

## **Plant Root Study**

### **1. General Aspects**

The plaintiffs in this case have alleged that the operations of BP have impacted an area of soil on the Guidry property. In order to determine the magnitude of the impacts, various studies were undertaken. The potential remediation of soils in oil fields is often dependent on the depth at which roots of plants extend into the soil. Without knowing plant root depths, no reasonable remediation plan can be formulated for a site that has or may have been impacted in an oil field. Since scant literature exists in the area of the effects of oil field E&P activities on plant roots, the authors have undertaken several site specific investigations to determine root depth and effective root zones (ERZs) of plants growing on the Guidry property. During the course of these investigations, they have found that root densities and penetrations in various soil types have varied greatly from site to site. This is particularly important with the changes in soil types, disturbance factors, area hydrology and the intended future use for various properties. As such, it is imperative to tailor an investigation that is specific to the plants and soils of the areas of alleged impact and surrounding areas in order to determine the particular depths at which plants grow and for the potential formulation of depths where remediation measures may be required.

Another important consideration that they have found in many studies is that depths or depth intervals of soil samples for salt parameters such as electrical conductivity (EC), exchangeable sodium percentage (ESP) and sodium adsorption ratio (SAR) generally overestimate (at many times grossly so) these parameters. For example, soil samples extracted from the 0 to 2 foot and 0 to 4 foot depths below ground surface, which is mixed for analysis, can show levels that are much higher than those within the ERZs that only extend to 6-12 inches in depth. To be accurate for salt parameters in root zones, soil samples should reflect specific depths of the ERZs and/or root zones, not deeper depths where roots do not occur or occur in only negligible quantities.

### **2. Plant Root Study**

To determine the root depths and distributions of the woody vegetation, four (4) trees were selected for study. The locations of these plants are shown in Figure 1. The general distribution of plants that grow on the Guidry property, as described above, represents a typical plant community distribution for the site and represent dominant species for the area. Trees selected for the study were measured (where possible) as follows: (1) diameter at breast height (dbh), (2) distance from the bole (trunk) of the tree (3) the deepest depth of the deepest root and

(4) depth to the top of the deepest root at its deepest depth. These data plus additional root depths of all major roots were entered on a root form along with species name and geographic coordinates showing the location of the plant.

Due to wet soils and rainy conditions most roots were measured to the tops of the roots. Extensive reviews were conducted of the dominant roots on the trees by probing with steel rods to determine the general depths of all of the major roots around the tree. After comparing to those with the greater depths, a root or several roots were selected to follow by either probing all along the length of the root or removing the soil from the top of the root to observe the root as it extended away from the bole of the tree. Along with the major roots, views of the roots and the growth of feeder roots (where practical) were also taken of the trees.

Root depths and other important information along with roots drawings of most trees depicting major roots extending from the boles of the trees are shown on the tree root forms in Appendix A. Photographs taken at each tree and areas around it are shown in Appendix B. with other sampling location photos. At the same time that the roots were viewed or probed, a review was made of the sample tree and existing plants around the sample point to determine the plant conditions and the notation of any impacts such as leaf scorch, leaf burning and dieback from any potential E&P impacts. Other factors watched for were epicormic branching, witches' brooms, dieback and other known features of salt impacts. Where applicable, this information is given in the results section below for various observation points. In addition to tree roots, observation points were established in a pipeline area on the tract. Roots were observed in the soil profile for general quantitative distribution by notations of very abundant, abundant, common, sparse and very sparse occurrences.

Based on the abundance factors and depths for both trees and herbaceous plants, effective root zones (ERZs) were determined for the plants. Effective root zone, according to one popular definition, represents the depth of the roots that are necessary for the plants to grow and complete their life cycles. The effective root zone does not represent the deepest roots but comprises the depth where the majority of the roots that sustain the plants through growth and reproductive phases reside. Another definition of effective root zone states that ERZ is the area where eighty percent of the roots reside beneath the plants and from where the plants receive their nutrients. The author has researched many areas in Louisiana and has found that this definition generally underestimates the depth of the ERZs. Therefore, the former definition was used for the Guidry property.

### 3. Results of Plant Root Study

Four (4) trees were investigated on the Guidry property for root depths. Figure 1 shows the location of the trees and the observation points. These trees included the dominant species that occur on the property. Appendix B shows the photographs of the plants that were observed and conditions of surrounding vegetative communities. Root diagrams and Individual measurements of roots are shown in Appendix C. Results of the tree root investigations for ERZs are shown in Table 1.

