HARKAND GULF SERVICES, LLC

MPSV Spearfish

NPDES General Permit No. GEG460000

Cooling Water Intake Structure Supplemental Information

August 8, 2014

1.0 INTRODUCTION

This submittal applies to the Siem Spearfish multi-purpose support vessel (MPSV) and includes the cooling water intake structure information addressed in Part I.D.3. of NPDES General Permit No. GEG460000 effective April1, 2010. The Spearfish is proposed to operate in various areas of the Gulf of Mexico (GOM). The Spearfish will use once-through cooling water as part of its normal operations. This permit Notice of Intent (NOI) supplemental information is being submitted to the United States Environmental Protection Agency (USEPA) to address requirements set forth by regulations under Section 316(b) of the Clean Water Act (CWA), 33 U.S.C. 1326(b) to address concerns of Cooling Water Intake Structures (CWIS) on impingement and entrainment (IM&E) of vulnerable marine organisms. This information is submitted in accordance with the provisions of the National Pollutant Discharge Elimination System (NPDES) permitting regulations as set forth in Title 40 of the Code of Federal Regulations (CFR) at §122.21. Specifically, this permit NOI supplemental information is intended to satisfy the requirements cited under the *Final NPDES General Permit for New and Existing Sources and New Dischargers in the Offshore Subcategory of the Oil & Gas Extraction Category for the Eastern Portion of the Outer Continental Shelf of the Gulf of Mexico (GEG460000)* (General Permit).

The Siem Spearfish was designed for light construction, light inspection and maintenance work. It has an overall length of 396ft (120.8m) and uses sea chests as the cooling water intake structure (CWIS). The vessel will be working in the Gulf of Mexico in deepwater depths of approximately 3,000ft to 9,000ft. As the Spearfish is a support vessel, it must operate in dynamic positioning (DP) mode to keep station while working. When in DP mode, the designed cooling intake capacity of the vessel will be limited to 3.44 million gallons per day (MGD), of which 100% will be used for cooling purposes. The firewater system on the vessel does not require positive pressure at all times and ballasting water to maintain the vessel stability is taken on at port or during transit. Those systems have been excluded from this submittal.

Since the Spearfish is a new vessel being constructed after July 17, 2006, and it has a combined intake flow of greater than 2 MGD, of which at least 25% is used for cooling purposes, the Clean Water Act section 316(b) Phase III cooling water regulations apply.

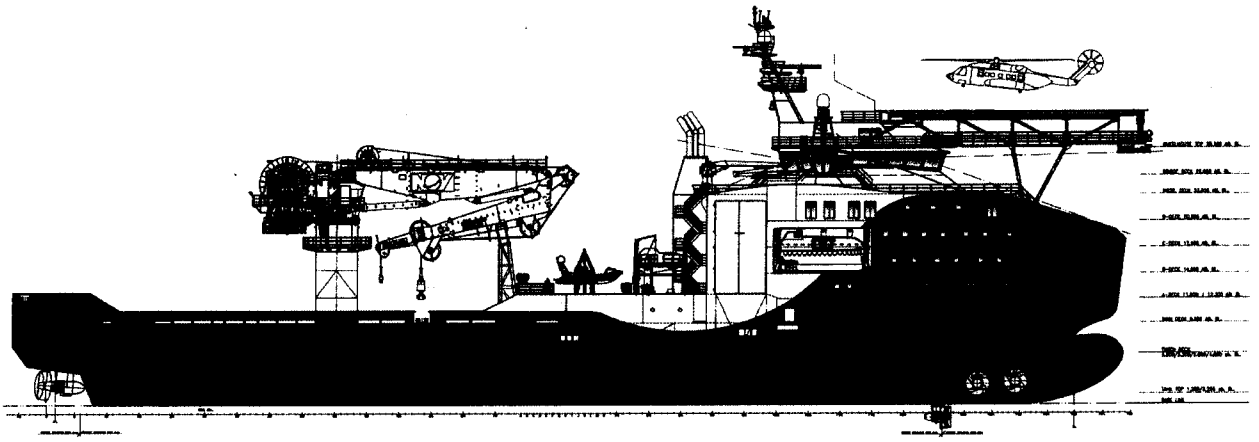


Figure 1. Siem Spearfish MPSV.

2.0 SOURCE WATER PHYSICAL DATA

A narrative description and/or maps providing sufficient information on the predicated locations during the permit term in sufficient detail for the Director to determine the appropriateness of additional impingement requirements. This information I only required to be submitted once for the facility.

The Spearfish plans on contracting to work in the GOM, at locations over 150 miles from the nearest shore. The GOM is the largest semi-enclosed coastal sea in the western Atlantic, encompassing about 579,150 mi^2 (1,500,000 km^2). The coastal areas contain more than 750 estuaries, bays, and sub-estuaries that are associated with 47 major estuaries. The GOM is divided into the continental shelf, continental slope and the GOM basin.

The Offshore Operators Committee (OOC) conducted an industry-wide study in 2009 to provide a comprehensive review of fishery data for the GOM and to evaluate the impacts of future CWIS on fish and shellfish in the GOM. This study concluded that the greatest biological concentration of key marine species that have the potential to be impinged or entrained by the CWIS, including their spawning habitat, is restricted to the waters of the continental shelf in depths of less than 656ft (200m) (LGL Ecological Research Associates, Inc., 2009).

The Spearfish will be operating at areas within the continental slope of the GOM, which is mostly frequented by species of pelagic fish, of which there are approximately 45 species and 17 families of pelagic fishes associated with offshore platforms in the GOM. Adult pelagic fishes are not candidates for entrainment and impingement due to their size and ability to swim away from the CWIS. Most pelagic fishes inhabiting the GOM have pelagic eggs and larvae that can drift with the prevailing water currents and could be susceptible to entrainment in the CWIS.

During 2011-2013 OOC conducted an industry-wide Gulf of Mexico Coolign Water Intake Structure Entrainment Monitoring Study. The final report of this study was issued in March 2014 (CSA Ocean Sciences, Inc., 2014) Results of the 2014 OOC GOM CWIS Entrainment Monitoring Study indicated that plankton and ichthyoplankton densities in deeper water of the GOM were only a small fraction of those found at the shallow depths (i.e. less than 200 meters) and the areas closer to shore along the continental shelf. The study concluded that the entrainment of ichthyoplankton by CWIS will not have a noticeable or biologically significant impact to commercially or recreationally important species.

CWIS impacts within the continental slope can be assessed using the two representative species, yellowfin tuna and red snapper due to their commercial and recreational significance. Yellowfin tuna adults may be found in the vicinity of the CWIS, but are too large to be entrained within the CWIS. Red snapper adults are not typically found in the deep waters of the continental slope.

The Spearfish will have no significant impacts on commercially or recreationally important aquatic species due to the projected operating locations and the engineering controls to be implemented to prevent impingement and entrainment.

3.0 COOLING WATER INTAKE STRUCTURE DATA

The CWIS will normally operate 24 hours a day for approximately 18 days for each planned well. The Spearfish utilizes two cooling systems:

3.1 Main Cooling System

The main cooling system supplies seawater to Engines 1-4, A/C Cooling, Chilled Water System and Provision Plants 1-3.

Table 2. Main Cooling System Capacity.

Pump	Rated Pump Capacity (GPM)	Capacity During DP (%)	Capacity During DP (GPM)
Pump 1	1440	50%	720
Pump 1/2	1440	0%	*SPARE*
Pump 2	1070	50%	535
Pump 3	771	50%	385
Pump 3/4	938	0%	*SPARE*
Pump 4	938	50%	469
		TOTAL	**2109 GPM**
			3.04 MGD

3.2 Secondary Cooling System

The secondary cooling system supplies cooling to the main propulsion thrusters on the port side and starboard side.

Table 3. Secondary Cooling System Capacity.

Pump	Rated Pump Capacity (GPM)	Capacity During DP (%)	Capacity During DP (GPM)
Pump 5	282	50%	141
Pump 6	282	50%	141
		TOTAL	**282 GPM**
			0.4 MGD

Pump 1/2 and pump 3/4 are spare pumps and not used. Both cooling systems will run at 50% capacity and together they will produce a combined intake flow of 3.44 MGD dedicated for vessel cooling. The full capacity of the system is not be needed while the vessel is maintains station on DP; the extra capacity is reserved for transit or inclement weather operations.

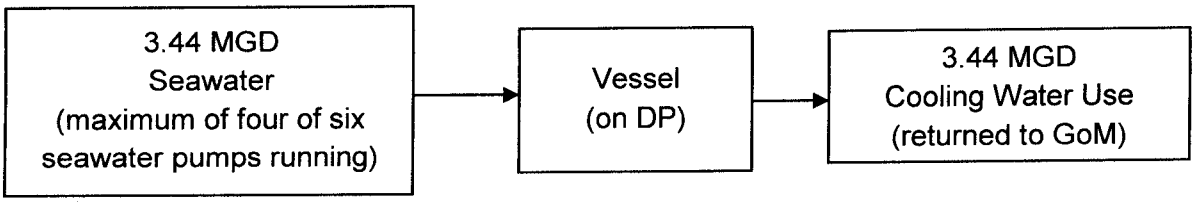


Figure 2. Seawater Intake Flow Diagram

For the main cooling system, the seawater intake structure consists of two low sea chests with two intake gratings each at the port side (PS) and starboard side (SB) located at approximately 22ft 7in below sea-level, and one high sea chest with two gratings on the SB located approximately13ft 5in below sea-level. A seawater intake manifold located in the center of the vessel hull collects water from the sea chests and distributes it to the four seawater lift pumps. The secondary cooling system seawater intake structure consists of one aft sea chest with one grate located approximately 19ft below sea level. This is connected via the aft intake manifold to two seawater lift pumps. . All gratings are manufactured from galvanized steel plate and have a mesh size that ranges from 1.0in x 6.3in to 1.0in x 14.6in (26mm x 160mm to 26mm x 370mm). A simplified diagram of the cooling system is shown below; see the Appendix for technical drawings specific to the vessel.

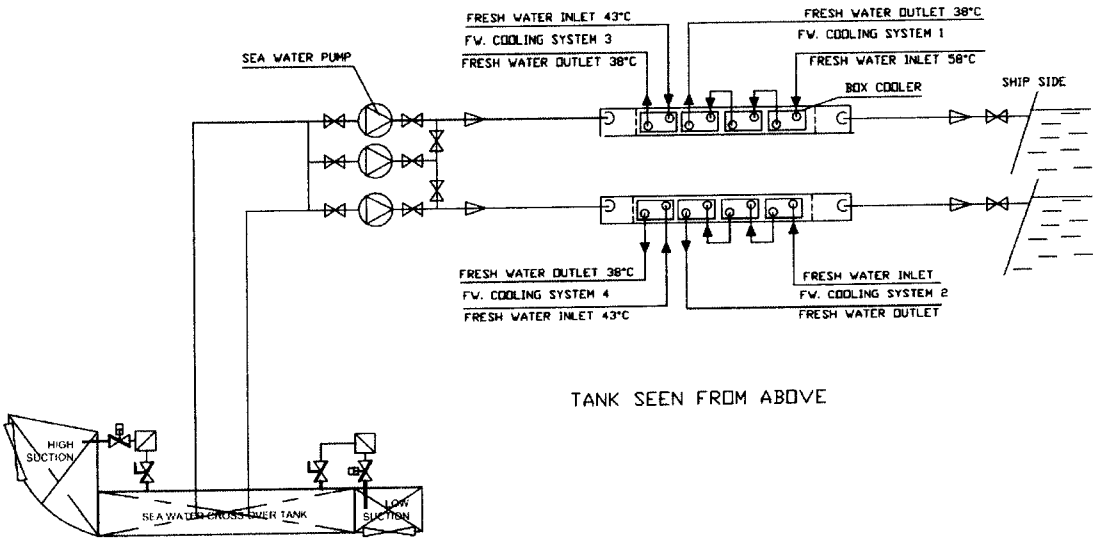


Figure 3. Piping Diagram, Simplified Cooling System (Sperre, 2013).

Both systems rely on rack coolers (a design based on a combination of plate and box coolers) to cool the vessel's freshwater system using incoming seawater. As the seawater enters the cooling rack, baffles direct it across the freshwater piping. The seawater makes several passes through the rack and is ultimately pumped out of the bottom and off board. There is no fluid or chemical exchange between with the incoming sea water; no antifouling agents are used in the cooling system as the water tubing is manufactured from a copper-nickel alloy. The seawater pumps are frequency-controlled by the automated seawater cooling system which automatically monitors and adjusts the pump capacity (flow rate). The system is able to run at or below 50% pump capacity because of its relatively large cooling area (8408ft^2 / 781.2m^2) compared to the heat output of the vessel systems used during station keeping (dynamic positioning).

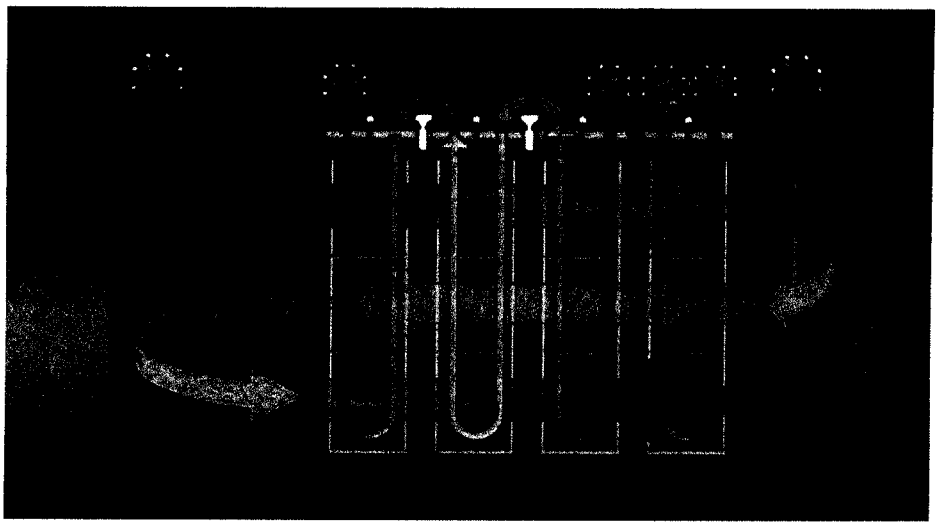


Figure 4. Sperre Rack Cooler System (Sperre, 2013)

The USEPA has defined a reduced intake velocity equal to 0.5 ft/s or less as a "best performing technology" in Volume 76, Section 76 of the Federal Register (page 22203) and states that greater than 90% of all species can avoid impingement when intake velocities are below the 0.5 ft/s threshold.

The Spearfish CWIS are designed and constructed to have through-screen velocities less than 0.5 ft/s for each sea chest screen. A plate shaped grating structure at the bottom of the sea chests is sized with a minimum 25% safety (fouling) factor on open area to maintain a velocity below 0.5 ft/s when the screen is 25% plugged. With no plugging, the maximum design through-screen velocities are 0.37 ft/s for the main cooling system and 0.34 ft/s for the secondary system. See the Appendix for the design calculations.

4.0 CWIS MAINTENANCE AND MONITORING

The Spearfish uses a combination of low through-screen velocities and cathodic protection to prevent biomass accumulation on the screens. If the intake structure requires cleaning, a remote operated vehicle (ROV) equipped with a high pressure wand or brush can be used to clean the grating externally.

During the period the CWIS is in operation weekly visual inspections will be conducted by deploying a camera on an ROV to inspect the screen from the outside looking in. The purpose of these visual inspections is to ensure that the required design and construction technologies are maintained and operated so they continue to function as designed The Siem Spearfish is equipped with two work class ROVs capable of these inspections. In the event that such visual monitoring is not possible due to hazardous factors beyond the Spearfish's control, the Spearfish will provide an explanation for the failure to provide the monitoring on its Discharge Monitoring Report (DMR) submittal.

Intake through-screen velocity will be calculated using the pump capacities displayed at the operator control station with the following equations:

Main System

Total Flow Rate = Pump1 * PumpCapacity1 + ... + Pump4 *PumpCapacity4

Velocity = Total Flow Rate / Effective Open Area

Secondary Cooling System

Total Flow Rate = Pump5 * PumpCapacity5 + Pump6 *PumpCapacity6

Velocity = Total Flow Rate / Effective Open Area

Example calculations are shown in the Appendix. A sample screen from the operator control station is below, showing the Seawater Cooling System Pump #1 at 26% Capacity:

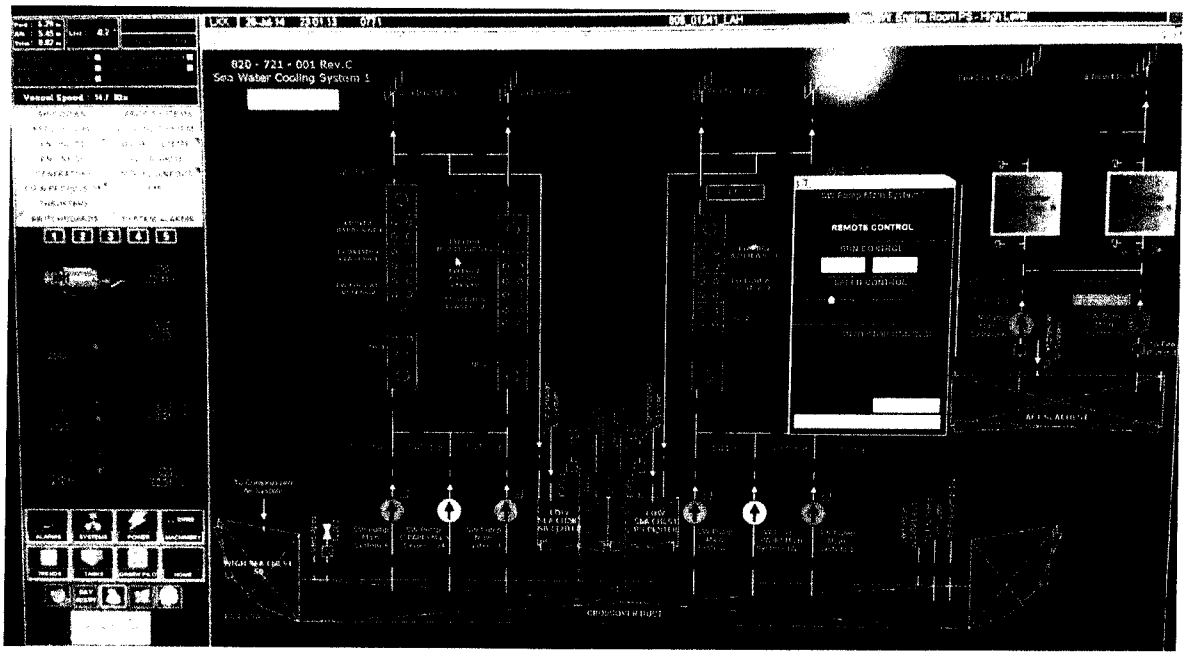


Figure 4. Photo of the Operator Control Station

5.0 REFERENCES

1. CSA Ocean Sciences Inc. 2014. Gulf of Mexico Cooling Water Intake Structure Entrainment Monitoring Study, prepared for the Offshore Operators Committee Environmental Sciences Subcommittee. March 2014.
2. LGL Ecological Research Associates, Inc. 2009. Gulf of Mexico Cooling Water Intake Structure: Source Water Biological Baseline Characterization Study, prepared for the Offshore Operators Committee Environmental Sciences Subcommittee.
3. Sperre. 2013. Sperre Technical Review No. 2, Performance Through Superior Technology.
4. US EPA Technical Development Document for the Final Section 316(b) Phase III Rule, EPA-821-R-06- 003. 2006.

6.0 APPENDIX

1. Calculations: Spearfish SW Cooling System Flow Rates - System 1 to 4
2. Calculations: Spearfish SW Cooling System Flow Rates - System 5 to 6
3. Drawing: 820-721-001 Rev C – Seawater Cooling System 1
4. Drawing: 820-262-049 Rev B – Grating for Sea Chests, Low Suction, Fwd
5. Drawing: 820-262-050 Rev A – Grating for Sea Chests, High Suction, Fwd
6. Drawing: 820-262-046 Rev B – Grating for Aft Sea Chest

M/V Spearfish - Seawater Cooling System Flow Rates **25 Jul 2014**
Cooling Systems 1 to 4 **F. Valica**

Input

$PFlow_1 := 327 \frac{m^3}{hr} = 1440 \cdot gpm$

$PFlow_2 := 243 \frac{m^3}{hr} = 1070 \cdot gpm$

$PFlow_3 := 175 \frac{m^3}{hr} = 771 \cdot gpm$

$PFlow_4 := 213 \frac{m^3}{hr} = 938 \cdot gpm$

Water Pump Flow Rates
Systems 1 through 4

$PCap_1 := 50\%$

$PCap_2 := 50\%$

$PCap_3 := 50\%$

$PCap_4 := 50\%$

Pump Capacity While in
Dynamic Positioning Mode

$LS_{GratingArea} := 1850cm^2 = 1.991 \cdot ft^2$

$LS_{GratingNo} := 4$

Low Seachest
Grating Area

$HS_{GratingArea} := 2170cm^2 = 2.336 \cdot ft^2$

$HS_{GratingNo} := 2$

High (Starboard) Seachest
Grating Area

$Velocity_{max} := 0.5 \frac{ft}{s}$

Maximum Allowed Water Velocity

Calculations

$TotalFlow := PFlow_1 \cdot PCap_1 + PFlow_2 \cdot PCap_2 + PFlow_3 \cdot PCap_3 + PFlow_4 \cdot PCap_4$

$TotalFlow = 2109 \cdot gpm$

Total Flowrate

$GratingArea := LS_{GratingArea} \cdot LS_{GratingNo} + HS_{GratingArea} \cdot HS_{GratingNo}$

$GratingArea = 12.6 \cdot ft^2$

Total Grating Area

Results

$$Velocity := \frac{TotalFlow}{GratingArea} = 0.372 \cdot \frac{ft}{s}$$

Water Velocity Across Grating

$$Fouling_{Allow} := \frac{Velocity_{max} - Velocity}{Velocity_{max}} = 25.6\%$$

Allowable Fouling

$$DailyFlow := TotalFlow \cdot 60 \frac{min}{hr} \cdot 24 \frac{hr}{day} = 3036922 \cdot \frac{gal}{day}$$

Flow Rate per Day While in Dynamic Positioning Mode

MPSV Spearfish - Seawater Cooling System Flow Rates **25 Jul 2014**
Cooling System 5 & 6 **F. Valica**

Input

$PFlow_5 := 64\frac{m^3}{hr} = 282 \cdot gpm$

$PFlow_6 := 64\frac{m^3}{hr} = 282 \cdot gpm$

Water Pump Flow Rates Systems 5 & 6

$PCap_5 := 50\%$

$PCap_6 := 50\%$

Pump Capacity While in Dynamic Positioning Mode

$Aft_{GratingArea} := 1704cm^2 = 1.834 \cdot ft^2$

$Aft_{GratingNo} := 1$

Aft Suction Seachest Grating Area

Calculations

$TotalFlow := PFlow_5 \cdot PCap_5 + PFlow_6 \cdot PCap_6$

$TotalFlow = 282 \cdot gpm$

Total Flowrate

$GratingArea := Aft_{GratingArea} \cdot Aft_{GratingNo}$

$GratingArea = 1.8 \cdot ft^2$

Total Grating Area

$Velocity_{max} := 0.5\frac{ft}{s}$

Maximum Allowed Water Velocity

Results

$Velocity := \frac{TotalFlow}{GratingArea} = 0.342 \cdot \frac{ft}{s}$

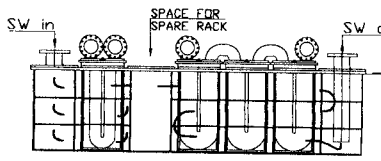
Water Velocity Across Grating

$Fouling_{Allow} := \frac{Velocity_{max} - Velocity}{Velocity_{max}} = 31.5\%$

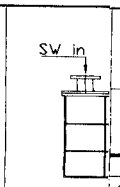
Allowable Fouling

$DailyFlow := TotalFlow \cdot 60\frac{min}{hr} \cdot 24\frac{hr}{day} = 405768 \cdot \frac{gal}{day}$

Flow Rate per Day While in Dynamic Positioning Mode



RACK COOLER TYPICAL DETAIL SYSTEM 1&4
(in double bottom)



RACK COO

EQUIPMENT IDENTIFICATION NUMBER
SFI.XXX.XXX
XXX.XXX.XX
ITEM NUMBER

ARMATURE IDENTIFICATION NUMBER
SFI CODE
XXX-XXXX
ARMATURE NUMBER

LINE IDENTIFICATION NUMBER
SFI CODE
XXX-XXX-XXX
LINE NUMBER
NOMINAL LINE SIZE
CuNi Pipe CNXX (CN50) — Copper Pipe CuXX (Cu15)

GA-IDENTIFICATIONS

SYMBOLS

ARMATURE / DIV.		EQUIPMENT	
FIRE VALVE (HYDRANT)	NR GLOBE VALVE		CENTRIFUGAL PUMP W/ELECTRICAL MOTOR
BUTTERFLY VALVE LUG TYPE	CHECK VALVE		CENTRIFUGAL PUMP W/ELECTRICAL MOTOR FREQUENCY OPERATED
BALL VALVE	FILTER		EJECTOR
REGULATING VALVE	MUD BOX		
ORIFICE	TEMPERATURE INDICATOR		
1/4" SOCKET FOR DPI-INSTRUMENTATION	PRESSURE INDICATOR		

SPECIFICATIONS

PIPES SPECIFICATION.:
PIPING SYSTEM CLASS: III — PIPE PRESSURE CLASS: PN10.
DESIGN WORKING PRESSURE: 3 BAR — TEST PRESSURE: 4,5 BAR.
PIPE TYPE ACC. PIPE DIM.:
COPPER NICKEL PIPES.
ND =<150: DIN 86019 CuNi PIPES 90/10. PN 16.
ND =>200: DIN 86019 CuNi PIPES 90/10. PN 10.
STEEL PIPES.
ND =<150: NS 2501 SEAMLESS STEEL PIPES. St. 37.0/St. 35.8.1(w/3.1 B cert.)
ND =>200: NS 2501 SEAMLESS STEEL PIPES. St. 37.0/St. 35.8.1(w/3.1 B cert.)

DnV product certificate for all overboard valves and valves on collision bulkhead according to DnV Pt.4 Ch.6 Sec 2 and Pt.4 Ch.6 Sec. 6 C300.

PIPE LEGEND.:
SW PIPE SYSTEM
MISC. SYSTEM

FLANGES/THREADS SPECIFICATION.:
FLANGE CONNECTIONS TO BE USED FOR PIPE DIMENSION DN=>40 AND UPWARDS.
FITTINGS WITH THREADS, PRESS OR CUT RING TO BE USED FOR PIPES LESS THAN ND < 40.
FLANGES FOR PIPE DIM. ND =<150: NS 2527 PRESSURE RATING PN16.
FLANGES FOR PIPE DIM. ND >150: NS 2526 PRESSURE RATING PN10

MATERIAL SPECIFICATION FOR VALVES (general).:
VALVE DIM. ND =< 40: BRONZE.
VALVE DIM. ND > 40: CAST IRON.
VALVES ON COLLISION BULKHEAD, SHIP SIDES: NODULAR CAST IRON. (GGG 40,3)

PIPES

STEEL PIPES NS 2501 (DIN 17177)

PIPE ND	EXT. DIAM.	WALL THICKNESS GENERAL. (mm)	WALL THICKNESS IN TANKS. (mm)
ND40	ø48,3	4,5	6,3
ND50	ø60,3	4,5	6,3
ND65	ø76,1	4,5	6,3
ND80	ø88,9	4,5	7,1
ND100	ø114,3	4,5	8,0
ND125	ø139,7	4,5	8,0
ND150	ø168,3	4,5	8,8
ND200	ø219,1	6,3	8,8
ND250	ø273,0	6,3	8,8

Cu. Ni. TUBES 90/10 DIN 86019

PIPE SIZE	EXT. DIAM.	WALL THICKNESS GENERAL. (mm)
CN25	ø 30,0	1,5
CN32	ø 38,0	1,5
CN40	ø 44,5	1,5
CN50	ø 57,0	1,5
CN65	ø 76,1	2,0
CN80	ø 88,9	2,0
CN100	ø 108	2,5
CN125	ø 133	3,0
CN150	ø 159	3,0
CN200	ø 219,1	3,5
CN250	ø 267,0	4,0
CN300	ø 323,9	4,0
CN350	ø 368,0	4,0
CN400	ø 419,0	4,5
CN500	ø 508,0	5,0

COPPER TUBES-ANNEALED (DIN 1786)

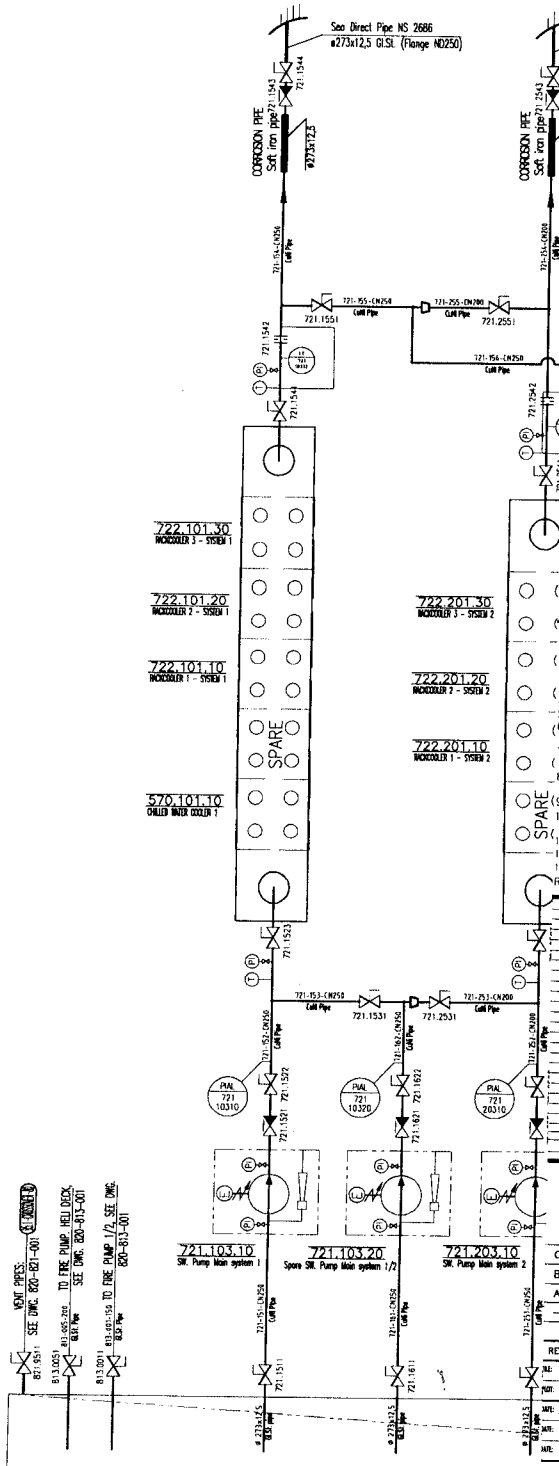
PIPE SIZE	(INCH)	EXT. DIAM.	WALL THICKNESS GENERAL. (mm)
Cu8	1/4"	ø 8	1,0
Cu10	3/8"	ø 10	1,2
Cu12	3/8"	ø 12	1,2
Cu18	1/2"	ø 18	1,2
Cu22	3/4"	ø 22	1,5
Cu28	1"	ø 28	1,5
Cu35	11/4"	ø 35	2,0
Cu42	11/2"	ø 42	2,0

NOTES

721-SEA WATER SYSTEM ITEMS no.
1. ALL PUMPS TO BE ARRANGED WITH PRESSURE/VACUUM GAUGE ON SUCTION AND DISCHARGE
2. BUTTERFLY VALVES TO BE OF LUG TYPE (MOUNTED w/BOLTED AT EACH SIDE).
3. SW. PIPES TO BE OF Cu. Nickel (90/10).
4. INLET/OUTLET OF COOLERS TO BE FITTED WITH THERMOMETERS.
5. SW. PUMPS TO BE PROVIDED WITH AUTOMATIC EJECTOR.
6. PIPES AND VALVES MOUNTED ON SHELL PLATING, BOTTOM AND SEA CHESTS ARE TO BE DELIVERED WITH DOC. ACC. TO DnV REQUIREMENTS.
7. THE SEA INLET VALVES TO BE BUTTERFLY VALVES OF TOUGH IRON, RUBBER LINED AND SOFT SEATED. THE SEA INLET FILTERS TO BE OF CAST IRON WITH STRAINER OF STAINLESS STEEL
8. SOFT IRON ANODES TO BE FITTED. THE ANODES TO BE THICK WALLED. SPARE PIPES TO BE DELIVERED ACC. TO CLASS REQ.
9. ANTIFOULING SYSTEM IN SEACHESTS TO BE ARRANGED ACC. TO SUPPLIERS RECOMMENTATIONS
10. ISOLATION SET WITH "PLASTIC WASHERS" AND "PLASTIC SLEEVES" TO BE INSTALLED BETWEE COOLERS AND PIPING SYSTEM. TO AVOID METALLIC CONTACT.
11. INSTRUMENTATION TO BE OF AISI-316 OR CuNi
12. HOSES TO BE PREPARED AND SUPPLIED FOR BACKFLUSHING PURPOSE
13. VALVE 721.9011 + 721.9021 + 721.9031 TO BE OPERATED FROM ABOVE FLOODING LINE (EO REQUIREMENT)

COMPONENTS

722.801.10	FW Cooler, System NO.6	300 kW – Flt. 64 m3/h		
722.801.10	FW Cooler, System NO.5	300 kW – Flt. 64 m3/h		
722.401.30	INCHCOOLER 3 – SYSTEM 4	2543kW/3 – SW. 213m3/h		SPERRE
722.401.20	INCHCOOLER 2 – SYSTEM 4	2543kW/3 – SW. 213m3/h		SPERRE
722.401.10	INCHCOOLER 1 – SYSTEM 4	2543kW/3 – SW. 213m3/h		SPERRE
722.301.30	INCHCOOLER 3 – SYSTEM 3	2383kW/3 – SW. 176m3/h		SPERRE
722.301.20	INCHCOOLER 2 – SYSTEM 3	2383kW/3 – SW. 176m3/h		SPERRE
722.301.10	INCHCOOLER 1 – SYSTEM 3	2383kW/3 – SW. 176m3/h		SPERRE
722.201.30	INCHCOOLER 3 – SYSTEM 2	2678kW/3 – SW. 243m3/h		SPERRE
722.201.20	INCHCOOLER 2 – SYSTEM 2	2678kW/3 – SW. 243m3/h		SPERRE
722.201.10	INCHCOOLER 1 – SYSTEM 2	2678kW/3 – SW. 243m3/h		SPERRE
722.101.30	INCHCOOLER 3 – SYSTEM 1	3033kW/3 – SW. 327m3/h		SPERRE
722.101.20	INCHCOOLER 2 – SYSTEM 1	3033kW/3 – SW. 327m3/h		SPERRE
722.101.10	INCHCOOLER 1 – SYSTEM 1	3033kW/3 – SW. 327m3/h		SPERRE
721.203.10	SW. Pump Main system 6	64 m3/h – 3,0 bar		Ing. Per Gjerdrum
721.203.10	SW. Pump Main system 5	64 m3/h – 3,0 bar		Ing. Per Gjerdrum
721.403.20	Spare SW. Pump Main system 3/4	213 m3/h – Appr. 1,5 bar		Ing. Per Gjerdrum
721.403.10	SW. Pump Main system 4	213 m3/h – Appr. 1,5 bar		Ing. Per Gjerdrum
721.303.10	SW. Pump Main system 3	176 m3/h – Appr. 1,5 bar		Ing. Per Gjerdrum
721.203.10	SW. Pump Main system 2	243m3/h – Appr. 1,5 bar		Ing. Per Gjerdrum
721.103.20	Spare SW. Pump Main system 1/2	327m3/h – Appr. 1,5 bar		Ing. Per Gjerdrum
721.103.10	SW. Pump Main system 1	327m3/h – Appr. 1,5 bar		Ing. Per Gjerdrum
570.101.10	CHILLED WATER COOLER 3			SPERRE
570.101.10	CHILLED WATER COOLER 1			SPERRE
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



REV.	DATE	TEXT	Prepared by:	Checked by:	Appr.	Cust. appr.
C	05.02.14	Added alarm tags	RS			
B	08.11.13	Changed overboard pipes material	RSP			
A	21.08.13	Renamed Sea Water Pumps main system 1–4	SAS			
–	21.11.12	ISSUED FOR APPROVAL	AHa	RF		
		Drawing also valid for NB 821				

FILE: 820-721-001 — SHEET: 1 of 1

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DATE: 22.10.2012 — DRAWN: RF — SCALE: % — DWG. NO. 820-721-001 — REV. C

DATE: — CHECKED:
DATE: — APPROVED:

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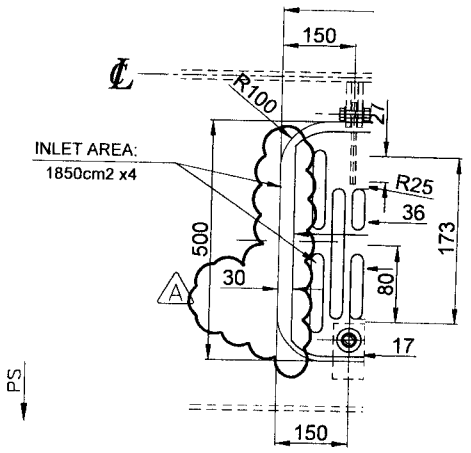
TITLE: Sea water cooling System 1

FORMAT	PROJECT	DESIGN
A1	NOD 1087	OSCV 03



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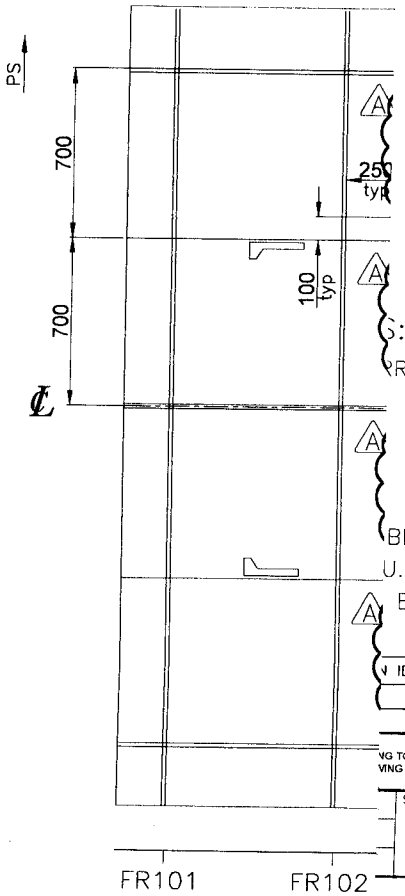

RANGEMENT SEACHESTS FWD AND CROSSOVER

BE FITTED ABOVE SEA CHEST STRAINERS.

U.N.O

BE ROUNDED

VIEW AT B

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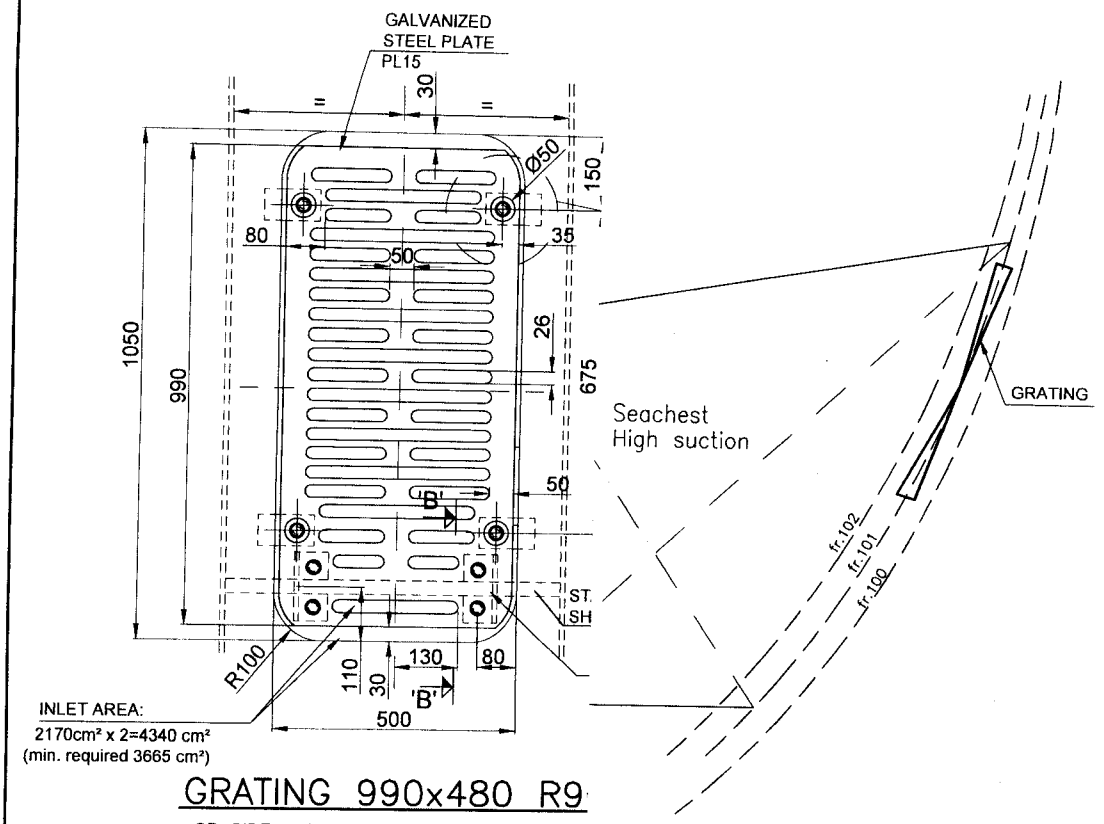
SCALE:	DWG NO.	REV:
1:20 (1:10, 1:5)	820-262-049	B

TITLE:

Grating for Sea chests
Low suction, FWD

FORMAT:	PROJECT:	DESIGN:
A2	NOD 1087	VARD 3 03



GRATING 990x480 R9

SB SIDE, VIEW FROM OUTSIDE SHELL
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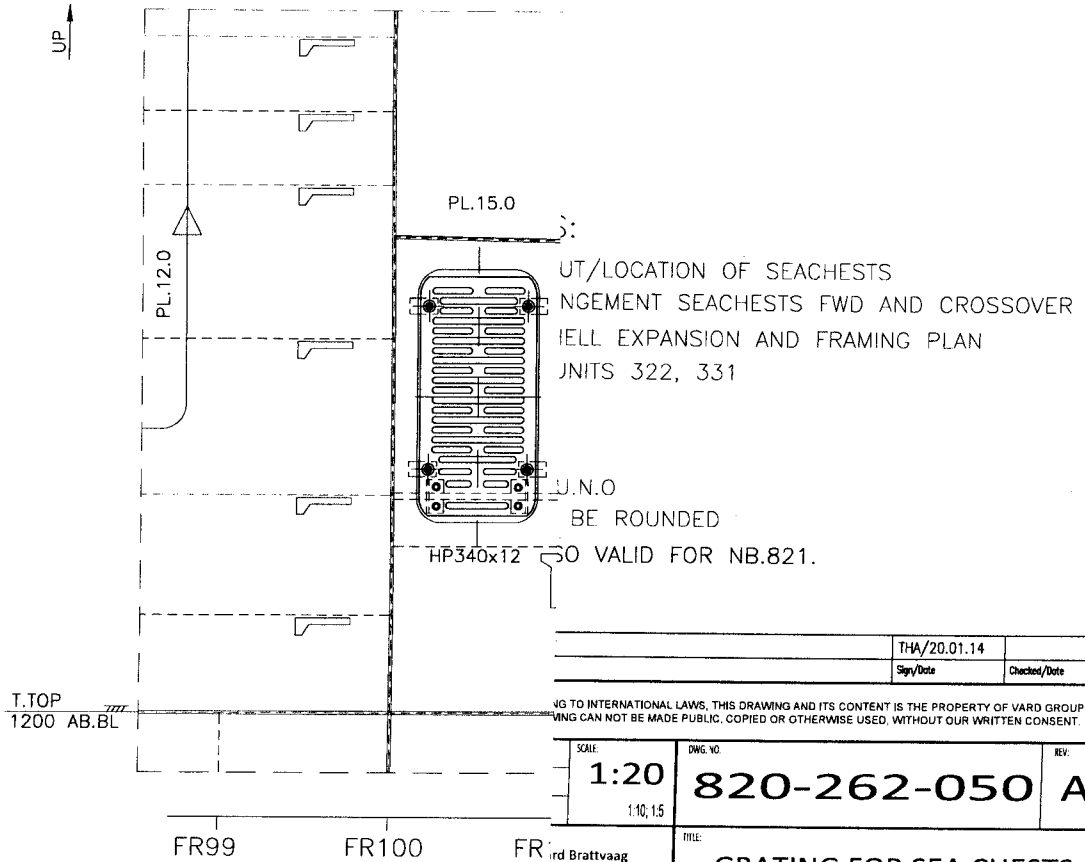

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SCALE:	DWG. NO.	REV:
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TITLE: GRATING FOR SEA CHESTS HIGH SUCTION, FWD

FORMAT:	PROJECT:	DESIGN:
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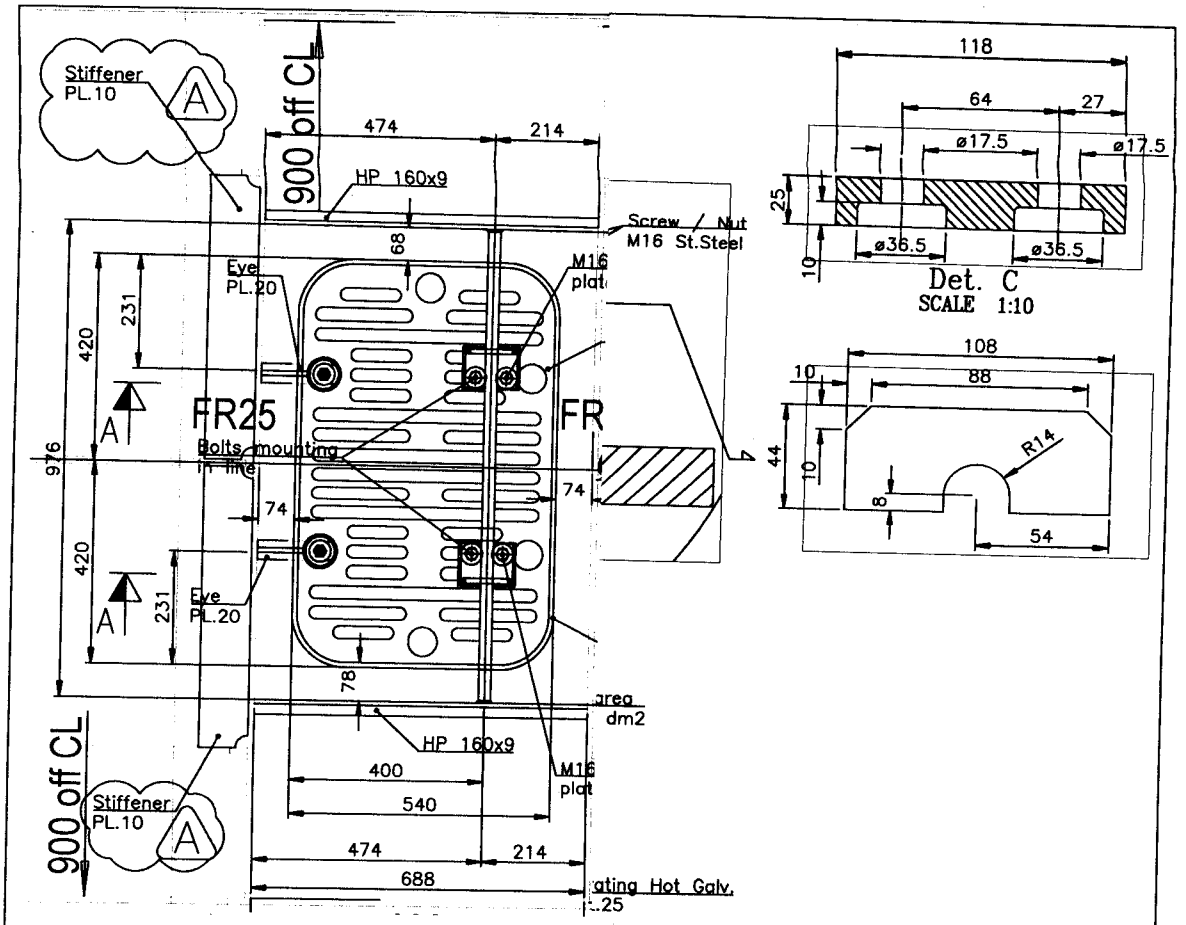

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REFERENCE DRAWINGS:
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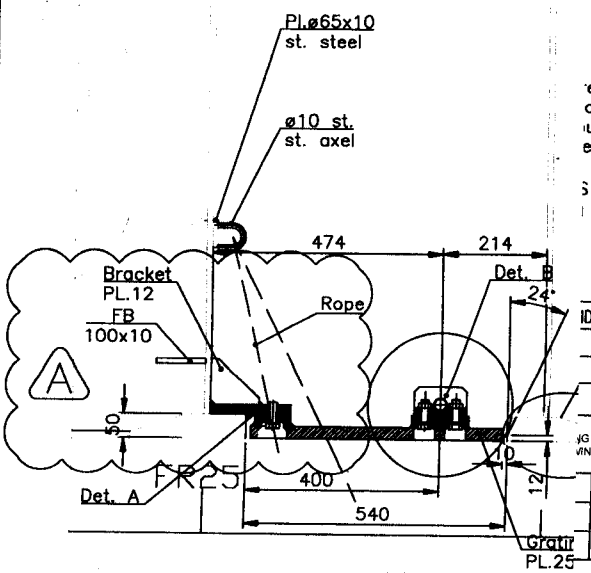
Unit 123: 820-209-123-1
3D Model
820-721-001 Sea water cooling system
820-262-010_B



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TITLE: Grating for aft sea chest

FORMAT:	PROJECT:	DESIGN:
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OFFSHORE OPERATORS COMMITTEE

September 22, 2015

Mr. Isaac Chen
USEPA REGION 6
1445 Ross Avenue
Suite 1200
Mail Code: 6WQ
Dallas, TX 75202-2733

Dear Mr. Chen:

SUBJECT: OFFSHORE OPERATORS COMMITTEE
PRODUCED WATER AND WATER BASED MUD CHARACTERIZATION STUDY

In accordance with Part I.B.1.d and 4.c of GMG290000 (2012), the Offshore Operators Committee (OOC) is submitting the attached *OOC Produced Water and Water Based Mud Characterization Study.* Tetra Tech, Inc. conducted the study under contract to the OOC.

The purpose of the Study was to enable participating companies, as a joint industry project, to meet the permit requirement to analyze selected dissolved constituents in produced water and water based mud. Thirty-eight (38) members of the OOC participated in the study, providing samples from producing facilities and drilling rigs throughout the Region 6 area of the Gulf of Mexico.

If there are any questions, need additional information or would like to meet to discuss the study, please call me at (504) 425-7693.

Robert Kuehn
Study Coordinator
On behalf of the Water Quality Subcommittee of the Offshore Operators Committee

/RK

Attachments

cc: Hardcopy with Attachments
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Physical Scientist
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Atlanta, GA 30303-8960

Via email with Attachments
OOC Participants (cover letter & final report only)
June Mire, Tetra Tech, Inc. (cover letter only)

Listing of Attachments
Letter to Mr. Isaac Chen Dated September 22, 2015
Subject: OOC – Produced Water and Water Based Mud Characterization Study

Attachment 1	OOC Produced Water and Water Based Mud Characterization Study – Final Report
Attachment 2	E-mail from June Mire to Isaac Chen dated March 24, 2014 – OOC Mud and Produced Water Characterization Study – Revised SAP/QAPP
Attachment 3	May 23, 2013 – Minutes from Tetra Tech Teleconference with EPA Region 6
Attachment 4	Work Order # 1312548
Attachment 5	Produced Water Analytical Results Summary
Attachment 6	Statistical Analysis of Produced Water and Water Based Mud Samples

OOC Produced Water and Water Based Mud Characterization Study

Final Report

September 2015

TETRA TECH

EXECUTIVE SUMMARY

The Mud and Produced Water Characterization Study (MPWCS) was conducted by the Offshore Operators Committee (OOC) as a Joint Industry Project (JIP) to enable study participants to comply with applicable requirements of the Region 6 United States Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Permit GMG290000 for the Western and Central Gulf of Mexico (GOM) Outer Continental Shelf (OCS) (EPA 2012). Tetra Tech, Inc. (Tetra Tech) conducted the MPWCS under contract to the OOC.

Thirty-eight (38) members of the OOC that chose to participate in the group study provided samples from producing facilities and drilling rigs throughout the EPA Region 6 OCS. Produced water (PW) and water based mud (WBM) samples were collected and analyzed for dissolved concentrations of arsenic, cadmium, copper, cyanide, hexavalent chromium, lead, mercury, nickel, selenium, silver, and zinc . A total of 270 PW samples from 27 lease areas were selected to represent overall offshore production. Eight duplicate PW samples were collected for quality assurance purposes. WBM samples were collected during active drilling according to the drilling schedule of participating operators during the study period. This study includes 102 samples from 21 lease areas collected between December 2013 and April 2015.

Despite extensive effort to extract aqueous samples from WBM, most WBM samples yielded insufficient water to conduct analysis of dissolved constituents. WBM is carefully formulated so that it will not release water, limiting the direct comparison of WBM discharges with dissolved WQC. This characterization study included analytical results of total concentrations of constituents in solid WBM samples in an effort to address the permit requirement to characterize WBM. However, correlation analysis demonstrated the lack of positive relationship between WBM-solid concentrations and WBM-aqueous concentrations from the same sample (Section 8.3), further limiting the interpretation of WBM-solid results using WQC. The WBM-aqueous results are the most reliable and representative of potential release of dissolved constituents in WBM to the GOM.

All constituents in PW meet the USEPA National Recommended Water Quality Criteria (WQC) for protection of marine aquatic life from chronic toxicity at the 100-meter mixing zone boundary. Therefore, PW discharges authorized in the general permit would not cause unreasonable degradation of the marine environment.

