

Appendix J
Phase 1 Geotechnical Report



EUSTIS ENGINEERING COMPANY, INC.

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8 July 2004

CH2M Hill
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Attention Mr. Christopher A. Arts, P.E.

Gentlemen:

Phase 1 Geotechnical Engineering Report
State of Louisiana
Mississippi River Water Reintroduction into Bayou Lafourche
Donaldsonville, Louisiana to the Gulf of Mexico
Eustis Engineering Project No. 17616

Transmitted are three copies of our 10% final geotechnical engineering report performed under Task 4.1.3 for the subject project. An electronic copy is also being forwarded to you in Microsoft Word format to facilitate the review process.

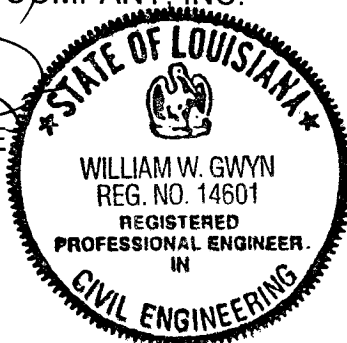
Thank you for asking us to perform these services. We look forward to continuing our work on this project.

Yours very truly,

EUSTIS ENGINEERING COMPANY, INC.

WILLIAM W. GWYN, P.E.

J. J. Hance:aln/jdl



PHASE 1 GEOTECHNICAL ENGINEERING REPORT

STATE OF LOUISIANA

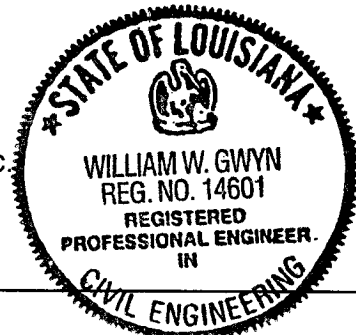
MISSISSIPPI RIVER WATER REINTRODUCTION
INTO BAYOU LAFOURCHE

DONALDSONVILLE TO GULF OF MEXICO, LOUISIANA

EUSTIS ENGINEERING PROJECT NO. 17616

FOR
CH2M HILL
NEW ORLEANS, LOUISIANA

By
Eustis Engineering Company, Inc.
Metairie, Louisiana



8 JULY 2004

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STATE OF LOUISIANA
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Introduction

This report summarizes the results obtained from the Phase 1 geotechnical investigation performed under Task 4.1.3. The purpose of this task is to provide a general characterization of the geologic conditions along Bayou Lafourche and the potential alternate conveyance channel routes. This characterization is based on available geologic and geotechnical information. This information will be used to develop the location of soil borings and cone penetrometer tests required for the 30% geotechnical investigation performed under Task 4.5.2.

The project site traverses along Bayou Lafourche from Donaldsonville to Larose, Louisiana. Two potential alternate (bypass) channel routes are being considered for the project. One potential bypass channel route is approximately two miles upstream of the Mississippi River from Bayou Lafourche in the vicinity of Smoke Bend. The other potential route is downstream of the Mississippi River from Bayou Lafourche.

Regional Geology

The area around Donaldsonville, Louisiana, is the apex area where the Mississippi River initiated several different major routes to the Gulf of Mexico over the last several thousand years. As a result, the dividing line between the Mississippi River Alluvial Valley and its deltaic plain transects the study area in a general north-south direction in its western section. Also, as a result of the continual migration of the Mississippi River across the study area occupying several different courses, including Bayou Lafourche, the landforms are low lying flatlands, criss-crossed by numerous abandoned distributaries which are themselves, lined by slightly higher natural levees. These natural levees represent the only relief within the study area. Southward in the study area, as the retreating shoreline of the Gulf of Mexico is approached, surficial marshlands with numerous small and intermediate size lakes are encountered. Elevations vary from approximately 20 plus feet at the northern beginnings of the study area to at or just below sea level at the southern distal terminus of the bayou.

The project area is characterized by Holocene deposits overlying Pleistocene Age soils. These depositional geologic types are described in the following paragraphs.

Geologic Depositional Types

Natural Levee. Natural levee deposits are generally comprised of silty clay, sandy clay, and silty sand deposits. Silts, clayey silts, and clay deposits may also comprise the natural levees. Natural levee deposits are typically oxidized and are thus brown, dark gray, and gray in color. These surficial deposits are usually desiccated with consistencies in the range of medium stiff to stiff. The natural levee deposits extend in a band paralleling the Mississippi River and Bayou Lafourche. The thickness of these deposits generally diminishes moving away from the Mississippi River and moving away from Bayou Lafourche.

Point Bar. The upper portions of point bar deposits (i.e., top few feet) are gray and tan silty clay, sandy clay, and silty sand. Below this upper stratum, the deposits are coarser and are poorly graded, fine and medium sands to medium and coarse sand with gravel. Abandoned distributary deposits are similar in nature to the point bar deposits.

Backswamp. Backswamp deposits generally consist of clay, organic clay, and peat with some silt, organic matter, and wood. These soils generally have consistencies that are extremely soft to medium stiff and are brown, dark gray, and black in color. Backswamp deposits are normally consolidated to underconsolidated, and thus highly compressible.

Abandoned Course. Abandoned course deposits typically have a thin fine grained upper stratum of very soft to soft gray organic clay and silt. These fine grained soils overly thick coarse grained deposits that represent channel fill sediments consisting of gray fine to medium poorly graded sands with layers of clay.

Distributary. Distributary deposits generally consist of silt, sandy silts, and sands with occasional layers and lenses of soft clay. They are generally brown and gray, and their thickness is totally dependent upon the original depth of the channel that they currently fill. The geotechnical characteristics of distributary deposits are similar to point bar deposits except they are generally slightly denser and coarser with depth.

Interdistributary. Interdistributary deposits encountered in this investigation underlie other depositional types such as natural levee and marsh. These deposits, which consist generally of gray and dark gray clay sequences with layers of silt and silty sand throughout, generally vary in consistency from very soft to soft plus with occasional layers of medium materials.

Inland Swamp. The deposits in the inland swamp depositional environment are generally soft gray, brown, and black clay and organic clay with lenses and layers of brown peat and decayed wood.

Substratum. The substratum is comprised of fine sands grading downward into progressively coarser sands. The relative density of these deposits will vary throughout the project area but will generally be medium dense to very dense in nature. Underlying

the fine and coarse sands, the substratum grades into gravels, which become more abundant and larger in size with increasing depth.

Pleistocene. The Pleistocene Prairie Complex generally consists of highly precompressed clay deposits. Pleistocene Age soils are erosion resistant and underlie the Holocene Age deposits that were previously described. In terms of geotechnical characteristics, these soils tend to be more competent than the overlying Holocene Age soils.

Geologic Subsoil Profiles

General. Eight geologic subsoil profiles were developed along and perpendicular to Bayou Lafourche and in the vicinity of the proposed conveyance channel alternate routes located upstream and downstream of the original channel entrance from the Mississippi River. Geologic profiles were prepared based on existing boring logs of the study area and the available geologic literature. Boring logs from the study area were obtained from the U.S. Army Corps of Engineers (USACE), various projects from the Louisiana Department of Transportation and Development (LaDOTD), and from pertinent projects performed by Eustis Engineering Company, Inc. (EE). A plan (six sheets) showing the locations of the available soil borings from these sources is shown in Appendix I. Figure 1 (four sheets) identifies the approximate locations of the referenced geologic subsoil profiles in plan view. The profiles are shown in cross-section view on Figures 2 through 6. Each of the profiles is described below. Various soil borings were used to supplement the geologic data in order to develop geologic subsoil profiles. Logs of these soil borings, as well as laboratory data, are shown in Appendix II.