In addition to reviewing the tree roots and the surrounding herbaceous vegetation at the tree root study site, an additional two (2) observation areas were viewed on the pipeline area on the west side of the Guidry property. These are shown in Figure 1. Photographs were taken to show the root profile under the plants and the general depths and quantities of roots that occurred at different levels beneath the plant. An example is shown for Tree T-04 in Photo PC150058. Each tree observation that was investigated is described in the following section:

#### 3.1. Tree T-01. Tree T-01. Honey locust (*Gleditsia triacanthos*) (dbh = 8.1 in.; ERZ = 6.0 in.)

Tree T-01 is a honey locust with a dbh of 8.1 inches. The tree is in good condition with no impacts from E&P activities such as sodicity factors or petroleum hydrocarbons. Photo PC130012 shows the bole of the tree and shallow root pattern while Photo P3280059 shows the crown of the tree. This tree is growing in a typical stand and is representative of the trees that grow on the Guidry property. Extensive probing around the tree indicated that the majority of the roots were located close to the surface with numerous feeder roots coming from the main roots that sat right on top of the soil surface. Trees in the surrounding area consist of sugarberry, American elm with an occasional sweetgum. Understory species included reproduction of the overstory such as rough-leaved dogwood, occasional small water oak, silverling and deciduous holly in the stand. Ground cover consists mostly of ragweed, *Rubus* sp., poison ivy and some goldenrod in patches. There is also some soft rush at the location. All of this vegetation is in good condition showing no impacts from E&P activities. Photo P3280060 shows the surrounding vegetation that is also in good condition. As shown in the diagram in Appendix C, numerous roots occurred at depths less than 3 inches on the tree with the maximum depth found at 5.75 inches on Root 1A. Based on the extremely shallow nature of the roots, the ERZ for Tree T-01 would be 6.0 inches or less.

### **3.2. Tree T-02. Sugarberry (*Celtis laevigata*) (dbh = 5.7 in.; ERZ = 6.0 in.)**

Tree T-02 is a 5.7 inch dbh sugarberry that is growing to the east of Tree T-01. Photo P3280063 shows the bole of the tree while Photo P3280062 shows the tree canopy. This tree is in excellent condition with no evidence of any kind of damage from E&P activities. Vegetation at the site consists of a heavy overstory of Chinese tallow with a number of honey locust dotted in the area. These are multi-trunked indicating that one time in their life history they were apparently mowed with something such a bushhog. There is basically no understory at this site. There are a couple of trifoliolate oranges dotted around this area and some small honey locust dotted in the area along with one small water oak at this site. Ground cover consists of basket grass, curly dock, ironweed and some *Rubus* sp. in this area. In looking at the overstory trees, there is no evidence of dieback of the vegetation, no limb dieback or sloughing of the bark with these trees. As shown in Appendix C, root depths on this tree are very shallow at a depth of less than 4.75 inches from the surface. There is only one root that was at 7.2 inches beneath the soil surface. All of the roots are healthy showing no signs of any kind of impacts. Based on these considerations, the ERZ for this tree is a generous 6.0 inches.

### **3.3. Tree T-03. Sugarberry (*Celtis laevigata*) (dbh = 10.5 in.; ERZ = 6.0 in.)**

Tree T-03 is a 10.5 dbh sugarberry that is in good condition with no evidence of dieback or any other symptoms related to E&P activities. Photo P328006 shows the crown of the tree while Photo P3280067 shows the bole of the tree. Vegetation in the surrounding area consists of primarily Chinese tallow with an occasional elm and sugarberry in the stand. A couple of trees have been overtopped with poison ivy and shaded out, however, this is not related to E&P activities. Vegetation in the understory consists of some reproduction of the overstory with Chinese tallow dominating along with some small water oaks. Ground cover consists of erigeron, ranunculus, groundsel, common vetch, sow thistle and giant ragweed. All of this vegetation is in excellent condition as of March 27 showing no evidence of any kind of impacts from E&P activities. As shown in Appendix C, all roots with the exception of one were less than 7.0 inches in depth to the tops of the roots with the overwhelming majority of the roots extending only 2.75 inches into the ground for the surface of the root. One root measured 11.5 inches in depth. Extensive review of this root showed that the site had been disturbed at this location and the root went into atypical soil for the site. Based on the very shallow nature of the roots on this tree, an ERZ of 6.0 inches would be appropriate for this tree.

