS) using percentages from grain size analysis from that segments sediment bed. Suspended detritus was based on VSS values. Detritus (in sediment bed) parameters used in the modeling were estimates based on field data and recommendations provided in the AQUATOX guidance documents (Park, 2004). Biotic inputs were based on data collected in the field (actual macroinvertebrate dry weights and fish dry weights). Note that this stage of the modeling does not include selenium uptake by aquatic organisms as Aquatox is not currently setup to handle selenium speciation or bioaccumulation kinetics. Biotic parameters were input as a place holder should selenium kinetics be added to the model. Therefore, the biotic inputs are not described further nor do they have an observable affect on other water quality parameters predicted by the model.

Table 7.3. Summary of AQUATOX State Variable initial conditions.

	Initial Conditions			
State Variable Name	Segment 1	Segment 2	Segment 3	Units
NH_3 & NH_4+	0.07	0.03	0.08	mg/L
NO_3	10.5	7.74	4.77	mg/L
Tot. Sol. P	0.09	0.16	0.14	mg/L
CO_2	2	2.6	6	mg/L
Oxygen	8.6	8.1	6.6	mg/L
Susp sand	0	0	0	mg/L
Susp silt	4.6	4.9	4.7	mg/L
Susp clay	3.7	2.5	2.7	mg/L
R detr sed	50	75	75	g/m2 dry
L detr sed	50	75	75	g/m2 dry
R detr diss	0	0	0	mg/L dry
L detr diss	0	0	0	mg/L dry
R detr part	0.37	0.37	0.42	mg/L dry
L detr part	3.33	3.33	3.78	mg/L dry
BuryRDetr	0	0	0	g/m2
BuryLDetr	0	0	0	g/m2
Crayfish	1	1	1	g/m2 dry
Chironomid	0.5	0.5	0.5	g/m2 dry
Oligochaete	0.5	0.5	0.5	g/m2 dry
Odonata	0.65	0.65	0.65	g/m2 dry
Green Sunfish, Adult	2	2	2	
Water Vol	1,458	1,487	4,688	cu. m.
Temp	22	20	20	deg. C
Wind	3.1	3.1	3.1	m/s
Light	750	750	750	Ly/d
pH	7.9	7.7	7.5	pH

7.6 Results of the AQUATOX Sediment Transport Calibration

The Aquatox model calibration was completed comparing its predicted results to observed stream data, for TSS, ammonia, and dissolved oxygen collected during the study. Aquatox runs on a daily time step over a defined time period, predicting changing water quality parameters for each day of the simulation. Therefore, model predictions in each segment were compared to field data collected in those segments under similar flow conditions. Nearly the entire field data set collected during the study was taken during fairly low flow conditions (as necessary to fulfill the driving study requirements) so little data was available to compare to the higher flow events depicted in the model. Considering this reality the model predictions at near baseflow were considered more heavily in the calibration while the predictions at high flow were calibrated to estimated targets based on knowledge of the stream system conditions. Basically, if the predictions at baseflow were accurate and the higher flow predictions were in a reasonable range the calibration for that parameter was considered acceptable. Target values for the calibration are provided in Table 7.4. Figures 7.2-7.7 below provide an example of results of the calibration to observed field conditions. A complete set of model output including charts of key parameters calibrated is provided in Attachment S.

Table 7.4. Target values for AQUATOX calibration.

Station	Baseflow TSS Range (mg/L)	Baseflow NH_3-N (mg/L)	Dissolved Oxygen Range (mg/L)	Baseflow Velocity (cm/s)	Volume Range (cu.m)
LC-3	3-42	0.1	7-10	Run - 15	1458-6305
LC-4	3-18	0.1	5-11	Run - 8	1487-4875
BDL-2	6-16	0.1	2-11	Riffle - 26	4688-26370

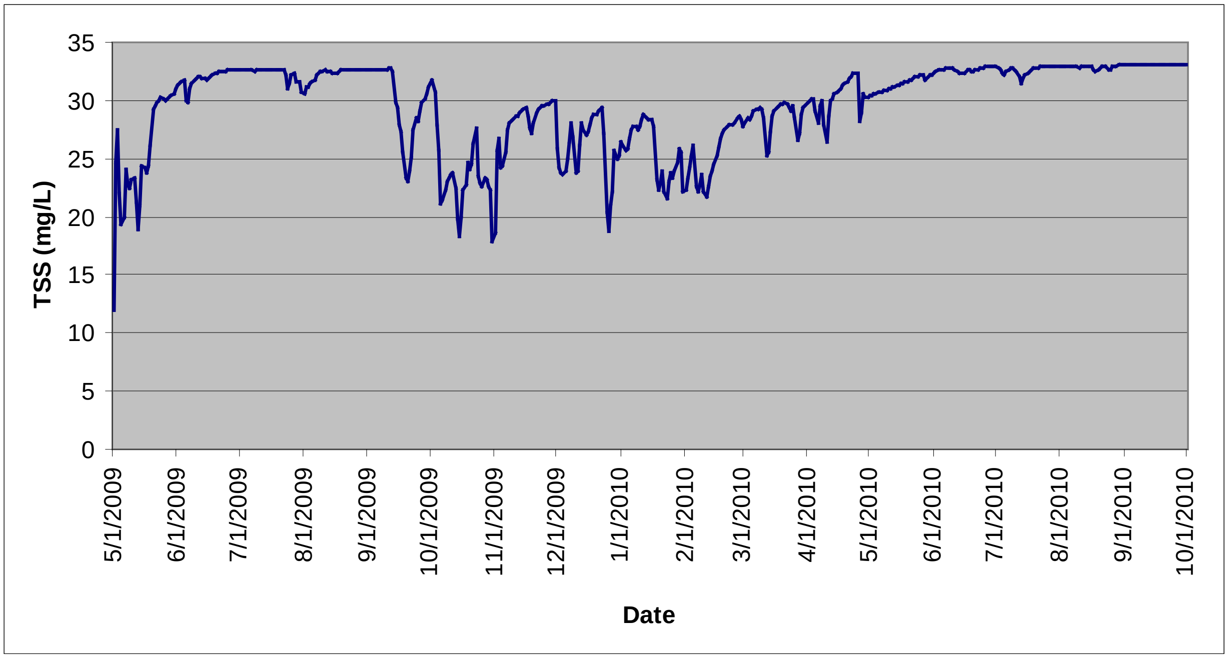


Figure 7.2. Calibration of TSS at LC-3.

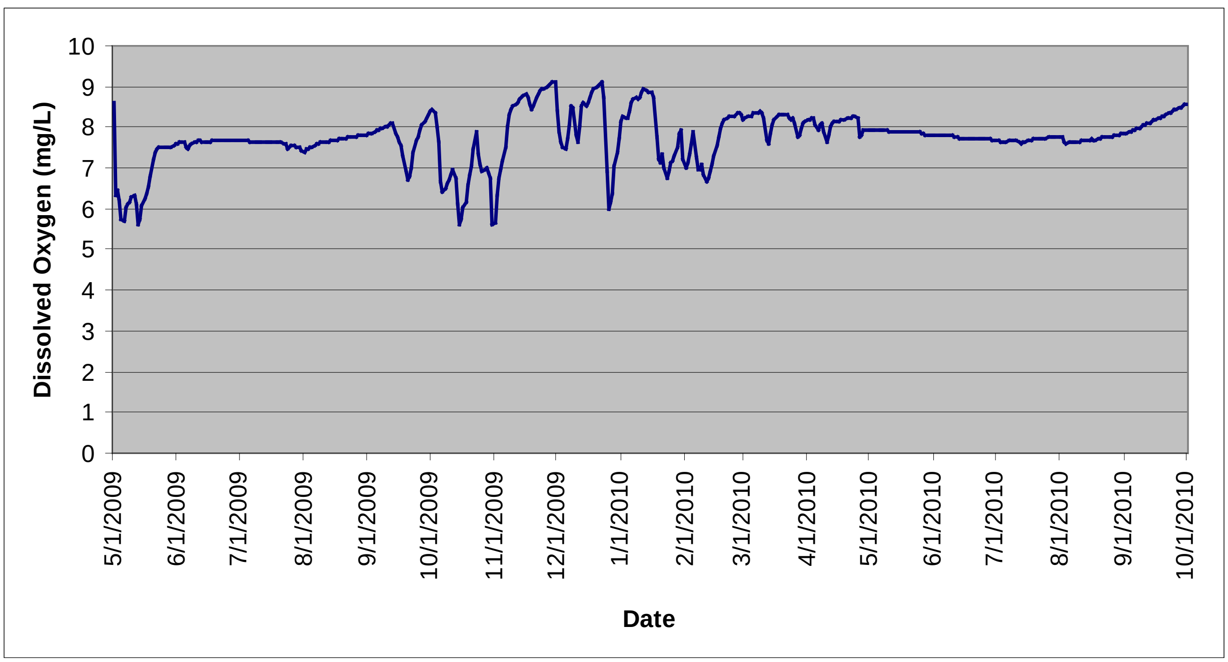


Figure 7.3. Calibration of dissolved oxygen at LC-3.