Geologic Subsoil Profile A-A'. Geologic Subsoil Profile A-A' begins on the west (right descending) bank of the Mississippi River, located approximately 10,500 feet (2 miles) upstream from the original channel entrance from the Mississippi River, and is in the vicinity of Smoke Bend. Profile A-A' is oriented in a north to south direction that terminates when it intersects Bayou Lafourche. This cross-section is approximately 6,700 feet (1.27 miles) in length. The beginning of Profile A-A' intersects the artificial levee on the west bank of the Mississippi River. Underlying this material and extending from the ground surface in all other areas are natural levee deposits. These deposits vary in thickness from approximately 15 feet adjacent to the Mississippi River and adjacent to Bayou Lafourche to approximately 10 feet for the remainder of the section away from the river. Backswamp deposits underlie the entire sequence of natural levee and artificial levee deposits. These deposits extend to approximately el -95 feet (msl) and are underlain by substratum deposits to the maximum depth investigated in this region.

Geologic Subsoil Profile B-B'. Geologic Subsoil Profile B-B' begins on the west (right descending) bank of the Mississippi River, located approximately at the original channel entrance from the Mississippi River, and is located in the town of Donaldsonville. Profile B-B' is oriented in a northeast to southwest direction that concludes at the first major

bend way in Bayou Lafourche. This cross-section is approximately 4,300 feet (0.81 mile) in length. Profile B-B' intersects the artificial levee on the west bank of the Mississippi River. Underlying this material and extending from the ground surface in all other areas are natural levee deposits. These deposits are approximately 15 to 20 feet thick, decreasing in thickness moving away from the river. Abandoned course deposits underlie the entire sequence of natural levee and artificial levee deposits to the maximum depth investigated in this region.

Geologic Subsoil Profile C-C'. Geologic Subsoil Profile C-C' begins on the west (right descending) bank of the Mississippi River, located approximately 9,000 feet (1.7 miles) downstream of the original channel entrance from the Mississippi River. Profile C-C' is oriented in a northeast to southwest direction that terminates at LA Highway 70. This cross-section is approximately 7,000 feet (1.33 miles) in length. Profile C-C' intersects the artificial levee on the west bank of the Mississippi River. Underlying this material and extending from the ground surface in all other areas of the cross-section are natural levee deposits. These deposits are approximately 4 to 18 feet thick, decreasing in thickness moving away from the river. Underlying the natural levee deposits to the southside of the artificial levee and the Mississippi River are backswamp deposits that extend approximately from el 6 to el -100. Continuing from this elevation are substratum deposits that extend to the terminal depth investigated in this region. Underlying the natural levee deposits and the Mississippi River at the location of this cross-section are point bar deposits that extend from el 6 to the terminal depth investigated at approximately el -136.

Geologic Subsoil Profile D-D'. Geologic Subsoil Profile D-D' begins in the southern portion of Donaldsonville, continuing from Profile B-B'. Profile D-D' traverses in a southerly direction approximately 35 miles along Bayou Lafourche. Underlying this entire cross-section is a surficial deposit of natural levee material that extends to depths of approximately 9 to 30 feet below existing grades. Abandoned course deposits underlie the entire sequence of natural levee to the maximum depth investigated in this region.

Geologic Subsoil Profile D'-D''. Geologic Subsoil Profile D'-D'' continues from Profile D-D' and navigates an additional approximate distance of 32 miles southbound along Bayou Lafourche, ending in Larose. Along this entire cross-section is a surficial deposit of natural levee material that extends to depths of approximately 7 to 23 feet below existing grades. Abandoned course deposits underlie the entire sequence of natural levee deposits. Intertributary deposits underlie the abandoned course deposits from approximately two miles upstream of Lockport to the end of Profile D'-D'' at Larose. The contact between the abandoned course and intertributary deposits varies between approximately el -42 and at least el -63 at approximately two miles upstream of Lockport.

Geologic Subsoil Profile E-E'. Geologic Subsoil Profile E-E' intersects and is in perpendicular to Bayou Lafourche from west to east, downstream of Plattenville and upstream of Church Spur. Natural levee deposits extend along the east and west banks

of Bayou Lafourche for the entire extent of the cross-section. The natural levee soils along the banks of Bayou Lafourche are approximately 8 feet thick. The thickness of the surficial natural levee deposits decreases from approximately 18 feet at approximately 1,000 feet from the Bayou Lafourche centerline to 7 feet at the horizontal extent of the cross-section. The base of the natural levee extends to el 0 on the east side of Bayou Lafourche and extends from el 3 to el 0 on the west side of Bayou Lafourche.

Beneath the natural levee deposits, for approximately 1,000 feet westward of the Bayou Lafourche centerline, these deposits are underlain by at least 95 feet of point bar deposits, which impinge against the abandoned channel deposits of Bayou Lafourche. Westward of these point bar deposits, backswamp deposits are encountered to approximately el -120. These same backswamp deposits, into which the ancient Bayou Lafourche was incised, underlie the natural levee on the east (left descending) bank. Substratum sands underlie this entire sequence.

Geologic Subsoil Profile F-F'. Geologic Subsoil Profile F-F' intersects and is perpendicular to Bayou Lafourche from the west bank to the east bank, downstream of Labadieville and upstream of Thibodaux. Natural levee deposits extend along the east and west banks of Bayou Lafourche for the entire extent of the cross-section. Along the banks of the bayou the natural levee is approximately 8 feet thick. East and west of the Bayou Lafourche centerline, backswamp deposits underlie natural levee deposits to the terminal depth investigated. An exception to this sequence is the remnant point bar and abandoned channel deposits at approximately 10,000 feet west of the Bayou Lafourche centerline. These deposits, which extend approximately to el -100, are the remnants of an old abandoned course of Bayou Lafourche. The thickness of natural levee deposits is approximately 20 feet and diminishes to approximately 7 feet at the horizontal limit of the cross-section. Underlying the natural levee deposits on the east and west sides of the abandoned course stratum are backswamp deposits that are encountered from approximately el -5 to el 2 and extend to the terminal depth investigated in this region.

Geologic Subsoil Profile G-G'. Geologic Subsoil Profile G-G' intersects and is perpendicular to Bayou Lafourche from the west bank to the east bank, downstream of Raceland and upstream of Mathews. Within approximately 1,000 feet from the bayou centerline, natural levee deposits extend from the ground surface to approximately el 7. Abandoned course deposits underlie the natural levee deposits for approximate distances of 900 feet east and west of the centerline of Bayou Lafourche and extend to el -120. Beyond approximately 900 feet from the Bayou Lafourche centerline, the abandoned course deposits are not encountered in the subsurface. On the east and west sides of the abandoned course deposit, the natural levee is approximately 38 feet thick and diminishes to approximately 15 feet thick at the eastern limit of the cross-section. Along the extreme western portion of the section, the natural levee is blanketed by a surficial marsh deposit that is up to approximately 6 feet thick. Underlying the natural levee deposits on the east and west sides of the abandoned course stratum are interdistributary deposits that are encountered from approximately el -14 to el -30 and extend to el -140 to el -160. Substratum deposits underlie the

interdistributary deposits for the entire cross-section. Note that a pocket of inland swamp deposit is also encountered within the subsurface off the west bank of Bayou Lafourche from approximately el -22 to el -26.

Geologic Subsoil Profile H-H'. Geologic Subsoil Profile H-H' intersects and is perpendicular to Bayou Lafourche from the west bank to the east bank, in the town of Larose. The surficial deposits along the eastern and western banks of Bayou Lafourche are natural levee that extend to approximately el -2. Abandoned course deposits underlie the natural levee deposits for approximate distances of 500 feet east and west of the centerline of Bayou Lafourche and extend to approximately el -100. Moving away from Bayou Lafourche, the thickness of the natural levee deposits decreases, similar to the other cross-sections located upstream. The horizontal extent of the surficial marsh deposits that is depicted in Profile G-G' has decreased to approximately 2,400 feet and extends from the ground surface to depths of approximately 6 feet. Within the subsurface off the eastern bank of Bayou Lafourche, two separate distributary deposits are encountered to approximately el -42. An inland swamp deposit is also encountered off the eastern bank of Bayou Lafourche from approximately el -51 to el -64. Interdistributary deposits underlie the surficial natural levee and marsh deposits as well as the embedded abandoned course and distributary deposits. The interdistributary deposits extend to approximately el -114 where the Pleistocene interface is encountered. The Pleistocene deposits extend to the terminal depth investigated in this region.