All constituents in WBM-aqueous samples, except lead, meet the chronic WQC at the 100-meter mixing zone boundary. Lead is greater than the chronic WQC by a factor of 1.4 but is far below the acute WQC. Given the decreased solubility of the inorganic lead contained in WBM compared with the lead salts used in developing the WQC, and the widely scattered locations of WBM discharge across the dynamically active GOM, the concentration of lead in WBM-aqueous samples is unlikely to cause adverse ecological impacts or degradation of water quality.

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A Sampling and Analysis Plan/Quality Assurance Project Plan
B Record of Communication with EPA Region VI
C Data Validation Reports

D Data Summary Results

E Statistical Analysis of PW and WBM Samples

ACRONYMS AND ABBREVIATIONS

#	number
%	percent
ALS	ALS Laboratories, Inc.
BOEM	Bureau of Ocean Energy Management
CCC	criterion continuous concentration
CD	critical dilution
CDF	critical dilution factor
COC	chain of custody
EPA	United States Environmental Protection Agency
GOM	Gulf of Mexico
JIP	Joint Industry Project
LOD	level of detection
m	meter
MDL	method detection limit
MEC	maximum expected concentration
mg/L	milligram per liter
ML	minimum level
MPWCS	Mud and Produced Water Characterization Study
MS	matrix spike
MSD	matrix spike duplicate
n/a	not applicable
NELAP	National Environmental Laboratory Accreditation Program
NPDES	National Pollutant Discharge Elimination System
OCS	Outer Continental Shelf
ODCE	Ocean Discharge Criteria Evaluation
OOC	Offshore Operators Committee
PQL	practical quantitation limit

PW	produced water
QAPP	Quality Assurance Project Plan
QC	quality control
QL	quantitation limit
RL	reporting limit
SAP	Sampling and Analysis Plan
SOP	standard operating procedures
Tetra Tech	Tetra Tech, Inc.
TOC	total organic carbon
UCL	upper confidence limit
UTL	upper tolerance limit
WBM	water based mud
WQC	water quality criterion (or criteria)

1 INTRODUCTION

The Mud and Produced Water Characterization Study (MPWCS) was conducted by the Offshore Operators Committee (OOC) as a Joint Industry Project (JIP) pursuant to the United States Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Permit GMG290000 for the Western and Central Gulf of Mexico (GOM) Outer Continental Shelf (OCS) (EPA 2012). Tetra Tech, Inc. (Tetra Tech) conducted the MPWCS under contract to the OOC.

1.1 Purpose of Study

The purpose of the MPWCS is to enable participating companies to meet the EPA permit requirements (at Part I.B.1.d and 4.c of GMG290000) to sample and analyze selected analytes in produced water (PW) and water based mud (WBM). The study was required by EPA "to ensure the availability of more current information to conduct a reasonable potential (RP) screening against federal water quality criteria (WQC) to determine whether discharges of PW [and WBMs] may cause or contribute to an exceedance of federal WQC."[1]

1.2 Description of Study Participants

The permit allowed operators to conduct studies as individuals or as a group. Thirty-eight (38) members of the OOC chose to participate in the group study (Table 1-1) and provided samples from producing facilities and drilling rigs throughout the EPA Region 6 OCS, covering the western and central GOM. The selection of sample locations is described in Section 3.0.

1.3 Overview of Study

PW and WBM samples were collected and analyzed for dissolved concentrations of arsenic, cadmium, copper, cyanide, hexavalent chromium, lead, mercury, nickel, selenium, silver, and zinc. PW sample locations were selected to represent overall offshore production (see Section 4.1.2). WBM samples were collected during active drilling according to the drilling schedule of participating operators during the study period (see Section 5.1.2). Samples were collected between December 2013 and April 2015.

1.4 Organization of Report

This report presents background on the permit requirements (Section 2); a description of sampling logistics and training for sample collectors (also referred to as "samplers" herein) (Section 3); methods of selecting sample locations and collecting samples for PW (Section 4) and WBM (Section 5); and data validation procedures and results (Section 6).

Sections 7 and 8 present the statistical results and discussion of results for PW and WBM samples, respectively. Concentrations of dissolved constituent in PW and WBM discharges are compared with

[1] *Response to Comments, Final NPDES General Permit for Discharges from New and Existing Sources in the Offshore Subcategory of the Oil and Gas Extraction Point Source Category for the Western Portion of the Outer Continental Shelf of the Gulf of Mexico (GMG290000),* 9/28/12. Page 9, Response to Comment 13(c).

WQC in Section 9. Toxicity of constituents detected at concentrations above WQC is summarized in Section 10. Conclusions are in Section 11, and References cited are in Section 12.

Table 1-1. Joint Study Participants

Anadarko Petroleum Corporation
Anglo-Suisse Offshore Partners, LLC
ANKOR Energy LLC
Apache Corporation
Arena Offshore, LP
Bennu
BHP Billiton Petroleum (GOM), Inc.
Black Elk Energy Offshore Operations, LLC
BP Exploration and Production
Castex Offshore, Inc.
Century Exploration New Orleans, LLC
Chevron U.S.A. Inc.
Cobalt International Energy Inc.
Contango Operators, Inc.
Energy Resource Technology GOM, Inc. (same as Talos)
Energy XXI GOM, LLC
Eni Petroleum
Enven (bought Tarpon)
EPL Oil and Gas, Inc.
ExxonMobil Production Company
Fieldwood Energy LLC (includes former Apache assets)
Freeport-McMoRan Oil and Gas
Gulf Coast Energy Resources LLC
Helis Oil and Gas Company, LLC
Hess Corporation
Marathon Oil
McMoRan Oil and Gas LLC
Murphy Exploration and Production Company-USA
Noble Energy, Inc
Petrobras America, Inc.
PetroQuest Energy, LLC
Renaissance Offshore, LLC
SandRidge Energy
Shell Offshore Inc.
Stone Energy Corporation
Talos (same as Energy Resource Technology GOM, Inc.)
Tana Exploration Company LLC
Tarpon Operating and Development, LLC
W&T Offshore, Inc.
Walter Oil & Gas Corporation

2 PERMIT REQUIREMENTS

This section discusses the requirements presented in NPDES Permit No. GMG290000 as they pertain to the MPWCS. A chronology of the issuance and modifications to NPDES Permit No. GMG290000 is presented in Section 2.0 of the MPWCS Sampling and Analysis Plan (SAP), dated June 25, 2013 (Appendix A).

2.1 Produced Water Lease Areas

In accordance with Part I. Section B.4.c of the permit (*Produced Water Characterization Study*), operators conducting a joint study "must collect at least ten (10) samples from each State or Bureau of Ocean Energy Management (BOEM) designated surface area (i.e., Green Canyon, Mississippi Canyon, and etc.). Each sample shall be taken from a different block, unless an additional duplicate sample is taken, or less than 10 active blocks are within one surface area." The SAP submitted to and approved by EPA projected that 231 PW samples would be collected. The JIP study exceeded that projection, collecting 270 samples from 27 lease areas (see Section 4.1.2). During discussion with EPA on June 9, 2014, it was agreed that repeated PW samples from the same platform(s) would be collected on different days to make up 10 samples when a lease area had too few PW discharges to meet the desired distribution of 10 separate blocks (Appendix B).

2.2 WBM Lease Areas

In accordance with Part I. Section B.1.d of the permit (*Water Based Drilling Mud Characterization Study*), operators conducting a joint study "must collect at least ten (10) samples from each State or BOEM designated surface area (i.e., Green Canyon, Mississippi Canyon, and etc.). Each sample shall be taken from a different block, unless an additional duplicate sample is taken, or less than 10 active blocks are within one surface area." This study includes 102 samples from 21 lease areas (see Section 5.1.2). During a teleconference with EPA on June 9, 2014, the OOC described the efforts made to sample all WBM discharges of the participating operators (see Section 5.1). EPA agreed that it may not be possible to collect 10 samples per lease block if the incidence of drilling did not support that many samples.

3 SAMPLING LOGISTICS AND TRAINING OF SAMPLE COLLECTORS

The MPWCS was conducted in accordance with the Sampling and Analysis Plan and Quality Assurance Project Plan (SAP/QAPP), approved by EPA on July 8, 2013, and subsequently revised following discussions with EPA on March 24, 2014. Records of communication with EPA are in Appendix B. The revised SAP/QAPP is provided as Appendix A.

The MPWCS SAP describes the samples to be collected; sampling methodologies; applicable holding times and record keeping; analytical techniques and target detection limits; and platforms and rigs to be sampled. Changes to the SAP necessitated by field conditions are described in the applicable sections below.

A sampling kit was sent to the designated shorebase for each sample location, then transported to the platform or rig by boat or helicopter. The sampling kit contained all supplies, sample containers, instructions, and documentation necessary to prepare a sample for laboratory analysis. Documentation included a Sampling Procedure, a Sampling Procedure Reference Checklist to be completed by the sample collector, and a Chain-of-Custody (COC) form. The Checklist and the COC were submitted with the sample to the laboratory for quality assurance documentation review.

Each of the study participants provided trained personnel to collect the samples. PW samples were generally collected by the same personnel who were responsible for regular NPDES sampling on the platforms. WBM samples were most often collected by personnel representing the service companies that supplied the drilling mud to the location. Tetra Tech provided all samplers specific training on the PW and WBM sample collection for this study via video (on YouTube) and on a DVD included in the sampling kit shipped to each location. Each sample collector was provided a laminated flip chart with step-by-step instructions of the sampling procedures to reinforce the video training. Tetra Tech contacted each sample collector by phone or email to verify that he had watched the training video and reviewed the procedure and checklist before collecting the sample. A list of frequently asked questions was maintained and distributed to all study participants so that lessons learned during the sampling event could be disseminated to all sample collectors.

4 PRODUCED WATER CHARACTERIZATION

This section discusses the selection of sample locations, changes to the PW filtration procedure, and analytical methods for PW.

4.1 Selection of PW Sample Locations

The study design called for collection of ten PW samples from each of the 28 lease areas where study participants held active leases. In lease areas that had ten or more active platforms, sample locations were selected through a stratified random sampling approach based on a representative, weighted distribution of participating operators. The goal was to have all study participants represented in proportion to their holdings in the study area. In lease areas that had fewer than ten active platforms, a given facility was sampled more than once on different days to achieve a total of ten samples from the lease area, to the extent practicable (see Appendix B for EPA concurrence on this approach). However, several of the planned samples were never collected because the platform stopped producing before the samples could be collected. Therefore, four lease areas (EC, EW, GA, and GC) are represented by nine rather than ten samples. The sole producing platform in Lease Area MU was permanently shut in before a sample could be collected, reducing the total number of lease areas sampled to 27. Locations of all PW samples are listed in Table 4-1 and shown on Figure 4-1. Estimated water depths of PW sample locations are in Table 4-2, based on the centroid bathymetric value for each lease block.

4.2 Changes to the Sample Filtration Procedure

Each PW sample was passed through a 0.45 micron filter to obtain dissolved phase results following standard EPA guidelines and Standard Operating Procedures (SOPs), including *Collecting Water-Quality Samples for Dissolved Metals in Water* (revised January 13, 2000). As described in the MPWCS SAP, the OOC initiated a separate study to compare results of PW samples filtered and preserved at the point of collection with results for samples filtered and preserved in the laboratory. Based on the similarity of analytical results of the 21 split samples, EPA agreed that field filtration of PW samples was not necessary. (See Appendix B for the letter report submitted to EPA Region 6 on May 21, 2014 and EPA concurrence on June 9, 2014). PW samples collected and submitted to the laboratory prior to concurrence were filtered and preserved in the field. PW samples collected after concurrence were filtered in the laboratory. Only the location of filtration was changed; the filtering protocol and filter size did not change.

4.3 Produced Water Analytical Methods

All PW samples were collected in accordance with the procedures outlined in the Sampling Procedure and Checklist (presented in the MPWCS SAP) and sent to ALS Laboratories, Inc. (ALS) in Houston, Texas, a Tetra Tech-procured laboratory certified by the National Environmental Laboratory Accreditation Program (NELAP). The laboratory analyzed the dissolved phase of arsenic, cadmium, copper, lead, nickel, selenium, silver, and zinc by EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846) Method 6020A, mercury by SW-846 Method 7470A, cyanide by SW-846 Method 9014, and hexavalent chromium by Determination of Dissolved Hexavalent Chromium in Drinking Water, Groundwater, and Industrial Wastewater Effluents by Ion Chromatography (EPA Method 218.6). Analysis by EPA Method 218.6 was subcontracted by ALS to their Rochester, New York location.

Table 4-1. Produced Water Sample Locations by Lease and Block

Lease Area	Block	Total # Samples
ALAMINOS CANYON (AC)	25	10
	25	
	25	
	25	
	25	
	857	
	857	
	857	
	857	
	857	
BRAZOS (BA)	105	10
	105	
	105	
	133	
	133	
	133	
	491	
	491	
	491	
	491	
BRETON SOUND (BS)	53	10
	53	
	53	
	53	
	53	
	53	
	53	
	53	
	53	
	53	

Lease Area	Block	Total # Samples
EAST BREAKS (EB)	602	10
	602	
	643	
	643	
	159	
	159	
	160	
	160	
	165	
	165	
EAST CAMERON (EC)	160	9
	334	
	346	
	381	
	46	
	321	
	33	
	14	
	261	
EUGENE ISLAND (EI)	53	10
	212	
	315	
	333	
	342	
	346	
	24	
	65	
	11	
	302	
EWING BANK (EW)	910	9
	826	
	873	
	873	
	873	
	873	
	305	
	305	
	305	

Lease Area	Block	Total # Samples
GALVESTON (GA)	355	9
	209	
	209	
	209	
	424	
	424	
	424	
	424	
	424	
GARDEN BANKS (GB)	668	10
	668	
	189	
	189	
	260	
	260	
	128	
	128	
	426	
	426	
GREEN CANYON (GC)	613	9
	608	
	680	
	787	
	205	
	641	
	338	
	237	
	158	
GRAND ISLE (GI)	43	10
	47	
	73	
	90	
	93	
	116	
	33	
	33	
	78	
	37	

Lease Area	Block	Total # Samples
HIGH ISLAND (HI)	573	10
	376	
	582	
	A474	
	531	
	557	
	22	
	110	
	379	
	446	
MISSISSIPPI CANYON (MC)	21	10
	941	
	650	
	127	
	582	
	736	
	109	
	194	
	807	
	243	
MATAGORDA ISLAND (MI)	669	10
	654	
	654	
	654	
	519	
	519	
	622	
	622	
	623	
	623	
	623	
MAIN PASS (MP)	153	10
	259	
	298	
	30	
	313	
	300	
	61	
	73	
	299	
	265	

Lease Area	Block	Total # Samples
SOUTH PELTO (PL)	13	10
	10	
	11	
	18	
	18	
	5	
	22	
	23	
	6	
	25	
NORTH PADRE ISLAND (PN)	891	11
	891	
	891	
	891	
	891	
	891	
	891	
	891	
	891	
	891	
	891	
SABINE PASS (SA)	13	10
	13	
	13	
	13	
	13	
	10	
	10	
	10	
	10	
	10	

Lease Area	Block	Total # Samples
SOUTH MARSH ISLAND (SM)	128	11
	128	
	268	
	132	
	149	
	141	
	288	
	130	
	39	
	239	
	217	
SOUTH PASS (SP)	62	10
	65	
	70	
	75	
	87	
	89	
	83	
	49	
	60	
	60	
SHIP SHOAL (SS)	229	10
	207	
	198	
	181	
	72	
	266	
	224	
	300	
	253	
	111	
SOUTH TIMBALIER (ST)	156	10
	52	
	151	
	37	
	148	
	30	
	100	
	300	
	295	
	229	

Lease Area	Block	Total # Samples
VIOSCA KNOLL (VK)	900	10
	786	
	915	
	915	
	826	
	989	
	956	
	956	
	823	
	823	
VERMILION (VR)	380	10
	326	
	265	
	214	
	170	
	331	
	256	
	279	
	371	
	38	
WEST CAMERON (WC)	65	10
	66	
	66	
	33	
	96	
	173	
	265	
	661	
	485	
	100	
	100	
WEST DELTA (WD)	105	10
	122	
	109	
	30	
	73	
	117	
	65	
	72	
	79	
	29	

Lease Area	Block	Total # Samples
WALKER RIDGE (WR)	249	10
	249	
	249	
	249	
	249	
	249	
	249	
	249	
	249	
	249	

Table 4-2. Bathymetry of Produced Water Sample Locations
(from shallowest to deepest)

Area Code	Block Code	Samples per Block	Approximate Depth (meters)
BS	53	10	-4
SM	217	1	-4
EI	11	1	-4
EI	24	1	-5
EI	53	1	-6
EI	65	1	-6
SM	239	1	-7
WC	33	1	-8
SS	72	1	-8
PL	11	1	-8
PL	13	1	-8
SM	268	1	-9
PL	10	1	-9
WC	65	1	-10
WC	66	2	-10
MP	30	1	-10
SA	13	5	-10
EC	14	1	-10
SS	111	1	-10
PL	5	1	-10
SA	10	5	-11
VR	38	1	-11
HI	22	1	-11
WC	96	1	-12
WC	100	2	-12
EC	33	1	-12
WD	29	1	-12
WD	30	1	-12
ST	30	1	-13
PL	6	1	-13
EC	46	1	-14
HI	110	1	-14
WC	173	1	-15
PL	18	2	-15
GI	37	1	-15

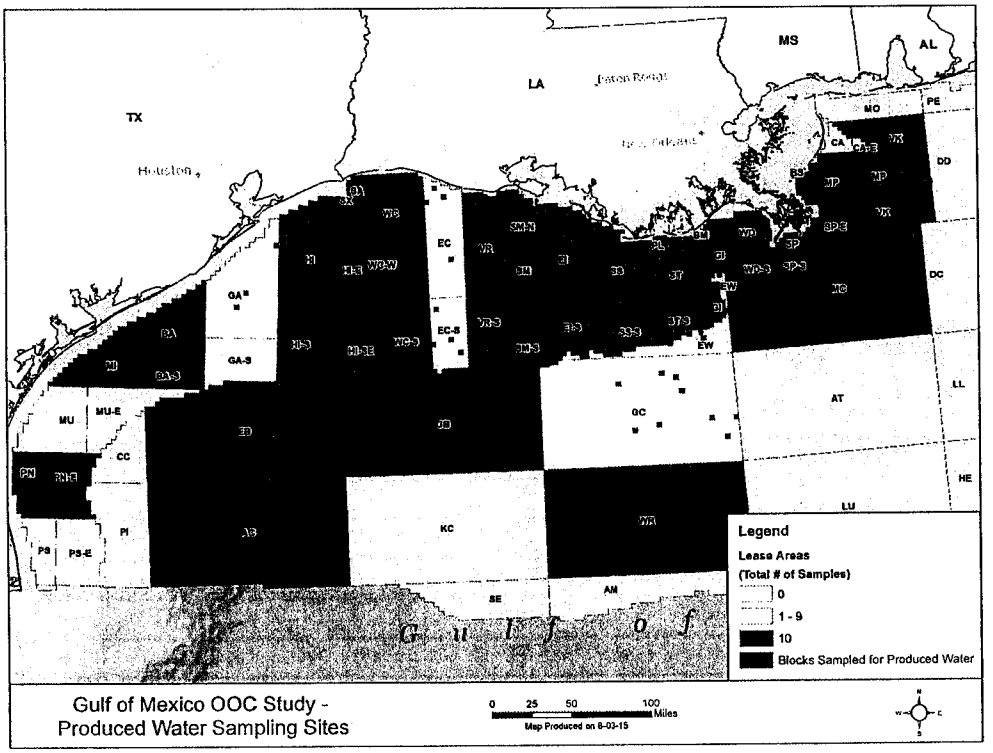
Area Code	Block Code	Samples per Block	Approximate Depth (meters)
ST	37	1	-16
SM	288	1	-17
ST	100	1	-17
PL	22	1	-17
PL	23	1	-17
GA	209	3	-17
ST	52	1	-18
PL	25	1	-18
MI	519	2	-20
SS	181	1	-21
BA	491	4	-23
WC	265	1	-24
MI	623	3	-24
MI	622	2	-25
EC	160	1	-26
MI	654	3	-26
VR	170	1	-27
EI	212	1	-27
GI	33	2	-27
GA	355	1	-27
GI	47	1	-28
SS	198	1	-29
SS	207	1	-29
SM	39	1	-30
MI	669	1	-31
GA	424	5	-32
ST	148	1	-33
GI	43	1	-34
GI	73	1	-35
MP	61	1	-36
WD	65	1	-36
SS	229	1	-37
WD	79	1	-37
VR	214	1	-38
ST	151	1	-43
WC	485	1	-44
SS	224	1	-45

Area Code	Block Code	Samples per Block	Approximate Depth (meters)
VR	256	1	-46
WD	72	1	-46
MP	73	1	-47
EC	261	1	-47
WD	73	1	-48
VR	265	1	-49
SS	253	1	-49
WD	109	1	-51
HI	474	1	-51
HI	446	1	-51
ST	156	1	-52
GI	78	1	-52
VR	279	1	-53
SS	266	1	-55
HI	531	1	-57
BA	105	3	-58
PN	891	11	-59
SP	60	2	-60
MP	300	1	-61
BA	133	3	-61
MP	299	1	-62
SM	132	1	-62
MP	265	1	-64
SM	128	2	-64
SM	130	1	-64
MP	298	1	-65
VR	326	1	-65
VR	331	1	-65
SM	141	1	-66
HI	557	1	-66
SM	149	1	-67
EI	302	1	-67
WD	117	1	-67
ST	229	1	-68
EC	321	1	-69
EI	315	1	-69
EI	333	1	-69

Area Code	Block Code	Samples per Block	Approximate Depth (meters)
GI	93	1	-69
GI	90	1	-70
EC	334	1	-73
WD	105	1	-74
SS	300	1	-77
MP	153	1	-80
MP	313	1	-80
WD	122	1	-81
EI	342	1	-82
EC	346	1	-88
ST	295	1	-89
VR	371	1	-91
SP	65	1	-91
SP	62	1	-96
EI	346	1	-99
HI	573	1	-99
SP	75	1	-102
HI	379	1	-102
GI	116	1	-103
HI	376	1	-103
VR	380	1	-106
ST	300	1	-107
SP	87	1	-109
HI	582	1	-111
SP	70	1	-112
SP	49	1	-115
MP	259	1	-117
SP	89	1	-121
EW	305	3	-131
VK	900	1	-139
WC	661	1	-144
SP	83	1	-152
EC	381	1	-154
MC	21	1	-159
EW	826	1	-182
EW	910	1	-185
GB	128	2	-217

Area Code	Block Code	Samples per Block	Approximate Depth (meters)
GB	189	2	-221
EW	873	4	-250
EB	165	2	-276
MC	109	1	-316
EB	159	2	-337
MC	194	1	-350
VK	989	1	-355
EB	160	2	-377
VK	823	2	-426
GB	260	2	-435
VK	826	1	-556
VK	786	1	-608
GC	237	1	-613
MC	582	1	-824
GB	426	2	-826
GC	205	1	-833
MC	243	1	-897
GC	158	1	-909
GB	668	2	-946
MC	807	1	-952
GC	338	1	-1004
EB	643	2	-1039
VK	956	2	-1040
EB	602	2	-1101
VK	915	2	-1122
MC	941	1	-1215
GC	641	1	-1223
GC	613	1	-1311
GC	608	1	-1320
AC	25	5	-1478
GC	680	1	-1574
MC	127	1	-1668
MC	736	1	-1910
MC	650	1	-1971
GC	787	1	-2180
WR	249	10	-2478
AC	857	5	-2562

Figure 4-1. Produced Water Sample Locations



5 WBM CHARACTERIZATION

This section discusses the sample locations, deviations from the SAP, and analytical methods for WBM samples.

The declining use of WBM in the OCS, especially in deep water, made it impractical to collect 10 samples from every active lease area. WBMs are often unsuitable for use in deep water wells, so synthetic base muds are generally preferred for all but the riserless portion of the well. As stated in the SAP, the mud used during drilling the riserless portion of the well, which is discharged directly at the sea floor, contains bentonite clay and barite.

5.1 Sample Locations

The permit requested ten WBM samples from ten different blocks within each active lease area and allowed operators participating in the joint study to submit a study plan, which was subject to EPA's approval. However, WBM samples can be collected only during active drilling, so sample locations were limited by factors outside the scope of this study.

The JIP study included an intensive effort to identify planned drilling in the study area, including regular requests for updates from all participants, personal contact with operators to track changes in rig movement, and direct coordination with the companies that provide WBM to study participants. Additional blocks were sampled in some lease areas where drilling was especially active (such as GC and MC) in an effort to collect the most complete and representative dataset possible under the terms of the permit. A total of 102 WBM samples were collected from 21 lease areas (Table 5-1 and Figure 5-1).

Figure 5-1. WBM Sample Locations

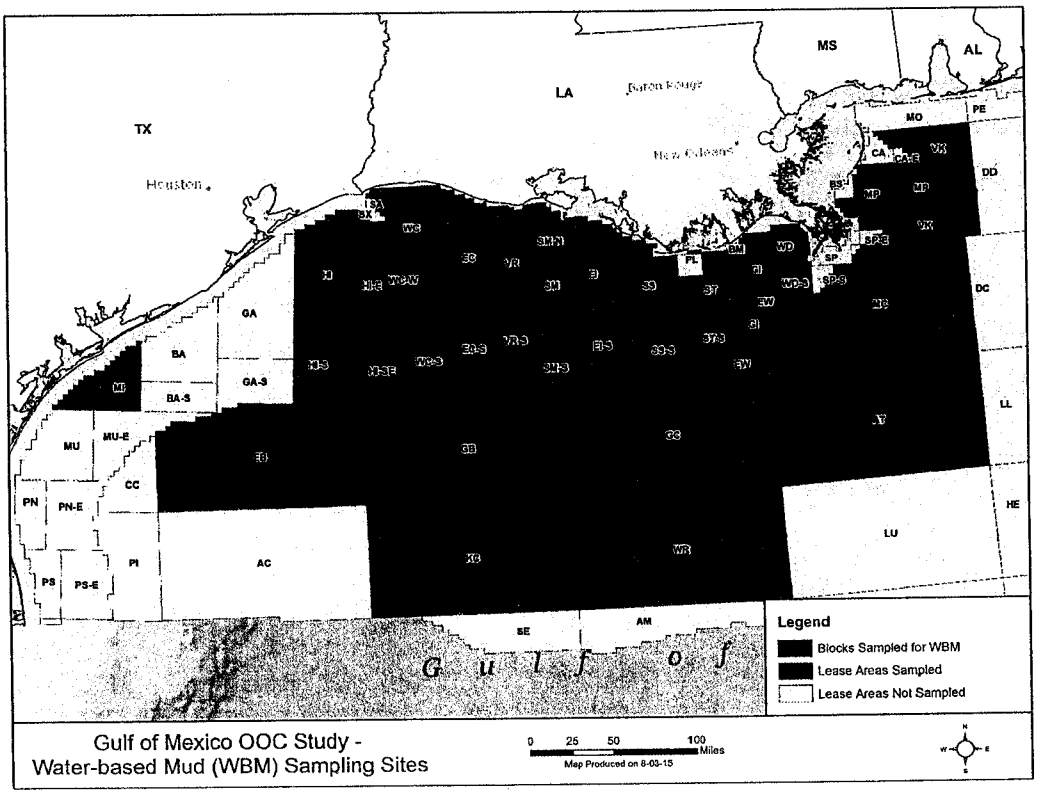


Table 5-1. WBM Sample Locations by Lease and Block

Lease Area	Block	Total # Samples
ATWATER VALLEY (AT)	362	2
	618	
EAST BREAKS (EB)	645	2
	646	
EAST CAMERON (EC)	321	1
EUGENE ISLAND (EI)	208	8
	214	
	227	
	276	
	302	
	338	
	360	
	360	
EWING BANK (EW)	901	1
GARDEN BANKS (GB)	372	2
	959	
GREEN CANYON (GC)	40	19
	64	
	245	
	248	
	248	
	610	
	643	
	653	
	683	
	727	
	782	
	782	
	782	
	782	
	782	
	859	
	859	
	903	
	903	
GRAND ISLE (GI)	82	1

Lease Area	Block	Total # Samples
HIGH ISLAND (HI)	131	4
	469	
	547	
	547	
KEATHLEY CANYON (KC)	10	5
	147	
	163	
	874	
	953	
MISSISSIPPI CANYON (MC)	21	18
	21	
	85	
	479	
	525	
	538	
	608	
	687	
	697	
	776	
	782	
	807	
	809	
	812	
	934	
	935	
	943	
	948	
MATAGORDA ISLAND (MI)	654	1
MAIN PASS (MP)	153	3
	244	
	302	
SOUTH MARSH ISLAND (SM)	48	7
	118	
	130	
	130	

Lease Area	Block	Total # Samples
SOUTH MARSH ISLAND (SM) (continued)	196	
	217	
	277	
SHIP SHOAL (SS)	193	5
	230	
	255	
	274	
	349	
SOUTH TIMBALIER (ST)	152	1
VIOSCA KNOLL (VK)	913	1
VERMILION (VR)	245	10
	245	
	245	
	284	
	284	
	284	
	342	
	342	
	379	
	379	
WEST CAMERON (WC)	176	1
WEST DELTA (WD)	28	2
	59	
WALKER RIDGE (WR)	143	8
	469	
	508	
	508	
	508	
	578	
	584	
	634	

5.2 Deviations from the Sampling Plan

The procedures as established in the MPWCS SAP required modification for WBM samples for the extraction of the WBM and the addition of analysis for total solid constituents. These deviations are discussed below.

5.2.1 Extraction of Aqueous Sample from WBM Samples

The MPWCS SAP states that upon receipt of a WBM sample, the laboratory would centrifuge the sample and decant sufficient water to analyze for dissolved constituents. The standard method for preparing a water sample for analysis of dissolved constituents is to pass the water sample through a 0.45 micron filter, as described in Section 4.2 of the SAP for PW. The same filtration method was used for the water sample extracted from a WBM sample whenever an aqueous sample could be obtained.

However, it became apparent early in the study that many WBM samples would not yield sufficient water for the required analyses. After extensive consultation with the JIP Analytical Subteam, independent mud engineers, and other technical experts, Tetra Tech instructed ALS to dilute the WBM sample with pure laboratory water and agitate the sample using a shaker device. After allowing the sample to settle overnight, the laboratory centrifuged the sample again to obtain water. Although this method was successful in extracting water from the WBM samples, this dilution process raised the quantitation limits (QL) for the samples above acceptable levels.

Alternate extraction methods, such as pressure filtration, were considered but rejected as impractical or unlikely to provide reliable results. Higher-speed centrifugation was attempted but was not successful in yielding adequate volumes of water. Following discussions with EPA (see Appendix B), ALS was instructed to discontinue prior dilution of WBM samples and perform dissolved analyses only on water that could be extracted through standard centrifugation without prior dilution of the WBM. Analytical results of the 22 samples subjected to prior dilution were not considered useable because the dilution step introduced uncontrolled variability into the results. These samples are not discussed further in this report.

5.2.2 Additional Analysis of Total Constituents in Solid Medium

Concurrent with the recognition that many WBM samples could not be analyzed for dissolved constituents as planned, EPA agreed that analysis of total constituents in the solid phase of the WBM was a reasonable way to achieve compliance with the permit (Appendix B). The laboratory began analyzing for total constituents on the solid phase of the WBM samples, and also on archived WBM samples (collected prior to the discussion with EPA) for which adequate solid phase volume was available. The laboratory continued to centrifuge each WBM sample and analyze the aqueous phase whenever it was available. Samples for which both aqueous phase and solid phase result were obtained were evaluated using correlation analysis to determine whether aqueous concentrations could be extrapolated from solid phase results (see Appendix E, Section 4.1.8 and Figures E-1 through E-11). The analyses and intended use of all WBM sample results are presented in Table 5-2 and explained further in Section 8. Approximate water depths of WBM sampling locations were estimated using the centroid bathymetric value for each lease block (Table 5-3).

Table 5-2. WBM Analyses by Matrix

Sample Matrix Analyzed	Number of WBM Samples	Use in this Report
WBM-aqueous (Dissolved)	24	Principal Dataset
WBM-solid (Total)	77	Principal Dataset
Both WBM-aqueous and WBM-solid when done on the WBM Sample	13	Correlation Analyses
Water added to WBM-solid prior to extraction of WBM-aqueous	22	Not Used – see section 5.2.1

Table 5-3. Bathymetry of WBM Sample Locations

Available Analytical Results	Area Code	Block Code	Samples per Block	Approximate Depth (meters)
WBM-Aqueous only	SM	277	1	-14
	SS	255	1	-45
	VR	284	3	-56
	GC	245	1	-930
	EB	645	1	-1079
	MC	934	1	-1107
	GC	727	1	-1421
	KC	163	1	-1665
	WR	508	3	-2764
WBM-Aqueous and WBM-Solid (total)	VR	245	3	-39
	VR	342	2	-67
	VR	379	2	-101
	SS	349	1	-111
	MC	21	2	-159
	EW	910	1	-185
	GC	40	1	-733
	VK	913	1	-982
	GC	643	1	-1205
	KC	147	1	-1320
	GB	959	1	-1342
	GC	610	1	-1347
	GC	859	2	-1627
	MC	479	1	-2158
	WR	584	1	-2193
	WR	469	1	-2727
WBM-Solid (total) Only	SM	217	1	-4
	HI	131	1	-15
	SS	193	1	-24

Available Analytical Results	Area Code	Block Code	Samples per Block	Approximate Depth (meters)
WBM-Solid (total) Only (continued)	MI	654	1	-26
	SM	48	1	-30
	EI	227	1	-38
	ST	152	1	-48
	EI	276	1	-52
	GI	82	1	-61
	HI	469	1	-62
	SS	274	1	-66
	EI	302	1	-67
	MP	302	1	-68
	EI	338	1	-77
	MP	153	1	-80
	EI	360	2	-91
	SM	196	1	-123
	GC	64	1	-338
	MC	538	1	-628
	MC	809	1	-1139
	MC	935	1	-1213
	KC	10	1	-1239
	GC	683	1	-1278
	GC	653	1	-1307
	MC	943	1	-1333
	MC	812	1	-1380
	MC	687	1	-1601
	GC	903	2	-1618
	MC	85	1	-1642
	AT	362	1	-1716
	MC	776	1	-1720
	MC	948	1	-1836
	AT	618	1	-1942
	MC	782	1	-2016
	MC	608	1	-2046
	WR	634	1	-2062
	WR	578	1	-2109
	MC	697	1	-2187
	KC	874	1	-2256
	MC	525	1	-2349

5.3 Analytical Methods for WBM Samples

The WBM samples were collected in accordance with the procedures outlined in the Sampling Procedure and Checklist (presented in the MPWCS SAP) and sent to ALS in Houston, Texas, a Tetra Tech-procured laboratory. Upon receipt of the WBM samples, the laboratory performed dissolved phase analysis (when sufficient water could be obtained from centrifugation) of arsenic, cadmium, copper, lead, nickel, selenium, silver, and zinc by SW-846 Method 6020A, mercury by SW-846 Method 7470A, cyanide by SW-846 Method 9014, and hexavalent chromium by SW-846 Method 7196A. Solid samples were analyzed for arsenic, cadmium, copper, lead, nickel, selenium, silver, and zinc by SW-846 Method 6020A, mercury by SW-846 Method 7471B, cyanide by SW-846 Method 9014, and hexavalent chromium by SW-846 Method 7196A.

6 DATA VALIDATION PROCEDURES AND FINDINGS

All analyses were performed by ALS in either Houston, Texas or Rochester, New York (for hexavalent chromium in PW). Level 4 validation, as defined by EPA *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use* (January 2009), was performed for all PW and WBM data packages. The validation was conducted in accordance with the standard EPA guidance (*National Functional Guidelines for Inorganic Superfund Data Review, EPA540-R-10-011* (January 2010). Data validation is an analyte- and sample-specific process to determine the analytical quality of a data set. Data quality flags assigned by the analytical laboratory were independently reviewed against the validation protocols.

The following qualifiers were variously applied to the project sample results based on the data validation findings.

- U = The analyte was analyzed for, but was not detected at or above the modified method detection limit (MDL).
- UJ = The analyte was analyzed for, but was not detected at or above the modified MDL, which is considered approximate due to deficiencies in one or more quality control (QC) criteria.
- J = The analyte was positively identified; the measured value is an estimated concentration of the analyte in the sample between the modified MDL and the reporting limit (RL), as described in Section 6.1 below.
- R = The sample result is rejected as unusable due to serious deficiencies in one or more QC criteria. The analyte may or may not be present in the sample.

6.1 Validation of Produced Water Results

Level 4 data validation was conducted on the 53 PW data packages (representing 274 PW samples) submitted by ALS (Appendix C). During data validation, an independent senior analytical chemist reviewed numerous QC and quality assurance parameters associated with each data package, including (1) COC, preservation, holding time, and sample preparation; (2) Calibration Verification Data; (3) Blanks; (4) Interference; (5) Laboratory Controls; (6) Duplicate and spike sample analysis; and others.

Selected arsenic, copper, cyanide, hexavalent chromium, nickel, and zinc results were rejected as unusable due to extremely low matrix spike (MS) and/or matrix spike duplicate (MSD) recoveries. Additionally, the sample collected from lease area EC-33 on April 13, 2015 arrived at the laboratory at a temperature above the established criterion, resulting in the rejection of the non-detect results (arsenic, cadmium, cyanide, hexavalent chromium, lead, mercury, nickel, selenium, and silver) and the positive results (copper and zinc) being qualified as estimated (flagged "J"). The percent difference in a serial dilution for selenium and MS and/or MSD recoveries for all reported analytes resulted in the associated sample results being flagged as estimated ("J" or "UJ", as appropriate). Several arsenic, copper, lead, mercury, nickel, selenium, and zinc results were qualified as non-detect (flagged "U") due to method, preparation, initial calibration, and/or continuing calibration blank contamination. Results less than the laboratory RL but above the MDL were qualified as estimated (flagged "J").

It should be noted that the detection limits presented in the QAPP were based on the laboratory's MDL study, which represents a best-case scenario for the analysis. The laboratory made every attempt to meet

these detection limits on the PW samples. However, matrix interferences from the make-up of the PW required the adjustment of the extraction/preparation volume of the original sample, dilution of the original sample, or both of these actions in order to achieve a result that met the quality criteria for the analysis (such as calibration acceptance criteria and method QC elements [e.g., laboratory control samples]) for most samples. Elevated detection limits are defined in this report as the modified MDLs or quantification limits (QL).

6.2 Validation of WBM Results

Level 4 data validation was conducted on the 49 WBM data packages submitted by ALS (Appendix C).

Selected copper, hexavalent chromium, and zinc were rejected as unusable due to extremely low MS and/or MSD recoveries. Problems with the percent difference in the serial dilutions for lead and zinc, MS and/or MSD recoveries for arsenic, copper, cyanide, hexavalent chromium, mercury, nickel, selenium and zinc, and the post digestion spike recoveries for arsenic and copper resulted in the associated sample results being flagged as estimated ("J" or "UJ", as appropriate). Several arsenic, cadmium, copper, mercury, nickel, selenium, silver, and zinc results were qualified as non-detect (flagged "U") due to method, preparation, initial calibration, and/or continuing calibration blank contamination. Results below the laboratory RL but above the MDL were qualified as estimated (flagged "J"). As noted above, matrix interference sometimes caused unavoidable elevated detection limits for WBM-aqueous and WBM-solid samples.

7 SUMMARY OF ANALYTICAL RESULTS: PRODUCED WATER

The PW dataset includes analytical results for 274 PW samples collected from December 11, 2013 through April 13, 2015, analyzed for dissolved arsenic, cadmium, hexavalent chromium, copper, cyanide, lead, mercury, nickel, selenium, silver, and zinc. All constituents in PW meet the USEPA National Recommended Water Quality Criteria (WQC) for protection of marine aquatic life from chronic toxicity at the 100-meter mixing zone boundary. The percentage of non-detects (qualified with a "U") in the PW dataset ranged from 100 percent (%) for dissolved silver to 55 % for dissolved zinc (Figure 7-1). The high incidence of non-detects (blue bars in figure 7.1) reflects the low concentrations of dissolved constituents in PW discharges. PW discharges authorized in the general permit would not cause unreasonable degradation of the marine environment.

Values qualified with a "J" by the laboratory indicate that a constituent has been detected but the laboratory is unable to report a concentration with 99% confidence; thus, the value reported by the laboratory is estimated. This report takes a conservative approach and treats "J"-qualified values as valid data. PW results summary tables are in Appendix D. Statistical methods and descriptive results are in Appendix E.

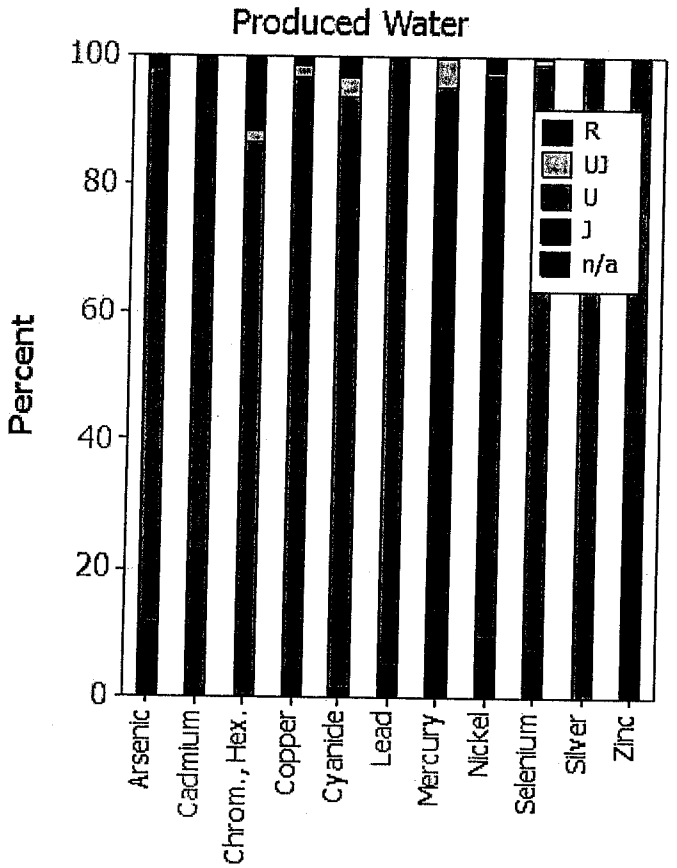


Figure 7-1. Percentages of Qualified and Unqualified Produced Water Data
(R = rejected; U = Non-detect; J = Estimated; n/a = no laboratory qualifier associated with the result)

7.1 Statistical Evaluation of Dataset to Account for Non-detects

As described in Appendix E, methods for accommodating censored observations (i.e., non-detects) most notably include simple substitution (such as zero or one-half the Detection Limit, DL). Although simple substitution is commonly used (and even recommended in the peer-reviewed literature and government reports), there is no real theoretical justification for this procedure. Substitution might perform poorly compared to other more statistically robust procedures, especially where censored data represent a high proportion of the entire data set. Substitution can introduce artificial patterns that are not present in the original data, leading to incorrect computation of summary statistics and hypothesis testing (Helsel 2012). Helsel (2012) discourages reporting non-detects as "less-than the RL," and gives preference to reporting non-detects as "less than the detection limit." As used within the JIP data set, the detection limit, or Quantitation Limit (QL), is the MDL adjusted for dilution and sample size used to set the MDL, referred to throughout this report as the "modified MDL." Use of the modified MDL is consistent with the EPA guidance (USEPA 2013), which defers to the analyst to use the correct numerical values for non-detects as the "reported detection limit or [RL] values."

The ProUCL statistical software package was used to describe statistical distributions. For data sets with eight or more valid data points and when ProUCL reported that the data follow a discernible distribution, the mean, standard deviation, and coefficient of variation were calculated. The ProUCL package provides a recommended data distribution type as well as possible alternative distribution methods (Appendix E).

Using the recommended data distribution, the projected 95% UCL on mean values of the data set was calculated for each constituent. A more conservative estimate using projected 95% Upper Tolerance Limit (UTL) on the 95th percentile concentrations was also calculated to represent the maximum expected concentration (MEC). When fewer than eight detected results were available, the maximum detected value was used instead of a calculated mean.

7.2 Summary Statistics: Produced Water

Summary statistics and concentration scatter plots of constituents in PW are provided in Appendix E. Scatter plots of the data are presented in Figures E-1 through E-11. Summary statistics, including mean, range (i.e., minimum and maximum detected and non-detected values), number of samples collected, and number of detected observations are in Table E-2. Distribution information and 95 % upper confidence limit (UCL) on mean values (used as mean values in the analyses described later in this report) are presented in Table E-6. Distribution and 95% UTL (used as maximum expected concentration [MEC] values in analyses) are in Table E-9.

8 SUMMARY OF ANALYTICAL RESULTS: WBM

Summary tables of analytical results for aqueous and solid WBM samples are in Appendix D. Statistical methods and descriptive results are in Appendix E.

8.1 Statistical Evaluation of Dataset to Account for Non-detects

The discussion in Section 7.1 of the various statistical techniques used to evaluate censored results applies equally to WBM results.

8.2 Dissolved Concentrations in Undiluted WBM

The data set includes analytical results for 24 WBM —aqueous samples collected from September 2, 2013 through March 18, 2015. Aqueous samples extracted from WBM were analyzed for dissolved arsenic, cadmium, hexavalent chromium, copper, cyanide, lead, mercury, nickel, selenium, silver, and zinc.

8.2.1 Sample Size

As described in Section 5.2.1 of this report, it became apparent early in the study that many WBM samples would not yield sufficient water for the required analyses. Centrifugation of the WBM samples rarely produced sufficient water for analysis, largely because water based drilling mud is specifically formulated to retain water. Forceful separation of the aqueous phase from the drilling mud does not adequately simulate environmental conditions in the receiving waters where WBM is discharged. Due to the difficulties in obtaining aqueous samples from WBM, fewer samples than planned were available for analysis.

8.2.2 Incidence of Low Concentrations (Non-Detects)

The percentage of non-detects ranged from 13 % for dissolved arsenic to 92 % for dissolved silver in the WBM—aqueous data set (Figure 8-1). The percentage of non-detects ranged from 0 % for total lead and total zinc to 91 % for total cyanide in the WBM —solids data set. Values qualified with a "J" by the laboratory indicate that a constituent has been detected but the laboratory is unable to report a concentration with 99% confidence; thus, the value reported by the laboratory is estimated. In this report, "J"-qualified values are treated as valid data to be conservative.

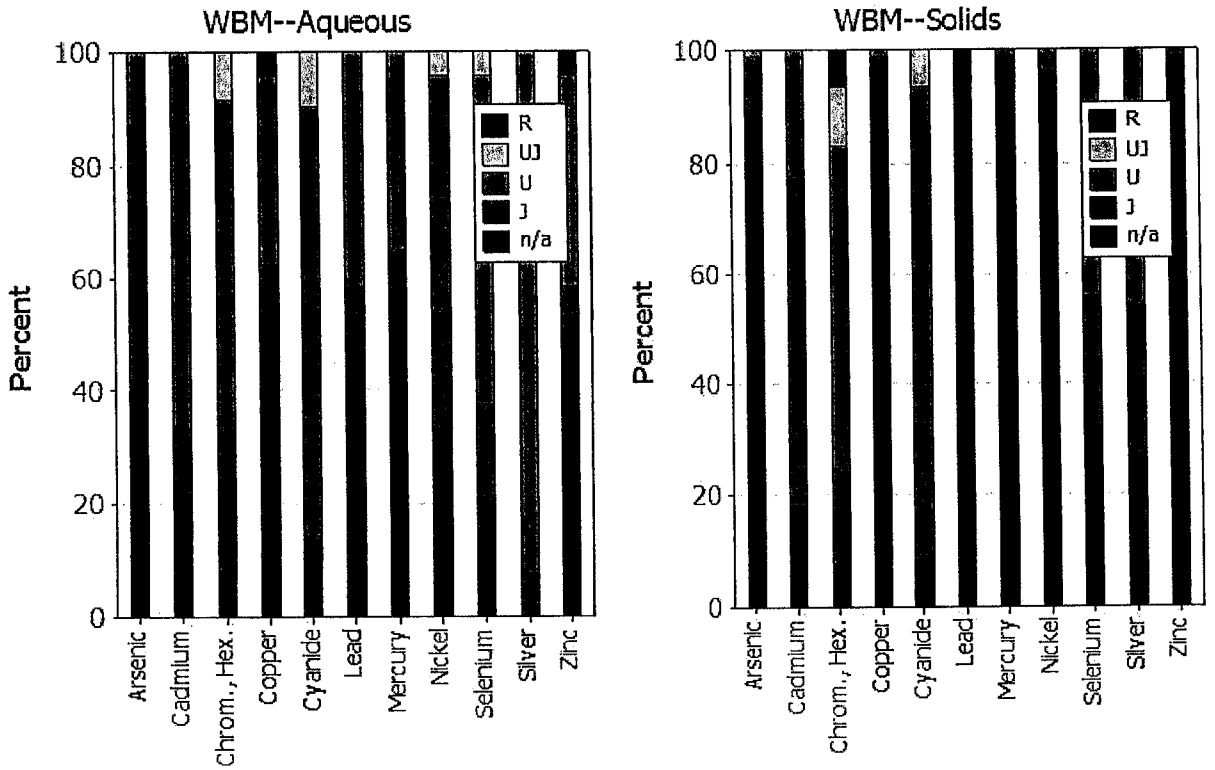


Figure 8-1. Percentages of Qualified and Unqualified WBM Results
(R = rejected; U = Non-detect; J = Estimated; n/a = no laboratory qualifier associated with the result)

8.2.3 Summary Statistics of Dissolved Concentrations in Undiluted WBM

Summary statistics and concentration scatter plots of constituents in WBM–aqueous samples are provided in Appendix E. Scatter plots of the data are in Figures E-34 through E-44. Summary statistics, including mean, range (minimum and maximum detected and non-detected values), number of samples collected, and number of detected observations are in Table E-4. Distribution information and 95 % UCL on mean values (used as mean values in the analyses described later in this report) are in Table E-8. Distribution and 95 % UTL (used as MEC values in analyses) are in Table E-11.

8.3 Summary Statistics of Total Concentrations in Undiluted WBM

The data set includes analytical results for 77 WBM—solids samples collected from January 23, 2014 through March 27, 2015 analyzed for total arsenic, cadmium, hexavalent chromium, copper, cyanide, lead, mercury, nickel, selenium, silver, and zinc.

Summary statistics and concentration scatter plots of constituents in WBM – solid samples are in Appendix E. Scatter plots of the data are presented in Figures E-23 through E-33. Summary statistics, including mean, range (i.e., minimum and maximum detected and non-detected values), number of samples collected, and number of detected observations are in Table E-3. Distribution information and 95 % UCL on mean values (used as mean values in the analyses described later in this report) are in Table E-7. Distribution and 95% UTL (used as MEC values in analyses) are in Table E-10.

8.4 Correlation Analysis of Dissolved and Total Concentrations from Same Discharge

Analytical results for 13 matched WBM-solids and WBM-aqueous samples were evaluated using correlation analysis (Appendix E). Results are presented in Table E-18 and scatterplots of these data are presented in Figures E-1 through E-11. The p-value associated with the Kendall's tau correlation coefficients for arsenic, lead, mercury, nickel, and zinc were less than 0.10. The p-value associated with the Kendall's tau correlation coefficients for cadmium, hexavalent chromium, copper and selenium were greater than 0.10. The Kendall's tau correlation coefficient could not be calculated for cyanide and silver due to lack of detected aqueous results. It should be noted that some intercepts and the slope for one chemical were negative, limiting their potential utility.

A strong correlation between the total concentration of a constituent in a WBM sample and in the water extracted from that WBM sample would allow prediction of dissolved concentrations in WBM samples that did not yield enough water for direct analysis. A weak correlation indicates that factors other than the total concentration in a WBM sample influence the measured concentration in the water extracted from the WBM (such as strong adsorption of metals to the particulates or other physico-chemical processes that retain inorganic constituents in the solid phase medium). Because the WBM-solids and WBM-aqueous concentrations were not significantly correlated, the WBM-solids concentrations cannot be used to estimate WBM-aqueous concentrations.

8.5 Dissolved Concentrations in Diluted WBM

As described in Section 5.2.1 of this report, when it became apparent early in the study that many WBM samples would not yield sufficient water for the required analyses, dilution of WBM samples before centrifugation was used to improve water recoveries from WBM. Following discussions with EPA (see Appendix B), ALS was instructed to discontinue prior dilution of WBM samples and perform dissolved analyses only on water that could be extracted through standard centrifugation without prior dilution of the WBM. Analytical results of the 22 samples subjected to prior dilution were not considered useable and are not further analyzed or discussed in this report.

9 WATER QUALITY EVALUATIONS OF PRODUCED WATER AND WATER BASED MUD DISCHARGES IN THE GULF OF MEXICO

9.1 Produced Water Analysis

Concentrations of PW constituents at the boundary of the mixing zone were estimated using statistical analysis of laboratory results and critical dilutions (CDs as percent produced water) at the boundary of the mixing zone from GMG290000. Actual CDs from production facilities in the GOM were used to develop Gulf-wide dilution factors for PW (see below for details). Critical dilution factors (CDFs, or the ratio of seawater to effluent resulting in the CD) used in the 2012 ODCE were also used to provide a basis for comparison between the predicted concentrations in the ODCE and the concentrations calculated using actual sampling results and reported CDs. Concentrations of constituents measured in the JIP characterization study were compared to the most stringent WQC to determine whether the estimated concentration at the boundary of the 100-meter mixing zone were above the WQC for any constituent of interest.

This analysis is divided into the following steps:

Step 1. Identify constituents sampled.

Step 2. Identify the applicable WQC.

Step 3. Assess data usability.

Step 4. Develop CDs representative of GOM operations.

Step 5. Analyze the statistical distribution of the data set and determine the expected concentration of each constituent at the boundary of the mixing zone.

Step 1: Identify Constituents Sampled

Section I.B.4.c. of NPDES General Permit GMG290000 requires characterization studies of PW for dissolved arsenic, cadmium, hexavalent chromium, copper, cyanide, lead, mercury, nickel, selenium, silver, and zinc.

Step 2: Identify the Applicable WQC for Comparison to Produced Water Samples

PW analytical results were compared with USEPA National Recommended Water Quality Criteria (WQC) for protection of marine aquatic life from chronic toxicity.