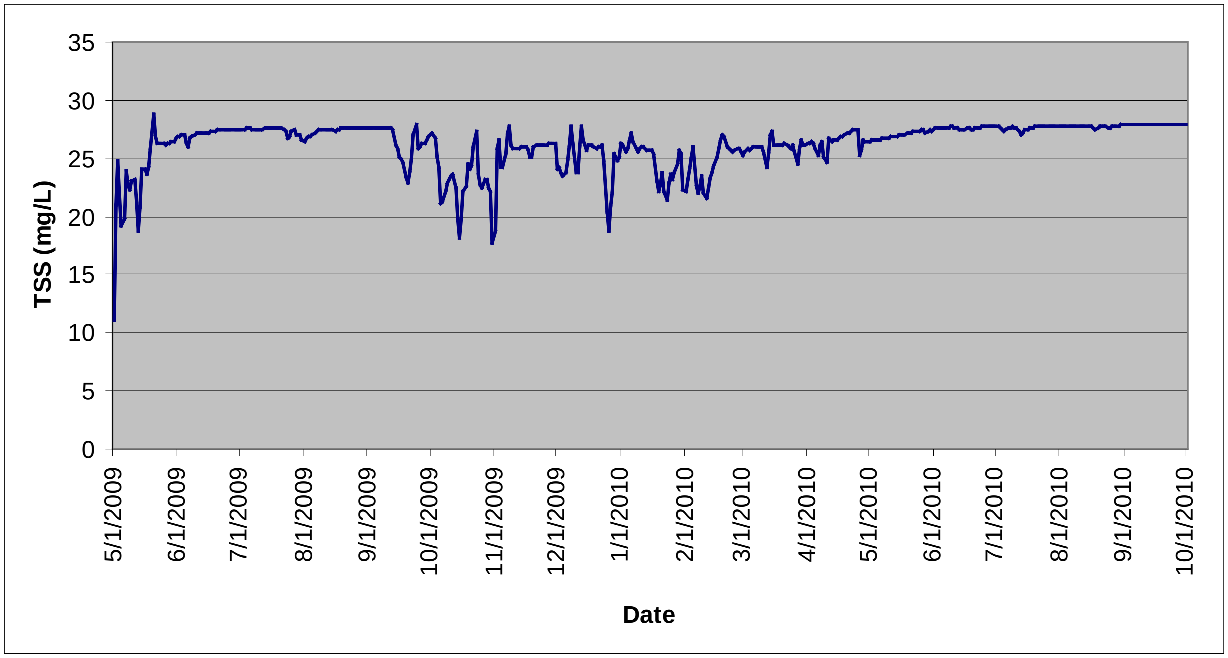


Figure 7.4. Calibration of TSS at LC-4.

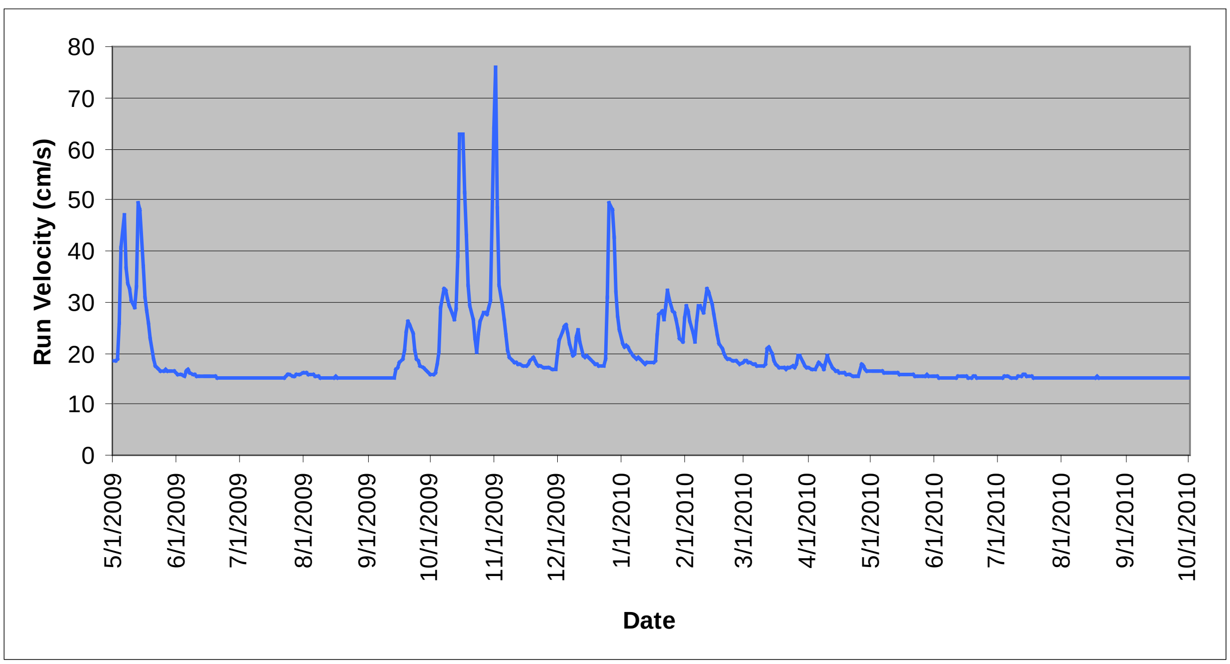


Figure 7.5. Calibration of velocity at LC-3.

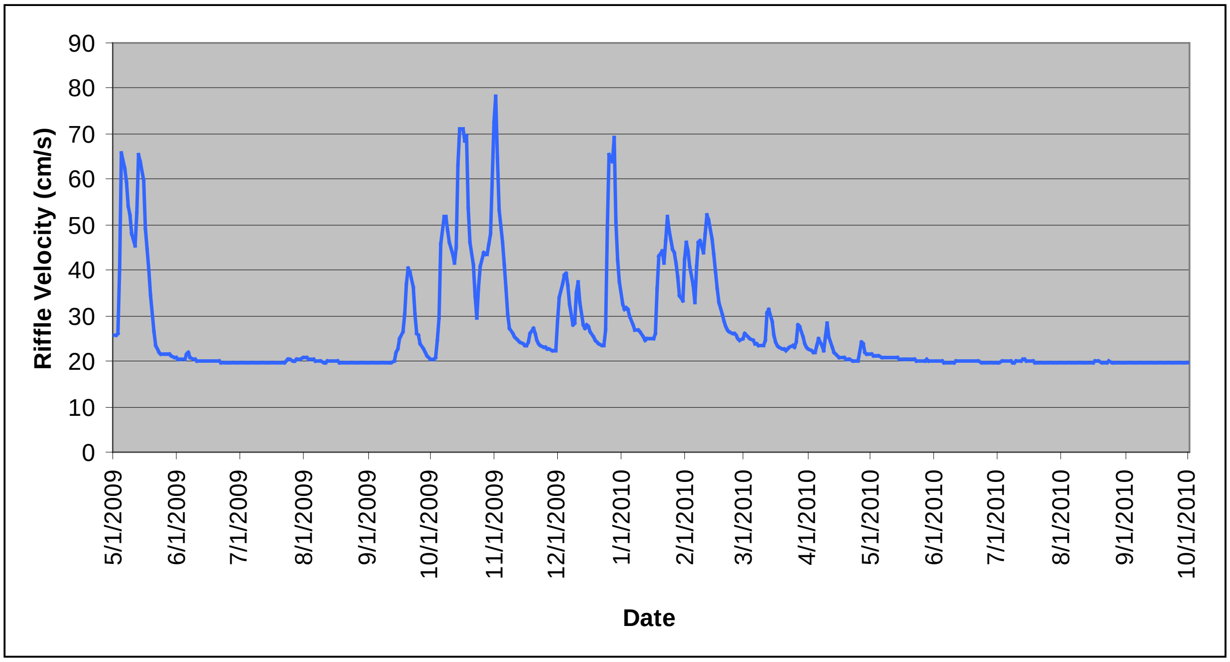


Figure 7.6. Calibration of velocity at BDL-2.