Description of Soil Properties

Anticipated soil properties for each geologic depositional environment previously described are summarized in Table 1. The data in Table 1 were primarily extracted from Geomorphology and Quaternary Geologic History of the Lower Mississippi Valley (1994) and were cross referenced with the soil types encountered in the relevant soil borings.

Table 1 - Anticipated Soil Properties

GEOLOGIC DEPOSITIONAL TYPE	% FINER THAN 0.05 mm (#200 SIEVE)	% ORGANIC MATERIAL	PLASTICITY INDEX (PI)	NATURAL WATER CONTENT (%)	SATURATED UNIT WEIGHT (PCF)	UNDRAINED SHEAR STRENGTH (PSF)	UNIFIED SOIL CLASSIFICATION (USC)
NATURAL LEVEE	85	NEGLIGIBLE	25 - 45	20 - 40	100 - 120	400 – 800 ⁽¹⁾	CL, SM, ML
POINT BAR	50	NEGLIGIBLE	15 - 45	20 - 40	100 - 115	300 – 500	CL, SM, SP, SW, ML
INTER-DISTRIBUTARY	80	5	30 - 60	50 – 90	90 - 105	200 – 400	CL, CH, ML, SM
ABANDONED COURSE	50	NEGLIGIBLE	15 - 60	20 - 50	95 - 115	300 – 800	CL, CH, ML, SM, SP
INLAND SWAMP	80	15	50 - 80	100 -120	70 - 90	200 – 300	CL, CH, OL, OH
BACKSWAMP	80	5	20 - 40	45 - 50	105 - 115	400 – 800	CL, CH, OL, OH
MARSH	35	60	HIGHLY VARIABLE	90 - 800	60 - 95	100 – 250	CL, CH, OL, OH, Pt
DISTRIBUTARY	50	NEGLIGIBLE	15 - 45	20 - 40	100 - 115	300 – 500	ML, SM, SP, CL
SUBSTRATUM	10	NEGLIGIBLE	NON-PLASTIC	20 - 40	110 - 125	N/A	SP, SW, GP, GW
PLEISTOCENE	70	NEGLIGIBLE	20 - 40	25 - 40	110 - 120	900 – 1700	CL, CH, SC

⁽¹⁾ Can range between 800 and 1,200 psf in desiccated, near surface areas.

Properties summarized in Table 1 should be considered values representing the statistical scatter of test data from the individual deposits. However, soil properties, in particular saturated unit weights and undrained shear strengths, are highly dependent upon area drainage, stress history, and confining overburden stresses. Surficial desiccation typically affects higher undrained shear strengths in well drained near surface deposits. Underlying deposits can typically be expected to exhibit increasing shear strength with increasing depth, with the ratio of the undrained shear strength to confining vertical stress being a constant for normally consolidated soils. This constant varies between approximately 0.18 and 0.28 and is approximately equal to 0.25 for soils in south Louisiana (Ladd & Foote, 1974).

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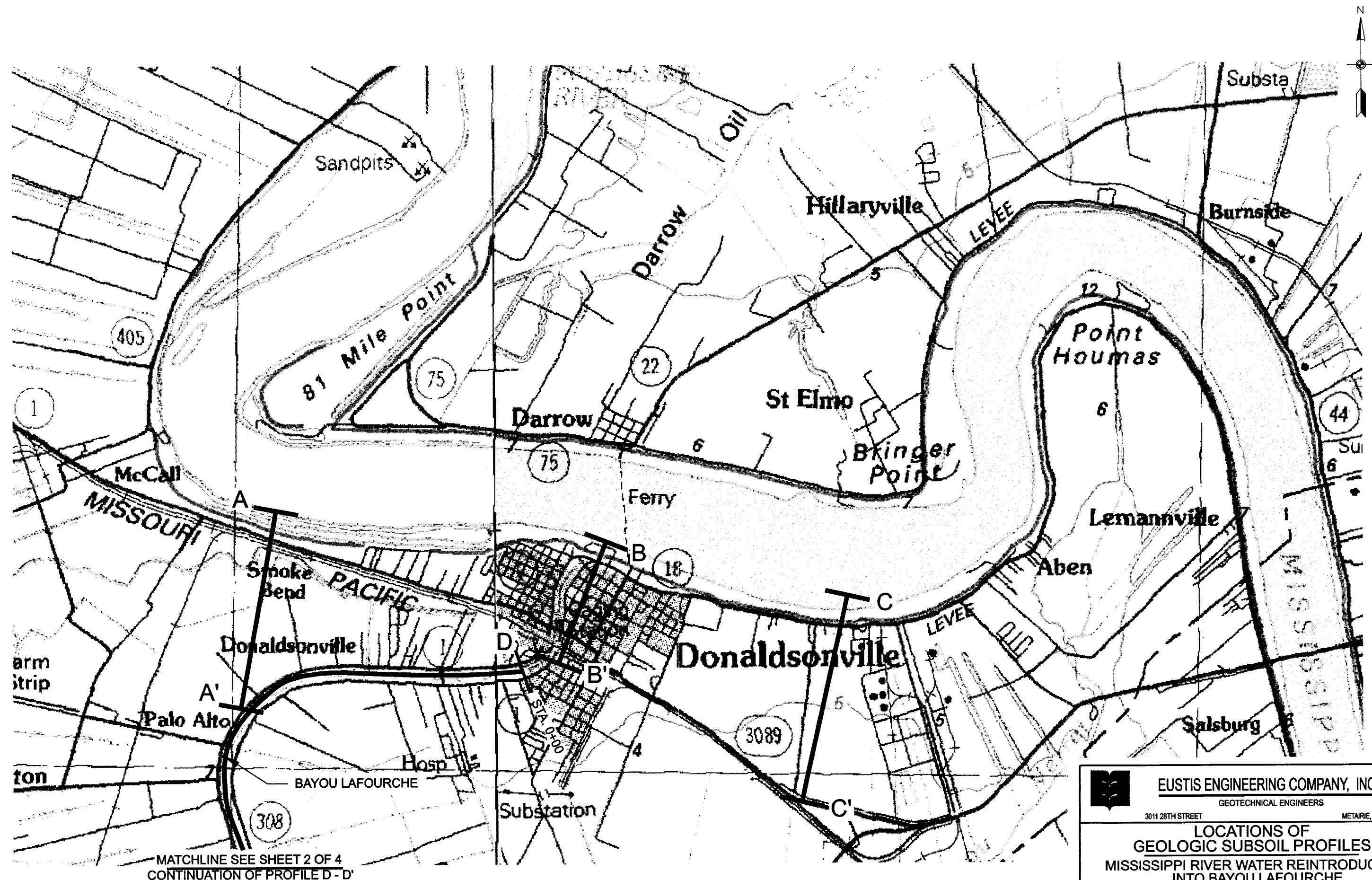
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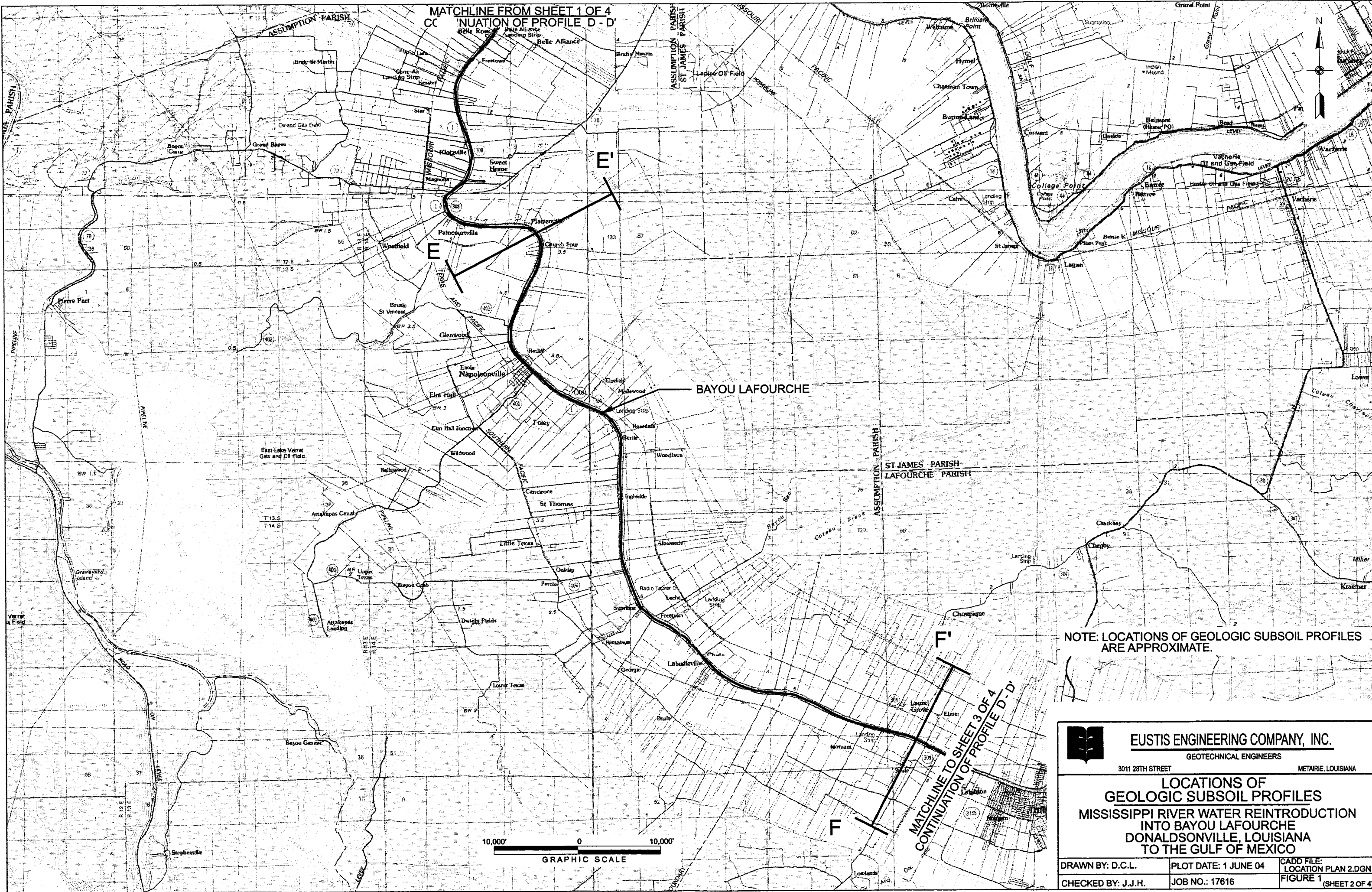
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NOTE: LOCATIONS OF GEOLOGIC SUBSOIL PROFILES ARE APPROXIMATE.