### **3.4 Tree T-04. Chinese tallow (*Sapium sebiferum*) (dbh = 6.4 in.; ERZ= 5.0 in.)**

Tree T-04 is a Chinese tallow tree that has a dbh of 6.4 inches. This tree is located just slightly east of the Limited Admission soil area. This tree is in excellent condition. Photo P3280069 is a view of the bole of the tree and surrounding vegetation. Photo P328006 shows the crown of the tree. This tree is in excellent condition with no evidence of any kind of damage from E&P activity. Extensive probing and uncovering of the roots around the tree showed very shallow roots extending out from the tree at a very shallow depth (Photo PC150058). Overstory in the surrounding area is overwhelmingly dominated by Chinese tallow with an occasional young sweetgum and American elm dotted around the area. Understory is reproduction of the overstory. Ground cover consists of weedy species and include broomsedge, a few small *Carex* sp., sugarberry and an occasional silverling in the understory. Weedy-type species consist of goldenrod, *Rubus* sp., Virginia creeper and poison ivy. Photo P32800 is facing to the west from the Tree T-04 across the BP alleged impacted soil area. The vegetation consists of a mixture of weeds and some wetland species. These are all in good condition and showing excellent growth. The vegetation is a healthy stand showing no evidence of impacts from E&P activities. Species include groundsel, fleabane, spikerush, goldenrod, sumpweed, buttercup, thistle and some verberna. Based on the very shallow distribution of roots on Tree T-04, a ERZ of 5.0 inches would be appropriate for this tree.

### **3.5 Observation 1-A.**

As shown in Figure 1, this observation is located within the pipeline ROW on the west side of the Guidry property south of the Bundrick property. Photo P3270001 shows the soil profile and roots. Roots in the first inch are very abundant while those from 1.0 inch to 3.25 inches are abundant. Roots from 3.25 to 7.0 inches are common to sparse and 7.0 to 10 inches are sparse. Below 10 inches the roots are sparse to none in the profile. Photo P3270007 shows vegetation growing around the area facing north. None of the vegetation in the area except from plants sprayed by herbicide shows any impacts related to E&P activities. The stand is represented by a lush growth of grasses and weedy species that are growing in a manner typical of those outside the oil field. Based on the root distribution an ERZ of 8.0 inches would be more than adequate for this site.