Step 3: Assess Data Usability

For the constituents and applicable criteria identified in Steps 1 and 2, available analytical data were assembled and verified as to the sufficiency to conduct a quantitative analysis. The data reporting thresholds for each constituent were verified as acceptable. Generally applied reporting thresholds are expressed as MDL, level of detection (LOD), practical quantitation limit (PQL), minimum level (ML) and quantification limits (QL). Elevated reporting thresholds may mask concentrations of pollutants that

would otherwise have been considered valid results using a more robust analytical method. Data sets may also contain different reporting thresholds for the same constituent. Results with highly elevated reporting or detection limits (e.g., one order of magnitude above other reported levels) could have been determined to be invalid and eliminated from the data set prior to statistical analysis, but no instance of such elevated RLs occurred. Elevated "modified MDLs," defined as an order of magnitude greater than others, were encountered (for example see Figure E-15: copper in PW). These elevated modified MDLs were likely due to dilution and so results were maintained in the analyses.

Per 40 CFR Part 136, Appendix B (that is, Appendix B to Part 136—Definition and Procedure for the Determination of the Method Detection Limit-Revision 1.11), "The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte." The lab MDL study was based on a lab water matrix which can reach a low DL. With a produced water matrix, the lab has to modify the MDL due to matrix interference because EPA does not have specific method for produced water.

The QL reported by the laboratory for this project are the equivalent of the MDLs adjusted for sample size and any subsequent dilutions performed during analysis, referred to in this report and in Appendix E as the "modified MDL." Therefore, anything below the modified MDL is considered to be non-detect. This practice is consistent with USEPA guidance (2013a,b), which allows the analyst to use the correct numerical values for non-detects as the "reported detection limit or [RL] values." Estimated concentrations (J values, between the modified MDL and the RL) were considered detected concentrations for the purposes of this analysis.

Step 4: Development of Critical Dilution Factors

Production facilities covered under the existing General Permit are required to monitor and determine CD to demonstrate compliance with effluent limits. For this analysis, 1,845 CDs used in compliance testing of discharges in the GOM[2] provided representative data on actual conditions. The maximum CD was 1.26, the minimum was 0.03, and the mean was 0.1715 percent produced water. The CDF utilized in the analysis was determined by taking the mean percent concentration value, dividing the mean by 100 to account for the percentage, and taking the inverse of the resulting value to obtain the dilution factor as shown below:

$$1/(\frac{0.1715}{100})=583$$

Of the 1,845 CDs examined, the effluent at the boundary of the mixing zone constitutes a mean of 0.1715 % of the total volume.

[2] Email from Joe Smith (ExxonMobil) to Taimur Shaikh (USEPA Region 6), 7/6/2011, ***Usage of Critical Dilution Tables for Region 6 Produced Water Discharges.*** The purpose of the submittal was a response to Mr. Shaikh's question about what portions of the CD tables receive the most use, as part of the 2012 renewal of GMG 290000. The data were prepared based on responses OOC received from laboratories that conduct regulatory produced water toxicity testing. OOC asked the labs to provide, after getting permission from their clients, data on the critical dilution table values that have been used since the effective date of the current permit [2007]. Data on a total of 820 distinct facilities were submitted to OOC.

Step 5: Analyze the statistical distribution of the data set and determine the expected concentration of each constituent at the boundary of the mixing zone Between 269 and 277 distinct measurements were available for each constituent. For all constituent except zinc, most results were non-detects (about 90% of the results). Zinc was detected in about 45% of the samples.

The projected 95% UCL on mean values of the data set was calculated and compared to the acute and chronic WQC for those constituents. A more conservative estimate using projected 95% Upper Tolerance Limit (UTL) on the 95th percentile concentrations was also calculated and compared to the WQC for those constituents. When fewer than eight detected results were available, the maximum detected value was used instead of a calculated mean. Where a mixing zone has been authorized, modeling is used to determine the appropriate dilution factor at the boundary of the mixing zone. Dilution factors were applied to these estimates of the mean to determine the concentration of a constituent at the boundary of the mixing zone for comparison against WQC. Because the mixing zone for acute and chronic WQC are the same, the most stringent criteria (chronic) were used in this analysis.

9.1.1 Calculating Critical Dilution Factors using 95% UCL of Mean Concentrations

Using 95% UCLs of the mean concentrations and the relevant WQC, CDFs were estimated for each constituent. The current General Permit authorizes a 100-meter mixing zone from the point of discharge. Four constituents (arsenic, hexavalent chromium, mercury, and selenium) meet the WQC at the point of discharge with no dilution factor. Silver was not detected in any PW samples. Cadmium, hexavalent chromium, and cyanide had fewer than eight detected results; thus the maximum detected concentration was used in lieu of the 95% UCL of the mean. Several constituents would require some dilution to meet the WQC. Zinc would require the greatest dilution factor (56.4:1) to meet the chronic WQC.

Projected mean concentrations of PW constituents at the boundary of a 100-meter mixing zone were estimated by two different approaches for comparison with marine chronic WQC (Table 9-1). The first approach made use of the representative CDF (222) used in the 2012 ODCE. The second approach used an average CDF (583) calculated from an OOC study of 1845 critical dilutions determined by operators as part of data required by EPA on permitted produced water discharges. For both approaches, the results were the same: the projected mean concentrations of all PW constituents at the boundary of the mixing zone were less than the marine chronic WQC.

Table 9-1. Projected Mean Produced Water Concentrations at the Boundary of the 100-Meter Mixing Zone Using Dilutions from the 2012 ODCE and OOC Critical Dilution Data Collected for the 2012 NPDES Permit at the Edge of the Mixing Zone

Dissolved Constituent	95% UCL of the Mean Concentration (mg/L)	EPA Marine WQC (mg/L)[a]	Projected Concentration at Boundary of 100-m Mixing Zone (mg/L) – 222:1 Dilution from 2012 ODCE	Above Chronic WQC at 222:1?	Projected Concentration at Boundary of 100-m Mixing Zone (mg/L) – 583:1 Dilution from Mean OOC Critical Dilution Data	Above Chronic WQC at 583:1?
Arsenic	0.0315	0.036	0.000142	No	0.0000540	No
Cadmium	0.102[b]	0.0088	0.000459	No	0.000175	No
Hexavalent Chromium	0.0219[b]	0.050	0.0000986	No	0.0000376	No
Copper	0.0125	0.0031	0.0000563	No	0.0000214	No
Cyanide	0.0415[b]	0.001	0.000187	No	0.0000712	No
Lead	0.0791	0.0081	0.000356	No	0.000136	No
Mercury	0.0000594	0.00094	0.000000268	No	0.000000102	No
Nickel	0.0188	0.0082	0.0000847	No	0.0000322	No
Selenium	0.0107	0.071	0.0000482	No	0.0000184	No
Silver	n/a	0.0019	n/a	No	n/a	No
Zinc	4.57	0.081	0.0206	No	0.00784	No

[a] The most stringent salt water criteria (i.e., EPA Criterion Continuous Concentrations [CCC]) were presented for all constituents except for silver. The EPA Criteria Maximum Concentration value was presented for silver because no EPA CCC value is currently available for this metal (refer to http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm). However, silver was not detected in PW.

[b] This constituent was detected in fewer than eight samples. The maximum detected concentration was used to calculate worst-case concentration at the critical dilution.

n/a = not applicable. Silver was not detected in PW samples, so no mean concentration was calculated.

9.1.2 Calculating Critical Dilution Factors using 95% UTL of 95th Percentile Values

CDFs were calculated for each constituent using the 95% UTL of the 95th percentile concentrations and WQC. Three constituents (hexavalent chromium, mercury, and selenium) meet the WQC at the point of discharge with no dilution factor. Silver was not detected in any PW samples. As described in Section 9.4.1.1, the maximum detected concentrations of cadmium, hexavalent chromium, and cyanide were used instead of a calculated mean concentration. Using the 95% UTL to calculate critical dilutions, several constituents would require some dilution to meet the WQC. Zinc would require the greatest dilution (165:1) to meet the chronic WQC.

The estimated 95th percentile PW concentration (the MEC) of all constituents was less than the marine chronic WQC at the boundary of the 100-meter mixing zone (Table 9-2). Concentrations of constituents at the edge of the mixing zone were estimated using two different dilution factors: (1) the 2012 ODCE dilution factor (222:1) and (2) an empirically-derived mean dilution factor based on the CDs from production facilities (583:1), described in Section 9.1 (Step 4) above. Both calculations yielded the same result: all constituents met the marine chronic WQC at the edge of the 100-meter mixing zone.

Table 9-2. Projected 95% UTL on the 95th Percentile PW Concentrations at the Boundary of the 100-Meter Mixing Zone Using Dilutions from the 2012 ODCE and OOC Critical Dilution Data Collected for the 2012 NPDES Permit at the Edge of the Mixing Zone

Dissolved Constituent	95% UTL on the 95th Percentile Expected Concentration (mg/L)	EPA Marine WQC (mg/L)[a]	Projected Concentration at Edge of Mixing Zone (mg/L) *222:1 Dilution from 2012 ODCE*	Above Chronic WQC at 222:1?	Projected Concentration at Edge of Mixing Zone (mg/L) *583:1 Dilution from OOC Critical Dilution Data*	Above Chronic WQC at 583:1?
Arsenic	0.171	0.036	0.000770	No	0.000293	No
Cadmium	0.102[b]	0.0088	0.000459	No	0.000175	No
Hexavalent Chromium	0.0219[b]	0.050	0.0000986	No	0.0000376	No
Copper	0.0215	0.0031	0.0000968	No	0.0000369	No
Cyanide	0.0415[b]	0.001	0.000187	No	0.0000712	No
Lead	0.0563	0.0081	0.000254	No	0.0000966	No
Mercury	0.000122	0.00094	0.00000055	No	0.000000209	No
Nickel	0.0434	0.0082	0.000195	No	0.0000744	No
Selenium	0.0251	0.071	0.000113	No	0.0000431	No
Silver	n/a	0.0019	n/a	No	n/a	No
Zinc	13.4	0.081	0.0604	No	0.023	No

[a] The most stringent salt water criteria (i.e., EPA CCC) were presented for all constituents except for silver. The Criteria Maximum Concentration value was presented for silver because no CCC value is available (refer to http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm).

[b] This constituent was detected in fewer than eight samples. The maximum detected concentration was used to calculate worst-case concentration at the critical dilution.

n/a = not applicable. Silver was not detected in PW samples, so no mean concentration was calculated.

9.1.3 Conclusions of Produced Water Characterization

Statistical characterization of 270 PW samples from 27 lease areas indicates that all constituents of interest in this study meet the marine chronic WQC at the edge of the 100-meter mixing zone. Consistent with the 2012 ODCE, discharges of PW in the GOM are not expected to cause unreasonable degradation of the marine environment.

9.2 Water Based Mud

As described above for PW, concentrations of WBM constituents at the edge of the mixing zone were estimated using statistical analysis of laboratory results and CDs. The CDFs used in the 2012 ODCE were used. Concentrations of constituents measured in the JIP characterization study were compared to the most stringent WQC to determine whether the estimated concentration at the boundary of the 100-meter mixing zone was above the WQC for any constituent of interest.

This analysis is divided into the following steps:

Step 1. Identify constituents sampled.

Step 2. Identify the applicable WQC.

Step 3. Assess data usability.

Step 4. Develop CDs representative of GOM operations.

Step 5. Analyze the statistical distribution of the data set and determine the expected concentration of each constituent at the boundary of the mixing zone.

Step 1: Identify Constituents Sampled

Section I.B.1.d. of NPDES General Permit GMG290000 requires characterization studies of WBM. Dissolved arsenic, cadmium, hexavalent chromium, copper, cyanide, lead, mercury, nickel, selenium, silver, and zinc were analyzed in aqueous samples extracted from WBM. Total concentrations of these constituents were analyzed in the WBM solid phase.

Step 2: Identify the Applicable WQC for Comparison to WBM – Aqueous Samples, and Values for Comparison to WBM – Solid Samples

The EPA marine WQC described in Section 9.4 were used to evaluate analytical results in WBM-aqueous samples and WBM-solid samples for which "aqueous" concentrations were estimated (see below).

Step 3: Assess Available Effluent Pollutant Data

Analytical results for WBM-aqueous and WBM-solid samples were evaluated for usability in quantitative analysis. The data reporting thresholds for all constituents were verified as acceptable. The discussion of RLs in Section 8 is also relevant to analysis of WBM results.

WBM-aqueous results were compared directly with dissolved WQC. WBM-solid results cannot be directly compared with WQC because the results are reported in total concentrations rather than dissolved concentrations. Furthermore, the WBM-solid results were reported in wet weight, and required conversion to dry weight before estimates of dissolved concentrations could be made. Wet weights were converted to dry weights using estimates of percent solids in WBM, which are reported to range from 9 to 32 % moisture in the GOM (R. Kuehn, personal communication). Density estimates of WBM were used to convert total concentrations in solids (reported in mg/kg) to aqueous concentrations (reported in mg/L) for comparison to WQC. Details are described in Appendix E.

Step 4: Critical Dilution Factors Used in the Analysis

The 2012 ODCE provides the number of dilutions for average discharge scenarios for WBM. This dilution factor (898:1) was used to estimate the constituent concentration at the boundary of the 100-meter mixing zone.

Step 5: Analyze the statistical distribution of the data set and determine the expected concentration of each constituent at the boundary of the mixing zone

The statistical methods described in Section 7.1 were also used to evaluate WBM analytical results, and so are not repeated here.

Using the 95% UCL of mean values, 95% UTL of 95th percentile values, the CD, and the applicable WQC, CDFs were determined for each constituent. In these instances, the CDF was calculated as the dilution of the mean or 95th percentile WBM-aqueous concentration required to meet the chronic WQC.

9.2.1 Calculating Critical Dilution Factors Using 95% UCL of Mean Values (WBM – Aqueous)

Hexavalent chromium and selenium in WBM-aqueous samples meet the WQC with no dilution. The CDF to meet WQC calculated using the 95% UCL of the mean of the WBM-aqueous analytical results and the chronic for other constituents range from less than 10:1 (arsenic, cadmium, and mercury) to 1266:1 (lead).

Lead is the only measured constituent in WBM-aqueous samples that was above the chronic WQC at the edge of the 100-meter mixing zone using the 898:1 dilution specified in the 2012 ODCE (Table 9-3). The 95% UCL of the mean lead concentration is above the chronic WQC by a factor of 1.4. This concentration of lead is far less than the acute WQC of 0.21, which is considered protective of marine organisms when the "1-hour average concentration of the chemical does not exceed the criterion more than once every 3 years (on average)" (http://water.epa.gov/learn/training/standardsacademy/aquatic_page3.cfm).

All other constituents in WBM-aqueous samples meet the WQC at the edge of the mixing zone.

Table 9-3. Projected WBM - Aqueous Concentrations at the Boundary of the 100-Meter Mixing Zone Using Dilutions from the 2012 ODCE at the Edge of the Mixing Zone

Dissolved Constituent	95% UCL of the Mean Concentration (mg/L)	EPA Marine WQC (mg/L)[a]	Projected Concentration at Boundary of Mixing Zone (mg/L) – 898:1 Dilution from 2012 ODCE[c]	Above Chronic Water Quality Criterion at 898:1?
Arsenic	0.28	0.036	0.000312	No
Cadmium	0.0619	0.0088	0.0000689	No
Hexavalent Chromium	0.00705	0.050	0.00000785	No
Copper	0.847	0.0031	0.000943	No
Cyanide[b]	0.499[b]	0.001	0.000556	No
Lead	10.3	0.0081	0.0114	Yes (1.4x)
Mercury	0.00704	0.00094	0.00000784	No
Nickel	0.15	0.0082	0.000167	No
Selenium	0.0219	0.071	0.0000244	No
Silver[b]	0.133	0.0019	0.000148	No
Zinc	15.0	0.081	0.0167	No

[a] The most stringent salt water criteria (i.e., EPA CCC) were presented for all constituents except for silver. The Criteria Maximum Concentration value was presented for silver because no CCC value is available (refer to http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm).

[b] This constituent was detected in fewer than eight samples. The maximum detected concentration was used to calculate worst-case concentration at the critical dilution.

[c] Blue shading indicates a concentration above the chronic WQC.

9.2.2 Calculating Critical Dilution Factors Using 95% UTL of 95th Percentile Values (WBM - Aqueous)

CDFs were calculated using the 95% UTL of the mean of the WBM-aqueous analytical results and the chronic WQC. The 95% UTL of hexavalent chromium and selenium in WBM-aqueous samples meet the WQC with no dilution. CDFs to meet WQC using the 95% UTL of the mean of the WBM-aqueous analytical results and the chronic WQC for other constituents range from 21:1 (mercury) to 2616:1 (lead).

Table 9-4 compares presents the MEC at the boundary of the 100-meter mixing zone, using the 898:1 dilution specified in the 2012 ODCE, with the chronic WQC. All constituents except lead were less than the WQC. The expected maximum result for lead may represent an overestimate of the actual concentration of dissolved lead because submicron particles of insoluble lead associated with barite may be included in the measured concentration (J. Neff, pers. comm.).

Table 9-4. Projected 95% UTL of the 95th Percentile WBM - Aqueous Concentrations at the Edge of the Mixing Zone Using Dilutions from the 2012 ODCE

Dissolved Constituent	95% UTL on the 95th Percentile Expected Concentration (mg/L)	EPA Marine WQC (mg/L)[a]	MEC at Boundary of 100 m Mixing Zone (mg/L) – 898:1 Dilution from 2012 ODCE[c]	Above Chronic Water Quality Criterion at 898:1?
Arsenic	0.844	0.036	0.00094	No
Cadmium	0.209	0.0088	0.000233	No
Hexavalent Chromium	0.0138	0.050	0.0000154	No
Copper	2.57	0.0031	0.00286	No
Cyanide	0.499[b]	0.001	0.000556	No
Lead	21.2	0.0081	0.0236	Yes (2.9x)
Mercury	0.0201	0.00094	0.0000224	No
Nickel	0.418	0.0082	0.000465	No
Selenium	0.055	0.071	0.0000612	No
Silver	0.133[b]	0.0019	0.000148	No
Zinc	21.6	0.081	0.0240	No

[a] The most stringent salt water criteria (i.e., EPA CCC) were presented for all constituents except for silver. The Criteria Maximum Concentration value was presented for silver because no CCC value is available (refer to http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm).
[b] This constituent was detected in fewer than eight samples. The maximum detected concentration was used to calculate worst-case concentration at the critical dilution.
c Blue shading indicates a concentration above the chronic WQC.

9.2.3 Mean WBM – Solid Concentrations Converted to "Aqueous" Concentrations for Comparison to Water Quality Criteria

Projected environmental concentrations based on WBM-solids (total metals) concentrations are not appropriate for direct comparison with WQC because of differences in media type and units. For this reason, comparison of WBM-aqueous concentrations is more relevant to the purposes of an ODCE. To make use of the data on WBM samples where not enough aqueous phase could be extracted, an alternative comparison can be made by converting WBM-solids concentrations (reported as mg/kg in whole WBM) to a volume basis and applying a dispersion factor for the dilution of solids to calculate a projected environmental concentration at the boundary of a mixing zone. This comparison is clearly very conservative in that it assumes that all the metals in drilling fluid solids are bioavailable. The 95% UCL of the WBM-solids concentration in (mg/kg) were converted to a volume basis using minimum and maximum drilling fluid densities of 1.2581 and 1.5377 g/cc, respectively (Table 9-5). Applying a factor of 4203 dispersions to these concentrations, as done in the 2012 ODCE, yields projected environmental concentrations at the boundary of a 100-meter mixing zone. Concentrations of copper and lead are greater than the WQC by relatively small factors of 4 and 6, respectively. These results are similar to the 2012 ODCE, in which total copper and total lead including mud solids were above dissolved WQC by similar factors, and in which EPA-Region 6 determined there would be no unreasonable degradation of the marine environment resulting from these discharges.

Table 9-5. Mean WBM-Solid (Total Metals) Concentrations Converted to "Aqueous" Concentrations at the Boundary of the Mixing Zone Using Dilutions from the 2012 ODCE at the Edge of the Mixing Zone

Constituent	95% UCL of the Mean Concentration (mg/kg, wet weight)	95% UCL of mean on volume basis assuming 1.2581 g/cc density (mg/L)	95% UCL of mean on volume basis assuming 1.5377 g/cc density (mg/L)	Projected Concentration at Boundary of 100 m Mixing Zone (mg/L) – 4203: Dispersions from 2012 ODCE - Minimum	Projected Concentration at Boundary of 100 m Mixing Zone (mg/L) – 4203: Dispersions from 2012 ODCE - Maximum	Marine Water Quality Criteria (mg/L)[c]	Pass at Minimum Concentra-tion	Pass at Maximum Concentra-tion
Arsenic	24.9	31.3	38.3	7.45E-03	9.11E-03	0.036	Yes	Yes
Cadmium	0.345	0.4	0.5	1.03E-04	1.26E-04	0.0088	Yes	Yes
Hexavalent Chromium	1.44	1.8	2.2	4.31E-04	5.27E-04	0.05	Yes	Yes
Copper	32.6	41.0	50.1	9.76E-03	1.19E-02	0.0031	No	No
Cyanide	1.14	1.4	1.8	3.41E-04	4.17E-04	0.001	Yes	Yes
Lead	126	158.5	193.8	3.77E-02	4.61E-02	0.0081	No	No
Mercury	0.187	0.2	0.3	5.60E-05	6.84E-05	0.00094	Yes	Yes
Nickel	5.25	6.6	8.1	1.57E-03	1.92E-03	0.0082	Yes	Yes
Selenium	0.454	0.6	0.7	1.36E-04	1.66E-04	0.071	Yes	Yes
Silver	0.299	0.4	0.5	8.95E-05	1.09E-04	0.0019	Yes	Yes
Zinc	69.6	87.6	107.0	2.08E-02	2.55E-02	0.081	Yes	Yes

[a] Minimum values are based on 32 % solids for converting wet weight to dry weight concentrations and 1.2581 kg/L density drilling fluid (R. Kuehn, pers. comm.)
[b] Maximum values are based on 9 % solids for converting wet weight to dry weight concentrations and 1.5577 kg/L density drilling fluid (R. Kuehn, pers. comm.)
[c] The most stringent salt water criteria (i.e., EPA CCC) were presented for all constituents except for silver. The EPA Criteria Maximum Concentration value was presented for silver because no EPA CCC value is currently available for this metal (refer to http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm).
[d] Fewer than eight detected results were available for cyanide, so the maximum detected result was used.

10 ADDITIONAL EVALUATION

The most stringent EPA marine WQC was used to calculate the CD for constituents detected in PW and WBM-aqueous samples. The chronic WQC (also called Criterion Continuous Concentration) is an estimate of the highest dissolved concentration of a material in surface water to which an aquatic community can be exposed *indefinitely* without resulting in an unacceptable effect.

No constituents in PW were greater than the chronic WQC. Only lead in WBM-aqueous samples was above d the chronic WQC.

Because lead in WBM-aqueous samples was above the chronic WQC, its potential to degrade water quality in the GOM was further evaluated. The discharge and exposure scenario were refined using more realistic assumptions of the physical and chemical conditions in receiving waters that can affect toxicity (the central measure of water quality addressed by the WQC).

The acute WQC (or Criteria Maximum Concentration) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed *briefly* without resulting in an unacceptable effect. These WQC were developed to be protective of the vast majority of marine and aquatic communities in the United States. Given the small volume of water released from WBM and the dynamic movement of water within the GOM, comparison with the acute rather than the chronic WQC is a reasonable measure of degradation.

Toxicity of lead in marine waters is a function of the exposure concentration and its bioavailability, which is influenced by the physical and chemical features of the receiving waters. Lead in WBM is derived from the barite that constitutes the bulk of the mud or from the rock that is being drilled through. The lead in WBM is generally in a mineralized insoluble form, rendering it less bioavailable than the soluble lead salts used to develop the WQC. In a technical memorandum on the interpretation of the new dissolved WQC in 1993, EPA explained that "Due to the likely presence of a significant concentration of metals binding agents in many discharges and ambient waters, metals in toxicity tests would be expected to be more bioavailable than metals in discharges or in ambient waters" (EPA Office Of Water 1993). Furthermore, the detected concentrations of lead in WBM-aqueous samples may contain submicron particles of insoluble lead associated with barite (J. Neff, pers. comm.).

In water, lead is most soluble and bioavailable under conditions of low pH, low organic content, low concentrations of suspended sediments, and low concentrations of the salts of calcium, iron, manganese, zinc, and cadmium (Eisler 1988). Accordingly, solubility of lead is low in marine waters typical of the GOM. Most lead discharged to natural waters is precipitated to the sediment bed as carbonates or hydroxides (Eisler 1988). Therefore, although lead in WBM-aqueous discharges is projected to be slightly above the chronic WQC at the 100-m mixing zone boundary, it is unlikely that most of the lead would be available to organisms. It should also be noted that lead does not generally biomagnify in marine food chains (Neff 2002; ATSDR 2007; Neff 2008). Lead and several other metals (barium, cadmium, mercury,

nickel, and vanadium) in clam and oyster tissues collected within 10 m of PW discharge pipes in the GOM were not statistically different from reference stations (Trefry et al., 1995).

Although localized impacts to comparatively small areas of the soft-bottom benthic habitats are known to occur within the 100-m mixing zone when WBM is discharged, the discharge affects only a relatively small area adjacent to the discharge (BOEM 2012). The impacted area is estimated to range from 0.01 to 0.03 % of the total area of the GOM leased for oil and gas production (BOEM 2012), based on potential impacts to a 100-m radius around each discharge.

11 SUMMARY AND CONCLUSIONS

All constituents in PW meet the chronic WQC at the 100-meter mixing zone boundary. Therefore, PW discharges authorized in the general permit would not cause unreasonable degradation of the marine environment.

All constituents in WBM-aqueous discharges, except lead, meet the chronic WQC at the 100-meter mixing zone boundary. Lead is above the chronic WQC by a factor of 1.4 but is far below the acute WQC. Given the decreased solubility of the inorganic lead contained in WBM compared with the lead salts used in developing the WQC, and the widely scattered locations of WBM discharge across the GOM, the small elevation of the chronic WQC for lead is unlikely to cause adverse ecological impacts or degradation of water quality

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From: Mire, June
To: chen.isaac@epa.gov; shaikh.taimur@epa.gov
Cc: Kuehn, Rob (robert.kuehn@shell.com); gail korenaga (gkorenaga@chevron.com); Smith, Joe P
Subject: OOC Mud and Produced Water Characterization Study - Revised SAP/QAPP
Date: Monday, March 24, 2014 11:34:11 AM

Hi, Isaac and Taimur,

I am following up on our February 25, 2014, conference call in which we discussed changes to the protocol for analyzing water based mud samples for the Mud and Produced Water Characterization Study in response to GMG290000. The attached file contains the complete revised SAP/QAPP. In addition to updating the text to reflect changes to the analytical protocols, we have included a new section (Appendix D) that provides the technical and logistical rationale for the revised plan.

Please let me know if you have any questions or comments on this revised SAP/QAPP. I am also sending you a hard copy by registered mail.

Thanks,

June

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TETRA TECH

March 24, 2014

By electronic mail to: chen.isaac@epa.gov; shaikh.taimur@epa.gov

Re: Sampling and Analysis Plan, including Quality Assurance Project Plan and Sampling Procedures; Revision 01

Joint Industry Project (JIP) Mud and Produced Water Characterization Study to Meet Requirements of the NPDES Permit for the Western and Central Gulf of Mexico Outer Continental Shelf (GMG 290000)

Dear Mr. Chen:

On behalf of the Offshore Operator Committee, we are submitting Revision 01 of the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) for the above-referenced project. As we discussed with you on February 25, 2014, we have modified the approach to analyzing water based mud samples to reflect the availability of aqueous phase in some samples. We are now analyzing all water based mud samples for total metals, hexavalent chromium, and cyanide. We are analyzing dissolved constituents in water based mud samples that yield adequate aqueous phase. We have de-prioritized analysis of dissolved cyanide, as agreed.

The attached file contains the complete Revision 01 of the SAP/QAPP. Please note that a new appendix has been added to the SAP. Appendix D, Water Based Mud Characterization, provides the technical and logistical rationale for the revised analytical plan.

To date we have collected and analyzed 47 water based mud samples from 16 different lease areas. We are in the process of analyzing total constituents in the archived water based mud samples collected earlier in the study; all constituents except mercury and cyanide are within holding times. Samples collected since our conversation on February 25, 2014 have been analyzed as described in the attached SAP/QAPP. If we do not hear from you by April 15, 2014, we will assume your concurrence with this revised SAP/QAPP.

Please do not hesitate to call me at (504) 834-6276 if you would like to discuss this revision or other aspects of the study.

June B. Mire, Ph.D.
Tetra Tech Project Manager

Robert H. Holmes
Tetra Tech Program Manager, Oil & Gas

Cc: OOC Core Team

Enclosure

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SAMPLING AND ANALYSIS PLAN (Revision 01)

MUD AND PRODUCED WATER CHARACTERIZATION STUDY (MPWCS) TO MEET REQUIREMENTS OF THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT WESTERN AND CENTRAL GULF OF MEXICO OUTER CONTINENTAL SHELF (OCS) NPDES PERMIT No.: GMG290000

Prepared for

OFFSHORE OPERATORS COMMITTEE (OOC)
ENVIRONMENTAL SUBCOMMITTEE

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D WATER BASED MUD CHARACTERIZATION

1.0 INTRODUCTION

The Offshore Operators Committee (OOC) directed Tetra Tech, Inc. (Tetra Tech) to prepare a sampling and analysis plan (SAP) for the Mud and Produced Water Characterization Study (MPWCS) for the Western and Central Gulf of Mexico Outer Continental Shelf (OCS) area (National Pollutant Discharge Elimination System [NPDES] Permit No. GMG290000). The purpose of the SAP is to specify the type, number, and location of samples to be collected during MPWCS activities, as well as the sampling methodology to be followed.

All activities and procedures discussed and described in this SAP will be conducted in accordance with the approved Quality Assurance Project Plan (QAPP), which is consistent with the Tetra Tech Quality Management Plan (Reference [Ref.] 1). Tetra Tech will perform activities in accordance with the prescribed guidance and informational documents listed below to further ensure that all data quality objectives (DQO) are met.

- Environmental Protection Agency (EPA) Test Methods for Evaluating Solid Waste, Fourth Edition, Including Updated, I through IVB, February 2007 (SW-846) Methods 6020A (dissolved metals), 7470A (dissolved mercury), 7196A (dissolved hexavalent chromium), and 9014 (dissolved cyanide) (Ref. 2)
- EPA Method 218.6: Determination of Dissolved Hexavalent Chromium in Drinking Water, Groundwater, and Industrial Wastewater Effluents by Ion Chromatography, Revision 3.3, 1994 (Ref. 3)
- EPA National Functional Guidelines (NFG) for Inorganic Superfund Data Review, EPA540-R-10-011, January 2010 (Ref. 4)
- EPA Guidance on Systematic Planning Using the Data Quality Objectives (DQO) Process, EPA QA/G-4, February 2006 (Ref. 5)
- EPA Region 6, Fact Sheet and Supplemental Information for the Proposed Reissuance of the NPDES General Permit for New and Existing Sources in the Offshore Subcategory for the Western Portion of the Outer Continental Shelf of the Gulf of Mexico (GMG290000), December 2012 (Ref. 8)
- EPA Region 6, The NPDES General Permit for New and Existing Sources and New Discharges in the Offshore Subcategory of the Oil and Gas Extraction Point Source Category for the Western Portion of the Outer Continental Shelf of the Gulf Of Mexico (GMG290000), 2012 (Ref. 9)

These guidance documents specifically apply to sampling locations, sample types, sampling procedures, use of data, data types, field quality assurance and quality control (QA/QC) samples, sample analyses, and data validation. The following web sites were used to provide information on the spatial distribution of the study region:

- Google Earth. Distance check from Central to Western portion of the Gulf of Mexico. May 2013. (Ref. 6)
- NOAA Ocean Explorer: Expedition to the Deep Slope. http://oceanexplorer.noaa.gov/explorations/06mexico/background/oil/media/platforms_600.htmlMay 2013 (Ref. 7)

The primary purpose of the MPWCS is to meet EPA permit requirements that include a characterization study of water based mud (WBM) and produced water (PW) for the express purpose of having "more area-specific data for future evaluations;" and to collect data in areas to characterize representative discharges from wells in the OCS area. Activities for the MPWCS will include the following:

- Identify sample locations using geographic information system (GIS) and a hierarchical optimization system
- Select produced water sample locations to ensure that the entire data set will be representative of overall offshore production
- Collect samples to determine the soluble concentration of arsenic, cadmium, copper, cyanide, hexavalent chromium, lead, mercury, nickel, selenium, silver, and zinc in WBM and PW

The remainder of this SAP for MPWCS activities in the OCS area is organized as follows:

- Section 2.0 presents background information, including the site description and environmental setting, and regulatory background.
- Section 3.0 summarizes proposed field sampling activities, including descriptions of sampling methods.
- Section 4.0 describes the data quality objectives.
- Section 5.0 describes the analytical methodology.
- Section 6.0 presents the project personnel and their responsibilities.
- Section 7.0 provides a list of references consulted.
- Appendix A provides sampling procedures and reference checklists.
- Appendix B provides the tables.
- Appendix C provides the quality assurance project plan (QAPP).
- Appendix D discusses the technical approach to characterizing water based mud samples that do not yield water when centrifuged.

2.0 SITE BACKGROUND

This section describes the site and environmental setting, discusses past operations, and summarizes previous investigations for the OCS area.

2.1 SITE DESCRIPTION AND ENVIRONMENTAL SETTING

The Western and Central OCS area is located on the southern boundary of the United States and extends from Alabama to the Texas coastline, a distance of approximately 630 miles (Refs. 6; 7). The central and western areas of the Gulf of Mexico have nearly 4,000 active oil and gas platforms (Ref. 7).

2.2 REGULATORY BACKGROUND

On April 3, 1981, the EPA published NPDES permit TX008562. The permit authorized discharges from facilities located seaward of the outer boundary of the territorial seas off Louisiana and Texas, an area commonly known as the Outer Continental Shelf. Permit restrictions limited oil and grease releases to 72 milligrams per liter (mg/L) a day; prohibited the discharge of oil based drilling fluids; imposed a limit of no free oil for drilling fluids, drill cuttings, deck drainage and well treatment fluids; and imposed a 1 mg/L residual chlorine limit for sanitary waste water (Ref. 8).

The permit was reissued on July 9, 1986 by EPA Region 6 and EPA Region 4 as permit number GMG280000. The permit prohibited discharge of oil based drilling fluids, oil contaminated drilling fluids, drilling fluids containing diesel oil, and drill cuttings generated using oil based drilling fluids. The permit also included new limits on suspended particulate phase toxicity in drilling fluids, on the drilling fluid discharge rate near areas of biological concerns, and on free oil drilling and drill cuttings. On November 19, 1992, the NPDES Permit was reissued by EPA Region 6 as GMG290000. New limits were included in the reissuance for produced water toxicity, for cadmium and mercury in stock barite, and prohibition on discharge of drilling fluids containing mineral oil (Ref. 8).

NPDES Permit GMG290000 underwent additional modifications over the years. A summary of the revisions is included below (Ref. 8):

- **December 3, 1993:** Offshore subcategory effluent limitations guidelines and more accurate calculations of produced water critical dilutions.
- **August 9, 1996:** New Sources combined into the permit.

- **November 2, 1998:** New discharges of saltwater and freshwater (biocides and corrosion inhibitors); maximum discharge rate for produced water removed; and critical dilutions required for produced water toxicity limit updated.
- **December 18, 2001:** New discharges associated with synthetic based drilling fluids and additional monitoring requirements for hydrostatic testing of existing piping and pipelines.
- **October 7, 2004:** Produced watering monitoring requirements for facilities in hypoxic zone; discharge prohibitions at National Marine Sanctuaries clarified; variability factor for determining compliance with the permit's limits for sediment toxicity and biodegradation removed; allowance for blending of compliant synthetic base fluids in drilling fluids added; and fourteen day advanced notification removed.
- **June 7, 2007:** Requirements to comply with new cooling water intake structure regulations added; sub-lethal effects for whole effluent toxicity testing to be measured; and new test methods allowed for monitoring cadmium and mercury in stock barite.

On October 1, 2012, the current reissued NPDES Permit GMG290000 went into effect and covers lease areas and discharges in the central and western portions of the Gulf of Mexico (Ref. 9).

3.0 PROPOSED SAMPLING PLAN

This SAP describes the samples to be collected; sampling methodologies; applicable holding times and record keeping; analytical techniques and target detection limits; as well as the platforms and rigs to be sampled. Sampling will be conducted, and QA/QC samples will be collected, in accordance with procedures detailed in the Sampling Procedures Reference Checklists found in Appendix A. Sample holding times will be minimized as much as possible by close coordination with the operators so that samples can be transported on supply vessels and helicopters to the nearest shore-based support facility.

The personnel that will collect the samples are the same personnel who currently collect samples under the NPDES monitoring programs on the rigs/platforms. These personnel on the rigs/platforms will receive training on the sampling procedures via a training video that will be made available to them prior to sampling. The Sampling Procedures Reference Checklists will be emailed to the sampling personnel and supervisors prior to sampling, and the Tetra Tech chemist will set up a pre-sampling conference with the personnel to verify that the training video has been viewed and to review the procedures. If the operators have access to a phone, the Tetra Tech chemist will be available to address any questions that may arise during sampling. If phone contact during sampling is not available, the sampling personnel will call the Tetra Tech chemist as soon as reasonably possible after sampling to debrief on the sample collection.

The sampling personnel will be required to check off the steps enumerated in the Sampling Procedures Reference Checklists in Appendix A, and to sign and date the checklists to verify that the procedures were followed. Because EPA Region 6 field sampling procedures were not available, the Sampling Procedures Reference Checklists were prepared by referencing the appropriate EPA Region 4, Science and Ecosystem Support Division (SESD), Field Branches Quality System and Technical Procedures (Refs. 10 through 15). Table 1 in Appendix B outlines the numbers and types of samples proposed, as well as sampling locations. Table 2 in Appendix B summarizes the QA/QC samples to be collected during field sampling activities. The analytical methodology is described in Section 5.0 of this SAP.

3.1 WATER BASED MUD SAMPLING

Sampling Design

The Western and Central OCS consists of 69 designated surface areas, each of which is divided into numerous lease blocks (a geographical area of approximately 9 square miles [5,760 acres]).

The ideal sampling design would include ten WBM samples from each of 10 different blocks within each State- or Bureau of Ocean Energy Management-designated surface area. However, WBM samples must be collected during active drilling, so actual sample collection will necessarily be opportunistic. Participating operators will identify where drilling will occur during the sample collection phase of this project. Drilling plans and locations are proprietary and cannot be presented in this sampling plan. Tetra Tech will work with the participating operators to obtain proposed drilling schedules, which will allow for optimization of the sampling design and ensure that representative samples are collected.

To the extent practicable, Tetra Tech will have the operators collect a WBM sample from each active drilling operation that satisfies the spatial criteria of the MPWCS. The goal is to collect a total of 10 WBM samples from each of 10 different blocks within each designated surface area. The schedule and locations must be flexible to accommodate unexpected changes in drilling activities. Estimated sample collection locations based on drilling activities between 2009 and 2012 are shown in Table 3 for illustration. Actual sample locations will be determined by drilling activity during the study period.

Sampling Procedure

The rig/platform personnel will collect WBM samples from wells during drilling activities. The WBM samples will be collected in accordance with the procedures outlined in the Sampling Procedure and Checklist (Appendix A) and sent to ALS Group (ALS) in Houston, Texas, a Tetra Tech-procured laboratory. If the offshore support location for the rig/platform is the Port of Galveston, ALS will pick up the sample cooler and transport it to their laboratory. If an alternate offshore support location is used, the cooler will be shipped by Federal Express to the laboratory. Shipping instructions are included in the Sampling Procedure and Checklist (Appendix A). Upon receipt of the WBM sample, the laboratory will homogenize the sample using procedures described in *Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual* (REF 17). A portion of the homogenized sample will be analyzed for total metals (arsenic, cadmium, copper, lead, mercury, nickel, selenium, silver, and zinc); cyanide; and hexavalent chromium using

methods suitable for either solids or water (depending on the consistency of the particular sample). The lab will centrifuge another portion of the homogenized WBM sample and decant available water to filter and analyze the sample for dissolved phase metals (arsenic, cadmium, copper, lead, mercury, nickel, selenium, silver, and zinc); dissolved hexavalent chromium; and dissolved cyanide.

As discussed with US EPA Region 6 personnel on February 25, 2014, some WBM samples collected to date have yielded very little water when centrifuged (see Appendix D for a discussion of the steps taken to extract water from WBM samples and summary notes of the February 25, 2014 meeting). If a WBM sample does not yield enough water to analyze all of the parameters listed above, the lab will analyze as many parameters as possible on each sample, in the following order of priority: metals, hexavalent chromium, cyanide. Table 1 in Appendix B outlines the numbers, types, and analytical methods for WBM samples. A discussion of the relative priority of cyanide analysis is in Appendix D.

In addition, water based muds collected under the original SAP (prior to this revision) have been archived in the lab. These samples will be analyzed for total constituents as described above, with the exception of mercury and cyanide in some of the older samples that have exceeded the holding time.

The spud mud used for drilling the top hole before the risers are in place can be characterized as "miscellaneous discharge" or as "drilling discharge" and is not representative of typical drilling mud because it usually contains bentonite clay (and sometimes barite), which is not implicated in toxicity. Additionally, because this mud is discharged directly to the sea floor, it would be impractical to collect quality-control samples as "used" mud for this study. This characterization study proposes to first sample returned "used" mud (after riser installation). If that is impracticable (due to the operator switching to synthetic mud after riser installation), the study proposes to take "unused" spud mud from the active pits rather than attempting to sample "used" mud from the seafloor to characterize this portion of drilling discharges.

3.2 PRODUCED WATER SAMPLING

Samples of produced water will be collected from offshore production platforms of participating operators. Participating operators currently control active produced water outfalls in 28 different surface areas (Table 4 in Appendix B). PW samples will be collected using a stratified random sampling approach based on the geographic location (surface area/block) and a representative, weighted distribution of operators. Outfalls will be selected for sampling to achieve the desired spatial distribution specified in the permit, with no more than 10 samples from each surface area and no more than one unique sample from each block. To the extent practicable, outfalls will be selected to ensure representation of all participating operators. In surface areas with more than 10 active blocks containing produced water outfalls controlled by participating operators, sample locations were randomly selected using a grid and random number generator. Proposed sample locations are shown in Table 4 in Appendix B.

The PW samples will be collected in accordance with the procedures outlined in the Sampling Procedure and Checklist (Appendix A) and sent to ALS in Houston, Texas, a Tetra Tech-procured laboratory. If the offshore support location for the rig/platform is the Port of Galveston, ALS will pick up the sample cooler and transport to laboratory. If an alternate offshore support location is used, the cooler will be shipped by Federal Express to the laboratory. Shipping instructions are included in the Sampling Procedure and Checklist (Appendix A). Upon receipt of the PW sample, the laboratory will analyze the sample for dissolved phase arsenic, cadmium, copper, cyanide, hexavalent chromium, lead, mercury, nickel, selenium, silver, and zinc. Table 1 in Appendix B outlines the numbers, types, and analytical methods for PW samples.

4.0 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) for the MPWCS are discussed in the Quality Assurance Project Plan (QAPP) included as Appendix C to this SAP. The QAPP was developed following EPA's Requirements for Quality Assurance Project Plans, EPA QA/R-5, EPA/240/B-01/003, reissued May 2006 (Ref. 15). DQOs were established to define the quantity and quality of the data to be collected in support of the MPWCS objectives.

Sampling and laboratory analysis will be conducted to provide information for comparing dissolved pollutant concentrations of the samples to EPA Ambient Water Quality Criteria for saltwater (Ref.16). Other uses of the study results may include EPA conducting reasonable potential analyses of discharge concentrations to exceed ambient water quality criteria, possible refinement of the NPDES permit and to inform future Ocean Discharge Criteria Evaluations, as well as to characterize representative discharges from the wells in the OCS area.

QA/QC samples will be collected during the sampling event to check for variations with sample collection, sample handling, and laboratory analysis. The QA/QC samples to be collected and their proposed frequencies are summarized in Table 2 of Appendix B.

Tetra Tech will assess the analytical results for initial acceptance during a Stage 4 validation of the samples that will determine the usability of the data. Any rejected data and the reasons for rejection will be summarized in the data quality assessment (DQA) report.

5.0 ANALYTICAL METHODOLOGY

WBM and PW samples will be submitted to ALS in Houston, Texas, a Tetra Tech-procured laboratory. Table 1 of Appendix B presents the analyses to be performed for WBM and PW samples. Table 5 of Appendix B presents the analytical methodology for each sample matrix, including required sample containers and preservatives. The analytical parameters for WBM and PW samples are described below:

- Selected dissolved metals (arsenic, cadmium, copper, lead, nickel, selenium, silver, and zinc) in PW and WBM and total metals (in WBM only) will be analyzed by EPA Test Methods for Evaluating Solid Waste, Fourth Edition, Including Updated, I through IVB, February 2007 (SW-846) Method 6020A (Ref. 2).
- Dissolved mercury will be analyzed by SW-846 Method 7470A and total mercury in WBM by SW-846 Method 7471B (Ref. 2).
- Dissolved and total cyanide will be analyzed by SW-846 Method 9014 (Ref. 2).
- Dissolved and total hexavalent chromium will be analyzed by SW-846 7196A (for WBM samples) (Ref. 2).
- Dissolved hexavalent chromium will be analyzed by EPA Method 218.6 (for PW samples) (Ref. 3).

Additionally, for the first 20 PW samples collected, an unfiltered and unpreserved sample container will be submitted to the laboratory. This sample aliquot will be filtered by the laboratory upon receipt, preserved with the buffer solution, and analyzed for dissolved hexavalent chromium by EPA Method 218.6.

Any variations in the analytical methodology will be specified in the monthly summary reports submitted to the OOC Steering Committee, as well as the DQA, and final report.

Data validation of the analytical data packages will be conducted by Tetra Tech. A Stage 4 data validation will be conducted in accordance with the EPA NFGs for Inorganic Superfund Data Review, EPA540-R-10-011, January 2010 (Ref. 4); as well as the associated analytical methods. The data packages will also be reviewed to determine whether any data should be rejected and whether any data qualifiers assigned during the validation process affect the usability of the data as defined in Section 1.5 of the QAPP (see Appendix C).

6.0 PROJECT PERSONNEL

Anticipated team members and their responsibilities are as follows:

- June Mire, PhD – Project Manager
- Jerry Neff; Randy Bassett, PhD; and Len Nelms, PhD – Scientific Advisors
- Matthew Soltis, CIH, CSP and John Schendel, PhD – Specialty Services
- Jessica Vickers – Laboratory/Analytical/Data Quality Leader
- Jim Collins; Theodore Donn, Jr., PhD; Blaine Snyder; Randy Mayer; and Bryan Vasser – Task Leaders

Additional team members will be determined prior to initiation of sample collection.

7.0 REFERENCES (Continued)

1. Tetra Tech EM Inc. (Tetra Tech), Quality Management Plan, Revision 2. November 2009.

2. EPA. Test Methods for Evaluating Solid Waste, Fourth Edition, Including Updated, I through IVB, February 2007 (SW-846) Methods 6020A, 7470A, 7196A, and 9014. February 2007.

3. EPA Method 218.6: Determination of Dissolved Hexavalent Chromium in Drinking Water, Groundwater, and Industrial Wastewater Effluents by Ion Chromatography, Revision 3.3, 1994.

4. EPA. CLP National Functional Guidelines for Inorganic Superfund Data Review, EPA540-R-10-011. January 2010.

5. EPA. Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4. February 2006. Accessed on-line at http://www.epa.gov/quality/qs-docs/g4-final.pdf.

6. Google Earth. Distance check from Central to Western portion of the Gulf of Mexico. May 2013.

7. NOAA. NOAA Ocean Explorer: Expedition to the Deep Slope. http://oceanexplorer.noaa.gov/explorations/06mexico/background/oil/media/platforms_600.html, May 2013.

8. EPA. EPA Region 6, Fact Sheet and Supplemental Information for the Proposed Reissuance of the NPDES General Permit for New and Existing Sources in the Offshore Subcategory for the Western Portion of the Outer Continental Shelf of the Gulf of Mexico (GMG290000), December 2012.

9. EPA. EPA Region 6, The NPDES General Permit for New and Existing Sources and New Discharges in the Offshore Subcategory of the Oil and Gas Extraction Point Source Category for the Western Portion of the Outer Continental Shelf of the Gulf Of Mexico (GMG290000), 2012.

10. U.S. Environmental Protection Agency (EPA), Region 4 Science and Ecosystem Support Division (SESD) Field Branches Quality System and Technical Procedure for Waste Sampling. January 2013. Accessed on-line at http://www.epa.gov/region4/sesd/fbqstp/Waste-Sampling.pdf.

11. EPA, Region 4 SESD Field Branches Quality System and Technical Procedure for Wastewater Sampling. February 2013. Accessed on-line at http://www.epa.gov/region4/sesd/fbqstp/Wastewater-Sampling.pdf.

12. EPA, Region 4 SESD Field Branches Quality System and Technical Procedure for Field Sampling Quality Control. February 2013. Accessed on-line at http://www.epa.gov/region4/sesd/fbqstp/Field-Sampling-Quality-Control.pdf.

13. EPA, Region 4 SESD Field Branches Quality System and Technical Procedure for Sample and Evidence Management. January 2013. Accessed on-line at http://www.epa.gov/region4/sesd/fbqstp/Sample-and-Evidence-Management.pdf.

14. EPA, Region 4 SESD Field Branches Quality System and Technical Procedure for Packing, Marking, Labeling, and Shipping of Environmental and Waste Samples. April 2011. Accessed on-line http://www.epa.gov/region4/sesd/fbqstp/Shipping-Environmental-and-Waste-Samples.pdf.

7.0 REFERENCES (Continued)

15. EPA. EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5, EPA/240/B-01/003, Reissued May 2006.

16. EPA. EPA Ambient Water Quality Criteria for saltwater. Accessed on-line http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#appendxa.

17. EPA. Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual, EPA/823/B-01/002. Office of Water. http://epa.gov/waterscience/cs/library/collection.html. 2001

APPENDIX A

SAMPLING PROCEDURES AND CHECKLISTS

(Twelve Pages)

WATER BASED MUD SAMPLING PROCEDURE (2 pages)

Contact Jessica Vickers at Jessica.Vickers@tetratech.com: (678) 983-6655.

This document details the process covered in the training video. You should watch the training video no more than five days before you collect the samples. We will email a copy of this procedure to you before we send you the Sampling Kit. The Sampling Kit will contain a checklist for this sampling procedure. Use both this procedure and the checklist to guide you during sampling. When finished, sign and date the checklist **and include it with the sample shipment**.

I. SAMPLING KIT – The Sampling Kit will include ***one cooler.*** Please open the cooler and confirm that it contains the following items:

- Checklist *(to be completed and returned to us)*
- Chain-of-custody (COC) form (see Attachment 1)
- Custody seals (2)
- Large garbage bags (2)
- Sampling gloves (5 pair)
- Paper towels
- Pre-labeled wide-mouth plastic jars (2 per sample [see Attachment 2])
- Ziploc bags (1 for COC form and checklist, and 1 for each sample container)
- Roll of clear plastic tape
- Pre-filled-out Federal Express shipping label
- A sharpie marker

II. PRE-SAMPLING INSTRUCTIONS

(Note: Before sample collection, have enough ice on hand to fill the cooler.)

- Place the sample containers and other supplies in a clean location.
- Place one large garbage bag inside the other one to form a double-layered garbage bag. Put the double-layered garbage bags inside the cooler, with their openings facing upward.
- Fill the double-layered garbage bag inside the cooler almost all the way with ice. Leave enough room for the sample containers to also fit inside.
- Write the current date, time, and your initials with a sharpie on the label of each sample jar.
- Write the current date and time on each row where a sample is listed on the COC form, using a sharpie (date and time on COC should match the sample container labels). Print and sign your name in the space provided for "Sampler(s)." Sign and write the current date and time in the "Relinquished by:" block.
- Sign and write the current date on each custody seal, using a sharpie

NOTE: WBM samples should be collected from the returned mud from the well borehole during riser installation. If this is not possible because the WBM will not be used after riser installation, WBM from an active pit (with mud discharge on the seafloor) will be collected instead. ***Make notes on the checklist to show where the sample was collected.***

[Continued on page 2]

III. SAMPLE COLLECTION

- If some of the ***labeled*** sample containers have a name ending in "-DUP", set those containers aside along with one of the ***unlabeled*** 1-gallon plastic bottles.
- Place the ***labeled*** sample containers ***without*** the "-DUP" ending in a convenient place for filling them.
- Put on a new, unused pair of gloves.
- Fill the sample containers to about 95% full with WBM.
- Clean the top rim and threads of the sample container with a paper towel. Close the sample container and hand tighten the lid.
- For sample containers with a name ending in "-DUP," repeat the sample collection steps. Start by putting on new gloves, and repeat the steps above for all containers labeled "-DUP".
- Note on the checklist where the WBM samples was collected.

IV. SAMPLE PACKING

- Put on a new, unused pair of gloves. Replace the glove whenever they are torn or become badly soiled.
- Dry all sample containers with paper towels; check that all lids are tight.
- Place each sample container inside a separate Ziploc bag and securely seal the bag.
- Bury each bagged sample container in the ice (in the double-layered garbage bags in the cooler). Make sure the sample bottles are upright and not touching each other or the sides of the cooler. Surround each bottle completely with a few inches of ice.
- Top off the garbage bag liner with ice so that sample containers will not move around.
- Take off and dispose of the gloves.
- Carefully pull up on the top edges of the garbage bags above the level of the ice and sample containers.
- Push out the excess air from the ***inner*** garbage bag as you twist it and tie it into a knot. Then, tape the knot down onto the bag using clear plastic tape.
- Repeat for the ***outer*** garbage bag. Tape the knot down onto the bag using clear plastic tape.
- Complete, sign, and date the checklist. Put the signed COC form and checklist in a Ziploc bag, securely seal the bag, and tape the bag to the inside of the cooler lid using clear plastic tape.

V. SAMPLE COOLER SHIPPING

- Close the cooler. Affix two signed and dated custody seals across the seam of the lid at diagonally opposite corners. Tape the lid of the cooler in two places, covering the custody seals, with clear tape.
- Affix the Federal Express shipping label to the top of the cooler; tape down its edges.
- Hand off the sample cooler to the person who will transport it to shore.

WATER BASED MUD SAMPLING CHECKLIST REV 01 (without duplicates)

Contact Jessica Vickers at Jessica.Vickers@tetratech.com or 678-983-6655 (cell).