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LOCATIONS OF GEOLOGIC SUBSOIL PROFILES MISSISSIPPI RIVER WATER REINTRODUCTION INTO BAYOU LAFOURCHE DONALDSONVILLE, LOUISIANA TO THE GULF OF MEXICO		
DRAWN BY: D.C.L. CHECKED BY: J.J.H.	PLOT DATE: 1 JUNE 04 JOB NO.: 17616	CADD FILE: LOCATION PLAN 1.DGN FIGURE 1 (SHEET 1 OF 4)



NOTE: LOCATIONS OF GEOLOGIC SUBSOIL PROFILES ARE APPROXIMATE.

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CHECKED BY: J.J.H.	JOB NO.: 17616	FIGURE 1 (SHEET 2 OF 4)

MATCHLINE FROM SHEET 2 OF 4
CONTINUATION OF PROFILE D'-D'

D'-D'
Sta. 34+89

BAYOU LAFOURCHE

G
G'

MATCHLINE TO SHEET 4 OF 4
CONTINUATION OF PROFILE D'-D'

NOTE: LOCATIONS OF GEOLOGIC SUBSOIL PROFILES
ARE APPROXIMATE.



GRAPHIC SCALE



EUSTIS ENGINEERING COMPANY, INC.

GEOTECHNICAL ENGINEERS

3011 28TH STREET

METairie, LOUISIANA

**LOCATIONS OF
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MISSISSIPPI RIVER WATER REINTRODUCTION
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TO THE GULF OF MEXICO**

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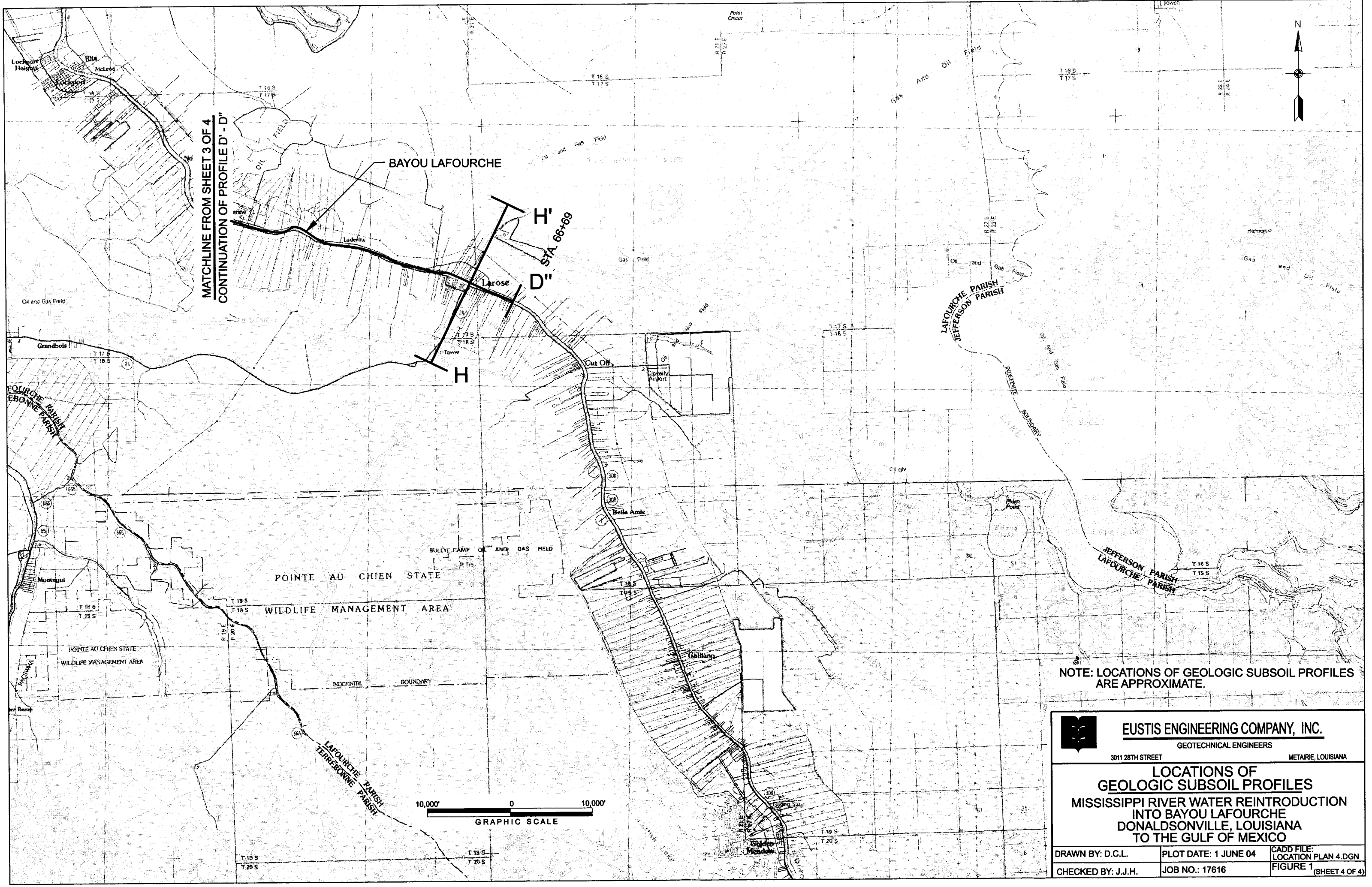
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FIGURE 1
(SHEET 3 OF 4)