### **3.6 Observation 2-A.**

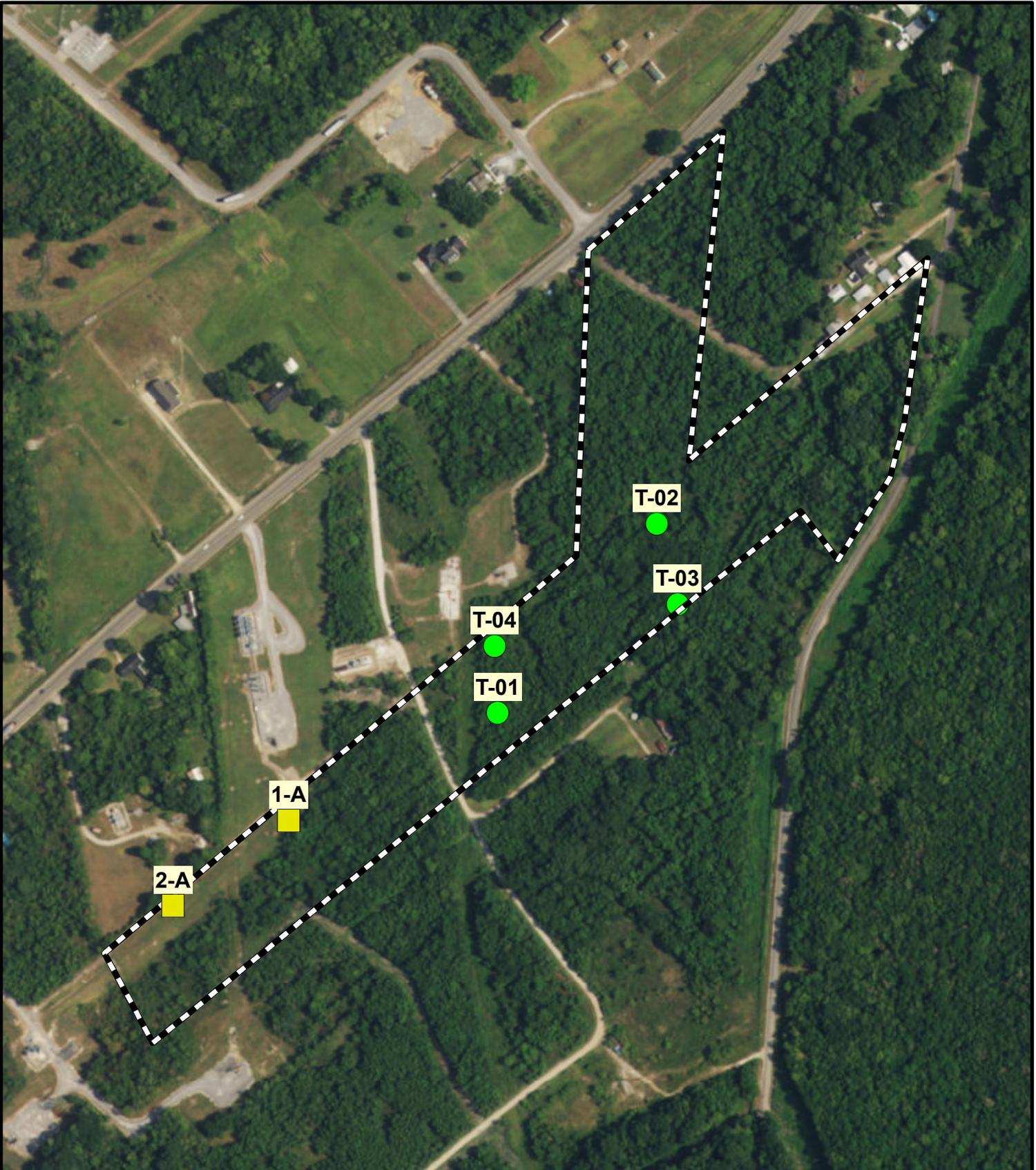
Observation 2-A is located in the southwest corner of the Guidry property (Figure 1). Root and soil profile as shown in Photo P3270017 consist of a very abundant root distribution in the first inch of soil followed by a common distribution from 1.0 to 5.0 inches and sparse from 5.0 to 10.0 inches. Below 10.0 inches root

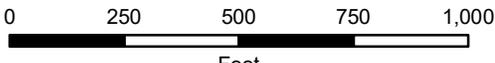
distribution is sparse to none. Photo P3270019 is facing north with a lush stand of St. Augustine grass and other species such as black medic and bahia grass. The line of trees in the background are growing on the property boundary with a band of dead vegetation along a pipeline in front. All of the unsprayed vegetation in the foreground is growing good showing no impacts from saline or sodicity factors or petroleum hydrocarbons from E&P activities. Root distributions at this location indicate that an ERZ of 8.0 inches would be generous for this site.

**Table 1. Effective Root Zone (ERZ) of tree and grass species**

T-01	Honey Locust	<i>Gleditsia triacanthos</i>	6.0
T-02	Sugarberry	<i>Celtis laevigata</i>	6.0
T-03	Sugarberry	<i>Celtis laevigata</i>	6.0
T-04	Chinese Tallow	<i>Triadica sebifera</i>	5.0
T-05	St. Augustine Grass	<i>Stenotaphrum secundatum</i>	8.0
T-06	St. Augustine Grass	<i>Stenotaphrum secundatum</i>	8.0

The data from the plant root study showed that the effective root zones were very shallow for both trees and herbaceous stands on the Guidry property and the plant communities at the Limited Admission soil area and all over the rest of the property showed no impacts to the vegetation from any indicia that could be caused by sodicity factors from E&P activities. The plants are growing in an excellent fashion and not showing any dieback, leaf burning, epicormic branching, witches' brooms or other features that could be indicative of sodic factors. These plant communities are indicative of similar plant communities that I reviewed around the Anse La Butte Oil & Gas Field.