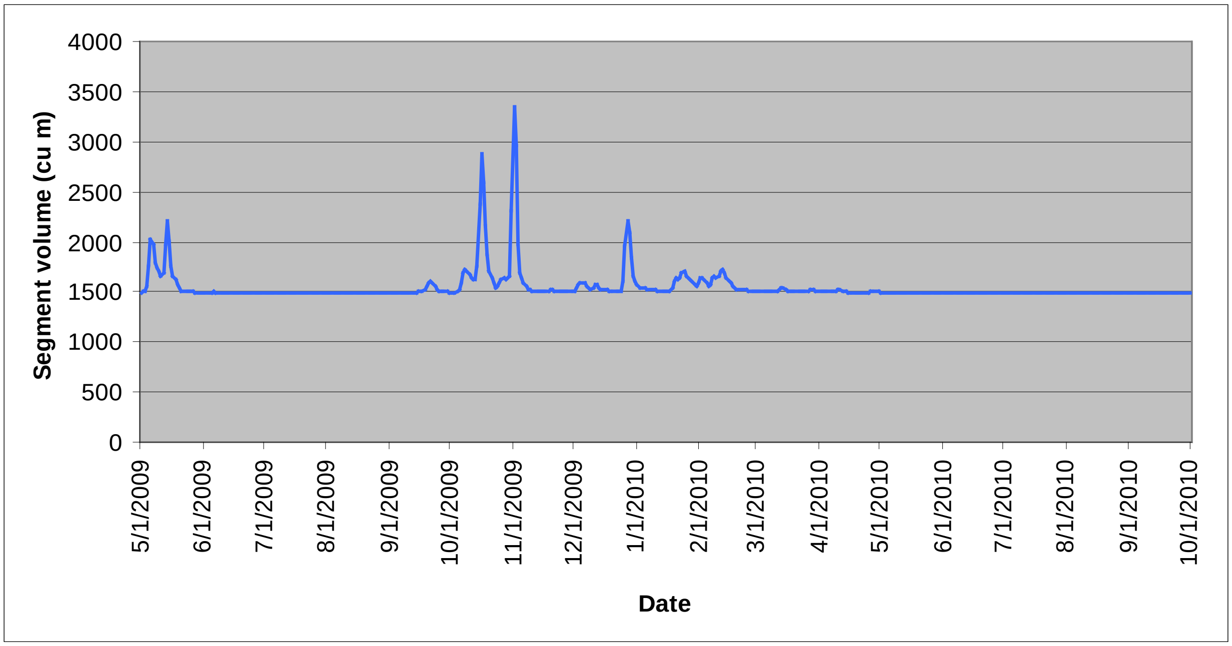


Figure 7.7. Calibration of volume at LC-4.

7.7 Aquatox Sediment Transport Predictions

AQUATOX provides predictions for TSS, suspended silt, and clay, and for deposition and scour of silts and clays into the stream system. The objective of the modeling simulation was to determine where in the Bayou de Loutre system (including Loutre Creek, a tributary to Bayou de Loutre) sediment was being scoured and deposited. Selenium is known to sorb to inorganic sediment both while in suspension and in the sediment bed. Therefore, tracking the fate of sediment in the system is a good surrogate monitor for the fate of selenium in the system. Results of the modeling indicated that the majority of the sediment deposition is occurring in the LC-4 reach while the other reaches are experiencing minor scour and re-suspension of sediments during high flow events (Figures 7.8). These model predictions are consistent with the samples of sediment collected during the field study, which had the highest concentrations of selenium in the LC-4 reach. Reach LC-4 is mostly pool and contains some of the deepest areas in the study reaches, which lends it to slower water movement and higher deposition rates.

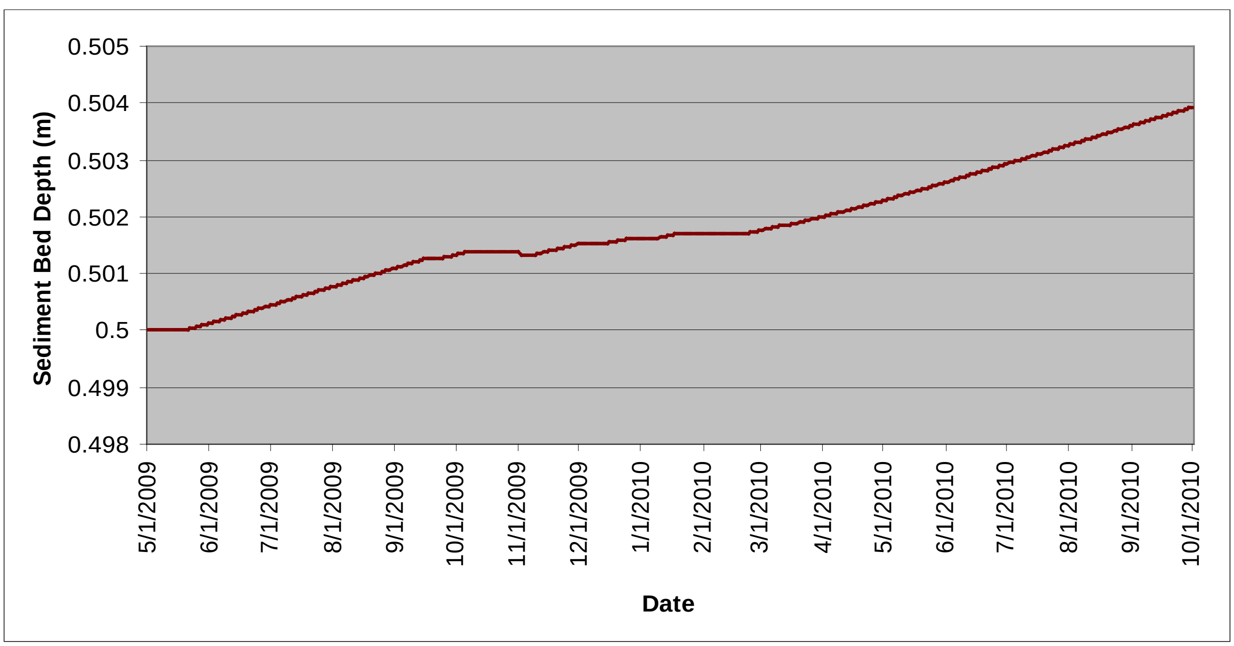


Figure 7.8. Model predictions of sediment bed deposition in reach LC-4.

7.8 Numerical Modeling of Selenium Fate and Bioaccumulation

Prediction of selenium fate in the aquatic environment is complicated. The primary selenium pathway to invertebrates and vertebrates is through diet, not through direct water contact or absorption (Luoma and Presser, 2006). Its biogeochemistry (speciation in relation to water chemistry and microbial degradation) is tightly linked to its ability to bind to sediment and then to its uptake rates (including dietary intake rate and assimilation efficiency) by organisms at the base of the food web. However, once selenium levels in base food web organisms (benthos in this case) is known, its bioaccumulation throughout the food web can be calculated with fairly good accuracy using the trophic transfer equations developed by Luoma and Presser (USGS Report 1646 and Environmental Science and Technology, 2009). Table 7.5 presents selenium levels measured in sediments and organism tissue from three points in the food web (e.g. periphyton, benthos and fish).

Table 7.5. Summary of total selenium levels from the study reaches in multiple tissue types and sediment.

Location	Sediment (Average Se mg/kg)	Periphyton Se (mg/kg)	Benthos Se (mg/kg)	Fish Se (mg/kg)	TTF* (Periphyton-Benthos)	TTF* (Benthos-Fish)
LC-1	<0.136	0.0067	<2.16	3.8	322.4	1.8
LC- 3	0.574	0.019	14.3	18.8	752.6	1.3
LC- 4	1.14	0.0222	7.65	9.5	344.6	1.2
BLD-1	0.383	---	<2.23	8.7	---	3.9
BDL- 2	0.578	0.0126	7.3	9.5	579.4	1.3

*Trophic transfer factors

Lion Oil Outfall 001 enters Loutre Creek at the head of study reach LC-3 which then flows into reach LC-4 and then to BDL-2. As depicted in Figure 7.9 the selenium levels in sediment are highest in reach LC-4, likely due to it being the deepest and slowest moving section of stream in the modeled system. Selenium levels in periphyton were also highest in reach LC-4. However, selenium levels in benthos (macroinvertebrates) and fish (sunfish) were highest in reach LC-3, nearest to the Lion Oil outfall, where sediment selenium levels were lower.