MATCHLINE FROM SHEET 3 OF 4
CONTINUATION OF PROFILE D' - D''

BAYOU LAFOURCHE

H'
D''
STA. 66+69

H

POINTE AU CHIEN STATE


WILDLIFE MANAGEMENT AREA

INDEFINITE BOUNDARY

LAFOURCHE PARISH
TERREBONNE PARISH

10,000' 0 10,000'
GRAPHIC SCALE

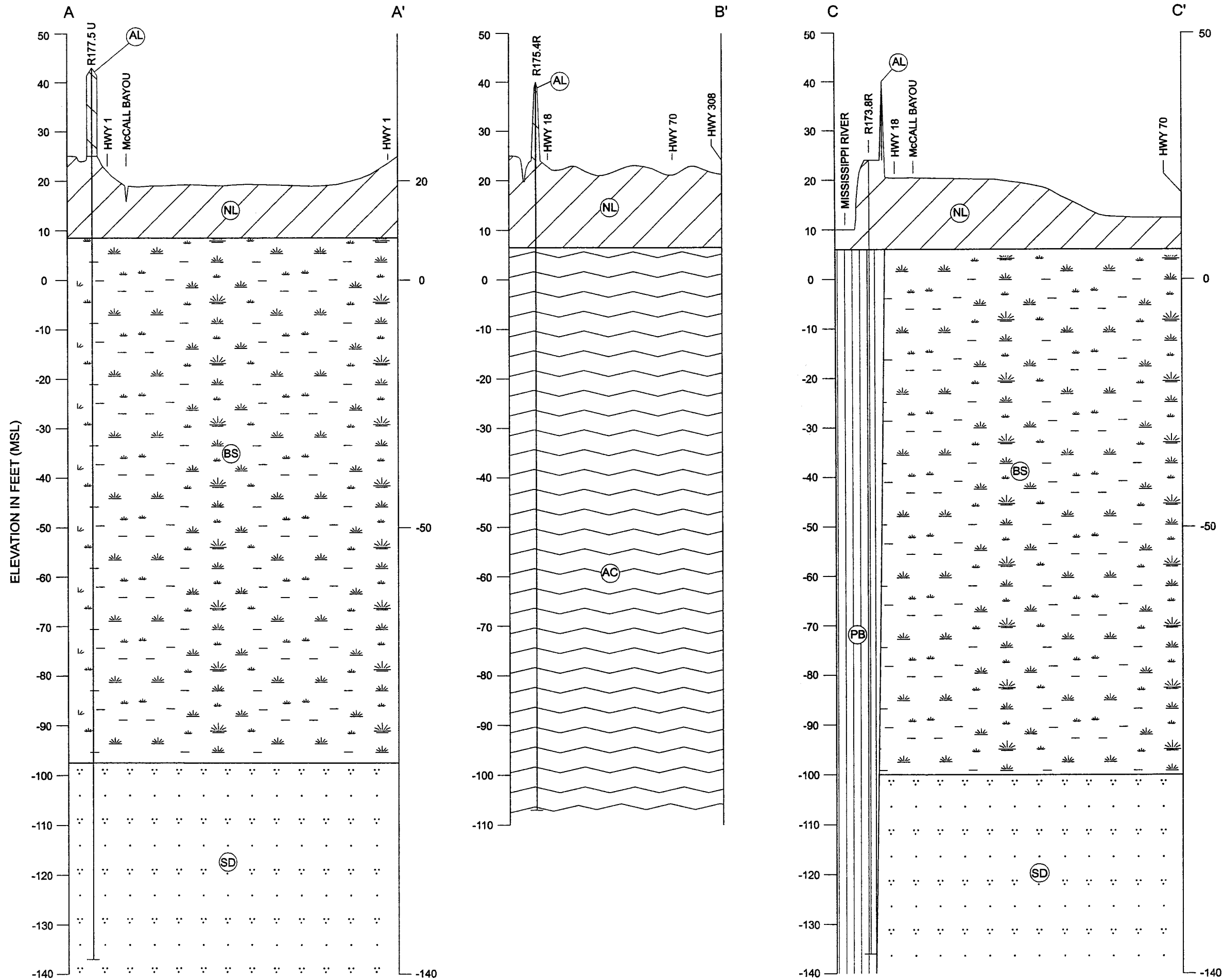
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**LOCATIONS OF
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CHECKED BY: J.J.H.	JOB NO.: 17616	FIGURE 1 (SHEET 4 OF 4)



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METAIRIE, LOUISIANA

GEOLOGIC SUBSOIL PROFILES A-A', B-B', AND C - C'
MISSISSIPPI RIVER WATER REINTRODUCTION
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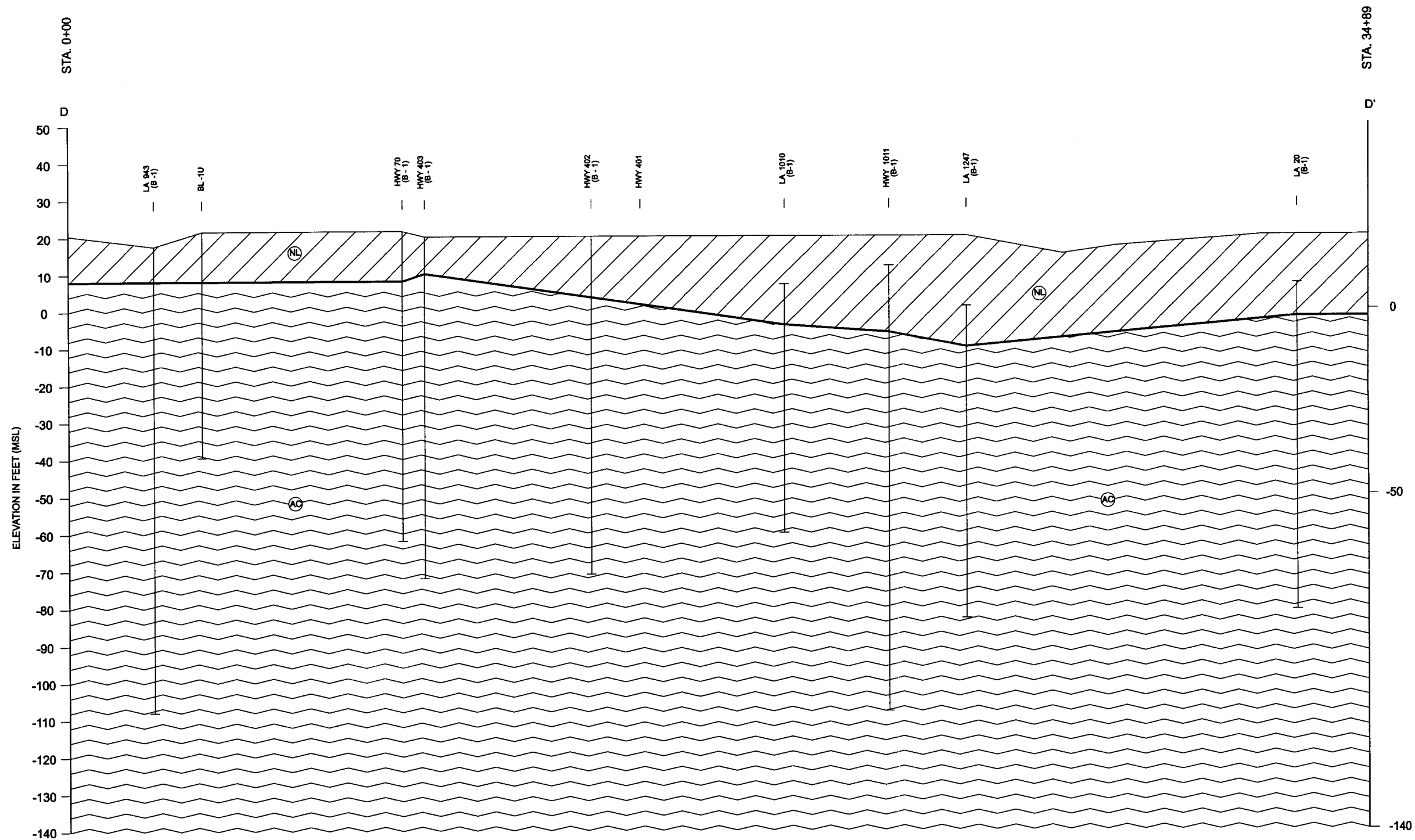
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FIGURE 2