This document lists the steps covered in the training video, which should be viewed no more than five (preferably within two) days before the day of sampling. Use the *Water Based Mud Sampling Procedure* to guide you during sampling. Check the boxes on this checklist as you complete each step. **When finished, sign and date this checklist at the bottom and include it with the sample shipment. Make sure all highlighted information is filled out.**

I. SAMPLING KIT *(Check the box to show that the statement is true.)*

☐ The sampling kit cooler contained all items listed in the SAMPLING KIT Section of the *WBM Sampling Procedure.*

II. DOCUMENTATION INSTRUCTIONS

☐ The current date, current time, and your initials have been written in the appropriate highlighted areas of the labels attached to the sample containers, as indicated in the DOCUMENTATION INSTRUCTIONS of the *WBM Sampling Procedure.*

☐ The current date and time have been written on the COC form in the highlighted areas for each sample; your printed name and signature have been written in the highlighted "Sampler(s)" block on the COC form; and the current date, current time, and your signature have been written in the highlighted "Relinquished by:" block on the COC form, as indicated in the DOCUMENTATION INSTRUCTIONS of the *WBM Sampling Procedure.*

☐ The current date, current time, and your signature have been written on both custody seals in the highlighted areas as indicated in the DOCUMENTATION INSTRUCTIONS of the *WBM Sampling Procedure.*

III. PRE-SAMPLING INSTRUCTIONS

☐ The cooler has been set up with double-layered garbage bags and ice as indicated in the PRE-SAMPLING INSTRUCTIONS of the *WBM Sampling Procedure.*

IV. SAMPLE COLLECTION

☐ New, unused gloves were put on when indicated in the SAMPLE COLLECTION Section of the *WBM Sampling Procedure,* and whenever the glove(s) were torn or badly soiled.

☐ WBM samples were collected as indicated in the SAMPLE COLLECTION Section of the *WBM Sampling Procedure.*

Indicate the location of mud sample by circling below. Add comments as needed to clarify the sample point and conditions:

- Mud returns via riser from well bore
- Active pit
- Air Cool Start Time:_____ Air Cool Stop Time:_____
- Comments/Coordinate Verification:
- Well depth:_____
- Mud weight:_____

_____

V. SAMPLE PACKING

☐ Samples were packed into the cooler and sealed as indicated in the SAMPLE PACKING Section of the *WBM Sampling Procedure.*

_____ Signature

_____ Date

_____ Printed Name

_____ Location ID

WATER BASED MUD SAMPLING CHECKLIST REV 01 (with duplicates)

Contact Jessica Vickers at Jessica.Vickers@tetratech.com or 678-983-6655 (cell).

This document lists the steps covered in the training video, which should be viewed no more than five (preferably within two) days before the day of sampling. Use the *Water Based Mud Sampling Procedure* to guide you during sampling. Check the boxes on this checklist as you complete each step. **When finished, sign and date this checklist at the bottom and include it with the sample shipment. Make sure all highlighted information is filled out.**

I. SAMPLING KIT *(Check the box to show that the statement is true.)*

☐ The sampling kit cooler contained all items listed in the SAMPLING KIT Section of the *WBM Sampling Procedure*.

II. DOCUMENTATION INSTRUCTIONS

☐ The current date, current time, and your initials have been written in the appropriate highlighted areas of the labels attached to the sample containers, as indicated in the DOCUMENTATION INSTRUCTIONS of the *WBM Sampling Procedure*.

☐ The current date and time have been written on the COC form in the highlighted areas for each sample; your printed name and signature have been written in the highlighted "Sampler(s)" block on the COC form; and the current date, current time, and your signature have been written in the highlighted "Relinquished by:" block on the COC form, as indicated in the DOCUMENTATION INSTRUCTIONS of the *WBM Sampling Procedure*.

☐ The current date, current time, and your signature have been written on both custody seals in the highlighted areas as indicated in the DOCUMENTATION INSTRUCTIONS of the *WBM Sampling Procedure*.

III. PRE-SAMPLING INSTRUCTIONS

☐ The cooler has been set up with double-layered garbage bags and ice as indicated in the PRE-SAMPLING INSTRUCTIONS of the *WBM Sampling Procedure*.

IV. SAMPLE COLLECTION

☐ New, unused gloves were put on when indicated in the SAMPLE COLLECTION Section of the *WBM Sampling Procedure,* and whenever the glove(s) were torn or badly soiled.

☐ WBM samples were collected as indicated in the SAMPLE COLLECTION Section of the *WBM Sampling Procedure*.

Indicate the location of mud sample by circling below. Add comments as needed to clarify the sample point and conditions:

- Mud returns via riser from well bore
- Active pit
- Air Cool Start Time:_____ Air Cool Stop Time:_____
- Comments/Coordinate Verification:
- Well depth:_____
- Mud weight:_____

_____

☐ For the "-DUP" sample, a new unused pair of gloves was put on and the WBM sample procedures were repeated for the containers labeled "-DUP" as indicated in the SAMPLE COLLECTION Section of the *WBM Sampling Procedure*.

V. SAMPLE PACKING

☐ Samples were packed into the cooler and sealed as indicated in the SAMPLE PACKING Section of the *WBM Sampling Procedure*.

_____ _____
Signature Date

_____ _____
Printed Name Location ID

Attachment 1

ALS Environmental Houston, Texas 77099
Phone: 281-530-5656

Client: Tetra Tech-GA Project: OOC-Water Based Mud

Sample ID: MPWCS-WBM-001

Date: _____ Time : _____ Collect By: _____

Analysis: Dissolved Metals,CN,CR6 Preservative: Neat

BO Prep'd on: 6/3/2013

ALS Environmental Houston, Texas 77099
Phone: 281-530-5656

Client: Tetra Tech-GA Project: OOC-Water Based Mud

Sample ID: MPWCS-WBM-001

Date: _____ Time : _____ Collect By: _____

Analysis: Dissolved Metals,CN,CR6 Preservative: Neat

BO Prep'd on: 6/3/2013

ALS Environmental

Cincinnati, OH +1 513 733 5336 | Fort Collins, CO +1 970 490 1511 | Everett, WA +1 425 356 2600 | Holland, MI +1 616 399 6070

Chain of Custody Form

Page ____ of ____

COC ID: 83675

Houston, TX +1 281 530 5656 | Spring City, PA +1 610 948 4903 | South Charleston, WV +1 304 356 3168 | Middletown, PA +1 717 944 5541 | Salt Lake City, UT +1 801 266 7700 | York, PA +1 717 505 5280

Attachment 2

ALS Project Manager: | ALS Work Order #:

Customer Information		Project Information		Parameter/Method Request for Analysis	
Purchase Order		Project Name	OCC-Water Based Mud	A	Dissolved Metals (6020/7000) As,Cd,Cu,Pb,Ni,Se,Ag,Zn,Hg
Work Order		Project Number		B	Dissolved Cyanide (9014)
Company Name	Tetra Tech	Bill To Company	Tetra Tech	C	Dissolved Hexavalent Chromium
Send Report To	Jessica Vickers	Invoice Attn	Jessica Vickers	D	
Address	1955 Evergreen Blvd. Bldg. 200, Ste. 300	Address	1955 Evergreen Blvd. Bldg. 200, Ste. 300	E	
				F	
City/State/Zip	Duluth, GA 30096	City/State/Zip	Duluth, GA 30096	G	
Phone	(678) 775-3104	Phone	(678) 775-3104	H	
Fax		Fax		I	
e-Mail Address		e-Mail Address		J	

No.	Sample Description	Date	Time	Matrix	Pres.	# Bottles	A	B	C	D	E	F	G	H	I	J	Hold
1	MPWCS-WBM-001			Water		2	X	X	X								☐
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Sampler(s) Please Print & Sign | Shipment Method | Required Turnaround Time: (Check Box) ☑ Std 10 WK Days ☐ 5 WK Days ☐ 2 WK Days ☐ 24 Hour ☐ Other ____ | Results Due Date:

Relinquished by:	Date:	Time:	Received by:	Notes: 10 Day TAT.
Relinquished by:	Date:	Time:	Received by (Laboratory):	Cooler ID / Cooler Temp:
Logged by (Laboratory):	Date:	Time:	Checked by (Laboratory):	QC Package: (Check One Box Below): ☐ Level I Std QC ☐ Level III Std QC/Raw Data ☑ Level IV SW846/CLP ☐ Other / EDD ____ ☐ TRRP Checklist ☐ TRRP Level IV

Preservative Key: 1-HCl 2-HNO_3 3-H_2SO_4 4-NaOH 5-$Na_2S_2O_3$ 6-$NaHSO_4$ 7-Other 8-4°C 9-5035

Note: 1. Any changes must be made in writing once samples and COC Form have been submitted to ALS Environmental.
2. Unless otherwise agreed in a formal contract, services provided by ALS Environmental are expressly limited to the terms and conditions stated on the reverse.
3. The Chain of Custody is a legal document. All information must be completed accurately.

Copyright 2011 by ALS Environmental.

PRODUCED WATER SAMPLING PROCEDURE (2 pages)

Contact Jessica Vickers at Jessica.Vickers@tetratech.com: (678) 983-6655.

This document details the process covered in the training video. You should watch the training video no more than five days before you collect the samples. We will email a copy of this procedure to you before we send you the Sampling Kit. The Sampling Kit will contain a checklist for this sampling procedure. Use both this procedure and the checklist to guide you during sampling. When finished, sign and date the checklist **and include it with the sample shipment.**

- SAMPLING KIT – The Sampling Kit will include ***one cooler*** and ***one tote***. Please open the ***cooler*** and confirm that it contains the following items:

  - Checklist *(to be completed and returned to us)*
  - Chain-of-custody (COC) form (see Attachment 1)
  - Custody seals (2)
  - Large garbage bags (2)
  - Sampling gloves (5 pair)
  - Paper towels; roll of clear plastic tape; and sharpie marker
  - Pre-labeled plastic bottles (3 per sample: 1 with nitric acid, 1 with sodium hydroxide, and 1 with buffer solution) [*Note: there will be an additional unpreserved plastic bottle for the first 20 locations sampled*]
  - Unlabeled gallon plastic bottle (1)
  - Ziploc bags (1 for COC form and checklist, and 1 for each sample container)
  - Pre-filled-out Federal Express shipping label

Please open the ***tote*** and confirm that it contains the following items:

- A pre-assembled peristaltic pump, set up
- Spare lengths of tubing (2) [for the "-DUP" samples]
- Spare 0.45 micron filters (2 to 5)
- Pre-filled-out Federal Express shipping label

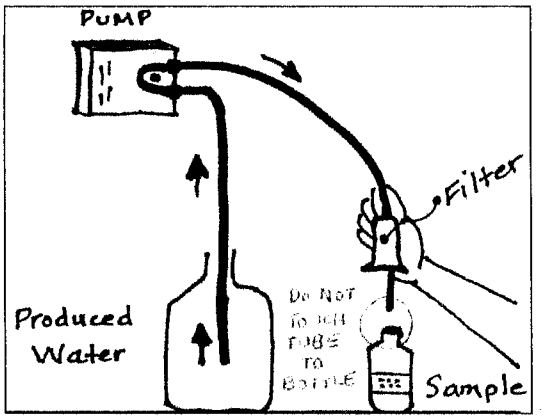
- PRE-SAMPLING INSTRUCTIONS

  (Note: Before sample collection, have enough ice on hand to fill the cooler.)

  - Put the sample containers and other supplies in a clean location.
  - Place one large garbage bag inside the other one to form a double-layered garbage bag. Place the double-layered garbage bags inside the cooler, with their openings facing upward.
  - Place enough clean, unused ice into the double-layered garbage bag inside the cooler to fill it almost all the way, but leave enough room for the sample containers to also fit inside.
  - Write the current date, current time, and your initials with a sharpie on the label of each sample bottle.
  - Write the current date and time on each row where a sample is listed on the COC form, using a sharpie (Date and time on COC should match the sample container labels). Print and sign your name in the space provided for "Sampler(s)." Sign and write the current date and time in the "Relinquished by:" block.
  - Sign and write the current date on each custody seal, using a sharpie.

➢ SAMPLE COLLECTION: ***(IMPORTANT: You must filter the sample immediately after it is collected.)***

- If some of the ***labeled*** sample containers have a name ending in "-DUP", set those containers aside along with one of the ***unlabeled*** 1-gallon plastic bottles.
- Place the ***labeled*** sample containers ***without*** the "-DUP" ending in a convenient place for filling them.
- Put on a new, unused pair of gloves.
- Remove the peristaltic pump with tubing and filter assembly from the tote and arrange it in a clean location.



- Fill the ***unlabeled*** sample container to about 95% full with PW. *(You have 15 minutes from this point to complete the filtration step and fill the sample bottles.)*
- Place the inlet tubing into the PW container and hold the tubing over the opening of a ***labeled*** sample container (Figure 2).
- Turn on pump and collect filtered water until sample container is about 95% filled. If the filter becomes clogged and the flow slows down too much, turn off the pump, pull the filter off the tubing, and replace it with a new filter. Make sure the new filter is oriented with the direction of flow (arrow pointing toward the container being filled).
- After filling, turn off the pump, clean the top rim and threads of the labeled sample container with a paper towel, and hand tighten the lid on the sample bottle. Repeat the filtering steps for the other labeled sample containers (without the "-DUP,")
- For sample containers with a name ending in "-DUP," remove the teflon tubing and filter from the pump and replace with the extras sent in your sampling kit tote as shown in Attachment 3. Repeat the sample collection steps, starting with putting on a new unused pair of gloves, for the rest of the sample containers.

➢ SAMPLE PACKING

- Put on a new, unused pair of gloves. Replace the gloves whenever they are torn or become badly soiled.
- Dry all sample containers with paper towels; check that all lids are tight.
- Place each sample container inside a separate Ziploc bag and securely seal the bag.
- Bury each bagged sample container in the ice (in the double-layered garbage bags in the cooler). Make sure the sample bottles are upright and not touching each other or the sides of the cooler. Surround each bottle completely with a few inches of ice.
- Top off the garbage bag liner with ice so that sample containers will not move around.
- Take off and dispose of the gloves.
- Carefully pull the top edges of the garbage bags up above the level of the ice and sample containers.
- Push out the excess air from the ***inner*** garbage bag as you twist it and tie it into a knot. Then, tape the knot down onto the bag using clear plastic tape.
- Repeat for the ***outer*** garbage bag. Tape the knot down onto the bag using clear plastic tape.
- Complete, sign, and date the checklist. Put the signed COC form and checklist in a Ziploc bag, securely seal the bag, and tape the bag to the inside of the cooler lid using clear plastic tape.

➢ SAMPLE COOLER AND TOTE SHIPPING

- Close the cooler. Affix two signed and dated custody seals across the seam of the lid at diagonally opposite corners. Tape the lid of the cooler in two places, covering the custody seals, with clear tape.
- Affix the Federal Express shipping label ***addressed to ALS*** to the top of the cooler; tape down its edges.
- Put the pump, tubing, and all filters (unused and used; with used filters placed inside a sealed Ziploc bag) into the tote. Pack the tote so that the items will not jostle around. Tape the tote closed in two places.
- Affix the Federal Express shipping label ***addressed to Tetra Tech*** to the top of the tote; tape down its edges.
- Hand off the sample cooler and tote to the person who will transport them to shore.

PRODUCED WATER SAMPLING CHECKLIST Rev01 (without duplicates)

Contact Jessica Vickers at Jessica.Vickers@tetratech.com or 678-983-6655 (cell).

This document lists the steps covered in the training video, which should be viewed no more than five (preferably within two) days before the day of sampling. Use the *Produced Water Sampling Procedure* to guide you during sampling. Check the boxes on this checklist as you complete each step. **When finished, sign and date this checklist at the bottom and include it with the sample shipment. Make sure all highlighted information is filled out.**

I. SAMPLING KIT *(Check the box to show that the statement is true.)*

☐ The sampling kit cooler contained all items listed in the SAMPLING KIT Section of the *PW Sampling Procedure*.

☐ The pump case contained all items listed in the SAMPLING KIT Section of the *PW Sampling Procedure*.

II. DOCUMENTATION INSTRUCTIONS

☐ The current date, current time, and your initials have been written in the appropriate highlighted areas of the labels attached to the sample containers, as indicated in the DOCUMENTATION INSTRUCTIONS Section of the *PW Sampling Procedure*.

☐ The current date and time have been written on the COC form in the highlighted areas for each sample; your printed name and signature have been written in the highlighted "Sampler(s)" block on the COC form; and the current date, current time, and your signature have been written in the highlighted "Relinquished by:" block on the COC form, as indicated in the DOCUMENTATION INSTRUCTIONS Section of the *PW Sampling Procedure*.

☐ The current date, current time, and your signature have been written on both custody seals in the highlighted areas as indicated in the DOCUMENTATION INSTRUCTIONS Section of the *PW Sampling Procedure*.

III. PRE-SAMPLING INSTRUCTIONS

☐ The cooler has been set up with double-layered garbage bags and ice as indicated in the PRE-SAMPLING INSTRUCTIONS Section of the *PW Sampling Procedure*.

IV. SAMPLE COLLECTION

☐ New, unused gloves were put on when indicated in the SAMPLE COLLECTION Section of the *PW Sampling Procedure*, and whenever the glove(s) were torn or badly soiled.

☐ PW samples were collected as indicated in the SAMPLE COLLECTION Section of the *PW Sampling Procedure*.

☐ The filter was replaced whenever it became clogged, as indicated in the SAMPLE COLLECTION Section of the *PW Sampling Procedure*.

V. SAMPLE PACKING

☐ Samples were packed into the cooler with ice and sealed as indicated in the SAMPLE PACKING Section of the *PW Sampling Procedure*.

Comments/Coordinate Verification: _____

_____ Signature

_____ Date

_____ Printed Name

_____ Location ID

PRODUCED WATER SAMPLING CHECKLIST REV 01 (with duplicates)

Contact Jessica Vickers at Jessica.Vickers@tetratech.com or 678-983-6655 (cell).

This document lists the steps covered in the training video, which should be viewed no more than five (preferably within two) days before the day of sampling. Use the *Produced Water Sampling Procedure* to guide you during sampling. Check the boxes on this checklist as you complete each step. **When finished, sign and date this checklist at the bottom and include it with the sample shipment. Make sure all highlighted information is filled out.**

I. SAMPLING KIT *(Check the box to show that the statement is true.)*

☐ The sampling kit cooler contained all items listed in the SAMPLING KIT Section of the *PW Sampling Procedure*.

☐ The pump case contained all items listed in the SAMPLING KIT Section of the *PW Sampling Procedure*.

II. DOCUMENTATION INSTRUCTIONS

☐ The current date, current time, and your initials have been written in the appropriate highlighted areas of the labels attached to the sample containers, as indicated in the DOCUMENTATION INSTRUCTIONS Section of the *PW Sampling Procedure*.

☐ The current date and time have been written on the COC form in the highlighted areas for each sample; your printed name and signature have been written in the highlighted "Sampler(s)" block on the COC form; and the current date, current time, and your signature have been written in the highlighted "Relinquished by:" block on the COC form, as indicated in the DOCUMENTATION INSTRUCTIONS Section of the *PW Sampling Procedure*.

☐ The current date, current time, and your signature have been written on both custody seals in the highlighted areas as indicated in the DOCUMENTATION INSTRUCTIONS Section of the *PW Sampling Procedure*.

III. PRE-SAMPLING INSTRUCTIONS

☐ The cooler has been set up with double-layered garbage bags and ice as indicated in the PRE-SAMPLING INSTRUCTIONS Section of the *PW Sampling Procedure*.

IV. SAMPLE COLLECTION

☐ New, unused gloves were put on when indicated in the SAMPLE COLLECTION Section of the *PW Sampling Procedure*, and whenever the glove(s) were torn or badly soiled.

☐ PW samples were collected as indicated in the SAMPLE COLLECTION Section of the *PW Sampling Procedure*.

☐ The filter was replaced whenever it became clogged, as indicated in the SAMPLE COLLECTION Section of the *PW Sampling Procedure*.

☐ For the "-DUP" sample, a new unused pair of gloves was put on; the tubing and filter were replaced; and the PW sample procedures were repeated for the containers labeled "-DUP" as indicated in the SAMPLE COLLECTION Section of the *PW Sampling Procedure*.

V. SAMPLE PACKING

☐ Samples were packed into the cooler with ice and sealed as indicated in the SAMPLE PACKING Section of the *PW Sampling Procedure*.

Comments/Coordinate Verification:_____

_____ _____
Signature Date

_____ _____
Printed Name Location ID

Attachment 1

ALS Environmental Houston, Texas 77099
Phone: 281-530-5656

Client: Tetra Tech-GA Project: OOC-Produced Water

Sample ID: MPWCS-PW-001

Date: _____ Time : _____ Collect By: _____

Analysis: Dissolved CR6 Preservative: Buffer

BO Prep'd on: 6/3/2013

ALS Environmental Houston, Texas 77099
Phone: 281-530-5656

Client: Tetra Tech-GA Project: OOC-Produced Water

Sample ID: MPWCS-PW-001

Date: _____ Time : _____ Collect By: _____

Analysis: Dissolved Cyanide Preservative: NaOH

BO Prep'd on: 6/3/2013

ALS Environmental Houston, Texas 77099
Phone: 281-530-5656

Client: Tetra Tech-GA Project: OOC-Produced Water

Sample ID: MPWCS-PW-001

Date: _____ Time : _____ Collect By: _____

Analysis: Dissolved Metals Preservative: HNO3

BO Prep'd on: 6/3/2013

ALS Environmental

Cincinnati, OH +1 513 733 5336 | Fort Collins, CO +1 970 490 1511 | Everett, WA +1 425 356 2600 | Holland, MI +1 616 399 6070

Chain of Custody Form

Page ____ of ____

COC ID: 83676

Houston, TX +1 281 530 5656 | Spring City, PA +1 610 948 4903 | South Charleston, WV +1 304 356 3168 | Middletown, PA +1 717 944 5541 | Salt Lake City, UT +1 801 266 7700 | York, PA +1 717 505 5280

Attachment 2

ALS Project Manager: | ALS Work Order #:

Customer Information		Project Information		Parameter/Method Request for Analysis	
Purchase Order		Project Name	COC-Produced Water	A	Dissolved Metals (6020/7000) As,Cd,Cu,Pb,Ni,Se,Ag,Zn,Hg
Work Order		Project Number		B	Dissolved Cyanide (9014)
Company Name	Tetra Tech	Bill To Company	Tetra Tech	C	Dissolved Hexavalent Chromium (SUB)
Send Report To	Jessica Vickers	Invoice Attn	Jessica Vickers	D	
Address	1955 Evergreen Blvd. Bldg. 200, Ste. 300	Address	1955 Evergreen Blvd. Bldg. 200, Ste. 300	E	
				F	
City/State/Zip	Duluth, GA 30096	City/State/Zip	Duluth, GA 30096	G	
Phone	(678) 775-3104	Phone	(678) 775-3104	H	
Fax		Fax		I	
e-Mail Address		e-Mail Address		J	

No.	Sample Description	Date	Time	Matrix	Pres.	# Bottles	A	B	C	D	E	F	G	H	I	J	Hold
1	MPWCS-PW-001			Water		3	X	X	X								☐
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Sampler(s) Please Print & Sign | Shipment Method | Required Turnaround Time: (Check Box) ☑ Std 10 WK Days ☐ 5 WK Days ☐ Other: 2 WK Days ☐ 24 Hour | Results Due Date:

Relinquished by:	Date:	Time:	Received by:	Notes: 10 Day TAT.
Relinquished by:	Date:	Time:	Received by (Laboratory):	Cooler ID / Cooler Temp.
Logged by (Laboratory):	Date:	Time:	Checked by (Laboratory):	

QC Package: (Check One Box Below)
- ☐ Level II Std QC
- ☐ Level III Std QC/Raw Data
- ☑ Level IV SW846/CLP
- ☐ Other / EDD _____
- ☐ TRRP Checklist
- ☐ TRRP Level IV

Preservative Key: 1-HCl 2-HNO_3 3-H_2SO_4 4-NaOH 5-$Na_2S_2O_3$ 6-$NaHSO_4$ 7-Other 8-4°C 9-5035

Note: 1. Any changes must be made in writing once samples and COC Form have been submitted to ALS Environmental.
2. Unless otherwise agreed in a formal contract, services provided by ALS Environmental are expressly limited to the terms and conditions stated on the reverse.
3. The Chain of Custody is a legal document. All information must be completed accurately.

Copyright 2011 by ALS Environmental.

APPENDIX B

TABLES

(Five Pages)

TABLE

1 SAMPLING LOCATIONS, ANALYSES, AND RATIONALE
2 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES
3 WATER BASED MUD SAMPLE LOCATIONS
4 PRODUCED WATER SAMPLE LOCATIONS
5 ANALYTICAL METHODOLOGY, REQUIRED SAMPLE CONTAINERS, AND PRESERVATIVES

TABLE 1
SAMPLING LOCATIONS, ANALYSES, AND RATIONALE

Sample ID	Sample Type	Analyses	Sample Location	Rationale
MPWCS-PW-001 through MPWCS-PW-250	Produced Water	Dissolved Metals (As, Cd, Cu, Pb, Hg, Ni, Se, Ag, and Zi), CN^-, and Cr^{+6}	To be determined as discussed in Section 3.0 of the SAP.	To characterize produced water discharges and provide data to support a reasonable potential analysis based on AWQC
MPWCS-WBM-001 through MPWCS-WBM-250	Water Based Mud	Dissolved and Total Metals (As, Cd, Cu, Pb, Hg, Ni, Se, Ag, and Zi), CN^-, and Cr^{+6}	To be determined as discussed in Section 3.0 of the SAP.	To characterize water based mud discharges and provide data to support a reasonable potential analysis

Notes:

Ag	Silver
As	Arsenic
AWQC	Ambient Water Quality Criteria
Cd	Cadmium
CN^-	Cyanide
Cr^{+6}	Hexavalent chromium
Cu	Copper
Hg	Mercury
ID	Identification
MPWCS	Mud and Produced Water Characterization Study
Ni	Nickel
Pb	Lead
PW	Produced water
SAP	Sampling and Analysis Plan
Se	Selenium
WBM	Water based mud
Zi	Zinc

TABLE 2
QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

Sample ID	Sample Type	Rationale
MPWCS-PW-###	MS/MSD	Determine the effect of each sample matrix on the sample preparation procedures and measurement methodology. One MS/MSD sample will be designated for every 20 samples collected per media.
MPWCS-WBM-###		
MPWCS-PW-###-DUP	Field duplicates	Measure both field and laboratory precision. One duplicate sample will be collected for every 20 samples collected per media.
MPWCS-WBM-###-DUP		

Notes:

##	Sample number to be determined in the field
DUP	Field duplicate
ID	Identification
MPWCS	Mud and Produced Water Characterization Study
MS/MSD	Matrix spike/matrix spike duplicate
PW	Produced water
WBM	Water based mud

TABLE 3
WATER BASED MUD SAMPLE LOCATIONS

Surface Area Code	Surface Area Label	Total Wells Drilled 2009-2012	Estimated Sample Number[1]
AT	ATWATER * 60.	1	1
EW	EWING BANK 60.	1	1
LL	LLOYD 60.	1	1
MU	MUSTANG ISLAND AREA 42.	1	1
DC	DESOTO CANYON 60.	2	2
EB	EAST BREAKS 60.	2	2
BA	BRAZOS AREA 42.	3	3
MI	MATAGORDA ISLAND AREA 42.	3	3
PL	SOUTH PELTO AREA 17.	3	3
SP	SOUTH PASS AREA 17.	4	4
MO	MOBILE 60.	6	6
SM	SOUTH MARSH ISLAND AREA 17.	8	8
AC	ALAMINOS CANYON 60.	9	9
VK	VIOSCA KNOLL 60.	9	9
WC	WEST CAMERON AREA 17.	10	10
EC	EAST CAMERON AREA 17.	11	10
HI	HIGH ISLAND AREA 42.	11	10
BM	BAY MARCHAND AREA 17.	12	10
VR	VERMILION AREA 17.	14	10
GI	GRAND ISLE AREA 17.	15	10
KC	KEATHLEY CANYON 60.	19	10
WD	WEST DELTA AREA 17.	19	10
GB	GARDEN BANKS 60.	27	10
EI	EUGENE ISLAND AREA 17.	42	10
SS	SHIP SHOAL AREA 17.	46	10
ST	SOUTH TIMBALIER AREA 17.	47	10
WR	WALKER RIDGE 60	48	10
GC	GREEN CANYON 60.	75	10
MP	MAIN PASS AREA 17.	86	10
MC	MISSISSIPPI CANYON 60.	89	10
	Total Wells Drilled in 3 Years	**624**	**213**
	Target Percent Sampled		**34%**

Notes:

1 Actual sample locations will be determined by drilling activities during the study period. These data are for illustration and estimation purposes only.

TABLE 4
PRODUCED WATER SAMPLE LOCATIONS

Surface Area Code	Surface Area Label	Unique Produced Water Outfalls	Target Sample Number
AC	ALAMINOS CANYON 60.	1	1
PN	NORTH PADRE ISLAND AREA 42.	1	1
BS	BRETON SOUND AREA 17.	2	2
CA	CHANDELEUR AREA 17.	3	3
SA	SABINE PASS (LOUISIANA) 17.	5	5
EW	EWING BANK 60.	6	6
GB	GARDEN BANKS 60.	8	8
PL	SOUTH PELTO AREA 17.	8	8
VK	VIOSCA KNOLL 60.	8	8
EB	EAST BREAKS 60.	9	9
GC	GREEN CANYON 60.	13	10
BA	BRAZOS AREA 42.	14	10
GA	GALVESTON AREA 42.	14	10
MU	MUSTANG ISLAND AREA 42.	14	10
MC	MISSISSIPPI CANYON 60.	15	10
GI	GRAND ISLE AREA 17.	17	10
MI	MATAGORDA ISLAND AREA 42.	21	10
WD	WEST DELTA AREA 17.	21	10
SP	SOUTH PASS AREA 17.	23	10
EC	EAST CAMERON AREA 17.	33	10
MP	MAIN PASS AREA 17.	46	10
ST	SOUTH TIMBALIER AREA 17.	47	10
SM	SOUTH MARSH ISLAND AREA 17.	52	10
VR	VERMILION AREA 17.	59	10
SS	SHIP SHOAL AREA 17.	68	10
WC	WEST CAMERON AREA 17.	77	10
HI	HIGH ISLAND AREA 42.	85	10
EI	EUGENE ISLAND AREA 17.	88	10
	Total Outfalls	758	**231**
	Percent Active Outfalls Sampled		**30%**

TABLE 5
ANALYTICAL METHODS, REQUIRED SAMPLE CONTAINERS, AND PRESERVATIVES

ANALYTICAL PARAMETER	MATRIX	ANALYTICAL METHOD[1]	NUMBER[2] AND TYPE OF SAMPLE CONTAINER	PRESERVATION METHOD	SAMPLE HOLDING TIME
WATER BASED MUD SAMPLES					
Total and dissolved metals (arsenic, cadmium, copper, lead, mercury, nickel, selenium, silver, and zinc)	Water Based Mud	SW-846 Method 6020A/7470A and 7471B (mercury)	Two 1-liter polyethylene jars	Cool to 4°C	28 days for mercury and 6 months for all other metals
Total and dissolved cyanide		SW-846 Method 9014			14 days
Total and dissolved hexavalent chromium		SW-846 Method 7196A			24 hours - not to exceed 48 hours
PRODUCED WATER SAMPLES					
Dissolved metals (arsenic, cadmium, copper, lead, mercury, nickel, selenium, silver, and zinc)	Produced Water	SW-846 Method 6020A/7470A (mercury)	One 500-milliliter polyethylene bottle	Nitric acid to pH<2; cool to 4°C	28 days for mercury and 6 months for all other metals
Dissolved cyanide		SW-846 Method 9014	One 250-milliliter polyethylene bottle	Sodium hydroxide to pH>12; cool to 4°C	14 days
Dissolved hexavalent chromium		EPA Method 218.6	One 250-milliliter polyethylene bottle	Ammonium sulfate buffer solution; cool to 4°C	14 days

Notes:

[1] EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846), located at http://www.epa.gov/SW-846/sw846.htm
EPA Method 218.6: Determination of Dissolved Hexavalent Chromium in Drinking Water, Groundwater, and Industrial Wastewater Effluents by Ion Chromatography, located at http://www.wcaslab.com/tech/218_6.pdf

[2] For samples designated for matrix spike and matrix spike duplicate (MS/MSD) analysis, double volumes will be collected.

°C Degrees Celsius

< Less than

> Greater than

APPENDIX C

QUALITY ASSURANCE PROJECT PLAN

(Thirteen Pages)

QUALITY ASSURANCE PROJECT PLAN (SHORT FORM)

MUD AND PRODUCED WATER CHARACTERIZATION STUDY (MPWCS) TO MEET REQUIREMENTS OF THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT WESTERN AND CENTRAL GULF OF MEXICO OUTER CONTINENTAL SHELF (OCS) NPDES PERMIT No.: GMG290000

Prepared for

OFFSHORE OPERATORS COMMITTEE (OOC)
ENVIRONMENTAL SUBCOMMITTEE

Revision 01: March 2014

Date Prepared:	June 5, 2013
OOC Point of Contact:	Robert Kuehn
Telephone No.:	(504) 425-7693
Prepared by:	Tetra Tech, Inc.
Tetra Tech Project Manager :	June Mire, Ph.D.
Telephone No.:	(504) 273-9186

Prepared by Jessica Vickers Tetra Tech Chemist	Reviewed by Jim Collins Tetra Tech Task Manager	Reviewed by John Schendel Tetra Tech Quality Assurance Officer
	Approved by June Mire, Ph.D. Tetra Tech Project Manager	Approved by Min Huang OOC Analytical Subteam Lead

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ATTACHMENTS

Attachment

1 LABORATORY DETECTION LIMITS

QUALITY ASSURANCE PROJECT PLAN (SHORT FORM)
OFFSHORE OPERATORS COMMITTEE AND TETRA TECH, INC.

Project Name:	Mud and Produced Water Characterization Study (MPWCS) to Meet Requirements of the National Pollutant Discharge Elimination System (NPDES) Permit	**Location:** Western and Central Gulf of Mexico Outer Continental Shelf (OCS)	
Prepared By:	Tetra Tech, Inc. (Tetra Tech)	**Date:** June 24, 2013	
Approved By	June Mire **Date:** 06/24/13	**Approved By:** Jim Collins	**Date:** 6/24/13
Title:	Tetra Tech Project Manager	Title: **Tetra Tech Task Leader**	
Approved By:	Jessica Vickers **Date:** 06/24/13	**Approved By:** Robert Kuehn	**Date: 6/24/13**
Title:	Tetra Tech Chemist	**Title:** JIP Core Team Lead, Environmental Subcommittee	

1.0 PROJECT INFORMATION

1.1 Distribution List:

Environmental Protection Agency (EPA) Region 6: Isaac Chen Taimur Shaikh Offshore Operators Committee (OOC): Robert Kuehn Joe Smith Gail Korenaga Min Huang Kitty Kong Ileana Rhodes James Fajt Lowell McLeroy	Tetra Tech: June Mire Jim Collins Jessica Vickers Randy Bassett Len Nelms John Schendel

1.2 Project/Task Organization:

Robert Kuehn will serve as the OOC point of contact for the activities described in this quality assurance project plan (QAPP). June Mire of Tetra Tech will serve as the Tetra Tech project manager and is responsible for maintaining an approved version of this QAPP. Jessica Vickers of Tetra Tech will serve as the Tetra Tech project chemist and is responsible for providing Tetra Tech approval of this QAPP. Additional specific Tetra Tech personnel will be determined prior to initiation of the work described herein.

1.3 Problem Definition/Background:

Tetra Tech has been contracted to conduct a MPWCS to meet the requirements of NPDES Permit GMG290000 for the Western and Central Gulf of Mexico OCS area. The purpose of the MPWCS is to meet EPA permit requirements that include a characterization study of water based mud (WBM) and produced water (PW) for the express purpose of having "more area-specific data for future evaluations;" and to collect data to characterize representative discharges from wells in the OCS area.

1.4 Project/Task Description:

To achieve the objectives of the MPWCS, Tetra Tech will conduct activities for the MPWCS, including the following:

- Identify sample locations using a geographic information system and a hierarchical optimization system.
- Stratify produced water sample locations so the data set will be representative of overall offshore production.
- Collect samples to determine the soluble concentration of selected analytes in WBM and PW.

Table 1 in Appendix B of the Sampling and Analysis Plan (SAP) provides details regarding the numbers, types, analytical suite, and locations of all samples proposed. Analytical data will be used to characterize representative discharges from the wells within the OCS area.

1.5 Quality Objectives and Criteria for Measurement Data:

DQOs were established for the OCS to define the quantity and quality of the data to be collected to support the objectives of the MPWCS. DQOs were developed using the seven-step process outlined in the following EPA guidance documents: "EPA Requirements for Quality Assurance Project Plans," EPA QA/R-5, March 2001; "Guidance for Quality Assurance Project Plans," EPA QA/G-5; and "Guidance on Systematic Planning Using the Data Quality Objectives Process," EPA QA/G-4, February 2006.

Step 1: State the Problem	**Stakeholders:** EPA, the OOC, and the affected shoreline communities **Site History/Conceptual Site Model:** See Section 2.0 of the SAP to which this QAPP is appended. **Statement of Problem:** Sampling and laboratory analysis will be required to provide more up-to-date information for refinement of the NPDES permit, and to characterize representative discharges from the wells in the OCS area.
Step 2: Identify the Goals of the Study	**Study Questions:** Are dissolved phase contaminants of concern present in the WBM and PW at concentrations that exceed the comparison criteria? **Decision Statements:** Evaluate analytical data from WBM and PW samples to determine whether contaminant concentrations are present above the comparison criteria.
Step 3: Identify Information Inputs	**Inputs:** Analytical results for the WBM and PW samples that will be collected, as well as representative salinity information that will be provided by OOC members, for the sites sampled.
Step 4: Define Study Boundaries	**Spatial Boundary:** The OCS area is that part of the continental shelf seaward of the line that marks State ownership along the southern boundary of the United States. It extends along the coastline from Alabama to the Texas, a distance of approximately 630 miles, and extends more than 200 miles offshore (National Oceanic and Atmospheric Administration [NOAA], Google Earth). **Temporal Boundaries:** Sampling activities are scheduled to commence in Summer 2013. The temporal boundaries for sampling activities extend from when sampling activities are initiated until the OOC declares sampling activities complete.

Step 5: Develop the Analytical Approach	**Analytical Methods:** Table 4 included in Appendix B of the SAP provides details regarding the analytical methodology for the MPWCS activities, including sample containers, preservatives, and holding times. Samples will be analyzed by the ALS Group, Inc. (ALS) laboratory in Houston, Texas, the Tetra Tech-procured subcontract laboratory. The following list summarizes analytical methods that will be used: • Select dissolved and total metals (arsenic, cadmium, copper, lead, nickel, selenium, silver, and zinc) will be analyzed by EPA Test Methods for Evaluating Solid Waste, Fourth Edition, Including Updated, I through IVB, February 2007 (SW-846) Method 6020A. • Dissolved mercury will be analyzed by SW-846 Method 7470A; total mercury will be analyzed by Method 7471A (in WBM samples). • Dissolved cyanide will be analyzed by SW-846 Method 9014; total cyanide will be analyzed by Method 9014 (in WBM samples). • Dissolved hexavalent chromium will be analyzed by SW-846 7196A; total hexavalent chromium will be analyzed by Method SW 7196A (for WBM samples). • Dissolved hexavalent chromium will be analyzed by EPA Method 218.6 (for PW samples). The laboratory reporting limits for the analyses to be performed are listed in Attachment 1. **Comparison Criteria:** Analytical results will be compared with the EPA Ambient Water Quality Criteria for saltwater: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#appendxa **Decision Rules:** Analytical results will be provided to EPA for inclusion in a Reasonable Potential Analysis.
Step 6: Specify Performance or Acceptance Criteria	Tetra Tech will assess the analytical results for initial acceptance during a Stage 4 validation of the samples that will determine the usability of the data. Any rejected data and the reasons for rejection will be summarized in the data quality assessment report. See Attachment 2.
Step 7: Develop the Plan for Obtaining Data	**Optimized Design:** Table 1 in Appendix B of the SAP details the samples proposed for collection.

1.6 Special Training/Certification Requirements:

☐ OSHA 29 CFR 1910.0 ☐ Special Equipment/Instrument Operator (describe below): ☒ Other (describe below):

Special Requirements: The personnel who currently collect samples under the NPDES monitoring programs on the individual rigs and platforms selected for sampling will collect the WBM and PW samples. By having the platform personnel, who have already had all relevant training/certification required to work on the rig/platform, collect the samples, Tetra Tech will be able to avoid having to train additional personnel or procure subcontractors with the appropriate training. The personnel on the rigs/platforms will receive training on the sampling procedures via a training video that will be made available to them prior to sampling. The Sampling Procedures Reference Checklists (see Appendix A of the SAP) will be emailed to the platform personnel prior to sampling, and the Tetra Tech chemist will set up a pre-sampling conference with the operator to verify that the training video has been viewed and to review the procedures. If the platform personnel have access to a phone during sampling, the Tetra Tech chemist will be available to address any questions that may arise during sampling. If phone contact during sampling is not available, the platform personnel will call the Tetra Tech chemist as soon as reasonably possible after sampling to debrief on the sample collection.

1.7 Documentation and Records:

The most current version of this QAPP will be distributed to the entire distribution list presented in Section 1.1. The Tetra Tech project manager will be responsible for maintaining the most current revision of this QAPP and for distributing it to all personnel and parties involved in the field effort. Field records that may be generated include the following:

- ☒ Chain-of-Custody Forms
- ☐ Field Instrument Calibration Logs
- ☐ Field Monitoring and Screening Results
- ☐ Well Logs
- ☒ Sampling Procedure Reference Checklists
- ☐ Photographs
- ☐ Site Logbook
- ☐ Site Maps and Drawings

Field documentation and records will be generated and maintained in accordance with the requirements presented in the Sampling Procedures Reference Checklists, located in Appendix A of the SAP. All field-generated data will also be maintained in the project file and included, as appropriate, in project deliverables in final form after all reviews and applicable corrective actions.

Laboratory analytical data will be generated and maintained in accordance with the associated analytical methods. A 15-business day turnaround time will be requested for ALS to submit final results to Tetra Tech.

A summary of field activities, findings and laboratory analytical results will be included in the final MPWCS report. All project records under Tetra Tech's control will be maintained and retained in accordance with Section 4.0 of the Tetra Tech Quality Management Plan (QMP).

2.0 DATA GENERATION AND ACQUISITION

2.1 Sampling Process Design:

Table 1 in Appendix B of the SAP present details on the types and numbers of samples to be collected, sample locations, sample matrices, and laboratory analytical methods. The rationale for this sampling process design is based on the DQO process discussed in Section 1.5 of this QAPP. Samples will be submitted to ALS for analyses of selected dissolved metals, dissolved cyanide, and dissolved hexavalent chromium.

2.2 Sample Methods Requirements:

Matrix	Sampling Method	EPA and Tetra Tech Standard Operating Procedures and Guidance
WBM	Refer to Table 1 in Appendix B of the SAP for more details, including requested laboratory analyses and methods.	Refer to the Sampling Procedures Reference Checklists located in Appendix A of the SAP.
PW		

Other Sample Method Requirements: The Tetra Tech project manager, in coordination with the Tetra Tech chemist, will be responsible for identifying failures in sampling and field measurement systems, overseeing any corrective actions, ensuring that the corrective actions are documented in appropriate records, and assessing the effectiveness of corrective actions. Equipment required for this sampling in detailed in the Sampling Procedures Reference Checklists located in Appendix A of the SAP.

2.3 Sample Handling and Custody Requirements:

Sample handling and chain-of-custody record keeping will be conducted in accordance with the Sampling Procedures Reference Sheets, located in Appendix A of the SAP. Once collected, samples will be placed on ice and kept in a custody-sealed cooler until the cooler can be transported to shore and shipped to ALS. The Tetra Tech chemist will coordinate with the sampling personnel on the rigs/platforms to ensure that custody of samples is maintained until they are shipped to the laboratory. Close coordination with the sampling personnel will focus on delivering WBM samples to the lab within the allowable 48-hr holding time for dissolved hexavalent chromium. Chain-of-custody records will be used to document the samples collected and delivered to the laboratory.

2.4 Analytical Method Requirements:

The analytical parameters and associated laboratory analytical methods that will be used for this project are listed in Table 1 of Appendix B of the SAP.

A 15-business day turnaround time will be requested for ALS to submit final results to Tetra Tech. Data validation of the analytical data packages will be conducted by Tetra Tech. A Stage 4 data validation will be conducted in accordance with the EPA National Functional Guidelines (NFGs) for Inorganic Superfund Data Review, EPA540-R-10-011, January 2010; as well as the associated analytical methods. Laboratory instruments required for sample analyses are contained in the associated methods.

The data packages will be reviewed to determine whether any data should be rejected and whether any data qualifiers assigned during the validation process affect the usability of the data as defined in Section 1.5 of this QAPP.

2.5 Quality Control Requirements:

QC requirements for laboratory analyses are presented in the EPA NFGs for Inorganic Superfund Data Review, EPA540-R-10-011, January 2010; as well as the associated analytical methods. Method detection limits and reporting limits are included in Attachment 1.

Laboratory and QC samples will include the collection of matrix spike and matrix spike duplicate (MS/MSD) sample sets at a frequency of one MS/MSD set for every 20 samples per medium collected. Field QC samples will include field duplicate samples collected at a frequency of one field duplicate sample for every 20 samples per medium collected. QC samples will be submitted for analyses listed in Table 2 of Appendix B of the SAP.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements:

Laboratory instrument testing, inspection, and maintenance requirements are contained in the associated analytical methods; as well as in the associated manufacturer's operating manuals.

2.7 Instrument Calibration and Frequency:

Instrument calibration and frequency requirements for analytical methods are specified in EPA NFGs for Inorganic Superfund Data Review, EPA540-R-10-011, January 2010; as well as the associated analytical methods.

2.8 Inspection/Acceptance Requirements for Supplies and Consumables:

Supplies and consumables required for this sampling event will be inspected and accepted by the Tetra Tech chemist or designated team member, and the items listed in the Sampling Procedures Reference Checklists, located in Appendix A of the SAP. All sample containers will meet EPA criteria for cleaning procedures for low-level chemical analysis. Sample containers will have certifications provided by the manufacturer in accordance with pre-cleaning criteria established by EPA.

2.9 Non-Direct Measurement Requirements:

Information pertaining to the site (including photographs, maps, and so forth) has been compiled from file information obtained from EPA, NOAA, Google Earth, and the OOC. The extent to which these data and information, if any, are used to achieve the objectives of this project will be determined by Tetra Tech in cooperation with the OOC. Any justifications and qualifications required for the use of these data and information will be provided in the reports generated for this project.

2.10 Data Management:

All reference materials generated during this study and included in the final MPWCS report will be submitted to EPA in portable document format on compact disc. All field-generated data will be managed as part of the permanent field record for the project. All laboratory analytical data will be managed in accordance with the requirements of the associated analytical methods; as well as applicable federal regulations. Finally, all field-generated data and other records generated or obtained during this project will be managed according to the requirements of Section 5.0 of the Tetra Tech QMP.

3.0 ASSESSMENT AND OVERSIGHT

3.1 Assessment and Response Actions:

A laboratory audit may be performed for the analyses that ALS will be performing for this project. This audit will be performed by the Tetra Tech chemist, Jessica Vickers, or appropriate designee. All deliverables that Tetra Tech contributes to in whole or in part, including the final MPWCS report, will be subjected to the corporate three-tiered review process, which includes a technical review, an editorial review, and a QC review, with each reviewer signing off on a QC review sheet when any issues or revisions have been addressed. These audits and reviews will be performed by qualified individuals in accordance with the requirements of Section 9.0 of the Tetra Tech QMP.

3.2 Corrective Action:

The Tetra Tech project manager, in coordination with the Tetra Tech chemist, will be responsible for identifying failures in sampling and field measurement systems, overseeing any corrective actions, ensuring that the corrective actions are documented in appropriate records, and assessing the effectiveness of corrective actions. Corrective action requirements for analytical methods are presented in the associated analytical methods, as well as Section 9.4 of the Tetra Tech QMP.

3.3 Reports to Management:

All formal deliverables to EPA associated with this project will be prepared, reviewed, and distributed in accordance with the requirements of the Section 9.4 of the Tetra Tech QMP, and under the supervision of the Tetra Tech chemist, Jessica Vickers, or appropriate designee.

4.0 DATA VALIDATION AND USABILITY

4.1 Data Review, Verification, and Validation Requirements:

All field-generated data and records (such as the sampling procedures checklists) will be reviewed for completeness and accuracy by the Tetra Tech chemist. These records will be reviewed upon completion of the sampling so that corrective actions, if necessary, can be made prior to transporting the samples to shore.

Data validation of the analytical data packages will be conducted by Tetra Tech. A Stage 4 data validation will be conducted in accordance with the EPA NFGs for Inorganic Superfund Data Review, EPA540-R-10/011, January 2010; as well as the associated analytical methods. The data packages will also be reviewed to determine whether any data are rejected and whether any data qualifiers assigned during the validation process affect the usability of the data as defined in Section 1.5 of this QAPP.

4.2 Verification and Validation Methods:

All field-generated data will be maintained in the project file and included (as appropriate) in project deliverables in final form after all reviews and associated corrective actions. The laboratory analytical data will be validated by Tetra Tech in accordance with the analytical data validation methods provided in the EPA NFGs for Inorganic Superfund Data Review, EPA540-R-10-011, January 2010; as well as the associated analytical methods. The validated analytical data packages will contain a summary of all data qualifier flags and their explanations.

4.3 Reconciliation of the Data to the Project-Specific DQOs:

The Tetra Tech project manager, in cooperation with the OOC, EPA, and the Tetra Tech chemist, will be responsible for reconciling the data and other project results with the requirements specified in this QAPP and by the data users and decision makers. Ultimate acceptance of the data is at the discretion of the EPA and the OOC. Depending on how specific data quality indicators do not meet the project's requirements, the data may be discarded, and resampling and reanalysis of the subject samples may be required. Resampling, reanalysis, or other out-of-scope actions identified to address data quality deficiencies and data gaps will require approval by the EPA and the OOC.

Limitations of the data and data rejection and qualification will be identified during the validation process conducted by Tetra Tech. The data will be reviewed to determine whether any data are rejected and whether any data qualifiers or limitations assigned during the validation process affect the usability of the data as defined in Section 1.5 of this QAPP. All final laboratory data packages will be reviewed to evaluate whether the site-specific DQOs, as defined in Section 1.5 of this QAPP, are met. The data will be reconciled with the project-specific DQOs also in accordance with EPA guidance documents, including "Guidance on Systematic Planning Using the Data Quality Objectives Process," EPA QA/G-4, February 2006.

ATTACHMENT 1

LABORATORY DETECTION LIMITS

(One Page)

LABORATORY DETECTION LIMITS

ANALYTE (WBM aqueous phase and PW)	METHOD	METHOD DETECTION LIMIT (mg/L)	REPORTING LIMIT (mg/L)[1]	Saltwater Chronic AWQC (mg/L)	Saltwater Acute AWQC (mg/L)
Dissolved arsenic	SW-846 6020A	0.001	0.005	0.036	0.069
Dissolved cadmium	SW-846 6020A	0.0008	0.002	0.0088	0.04
Dissolved copper	SW-846 6020A	0.001	0.005	0.0031	0.0048
Dissolved lead	SW-846 6020A	0.0007	0.005	0.0081	0.21
Dissolved nickel	SW-846 6020A	0.001	0.005	0.0082	0.074
Dissolved selenium	SW-846 6020A	0.001	0.005	nd	nd
Dissolved silver	SW-846 6020A	0.0008	0.005	nd	0.0019
Dissolved zinc	SW-846 6020A	0.0025	0.005	0.081	0.09
Dissolved mercury	SW-846 7470A	0.000042	0.0002	0.00094	0.0018
Dissolved cyanide[2]	SW-846 9014	0.003	0.02	0.001	0.001
Dissolved hexavalent chromium (WBM)	SW-846 7196A	0.006	0.01	0.05	1.1
Dissolved hexavalent chromium (PW)	EPA 218.6	0.003	0.01	0.05	1.1

ANALYTE (WBM solid phase)	METHOD	METHOD DETECTION LIMIT (mg/kg)	REPORTING LIMIT (mg/kg)[1]
Total arsenic	SW-846 6020A	0.1	0.5
Total cadmium	SW-846 6020A	0.05	0.5
Total copper	SW-846 6020A	0.1	0.5
Total lead	SW-846 6020A	0.05	0.5
Total nickel	SW-846 6020A	0.09	0.5
Totalselenium	SW-846 6020A	0.18	0.5
Total silver	SW-846 6020A	0.08	0.5
Total zinc	SW-846 6020A	0.25	0.5
Total mercury	SW-846 7471B	0.00047	0.003325
Total cyanide	SW-846 9014	0.6	2
Total hexavalent chromium	SW-846 7196A	0.7	2

SW-846 — EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods
PW — Produced Water
WBM — Water based mud

ATTACHMENT 2

PERFORMANCE OR ACCEPTANCE CRITERIA

(One Page)

PERFORMANCE OR ACCEPTANCE CRITERIA

DATA QUALITY MEASUREMENTS	
Accuracy	Refer to the Sampling Procedures Reference Checklists in Appendix A of the SAP; SW-846 Methods 6020A, 7470A, 7471A, 7196A, and 9014; EPA Method 218.6; and the EPA NFGs.
Precision	Refer to the Sampling Procedures Reference Checklists in Appendix A of the SAP; SW-846 Methods 6020A, 7470A, 7471A, 7196A, and 9014; EPA Method 218.6; and the EPA NFGs.
Representativeness	Refer to the Sampling Procedures Reference Checklists in Appendix A of the SAP.
Completeness	As discussed in Section 3.0 of the SAP, water based mud and produced water samples are scheduled for collection. The Tetra Tech project manager and Tetra Tech chemist are responsible for determining if the laboratory data collected achieve the level of completeness required to meet the objectives of the project.
Comparability	Sample and data comparability is expected to be achieved by conducting all field and laboratory work using the same, well-documented, and uniform procedures.

Notes:

EPA	Environmental Protection Agency
EPA Method 218.6	Determination of Dissolved Hexavalent Chromium in Drinking Water, Groundwater, and Industrial Wastewater Effluents by Ion Chromatography, located at http://www.wcaslab.com/tech/218_6.pdf
EPA NFGs	EPA National Functional Guidelines for Inorganic Superfund Data Review, EPA540-R-10/011, January 2010
SAP	Sampling and Analysis Plan
SW-846	EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846), located at http://www.epa.gov/SW-846/sw846.htm

APPENDIX D

WATER BASED MUD CHARACTERIZATION

(Seven Pages)

SAP Appendix D

Alternate Approach for Characterizing Dissolved Metals (Including Cyanide) in Water Based Mud

EXECUTIVE SUMMARY

All drilling mud samples collected to date are clearly characterized as water based mud, but some samples do not yield adequate water to perform the required analyses for dissolved metals and cyanide. Attempts to dilute the drilling mud and then extract water have raised concerns about the interpretation of the results. The use of alternate methods for separating more water from the water based mud has been studied and rejected. A discussion of the issues with US EPA Region 6 supported a revision of the SAP/QAPP to perform analysis of total metals, hexavalent chromium, and cyanide in each water based mud sample. Samples that yield enough water will be analyzed for dissolved constituents also, on a priority basis.