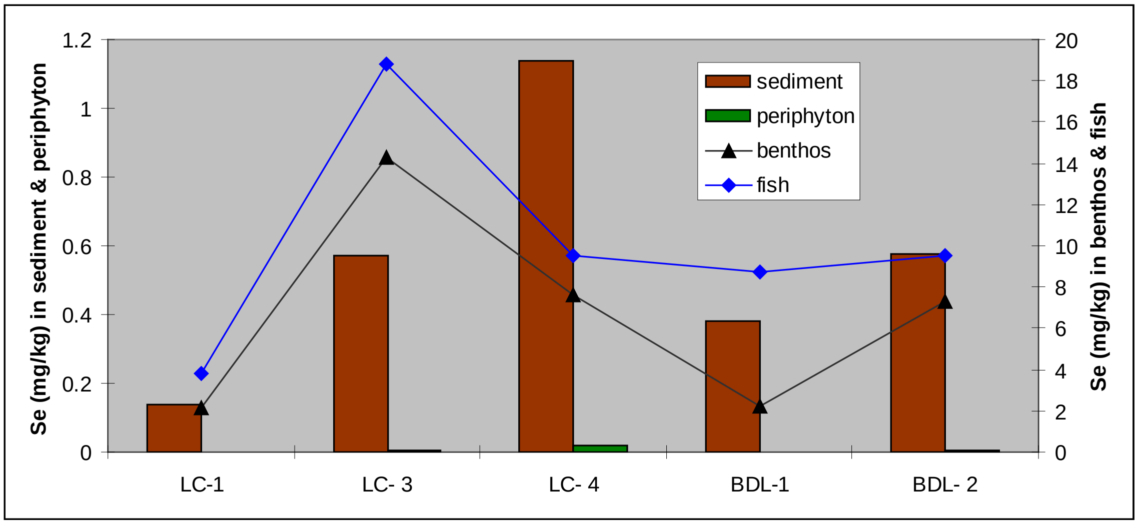


Figure 7.9. Relationship of selenium in various sediments and tissues.

Trophic transfer factors (TTF) were calculated from field data for each organism relationship (periphyton to benthos and benthos to fish). TTF can be used to predict selenium bioaccumulation at the next higher trophic level if selenium levels are known in the base trophic level. That is, if selenium concentrations are known in the benthos then the benthos TTF can be used to predict selenium bioaccumulation in fish that consume benthos, such as sunfish. Consistent factors (that did not vary much between stream stations) resulted from only the benthos to fish relationship, which was generally in line with that reported for freshwater crustaceans by Luoma and Pressor (2006), of approximately 1.5. The relationship of fish to benthos was not surprising in that the sunfish (the target species used for tissue analysis) is an insectivore and only grazes on algae occasionally or indirectly through consumption of insects that graze on algae. Insects (macroinvertebrates) that scrape algae from rocks are not abundant in the stream systems being evaluated, and would therefore not be a significant source of selenium to the fish diet. In addition, periphyton is not abundant in either Loutre Creek or Bayou de Loutre and would not be expected to contribute significantly to food web selenium levels. The data described above indicates that the selenium in Loutre Creek and Bayou de Loutre is bioaccumulating from the benthos to the fish in a manner similar to that described in recent literature. Therefore, the level of selenium in fish (sunfish) tissue can be accurately predicted using the TTF model and known selenium levels in the benthos.

Two key factors that generally control the ability of selenium to bioaccumulate in aquatic organisms are the form of selenium that dominates in the aqueous environment and the affinity of the selenium to attach to or sorb to suspended sediments. Selenite (SeO_3^{2}-) is much more likely to bind to sediment particles and thus become biologically available than is selenate (SeO_4^{2}-). Water samples were collected from each station so that selenium could be speciated (Table 7.6).

Table 7.6. Summary of selenium speciation.

Station	Total Se (mg/L)	Selenite (%)	Selenate (%)
LC-1	0.013	92	8
LC-3	0.059	63	37
LC-4	0.059	59	41
BDL-2	0.045	71	29
Outfall 001	0.073	60	40

Results of the speciation indicate that selenite is the dominant form in all stream reaches, and that the proportion of selenite generally increases with residence time in the system. The portion of the selenium that was in the form of selenite was slightly higher in reach LC-3 than in reach LC-4 which could partially explain why the benthos selenium levels were higher in that reach. However, the partitioning coefficients calculated from monitoring data (Table 7.7) indicate that the selenium is not prone to sediment sorption and therefore not as available for food chain assimilation.

Partitioning coefficients (kd) calculated according to equation, Kd = Particulate Se (ug/kg solids) / Dissolved Se (ug/L), from samples collected during the study are considerably lower than those found in the literature (Presser and Luoma, 2006) which generally ranged from $0.2X10^3$–$4.0X10^4$. High partitioning coefficients indicate an affinity for selenium to sorb to suspended inorganic sediments while low coefficients indicate a lack of ability to sorb to sediments. Partitioning coefficients below $1.0X10^3$ are generally considered to be representative of low selenium bioavailability (Presser and Luoma, 2006). The unusually low values found during this study indicate that the selenium in Loutre Creek and Bayou de Loutre system has a tendency to remain in the dissolved state where it is less biologically available. Since the primary conduit of selenium into the food chain is through dietary uptake of organisms that feed in or on sediments, and the selenium in the stream does not appear to have an affinity to sediments, then the ecological risk to higher level aquatic organisms in the system is low.

Table 7.7. Summary of distribution (partitioning) coefficients calculated from Loutre Creek and Bayou de Loutre sample data.*

Station	Mean TSS (mg/L)	Mean Total Se (ug/L)	Mean Dissolved Se (ug/L)	Mean Partitioning Coefficient (L/kg)
LC-3	12.0	27.3	20.0	$3.05X10^1$
LC-4	11.1	22.4	18.3	$1.93X10^1$
BDL-2	11.6	16.1	12.5	$2.22X10^1$

* Kd = Particulate Se (ug/kg solids) / Dissolved Se (ug/L)

7.9 Conclusions of Fate and Transport in the Loutre Creek Ecosystem

Fate and transport modeling of the selenium in the Loutre Creek ecosystem demonstrated that:

1. Results of the modeling indicated that the majority of the sediment deposition is occurring in the LC-4 reach while the other reaches are experiencing minor scour and re-suspension of sediments during high flow events. These model predictions are consistent with the samples of sediment collected during the field study, which had the highest concentrations of selenium in the LC-4 reach.
2. Selenium levels in benthos (macroinvertebrates) and fish (sunfish) were highest in reach LC-3, nearest to the Lion Oil outfall, where sediment selenium levels were lower.
3. The selenium levels in sediment are highest in reach LC-4, likely due to it being the deepest and slowest moving section of stream in the modeled system. Selenium levels in periphyton were also highest in reach LC-4.
4. Results of the speciation indicate that selenite is the dominant form in all stream reaches, and that the proportion of selenite generally increases with residence time in the system.
5. Partitioning coefficients (kd) calculated according to equation from samples collected during the study are considerably lower than those found in the literature.
6. Low coefficients indicate a lack of ability to sorb to sediments.
7. The unusually low partitioning coefficients found during this study indicate that the selenium in Loutre Creek and Bayou de Loutre system has a tendency to remain in the dissolved state where it is less biologically available. Since the primary conduit of selenium into the food chain is through dietary uptake of organisms that feed in or on sediments, and the selenium in the stream does not appear to have an affinity to sediments, then the ecological risk to higher level aquatic organisms in the system is low.
8. The continued presence of a fish and benthic community demonstrates that the biotic communities exist in the presence of the existing selenium concentrations.

8.0 ALTERNATIVE ANALYSES

This section summarizes the analyses of alternatives for Lion Oil to maintain the selenium and dissolved minerals water quality criteria for Loutre Creek.
Six (6) alternatives were identified:

1. no action,
2. no discharge,
3. hydrograph controlled release,
4. treatment,
5. source reduction/pollution prevention, and
6. water quality standards modification.