PROFILE D - D'

LEGEND		
	NL	NATURAL LEVEE
	ID	INTERDISTRIBUTARY
	IS	INLAND SWAMP
	AL	ARTIFICIAL LEVEE
	D	DISTRIBUTARY
	BS	BACKSWAMP
	M	MARSH
	SD	SUBSTRATUM DEPOSITS
	PB	POINT BAR
	AC	ABANDONED COURSE
	P	PLEISTOCENE

HORIZONTAL SCALE - 1" = 3 MILES



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METAIRIE, LOUISIANA

GEOLOGIC SUBSOIL PROFILE D-D'
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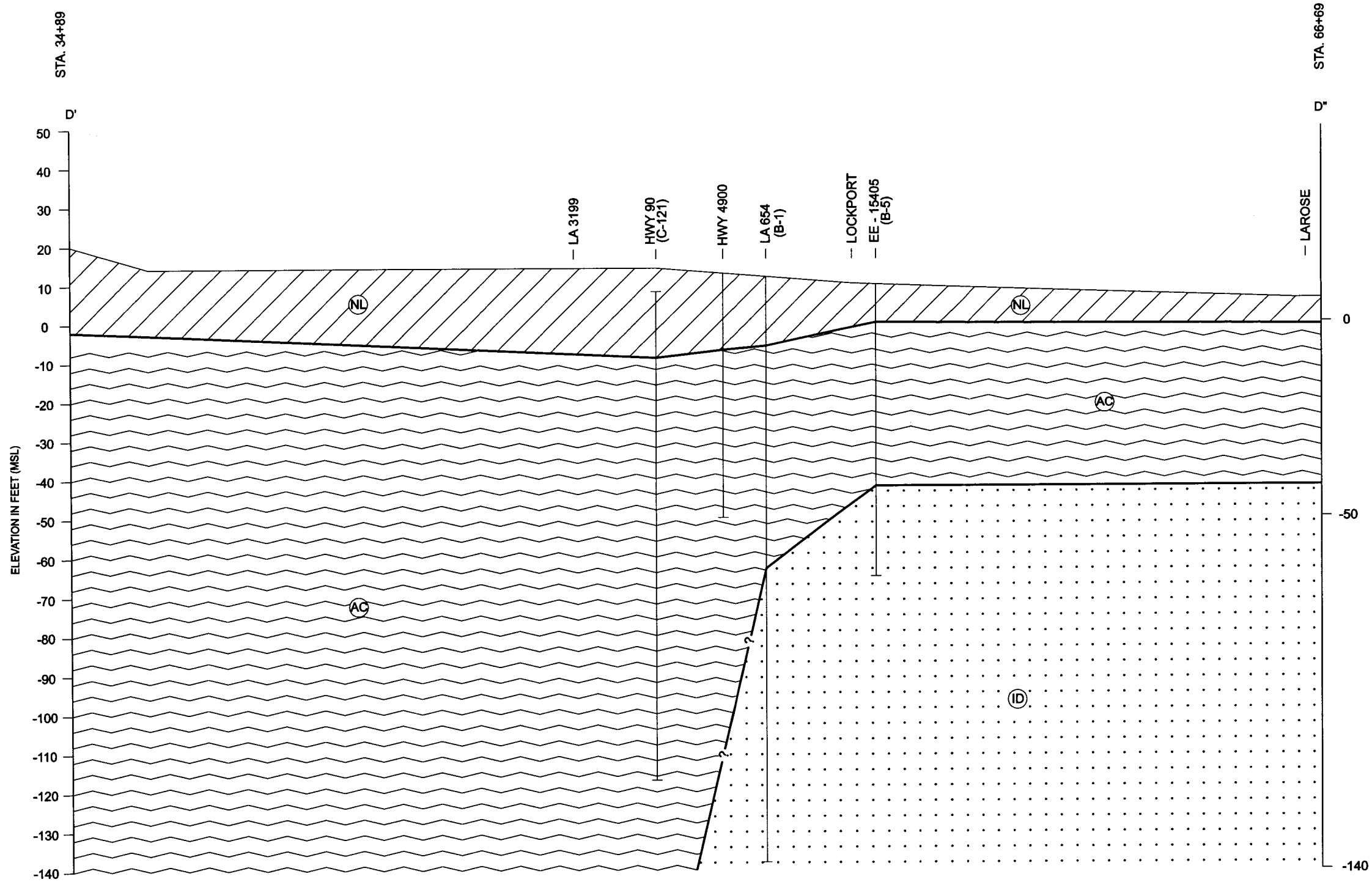
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FIGURE 3



PROFILE D' - D''

LEGEND		
	NL	NATURAL LEVEE
	ID	INTERDISTRIBUTARY
	IS	INLAND SWAMP
	AL	ARTIFICIAL LEVEE
	D	DISTRIBUTARY
	BS	BACKSWAMP
	M	MARSH
	SD	SUBSTRATUM DEPOSITS
	PB	POINT BAR
	AC	ABANDONED COURSE
	P	PLEISTOCENE

HORIZONTAL SCALE - 1" = 3 MILES



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GEOLOGIC SUBSOIL PROFILE D' - D''