D.1 FUNCTION OF WBM IN DRILLING

Water based drilling muds (also called drilling fluids) are specifically blended to improve safety and yield during drilling while minimizing adverse environmental effects upon discharge. The mud must simultaneously cool, lubricate, and support the weight of the drilling apparatus; stabilize the borehole walls; block movement of mud laterally out of the borehole; balance pressure from the formation; suspend cuttings during drilling; and ultimately carry cuttings out of the borehole (Neff 2010). Water based mud is used during variable stages of drilling wells in the Gulf of Mexico (BOEM 2014).

D.2 PHYSICAL CHARACTERISTICS AND CHEMICAL COMPOSITION OF WATER BASED MUD

Water based drilling mud differs from other types of drilling muds that have oil or synthetic fluids as their base. Each water based mud is developed by adding a variety of ingredients to an aqueous base fluid that may be freshwater, marine water, or concentrated brine.

D.3. INTENTIONAL LACK OF FREE WATER IN WBM

The physical and chemical properties of additives that promote water retention and increase viscosity of water based mud also make it difficult to extract water from the muds. In general, it has been more difficult to separate water from heavier water based muds that are necessary for drilling deeper sections of a well. The proposed modifications to the sampling and analysis protocols were developed in response to samples that were difficult to separate by centrifugation, but will be applied to the remainder of the water based mud samples collected for this study.

D.4 EXTRACTION PROCESSES

The permit requires that operators measure dissolved metals, hexavalent chromium, and cyanide concentrations in water based mud. These analyses require the following steps: (1) extraction of an aqueous phase out of the water based mud; (2) filtration of the aqueous phase; and (3) analysis of the filtrate. Determinations of metals, hexavalent chromium, and cyanide each require a 50-mL aliquot of aqueous sample.

D.4.1 Centrifugation of Whole WBM Sample

As described in the SAP presented to and approved by EPA on July 8, 2013, water based mud samples are centrifuged in the laboratory to extract an aqueous sample for analysis. To date, the laboratory has received and analyzed 31 water based mud samples. About one-third of the water based mud samples yielded an adequate volume of water when centrifuged. Another one-third of the samples required 2x to 5x dilution with deionized water prior to centrifugation before yielding adequate water volume. The final one-third of the water based mud samples required 10x to 40x dilution with deionized water. All samples were soluble in deionized water and eventually yielded adequate water volume when centrifuged, indicating that they met the definition of water based drilling fluid. However, extensive dilution of the water based mud samples has the undesirable consequence of increasing the reporting limits of the analysis, leading to frequent non-detect results above the corresponding screening criteria. Furthermore, it is not known whether dilution of the water based mud sample with deionized water alters the relative dissolved metals concentrations in the extracted water sample.

D.4.2 Confounding Effects of Centrifugation of WBM after Dilution with Deionized Water

Dilution of the water based mud samples has the undesirable consequence of increasing the reporting limits of the analysis relative to undiluted samples, leading to more frequent non-detect results. The nature of the analysis makes it difficult to overcome this unfortunate confounding feature of dilution.

A second difficulty with the dilution approach is that it is not known whether dilution of the water based mud sample with deionized water alters the relative dissolved metals concentrations in the extracted water sample. To explore this, OOC compared the results of undiluted with diluted extracts from a WBM sample that did yield adequate extract water without dilution: the results showed no consistent pattern or trend across analytes. It could be that dilution with deionized water releases additional metals into the aqueous phase. Conversely, concentrations of some metals may be unaffected by the dilution. More than likely, not all metals respond alike. Furthermore, the complex chemical interactions occurring among the numerous additives in each water based mud sample makes it difficult to examine any potential correlations. Fundamental physio-chemical parameters such as pH, sulfide content, suspended solids, viscosity, redox state, and other characteristics vary among water based mud samples. All of these parameters can influence the solubility of an individual metal and its relative concentration in the aqueous extract.

D.4.3. Filter Press: Considered and Rejected

In an attempt to eliminate some of the confounding variables inherent in the dilution approach, the OOC Characterization Study Team investigated using a filter press to extract water from water based mud samples. Mud engineers routinely use a multi-unit filter press (such as the one manufactured by OFI Testing Equipment, Inc. (http://www.ofite.com/products/140-40.asp) to separate aqueous samples from water based mud. The filter press exerts 100 pounds per square inch (psi) of pressure to the mud sample, literally squeezing the water based mud so that even firm gel structures are broken down and water is released. Although this technique has some appealing features, the OOC Characterization Study Team ultimately rejected the approach for the reasons presented below.

The filter press presents the same problem mentioned above for the dilution approach in that it may actually force more metals into the extract than would normally be in the aqueous phase. Because the filter press is not a EPA standardized method for extracting water from water based mud, or even from sediment, a separate validation study would have to be conducted to provide an interpretive context for the results. Moreover, the filter press equipment poses logistical difficulties for quality control. The individual cells and collecting vessels would have to be thoroughly decontaminated between samples. In addition, the filter press does not work quickly; it could take several hours to extract enough water for a single set of analyses. A very large volume of water based mud (about 3 gallons) would have to be collected and pressed, creating a storage and disposal problem for the laboratory. Finally, the filter presses are custom-built to order, and the manufacturer has a waiting period of several weeks. For these reasons, the OOC Characterization Study Team determined that switching the extraction method to the filter press is not technically sound.

D.4.4 Revised Approach to Determining Dissolved Metals in Water Based Mud

Based on a meeting with EPA Region 6 personnel on February 25, 2014, the OOC has revised the approach to determining concentrations of dissolved metals in water based mud using standard EPA methods of digestion and analysis for evaluating effluent (see Attachment D-1). OOC will analyze total constituents in water based mud samples using the EPA SW-846 methods listed below:

Analytes	Method	Prep	Equipment	Citation
As, Cd, Cu, Pb, Ni, Se, Ag, Zn	SW6020	SW3050A	ICP-MS	http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/6020a.pdf
Hg	SW7471B	SW7471A	cold-vapor atomic absorption	http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/7471b.pdf
CN-	SW9014	SW9010C	titrimetric and manual spectrophotometric	http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/9014.pdf
Cr6+	SW7196 A	SW3060A	colorimetric	http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/7196a.pdf

In addition to the analysis of total constituents, WBM samples will be centrifuged and the resulting aqueous sample (if any) will be analyzed for dissolved constituents to the extent practicable. Methods for analyzing dissolved constituents are in Section 5.0 of the SAP. The concentrations of dissolved components may help determine a correlation between dissolved and total concentrations in the drilling mud. If the WBM sample does not yield enough water to analyze all of the metals listed above, the lab will analyze as many metals as possible on each sample, in the following order of priority: metals, hexavalent chromium, cyanide.

Cyanide has been assigned the lowest relative priority because water based drilling muds do not contain any known source of cyanide. Interviews with several mud engineers and experts in the field confirmed that none of the ingredients permitted for addition to water based mud contain cyanide or chemicals that could degrade to cyanide (Dr. Jerry Neff, personal communication). Cyanide is unlikely to occur naturally in offshore marine sediments or drill cuttings. One exception is organically-enriched low-oxygen sediments (and presumably cuttings) in salt marsh environments (Kamyshny et al., 2013 and references within). It is reported that plants, fungi and bacteria rapidly degrade cyanide

in the marine environment; most cyanide in oceanic waters originates from burning of biomass in terrestrial settings (Kamyshny et al., 2013 and references within). In short, no association of cyanide with drilling muds was found in the published literature.

D.4 Summary

All drilling mud samples collected to date are clearly characterized as water based mud, but many of the samples do not yield adequate water to perform the required analyses for dissolved metals. The initial approach of diluting the water based mud to increase the yield of centrifuged water has raised some concerns and caused the OOC Characterization Study Team to consider a more robust plan for obtaining the data required by the permit. The dilution step of the procedure is being eliminated out of concern that the dilution process may not yield meaningful results due to elevated reporting limits and variability among proprietary recipes of WBM. The use of a filter press was considered and rejected because of numerous concerns about method standardization, decontamination, and other logistical issues. Therefore, as agreed with US EPA in a meeting 2/15/14, this revised SAP/QAPP will analyze total metals, hexavalent chromium, and cyanide in water based mud samples. In cases where adequate volume of water can be obtained from the water based mud samples by centrifugation, dissolved constituents will be analyzed in order of priority: (1) metals; (2) hexavalent chromium; (3) cyanide.

D.4 References

Boehm, P., D. Turton, A. Raval, D. Caudle, D. French, N. Rabalais, R. Spies, and J. Johnson. 2001. Deepwater Program: Literature Review, Environmental Risks of Chemical Products Used in Gulf of Mexico Deepwater Oil and Gas Operations. New Orleans, LA. I: Technical Report: 325.

Bureau of Ocean Energy Management (BOEM). 2014. "Questions, Answers, and Related Resources." Retrieved January 27, 2014, from http://www.boem.gov/Environmental-Stewardship/Environmental-Assessment/CWA/Offshore-Discharges-From-Oil-and-Gas-Development-Operations---FAQ.aspx.

Kamyshny, A., Jr., H. Oduro, et al. (2013). "Hydrogen Cyanide Accumulation and Transformations in Non-polluted Salt Marsh Sediments." Aquatic Geochemistry 19(2): 97-113.

Neff, J.M. 2010. Fate and Effects of Water Based drilling Muds and Cuttings in Cold Water Environments. Report to Shell Exploration and Production Company, Houston, Texas. May 25, 2010. 287 pp.

U.S. EPA. 2012. Final NPDES General Permit for New and Existing Sources and New Dischargers in the Offshore Subcategory of the Oil and Gas Extraction Category for the Western Portion of the Outer Continental Shelf of the Gulf of Mexico (GMG290000). 77 *Federal Register* No. 196 [October 10, 2012: 61605 – 61606].

ATTACHMENT D-1

NOTES ON THE TELECONFERENCE WITH EPA REGION VI

FEBRUARY 25, 2014

(2 Pages)

A teleconference was held on February 25, 2014 to discuss an alteration in the study plan for the Water Based Mud and Produced Water Characterization Study (the "Study")being carried out by a group of Gulf of Mexico operators to meet their requirements for water based drilling fluid and produced water characterization under NPDES Permit GMG290000. The participants in the call were Taimur Sheikh and Isaac Chen (EPA Region 6), Joseph Smith (ExxonMobil Upstream Research Company, representing the Study participants, June Mire and Len Nelms (both of Tetra Tech Inc., contractor for the Study).

Background

NPDES Permit GMG290000 requires analysis of the dissolved concentrations of certain components in water based drilling mud. It has proved to be difficult to get an adequate volume of water from water based drilling mud for analysis of soluble components. This difficulty arises because the muds are formulated to be stable suspensions and to resist filtration so that they can have the desired operational properties.

The study participants and Tetra Tech asked to have a discussion of possible solutions to this problem with EPA Region 6 so that EPA would be informed of the need to change the original study plan.

Discussion Notes

The study participants and Tetra Tech have considered analyzing the total concentrations of the target analytes in drilling mud (as opposed to the dissolved concentrations) as well as diluting the mud with deionized water or artificial seawater to facilitate obtaining a sample of the dissolved phase of the drilling mud. EPA Region 6 expressed a preference for avoiding dilution. The group acknowledged uncertainties associated with developing equilibrium coefficients for such a large set of variable drilling mud formulations.

It was agreed that the total concentrations of target analytes in drilling mud would be determined using SW 6020. In cases where sufficient water can be extracted from the drilling mud without dilution, the concentrations of dissolved components will be determined to help understand the correlation between dissolved and total concentrations in the drilling mud.

Determination of dissolved concentrations requires separate analyses for metals, hexavalent chromium, and cyanide. It was agreed that in situations where water could be extracted from drilling mud, the water would be used to determine concentrations of hexavalent chromium first, then metals. Cyanide will not be analyzed. The group discussed the wisdom of changing from drilling mud, the water would be used to determine concentrations of hexavalent chromium first,

then metals. Cyanide will not be analyzed. The group discussed the wisdom of changing analytical methods to use instruments that require less water volume, such as gas furnace atomic absorption spectroscopy, but determined that such a change was not warranted.

The occurrence of cyanide in drilling fluid is considered highly unlikely. EPA requested that the operators provide them with information on the use of materials containing cyanide in water based drilling mud.

It was agreed that the results of samples already analyzed using dilution with deionized water would be reported to EPA as a separate data set. Any available residual samples of previously analyzed drilling muds will be subjected to a determination of total concentrations of metals if sufficient sample volume is available.

Follow Up After the Teleconference

Follow up conversations with drilling fluid suppliers and a brief search of the literature supported the view that the occurrence of cyanide in drilling fluids was highly unlikely. Discussions with drilling fluid suppliers indicated that materials with cyanide are not deliberately added to drilling fluids. A brief search of the literature failed to turn up any studies that showed the presence of cyanide in drilling fluids.

TETRA TECH

May 24, 2013

By electronic mail to: ***Robert.Kuehn@shell.com***

Re: Minutes
Tetra Tech Teleconference with EPA Region 6
May 23, 2013

Mud and Produced Water Characterization Study to Meet Requirements of the NPDES Permit for the Western and Central Gulf of Mexico Outer Continental Shelf (GMG 290000)

Dear Mr. Kuehn:

The attached minutes reflect the general discussion and decisions made during the teleconference but are not a verbatim record of the meeting. Please let me know if you have any comments or questions about these minutes, or if you prefer another format (office: 504-834-6276; cell: 504 273-9186; june.mire@tetratech.com).

June B. Mire, Ph.D.
Project Manager

Attachment

TETRA TECH

Participants:

EPA Region 6	Tetra Tech
Isaac Chen	June Mire
Taimur Shaikh	Jessica Vickers
	Alberto Tohmé
	Jim Collins
	Randy Bassett

Agreements and Decisions

Holding Time for Unfiltered Produced Water Sample

Samples of produced water will be collected on the rig platform by operator personnel according to approved EPA procedures and sent to the lab for filtration. EPA agrees that an elapsed time of 48 hours from time of produced water collection to stabilization of the filtered sample in the lab would not require any qualification of the results for dissolved hexavalent chromium. Any produced water sample that was not filtered and stabilized within 48 hours of collection would be discarded. As a back-up plan for obtaining analytical results for samples that exceed the 48-hr holding time (due to unforeseen delays), Tetra Tech is considering collecting a second sample of produced water in a container preserved with a buffer solution that would extend the holding time to 14 days (for total hexavalent chromium, using EPA Method 218.7). In the unfortunate event that the holding time on the unpreserved sample expires before it can be filtered and stabilized, the preserved sample would be analyzed for total rather than dissolved hexavalent chromium. Both EPA and Tetra Tech are conducting literature reviews to develop a reasonable approach to interpreting any results on total hexavalent chromium with respect to national ambient water quality criteria.

If the OOC wants to explore the option of exceeding the 48-hour holding time for dissolved hexavalent chromium, EPA would like to see justification in the form of a literature review or a separate study using split samples to demonstrate the effect of various holding times on dissolved hexavalent chromium concentrations.

Holding Time for Water Based Mud (WBM)

Samples of WBM will be collected and sent to the lab for centrifugation and analysis of the extracted aqueous portion. EPA agrees that an elapsed time of 48 hours from time of WMB collection to stabilization of the aqueous sample in the lab would not require any qualification of the results for hexavalent chromium.

Piggybacking on the Suspended Particulate Phase of the WBM Sample Used for Monthly Toxicity Testing

The purpose of the characterization study is to provide data that EPA will use to prepare a Reasonable Potential analysis, which is based on water quality criteria for dissolved metals. The samples used for toxicity testing are not filtered and are not representative of the WBM or produced water samples to be used for the Reasonable Potential analysis. Therefore, EPA stated that the samples used for toxicity testing are not suitable for the characterization study.

Action Items

Tetra Tech and EPA will each conduct a brief literature review on the effect of holding times of dissolved hexavalent chromium concentrations in produced water (or sea water). We will also search for information on the relationship between dissolved and total hexavalent chromium in produced water (or sea water).

At Tetra Tech's request, EPA agreed to review the draft sampling and analysis plan prior to the OOC initiating any sampling. However, EPA emphasized that the OOC is not required to wait for EPA approval before initiating sampling.

Summary of February 25 Teleconference on the Mud and Produced Water Characterization Study Being Carried out for NPDES Permit GMG290000

A teleconference was held on February 25, 2014 to discuss an alteration in the study plan for the Water Based Mud and Produced Water Characterization Study (the "Study")being carried out by a group of Gulf of Mexico operators to meet their requirements for water based drilling fluid and produced water characterization under NPDES Permit GMG290000. The participants in the call were Taimur Sheikh and Isaac Chen (EPA Region 6), Joseph Smith (ExxonMobil Upstream Research Company, representing the Study participants, June Mire and Len Nelms (both of Tetra Tech Inc., contractor for the Study).

Background

NPDES Permit GMG290000 requires analysis of the dissolved concentrations of certain components in water based drilling mud. It has proved to be difficult to get an adequate volume of water from water based drilling mud for analysis of soluble components. This difficulty arises because the muds are formulated to be stable suspensions and to resist filtration so that they can have the desired operational properties.

The study participants and Tetra Tech asked to have a discussion of possible solutions to this problem with EPA Region 6 so that EPA would be informed of the need to change the original study plan.

Discussion Notes

The study participants and Tetra Tech have considered analyzing the total concentrations of the target analytes in drilling mud (as opposed to the dissolved concentrations) as well as diluting the mud with deionized water or artificial seawater to facilitate obtaining a sample of the dissolved phase of the drilling mud. EPA Region 6 expressed a preference for avoiding dilution. The group acknowledged uncertainties associated with developing equilibrium coefficients for such a large set of variable drilling mud formulations.

It was agreed that the total concentrations of target analytes in drilling mud would be determined using SW 6020. In cases where sufficient water can be extracted from the drilling mud without dilution, the concentrations of dissolved components will be determined to help understand the correlation between dissolved and total concentrations in the drilling mud.

Determination of dissolved concentrations requires separate analyses for metals, hexavalent chromium, and cyanide. It was agreed that in situations where water could be extracted from drilling mud, the water would be used to determine concentrations of hexavalent chromium first, then metals. Cyanide will not be analyzed. The group discussed the wisdom of changing analytical methods to use instruments that require less water volume, such as gas furnace atomic absorption spectroscopy, but determined that such a change was not warranted.

The occurrence of cyanide in drilling fluid is considered highly unlikely. EPA requested that the operators provide them with information on the use of materials containing cyanide in water based drilling mud.

It was agreed that the results of samples already analyzed using dilution with deionized water would be reported to EPA as a separate data set. Any available residual samples of previously analyzed drilling muds will be subjected to a determination of total concentrations of metals if sufficient sample volume is available.

Follow Up After the Teleconference

Follow up conversations with drilling fluid suppliers and a brief search of the literature supported the view that the occurrence of cyanide in drilling fluids was highly unlikely. Discussions with drilling fluid suppliers indicated that materials with cyanide are not deliberately added to drilling fluids. A brief search of the literature failed to turn up any studies that showed the presence of cyanide in drilling fluids.

May 21, 2014

By electronic mail to: chen.isaac@epa.gov; shaikh.taimur@epa.gov

Re: Comparison of Produced Water Samples Preserved in the Field and in the Lab: Joint Industry Project (JIP) Mud and Produced Water Characterization Study to Meet Requirements of the NPDES Permit for the Western and Central Gulf of Mexico Outer Continental Shelf (GMG 290000)

Dear Mr. Chen and Dr. Taimur:

On behalf of the Offshore Operators Committee, we are submitting this evaluation of the results of dissolved constituent analysis of produced water samples filtered and preserved on site compared with results for samples filtered and preserved in the laboratory. This letter report details the findings of this comparison evaluation, as well as our recommendation to discontinue the on-site filtration and preservation of the samples.

BACKGROUND

As discussed in the Sampling and Analysis Plan and Quality Assurance Project Plan (SAP/QAPP), Revision 01, the produced water samples have been filtered on-site using a peristaltic pump and collected in pre-preserved containers. Samples have been preserved in the field to address concerns that the concentration of hexavalent chromium may differ between samples preserved in the field and samples preserved in the laboratory. The analytical method requires that filtration occur prior to adding preservative. Therefore, samples were filtered in the field. The filtering has been performed on-site in an effort to extend the holding time for hexavalent chromium to accommodate logistical challenges in transporting samples from offshore platforms to the laboratory.

The numerous challenges of field-filtering water samples across the offshore operations led the OOC to investigate the differences in analytical results in field-preserved and lab-preserved produced water samples. No correlational data for field-preserved versus lab-preserved dissolved metals, hexavalent chromium, or cyanide could be located in the literature. Therefore, we conducted a split-sample study to compare these two types of sample preparation for produced water. At the randomly selected 21 discharges included in the study, two identical produced water samples were collected. One sample of each pair was filtered and preserved as described in the SAP/QAPP. The other sample was collected into an unpreserved container without being filtered. The unfiltered/unpreserved samples were filtered and preserved when they were received at the laboratory. All samples were then analyzed for the dissolved phase of the analytes of concern for this study – arsenic, cadmium, copper, cyanide, hexavalent chromium, lead, mercury, nickel, selenium, silver, and zinc.

OVERALL ASSESSMENT OF COMPARISON DATA

Concentrations of dissolved metals in field-preserved and lab-preserved sample pairs were compared. For all detected analytes, the relative percent difference (RPD) in concentration of each pair was calculated. The criteria used for comparison was a RPD of greater than 20 percent for results greater than highest reporting limit. These criteria are discussed in the EPA Contract Laboratory Program (CLP) National Functional Guidelines (NFG) for Inorganic Superfund Data Review (January 2010)[1]. Note that the

[1] http://www.epa.gov/superfund/programs/clp/guidance.htm

criteria in the EPA CLP NFG (2010) were developed for evaluating duplicate/replicate values from a single sample location

We analyzed 21 pairs of produced water samples for the following dissolved constituents: arsenic, cadmium, copper, lead, nickel, selenium, silver, zinc, hexavalent chromium, mercury, and cyanide. The most frequently detected metal was zinc, which was detected in 11 of the 21 samples. Lead was detected in one sample. Arsenic was detected in one sample and estimated in another sample. Cadmium, copper, nickel, selenium, silver, hexavalent chromium, mercury, and cyanide were not detected in any sample (Enclosure 1).

In general, except for a two pairs, the two types of sample preparation were within acceptance criteria. The overall concentrations of dissolved metals in this preliminary dataset indicate that none of the produced water samples would exceed the recommended Ambient Water Quality Criteria after post-discharge mixing is accounted for. These observations suggest that filtering and preserving the samples in the field is not warranted. Because of the logistical difficulties posed by filtering and preserving samples in the field (including shipment and maintenance of peristaltic pumps), Tetra Tech requests EPA's concurrence in our recommendation to discontinue on-site filtration and preservation of produced water samples. Samples would be filtered and preserved when received by the lab.

Please contact June Mire at (504) 834-6276 or Jessica Vickers at (662) 681-5727 if you have any questions or comments on this recommendation. We look forward to discussing these results with you.

Sincerely,

June B. Mire, Ph.D.
Project Manager
june.mire@tetratech.com

Jessica A. Vickers
Laboratory/Analytical/Data Quality Leader
jessica.vickers@tetratech.com

Enclosure

cc: OOC Core Team

ENCLOSURE 1

COMPARISON OF SPLIT SAMPLE RESULTS
PRODUCED WATER SAMPLING
DETECTED RESULTS ONLY
2013 - 2014

(One Page)

TETRA TECH

Analyte[1]	Sample Preparation		Relative Percent Difference
	Field Preserved Result (mg/L)	Lab Preserved Result (mg/L)	
Dissolved arsenic	**0.0614**	**0.00753**	**156**
	ND	ND	NC
	ND	ND	NC
	ND	ND	NC
Dissolved lead	1.86	1.67	10.8
Dissolved selenium	ND	ND	NC
	ND	ND	NC
	ND	ND	NC
	ND	ND	NC
	0.00570	ND	NC
	ND	ND	NC
Dissolved zinc	**0.00857**	**0.0152**	**55.8**
	0.0163	0.0147	10.3
	0.00982	0.0106	7.6
	12.7	11.9	6.5
	0.336	0.355	5.5
	0.116	0.122	5.0
	0.0495	0.0510	3.0
	0.280	0.273	2.5
	14.6	14.8	1.4
	0.529	0.529	0.0
	ND	ND	NC
	ND	ND	NC
	0.266	ND	NC
	ND	ND	NC
	ND	ND	NC
	ND	ND	NC

1 21 pairs of produced water samples were analyzed for dissolved arsenic, cadmium, copper, lead, nickel, selenium, silver, zinc, hexavalent chromium, mercury, and cyanide. Cadmium, copper, nickel, silver, hexavalent chromium, mercury, and cyanide were not detected in any sample.

BOLD The relative percent difference exceeds the precision criterion.

mg/L Milligrams per liter

NC The relative percent difference was not calculated because at least one of the results was non-detect.

ND The analyte was not detected at or above the reporting limit.

From: Mire, June
To: shaikh.taimur@epa.gov; chen.isaac@epa.gov; Vickers, Jessica; ileana.rhodes@shell.com; "robert.kuehn@shell.com"; gkorenaga@chevron.com; joe.p.smith@exxonmobil.com
Subject: OOC Produced Water Protocol Change
Date: Monday, June 09, 2014 4:35:36 PM

Isaac and Taimur,

Thank you for making the time to talk with us today. This email documents the discussion and conclusions of our call on the protocol for collecting produced water samples as part of the Joint Industry Program.

Participants: Isaac Chen (EPA), Taimur Shaikh (EPA), Rob Kuehn (Shell), Gail Korenaga (Chevron), Jessica Vickers (Tetra Tech), June Mire (Tetra Tech)

Background:

1. No consistent trend in metals concentrations was observed between field-filtered and lab-filtered produced water samples.
2. Most constituents were not detected in either field-filtered or lab-filtered samples.
3. Laboratory filtration offers benefits of better pumps, more consistent personnel, more quality control, and potentially more representative equilibria.

Decision:

1. Field filtering of produced water samples can be discontinued immediately.
2. Samples should be collected with near-zero head space.

Other topics:

- When a lease area has too few produced water discharges to meet the desired distribution of 10 separate blocks, we have been collecting repeated produced water samples from the same platform(s) on different days. All agreed that this is an acceptable way to obtain the required 10 samples per lease area.

- We anticipate collecting our last samples in April, 2015 and submitting the report to EPA in October, 2015.

June B. Mire, Ph.D. | Senior Ecologist and Project Manager
Direct **(504) 834-6276** | Mobile **(504) 273-9186** | june.mire@tetratech.com

Tetra Tech | Complex World, Clear Solutions™

1408 Pasadena Avenue, Metairie, LA 70001 | tetratech.com

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1.3 Certification by Operator Representative

CERTIFICATION BY AUTHORIZED REPRESENTATIVE OF ANADARKO PETROLEUM CORPORATION

NPDES Permit No.: GEG460000

I certify that this BMP3 is complete, onsite, and implemented.

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

Todd G. Durkee
Name

Drilling Manager
Title

Signature

4 MAR 2015
Date

1.3 Certification by Operator Representative

CERTIFICATION BY AUTHORIZED REPRESENTATIVE OF ANADARKO PETROLEUM CORPORATION

NPDES Permit No.: GEG460000

I certify that this BMP3 is complete, onsite, and implemented.

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

Todd G. Durkee
Name

Manager, Drilling & Completions
Title

Signature

05 MAY 2014
Date

ANADARKO PETROLEUM CORPORATION

1201 LAKE ROBBINS DRIVE • THE WOODLANDS, TEXAS 77380
P.O. BOX 1330 • HOUSTON, TEXAS 77251-1330

Anadarko
Petroleum Corporation

March 4, 2015

Director
Water Protection Division
US EPA - Region 4
Sam Nunn Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303-8960

2015 MAR 10 10:57 AM

Re: Anadarko Petroleum Corporation
Request for Subsequent Coverage
NPDES General Permit No. GEG460000 for Offshore Oil & Gas Activities in the Eastern Gulf of Mexico

Dear Director:

In accordance with Part I.A.8 of NPDES General Permit GEG460000, Anadarko Petroleum Corporation (Anadarko) hereby requests subsequent coverage under the reissuance of a subsequent general permit of the permit numbers on the attached list. The current permit will expire March 31, 2015.

If you have any questions, please contact Sofia Lamon at (832) 636-2488.

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

Todd G. Durkee
Drilling Director, Deepwater

Enclosure

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

APR 03 2018

CERTIFIED MAIL 7017 1450 0000 7972 7225
RETURN RECEIPT REQUESTED

Mr. Brady McNew
Transcontinental Gas Pipe Line Company, LLC.
2800 Post Oak Boulevard
Houston, Texas 77056

Subject: National Pollutant Discharge Elimination System General Permit Coverage
Permit No. GEG460000

Dear Mr. McNew:

We received your letter postmarked February 16, 2018 in which you submitted one (1) Notice of Intent (NOI) for coverage under the National Pollutant Discharge Elimination System (NPDES) General Permit (GEG460000). In accordance with Part I.A.4 of the General Permit, Notification Requirements (Existing Sources and New Sources), your NOI fulfills the notification requirements in the General Permit, allowing Region 4 to determine that your filing contains the necessary information to include these facilities under the General Permit as existing sources.

Permit coverage is hereby authorized under the NPDES General Permit for the operational facility listed on the enclosure. In accordance with Part I.A.4 of the General Permit, coverage for this facility is effective on the postmarked date for submittal of the NOI, February 16, 2018. General Permit coverage will terminate on January 19, 2023 unless EPA Region 4 is otherwise notified.

If you have any questions, please contact Mrs. Bridget Staples of the Municipal and Industrial NPDES Permit Section at (404) 562-9783.

Sincerely,

Mary S. Walker
Director
Water Protection Division

Enclosure

B. Staples ___Gladys ____Davis ___P. Marcus _____Zapata ___Walker ___Marcus ___Gladys

3/29

CC to Mary Mattox

Gas Pipelines – Transco
2800 Post Oak Boulevard
Houston, Texas 77056
713.215.2000

By Certified Mail; Return Receipt Requested

Bates: 002791

August 27, 2014

Ms. Karrie-Jo Robinson-Shell
U. S. Environmental Protection Agency Region 4
Water Protection Division
Pollution Control and Implementation Branch
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, Georgia 30303

RE: NOI for NPDES General Permit No. GEG460000
Transcontinental Gas Pipe Line Company, LLC (Transco)
Pipeline Junction Platform MO822

Dear Ms. Robinson-Shell,

As a follow-up to Mr. Doug Russell's request for permit applicability determination (Attachment 1) and our subsequent phone conversation, Transcontinental Gas Pipe Line Company, LLC (Transco) is providing the Notice of Intent (NOI) for a pipeline junction platform owned by Transco to be covered under the GEG460000 NPDES General Permit. As per Part I, Section A.4 of the permit, the required information is provided below.

a. *Legal Name and Address of the owner or operator*:

Legal Name: Transcontinental Gas Pipe Line Company, LLC (Transco)
Address: 2800 Post Oak Blvd., Houston, TX 77056

b. *The facility name, OCS number location, including the lease block assigned by MMS, or if none, the name commonly assigned to the lease area:*

Facility Name: Transco Junction Platform
OCS number: G18794
Lease Block: Mobile Block 822

c. *Number and type of facilities and activities proposed within the lease block*:

One (1) pipeline junction platform

d. ***Map with lat/long of the facility and the expected discharges*:**

Map: See Attachment 2 for as built in location map of facility
Lat/Long: Lat 30 Deg 09' 53.701"N and Long 88 Deg 11' 55.988"W.

e. ***Date on which the owner/operator commenced/will commence onsite construction*:**

July 1998

f. ***The date on which the facility plans to commence exploration activities at the site, if applicable*:**

N/A – No exploration activities

g. ***Date of purchase of equipment*:**

N/A – This is an existing platform

h. ***Date the operator plans to commence development*:**

N/A – No development activities

i. ***Date to commence production*:**

N/A – No production activities.

j. ***Technical information on the characteristics of the sea bottom in accordance with MMS Notice to Lessees (NTL) no. 9820, Shallow Hazard Requirements, or the most current MMS guidelines for shallow hazard investigation and analysis within 1000 meters of the discharge point. For those facilities that submitted this information to EPA Region 4 as part of the previous NPDES general permit (GMG460000), only indicate the previous submittal date of the information to meet the requirement of this NOI element*:**

Please see Attachment 3 for the Archeological, Engineering and Hazard Study submitted as part of the January 1998 MMS Right of Way approved application.

k. ***For facilities in less than 100 meters water depth for offshore Mississippi and Alabama in the Mobile and Visoca Knoll lease blocks, permittee's must submit a LiveBottom Survey using either digital high resolution acoustic data (sidescan sonar) or photodocumentation.***

The acoustic data may be either new data acquired for this purpose or data obtained by the permittee for lease or site specific surveys in compliance with MMS requirements, as per NTL No. 2008G04 Information Requirements for Exploration Plans and Development Operations Coordination Documents, or most current MMS guidelines. Digital (or digitized analog data) sidescan sonar data obtained by survey methods described in NTL No. 2008G05 Shallow Hazard Program, or most current MMS guidelines, if sufficient, may be used as the source of acoustic data for preparation of a LiveBottom Survey report. EPA will consider all natural or artificial hard structure detected by acoustic data to be livebottom unless other data (i.e. video, still photographs, diver visual etc.) determines otherwise. Permittees choosing to continue providing photo documentation will continue to conduct such surveys, as per NTL No. 2004G05, attachment 7, or most current MMS guidelines. Final siting of proposed outfalls must be no further than 500 meters from the proposed surface location. See Part I.D.5 for specific permit requirements pertaining to preparation of reports using high resolution acoustical data. For those facilities that submitted this information to EPA Region 4 as part of the previous NPDES general permit (GMG460000), only indicate the previous submittal date of the information to meet the requirement of this NOI element; **:**

Please see Attachment 3 (page 64 of 194 through page 91 of 194) which includes the sonar scan information submitted as part of the January 1998 MMS Right of Way approved application.

l. ***Type of drilling fluids*****:**

N/A – No drilling at this platform

m. ***Documentation that an Application for Permit to Drill (APD), EP, DOCD or DPP has been submitted to MMS or approved by MMS:***

N/A – No E&P activities.

n. ***Date of end of protection from more stringent NSPS or technology-based limitations*****:**

2008

o. ***The general permit coverage number for the previous general permit (GMG460000) and/or the individual NPDES permit number of any individual permit issued by EPA Region 4 for this activity*****;**

NOI for Region 6 GMG 290000 (not assigned).

p. ***For production platforms, indicate the estimated distance (in meters) from the platform to the nearest Federally Designated Dredged Material Ocean Disposal Site;***

N/A – Not a production platform

q. ***Any permit violations or under the previous Region 4 General Permit (NPDES No. GMG460000 issued December 9, 2004) for the facility***

None

r. ***Indicate if Phase III of EPA's Cooling Water Intake Structure Rule (CWIS) applies to the facility for which you are applying for coverage under this permit, et al.***

N/A - No cooling water intake

s. ***If known, indicate the name and NPDES permit coverage number under GEG460000 for contractors that are, or will be, performing work at your facility that are new oil and gas facilities subject to Phase III of the CWIS Rule***

N/A – This is not applicable for MO822.

Should you have any questions, please feel free to contact me at (713) 215-2641, or by e-mail at rafael.castillo@williams.com.

Sincerely,

Rafael Castillo
Senior Environmental Specialist

Attachment 1

Correspondence

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

USEPA REGION IV
WATER PROTECTION DIV
POLLUTION CONTROL & IMPLEMENTATION BRANCH
ATLANTA FEDERAL CENTER
61 FORSYTH STREET, SW
ATLANTA GA 30303

ATTN: MS KARRIE-JO ROBINSON-SHELL

COMPLETE THIS SECTION ON DELIVERY

A. Signature

X Matthew Abley

☑ Agent
☐ Addressee

B. Received by (Printed Name)

C. Date of Delivery

Apr 1-12-13

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type

☑ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number
(Transfer from service label) 7012 1010 0003 1227 4753

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

2988 Hwy 964
Jackson LA 70748
225-603-8043

April 9, 2013

U. S. Environmental Protection Agency Region 4
Water Protection Division
Pollution Control and Implementation Branch
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, Georgia 30303

Attention: Ms. Karrie-Jo Robinson-Shell

Subject: NPDES Permit Applicability Determination for Williams/Gulfstream Offshore Natural Gas Pipeline Junction Platform MO822

Dear Ms. Robinson-Shell,

The purpose of this letter is to request a determination of how the above platform fits into the current EPA Region IV NPDES permitting process.

Williams is the operator and joint owner of the Gulfstream interstate natural gas pipeline junction platform located in lease sale block Mobile 822, constructed in 1998. The function of a pipeline junction platform is to provide above-sea access to valves and piping to control flows from two or more under-sea natural gas pipelines that meet at one location to combine the natural gas into a main line(s) that transports the natural gas to on-shore facilities.

However, Williams is not the lease holder or lease operator, nor is this platform involved in the exploration, development, and production of offshore oil or gas. Interstate natural gas transmission pipelines are not considered to be included in the Oil and Gas Extraction Point Source Category (40 Code of Federal Regulations (C.F.R.) Part 435, Subpart A). Therefore, it appears that the platform does not meet the applicability of the GEG460000 General Discharge Permit. The Standard Industry Classification (SIC) for this facility is 4922, and the North American Industry Classification System is 486210. As stated in 40CFR 122.26(a)(2)(ii), natural gas transmission facilities with the SIC of 4922 are exempt from the NPDES storm water discharge permitting requirements for onshore facilities, but it is unclear if this exemption extends to similar offshore facilities.

The storm water discharged from the facility consists of storm water through open grating decks and walkways, or through drains from solid decks where valves, piping, pig launchers/receivers,

and associated equipment are located. The storm water flowing from the drains passes through a baffled weir separator to collect any potential *de minimis* hydrocarbons that may cause a sheen, and is then discharged through a four-inch line. No other wastewater or produced water is generated on or discharged from the platform.

The platform is currently 14 years old, and future maintenance plans include blasting and painting to address saltwater corrosion issues. While best practices (as outlined in the Williams offshore BMP) will be made to contain and collect the spent blast media, some fugitive dust may be blown from the platform due to constant strong breezes, or escape containment efforts and reach the waters of the Gulf of Mexico. The Region VI offshore general permits specifically address such maintenance activities for "supporting pipeline facilities," but we can find no such references in the Region IV general permit. Previously, NOI's and annual DMR letters of no violations were submitted to Region VI, due to an error in determining the EPA regional boundaries years ago. We were recently informed by EPA Region VI that the platform lies outside of their area.

We see three permitting options for this interstate natural gas pipeline platform:

1. Apply for an individual discharge permit for storm water discharges and maintenance activities (however, since the platform is unmanned, designed without any sample locations (the outfall is five feet below the sea surface), and is without a constant source of power, it would be impractical to comply with any sampling requirements, including the initial Form 2C required samples);

2. Apply for coverage under the current GEG460000 general permit;

3. Recognize the exemption from permitting following the precedents of 40CFR 122.26(a)(2)(ii) until the DEG46000 general permit can be modified during the next renewal process to include maintenance activities at "supporting pipeline facilities."

If you require further information or discussion, please feel free to call me at 225-603-8043.

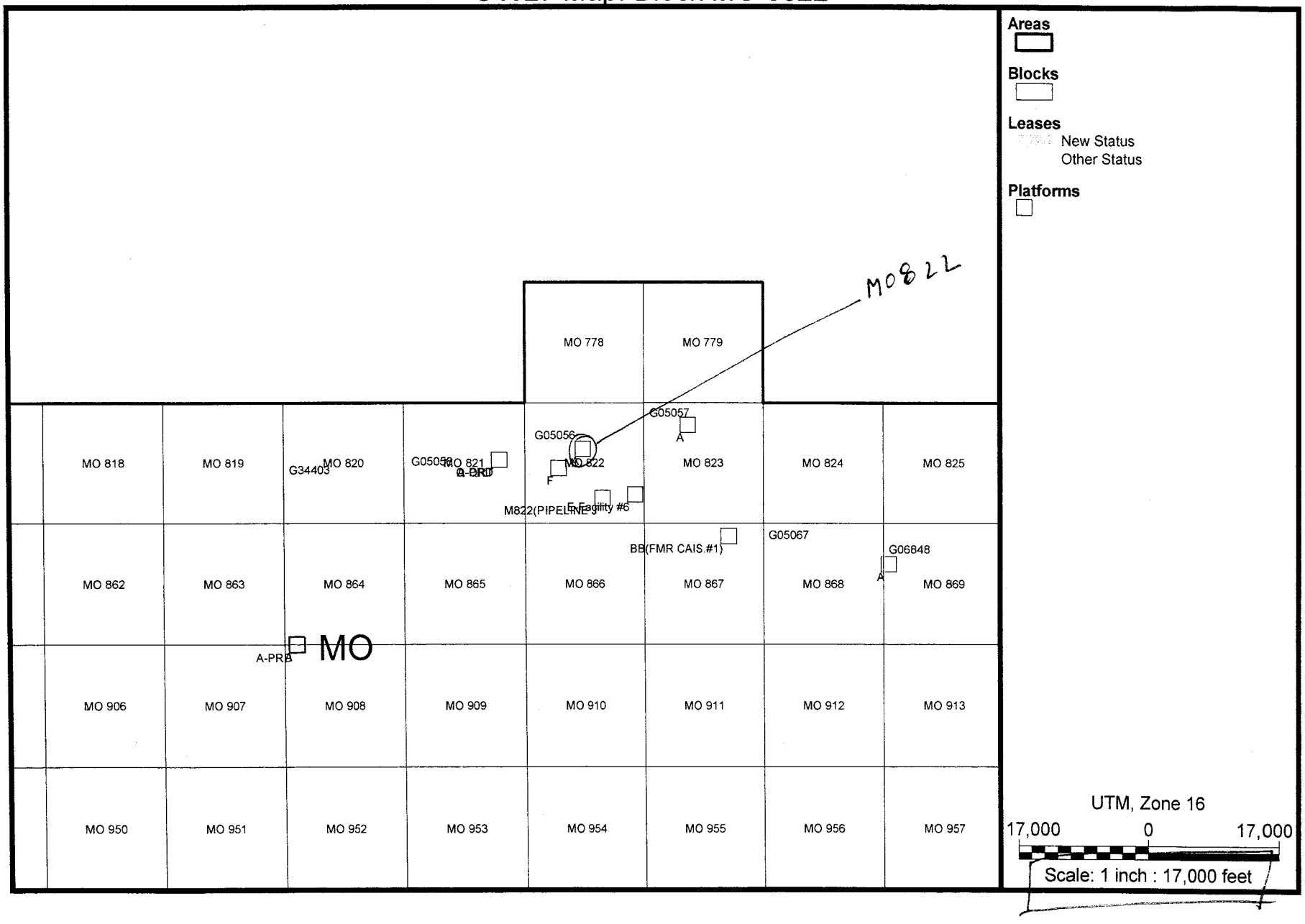
Sincerely,

Doug Russell
Senior Environmental Scientist
The Williams Companies
225-603-8043
Doug.M.Russell@Williams.com

Attachment 2

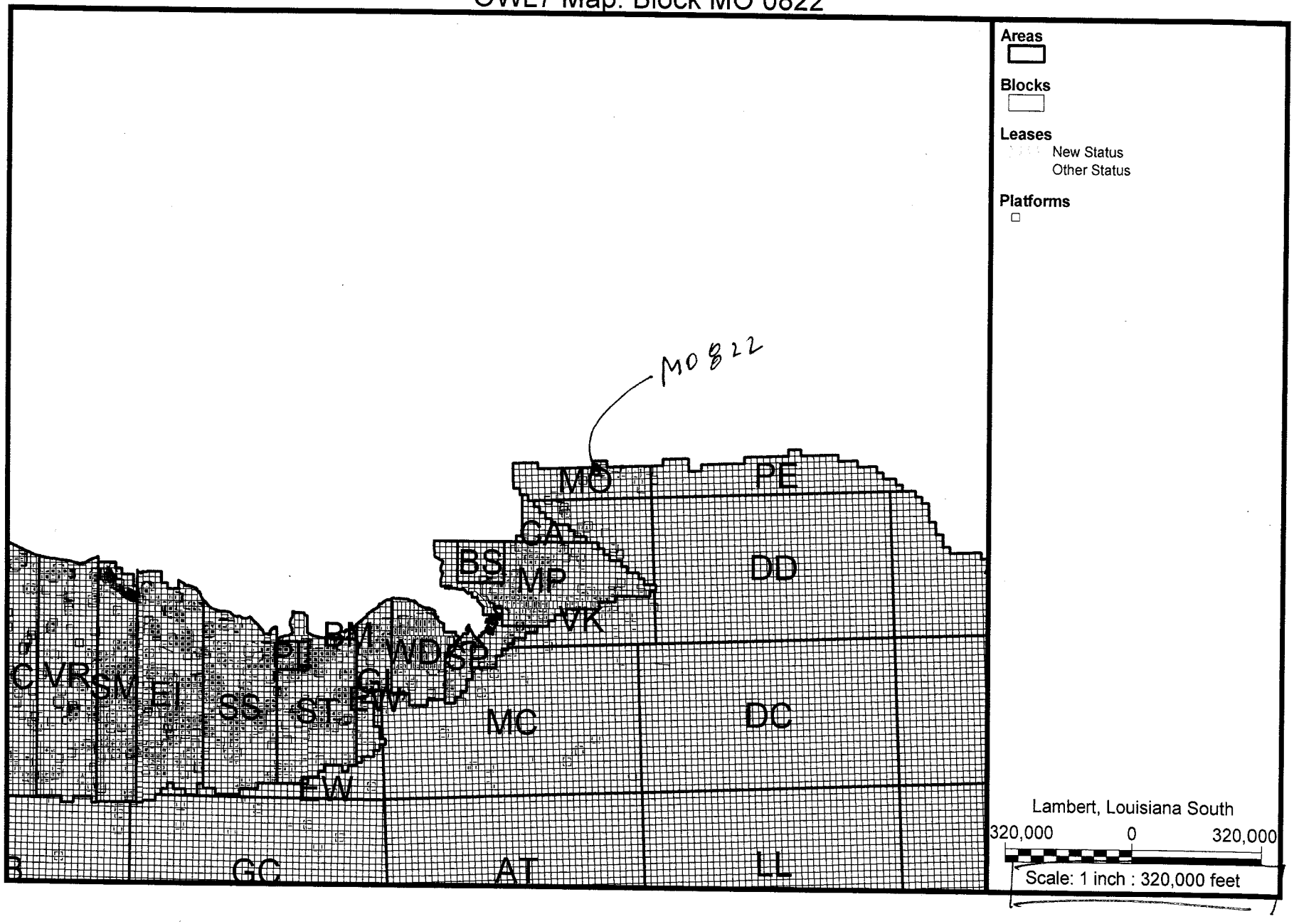
Location Map of MO822 Facility at 3 Different Scales

OWL7 Map: Block MO 0822



OWL Database ©1991-2013, Lexco Data Systems, L.P. Map Printed 8/22/2014.

OWL7 Map: Block MO 0822



OWL Database ©1991-2013, Lexco Data Systems, L.P. Map Printed 8/22/2014.

Attachment 3

1998 Archeological, Engineering and Hazard Study

OCS-G 18794
OCS G18795

Transco

TRANSCONTINENTAL GAS PIPE LINE CORPORATION

ONE OF THE WILLIAMS COMPANIES, INC

ARCHAEOLOGICAL, ENGINEERING AND HAZARD STUDY

PROPOSED 24" PIPELINE ROUTE G18794

Bock 261, Main Pass Area

to

Block 822, Mobile Area

and

PROPOSED 30" PIPELINE ROUTE G18795

Bock 822, Mobile Area

to

Shore, Alabama

C&C Technologies
SURVEY SERVICES

January, 1998

TONY GEORGE
Senior Geophysicist

LAURA A. LANDRY
Consulting Marine Archaeologist

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1.0 INTRODUCTION

Transcontinental Gas Pipe Line Corporation (Transco) contracted C & C Technologies, Inc. (C & C) to provide a revised Archaeological, Engineering and Hazard Study for their proposed 24" and 30" Gas Pipeline Route which extends north from Block 261, Main Pass Area and ties to a western shoreline point in Alabama (see Regional Map, p. 7 and Vicinity Map, p. 8). The purpose of the high-resolution geophysical survey was to identify any potential hazards or engineering constraints to the pipeline construction, collect bathymetric data, determine the seafloor and subbottom conditions, and assess cultural resource potential in compliance with the guidelines set forth by the Minerals Management Service.

An overview of the routes is provided on the Index Map. Flow through the proposed 24" gas route will originate in Block 221, Main Pass Area at the existing "A" Platform (X = 1,285,851.34', Y = 10,652,252.09'; Lat. = 29° 20' 50.645" N, Long. = 88° 06' 47.704" W) where the existing Well No. 2 (OCS-G-13035) is located. The route extends north and will cross the Pascagoula Fairway, Gulf Outlet Fairway, and the Horn Island Pass Fairway. The 24" route will terminate at the proposed Transco Junction Platform (X = 1,261,662.12'; Y = 10,949,735.27'; Lat. = 30° 09' 53.698" N, Long. = 88° 11' 55.988" W) in Block 822, Mobile Area. The 30" route will extend north from the Junction Platform to a borehole beginning point (X = 1,256,077.60', Y = 11,025,493.51'; Lat. = 30° 22' 23.140", Long. = 88° 13' 08.872") on the western coastline of Alabama. The 30" pipeline is proposed to be bored under Dauphin Island and will cross the Intracoastal Waterway in the Mississippi Sound Area. Flow will be toward the north in both pipelines. Total length of the 24" pipeline route is calculated at 302,272.12 feet or 57.25 statute miles. The 30" route horizontal alignment measures 79,628.64 feet or 15.08 statute miles.

An Archeological, Engineering and Hazard Study along the original route was completed by John E. Chance and Associates (JECA) in March of 1997 with the hazard interpretation performed by Ms. Barbara J. DuVal (JECA) and Mr. Mike Kaluza (Consultant). Ms. Laura A. Landry (Consultant) provided the Archeological Assessment for JECA and has authored the Assessment for this report. Digital files of the JECA maps and a hard copy of the report text were provided to C & C by Transco in order to incorporate into a supplemental report the survey results of additional field work performed by C & C for three route alternatives. The southernmost reroute was needed due to a recently completed well which was drilled near to the centerline in Block 226, Main Pass Area (Maps 2 & 3). The other two of the route alternates occurred at the navigation fairways. The route surveyed by C & C across the Pascagoula Fairway (Maps 8 & 9) in the Viosca Knoll Area was abandoned by Transco in favor of the original alignment. The pipeline route alternative at the crossings of the Horn Island and Gulf Outlet Fairways (Maps 12 - 14) in the Mobile Area was adopted, changing the route crossings to near normal to the fairway orientations in order to reduce the crossing length. C & C provided Transco the supplemental report addressing the route revisions in September of 1997.

Transco contracted C & C in December of 1997 to produce this single report incorporating the latest route revisions, the results of diver investigations by Oceaneering and additional engineering data provided by Transco. This combined report also addresses some concerns raised by the Minerals Management Service upon review of the original JECA report. The proposed route crosses three local coordinate systems. These are the Lousiana South Lambert Coordinate System across the Main Pass Area (Maps 1-5), the UTM Zone 16 Coordinate System across the Viosca Knoll and Mobile Areas (Maps 5-16) and the Alabama West Coordinate System for the portion in State waters (Maps 17-21). For simplicity, the maps and report text reference the UTM Zone 16 System.

The sea conditions were moderate (1 to 5 foot seas) for the JECA data acquisition resulting in adequate data recovery for geological interpretation. The JECA field operations were conducted in September 1996 through February 1997 aboard six different vessels which include:

M/V Polo Pony - September 29, October 19-25, 28-31, and November 1, 18-24. 1996.
R/V Kit Jones - September 16-19, 1996
M/V Mr. Adam - September 24-26, 1996
R/V Seis Surveyor - December 5, 1996
M/V Millers Divers III - January 18, 1997
M/V L'Arpenteur - February 3-5, 1996

Horizontal positioning of these survey vessels was accomplished with the STARFIX® System which provided 24 hour operation. Geophysical systems deployed on the *M/V Polo Pony* and *M/V L'Arpenteur* included the Pinger Profiler, Echotrac Bathymetric System, Microsystems Sound Velocity Profiler, Magnetometer, and SMS-260 Side Scan Sonar. Geophysical systems deployed on *R/V Kit Jones* included the Boomer Profiler, Echotrac Bathymetric System, Microsystems Sound Velocity Profiler, Proton Magnetometer, and SMS-260 Side Scan Sonar. Geophysical systems deployed on the skiffs, *M/V Mr. Adam* and *M/V Miller Divers III,* included the Echotrac Bathymetric System and Proton Magnetometer. The Kullenburg Piston Coring Device and Pneumatic Hammer Coring Device were used to collect core samples along the proposed route. The core samples were collected aboard the *M/V Polo Pony* on November 22-24, 1996, *R/V Kit Jones* on September 18-19, 1996, *R/V Seis Surveyor* on December 5, 1996, and *M/V L'Arpenteur* on February 5, 1997.

Field operations were conducted by C & C aboard the *R/V Ocean Surveyor* between June 25 and July 1, 1997. Sea conditions were satisfactory (1 to 3 foot seas) for quality data acquisition and for geological interpretation. Geophysical instruments utilized for the survey included a towed Datasonics SIS-1000 Sonar and Subbottom Profiler, SeaBird Seacat 19 CTD Profiler, and Geometrics 880 Cesium Magnetometer. Water depths along the route were collected with a Simrad

EM-1000 Multibeam and Imaging System. Horizontal positioning of the survey vessel was accomplished using differential GPS with a Trimble Receiver and SATLOC'S L-Band System used for relaying differential corrections. A U.S. Coast Guard beacon was also monitored as a secondary source of differential corrections. The SIS-1000 Towfish was tracked acoustically using a Simrad Ultra-Short Baseline Positioning System.