8.1 No Action

This alternative would maintain the current discharge situation. As demonstrated in Section 4.0, the historic level of total selenium and dissolved minerals in the Outfall 001 discharge has maintained an aquatic community in Loutre Creek downstream of the discharge; however, under the no action alternative, the total selenium and dissolved minerals water quality criteria in Loutre Creek would not be maintained.

8.2 No Discharge

Lion Oil employs approximately 550 employees with an annual payroll estimated at approximately $38.8 million dollars. Lion Oil is a significant employer in Union County. The Company's annual impact on the local economy exceeds $200 million dollars. In addition, Lion Oil pays approximately $2.25 million in local and state taxes.

Further, in order to meet the increasing need for gas and low sulfur diesel fuels, Lion Oil anticipates upgrades to its refinery capacity above 85,000 bpd. Increases in production capacity will result in additional jobs and taxes to the local and state economy. Due to limited production capacity elsewhere in the United States, any increase in capacity is beneficial to the product supply.

The no discharge alternative would require the cessation of operations at Lion Oil, an action which would greatly affect the local economy and place increased burden on the US fuel supply. This alternative is considered infeasible due to the socioeconomic effects to the local area and the effect on the domestic fuel supply should the Lion Oil facility close.

8.3 Hydrograph Controlled Release (HCR)

HCR involves the storage of wastewater and its controlled release at times when instream flow is sufficient to avoid an exceedance of water quality criteria. The feasibility of a HCR was examined as an alternative for minimizing the impact of Lion Oil's discharges. In Lion Oil's situation, an HCR system would not achieve compliance with the total selenium or dissolved minerals water quality criteria because the hydrology of Loutre Creek is impacted by limited watershed size (<3 mi^2) at the downstream most storm water outfall location. The small watershed size and the continued urban development in the watershed have resulted in storm hydrographs that respond quickly to storm events (water level quick to rise and then recede). Therefore, storm water flows through the Loutre Creek watershed are highly variable with flash response to storm events in the urban use dominated watershed.

In addition the Lion Oil facility comprises a large percent of the Loutre Creek watershed, further reducing the effectiveness of an HCR system to manage the discharge for the facility. The timing of storm runoff, the development within the watershed upstream of the facility storm water discharges, and the proportion of facility storm water to watershed waters limits the application of an HCR system. The HCR discharge operational scenario is not considered to be feasible due to urban modification in the small watershed.

For selenium, a runoff model was developed to determine the upstream flow required to allow the discharge through Outfall 001, with the existing total selenium that will meet the existing Loutre Creek criteria. The model applied the highest monthly flow from Outfall 001 (POR January 2004-December 2009), during typical ambient conditions (neither wet nor dry conditions) and a background concentration as stipulated in the ADEQ CPP for Gulf Coastal streams. The model projected that it would take a nine inch storm event to generate sufficient background flow to allow the discharge from Outfall 001 to maintain the existing instream standard. According to the Rainfall Frequency and Magnitude Atlas for the South Central United States (SRCC Technical Report 97-1), the 100 year 24 hour storm event is approximately 10 inches for this area of Arkansas. This further demonstrates that an HCR approach to permit compliance with the selenium permit limits is not feasible. The calculations are provided in Attachment T.

Likewise, a runoff model was developed to determine the upstream flow required to meet the existing Loutre Creek dissolved mineral criteria with the existing Outfall 001 dissolved mineral concentrations. The model applied the highest monthly flow from Outfall 001 (POR January 2004 - June 2012), during typical ambient conditions (neither wet nor dry conditions) and a background concentration as stipulated in the ADEQ CPP for Gulf Coastal streams. The model projected that it would take a 15 inch storm event to generate sufficient background flow to allow the discharge from Outfall 001 to maintain the existing instream standard. This further demonstrates that an HCR approach to permit compliance with the dissolved minerals permit limits is not feasible.

8.4 Selenium Removal or Reduction Technologies

This subsection provides information on various selenium removal or reduction approaches. Some of the technologies presented for the reduction and/or removal of Selenium are also relevant to control of dissolved minerals (see Section 8.5).

8.4.1 Background

While there have been various applications of treatment methods in the reduction of total selenium ion, these methods currently are not cost effective on a large scale and are not typically used in large scale (high volume) for treatment of waters prior to discharge to the levels required in the current instream water quality criterion. Also, treatment options often require additional treatment of a concentrated waste/reject stream. The concentrated reject streams generated from such processes present their own unique set of potential environmental risks which can be much greater than the wastewaters from which the contaminates were extracted. In addition this advanced treatment places large burdens on the cost effectiveness of the facility and goods produced.

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

Despite these limitations, Lion Oil has investigated the capital and annual operating costs to install advanced treatment for reduction of total selenium in the current effluent. Attachment U provides the details of the literature reviewed during the evaluation of the treatment alternatives considered. The estimated capital and annual operating costs for the treatment options as summarized in Table 8.1 would be overly burdensome and place the facility at a significant competitive disadvantage. Thus, treatment is infeasible in consideration of other alternatives.

8.4.2 Technologies Considered

A search of EPA's literature for selenium removal technology yielded information about ferrihydrite adsorption of selenium, catalyzed cementation of selenium, and biological selenium reduction at a mine site (EPA, 2001). Additional selenium removal technology information was found through searching vendor information, news articles, journal articles, and patent information on the internet. There is little information for influent concentrations of less than 1 mg/l. In addition, other wastewater constituents may interfere with selenium detection at low levels (EPA, 2001; CH2M Hill, 2010).

During the last few years, several in depth analyses of alternative treatment technologies for selenium have been presented for various types of environmental media, including a technical briefing paper prepared for TVA by Exponent (July 2010 Doc no 0900462.00002010609AF26). CH_2M Hill (Sandy, Tom and C. DiSante, June 2010) produced a Review of Available Technologies for the Removal of Selenium from Water for the North American Metals Council (NAMC). These are only a few of the documents that have evaluated treatment options for a variety of environmental media including refinery waste (as in Lion Oil situation), coal ash, storm water runoff from coal mining areas to name a few. The Final Report for the NAMC states:

> "While these physical, chemical and biological treatment technologies have the potential to remove selenium, there are very few technologies that have successfully and /or consistently removed selenium in water to less than 5 ug/L at any scale. There are still fewer technologies that have been demonstrated at full scale to remove selenium to less than 5 ug/L or have been in full scale operation for sufficient time to determine the long–term feasibility of the selenium removal technology. "

The technologies available from all searches yielded information on reverse osmosis, biological treatment systems including wetlands and biological digesters, adsorption systems including various types of media, ferrous iron addition, ion exchange, and catalyzed cementation (CH_2M Hill, 2010). A few technologies, like ion exchange, ferrous iron addition, and catalyzed cementation were not considered viable options based upon poor removal efficiency in pilot scale data or lack of pilot scale data (EPA, 2001, CH_2M Hill, 2010). Evaporative processes can be used as a secondary means of reducing discharge after other treatments. Additional information on the various technologies is included below.

8.4.3 Reverse Osmosis

Reverse osmosis (RO) membranes are capable of very high selenium rejection. Significant pre-treatment prior to reverse osmosis is necessary to avoid plugging of the membrane module. The RO reject water must be treated and disposed of using techniques like evaporation (crystallization), deep well injection, or possibly even an additional treatment for selenium reduction.

8.4.4 Biological Systems

Constructed treatment wetlands (Hansen et al, 1998) and biological digesters have shown some ability to remove selenium during pilot trials. Both options require large areas for set up. Biological digester systems require pilot testing, bench scale testing, and some start up time before the microbes optimize selenium conversion. Changes in selenium concentrations due to a spike at the inlet or dilute selenium levels due to rainfall may upset the microbial community.

Treatment wetlands may allow wildlife access to water that could be detrimental to aquatic life. Biological digester systems, anoxic biotreatment cells, and recently patented digester cells have proven to be effective on a small scale. Most data provided was for selenium concentrations starting in 1 mg/l while Lion's maximum concentration is 0.08 mg/l. The effectiveness of a biological system with such a dilute selenium influent concentration is unknown.