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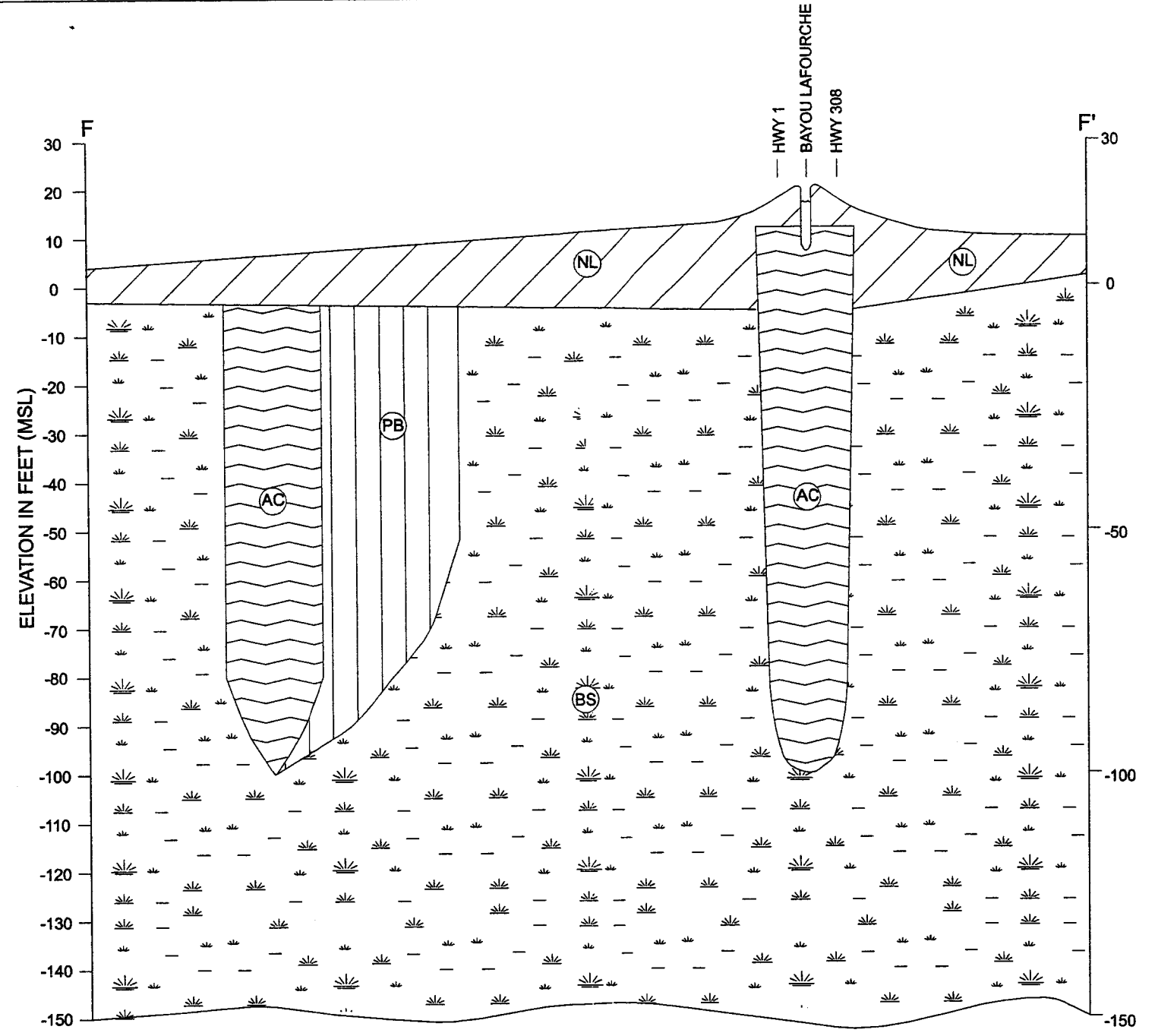
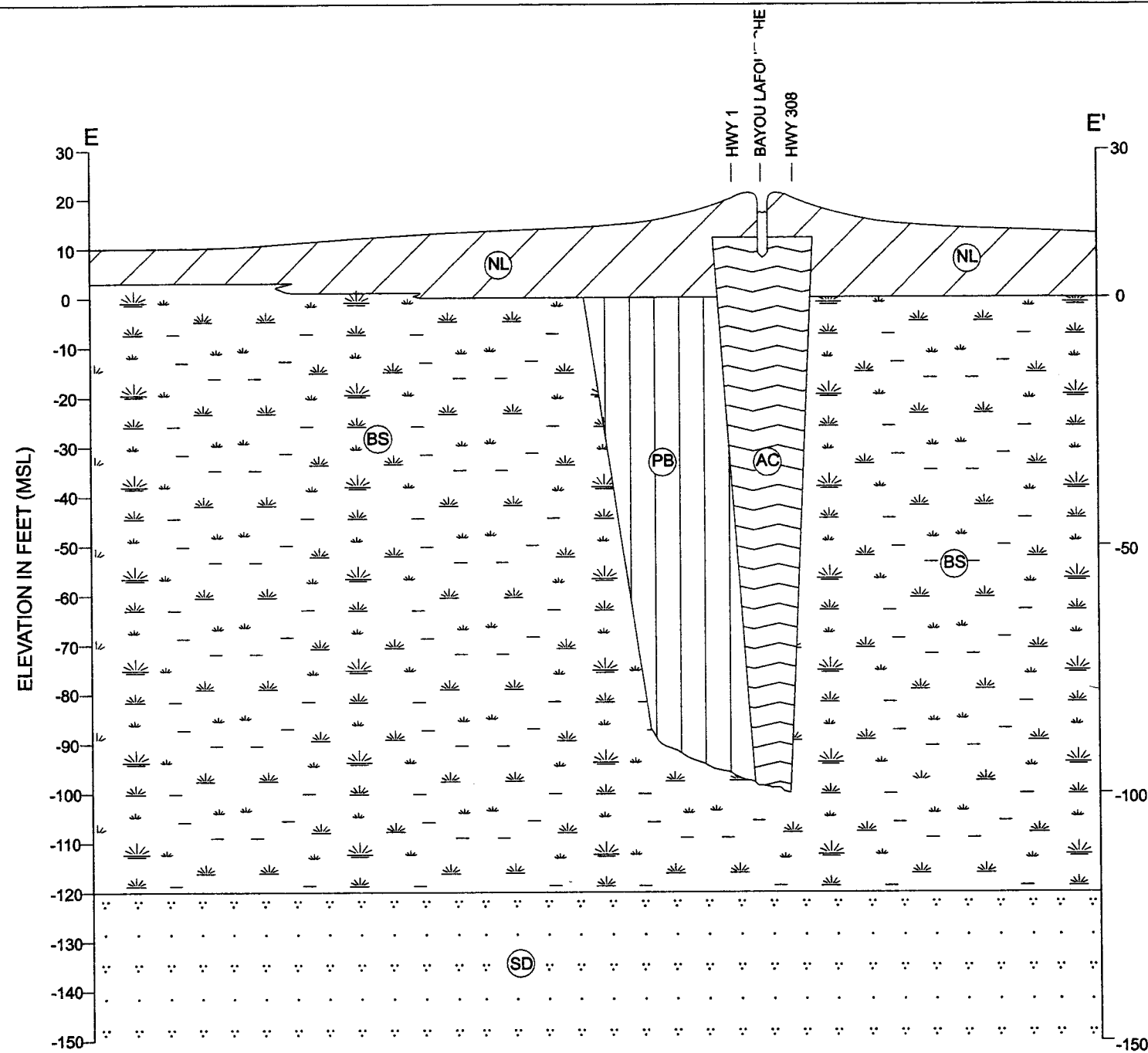
PLOT DATE: 26 MAY 04