 Property Boundary	 <p>0      250      500      750      1,000</p> <p>Feet</p>
 Observations of Plants and Soil Profile Locations	
 Tree Root Study and Soil Profile Locations	

**Figure 1**  
**Tree Root Study and Plant Observation Locations**  
*Harold Guidry, et al. vs. BP America Production, et al.*  
*Anse la Butte Field, St. Martin Parish, Louisiana*

	Project: 07-181	<b>Holloway Environmental Services, Inc.</b> 9269 Hwy. 124 Harrisonburg, LA 71340
	Date: 4/17/2017	
	Drawn: PMR	
	Checked: LH	

## APPENDICES

## Appendix A

### SOIL DESCRIPTIONS AT TREE STUDY LOCATIONS ON THE GUIDRY PROPERTY

#### Tree T-01

Location (See Figure \_\_)

N 30° 15' 21.4"

W 91° 56' 24.8"

#### Soil—Acy silt loam (wet)

A1—0 to 2.5 inches; dark grayish brown (10YR 4/2) silt loam; structureless; wet slightly sticky; (large tree roots above ground on top of a dense compacted layer); massive; fine and very fine feeder root masses; abrupt wavy boundary.

A21-2.5 to 5.5 inches; light brownish gray (10YR 6/2) and brown (10YR 5/3) silt loam; strong thin platy structure; dry very hard; few fine and medium roots in old silted crawfish burrows; common fine black concretions; clear wavy boundary.

A22-5.5 to 10 inches; light brownish gray (10YR 6/2) silt loam; common medium distinct yellowish brown 10YR 5/6 mottles; massive; dry hard; common fine black concretions; abrupt smooth boundary.

Bt—10 to 42 inches; grayish brown (10YR 5/2) silty clay loam; many fine prominent red (2.5YR 5/6) mottles; moderate medium subangular blocky structure; dry hard; few fine roots; few medium Ca CO<sub>3</sub> concretions.

#### Tree T-02

Location

N 30° 15' 25.4"

W91°56' 19.7"

#### Soil—Acy silt loam (wet)

A1—0 to 2 inches; dark brown (10YR 3/3) silt loam; structureless; wet slightly sticky; (large roots above ground on top of a dense compacted layer); massive; fine and very fine feeder root masses; abrupt wavy boundary.

A2—2 to 8 inches; light brownish gray (10YR 6/3) silt loam; strong thin platy structure; dry very hard; few fine and medium roots in old silted crawfish burrows; clear wavy boundary.

Bt1—8 to 16 inches; light brownish gray (10YR 6/3) silty clay loam; many fine prominent red (2.5YR 5/6) mottles; moderate medium subangular blocky structure; dry hard; few fine roots; few medium CaCO<sub>3</sub> concretions; gradual wavy boundary.

Bt2—16 to 42 inches; light yellowish brown (10YR 6/4) silty clay loam; weak medium subangular blocky structure; dry hard; few fine roots.

### Tree T-03

N30° 15' 23.1"

W91° 56' 19.1"

### Soil-- Acy silt loam (wet)

A—0 to 3 inches; dark brown (10YR 3/7) silt loam; structureless; wet slightly sticky (large tree roots above ground on top of a dense compacted layer); massive; fine and very fine feeder root masses; abrupt wavy boundary.

A2—3 to 6 inches; grayish brown (10YR 5/2) silt loam; strong thin platy structure; dry very hard; few fine and medium roots in old silted crawfish burrows; clear wavy boundary.

Bt1—6 to 20 inches; brown (10YR 5/3) silty clay loam; many fine prominent red (2.5YR 5/6) mottles; moderate medium subangular blocky structures; dry hard; few fine roots; few medium CaCO<sub>3</sub> concretions; gradual wavy boundary.

Bt2—20 to 42 inches; light brownish gray (10YR 6/2) silty clay loam; common medium distinct yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; dry hard; few fine roots.

### Tree T-04

N 30° 15' 21.97"

W 91° 56' 25.08"

### Soil—Acy silt loam (wet)

A—0 to 3.5 inches; dark grayish brown (10YR 4/2) silt loam; structureless; wet slightly sticky; (large tree roots above ground on top of a dense compacted layer); massive; fine and very fine feeder root masses; abrupt wavy boundary.

A2—3.5 to 7 inches; grayish brown (10YR 5/2) silt loam; strong thin platy structure; dry very hard; few fine and medium roots in old silted crawfish burrows; clear wavy boundary.