Lion Oil evaluated, for example, the "AB Met" technology that uses bacteria to reduce divalent cations, nitrates, and nitrites (Lion communication with vendor). Selenium is reduced to its elemental state and attaches to the biomass (GE). Approximately once a month, the reactors are backwashed and the selenium goes with the backwash (Lion communication with vendor). A backwash tankage and dewatering system would also need to be constructed to dewater the backwash water, and the filter cake may have to be disposed of as hazardous waste. Lion considered the option of installing the selenium treatment on the sour water stream, which contains most of the selenium. However, the AB Met technical representatives have told Lion that they have tried this option at another refinery, but the AB Met process is not effective at removing selenium in sour water due to the valence state of the selenium

8.4.5 Adsorption Systems

Adsorption is a process where the selenium is removed from the wastewater stream by attaching to a solid particulate media. Adsorption media are typically inorganic metallic hydroxide whose surface is selective for specific contaminants. Bayoxide, a granular ferric oxide, is one adsorption media recently demonstrated to be effective at a 160,000 barrel Ohio refinery for selenium reduction to meet a permit limit of 12 ppb (Snyder, 2010). The concentration of the selenium prior to treatment at the Ohio refinery is not reported in literature at this time. Once Bayoxide media is “spent”, it may be disposed of in a landfill (Severn Trent, 2006). Additional media that have been used on a small scale for selenium removal include NXT-2, Pureflow Adsorbsia GTO, and Pureflow Activated Alumina (vendor brochures). Pureflow adsorption media are typically used to reduce selenium concentration from ground water used for drinking water (vendor communication).

8.4.6 Deep Well Injection

An option that does not reduce the selenium, but disposes of wastewater is deep well injection. Lion evaluated the development of nine, Class 1, UIC disposal wells. The well field would be five miles from the refinery and five miles away from each other. The wells would have to be capable of receiving 2.61 million gallons per day to handle all of the refinery’s effluent. Construction of the deep well injection system would be a single trunk line to the well field with multiple branch lines distributing wastewater to the individual disposal wells.

Deep well injection would require obtaining permits for UIC disposal wells, acquisitions of easements for pipelines and subsurface facilities and subsurface injection lease rights, as well as the construction of the pipelines and well heads. The biggest difficulty for this option is finding a suitable non-producing formation removed from existing UIC wells. GLCC has injected wastewater into the non-productive Hosston Formation through numerous Class 1 wells. Increases in reservoir pressure resulting from past, as well as future, fluid injection could limit the longevity of any proposed new wells.

8.4.7 Ouachita River Pipeline

Lion Oil has joined with three other entities in the El Dorado area (El Dorado Chemical Company, Great Lakes Chemical Corporation and the City of El Dorado, Arkansas) to develop an alternative discharge point. This group of direct dischargers have developed and are implementing a plan to transfer their wastewater discharges to Ouachita River through the construction of a pipeline.

A Notice of Award for construction was issued on June 21, 2012. The pipeline construction was initiated on August 21, 2012 and as of January 1, 2013 is approximately 65% complete. It is anticipated that the pipeline construction will be completed by October 2013. Operating cost is based on pumping power and shared maintenance with pipeline participants. After construction of the pipeline, Lion Oil will be able to meet its limits that apply to its outfall to the Ouachita River, but not the limits that apply to its outfall on Loutre Creek.

8.4.8 Third Party Rulemaking

The option to modify the selenium and dissolved minerals criteria for site specific conditions is available through the third party rulemaking in Arkansas. Site specific criteria would allow an increase in the selenium and dissolved minerals effluent limitations, allowing Lion Oil to meet future permit limits.

8.5 TDS Removal or Reduction Technologies

EPA has no Best Available Technology (BAT) for removal of chloride, sulfate, or TDS from waste streams. While ion exchange (anion) and reverse osmosis treatment technologies exist, these methods currently are not cost effective on a large scale and are not typically recommended for treatment of waters prior to discharge to the levels required in the current instream water quality criteria. Also, as noted above, the concentrated reject streams generated from such processes present their own unique set of potential environmental risks which can be much greater than the waste waters from which the contaminants were extracted. In addition this advanced treatment places large burdens on the cost effectiveness of the facility and goods produced.

The technical limitations and uncertain environmental effects of concentrated waste streams generated from ion exchange and reverse osmosis treatment make the treatment alternative infeasible when other alternatives are considered. Lion Oil has investigated the capital and annual operating costs to install advanced treatment for reduction of TDS in the effluent and those alternatives are summarized in Table 8.1.

8.6 Cost of Technologies, Timing, and Feasibility for the Compliance with the Current Total Selenium and Dissolved Minerals NPDES Permit Limits

This section presents information on the cost of the various technologies and timing to implement such options to comply with the NPDES permit limits for selenium and dissolved minerals.

8.6.1 Reverse Osmosis (RO) (for selenium and dissolved minerals)

Reverse osmosis (RO) with a crystallizer for the reject stream could take 4 years to implement. During that time pilot testing, engineering design, permitting, and construction of the RO system would occur for approximately $44,000,000 capital cost and annual operating and maintenance cost of $5,800,000 ($5.8 Million).

RO with deep well injection of the RO reject stream is estimated to take 5 years to implement. The additional hurdle for this option is finding a suitable non-producing formation removed from existing UIC wells. The most probable capital cost is $33,800,000 with $4,400,000 annual operating and maintenance cost.

8.6.2 Biological Reduction Processes after RO (for additional selenium treatment)

RO may not adequately remove selenium, but it is a treatment option evaluated to meet dissolved minerals permit limits. The cost of RO with, for example, AbMet biological treatment ranges from $55,800,000 to $66,000,000 depending upon the method of disposal of the reject water, deep well injection or crystallizer respectively. The annual operating and maintenance cost ranges from $10,400,000 to $11,800,000 for deep well injection or crystallizer respectively. The estimated time to implement is 4.5 years for the RO with crystallizer biological option, and 5 years for the RO with deep well injection biological option.

8.6.3 Adsorption Technology Treatment after RO (for additional selenium treatment)

RO may not adequately remove selenium, but it is a treatment option evaluated to meet dissolved minerals permit limits. The cost of RO with, for example, Bayoxide adsorption treatments range from $40,400,000 to $50,700,000 depending upon method of disposal of the reject water, deep well injection or crystallizer respectively. The annual operating and maintenance cost ranges from $6,400,000 to $7,800,000 for deep well injection or crystallizer respectively. The estimated time to implement is 4.5 years for the RO with crystallizer adsorption option, and 5 years for the RO with deep well injection adsorption option.

8.6.4 Deep Well Injection (for selenium and dissolved minerals)

An option that does not reduce the selenium or dissolved minerals, but disposes of wastewater is deep well injection. The long term effectiveness of the option is uncertain due to the difficulty in finding a suitable non-producing formation and the separation for existing UIC wells. The time to implement the deep well injection is 5 years and estimated to have capital costs of $47,400,000 with annual operating and maintenance costs of $4,200,000.

8.6.5 Water Quality Standards Modification (for selenium and dissolved minerals)

The water quality standards modification allows the continuation of the existing discharge in Loutre Creek, and maintains the existing instream aquatic life uses that are characterized by a Limited Gulf Coastal Fishery as allowed by the small watershed (less than $5 mi^2$ at the mouth of Loutre Creek) in an urban use dominated watershed with historical oil field/resource extraction.

8.6.6 Ouachita River Pipeline (for selenium and dissolved minerals)

This option has two possibilities. One option is an individual City of El Dorado Water Utility (EDWU) pipeline to the Ouachita River. Under this option, GLCC, EDCC, and Lion Oil would pay for disposal of their wastewater based on current EDWU sewer rates. The second option is the Joint Pipeline discussed in detail in Section 8.4.7 where the operating costs are based upon power usage for pumps and shared pipeline maintenance costs.

Summary of costs, time to implement, and feasibility is summarized in Table 8.1.

Table 8.1. Summary of alternative for selenium and dissolved minerals permit compliance at Lion Oil.