Survey coverage for the JECA work consisted of two sets of parallel tracklines spaced 300 meters apart (Lines 173-179 and Lines 32-37, 1031), Maps 1-11, and three sets of parallel tracklines spaced 50 meters apart (Lines 38-74, 75-99, and 100-124), Maps 11-17. Survey coverage within Mississippi Sound Area consisted of 3 sets of parallel tracklines spaced 50 meters apart (Lines 125-129, 130-138, and 140-145), and 9 tracklines perpendicular to the proposed route (Lines 1147, 148, 149, 152-155, 163, and 167), Maps 17-21. Seven investigation line (Lines 400-406) were run around the shipwreck in Block 31, Viosca Knoll Area. Other tracklines run included rerun lines, investigation lines, and lines tangent to the pipeline curves. Not all these lines have been included on the final maps. Navigational fixes (shot points) were recorded at 150-meter intervals along all survey lines, and each point was automatically annotated on the geophysical strip charts for post reference. The survey grid was designed to provided completed lateral coverage with the sonar system and a representative sampling with the seismic and magnetometer systems.

C & C survey coverage of the route alternative between Block 226 and 216, Main Pass Area (Maps 2 & 3) consisted of centerlines (Lines TU5, ST4, QR2, PQ1, and RS3) where the route was deviated 300 m to the west to avoid a well location and a western wing line (Line 261). A 300-meter line spacing interval (Lines 247-260) was added to the JECA survey coverage and new centerlines (Lines 304-306) were surveyed for the proposed route deviation across the Pascagoula Fairway in the

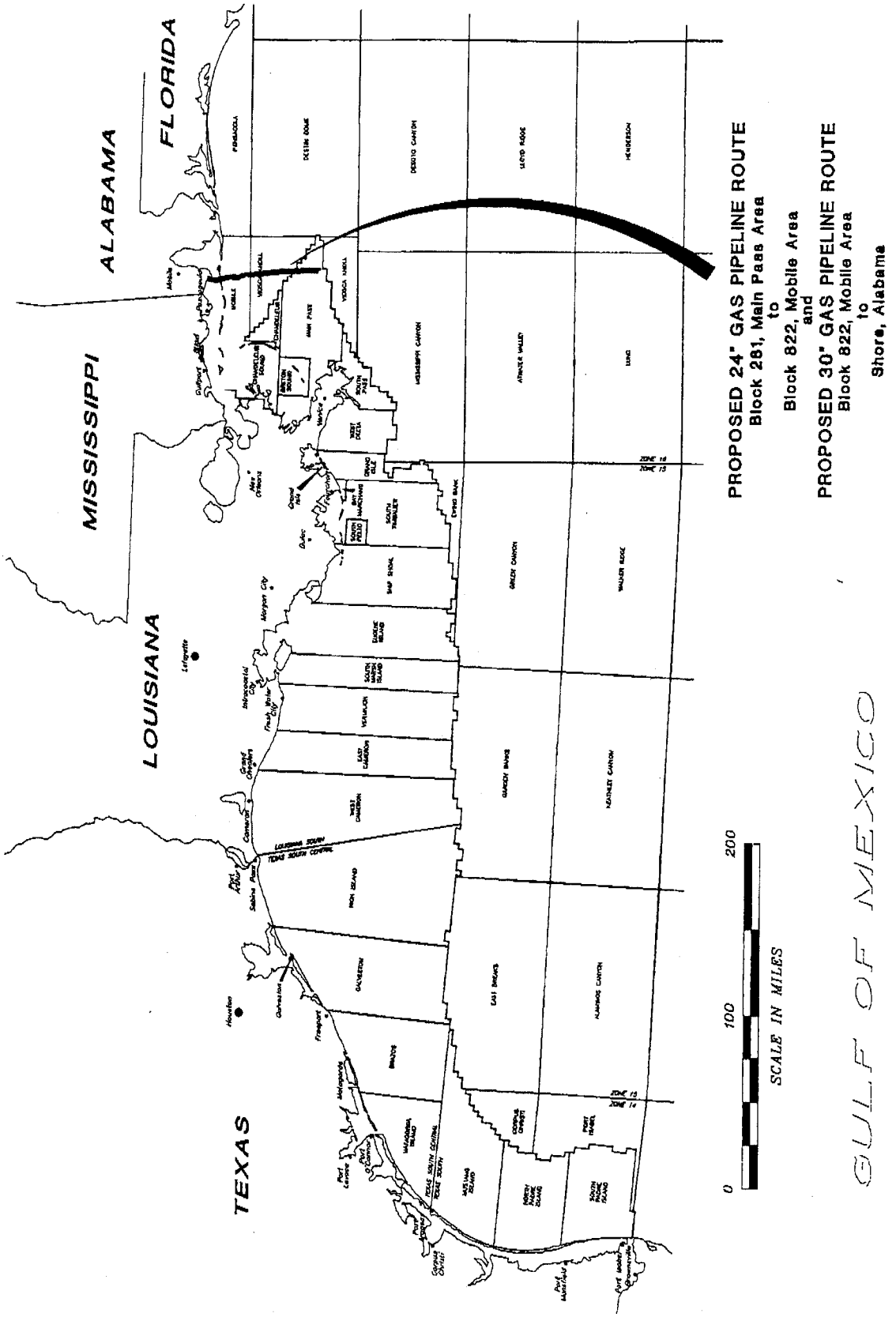
Viosca Knoll Area (Maps 8 & 9). Forty-one tracklines at a 50-meter primary line spacing (Lines 206-246) and new centerlines (Lines 300-302) were run for the reroute across the Gulf Outlet Fairway and Horn Island Pass Fairway in the Mobile Area (Maps 12-14). The primary lines were run parallel and adjacent to the original JECA survey tracklines. Plats showing the results of the diver investigations performed by Oceaneering of selected magnetic anomaly and sonar contact positions are included in Appendix F. The locations and results of these investigations are also presented on the plan view maps.

Geophysical data reproductions of pertinent features found in the survey area may be observed in Appendix A. Tables of Magnetic Anomalies, Magnetic Anomaly Table User's Guide, Breiner's Nomogram and Side Scan Sonar Contact Tables are presented in Appendix B. Instrument settings, equipment descriptions, sensor setback diagrams, survey personnel lists and survey logs are located in Appendix C. Appendix D contains the velocity and tide data information used to correct the bathymetric data and the core analysis is located in Appendix E.

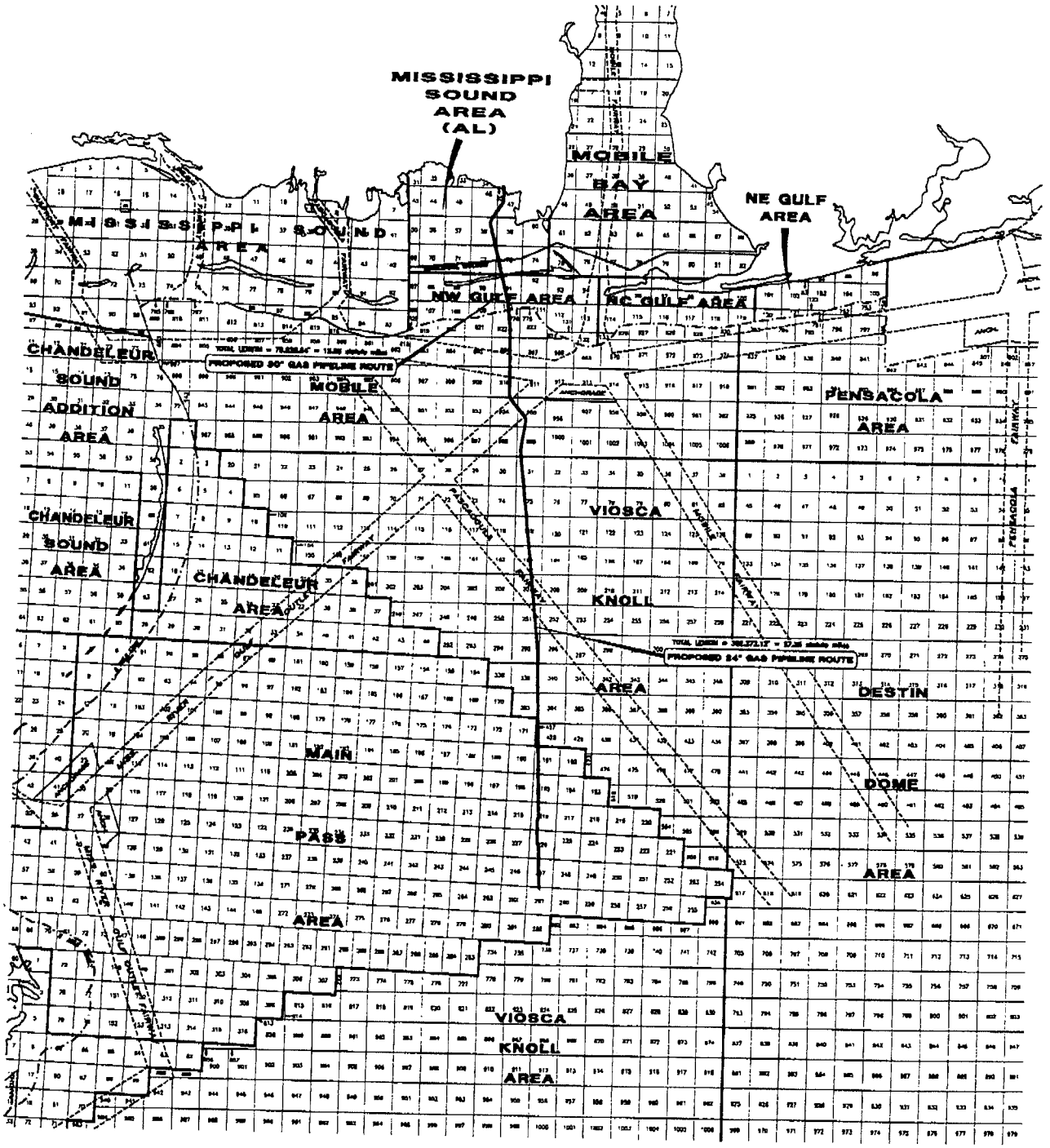
Geophysical data collected from the remote sensing systems were reviewed for geologic interpretation and for evidence of potential pipeline construction hazards. The survey results pertinent to pipeline construction are projected on the Archaeological, Engineering and Hazard Maps (Maps 1-21). A Profile View depicting the near-seafloor stratigraphy and geologic features along the routes is included as a bottom panel on each of the plan view sheets. The maps in the State and Federal waters south of Dauphin Island were constructed at a scale of 1 inch = 1,000 feet (Maps 1-16) and those in the shallow State waters north of Dauphin Island were constructed at a scale of 1 inch = 500 feet (Maps 17-21). The following written text is intended to be viewed in conjunction

with the study maps to provide a comprehensive overview of the seafloor, near-subsurface, and man-made features within the survey corridor.

REGIONAL MAP



VICINITY MAP



2.0 REGIONAL GEOLOGIC SETTING

The near-surface geology across the Gulf Coast region has been largely influenced by fluctuating sea levels associated with climatic variations during the Pleistocene Epoch. During low sea level stands which occurred due to the ice ages, the shelf area was an exposed land mass which was subjected to subaerial weathering and erosional processes. The last major ice age (Late Wisconsin Glacial) peaked 18 to 20 thousand years before present. Streams and rivers meandered across the exposed shelf and created deltas along the current position of the shelf break. As the climate warmed and seas transgressed, marine sediments were deposited over the shelf and infilled the erosional cuts left by the rivers and streams. The unconformities and buried erosional cuts are common features on high-resolution seismic profiles collected over the shelf area. The Mississippi River has abandoned and created a number of delta complexes across the north-central Gulf of Mexico in the past 10,000 years (Frazier, 1967).

Coleman and Roberts (1988) have analyzed over 450 cores from foundation borings and thousands of kilometers of high-resolution seismic data from across the Louisiana shelf and upper slope region. These data were used to document the sedimentological characteristics, spatial depositional patterns, and seismic/lithofacies response during three complete sea level cycles. Their findings resulted in two types of depositional sequences being defined which they referred to as condensed and expanded sections. Condensed sections are deposited during the periods of high sea level stands and expanded sections are formed during low sea stands. Condensed sections are generally thin, slowly accumulating deposits of hemipelagic clays with a lower unit of a transgressive sequence consisting of calcareous-rich shell hashes. These condensed sections displayed wide lateral continuity and high amplitude acoustic response. Rapidly accumulated expanded sections were of variable thickness

with abundant coarse grained clastic deposits (sands and gravels). These units displayed a wide variety of seismic response on high-resolution seismic profiles.

Diapiric intrusions have also influenced the regional geology of the Gulf Coast. Many of these mobile salt bodies have protruded through the thick Pleistocene deposits and exist very near the seafloor. These salt bodies have uplifted, deformed, and faulted the overlying deposits, as well as creating bathymetric highs on the seafloor. This uplifted strata may have been eroded during low sea level stands, exposing hard rock outcrops. As sea level rose and these uplifted areas were covered with shallow seas, reef communities developed over the hard outcrop zones. When the sea level rise rate out paced the rate of the reefal growth and/or the water turbidity increased due to changing depocenters, most of the reefs drowned or suffocated. Many of the locations of these reefs which formed over salt intrusions are known as named banks across the northwestern Gulf of Mexico. Some of those diapirs which are found in the deeper portions of the shelf and upper continental slope consist of authigenic carbonate derived from bacterial reduction of hydrocarbons escaping through the seafloor.

A portion of the southern end of the pipeline route was contained in a Minerals Management Service survey conducted in 1990 which is named the Mississippi-Alabama Marine Ecosystem Study (MAMES). The pinnacles identified in the baseline study were referred to as Reef-Like Mounds (RLM's) which range in diameters from 2 to 1000 meters and have heights from < 1 to 18 meters (Laswell et al., 1992). Many of the pinnacles or continuous zones of pinnacles included in the study were flat-topped like small mesas. The elevations at which RLM's occur are evidence for the last sea level transgression being nonuniform. The study found that the RLM's occurred in two isobath bands which ranged in depth from 74 to 90 meters (242 to 295 feet) and 105 to 120 meters (344 to

394 feet). A Late Wisconsin Unconformity was associated with the deeper isobath band. Other topographic features identified in the study included ridges with heights between 1 and 8 meters and up to 250 m in width and pockmarks or shallow depressions < 1 meter in depth and < 10 meters in diameter.

3.0 LIVE BOTTOM (PINNACLE TREND) STIPULATION AREA

Blocks 261, 247 and 226, Main Pass Area (Maps 1-3) are located at the southern end of route within a seventy block contiguous area designated by the Minerals Management Service as the Live Bottom (Pinnacle Trend) Stipulation Area. The topographic features consisting of pinnacle and reef outcrops observed in this area of the outer shelf area were most likely formed during the still stands or reversals of sea level which occurred 15 to 20 thousand years ago during the early Holocene transgression. "Live bottom areas" for the purpose of the MMS stipulation are defined as seagrass communities; or those areas which contain biological assemblages consisting of such sessile invertebrates as sea fans, sea whips, hydroids, anemones, ascidians, sponges, bryozoans, or corals living upon and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; or areas whose lithotope favors the accumulation of turtles, fishes, and other fauna. The Regional Director for the MMS determines if the oil and gas activities for a particular project in the Pinnacle Trend will adversely affect the pinnacle area. The Regional Director can ask the lessee or pipeline operator to take the following actions if it is determined that live bottoms in the area may be adversely affected by the activities:

(a) the relocation of operations; and

(b) the monitoring to assess the impact of the activity on the live bottoms.

The stipulation is designed to protect the sessile and pelagic (fish) communities associated with the crest and flanks of the pinnacles and hard-bottom features. Of particular concern for the protection of the pinnacle areas is the placement of anchors used in construction projects. Anchor placements within zones of pinnacles are expected to severely damage individual pinnacles and possibly destroy some biologic communities. Recent dive video collected by the Minerals Management Service and shown recently at 1997 MMS Information Technology Exchange Conference in New Orleans

showed that sessile invertebrates such as sea fans, sea whips, and sponges cover portions of the topographic features. Numerous species of fish were also observed in and around the pinnacles on the dive video. The coral which formed the topographic highs or pinnacles was generally silted over with a thin veneer sediment.

Zones of outcrops and/or pinnacles have been identified on the survey data in Blocks 226 and 247, Main Pass Area within the Live Bottom (Pinnacle Trend) Stipulation Area. The proposed pipeline route in this area has been designed to avoid the outcrop zones identified on the high-resolution geophysical data. The pipeline crosses through a narrow pass measuring 260 feet in width. The pipeline construction vessel to be used on this portion of the pipe lay project is to be dynamically positioned and no anchors will be used. Impact to the biological assemblages occupying the pinnacles is anticipated to be minor. Some sediment may be disturbed and carried away quickly by the bottom currents at the pipe touch down point and the pelagic species may be temporarily displaced until the local environment returns to "quiet". An ROV inspection of the pipeline in this vicinity may be prudent in order to ensure the pipeline is not spanning across any small, low relief pinnacles which were too small to be detected by the geophysical instruments deployed.

4.0 INTERPRETATION

An overview of the data processing for the geophysical data and the generalized conditions along the routes are presented in Sections 4.1-4.6. The subsections contained under the Map Descriptions (Section 4.7) summarize the seafloor and subbottom conditions as they relate to pipeline construction operations on a map by map basis. The written interpretations, conclusions and recommendations made by Ms. Duval and Mr. Kaluza are paraphrased where appropriate. The bathymetry, seafloor features, near-seafloor soil conditions, near-surface geology, existing infrastructure, and man-made hazards are discussed for each chart area. The report text and maps additionally present the results of diver investigations by Oceaneering of a number of centerline magnetic anomalies. Plats of the diver investigations are presented in Appendix F. These investigations were undertaken by Transco in order to clear debris which would hamper the pipeline construction operations.

4.1 Bathymetry

Water depths along the pipeline route were collected by JECA with an Echotrac fathometer (Appendix A, Figure 1). C & C used a multibeam Simrad EM-1000 System to determine water depths. Boat draft and transducer depth were compensated for on each of the systems. Both contractors velocity corrected the traveltime values in depths greater than 60 feet with a harmonic mean velocity (Appendix D). Full coverage of the seafloor was not obtainable with the multibeam system due to the line spacing interval and the water depths. Heave compensation values were applied to the multibeam digital soundings utilizing a TSS Heave Compensator. The SIS-1000 Sonar System operated by C & C was equipped with a precision depth sensor which when added to the fish altitude provided a quality control check for the depths which the EM-1000 System provided.

Water depths in less than 60 feet were tide corrected to mean lower low water (MLLW) using predicted tide tables provided by Tide I Software (Micronautics, Inc.). Tide tables from the Fort Gaines, Mobile Bay Entrance, Alabama, (reference point, 30° 15' N, 88° 04' W) were utilized north of Block 866, Mobile Area to the south shoreline of Dauphin Island. North of Dauphin Island, projected tides for Bayou La Batre, Mississippi Sound, Alabama, (reference point 30° 22' N, 88° 16' W) were applied to the soundings. Tide tables for the survey dates are located in Appendix D. A one-foot contour interval was used north of Dauphin Island and a four-foot interval was utilized south of the island to the 160-foot contour. A two-foot interval was utilized south of the 160-foot contour across the portion of the route (Maps 1-3) which crosses the MMS Pinnacle Trend Stipulation Zone.

The proposed route extends from the Alabama shoreline across the shelf to Block 261, Main Pass Area where the recently constructed "A" Structure lies in water depth of -283 feet below sea level (BSL). Seafloor gradients average 12 to 14 feet per mile (0.15°) to the 260-foot water depth in Block 247, Main Pass Area. The southerly slope increases to about 40 feet/mile (0.43°) in the northern half of Block 247, and decreases to 12 to 14 feet per mile into Block 226. North of Block 216, the grade lessens to 3 to 4 feet per mile (less than 0.04°) and is more or less constant across the shelf to Block 91 (Map 16) where the route approaches Dauphin Island.

Subtle highs and lows were generally associated with textural variations observed on the sonar and subbottom data. The small irregularities are generally insignificant with only a few feet of relief over hundreds or thousands feet of horizontal distance (Figure 2). These irregularities are associated with migrating sand bodies which produced textural variations on the side scan sonar and subbottom profiles (Figures 3, 4, & 5).

Water depths range from 0 to 15 feet mean lower low water (MLLW) north of Dauphin Island across the Mississippi Sound Area. The deepest depths occur across the Intracoastal Waterway (Map 17, Figure 1). Depths decrease south of the shipping lane towards Dauphin Island where the gradients of 5 feet per 500 feet (0.57°) occur along the northern shoreline. A smooth and featureless seafloor characterizes the Mississippi Sound Area (Maps 17-21).

4.2 Seafloor Features

Side scan sonars were utilized to map the seafloor reflectivity, existing man-made features and any obstructions which may affect the construction of the pipeline. Variations (dark and light returns) in seafloor reflectivity (Figures 3 and 12) were observed on the sonar data collected between Block 195, Main Pass Area and Block 75, Viosca Knoll Area (Maps 2 through 11) and between Blocks 955 and 866, Mobile Area (Maps 13 and 14). The darker reflectivities represent probable seabed accumulations of coarser-grained sediments or shell fragments. These variations are evident when comparing soils sampled in the following cores.

Low to Moderate Reflectivity	Dark or Strong Reflectivity
16B, 18, 18A, 19, 20B, 21B, 23, 52, 54, 76, and 176	15, 17B, 21A, 22A, 74, 75, 77, 78, and 79

Cores in the low to moderate reflectivity zones typically contain soft clay or fine granular material at the seabed, while the cores in the darker reflectivity zones have more granular or coarser (sand or shell) mixtures.

Outcrops (Figures 4 & 5) were observed in Blocks 261 and 247, Main Pass Area (Maps 1 & 2) within the area designated as the Live Bottom (Pinnacle Trend) Stipulation Area. The outcrops range from 1 to 16 feet in height and are discussed in more detail in Sections 3.0, 4.7.1, and 4.7.2

of this report. The route was designed to avoid the individual outcrops by 150 feet and construction activities utilizing seafloor moorings should avoid the locations of pinnacle zone areas. Also associated with some of these outcrop zones are potential gas or fluid vents at the seafloor (Figures 4 & 6).

Seafloor pockmarks (Figure 4) were common features along the offshore portion of the route. These features result from the de-watering or degassing of the shallow soils and disturb only the first few feet of the soils below the seafloor. No active gas venting was observed in association with the features and they are not considered an engineering constraint or hazard.

Fish and marine fauna contacts were quite numerous on the sonar records. Anchor and trawl (shrimping) scars were also quite common on the sonar records.

4.3 Near-Seafloor Sediments

The Minerals Management Service's Visual No. 3 (1983) indicates that the seafloor soils along the route are predominately composed of sand. Forty-three (43) cores ranging from 0.3 to 15.8 feet in length, were collected along the route in order to provide a detailed description of the seafloor and near-seafloor sediments. A Pneumatic Hammer Coring device was used to collect several of the core samples (Cores 1, 2, 18, 28, 30, 35B and 36). This device collects samples with a diameter of 2.75 inches and up to 20 feet in length. A Kullenburg Piston Coring device was used at the other core locations. This sampler can collect cores up to 8 feet and length and 2 inches in diameter. Each core (one to three samples per core) was analyzed in the laboratory for sediment description, moisture content, shear strength, mass specific gravity (bulk density), and wet and dry densities.

4.4 Stratigraphy

Geologic interpretation is based on pinger data in the offshore portion of the route, boomer data in the sound and nearshore portion of the route, and drop core analysis. A representative profile of the subbottom structure underlying the route was constructed from the high-resolution seismic data collected on the centerlines of the survey.

Acoustic penetration ranged from extremely limited (immediately below the seafloor) to well-stratified sequences upwards of 75 feet in thickness. Limited penetration occurred in association with the higher acoustic impedances of the sediment density variations (higher reflectivity zones). Some zones of limited penetration may also be due to minor, very low pressure accumulations of gas. These shallow gas zones should have no impact on the pipe laying activities, although the presence of the gas may reduce the shear strength of cohesive sediments (clays) which are present.

A prograding sequence of inclined and intermittent bedding planes underlies a drape sequence ranging in thickness from a few feet to 10 feet along the route across Block 261 to 226, Main Pass Area (Maps 1 & 2). These inclined bedding planes are probably the result of deltaic outbuilding which occurred during the most recent Pleistocene low sea level stand.

Across Main Pass 226, 216, and 195 (Maps 2 & 3), the pinger profiles reveal irregular to inclined patterns of reflectors overlying the acoustically transparent sequence. Acoustic voids and reflectors suggestive of channels were evident within the upper 50 feet of sediment. The acoustic void zones may represent channel fill sediment or gas saturated sediment zones. The channels become more defined to the north, as shown on the Profile Views of Maps 6 through 8. The tops of these channels

wells, pipelines and structures (Figure 6) are shown on the enclosed maps. Eight pipeline crossings are proposed south of Dauphin Island (Maps 1 - 17). All of these are buried, except for the southernmost 18-inch pipeline in Block 247, Main Pass Area (Map 2), which is exposed on the seafloor. Four additional pipeline crossings are located within the Mississippi Sound Area. Can holes, anchor drag marks, and drilling residue were additional man-made bottom disturbances observed across the area. The "A" Structure, Soco 6" Pipeline, and the Viosca Knoll Gathering 20" Pipeline in Block 261, Main Pass Area were installed after the field work (Map 1). A sunken barge and debris field (Figure 11) were identified in Block 31, Viosca Knoll Area (Map 12). An anomaly with an amplitude in excess of 1,000 gammas was recorded at the barge site. A channel marker buoy for the Intracoastal Waterway occurs 200 feet west of the route in Block 73, Mississippi Sound Area. Caution is recommended when pipeline construction operations are in proximity to the existing man-made features.

4.6 Unidentified Magnetic Anomalies and Sonar Contracts

There were 1,092 magnetic anomalies detected on the JECA survey and an additional 116 were identified on the data collected by C & C. Of these, 778 from the magnetometer data collected on the JECA survey and 78 from the C & C data were unidentified. Their positions are shown on the plan view maps with amplitude in gammas and duration in feet. The amplitude and duration of a magnetic anomaly are dependent on several factors such as the ferromagnetic content of the object, its shape, size, and distance from the sensor (Breiner, 1973). The nomogram in Appendix B provides a visual reference between a ferrous source and the amplitude of the magnetic anomaly generated when the distance from the sensor is known. The magnetic anomalies recorded on the C & C survey are listed in the C & C Table of Magnetic Anomalies in Appendix B. The JECA Magnetic Anomaly Tables are also found in this Appendix, and are grouped into those north of

Dauphin Island (Mississippi Sound Area) and those in State and Federal offshore waters which lie to the south of the barrier island.

Thirty-seven centerline anomalies were identified in the State and Federal offshore waters south of Dauphin Island and 23 were recorded in the Mississippi Sound Area for the centerlines which were surveyed by JECA. The centerline anomalies greater than 50 gammas in amplitude, side scan sonar targets within 250 feet of the route, and selected anomalies of interest in the shallower waters were investigated by divers after completion of the JECA report. The investigation sites and results of the dives are shown on each of the enclosed maps. At about half of the dive sites, no ferrous objects were found, and it is assumed that the ferrous articles of debris either lie further off line or are deeply buried in the sediment. Materials recovered and disposed of by the dive team included wire rope (cable), angle iron, welding rods, steel plates and damaged crab traps A 1-1/4" cable found in the shipping fairway in Block 75, Viosca Knoll was too large for the dive team to recover and the lay-barge will cut and pull the cable away from the route right-of-way before the pipeline is placed. Results of the diver investigations are provided in Appendix F.

Five zones of linear magnetic anomalies which could represent sections of chain or wire rope were recorded within the survey corridor. These are discussed in detail in the map description sections. Several zones of geologic anomalies, which are characterized by relatively low gamma counts and wide signature widths, were recorded on the magnetometer data collected across the area. Some of these correlated with the textural variations occurring on the sonar records and others may be associated with near-seafloor subbottom features. These geologic magnetic deflections are not considered hazardous and are not included in the tables or on the maps.

Forty-nine sonar contacts (Figures 11 - 13) were recorded on the survey data collected by JECA. Thirty of these were associated with magnetic anomalies. A review of the C & C data resulted in a total of 21 targets. Sonar contact tables are included in Appendix B and they are discussed in detail in the following section. JECA Sonar Contact 22 represents a sunken barge located in Block 31, Viosca Knoll Area (Figure 11). The table following this paragraph lists the side scan sonar contacts which were identified very near the route. The locations of the sonar contacts and magnetic anomalies should be avoided, if possible, during the construction operations.

CENTERLINE SIDE SCAN SONAR CONTACTS

SONAR NO.	BLOCK NO. and AREA	X and Y COORDINATE	SIZE and DESCRIPTION	ASSOCIATED MAGNETIC ANOMALY	MAP NO.
6	Block 31 Viosca Knoll	X = 2,271,542' Y = 10,867,832' 220' east of route	12' x 2' x .5' Linear Debris	35 gammas 50' width	Map 11
11	Block 31 Viosca Knoll	X = 1,270,414' Y = 10,873,446' 200' west of route	3' diameter Debris	None	Map 12
26	Block 31 Viosca Knoll	X = 1,270,448' Y = 10,875,543' 60' east of the route	6' diameter Debris	30 gammas 70' width	Map 12
27	Block 31 Viosca Knoll	X = 1,269,881' Y = 10,880,450'	12' x 3' Linear Debris	None	Map 12
43	Block 955 Mobile Area	X = 1,268,344' Y = 10,906,577' 100' southwest of route	12' x 2'	5 gammas 60' width	Map 13

Three of these sonar contact locations were investigated by the dive team. Two automobile tires (Site 181-A) were recovered at the location of Sonar Contact No. 26. Divers also investigated Contact 27 (Site 174) and 43 (Site 122) and could not locate any targets.

4.7 Map Descriptions

The following sections detail on a map-by-map basis the bathymetry, seafloor features, near-seafloor sediments, shallow subsurface geology, existing infrastructure and seafloor features as they relate to the pipeline construction operations. This map-by-map format should aid the reader by reducing the shuffling of maps while reviewing the report text.

4.7.1 Map No. 1

This map covers lease blocks which are located within the Minerals Management Service's Live Bottom (Pinnacle Trend) Stipulation Zone which is detailed in Section 3.0. Water depth at the southern end of the route and the site of the Block 261 Main Pass "A" Platform is -283 feet below sea level. The seafloor slopes to the south-southeast north of platform site at a gradient of about 18 feet/mile (0.20°). This gradient lessens to the south and the seafloor becomes slightly more irregular. A zone of pinnacle outcrops lies in a water depth of -298 feet at a distance of 9,000 feet south of the "A" Platform in Block 261. Another zone of pinnacles lies east of the route in the southern portion of Block 247 (Figures 4 & 5). These outcrops occur in the -274-foot to -280-foot isobath band and individual pinnacle heights within these zones were measured at seafloor heights ranging between 5 and 16 feet. These seafloor features measure 30 to 60 feet in diameter. The proposed route was designed to avoid the features and passes through an opening in the outcrops which is 260 feet in width. Gas vents were also observed in some locations within the corridor (Figure 6).

An ROV may need to be employed in order to ensure the pipeline is not spanning across any low relief outcrops which cannot be resolved with the geophysical instruments.

Subbottom profiler data recorded over 50 feet of penetration across the map area. The subbottom horizons reflect a prograding sediment sequence. A localized fault lies 400 feet south of the proposed platform location and is buried 6 feet below the mudline and downthrown to the south. A prominent fault occurs in the southern portion of Block 261 and extends across the entire survey corridor (Figure 9). The fault is downthrown to the south-southwest and is buried 4 to 5 feet below the seafloor. The upper 3 feet of Core 176 consisted primarily of a very soft, silty clay with sand pockets and shell fragments. A sandy clay was logged between 3 and 3.5 feet and a soft clay was indicated between 3.5 and 5.7 feet.

A Shell 8" Pipeline exists 2,500 feet south of the existing "A" Platform. A Soco 6" Pipeline and Viosca Knoll Gathering 20" Pipeline tie to the platform. The "A" Platform, Soco 6" Pipeline, and the Viosca Knoll Gathering 20" Pipeline were all installed after the field work. The Block 247 Well No. 1 (OCS-G-16513) lies 2,150 feet east of the route. No magnetic anomalies or sonar contacts were recorded across the bounds of the map.

4.7.2 Map No. 2

Curves 10 and 11 deviate the route to the west to avoid the surface location of the recently drilled Well Nos. 1 & 2 (OCS-G-16508) in the extreme northern portion of Block 226. C & C collected data along the route deviation. Water depths along the route range from -178 to -264 feet below sea level. Seafloor slopes are to the south-southeast with a noticeable increase in the seafloor gradient occurring south of the -220-foot isobath. Maximum seafloor gradients of 0.57° (20 feet per 2,000 feet) were calculated between the -230-foot and -250-foot contours. North of Block 247, the seafloor slope lessens and the topography becomes slightly irregular. High reflectivity zones (sediment density variations) were observed on the seafloor across Block 226. These variations represent an

increase in the granularity of the seafloor soils. The northern blockline of Block 226 is the northern boundary line of the Live Bottom (Pinnacle Trend) Stipulation Area. Two small zones of outcrops were identified 1,500 feet west of the route in the northern portion of Block 247. No individual pinnacle heights were measured within the zone and construction anchors should avoid the location. The 200-foot water depth, the depth to which the proposed pipeline is required to be buried, lies near PT 11 in Block 226, Main Pass Area.

Subbottom penetration on the pinger profiles was over 50 feet across the map bounds. Two acoustic void zones and a normal fault were mapped along the route at a depths below the seafloor which are greater than 10 feet. Core 52, 3.5 feet in length, showed the near-seafloor soils consist primarily of silty sand with shell fragments.

The Amoco 18" Pipeline is the only known man-made feature within the survey corridor. The pipeline is not buried and lies in a water depth of -229 feet BSL. No unidentified magnetic anomalies or side scan sonar contacts were identified within this portion of the survey corridor.

4.7.3 Map No. 3

The alternate portion of the route, due to a recently drilled well site, ties back to the original in the central portion of Block 216, Main Pass Area. The seafloor ranges in depth from -144 to -176 feet BSL across the map limits. A 4-foot contour interval is presented north of the 160-foot isobath and a 2-foot interval is exhibited to the south. The seafloor is irregular north of the 160-foot contour with numerous topographic highs and depressions on the order of 2 to 4 feet (Figure 2). This type of topography is often associated with near-seafloor sediments composed of sand. High reflectivity

zones were identified on the sonar data collected across the map area. These are areas where coarse-grained sediments or accumulations of shells exist.

Subbottom profiler data suggest that there are some possible channels underlying the route at depths which are much greater than the pipeline burial depth. Core 54 was sampled near the northern end of the realignment in Block 216, Main Pass Area. The sediment sampled indicated the near-seafloor soils consist primarily of sand. A gray, medium-fine sand was logged in the upper 3.3 feet. A gray, clayey medium-fine sand was logged between 3.3 feet and 3.8 feet. Coarser-grained sands or shell hashes can be anticipated on the seafloor in the shaded sediment variation zones shown on the plan view map.

The route crosses a Centana 20" Pipeline in the central area of Block 216, Main Pass Area. Water depth at the crossing position is -167 feet BSL. The abandoned Well No. 1 (OCS-G-14578) lies 650 feet west of the route in Block 195. An anomaly of 230 gammas in amplitude and 250 feet in width was recorded in Block 216. The anomaly was very near the original route and the site was investigated by divers (Site 221). The divers found a 1-1/4" piece of wire rope existing about 100 feet east from the original route. The cable was about 40 feet in length and was coiled in 8-foot loops at one end. A small centerline magnetic anomaly measuring 5 gammas in amplitude and 100 feet in duration was recorded in the southern portion of Block 195.

4.7.4 Map No. 4

The seafloor undulates between -140 and -148 feet BSL across the map limits. These undulations are apparently due to migrating deposits of sand. Sediment density variations also occur which are

an indication of nonhomogeneous seafloor sediments (Figure 12). These areas shaded on the map are probably due to accumulations of shell.

Subbottom profiles indicated an erosional valley is buried in the northern portion of the survey area. A fine sand was logged in both of Cores 69 and 70 which lie a significant distance to the east of the route.

JECA Sonar Contact No. 1 was recorded 1,000 feet east of the route in Block 191 (Figure 12). A 7-gamma anomaly with a 100-foot duration was associated with the target. The target consists of two pieces of debris with the larger measuring 10' x 4' x 2.5' and the smaller measuring 5' x .5' x .2'.

4.7.5 Map No. 5

The route crosses the Viosca Knoll-Main Pass Area boundary in the southern portion of the map area. Seafloor depths range from -132 to -148 feet BSL. The regional slope is to the south and irregularities occur in association with sediment density variations (higher reflectivity zones).

Pinger data show an acoustically turbid sediment sequence with discontinuous reflecting horizons present. An erosional valley was recorded 10 feet below the seafloor in the extreme southern portion of the map. Core 71, 3.0 feet in length, revealed a soil type of fine sand. Three feet of silty sand was recorded at the location of Core 72.

No sonar contacts, magnetic anomalies or man-made features occur within the bounds of the chart.

4.7.6 Map No. 6

Bathymetric contours show the seafloor topography is slightly irregular with depths ranging between -120 and -128 feet BSL. The sonar data show the seafloor to be covered with zones of sediment density variations. North of Block 383 and 384, Viosca Knoll Area, the high reflectivity becomes homogeneous across the entire survey area.

Pinger data recorded discontinuous reflectors of varying amplitudes. Channel features were identified at a depth of 8 feet below the seafloor in Blocks 339 and 340, Viosca Knoll Area. These features should not be impacted by the pipeline burial operations. Cores 73, 74, 75, and 79 were sampled across the chart limits. These cores ranged in length from 3 to 5 feet and contained medium to coarse sand with shell fragments. The upper foot of Core 79 contained a very soft clay.

No man-made features, sonar contacts, or magnetic anomalies exist across the map bounds.

4.7.7 Map No. 7

C & C surveyed an alternate route across the Pascagoula Fairway, however, Transco decided to go with the original alignment. Water depths range from less than -116 feet BSL to slightly more than -124 feet BSL. Some low relief irregularities occur along the route in association with the migration of seafloor sand deposits.

Seafloor channels were observed buried 5 to 6 feet below the seafloor in the extreme southern portion of Block 295. The pinger profiles suggest the near-seafloor sediments are composed primarily of sand. Cores 76, 77, 78 and 15 were sampled within the chart limits. Medium to coarse sand was found in each of sediment samples.

The locations of the magnetic anomalies found across the northern half of Block 295 and 296 should be avoided by the pipeline construction operations.

4.7.8 Map No. 8

The route crosses the Pascagoula Fairway in the northern portion of Block 251, Viosca Knoll Area. The pipeline is required to be buried 10 feet below the mudline across the shipping lane. Route depths range from shallower than -116 feet BSL over the topographic high areas in Block 251 to -124 feet BSL in the bathymetric low area in the northern portion of Block 251. The sediment density variation zones exist over the topographic high areas in Block 251.

Pinger profiles revealed a uniform reflecting horizon representing an unconformable surface across the map area. A large channel system was observed buried 8 to 10 feet below the seafloor in the northern portion of Block 251, Viosca Knoll Area. Some seafloor subsidence was associated with the channel position. Cores 16B, 17B and 18 were sampled along the proposed route. Five feet of a fine to medium sand was recovered at the location of Core 16B and 3.5 feet of a similar sediment type were logged at the location of Core 17B. Core 18 was sampled in the central area of the Pascagoula Fairway with a Pneumatic Coring Device. This sediment sample consisted of silty, very fine sand in the upper foot and gray sand with a silt and clay horizon occurring between 1 and 2.5 feet.

No existing man-made features occur in close proximity to the route. Three small magnetic anomalies occur on the centerline. The low gamma counts associated with these anomalies suggest they are minor articles of debris. The 8-gamma anomaly with the 200-foot duration may be caused by the subbottom channel margin. C & C Sonar Contact Nos. 3, 7, and 17 exist within the limits of

the map. These contacts are all a significant distance from the route and should not be impacted by the construction operations.

4.7.9 Map No. 9

Water depth across the chart averages about -120 feet BSL. The northern boundary of the Pascagoula Fairway lies in Block 163, Viosca Knoll Area.

Pinger profiles revealed discontinuous reflectors and horizons suggestive of channels across the area. Cores 18A, 19, and 20B were sampled along the route. Fine and silty sand was logged in each of the samples. The recovery lengths ranged between 3 and 5 feet.

A number of sonar contacts were recorded across the chart area, however, none of these are in close proximity of the route. Divers investigated four centerline magnetic anomaly locations within Block 163, Viosca Knoll Area. The divers could not locate any ferrous debris at three of the four sites investigated. The divers recovered two pieces of 3/4" wire rope measuring 8 feet and 12 feet in length at the location of the 30-gamma, centerline magnetic anomaly (Site 208).

4.7.10 Map No. 10

Seafloor depths across the chart limits range from -108 to -116 feet BSL. The profile along the route depicts a broad, topographic high or ridge with the crest centered in Block 119. The orientation of the ridge is roughly east-west and the northern side is steeper and more irregular than the smooth slope of the south side. The gradient on the northern side of the ridge is 0.57° (8 feet of vertical relief over a distance of 800 feet). Patchy high reflectivity zones (sediment density variations) occur across the map bounds (Figure 3).

The subbottom profiles show evidence of an unconformable surface buried 3 to 10 feet along the proposed route. A sand body deposit which may be a remnant shoal appears to overlie the unconformable surface and evidence of channel downcutting was observed along the unconformable surface. Core 21B was sampled on the crest of the topographic high and Core 21A was taken near the base of the low relief ridge in a high reflectivity zone. Core 21B was 3 feet in length and was described as a black, coarse sand with shell hash. The sand contained in the 5-foot sample of Core 21B was finer and clay pockets were noted.

A few isolated magnetic anomalies were recorded across the map limits. No sonar contacts were associated with the anomaly positions. A number of sonar contacts were identified on the C & C data collected east of the route and none of these were associated with magnetic anomalies. A small 3-gamma anomaly with a 150-foot signature was recorded very near the route on the C & C survey data. The anomaly was not confirmed on the JECA data and may be caused by geology.

4.7.11 Map No. 11

Water depths across the chart range from shallower than -104 feet BSL to deeper than -112 feet BSL. The seafloor slope is to the south at a gradient which less than 0.06°. The sediment variation zones form narrow bands oriented northwest to southeast across Viosca Knoll 75. These zones are absent in survey corridor north of the central portion of Block 75.

Pinger profiles show some evidence of near-seafloor channels in the southern half of Block 75. Core 22A was taken in the southern half of Block 75 in a sediment density variation zone. The 5.5-foot core was described as a silty medium sand with a few shell fragments. Core 23 was sampled in the central area of Block 75. The 5-foot of sediment recovered consisted of a silty medium sand and a

medium sand with shell fragments. Only a small amount (0.3 feet) of silty-medium sand with shell fragments was recovered at the Core 24 location.

An Enron 6" Pipeline crosses the route in Block 31 and ties to the "A" Structure. The "A" Structure exists 2,000 feet east of the route. Centerline magnetic anomalies with amplitudes of 5, 9, 10, and 12 gammas were recorded across the chart. The amplitudes indicate that they are relatively minor articles of ferrous debris, although the broad 450-foot signature width of the 10-gamma anomaly suggests a significant mass which is a considerable distance off line. Divers investigated this location and found nothing within a 100-foot radius of the magnetic anomaly. The 12-gamma anomaly position was also investigated and the divers discovered a 1-1/4" wire rope or cable. The divers did not remove the cable which will be cut back and moved away from the pipeline installation. JECA Sonar Contacts 4-9 were identified across the southern portion of Block 31 where the line spacing is 50 meters. Contact No. 6 (X = 1,271,542', Y = 10,867,832') lies 220 feet east of the route and appears as 12' x 2' x .5' piece of linear debris. A 35-gamma anomaly with a 50-foot signature width was associated with target position. Contact No. 9 lies 500 east of the route in Block 31 and measures 2' x 2'.

4.7.12 Map No. 12

Route depths range from less than -88 feet BSL in the north to -104 feet BSL in the south. The seafloor gradient averages about 5 feet/mile (0.05°). Transco altered the original route in order to make the route distances across the Gulf Outlet and Horn Island Pass Fairways as short as possible. Additional survey coverage was collected by C & C across the shipping lanes.

Core 25B indicates the seafloor sediments consist primarily of a very soft clay in the upper 4.5 feet of sediment. A sandy clay was recovered between 4.5 and 5.3 feet. No sediment was recovered at the Core 26 location. Over 25 feet of sediment was resolved on the pinger profiles which revealed a sediment column consisting of discontinuous reflectors which generally parallel the seafloor.

A Dauphin Island 12" Pipeline lies east of the route and intersects the survey corridor at an acute angle. A sunken barge and associated debris field lies in the eastern portion of the survey corridor (Figure 10 & 11). A linear string of sonar contacts and magnetic anomalies occurs northwest of the barge location suggesting this was the direction from which vessel came before it settled to the bottom. JECA Sonar Contact No. 26 occurs within this debris trail and lies 60 feet east of the route. JECA Contact No. 11 exists 200 feet west of the route and measures 6 feet in diameter. Divers investigated the site (181-A) and found 2 automobile tires. JECA Contact No. 27, a linear target, lies 60 feet east of the route and measures 12' x 3'. Divers investigated the sonar target site (174), but could find no source for the target. No magnetic anomalies were associated directly with either JECA Contact No. 11 or 27. JECA Contact No. 33, which lies in Block 999, Mobile Bay Area, was also investigated by the dive team (Site 1225 & Figure 13). The sonar target appears as a depression measuring 30 feet in diameter with debris located inside the outside circumference. The divers recovered a single piece of 36" inside diameter culvert measuring 10 feet in length and sticking 5 feet off the bottom. Several PVC pipes were also found at the location which was apparently constructed as a fish haven. The divers also investigated (Site 166) an anomaly along the original route which measures 6-gammas in amplitude with a 100-foot signature width duration. An 8-foot long, 3" O.D. pipe was found at the locality. Additional sonar contacts and magnetic anomalies were recorded across the map area and the locations should be avoided when possible.

4.7.13 Map No. 13

Water depths across the survey corridor range from -72 feet BSL in the north to -85 feet BSL in the south. The seafloor slope is to the south at an average gradient of 3.5 feet/mile (0.04°). Seafloor sediment variations were mapped in the extreme northeastern corner of the map bounds.

Pinger profiles revealed discontinuous, parallel reflectors underlying the route. A subbottom channel is buried at a depth of 5 feet below the seafloor at the southern end of the Fairway. Core 27 was taken in the southwest corner of Block 955, Mobile Area. A silty fine sand, 1-foot in length, was recovered. A hammer core, shown with the asterisk, and a gravity core were sampled at the Core 28 locations within the Gulf Outlet Fairway. The hammer core recovery length was 6.7 feet and the piston coring device recovery length was 4.5 feet. Both of these cores indicate the near-seafloor soils within the upper 3.5 feet are composed primarily of silty sand. A firm clay was identified below 4.8 feet in the hammer core. Vane shear within the clay zone was measured at 633 lbs./sq.ft., the maximum vane shear measured for the cohesive soils recovered along the route.

A number of magnetic anomalies lie within 50 feet of the centerline, however, most of these are of small duration and represent relatively minor articles of ferrous debris. An exception is the 210-gamma anomaly with a 50-foot signature width recorded in Block 999, Mobile Area. JECA Sonar Contact No. 43 (X = 1,268,344'; Y = 10,906,577') lies about 75 feet southwest of the route in Block 955, Mobile Area. A small 5-gamma anomaly (JECA) with a 60-foot signature width occurs in association with JECA Contact No. 43 which measures 12' x 2'. Divers investigated the location (Site 122) and could not find any source for the contact or the anomaly. Divers investigated three other sites along the original route and recovered a steel plate and a piece of cable (Site 116 & 133) at two of the locations. The remaining dive investigation site (123) occurs in a zone where the

spatial distribution (linear) of the magnetic anomalies within the Gulf Outlet Fairway suggests a passing ship or ships have lost or discarded debris while utilizing the shipping lane. The divers recovered a 20-foot long section of 1" diameter pipe buried 1.5 feet in the sand. The pipe had generated an anomaly with an amplitude of 61 gammas. The abandoned Well No. 1 (OCS-G-05757) exists 900 feet east of Curve No. 5. A Murphy 12" Pipeline crossing occurs in Block 955, Mobile Area. A Dauphin Island Gathering Partners 12" Pipeline is permitted parallel to and northeast of the Transco route.

4.7.14 Map No. 14

Seafloor depths across the map range from -64 feet BSL at the northern match line to -72 feet BSL at the southern match line. Some subtle seafloor undulations on the order of 1 to 3 feet occur in southern portion of Block 911. Seafloor sediment variations were associated with the low ridge and trough features. A sand stringer is oriented northwest to southeast in the northern portion of Block 910.

Pinger profiles collected revealed an acoustically turbid sediment sequence with discontinuous reflectors. A near-seafloor channel system exists along the mutual boundary of Blocks 866 and 910 (Figure 7 & 13). These channels are buried 2 to 3 feet below the seafloor and will be impacted when the pipeline is buried to the required 10- foot burial depth. Core 29B was taken between the shipping lanes in Block 910, Mobile Area in the vicinity of where sediment variation zones were observed on the seafloor. A medium sand measuring 1.5 feet in length was recovered at the site of Core 29B. Cores 30, 30A and 30B were taken in the central portion of the Fairway in Block 866 and 910, Mobile Area. Core 30, which is shown with an asterisk, was a hammer core sample. This sample penetrated to a depth of 8.7 feet and penetrated a wide variety of sediment zones. The upper 2.2 feet

of sediment was described as a sand. Soft clay and a soft sand, silt, and clay mixture were logged between 2.2 and 3.5 feet. Between 3.5 and 6.0 feet, clayey silt was described and below 6 feet, thin layers of clay, sand and silt were noted. Ferrous oxide stains, and indication of subaerial exposure, were observed between 2.2 and 6.0 feet. A medium sand of 3.0 feet in length was logged in Core 30A. Core 30B was sampled in the thalweg of a near-seafloor subbottom channel. The upper foot of sample was a medium sand and a very soft clay was logged between 1 foot and 5.2 feet. Shell fragments were also contained in the sample. Burial operations can anticipate low to moderate resistance through the clay zones which have filled the subbottom channel.

There are a number of anomalies with relatively low amplitudes and broad signatures recorded along the margins of the buried channels located within the Horn Island Pass Fairway. Differences in the ferromagnetic properties of the channel fill and bounding deposits probably resulted in these magnetic anomalies. There were three zones of debris located in the western portion of the route corridor in Block 910, Mobile Area (Figure No. 14). There are a few magnetic anomalies clustered in the vicinity of these debris zones, but much of the debris appears to be nonferrous as no large scale magnetic deflections were associated with the zones. Pipeline construction barges should avoid the debris zones as potential mooring locations. Divers investigated 3 locations along the original centerline and found a rusty 55 gallon drum lid and a 4-foot pipe measuring 3 ½" in diameter at two of the sites.

4.7.15 Map No. 15

The northern boundary of the Horn Island Fairway Crossing exists in the southern portion of the map. The southern boundary of a Corp of Engineers Disposal Area extends east-west across Block 866, Mobile Area. The seafloor slope is to the south-southwest across the chart limits with the water

depth increasing from -48 feet mean lower low water (MLLW) to -64 feet BSL. The seafloor gradient averages 4 feet/mile (0.04°) and water depth at the site of the proposed Transco Junction Platform is -52 feet MLLW.

Pinger profiles revealed portions of 2 buried channel systems in the eastern half of the survey corridor. Subbottom channels were observed at 4 feet and 10 feet below the mudline. Core 31A was sampled at a location where near-seafloor organics were interpreted on the pinger profiles. The sediment sample was 5 feet in length with sand occurring in the upper foot. A very soft, sandy clay was logged between 1 and 3 feet and the remainder was silty fine sand. Core 32, 5.3 feet in length, contained a silty fine to medium sand. Ferrous oxide stains, suggestive of a subaerial event, were noted in bottom portion of the core.

Two pipeline crossings exist along this portion of the 24" route in Block 822. The Chevron 10" Pipeline was constructed after the survey was completed and is shown from as-built information only. The Dauphin 20" Pipeline also crosses the route and connects to the Block 822 "A" Structure in the western portion of the survey corridor. A linear string of magnetic anomalies representing a probable cable occurs east of the route in Block 822. Divers investigated two magnetic anomaly positions and could locate no source at either site.

4.7.16 Map No. 16

The 3-Mile Line is the boundary line between the Mobile and Northwest Gulf Areas, the Federal and Alabama State waters, and the U.T.M. Zone 16 and Alabama West Coordinate Systems. Water depth increases to the south from -24 to -48 feet MLLW. Slope between the -24-foot and -28-foot isobath bands is calculated at 0.14°.

Boomer data revealed low to medium amplitude reflectors which generally parallel the seafloor. Buried channels were identified on the subbottom data at depths greater than 15 feet in some localities (Figure 8).

A Dauphin 8" Pipeline has been permitted across the route in Block 58, Mississippi Sound Area. An Arco 12" and an Offshore Energy Development 20" Pipeline lie west of and subparallel to the route. One small centerline anomaly (7 gammas) was recorded in Block 58, Mississippi Sound. Divers investigated three sites which are off the centerline. Wire rope was found at two of the locations and nothing was recovered at the third.

4.7.19 Map No. 19

Water depths range from less than -4 feet MLLW in Curve No. 2 to -8 feet MLLW in southern portion of the map.

Subbottom penetration ranged from near 0 feet to 16 feet in the southern portion of the work area. Core 1 was sampled with the pneumatic hammer device. A 5-foot sediment sample of fine sand was recovered at the location.

The Arco 12" and Offshore Energy Development 20" Pipelines parallel the route to the west. A number of relatively minor magnetic anomalies exist in proximity of Curve No. 1. Divers investigated two magnetic anomalies in Curve No. 2. A crab trap and piece of 2-foot long wire rope were recovered.

4.7.20 Map No. 20

Route depths range from -4 feet MLLW in the south to just over -5 feet MLLW in the trough in Block 47, Mississippi Sound.

Very little subbottom information was imaged on the subbottom profiles.

An Arco 12" and Offshore Energy Development 20" Pipeline parallel the route to the west. Ten centerline anomalies were recorded across the chart. The amplitude and signature width of these suggests that they represent relatively minor articles of ferrous debris. Three of the larger ones were investigated and 2 crab traps and a 2' x 2.5' steel plate were retrieved.

4.7.21 Map No. 21

Water depth averages about 4.5 feet MLLW across the map limits. The pipeline is proposed to be bored under the beach and oyster leases near the coastline. Water depth is -4 feet MLLW at the exit bore location. The total horizontal length of the proposed boring is 2,600 feet.