Bt1—7 to 18 inches; dark grayish brown (10YR 4/2) silty clay loam; many fine prominent red (2.5YR 5/6) mottles; moderate coarse subangular blocky structure; dry hard; few fine roots; few medium CaCO<sub>3</sub> concretions; gradual wavy boundary.

Bt2—18 to 42 inches; grayish brown (10Y 5/2) silty clay loam; few medium distinct yellowish brown (10YR 5/6) mottles; moderate coarse subangular blocky structure; dry hard; few fine roots.

Appendix B

**PHOTOS**

Photo PC130012. Tree T-01 showing



Photo P3280059. Tree T



Photo P3280060. Bole of Tree T-01 with vegetation around it



Photo P3280063. Bole of Tree T-02, sugarberry



Photo P3280062. Crown of Tree T-02



Photo P3280066. Crown of Tree T-03



Photo P320067. Bole of T-03, sugarberry



Photo P3280069. Bole of Tree T-04, Chinese tallow



Photo P3280068. Crown of Tree T-04



Photo PC150058. Shallow roots of Tree T-04



Photo P3280070. Facing W from across BP soil impacted area



Photo P327001. Root Observation at 1A



Photo P327007. Facing N at Observation 1A.



Photo P3270017. Root Observation at 2A

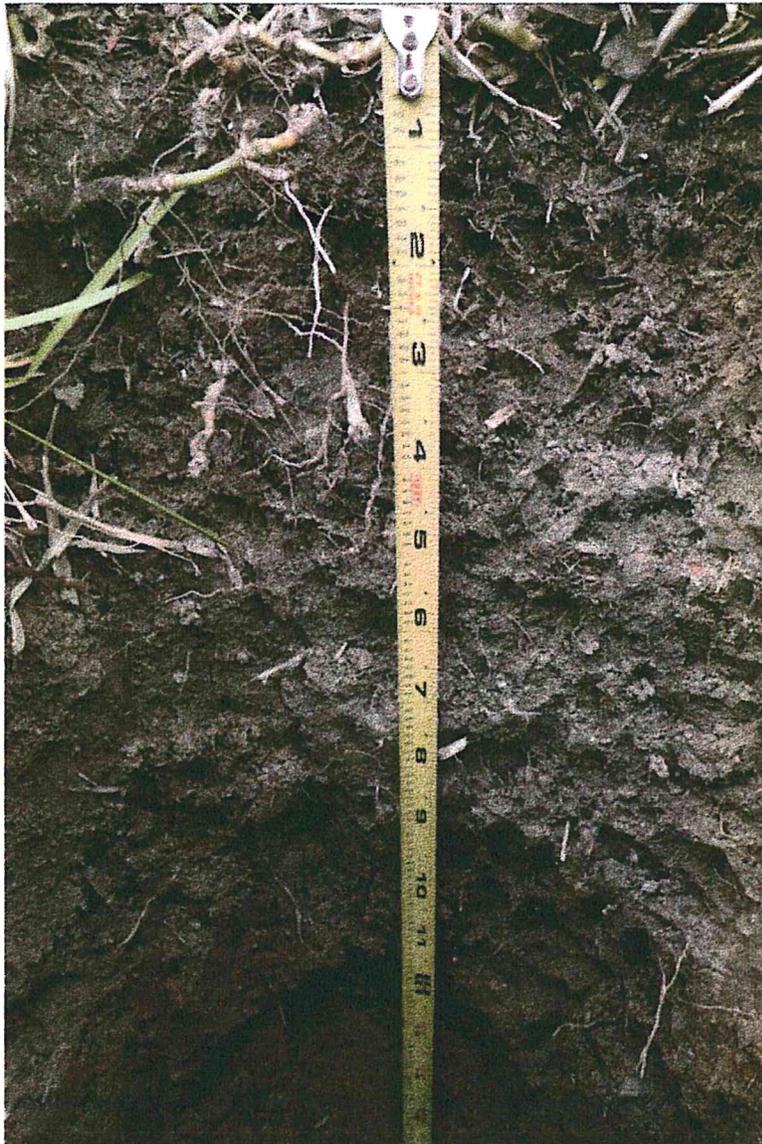


Photo P3270019. Facing N at 2A



Photo P3280051. Facing N at W side of BP soil impact area in pipeline ROW



Photo P3280052. Facing NE at center of BP soil impact area in pipeline ROW



Photo 3280053. Facing NE on E side of BP soil impact area in pipeline ROW



Appendix C

**TREE ROOT FORM**

TREE ROOT FORM

Date 12.13.2016 Observ. No. T-01 By Holloway/Touchet

Property Guidry Coords. 30°15'21" N 91°56'24.8" W

Other Info. See next page for roots and depths  
\_\_\_\_\_  
\_\_\_\_\_

Species Honey Locust (*Gleditsia triacanthos*) DBH/Circ. 8.1" / 25.5"