Technologies / Approaches Considered	Timing to Implement	Estimated Capital Cost	Annual Operating Cost	Feasibility Summary
Reverse osmosis ("RO") with crystallizer for the RO reject steam (for selenium and dissolved minerals)	4 years	$44,000,000	$5,800,000	Pilot testing, engineering design, permitting, construction.
RO with deep well injection of the RO reject (for selenium and dissolved minerals)	5 years	$33,800,000	$4,400,000	Deep well injection depends on suitable non-producing formation and well location(s) removed from existing UIC wells.
RO with deep well injection of the RO reject and adsorption technology add-on selenium treatment (if options (1) and (2) stated above do not adequately address selenium) (for additional selenium treatment)	5 years	$40,400,000	$6,400,000	Deep well injection depends on suitable non-producing formation and well location(s) removed from existing UIC wells.
RO with crystallizer for the RO reject steam and adsorption technology selenium treatment (for additional selenium treatment, if options (1) and (2) stated above do not adequately address selenium) (for additional selenium treatment)	4.5 years	$50,700,000	$7,800,000	Pilot testing, engineering design, permitting, construction.
RO with deep well injection of the RO reject and biological reduction technology add-on selenium treatment (if options (1) and (2) stated above do not adequately address selenium) (for additional selenium treatment)	5 years	$55,800,000	$10,400,000	Deep well injection depends on suitable non-producing formation and well location(s) removed from existing UIC wells.
RO with crystallizer for the RO reject steam and biological reduction technology add-on selenium treatment (for additional selenium treatment)	4.5 years	$66,000,000	$11,800,000	Pilot testing, engineering design, permitting, construction

Technologies / Approaches Considered	Timing to Implement	Estimated Capital Cost	Annual Operating Cost	Feasibility Summary
Deep well injection of all of the refinery's effluent (for selenium and dissolved minerals)	5 years	$47,400,000	$4,200,000	Deep well injection depends on suitable non-producing formation and well location(s) removed from existing UIC wells.
Third party rulemaking for selenium and dissolved minerals, including supporting analyses (for selenium and dissolved minerals)	2 years	$750,000 to $1,250,000 (an estimate of consulting costs)	N/A	Decision on selenium and dissolved minerals rulemaking within 12-18 months of submittal to ADEQ. With successful modification of criteria no additional operating cost.
Individual (EDWU) pipeline to the Ouachita River (for selenium and dissolved minerals)	1.25 years	$2,600,000 (Lion Oil allocation of total project cost)	$2,100,000	Design/permitting complete based on Joint Pipeline, one year construction. Assumes Lion's share of pipeline capital cost is paid in year one. Operating cost is based on the current EDWU sewer rate.
Joint (EDWU, GLCC, EDCC, and Lion) pipeline to the Ouachita River (for selenium and dissolved minerals)	1.25 years	$2,600,000	$305,000	Notice of Award for construction issued 6/21/12. Construction began on 8/1/2012 and as of January 1, 2013 the pipeline construction is approximately 65% complete. One year construction period on schedule. Operating cost is based on pumping power and shared maintenance with pipeline participants.

8.6.7 Source Reduction/Pollution Prevention

The primary factor determining the concentrations of selenium is the source of the crude oil and the concentration of selenium in the raw crude oils. The total selenium in the waste water is primarily contributed from refining operation as a waste by-product of the cracking process. Recent facility improvements to conserve energy resources, to produce ultra-low sulfur fuels, to reduce sulfur in air emissions, and water conservation efforts have not had appreciable effects on the concentration of selenium in the wastewater. However, recent facility improvements to reduce sulfur in air emissions have contributed to the increase in dissolved minerals in the process wastewater. The facility has implemented pollution prevention activities to limit contamination.

8.6.8 Alternative Selected

The alternative selected is the modification of the water quality criteria as discussed in Section 8.6.5. The proposed changes to the dissolved minerals water quality criteria are more stringent than those approved by the Commission in 2007 and are possible due to the addition of SO2 reducing catalyst additives to Lion Oil's fluid catalytic cracking unit regenerator.

In addition, Lion Oil is committed to continued participation in the joint pipeline discussed in Section 8.6.6.

The details of the selected alternative are provided in Section 9.

9.0 SELECTED ALTERNATIVE

Based on the documentation of the existing fisheries use and the historical and existing instream conditions, the following modifications to the water quality standards are proposed:

1. Modification of the Loutre Creek fishery use to a new subcategory called Limited Gulf Coastal Fishery due to the small and urbanized watershed and historical resource extraction land-use.

2. Modification of the total selenium criteria for Loutre Creek to 38 µg/L, which is the 95th percentile of the instream concentrations as measured over the entire length of Loutre Creek during the implementation of the Loutre Creek UAA QAPP.

3. Modification of the dissolved minerals criteria for Loutre Creek to make them more stringent when compared to the criteria adopted by the Commission in 2007, but not approved by EPA. The proposed modifications are as follows:

   - Chloride from 256 mg/L to 241 mg/L
   - Sulfate from 997 mg/L to 645 mg/L
   - TDS from 1756 mg/L to 1354 mg/L

These proposed modifications are supported by the documentation which meets the requirements of Regulation 2.303 for fishery use modification.

Table 9.1 summarizes the recommended changes to the designated use and the water quality criteria for selenium and dissolved minerals for Loutre Creek. Figure 9.1 depicts the reach of Loutre Creek for which modifications are proposed.

Table 9.1. Proposed water quality standards modifications for Loutre Creek. 2012.

Loutre Creek
Modify fisheries use: From Typical Gulf Coastal Fishery to To Limited Gulf Coastal Fishery (Small/Urbanized/Historical Resource Extraction)
Loutre Creek – from Hwy 15 South to the confluence of Bayou de Loutre Instream Criteria:
Amend stream selenium criteria: From 5 ug/L (chronic) and 20 ug/L (acute) to 38 ug/L Amend stream dissolved minerals criteria. These changes are in relation to the criteria approved by the Commission in 2007, but not approved by EPA. Chloride from 256 mg/L to 241 mg/L Sulfate from 997 mg/L to 645 mg/L TDS from 1756 mg/L to 1354 mg/L

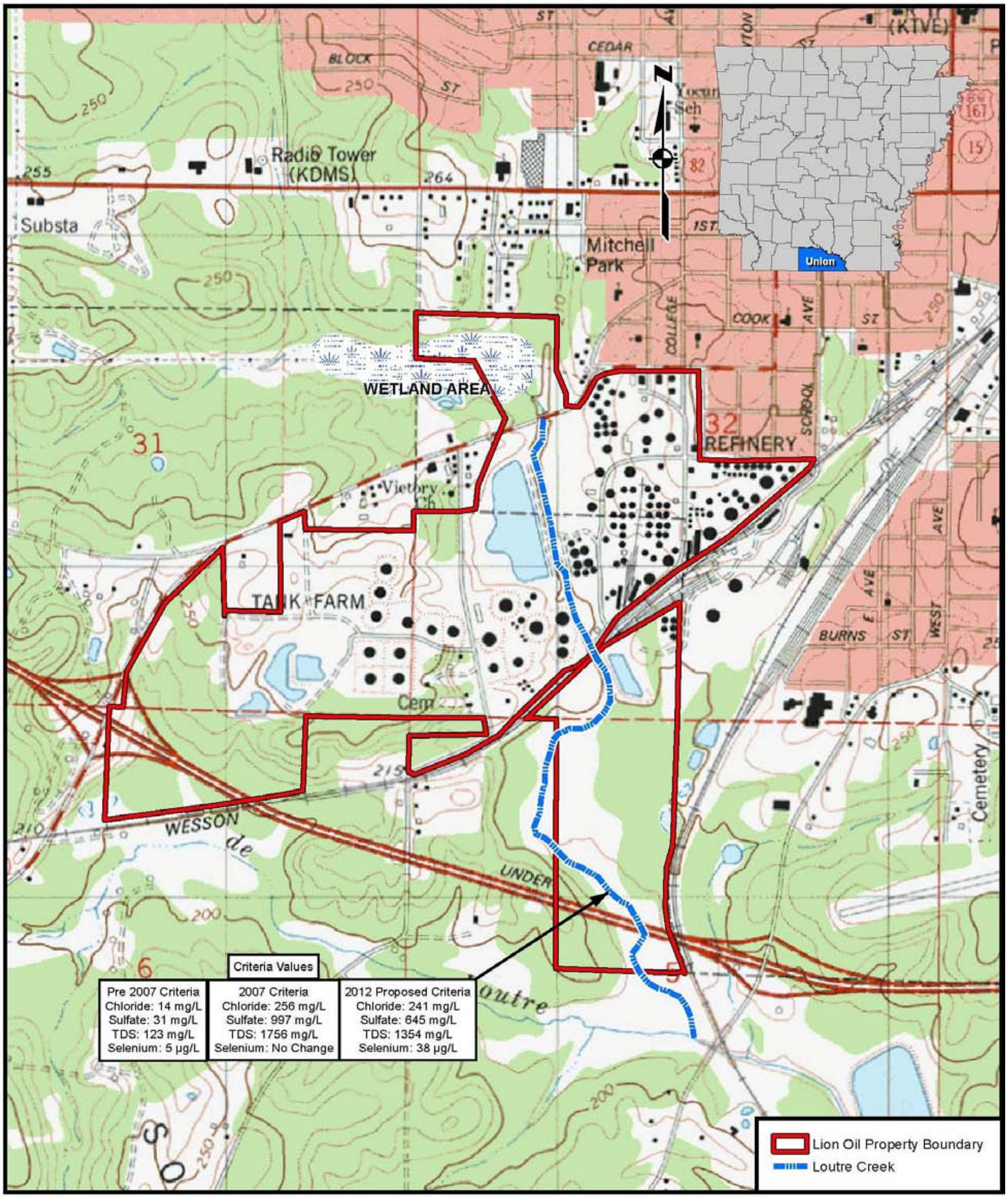


Figure 9.1. Existing and proposed selenium and dissolved minerals for Loutre Creek.