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FIRST PROFILE.DGN

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JOB NO.: 17616

FIGURE 4

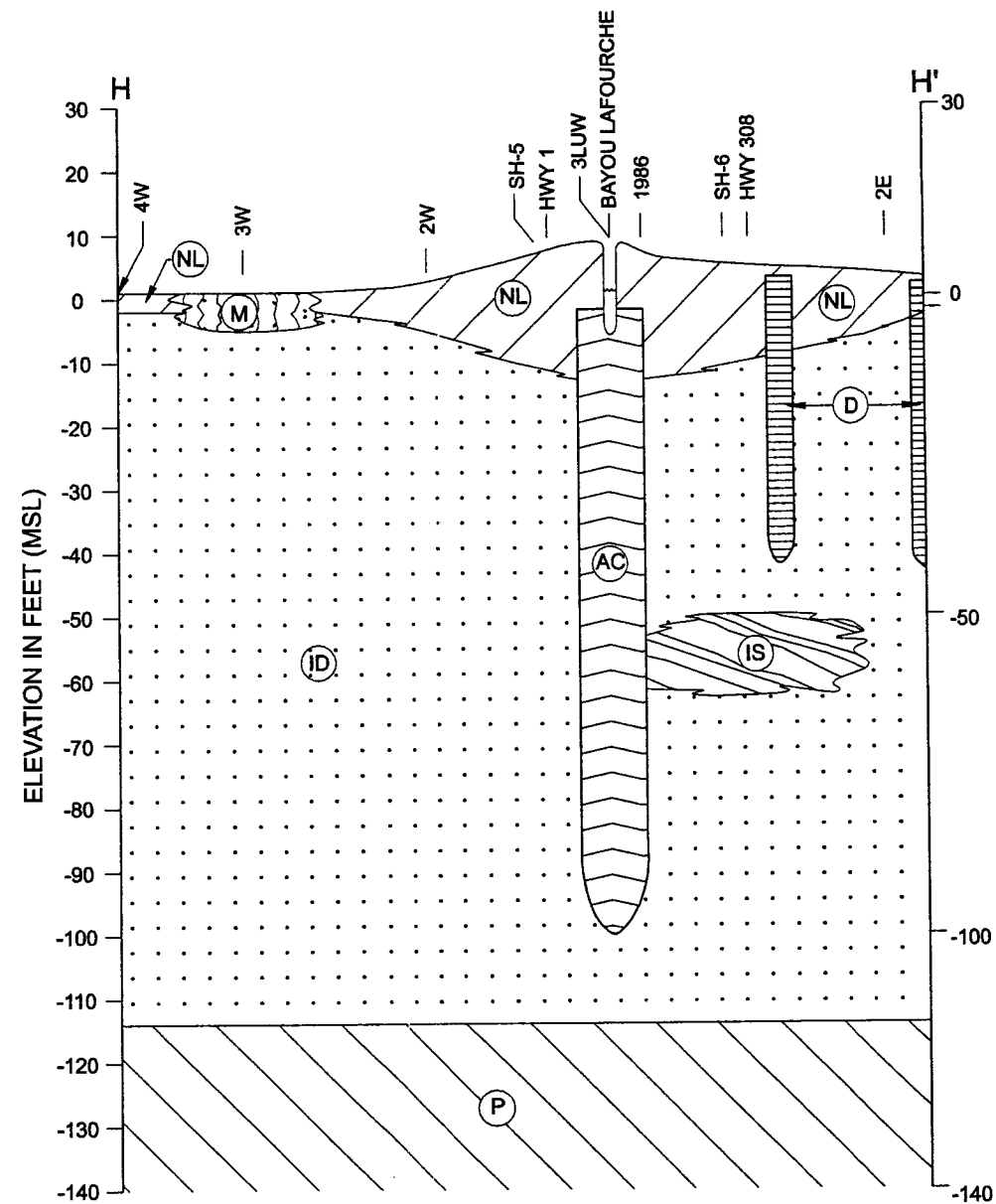
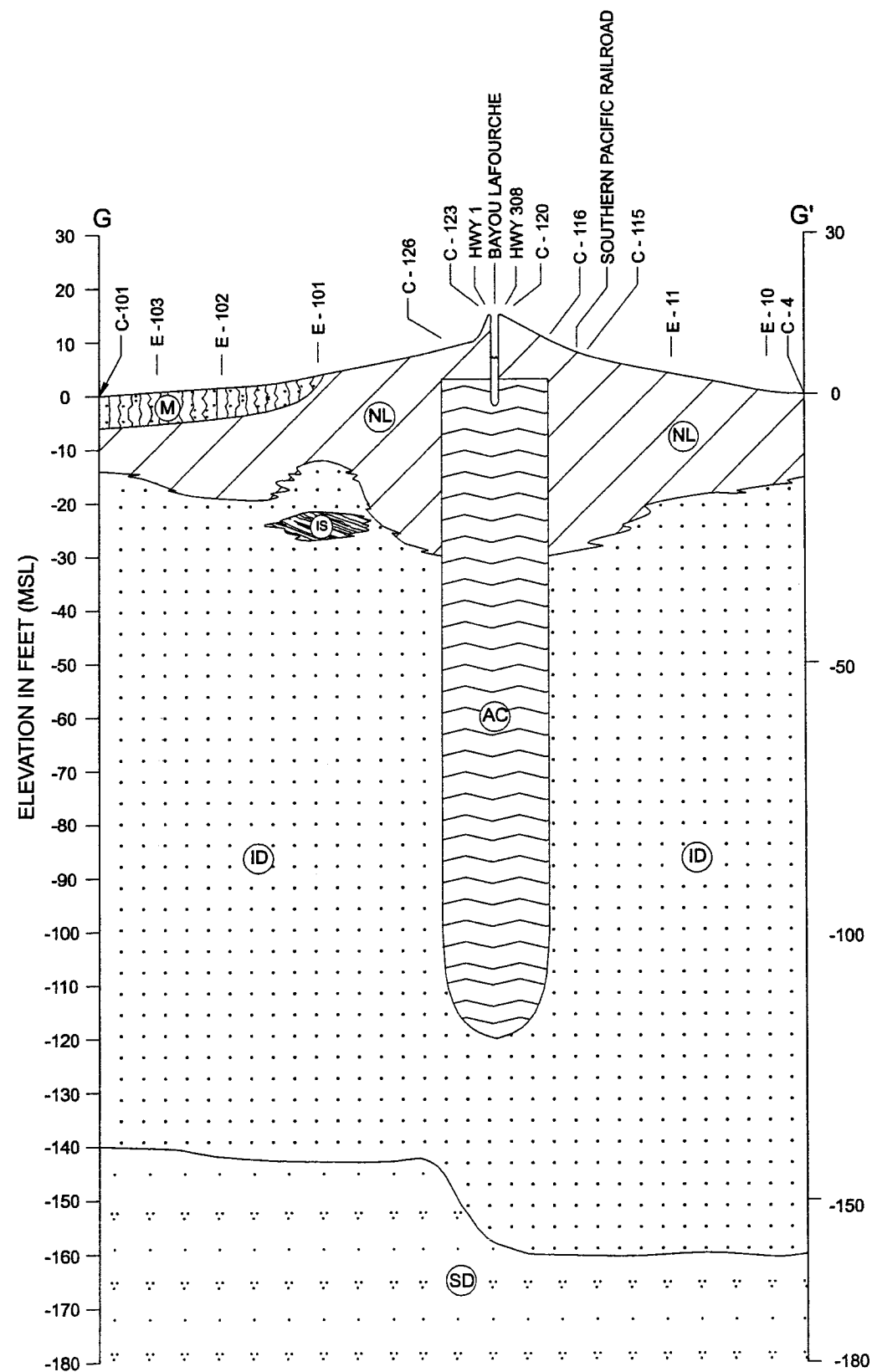


PROFILES E - E' AND F - F'

LEGEND		
	NL	NATURAL LEVEE
	ID	INTERDISTRIBUTARY
	IS	INLAND SWAMP
	AL	ARTIFICIAL LEVEE
	D	DISTRIBUTARY
	BS	BACKSWAMP
	M	MARSH
	SD	SUBSTRATUM DEPOSITS
	PB	POINT BAR
	AC	ABANDONED COURSE
	P	PLEISTOCENE

HORIZONTAL SCALE - 1" = 3000'

EUSTIS ENGINEERING COMPANY, INC. 3011 28TH STREET METAIRIE, LOUISIANA		
GEOLOGIC SUBSOIL PROFILES E - E' AND F - F' MISSISSIPPI RIVER WATER REINTRODUCTION INTO BAYOU LAFOURCHE DONALDSONVILLE, LOUISIANA TO THE GULF OF MEXICO		
DRAWN BY: D.C.L. CHECKED BY: J.J.H.	PLOT DATE: 26 MAY 04 JOB NO.: 17616	CADD FILE: SECOND PROFILE.DGN FIGURE 5



PROFILES G - G' AND H - H'

LEGEND		
NL	NATURAL LEVEE	
ID	INTERDISTRIBUTARY	
IS	INLAND SWAMP	
AL	ARTIFICIAL LEVEE	
D	DISTRIBUTARY	
BS	BACKSWAMP	
M	MARSH	
SD	SUBSTRATUM DEPOSITS	
PB	POINT BAR	
AC	ABANDONED COURSE	
P	PLEISTOCENE	

HORIZONTAL SCALE - 1" = 3000'



EUSTIS ENGINEERING COMPANY, INC.

3011 28TH STREET

METAIRIE, LOUISIANA

GEOLOGIC SUBSOIL PROFILES G - G' AND H - H'
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TO THE GULF OF MEXICO

DRAWN BY: D.C.L.

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SECOND PROFILE.DGN

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FIGURE 6