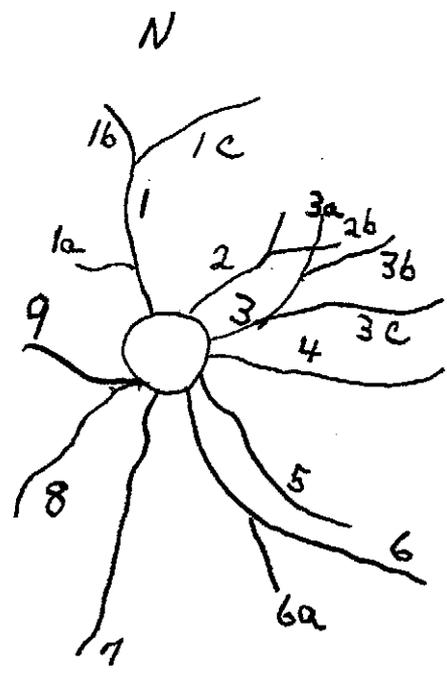
Root No. \_\_\_\_\_ Distance From Bole \_\_\_\_\_ Depth Top of Root \_\_\_\_\_

Depth Bottom of Root \_\_\_\_\_ Root Dia./Circ. \_\_\_\_\_

Root No. \_\_\_\_\_ Distance From Bole \_\_\_\_\_ Depth Top of Root \_\_\_\_\_

Depth Bottom of Root \_\_\_\_\_ Root Dia./Circ. \_\_\_\_\_

Notes: \_\_\_\_\_



# TREE ROOT FORM

Date 12.13.2016 Observ. No. T-01 Property Guidry

Species Honeylocust DBH/Circ. 8.1" / 25.5"

Added Roots		Depth In.		Root Dia.	Added Roots		Depth In.		Root Dia.
Root No.	Distance	Top	Bottom	Dia.	Root No.	Distance	Top	Bottom	Dia.
1	2.0'	+2.5"			5b	5.0'	2.0"		
1	5.0'	+1.8"			6	10.25'	3.0"		
1	9.0'	0.0"			6	12.6'	5.0"		
1a	2.0'	5.75"			6b	max	2.0"		
1c	10'	1.5"			7	6.5'	0.0"		
2	2.0'	2.5"			7	13.0'	5.0"		
2	4.0'	0.0"			7	15.0'	4.0"		
2	5.5'	0.5"			8	6.0'	0.0"		
3a	5.6'	1.75"			8	6-10'	3.0"		
3b	5.0'	0.0"			9	1.3'	2.0"		
3c	5.0'	0.0"	1.0"						
4	6.7'	4.0"							
4	7.0'	5.0"							

TREE ROOT FORM

Date 12.14.2016 Observ. No. T-02 By Holloway/Touchet

Property Guidry Coords. 30°15'25.4" N 91°56'19.8" W

Other Info. See next page for roots and depths

Species Sugarberry (*Celtis laevigata*) DBH/Circ. 5.7" / 18.0"