10.0 REFERENCES

Arkansas Department of Pollution Control and Ecology , 1987. Physical, chemical, and biological characteristics of Least disturbed Reference streams in Arkansas' Ecoregions. Volume I : Data Compilation. 685 pp.

Arkansas Department of Pollution Control and Ecology , 1987. Physical, chemical, and biological characteristics of Least disturbed Reference streams in Arkansas' Ecoregions. Volume II : Data analyses. 148pp.

ADEQ, 1988. Rapid Bioassessment of Lotic Macroinvertebrate Communities: Biocriteria Development. 45 pp.

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

ADEQ, 2000. Administrative Guidance Document Pages IX-5 through IX-7 as approved on January 1994 by Director Randall Mathis and as provided in ADEQ CPP dated January 2000 (update and revisions).

ADEQ, 2007. Regulation No. 2, As Amended: Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas, January 2007 (Regulation No. 2).

APCEC, 2007. Regulation No. 2, As Amended: Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas, January 2007 (Regulation No. 2).

Booth, D. B. and C.R. Jackson, 1997. Urbanization of Aquatic systems, degradation threshold, stormwater detection and the limits of mitigation, Journal of the American Water Resources Association 33, 1077-1090.

Coyle, J.J. Bucker, D.R., Ingersoll, C.G., Fairchild, J.F. and May, T.W. (1993), effect of dietary selenium on the reproductive success of bluegills (*Lepomis macrochirus*). Environmental Toxicology and Chemistry, 12:551-565.doi:10.1002/etc.5620120315

Cuffney, T.F., R.A. Brightbill, J.T. May, and I.R. Waite, 2010. Responses of Benthic Macroinvertebrates to Environmental Changes Associated with Urbanization in Nine Metropolitan Areas. Ecological Applications, 20(5), 2010. Pp 138-1401.

EPA, 1991. Technical Support Document for Water Quality Based Toxics Control. EPA/505/2-90-001. March 1991.

EPA, 2001. Selenium Treatment/Removal Alternatives Demonstration Project Mine Waste Technology Program Activity III, Project 20. EPA/600/R-01/077. June 2001.

Barbour, M.T. 1999. Rapid Bioassessment Protocols for use in Wadeable Streams and Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. USEPA. EPA 841-B-99-002.

Booth, D. B. and C.R. Jackson, 1997. Urbanization of Aquatic systems, degradation threshold, stormwater detection and the limits of mitigation, Journal of the American Water Resources Association 33, 1077-1090.

Brown and Caldwell. 1986. UAA of Loutre Creek, Final Report Water Quality evaluation of Loutre Creek. January 17, 1986.

Buckalew, A.R. and R.B. Buckalew. The Discovery of Oil in South Arkansas, 1920-1924. Union County Sheriff's Office Web site. http://www.unioncountysheriff.net/viewpage.php?page_id=19

Cuffney, T.F., R.A. Brightbill, J.T. May, and I.R. Waite, 2010. Responses of benthic macroinvertebrates to environmental changes associated with urbanization in nine metropolitan areas. Ecological Applications, 20(5), 2010. Pp 138-1401.
Exponent, 2010. Technical Briefing Paper on Selenium for Tennessee Valley Authority. Doc No. 0900462.00002010609 AF26.

GBMc and Associates. 2006. Loutre Creek Section 2.306 Site Specific Water Quality Study. October 2006.

GE, 2010. ABMet – Advanced Biological Metals Removal Process from web-site accessed October 25, 2010 www.gewater.com/products/equipment/other_equipment/ABMet.jsp

Hansen Drew. 1998, Drew Hansen, Peter J. Duda, Adel Zayed, and Norman Terry. 1998. Selenium Removal by Constructed Wetlands: Role of Biological Volatilization. Environ. Sci. Technol. 1998, Vol 32. pp 581-597 (Environmental Science & Technology, Vol. 32, No. 5, 1998) FOUND on the web here:www.bren.uwww.bren.ucsb.edu/academics/courses/219/Readings/Hansen et al_EST_1998_v32p591.pdf

Lazorchak, J.M. 1998. Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters. USEPA. EPA 600-4-90-030.

Lemly, A.D. 1993. Tevatogenic Effects of Selenium in Natural Populations of Freshwater Fish. Ecotoxicol Environ 1993; 26: 181-204.

Luoma, S.N. Presser, T.S. 2009. Emerging Opportunities in Management of Selenium Contamination. Environmental Science and Technology, Vol 43 No 22 pp 8483-8487.

Merritt R&J.C. Cummings 1989. Aquatic insects of North America. 862 pp.

Moyle, P.B, and R.D. Nichols. 1973. Ecology of some native and introduced fishes of the Sierra Nevada foothills in central California. Copeia 1973:478-490.

Paul, M.J. and J.L. Meyer, 2001. Streams in the Urban Landscape. Annual Review of Ecology and Systematics. 32:333- 365

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

Presser, T.S.; Luoma, S.N. 2006. Forecasting Selenium Discharges to the San Fransico Bay – Delta Estuary: Ecological Effects of a Proposed San Luis Drain Expansion. Professional Paper 1646. USGS, Reston Virginia, 2006.

Presser, T.S. and Luoma, S.N. 2010. A Methodology for Ecosystem Scale Modeling of Selenium. Integrated Environmental Assessment and Management, V6 No 4, pp 685-710.

Ralston, N.V.C, et. al. Biogeochemistry and Analysis of Selenium and its species. Prepared for North American Metals Council. Washington D.C.

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

Sandy, Tom and Cindy DiSante, 2010. Review of Available Technologies for the removal of Selenium from water. Prepared for North American Metals Council by CH2M Hill. Available at www.namc.org/docs/00062756.pdf

Sarver, R. 2000. Missouri Department of Natural Resources SRCC Technical Report 97-1.

Severn Trent, 2006. Bayoxide® E IN-20: Adsorptive Solutions for Non-Drinking Water Applications, vendor brochure June 2006 found at www.severntrentservices.com

Simon, Thomas P. 2003. Biological response signatures; indicator patterns using aquatic communities.576pp.

Snyder, J. Unique Technology Removes Selenium from Wastewater. From Water and Wastewater.com (wateronline.com) September 13, 2010 10:58:01 PM (same as from http://www.kroff.com/pdf/selenium_abatement_case_study.pdf)

Stuber, R.J., G. Gebhart, and O.E. Maughan. 1982. Habitat suitability index models: Bluegill. U.S.D.A. Fish and Wildlife Service. FWS/OBS-82/10.8. 26pp.

VSEP® STS, Vibratory Shear Enhanced Process Selenium Treatment System, (no date – vendor brochure). www.vsep.com.

Wang , L and J. Lyons, 2003. Fish and benthic macroinvertebrate assemblages as indicators of Stream Degradation in Urbanizing Watersheds. Chapter 13 IN Biological Response Signatures, Ed T.P.Simon.QH541.1515B562002.

[1]Wang, L and P Kanehl, 2003. Influences of Watershed urbanization and instream habitat on Macroinvertebrates in cold water streams. Paper No. 02152 Journal of the American Water Resources Association. 1181-1196.

Whitmore, C.M., C.E. Warren, and P. Doudoroff. 1960. Avoidance reactions of salmonid and centrarchid fishes to low oxygen concentrations. Trans. Am, fish. Soc. 89:17-26.

.

[1] Stuber, R.J., G. Gebhart, and O.E. Maughan. 1982. Habitat suitability index models: Bluegill. U.S.D.A. Fish and Wildlife Service. FWS/OBS-82/10.8. 26pp.