The Arco 12" and Energy Development 20" Pipelines parallel the route to the west. A marker post exists 100 feet east of the route at a distance of 2,950 feet from the shoreline. Divers investigated two locations of the centerline magnetic anomalies. The divers recovered a crab trap at one location (Site 10) and nothing at the other (Site 15).

5.0 CONCLUSIONS AND RECOMMENDATIONS

- Water depths along the 24" route range from -283 feet BSL in Block 261, Main Pass Area to -52 feet MLLW at the proposed Junction Platform in Block 822, Mobile Area.
- Pinnacle and outcrop zones were identified in Blocks 261 and 247, Main Pass Area. The pipeline was designed to avoid the pinnacles, however, an ROV inspection of the pipeline may be prudent in Block 247, Main Pass Area where the route is near the outcrop zones.
- No areas other than the outcrop zone in Block 247, Main Pass Area were identified as having the potential for pipeline span.
- Sand and silty sediments are the primary sediment type found along the routes. The highest shear strength measured for the cohesive soils was 633 lbs./sq.ft. Some flowback of granular sediments may occur during the trenching operations.
- Caution should be used when working in the vicinities of the existing structures, pipelines and wells.
- A number of the larger magnetic anomalies and sonar contacts nearest the centerline were investigated by a dive team. The divers recovered a variety of ferrous plates, pipes, flat plates, angle iron, wire rope. Most of these items were removed and disposed of.
- Anchors used in the pipeline construction and subsequent maintenance should avoid the locations of the magnetic anomalies and sonar contacts.

Near-seafloor buried channel systems were mapped across the survey corridor in Block 91, Northwest Gulf Area. Cores 33 and 34 were sampled very near the 3-Mile Line crossing within the C.O.E. Disposal Area. Fine sands were found in both of the samples which were 5.0 and 5.5 feet in length, respectively.

An unidentified structure occurs in the extreme southwestern portion of map limits. An Offshore Energy Development 4" Pipeline crosses the route in Block 822, Mobile Area and two Dauphin 12" Pipelines run subparallel to the route to the west. The reported location of fishing vessel, *F/V On-Time,* is shown on the map. No evidence of the foundered vessel was presented on the geophysical instruments. Two linear strings of magnetic anomalies lie within the chart bounds. The southernmost string parallels the 3-Mile Line and extends east from the route for a distance of 1,500 feet. Divers (Site 82) investigated the westernmost anomaly of this linear string, but could locate nothing. No cable was found, but a large deteriorated valve handle was found. Another string of anomalies lies 150 feet east of the route and extends eastward for a distance of 1,000 feet across Block 91. These anomalies are characterized by low gamma counts and relatively broad signature widths. Divers found a piece of slate and a chunk of iron ore slag at the location of the 23-gamma, 60-foot duration magnetic anomaly on the centerline (Site 75).

4.7.17 Map No. 17

A borehole, 2,300 feet in length, through which the pipeline is to be pulled is proposed for the Dauphin Island crossing. Water depth at the entrance point is -6 feet MLLW and at the exit point the water depth is -18 feet MLLW. The seaward flank of Dauphin Island is steeper (0.80°) than the northern side. The steepest slopes on the north side of the barrier island exist between the -8-foot

Near-seafloor buried channel systems were mapped across the survey corridor in Block 91, Northwest Gulf Area. Cores 33 and 34 were sampled very near the 3-Mile Line crossing within the C.O.E. Disposal Area. Fine sands were found in both of the samples which were 5.0 and 5.5 feet in length, respectively.

- An unidentified structure occurs in the extreme southwestern portion of map limits. An Offshore Energy Development 4" Pipeline crosses the route in Block 822, Mobile Area and two Dauphin 12" Pipelines run subparallel to the route to the west. The reported location of fishing vessel, *F/V On-Time,* is shown on the map. No evidence of the foundered vessel was presented on the geophysical instruments. Two linear strings of magnetic anomalies lie within the chart bounds. The southernmost string parallels the 3-Mile Line and extends east from the route for a distance of 1,500 feet. Divers (Site 82) investigated the westernmost anomaly of this linear string, but could locate nothing. No cable was found, but a large deteriorated valve handle was found. Another string of anomalies lies 150 feet east of the route and extends eastward for a distance of 1,000 feet across Block 91. These anomalies are characterized by low gamma counts and relatively broad signature widths. Divers found a piece of slate and a chunk of iron ore slag at the location of the 23-gamma, 60-foot duration magnetic anomaly on the centerline (Site 75).

4.7.17 Map No. 17

A borehole, 2,300 feet in length, through which the pipeline is to be pulled is proposed for the Dauphin Island crossing. Water depth at the entrance point is -6 feet MLLW and at the exit point the water depth is -18 feet MLLW. The seaward flank of Dauphin Island is steeper (0.80°) than the northern side. The steepest slopes on the north side of the barrier island exist between the -8-foot

and -14-foot isobaths. The maximum slope along this ridge was measured at 1.27°. Maximum water depth across the Intracoastal Waterway is -15 feet MLLW (Figure 1).

Only a few reflectors were present on the subbottom profiles across the chart limits. Cores 35B and 2 were sampled with the Pneumatic Hammer near the location of the borehole entrance and exit points. Both cores penetrated to depths of just over 15 feet. Soft to firm clays were the primary sediment recovered on the south side of Dauphin Island. At the borehole entrance point, Core 2 revealed the upper 8.3 feet of sediments consist primarily of sand. Very soft clays can be anticipated at the borehole entrance location between 8 and 15 feet. A hammer core (Core 36) was also taken within the central area of the Intracoastal Waterway. The core penetrated to a depth of 12.4 feet below the mudline and consisted of very soft silty clays. Organics were noted in the upper 4 feet of the core and the highest shear strength values measured were 107 lbs./sq.ft.

Three Arco 6" Pipelines cross the route in Block 73, Mississippi Sound Area. Divers investigated all of the centerline anomalies. Wire rope, flat bars, welding rods, and twisted sheet metal were recovered. An old Intracoastal Waterway beacon and wire rope with a possible anchor still attached were found within the shipping channel.

4.7.18 Map No. 18

Water depth across the map ranges from shallower than -9 feet MLLW to slightly deeper than -10 feet MLLW.

Boomer data revealed low to medium amplitude reflectors which generally parallel the seafloor. Buried channels were identified on the subbottom data at depths greater than 15 feet in some localities (Figure 8).

A Dauphin 8" Pipeline has been permitted across the route in Block 58, Mississippi Sound Area. An Arco 12" and an Offshore Energy Development 20" Pipeline lie west of and subparallel to the route. One small centerline anomaly (7 gammas) was recorded in Block 58, Mississippi Sound. Divers investigated three sites which are off the centerline. Wire rope was found at two of the locations and nothing was recovered at the third.

4.7.19 Map No. 19

Water depths range from less than -4 feet MLLW in Curve No. 2 to -8 feet MLLW in southern portion of the map.

Subbottom penetration ranged from near 0 feet to 16 feet in the southern portion of the work area. Core 1 was sampled with the pneumatic hammer device. A 5-foot sediment sample of fine sand was recovered at the location.

The Arco 12" and Offshore Energy Development 20" Pipelines parallel the route to the west. A number of relatively minor magnetic anomalies exist in proximity of Curve No. 1. Divers investigated two magnetic anomalies in Curve No. 2. A crab trap and piece of 2-foot long wire rope were recovered.

4.7.20 Map No. 20

Route depths range from -4 feet MLLW in the south to just over -5 feet MLLW in the trough in Block 47, Mississippi Sound.

Very little subbottom information was imaged on the subbottom profiles.

An Arco 12" and Offshore Energy Development 20" Pipeline parallel the route to the west. Ten centerline anomalies were recorded across the chart. The amplitude and signature width of these suggests that they represent relatively minor articles of ferrous debris. Three of the larger ones were investigated and 2 crab traps and a 2' x 2.5' steel plate were retrieved.

4.7.21 Map No. 21

Water depth averages about 4.5 feet MLLW across the map limits. The pipeline is proposed to be bored under the beach and oyster leases near the coastline. Water depth is -4 feet MLLW at the exit bore location. The total horizontal length of the proposed boring is 2,600 feet.

The Arco 12" and Energy Development 20" Pipelines parallel the route to the west. A marker post exists 100 feet east of the route at a distance of 2,950 feet from the shoreline. Divers investigated two locations of the centerline magnetic anomalies. The divers recovered a crab trap at one location (Site 10) and nothing at the other (Site 15).

5.0 CONCLUSIONS AND RECOMMENDATIONS

- Water depths along the 24" route range from -283 feet BSL in Block 261, Main Pass Area to -52 feet MLLW at the proposed Junction Platform in Block 822, Mobile Area.
- Pinnacle and outcrop zones were identified in Blocks 261 and 247, Main Pass Area. The pipeline was designed to avoid the pinnacles, however, an ROV inspection of the pipeline may be prudent in Block 247, Main Pass Area where the route is near the outcrop zones.
- No areas other than the outcrop zone in Block 247, Main Pass Area were identified as having the potential for pipeline span.
- Sand and silty sediments are the primary sediment type found along the routes. The highest shear strength measured for the cohesive soils was 633 lbs./sq.ft. Some flowback of granular sediments may occur during the trenching operations.
- Caution should be used when working in the vicinities of the existing structures, pipelines and wells.
- A number of the larger magnetic anomalies and sonar contacts nearest the centerline were investigated by a dive team. The divers recovered a variety of ferrous plates, pipes, flat plates, angle iron, wire rope. Most of these items were removed and disposed of.
- Anchors used in the pipeline construction and subsequent maintenance should avoid the locations of the magnetic anomalies and sonar contacts.

6.0 ARCHAEOLOGICAL ASSESSMENT

6.1 Introduction

This document presents the evaluation of the high resolution geophysical data for the proposed Transco 24-inch and 30-inch pipelines offshore of Alabama. The data have been assessed for evidence of historic shipwrecks and high probability areas for prehistoric archeological sites associated with formerly subaerially exposed landforms. The lease tracts are in an area of high probability for historic and prehistoric cultural Resources (U.S. Department of the Interior, Mineral Management Service [USDI MMS] 1991; USDI MMS 1986:Visual 1; Coastal Environments, Inc. [CEI], 1977). Regional and Vicinity Maps in the hazard report show the survey locations in relation to the Alabama coast.

The proposed pipeline will originate at the "A" Platform in Main Pass Area Block 261, and transects Blocks 247, 226, 216, 195, 191, Main Pass Area, Viosca Knoll Area Blocks 428, 427, 383, 339, 295, 251, 207, 163, 119, 75, and 31, and Mobile Area Blocks 999, 955, 954, 910, 866, and 822. It crosses Alabama state waters in Blocks 110 and 91, Northwest Gulf Area, and Dauphin Island, enters the Mississippi Sound Area Block 73, then crosses Blocks 72, 58, and 46, to come ashore in Block 47. All of the Blocks north of Main Pass Blocks 215 and 216 require and archeological assessment.

A 24-inch pipeline will be laid from the point of origin in Main Pass Area to a proposed junction platform in Mobile Area Block 822. From this site to shore, a 30-inch pipeline is proposed.

An Archeological, Engineering, and Hazard Study along the original proposed route was prepared by John E. Chance and Associates, Inc. (CHANCE), for Transco Production and Exploration Company in March of 1997. In September, 1997, C&C Technologies, Inc. (C&C) conducted a geophysical survey and prepared an Archeological, Engineering and Hazard report for Transcontinental Gas Pipe Line Corporation addressing three alternate rights-of-way.

The southernmost realignment (Alternate I) avoids an existing well drilled very near the original centerline in Main Pass Block 226. Alternate II and Alternate III are located at the crossings of existing navigation fairways or ship channels, and were conducted to shorten the transect of the pipeline across these fairways. Alternate II was between Blocks 295 and 119, Viosca Knoll Area, crossing the Pascagoula Fairway, and was abandoned to follow the original route. The Alternate III route crossed the Gulf Outlet Fairway and the Horn Island Pass Fairway between Blocks 999 and 822, Mobile Area.

In December, 1997, Transco contracted C&C to produce a single report incorporating the latest route revisions, the results of diver investigations by Oceaneering conducted in July and August, 1997, and additional engineering data provided by Transco.

The JECA survey of the proposed ROW was conducted onboard six different vessels: the *M/V Polo Pony*, in September, October and November, 1996; the *R/V Kit Jones*, September, 1996; the *M/V Mr. Adam* in September, 1996; the *R/V Seis Surveyor* in December 1996; the *M/V Miller Divers III* in January, 1997; and the *M/V L'Arpenteur* in February, 1997. Sea state was variable from one to five feet, allowing adequate data acquisition.

Horizontal positioning was provided by the JECA STARFIX satellite navigation system. Systems used on the *M/V Polo Pony* for the offshore survey include an Applied Microsystems SVP-16 Velocimeter, an Echotrac Bathymetric system, an EG&G SMS-260 side scan sonar, a Geometrics 801/803 proton magnetometer, and an O.R.E. 3.5 kHz Pinger Profiler. These systems were also used on the *R/V Kit Jones*, although a Boomer Profiler was substituted for the Pinger. Skiffs, the *M/V Mr. Adam* and the *M/V Miller Divers III* utilized the Echotrac Bathymetric system and the Geometrics magnetometer. Gravity piston cores were gathered with a Modified Kullenberg Coring device along the centerlines.

The original survey grid was comprised of eight sets of parallel primary lines providing coverage extending 300 meters to each side of the ROW in the offshore waters. Two sets of lines were run at 300-meter offsets, and three sets were spaced at 50-meter intervals. The Mississippi Sound Area grid consisted of three sets of parallel lines spaced 50 meters apart. Investigation lines were run to check sonar targets and magnetic anomalies. Other lines included reruns to assure data quality and complete coverage as well as tangents to the pipeline curves. Navigation fixes (shot points) corresponding with the position of the navigation antenna are annotated at 150-meter intervals along all survey tracks.

The C&C survey was conducted onboard the *R/V Ocean Surveyor* between June 25 and July 1, 1997. Sea state was one to three feet, allowing adequate data acquisition.

Horizontal positioning was provided by SATLOC's L-Band differential correction system with differential GPS, while a U.S. Coast Guard beacon was referenced as a back-up source of differential corrections. The geophysical instrumentation included a Simrad EM-1000 Multibeam and Imaging

System, a Geometrics G-880 Cesium Magnetometer, and a Datasonics SIS-1000 Sonar and Subbottom Profiler. Water column velocity data were gathered with a SeaBird Seacat 19 CTD Profiler. The data were of good quality and tie well from line to line. Specifications published by the USDI MMS for hazard and cultural resources surveys were met.

The C&C Alternate I centerline follows an existing CHANCE survey line, Line 177, 1,000 feet west of the first proposed route. Lines surveyed for this route include lines tangent to the pipeline curves and an additional survey line parallel to and west of the original set of survey lines to cover the lay-barge anchor spread. Although Block 226 Main Pass is outside of the zone of lease blocks requiring an archeological assessment, the extension of this line into Block 216, Main Pass Area, does require an assessment. Survey lines along the Alternate II route included new center lines and a line spacing of 300 meters for the transect of the Pascagoula. The line spacing for Alternate III, the northernmost route, was at 50-meter intervals. Navigation fixes (shot points) corresponding with the position of the navigation antenna are annotated at 150-meter intervals along all survey tracks.

The figures, tables, maps and other pertinent information may be found in the appendices following the report text. Selected examples of the data are presented as figures in Appendix A. Appendix B contains the tables of the magnetic anomalies from the JECA and C&C surveys, along with the X-Y coordinates of the unidentified magnetic anomalies and a user's guide and nomogram. The tables of side scan sonar contacts is included in this Appendix. The descriptions of the geophysical instrumentation and the navigation system, the instrument settings, the diagrams of the survey vessels and the sensor towing configurations, the lists of the survey and office personnel, and copies of the daily survey logs, with information on the sea state, weather conditions, and other commentary by the operators, may be found in Appendix C. In Appendix D are the velocimeter data lists and

profiles, as well as the tidal curves showing the daily fluctuations for the survey days. The analysis of the cores comprise Appendix E, and in Appendix F are the results of the Oceaneering divers investigations of magnetic anomalies and sonar targets conducted in July and August, 1997. There are 21 Archaeological, Engineering and Hazard Maps. The maps in the State and Federal waters south of Dauphin Island are produced at a scale of one inch equals 1,000 feet, and those showing shallow State waters are produced at a scale of one inch equals 500 feet. All of the maps include a plan display and profile section illustrating pertinent features within the survey corridors. A copy of the magnetometer data from Line 112 is included as an enclosure.

6.2 Cultural Features Reported in the Survey Area

Colonial and historic period shipping routes commonly traversed this area. The historic period settlement and development has been closely tied to waterborne transportation and commerce and the Gulf of Mexico, with settlers traveling by boat to coastal communities for goods and supplies. New Orleans, Mobile and Galveston served as major brokers for cotton export and the import of manufactured goods from Europe and the east coast states. For more than 200 years, many versions of canoes, skiffs, and flatboats were used for lightering goods and people from offshore across the shoaler waters of Mobile Bay.

Overland transport for commercial development was difficult until the early 20th century with the coming of the railroads and improved road construction, therefore settlers were dependent upon a variety of different vessel types to support their transportation needs. During the 19th century, schooners and sloops were the principal sailing rigs used for fishing and the transport of passengers and goods, and were popular as pleasure craft. By the 1830s steamboats were becoming increasingly common offshore as well as on the inland waterways. Larger oceangoing steamboats traveled from

New Orleans and ports to the east in the Gulf as well as the Atlantic seaboard and Europe, and smaller classes of both steam and sailing vessels worked the water ways. In the early 20th century, sails were generally abandoned with the advent of gasoline and diesel engines. Some of the largest shipyards in the nation were established between Mobile and Galveston as oil production increased along the Gulf coast (CEI 1977:75-76). Fishing and oil and gas production became major offshore industries during the mid 20th century, and continue to be so today.

With improvements in dredging to maintain passes to the shallow harbors along the coast, aids to navigation became increasingly important. As a result of the dredging of the intracoastal waterway, begun at the end of the 19th and continuing into the 20th century, and the Main Ship Channel into Mobile Bay, spoil was commonly disposed of offshore. Numerous unidentified obstructions reported over the past 40 years are charted on the navigation charts at the intersection of the Horn Island Pass and Gulf Outlet Safety Fairways. Some of these comprise the artificial reefs and disposal areas that have been designated in Blocks 822, 866, 955 and 999, Mobile Area. These have been recognized as dump sites since before 1964, when records of materials disposed of at these locations began to be maintained by the Army Corps of Engineers, the U.S. Coast Guard, and various agencies of Alabama, including the Department of Conservation and the Mobile County Wildlife Conservation Association.

A considerable amount of oil and gas development has occurred in and adjacent to the survey area (Transco Energy Company 1994). The identities and locations of pipelines, wells, structures, and other pertinent features within and adjacent to the survey area are shown on the Archeological, Engineering and Hazard Maps.

Because of the maritime influence on settlement and economic development, the potential for shipwrecks is high. Preservation of a wreck in this area off of Mobile Bay would range from moderate to good (Garrison, Giammona, Kelly, Tripp, and Wolff 1989; Mistovich and Knight 1983).

Reference to lists and charts published by the U.S. Department of Transportation (1984 to Present), the National Ocean Service (1993, 1991), the cultural resource baseline studies for Mobile Bay and area by Mistovich and Knight (1983) and the offshore Gulf of Mexico by CEI (1977) and Garrison, et al. (1989), as well as files maintained by the USDI MMS, indicates that no shipwrecks have been reported in the survey areas, although a number of wrecks have been reported off of Alabama whose locations and identities remain unconfirmed. These are primarily large commercial craft; the numerous incidents of early colonial and historic period vessels and small craft losses are usually overlooked in these references. American Civil War naval activity resulted in numerous losses in the nearshore area. Adverse weather conditions have had a serious affect on offshore and inshore shipping since a convoy of Spanish vessels was lost during the hurricane of 1780. Major losses were also reported from storms and hurricanes in 1819, 1852, 1906, 1926, 1947, 1965, and 1979 (Mistovich and Knight 1983; Otvos 1982; Garrison, et al. 1989; Berman 1972).

Six sites are listed on the National Register of Historic Places north of the survey areas. These include the Sand Island Light, the Mobile Point Light Station Keeper's Quarters, Fort Morgan, Fort Gaines, the Dauphin Island Indian Shell Mound at Indian Mound Park, and the U.S.S. Tecumseh.

6.3 Previous Cultural Resources Investigations

Some of the earliest archeological data from the Mobile region were presented by Clarence B. Moore in 1905 from a burial mound near present day Daphne and from shell middens near Fish River, Bon

Secour, Seymour's Bluff, and Strong's Bayou, as well as the large shell mounds located on the northern side of Dauphin Island. Professional archeological research conducted between 1929 and 1935 by the Alabama Museum of Natural History and the Federal Works Progress Administration in the 1940's helped to establish the prehistoric chronology. Subsequent archeological research is reviewed in the works of DeJarnette (1952), Trickey (1958), Curren (1976) and Knight (1976), and data from site surveys, excavations and cultural resources assessments are presented by Trickey and Holmes (1971), Harris and Neilson (1972), Lau, Stowe and Fuller (1978), Marine Environmental Sciences Consortium (1979), and the University of South Alabama Archaeological Research Laboratory (1970-1979).

Since 1974, numerous marine archeological remote sensing surveys have been conducted in Mobile Bay and offshore in relation to navigation improvements, shell dredging permits, and hydrocarbon resource development. These surveys have primarily been conducted at the archeological reconnaissance level (Phase I) for the location and identification of cultural resources (Mistovich and Knight 1983).

More recent publications of work conducted for the U.S. Army Corps of Engineers, Mobile District, provide additional information pertinent to the study area. Included is the baseline study consisting of a documentary review and remote sensing survey by Mistovich and Knight (1983), augmented by a listing of reported shipwreck locations and potentially significant bottom obstructions in Mobile Bay and offshore state waters.

Several models for the identification of shipwrecks by magnetic anomalies and seafloor targets have been proposed by previous geophysical surveys using magnetometer and side scan sonar equipment.

Shipwrecks may be found intact or the debris may be scattered over an area greater than 100,000 square feet.

Clusters of magnetic anomalies against a magnetically clean background, a model proposed for shipwrecks found along the Texas coast, generally occurs with wooden hulled vessels in a nearshore marine environment where the vessel may be broken up and the debris distributed by storm waves and currents (Arnold 1976, 1978, 1982, 1987). In the offshore marine environment, metal hulled vessels and vessels which sink in deeper water may remain intact, although they can settle into and below unconsolidated seafloor sediments, occasionally leaving only a depression or scour zone to mark the site (Garrison et al. 1989). Vessels may also sink into the soft sediments of bay bottoms, and be covered by recent sediment deposition (CEI 1989). Where hard bottom conditions prevail, the wreck and debris may be clearly evident.

Archaeologists Clell Bond and Jack Irion of Espey, Huston and Associates, Inc., (Bond and Irion 1984, Bond 1985; Irion 1986) have reported on the Phase II investigations and assessments of 34 magnetic anomalies recommended for investigation by the Mobile Bay and Offshore Alabama waters baseline study (Mistovitch and Knight 1983). Except for the identification of a Civil War obstruction near Mobile Harbor constructed of wrecks and other materials, the remaining magnetic anomalies were identified as modern debris with no historic or archaeological significance.

In the Mobile Bay anomaly investigations (1986), Irion noted that a constant scattering of debris across the Bay has resulted from commercial shrimping and fishing activities. Shrimp boats working the deeper water areas of the bay deposit their snagged seafloor debris in shoaler waters while the shrimpers working the shallow water mudflats dump their debris in the deeper water channels. In

this manner, modern debris is continually redistributed. A ground truthing of selected magnetic anomalies in Mobile Bay found that all that could be relocated represented modern debris, and one-third of them represented steel cable, commonly used by boats and ships, which, when broken, is continually discarded.

As a result of the work conducted by EH&A in 1984 and 1985, a model for the identification of shipwrecks by magnetometer survey was proposed (Irion 1986). In zones of high sedimentation rates and relatively calm water, shipwreck remains do not become widely scattered, as they often do offshore. The magnetic signature of such a wreck may be indicated by a low amplitude, broad duration magnetic field variation, with short-duration anomalies adjacent to and superimposed on the larger anomaly. These smaller features represent point source ferrous objects. Clusters of magnetic anomalies against a magnetically clean background is a model proposed for shipwrecks found along the Texas coast. Although such anomaly clusters in Mobile Bay have been found to represent modern ferrous debris associated with modern dredging, fishing, and trash disposal activities, this type of anomaly pattern could indicate a wreck in the offshore Alabama area.

Delineation of an offshore wreck and debris pattern by a magnetometer is dependent upon the survey grid dimensions (CEI 1977; Arnold 1982; Saltus 1982; Gearhart 1992). Small vessels, such as the schooner *Percy Pain* found offshore from St. Andrew's Bay, Florida, and the wreck of the Spanish vessel, *El Nuevo Constante*, found off the western coast of Louisiana, were delimited by single, low amplitude, short duration dipolar anomalies and a hard reflective sonar target or irregular bottom surface (Landry 1995; Pearson and Hoffman 1995; Garrison, et al. 1989a). An archeological magnetometer and side scan sonar investigation of an 18th century ballast pile with cannon near the Chandeleur Islands conducted in 1989 revealed a distinctive bottom feature associated with a slight

depression or scouring, and magnetic anomalies of less than 90 gammas (Garrison, et al. 1989b). Ground truthing by divers revealed the significance of these features as an historic ship related site. On a 200-meter per channel scale on the sonar, none of the targets associated with these wreck sites were readily identifiable as ship remains. They would be recognizable as an anomalous bottom feature where a 50-meter per channel range is deployed.

A wreck may also be evident in the bathymetric and subbottom profiles if exposed above the seafloor sediments and in the beam range of the survey instruments. It could appear as a diffraction anomaly at the surface, similar to those noted over buried pipelines and well sites, as well as an irregularity in the surface topography. It may be missed entirely by these instruments if situated parallel to and midway between the lines.

Detailed chronologies of the prehistory and history of Mobile Bay have been published elsewhere (Trickey 1958; Trickey and Holmes 1971; Knight 1976; Walthall 1980; Mistovich and Knight 1983).

6.4 Geophysical Data Analysis

The analysis of the geophysical survey data is presented in the following sections.

6.4.1 *Bathymetry and Seafloor Features*

The digital echo sounder data were adjusted to compensate for the boat drafts and transducer depths. The JECA Echotrac fathometer data and the C&C Multibeam EM-1000 data were velocity corrected from velocimeter casts within the specific survey areas. At depths less than 60 feet, the values were tide adjusted to Mean Lower Low Water. The water depth contours are projected on the Archeological, Engineering, and Hazard Maps.

The bathymetry data record a relatively smooth seafloor where the proposed ROW crosses Mississippi Sound, as well as south of Dauphin Island into federal waters. A maximum depth of about -15 feet MLLW was recorded in the cut of the Intracoastal Waterway (see Appendix A:Figure 1). Low relief sand waves produce a slightly irregular topography in Mobile Area Blocks 910 and 911, and from Block 75, Viosca Knoll Area, to Main Pass Area Block 216, where prodeltaic marine sediments from the Mississippi River have settled over the MAFLA sands. Generally, the seafloor slopes to the south.

6.4.2 *Subbottom Profiler Analysis*

The subbottom profiler data record acoustic penetrations from five feet to about 75 feet Below Mud Line (BML). Stepped and enhanced reflectors and amorphous and transparent zones indicate the presence of interstitial gas throughout the survey area. The gas is derived from the decomposition of fine-grained organic matter embedded in the subsurface sediments. Limited penetrations result from the scattering of the acoustic signal by sandy deposits. Profiles showing the subseafloor stratigraphy following the proposed ROW are presented on the Archeological, Engineering and Hazard Maps.

Recent sediments appear as acoustically amorphous wedges and drapes overlying deeper parallel and foreset strata (see Appendix A:Figures 2 and 5). Zones of foreset strata and limited acoustic penetrations correspond with the migrating barrier sands noted in the sonar and Echotrac data.

In the Mobile and Northwestern Gulf Areas, the 3.5 kHz profiles record relic nearshore fluvial and tidal pass channeling and evidence of westwardly migrating barrier islands typical of the offshore area that have characterized this portion of the northern Gulf of Mexico (see Appendix A:Figure No.

7 and Profile Views, Maps 1-21). The channel margins occur five to ten feet BML, and are covered by acoustically transparent and amorphous sediments. Subbottom deposits have been incised from a few feet to almost 30 feet Below Mud Line (BML). The distributions of the channels are shown on the Archaeological, Engineering, and Hazard Maps. The channel margins often appear truncated or poorly resolved. Their depths below mudline preclude any adverse affects by pipeline burial.

The boomer data acquired from the northern side of Dauphin Island recorded 3.5 meters of acoustically transparent and amorphous recent material that comprise the bottom sediments of the modern day Mississippi Sound. These deposits lie above the relic east-west trending channel that flowed between the mainland and the Pleistocene ridge upon which Dauphin Island developed (see Appendix A:Figure No. 8); it drained into the ancestral Mobile River to the east (Otvos 1982). The margins of this channel, which do not appear to be truncated by erosion, represent high probability areas for prehistoric archeological sites. These occur below the three-foot recommended depth of burial for the pipeline in this area, and should not be adversely affected by pipeline construction activities.

During the late Quaternary, sea level fluctuations resulted in extensive relocations of the coastal zone in the northern Gulf of Mexico. As portions of the present shelf were exposed, drainage networks were extended and new alluvial sequences developed (Curray 1960; May 1976; Frazier 1974; Ludwick 1964). The present-day Mobile Bay estuary formed as sea level rose in response to glacial melting beginning more than 10,000 years ago, flooding the entrenched valley of the Mobile River. It was gradually filled with sands, silts and clays, deposited at varying rates, until about 6,500 years ago, when sea level rise reached its present stand in the Bay.

Dauphin Island is the largest of the barrier islands which formed just inland of the late Holocene shorelines. It is built upon a core of Pleistocene sand, and has been veneered by early Holocene and recent beach and dune deposits and marshes. The western end has continually migrated westward, prograded by erosion of sediments deposited off of the mouth of Mobile Bay and littoral drift from the eastern end of the island (Otvos 1982). A muddy bottom composed of silts and clays characterizes the floor of Mississippi Sound.

More than 4,000 years of human occupation of the Mobile Bay area and northwestern Gulf of Mexico have been documented (Stright 1990; CEI 1977; Gagliano 1984). While prehistoric sites older than 4,000 years have been found elsewhere in the state of Alabama and on the Mississippi and Louisiana Gulf Coastal Plain, no Paleo-Indian sites and few Early and Middle Archaic sites have been found along the terrestrial perimeters of Mobile Bay or in its shallow waters (Trickey and Holmes 1971; Curren 1976).

It is possible that sites predating 5,000 BP (years Before Present) associated with previously subaerially exposed landforms are present in areas which are now submerged. Predictive modeling based on correlations between prehistoric archaeological sites and geomorphic landforms on the Gulf Coastal Plain which have been proposed by CEI (1977, 1982, 1986), Gagliano (1984), and Mistovich and Knight (1983) suggests that Paleo-Indian and early Archaic period sites may be located along the natural levees, margins, point bars, and terraces of alluvial streams, and also at stream confluences, along the margins of lakes and estuaries, and on relict beach ridges. The identification of such landforms in presently submerged areas would represent high probability areas for prehistoric archeological sites.

Sites associated with geomorphic landforms covered by sediments in a low-energy environment should be well preserved. Silts and clays provide greater cohesiveness and more stability of the matrix surrounding site components and delay or prevent oxidation, or decay, of organic remains (Stright 1985; Grebmeier 1983). Sites associated with sands and gravels, which are indicative of high-energy environments, are not as likely to remain in situ, although prehistoric artifacts could be present in lag deposits.

Within the survey areas, the margins of the buried channels represent possible high probability areas for prehistoric archeological sites. The upper channel margins and fill appear truncated by marine transgression and nearshore erosional processes. In situ prehistoric remains are unlikely to be present, although they could be incorporated in the fill as lag deposits. The margins of the offshore channels are buried below the zone to be impacted by pipeline construction and lay barge anchors. There is no evidence of shell midden accumulations adjacent to any of these areas.

6.4.3 *Side Scan Sonar and Analysis*

The JECA SMS 260 side scan sonar was operated at 100 kHz with a range of 200 meters per channel where line spacing is 300 meters. Where a 50-meter line spacing was run, the sonar data were recorded at 50 meters per channel. The C&C Datasonics side scan sonar was operated at 100 kHz with a range of 90 or 187 meters per channel, depending on the line spacing interval. Both data sets are of good quality.

Seafloor sediments are reported to consist of silty sands trending into sandier sediments to the north (USDI MMS 1986:Visual 3). The sonar data depict a seafloor characterized by moderate to high reflectivity, where zones of higher reflectivity indicate sandier sediments and patches of shell hash

which interfinger with the more moderately to weakly reflecting silty deposits (see Appendix A:Figure No. 3). These areas are delineated on the Archaeological, Engineering and Hazard Maps. Water column anomalies, representing schools of fish and shrimp and seaweed, are common, and recent fishing activities are indicated by occasional drag scars.

Notable bottom features in the data are typical of pipelines, wells and platforms, and include faint and well defined anchor scars, as well as tripodal jack-up rig impressions, filled pipeline trenches, and disturbed sediments around the wells and platforms.

There were 49 unidentified sonar targets recorded in the JECA data set. Thirty of these were associated with magnetic anomalies. C&C recorded 21 unidentified sonar targets. The targets are listed in the tables in Appendix B, with the X-Y coordinates and descriptions; all of them are plotted on the Archeological, Engineering and Hazard Maps, their positions corrected for sensor offset.

The most significant of these targets is a sunken barge in Viosca Knoll Block 31 associated with a 1,000+ gamma anomaly (see Appendix A:Figure Nos. 10 and 11). The wreck is 90 to 100 feet long and about 35 feet wide and has numerous pieces of debris scattered across the area. It was previously recorded during the WIMPOL 1993 hazard and archaeological survey for the OEDC 12-inch pipeline. The vessel remains unidentified, with no record of a sunken barge in the USCG or NOS lists. In the archeological report for the WIMPOL survey, the wreck was tentatively identified as possibly the liberty ship sunk as a reef site in 1979 in Viosca Knoll Block 32, to the east. Sonar Target No. 26 is interpreted as debris associated with this wreck site. This site should be avoided and lies over 2,200 feet from the pipeline alignment.

Most of the unidentified sonar targets occur in the debris fields evident on Maps 12-15 where seafloor reflectivity varies within or adjacent to designated disposal areas or the fairways (see Appendix A:Figure Nos. 12 and 13). None of them are part of anomaly clusters that can be interpreted as possible shipwreck remains. They are interpreted as modern debris.

Three of these contacts are associated with magnetic anomalies and all are more than 1,000 feet from the centerline. Target 3 is a half-moon shaped contact about 21 feet by eight feet by 3.7 feet near a 4-gamma, 150-foot duration anomaly (Maps 8 and 9). Target 19 is near a 40-gamma, 400-foot duration anomaly, and measures about 20 feet by six feet with a height of about one foot above the seafloor (Map 13). Target 21 is 15 feet by nine feet with a relief of about six feet above the seafloor that is near a ten-gamma, 200-foot duration anomaly (Map 14).

A GeoMetrics model 801/803 marine magnetometer was used during the JECA surveys. The data were recorded on 100-gamma and 1,000-gamma scales (see the reproduction of the centerline, Line 112). The magnetometer sensor was towed three to 19 feet above the seafloor where a 50-meter line spacing was utilized. Sensor depths below local sea level were noted in the Daily Survey Logs at the beginning and end of each line (Appendix C). The background noise was two to three gammas peak-to-peak. The data are of good quality.

A total of 1,092 magnetic anomalies were recorded within the original survey area by JECA, 778 of which remain unidentified. There are 60 unidentified anomalies on the centerlines, 37 of which are in the offshore survey areas; 23 occur in Mississippi Sound. The larger centerline anomalies were investigated or removed divers and the remainder are represented by small anomalies representing minor ferrous debris.

C&C used a GeoMetrics Cesium magnetometer. The data were recorded on 100-gamma and 1,000-gamma scales at a 0.1 second sample rate (see Appendix A:Figure No.16). The magnetometer sensor height varied within the different survey areas. Where a 50-meter line spacing was utilized, a height of five to 18 feet above the seafloor was recorded. There were 78 unidentified magnetic anomalies recorded by C&C.

Zones of low amplitude oscillations were noted along some traces which are interpreted as geological in origin. They appear to coincide with buried channels and amplitude changes in the near seafloor sediments. Similar geological anomalies over gas-saturated sediments have been noted elsewhere in the Gulf of Mexico (Machel and Burton 1991). These did not interfere with interpretation of the data set, which is of good quality, and they have not been included in the Tables of Magnetic Anomalies.

All of the anomalies are listed and described in the Tables of Magnetic Anomalies (Appendix B). For the JECA surveys, one table lists the offshore anomalies, and the other is for anomalies recorded in Mississippi Sound. The anomalies are listed sequentially by line number, with the uncorrected and corrected fixes, amplitude in gammas, duration in feet, anomaly signature, and sensor height above the seafloor. The tables include X-Y coordinates for the unidentified anomalies. The unidentified anomalies are charted, their positions corrected for sensor setback, on the Archeological, Engineering, and Hazard Maps. A copy of the magnetometer data from the Line 112 is an enclosure.

The original survey report recommended investigation of ten centerline anomalies with amplitudes greater than 50 gammas and the sonar targets that were within 250 feet of the route. A number of anomalies in shallow water were also selected for investigation. Oceaneering conducted the diver

investigation in compliance with MMS specifications, although an archaeologist was not present on the vessel. The results of the diver investigations may be found in Appendix F. At five of the sites, nothing was found within a 100-foot radius of the reported position, concluding that the anomaly sources were further off-line and not presenting a hazard to pipe installation. The remaining dive sites encountered modern debris, including pieces of cable, wire rope, angle iron, welding rods, small steel plates, and damaged crab traps. No historically significant materials were detected. Of the five sonar targets noted close to the route, two were found to represent automobile tires (Sonar Contact 26), while the others could not be located.

An examination of the signatures and distribution of the remaining unidentified anomalies indicates that most are short duration features that can be interpreted as point source ferrous objects embedded in the seafloor sediments or too small to be resolved by the sonar. Scatters of anomalies following the linear trends of the irregular bottom topography and reflectivity changes noted on the sonar are evident in and adjacent to the disposal areas and the fairways, and probably represent sections of cable or chain.

It is possible that buried shipwreck debris could be masked by the scatter of recent ferrous materials. Included in Appendix B is a list of magnetic anomalies that could represent historically significant materials that should be avoided.

6.5 SUMMARY AND CONCLUSIONS

In summary, the evaluation of the high resolution geophysical data for the proposed pipeline right-of-way indicates that no high probability areas for prehistoric archeological sites are recorded within the upper three to ten feet of subbottom sediments. The pipeline will be buried 3 feet or 10

feet in the areas where the water depth is less than 200 feet and 1 foot in the areas where the water depths are greater than 200 feet. The channels are buried well below the zone of near surface sediments that will be impacted by pipeline dredging activities and lay barge anchor placement.

There are 70 unidentifiable sonar targets recorded in the data sets. Of the five near the proposed centerline that were investigated by divers, two proved to represent modern automobile tires. The contacts lie more than 50 feet from the pipeline right-of-way. The others could not be relocated. The contacts that are listed in the tables in Appendix B should be avoided.

There are 59 unidentified magnetic anomalies with amplitudes greater than 50 gammas that could possibly represent historically significant material. These are included in a separate table in Appendix B. Because historic shipwreck remains could be buried by dredge deposits and other spoil and obscured by the modern debris, these anomalies should be avoided. The proposed pipeline route alignment has avoided these anomalies by the distance recommended in table.

If any wooden planking or other cultural materials that could represent shipwreck remains are encountered during the proposed pipeline construction, the USDI MMS archaeologists should be contacted to provide an assessment of these artifacts.

January, 1998

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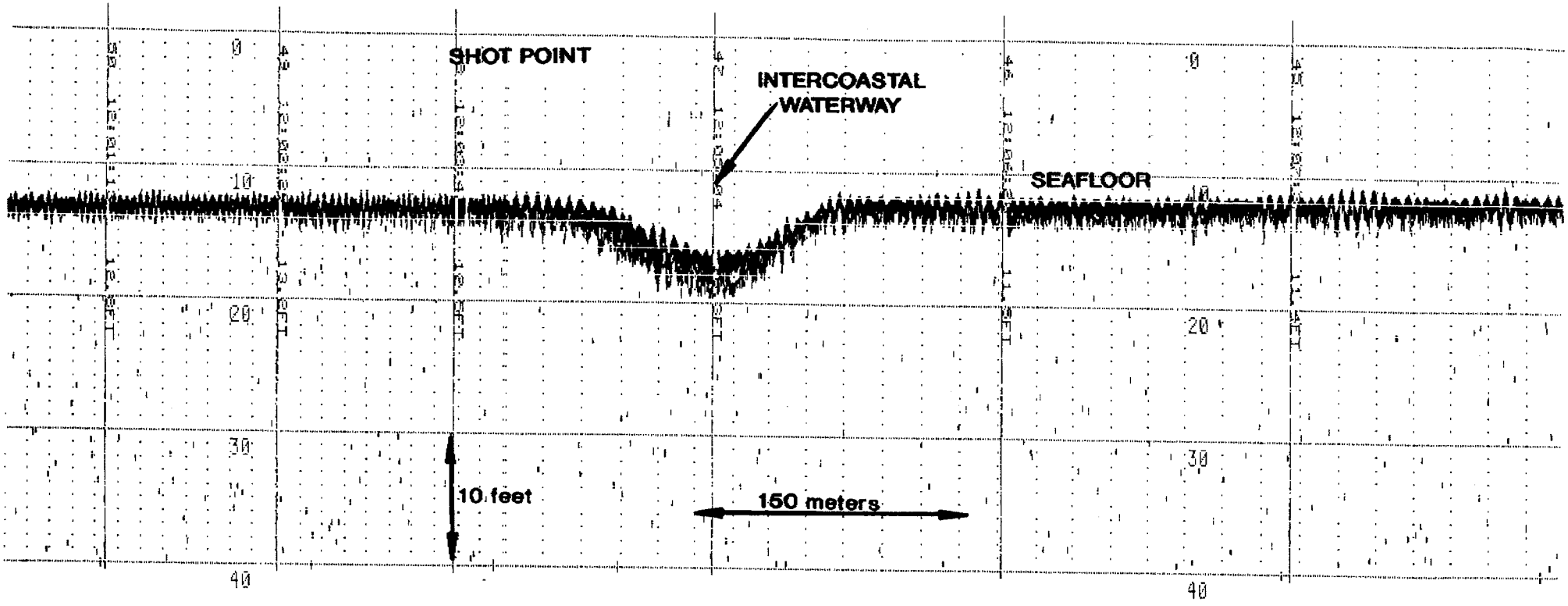
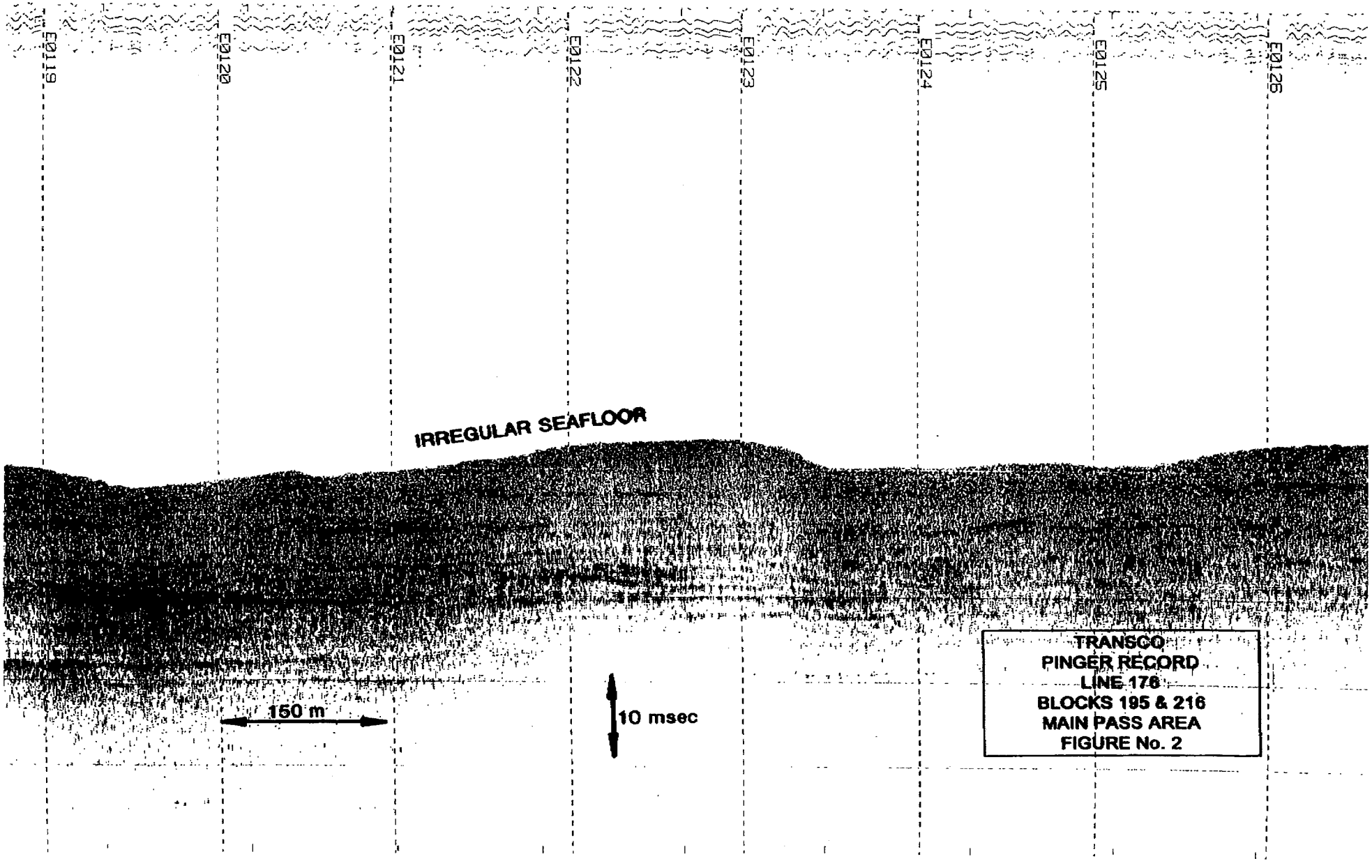
APPENDIX A