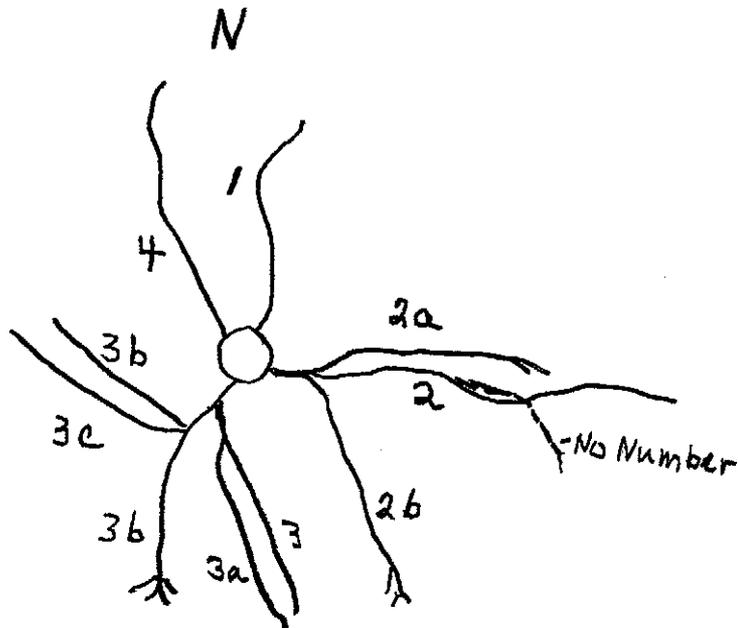
Root No. \_\_\_\_\_ Distance From Bole \_\_\_\_\_ Depth Top of Root \_\_\_\_\_

Depth Bottom of Root \_\_\_\_\_ Root Dia./Circ. \_\_\_\_\_

Root No. \_\_\_\_\_ Distance From Bole \_\_\_\_\_ Depth Top of Root \_\_\_\_\_

Depth Bottom of Root \_\_\_\_\_ Root Dia./Circ. \_\_\_\_\_

Notes: \_\_\_\_\_





TREE ROOT FORM

Date 12.14.2016 Observ. No. T-03 By Holloway/Touchet

Property Guidry Coords. 30°15'23.1" N 91°56'19.1" W

Other Info. See next page for roots and depths

Species Sugarberry (*Celtis laevigata*) DBH/Circ. 10.5" / 33.0"

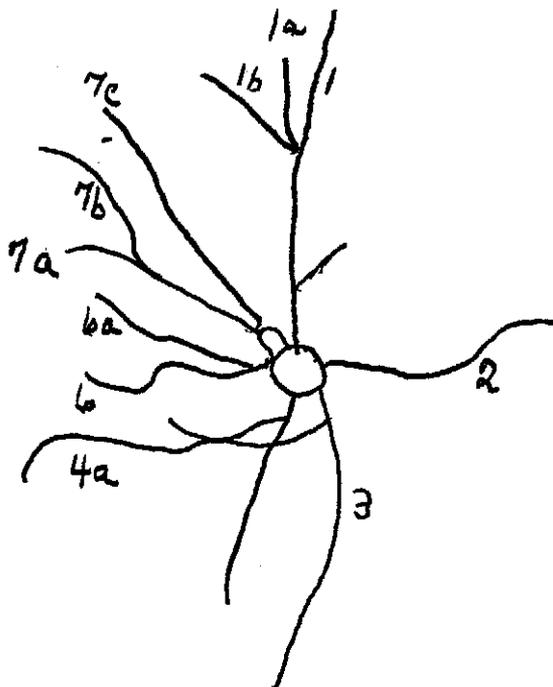
Root No. \_\_\_\_\_ Distance From Bole \_\_\_\_\_ Depth Top of Root \_\_\_\_\_

Depth Bottom of Root \_\_\_\_\_ Root Dia./Circ. \_\_\_\_\_

Root No. \_\_\_\_\_ Distance From Bole \_\_\_\_\_ Depth Top of Root \_\_\_\_\_

Depth Bottom of Root \_\_\_\_\_ Root Dia./Circ. \_\_\_\_\_

Notes: \_\_\_\_\_





TREE ROOT FORM

Date 12.15.2016 Observ. No. T-04 By Holloway/Touchet

Property Guidry Coords. 30°15'22.8" N 91°56'24.9" W

Other Info. See next page for roots and depths

Species Chinese Tallow (*Sapium sebiferum*) DBH/Circ. 6.4" / 20.25"

Root No. \_\_\_\_\_ Distance From Bole \_\_\_\_\_ Depth Top of Root \_\_\_\_\_

Depth Bottom of Root \_\_\_\_\_ Root Dia./Circ. \_\_\_\_\_

Root No. \_\_\_\_\_ Distance From Bole \_\_\_\_\_ Depth Top of Root \_\_\_\_\_

Depth Bottom of Root \_\_\_\_\_ Root Dia./Circ. \_\_\_\_\_

Notes: \_\_\_\_\_