DATA REPRODUCTIONS



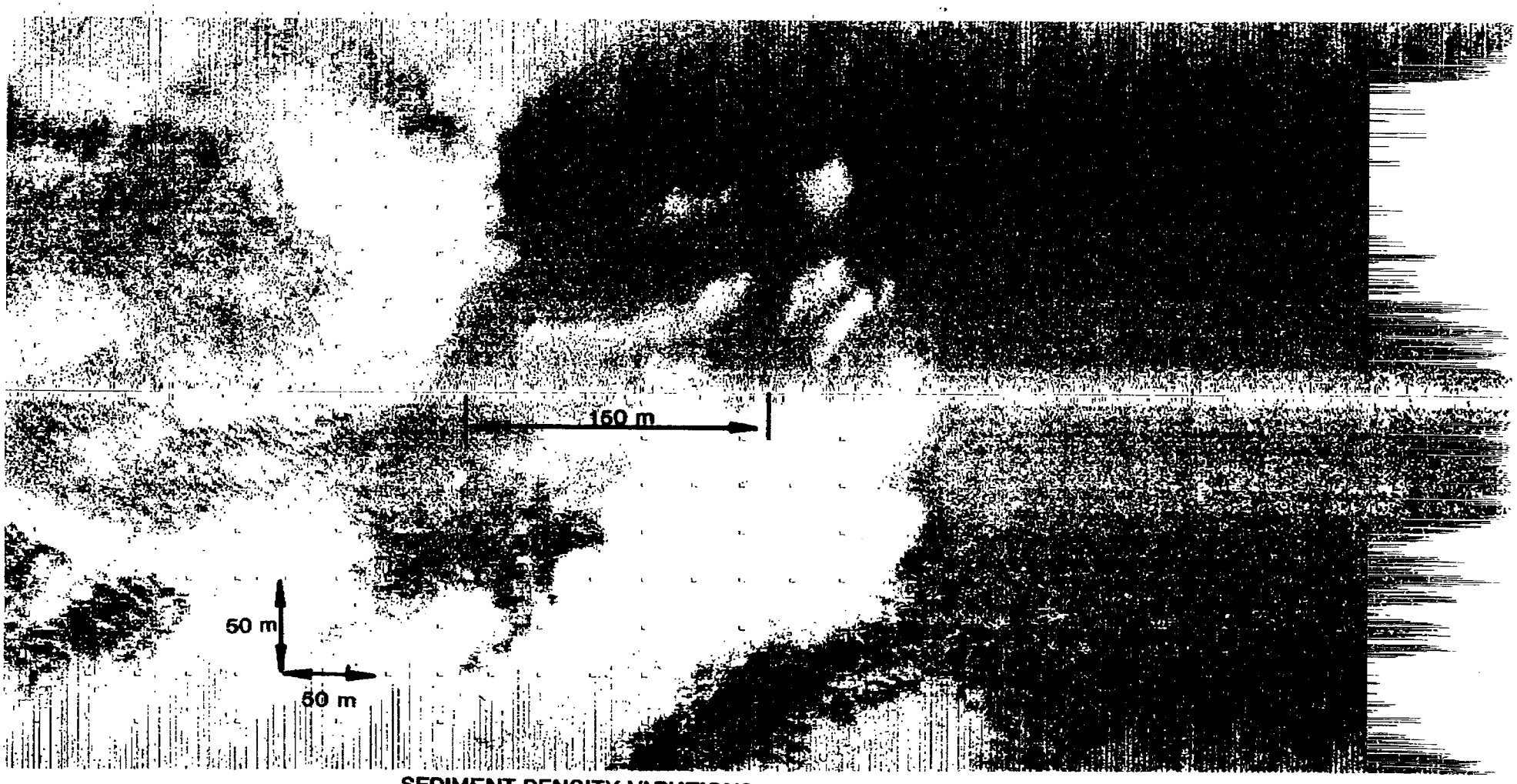
TRANSCO
ECHOTRAC RECORD
LINE 127

STATE WATERS
FIGURE No. 1

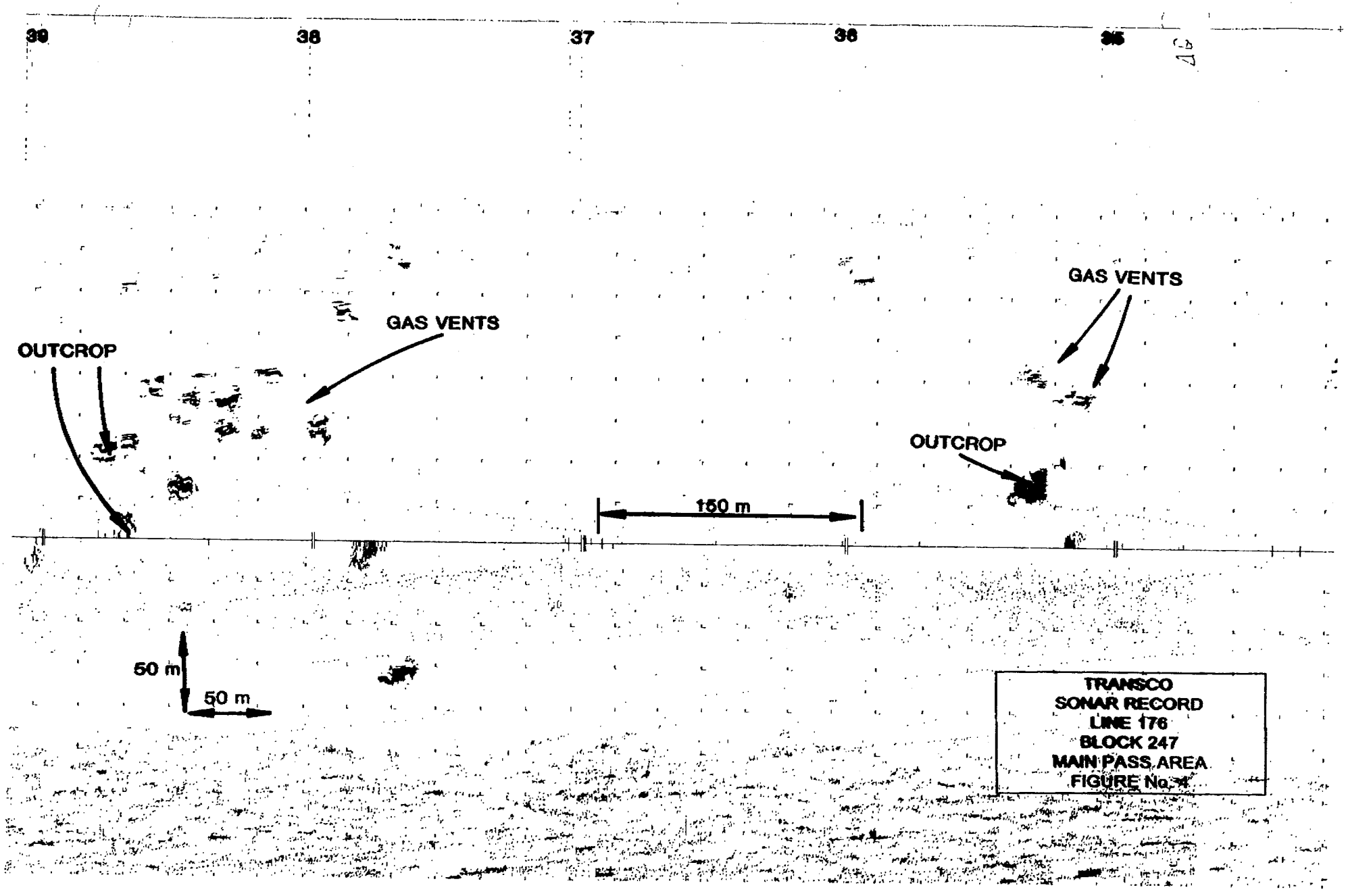


TRANSCO
PINGER RECORD
LINE 176
BLOCKS 195 & 216
MAIN PASS AREA
FIGURE No. 2

TRAMSOC
SONAR RECORD
LINE 34
BLOCK 119
VIOSCA KNOLL AREA
FIGURE No. 3



SEDIMENT DENSITY VARIATIONS



TRANSCO
SONAR RECORD
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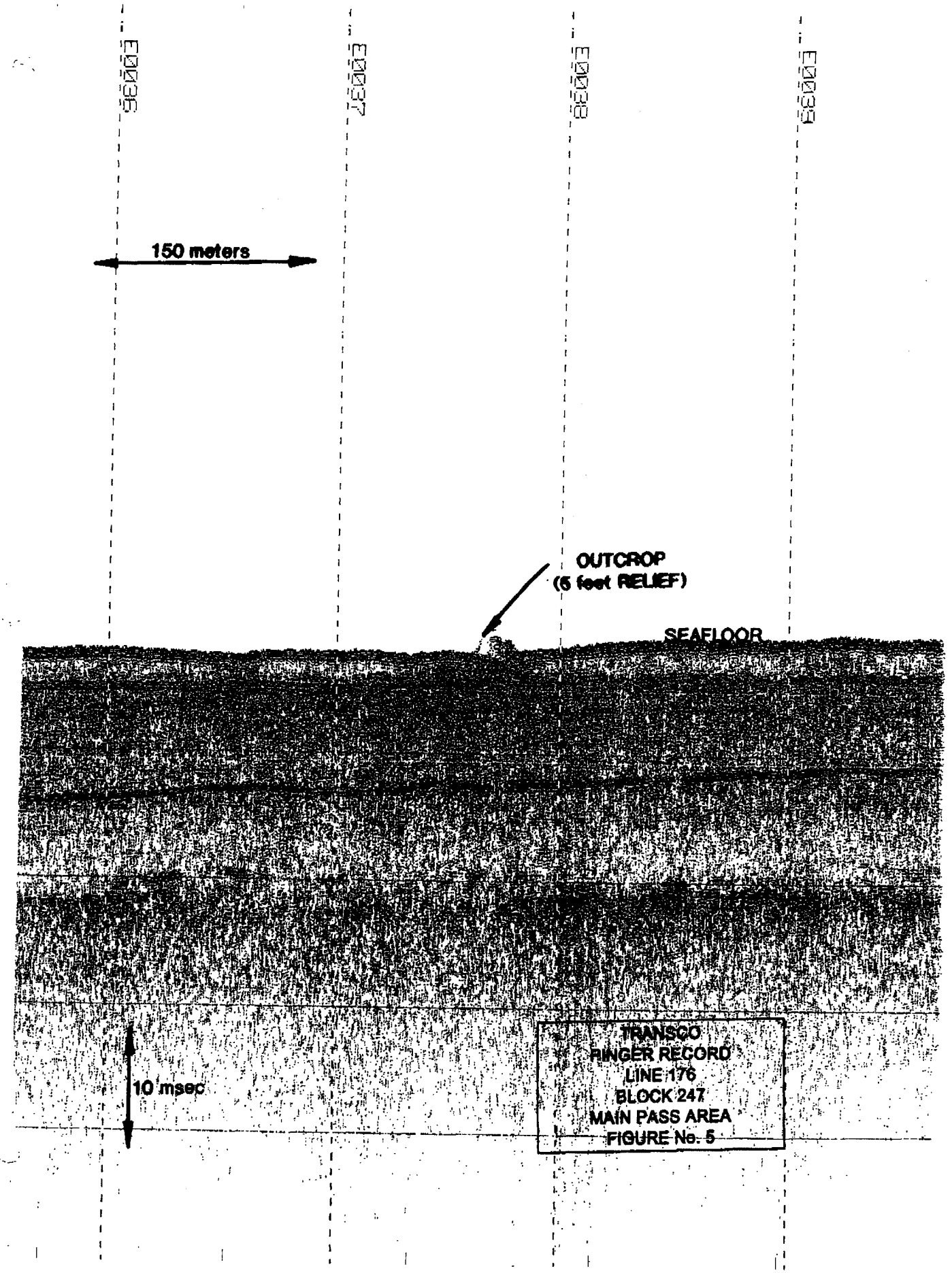
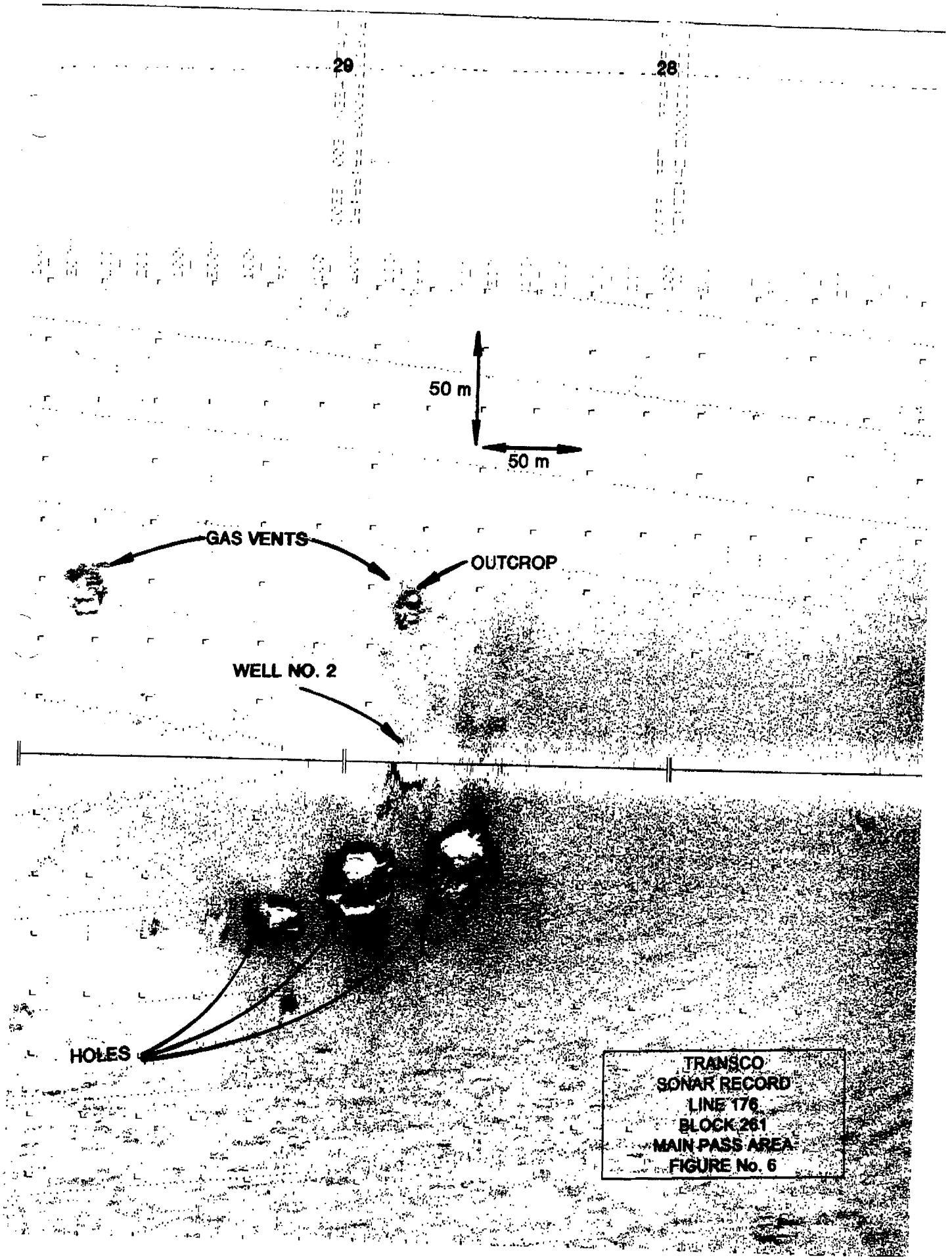
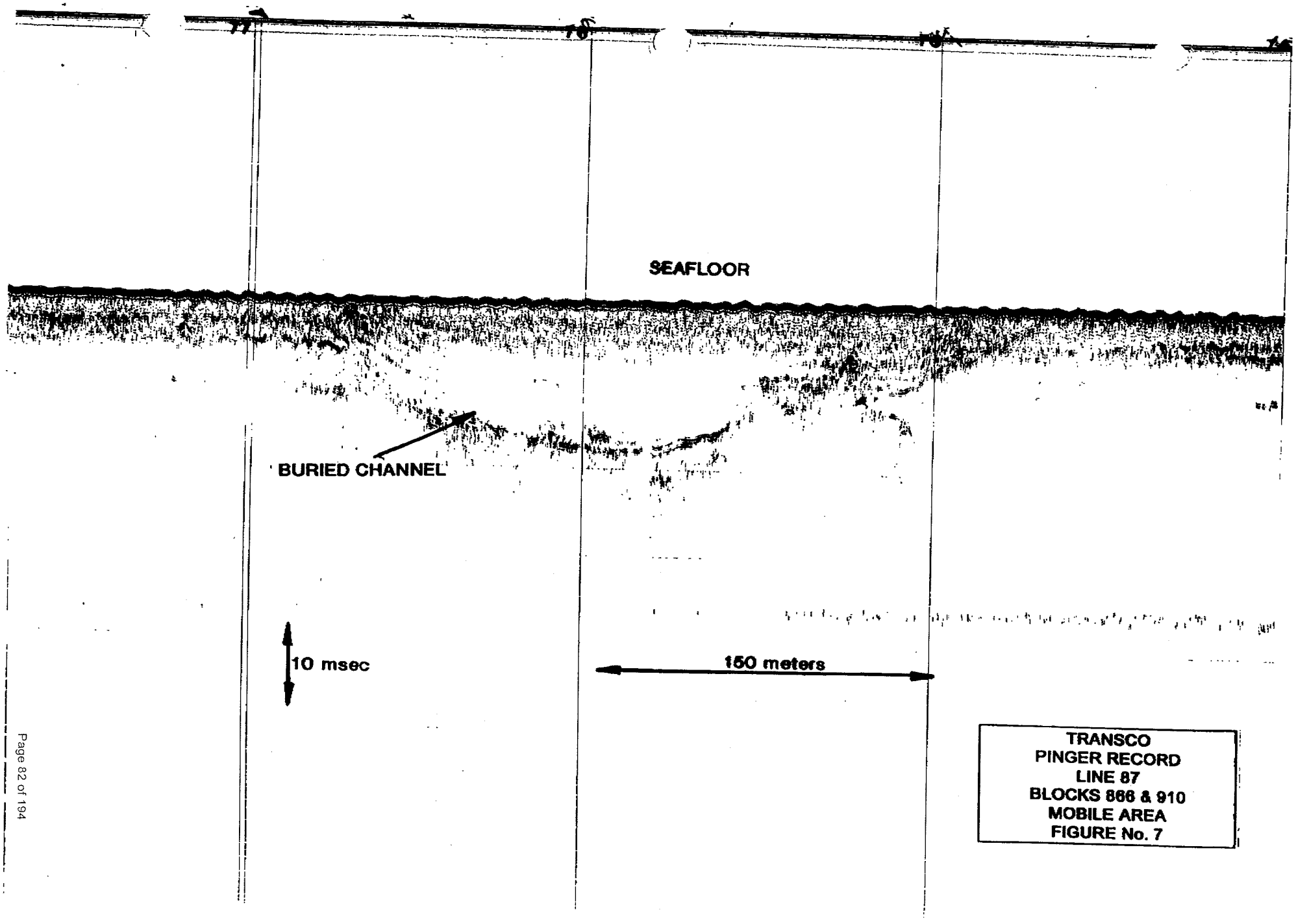
BLOCK 247
MAIN PASS AREA
FIGURE No. 4

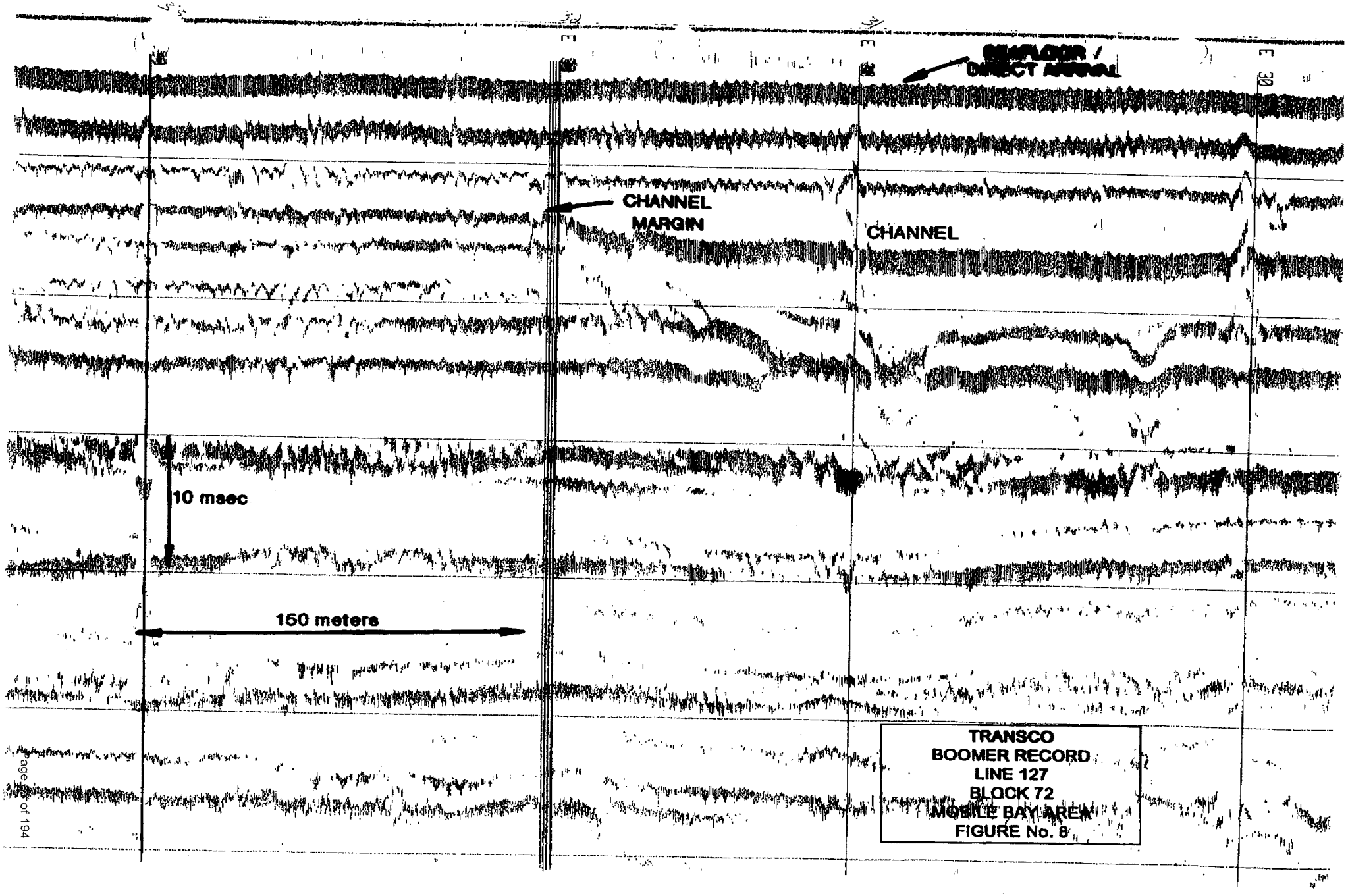

150 meters
OUTCROP
(5 feet RELIEF)
SEAFLOOR
10 msec
TRANSCO
PINGER RECORD
LINE 176
BLOCK 247
MAIN PASS AREA
FIGURE No. 5



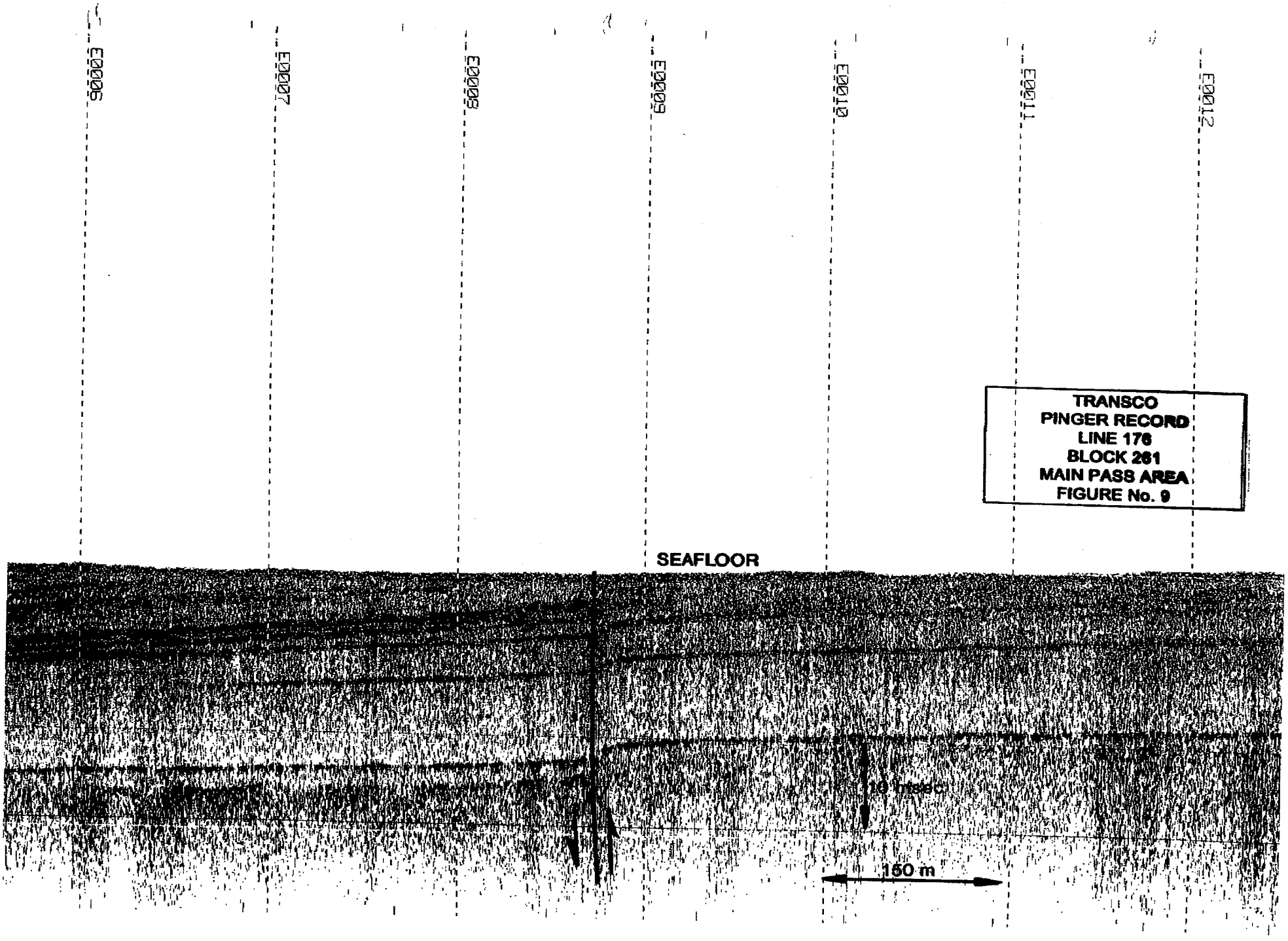
TRANSCO
SONAR RECORD
LINE 176
BLOCK 261
MAIN PASS AREA
FIGURE No. 6



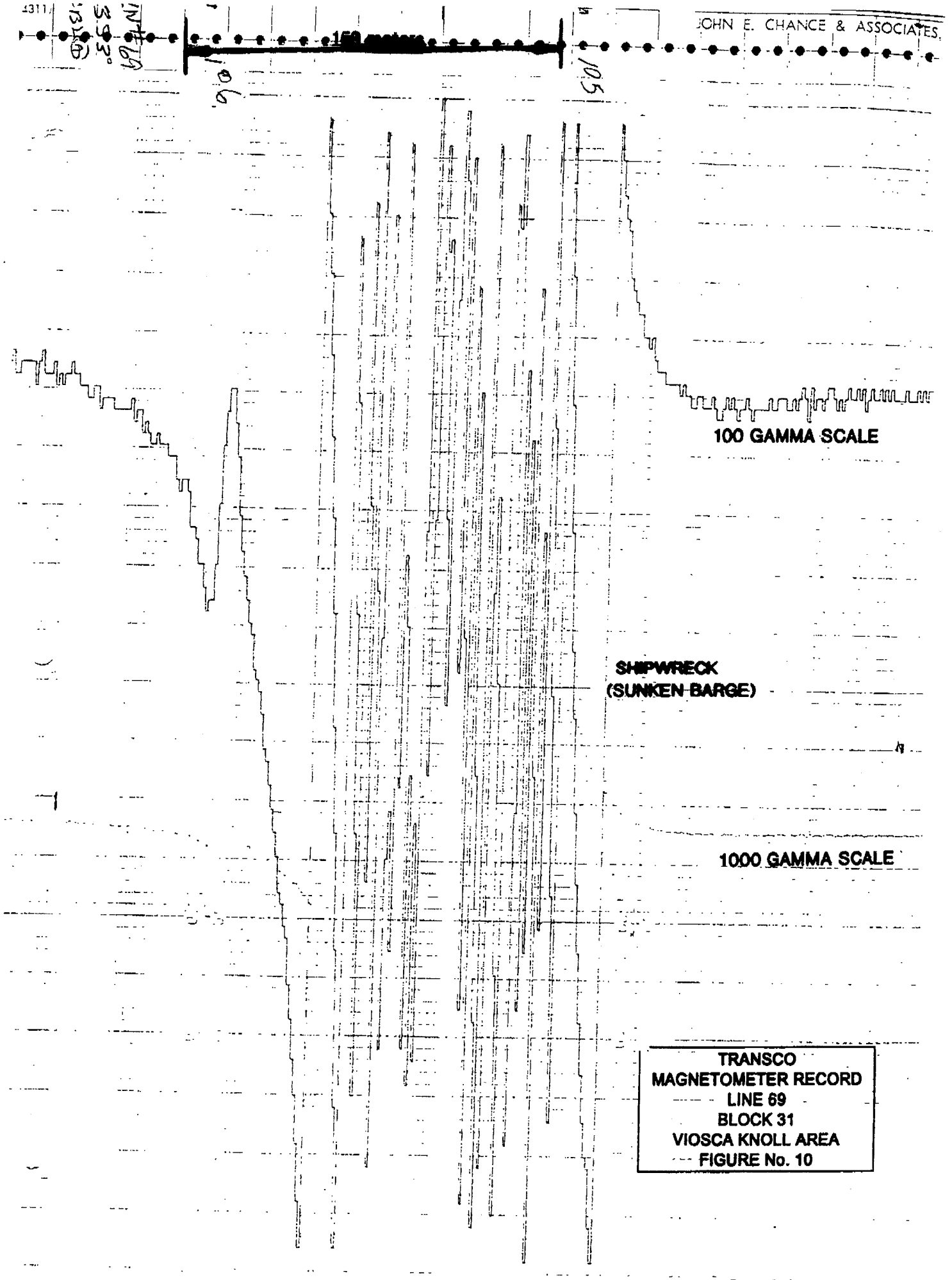
TRANSCO
PINGER RECORD
LINE 87
BLOCKS 866 & 910
MOBILE AREA
FIGURE No. 7



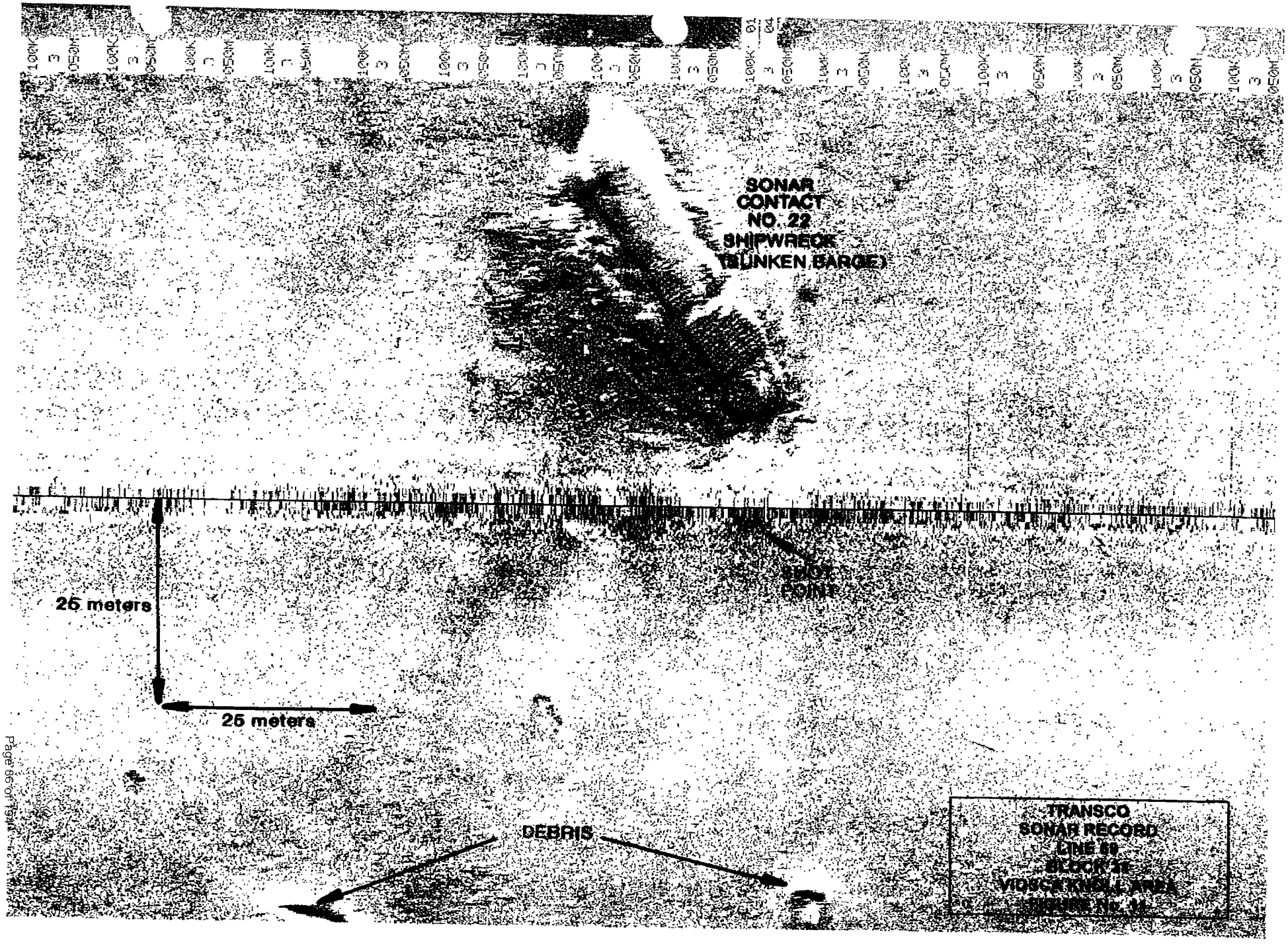
TRANSCO
BOOMER RECORD
LINE 127
BLOCK 72
MOBILE BAY AREA
FIGURE No. 8



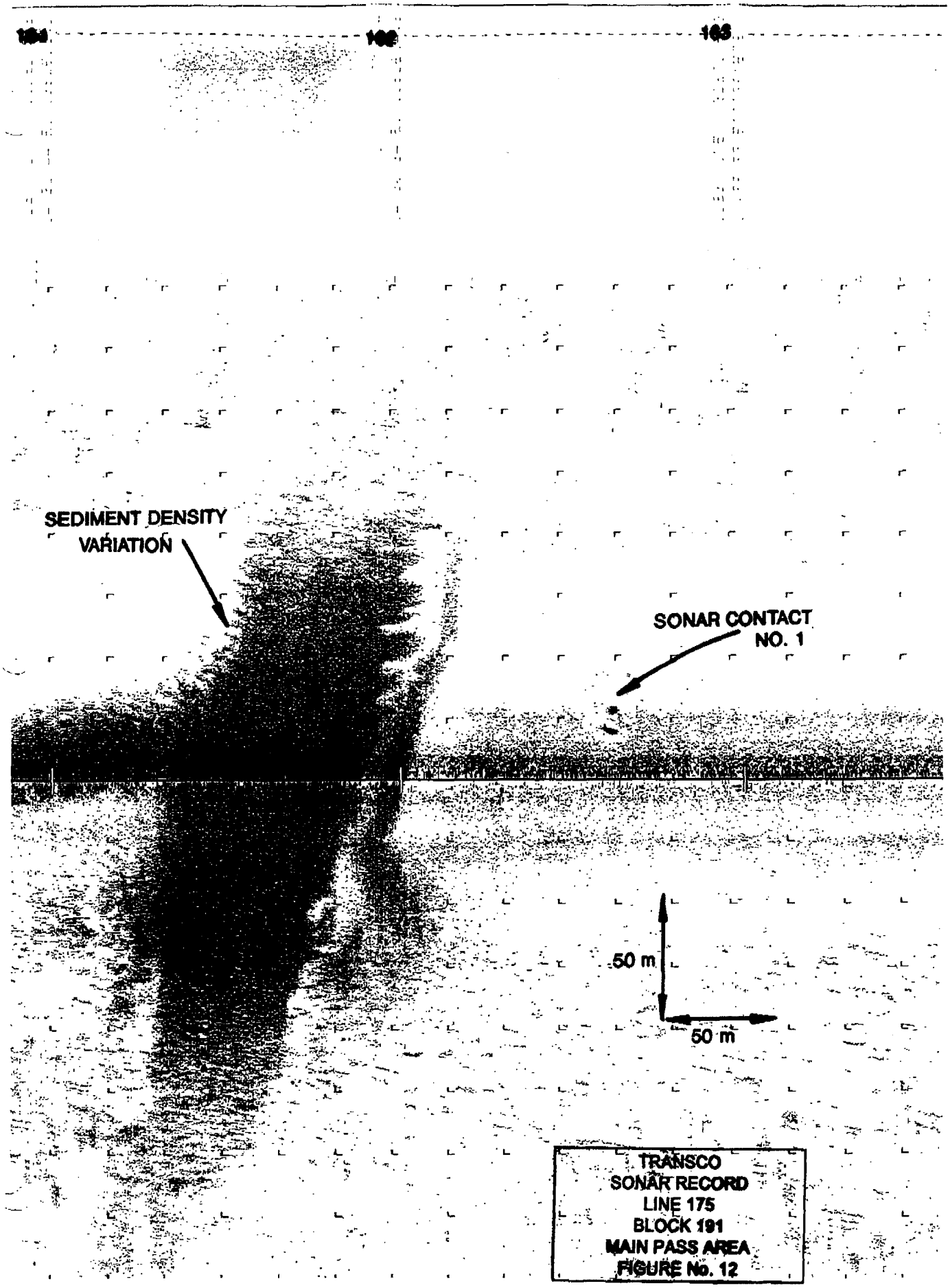
TRANSCO
PINGER RECORD
LINE 176
BLOCK 261
MAIN PASS AREA
FIGURE No. 9



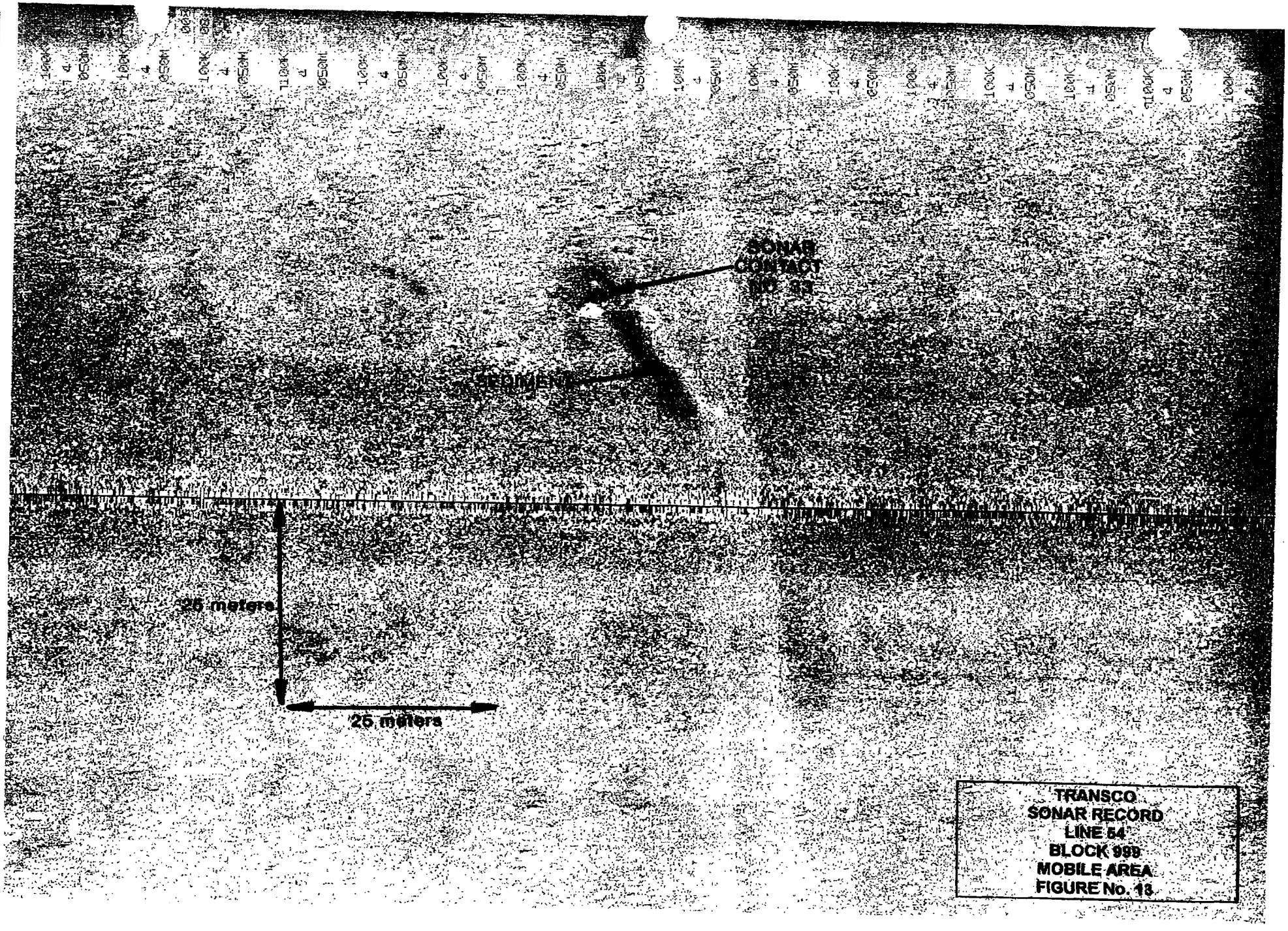
TRANSCO
MAGNETOMETER RECORD
LINE 69
BLOCK 31
VIOSCA KNOLL AREA
FIGURE No. 10



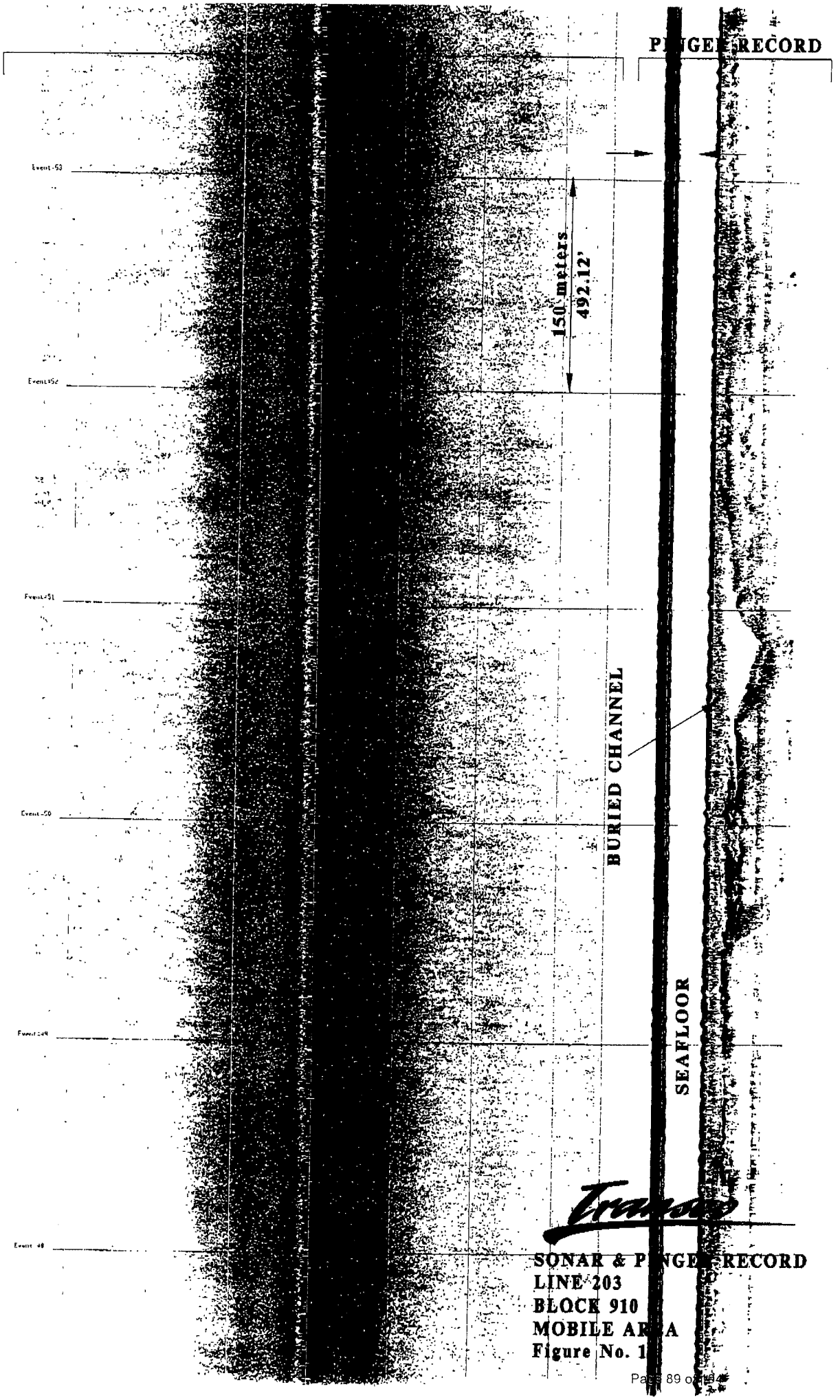
TRANSCO
SONAR RECORD
LINE 59
BLOCK 32
VIOSCA KNOLL AREA
FIGURE No. 11



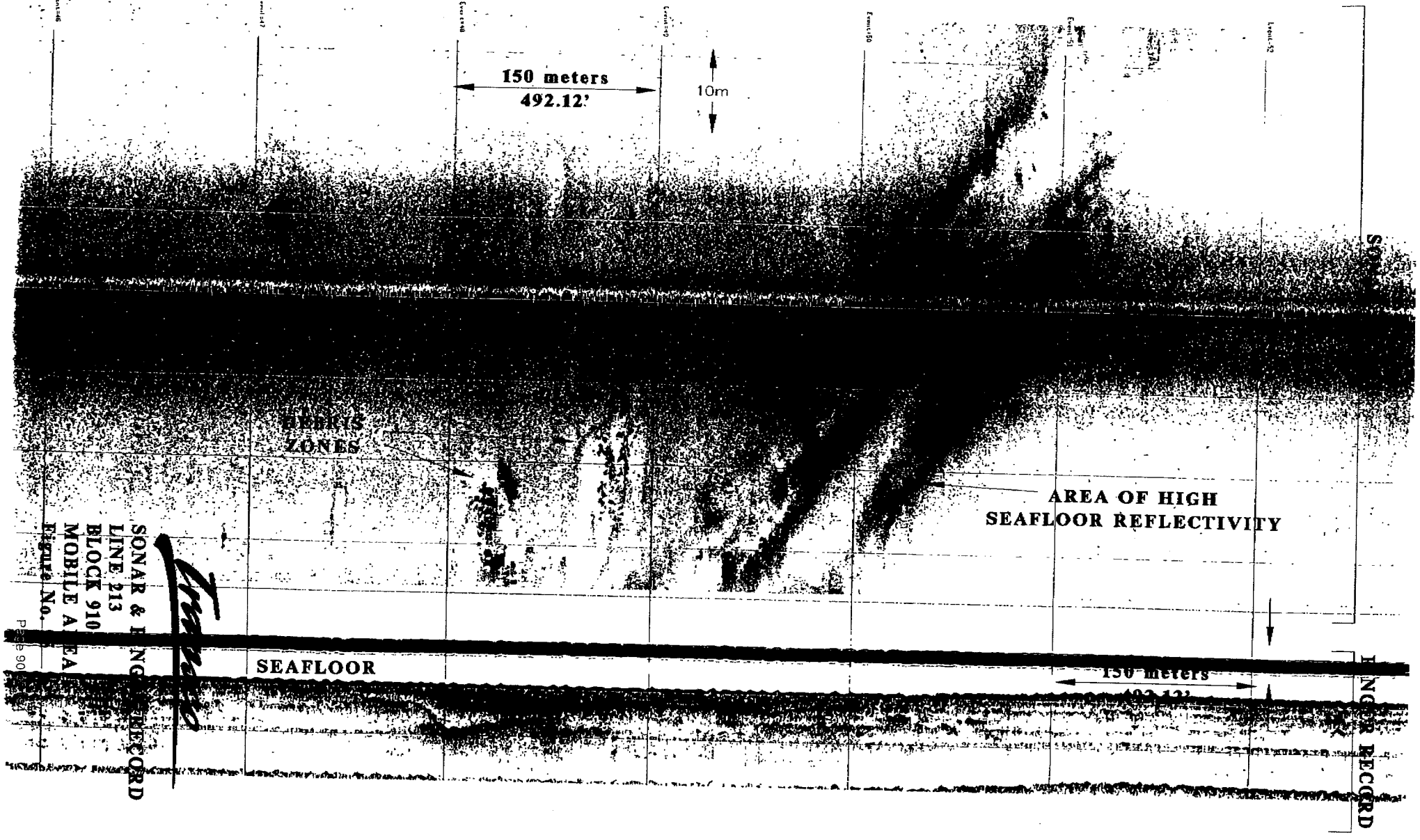
TRANSCO
SONAR RECORD
LINE 175
BLOCK 191
MAIN PASS AREA
FIGURE No. 12



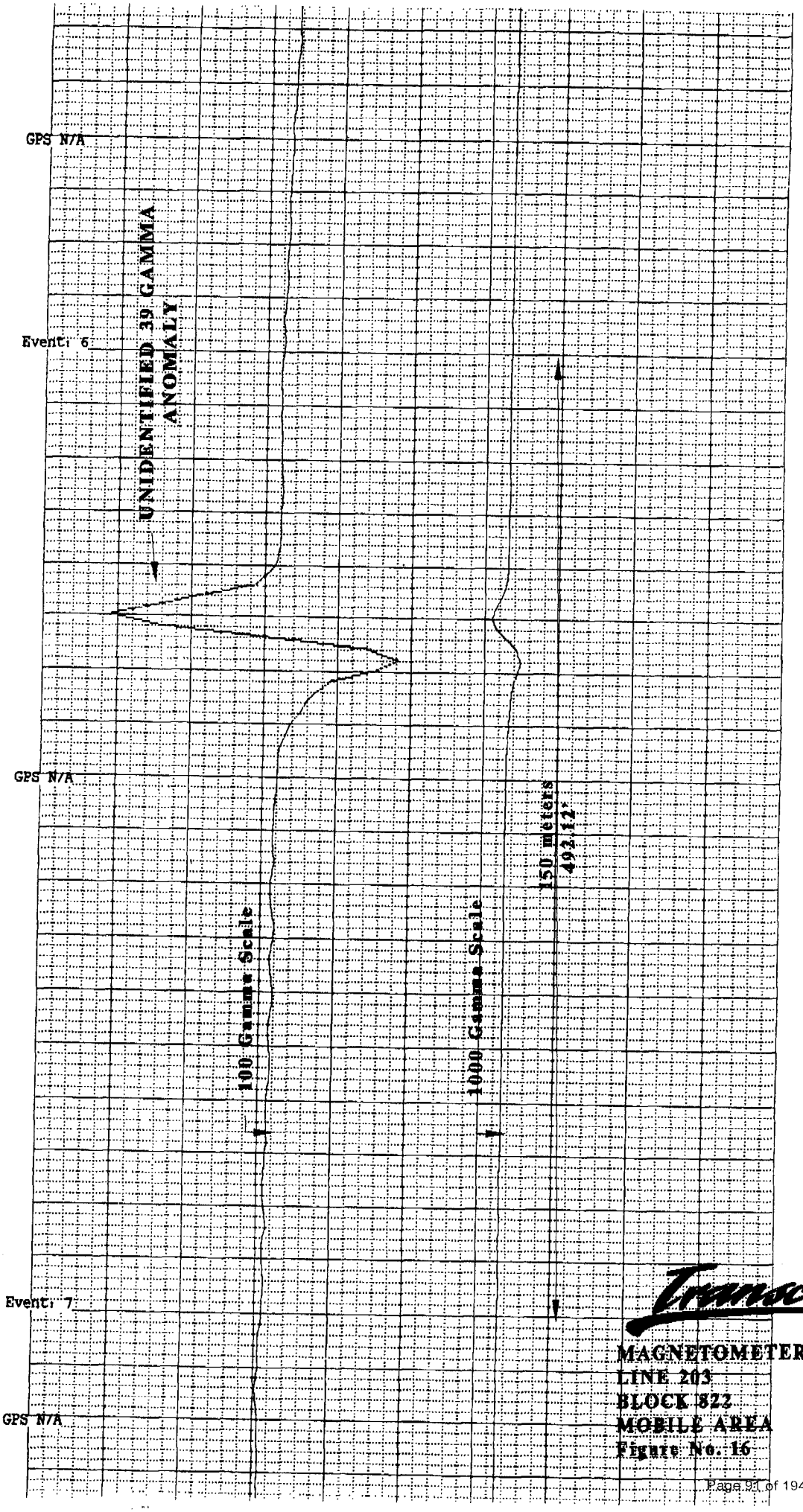
TRANSCO
SONAR RECORD
LINE 54
BLOCK 999
MOBILE AREA
FIGURE No. 13



SONAR & PINGER RECORD
LINE 203
BLOCK 910
MOBILE AREA
Figure No. 1



SONAR & ENGINEER RECORD
LINE 213
BLOCK 910
MOBILE AREA
Figure No.



Transco

MAGNETOMETER RECORD
LINE 203
BLOCK 822
MOBILE AREA
Figure No. 16

APPENDIX B

MAGNETIC ANOMALY TABLE USER'S GUIDE
MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS
MAGNETIC ANOMALY TABLE - MISSISSIPPI SOUND AREA
MAGNETIC ANOMALY TABLE - C & C SURVEY AREAS
TABLE OF MAGNETIC ANOMALIES TO AVOID
NOMOGRAM
JECA SIDE SCAN SONAR CONTACT TABLE
C & C SIDE SCAN SONAR CONTACT TABLE

Glossary of terms:

LINE NO. - The survey trackline followed by the survey vessel. On occasion a rerun of the Line may have been performed. All Lines will be posted on the Hazard map unless they would clutter hazards presentation. Where matching anomalies are recorded, the larger gamma reading will be posted.

RECORDED POSITION - The Shot Point where the anomaly can be found on the original records. No towing setback is applied.

CORRECTED POSITION - The Shot Point where the anomaly can be found on the Hazard Map. Setback from the navigation antenna is applied.

AMPLITUDE IN GAMMAS - Maximum magnetic field deflection from crest to trough of an anomaly.

WIDTH IN FEET - The distance from start of magnetic field deviation to end.

MONOPOLE/DIPOLE - Description of anomaly signature. Either it has a positive or negative field change (Monopole) or the signature changes from positive to negative across a single anomaly (Dipole).

SENSOR HEIGHT OFF BOTTOM - Determined with depth sensor attached near the magnetometer sensor. This elevation can be used on the Briener nomogram as minimum distance from ferrous source.

DESCRIPTION - Source of anomaly i.e., pipeline or structure. If source cannot be identified, the anomaly is quoted as DEBRIS. Broad signatures with low gamma amplitudes are quoted as GEOLOGIC SOURCE if they correlate to near-surface structural features.

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
30	10.53	12.13	9	100	MONOPOLE	87'	DEBRIS (VK-295)	1,281,289'	10,780,423'
32	10.20	8.60	27	40	MONOPOLE	16'	DEBRIS (VK-296)	1,283,462'	10,781,389'
32	31.80	30.20	870	150	DIPOLE	12'	DEBRIS (VK-251)	1,282,243'	10,791,946'
32	87.40	85.80	8	100	DIPOLE	18'	DEBRIS (VK-163)	1,279,028'	10,819,120'
32	90.10	88.50	11	300	DIPOLE	17'	DEBRIS (VK-163)	1,278,864'	10,820,437'
32	95.20	93.60	7	100	DIPOLE	17'	DEBRIS (VK-163)	1,278,560'	10,822,932'
32	97.70	96.10	15	150	DIPOLE	18'	DEBRIS (VK-163)	1,278,432'	10,824,154'
32	102.00	100.40	10	200	DIPOLE	17'	DEBRIS (VK-163)	1,278,190'	10,826,255'
32	103.40	101.80	8	100	MONOPOLE	17'	DEBRIS (VK-163)	1,278,114'	10,826,941'
32	103.80	102.20	24	60	DIPOLE	17'	DEBRIS (VK-163)	1,278,093'	10,827,136'
32	108.40	106.80	22	140	DIPOLE	14'	DEBRIS (VK-163)	1,277,817'	10,829,385'
32	116.90	115.30	16	200	DIPOLE	12'	DEBRIS (VK-163)	1,277,338'	10,833,538'
32	155.40	153.80	20	250	DIPOLE	11'	DEBRIS (VK-75)	1,275,108'	10,852,353'
32	169.60	168.20	10	100	DIPOLE	5'	DEBRIS (VK-75)	1,274,284'	10,859,389'
33	21.60	22.90	14	40	MONOPOLE	8'	DEBRIS (VK-251)	1,281,648'	10,788,230'
33	45.60	46.90	13	350	DIPOLE	8'	DEBRIS (VK-251)	1,280,291'	10,799,996'
33	68.50	69.80	12	50	MONOPOLE	9'	DEBRIS (VK-207)	1,278,961'	10,811,179'
33	77.30	78.60	6	200	MONOPOLE	9'	DEBRIS (VK-207)	1,278,467'	10,815,536'
33	97.00	98.20	7	300	DIPOLE	18'	DEBRIS (VK-163)	1,277,334'	10,825,050'
33	102.10	103.30	13	200	MONOPOLE	18'	DEBRIS (VK-163)	1,277,050'	10,827,541'
33	111.30	112.50	44	150	MONOPOLE	18'	DEBRIS (VK-75)	1,276,496'	10,832,052'
33	160.70	161.90	10	350	DIPOLE	14'	DEBRIS (VK-75)	1,273,662'	10,856,201'
33	162.10	163.30	5	75	MONOPOLE	14'	DEBRIS (VK-75)	1,273,593'	10,856,884'
33	167.10	168.30	10	50	DIPOLE	12'	DEBRIS (VK-75)	1,273,294'	10,859,326'
34	39.00	37.40	6	100	MONOPOLE	11'	DEBRIS (VK-251)	1,279,863'	10,795,237'
34	47.60	46.00	8	200	DIPOLE	7'	DEBRIS (VK-251)	1,279,386'	10,799,442'
34	56.80	55.20	8	50	MONOPOLE	11'	DEBRIS (VK-207)	1,278,840'	10,803,932'
34	92.80	91.20	6	60	MONOPOLE	10'	DEBRIS (VK-207)	1,276,755'	10,821,529'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
34	95.20	93.60	21	300	DIPOLE	7'	DEBRIS (VK-163)	1,276,622'	10,822,700'
34	95.80	94.20	18	250	DIPOLE	7'	DEBRIS (VK-163)	1,276,584'	10,822,995'
34	96.90	95.30	11	200	MONOPOLE	10'	DEBRIS (VK-163)	1,276,521'	10,823,531'
34	99.10	97.50	30	60	DIPOLE	11'	DEBRIS (VK-163)	1,276,399'	10,824,608'
34	103.80	102.40	9	75	MONOPOLE	8'	DEBRIS (VK-163)	1,276,121'	10,827,002'
34	108.80	107.40	10	300	DIPOLE	5'	DEBRIS (VK-163)	1,275,835'	10,829,447'
34	158.70	157.20	12	200	DIPOLE	28'	DEBRIS (VK-75)	1,272,967'	10,853,786'
34	179.50	178.30	10	450	DIPOLE	22'	DEBRIS (VK-75)	1,271,758'	10,864,099'
35	16.85	15.65	95	50	DIPOLE	10'	DEBRIS (VK-295)	1,280,126'	10,784,487'
35	84.00	82.90	11	200	MONOPOLE	20'	DEBRIS (VK-207)	1,276,257'	10,817,355'
35	95.15	94.00	8	150	MONOPOLE	17'	DEBRIS (VK-163)	1,275,604'	10,822,777'
35	95.70	94.60	16	200	DIPOLE	19'	DEBRIS (VK-163)	1,275,572'	10,823,073'
35	101.80	100.10	9	100	MONOPOLE	19'	DEBRIS (VK-163)	1,275,276'	10,825,761'
35	102.95	101.85	12	125	MONOPOLE	16'	DEBRIS (VK-163)	1,275,186'	10,826,620'
35	103.35	102.25	11	100	MONOPOLE	16'	DEBRIS (VK-163)	1,275,160'	10,826,815'
35	103.90	102.80	16	200	DIPOLE	15'	DEBRIS (VK-163)	1,275,121'	10,827,083'
35	110.65	109.55	10	100	MONOPOLE	13'	DEBRIS (VK-163)	1,274,731'	10,830,379'
35	172.00	170.60	4	50	MONOPOLE	24'	DEBRIS (VK-75)	1,271,205'	10,860,217'
35	180.15	178.75	7	75	DIPOLE	22'	DEBRIS (VK-75)	1,270,739'	10,864,203'
36	6.40	8.00	23	50	DIPOLE	18'	DEBRIS (VK-295)	1,279,577'	10,780,634'
36	18.75	20.35	20	50	DIPOLE	19'	DEBRIS (VK-295)	1,278,875'	10,786,671'
36	68.20	69.80	5	50	MONOPOLE	11'	DEBRIS (VK-207)	1,276,031'	10,810,840'
36	147.40	148.80	5	200	DIPOLE	4'	DEBRIS (VK-119)	1,271,489'	10,849,451'
36	161.30	162.70	10	40	DIPOLE	4'	DEBRIS (VK-75)	1,270,680'	10,856,241'
36	180.80	182.20	21	60	DIPOLE	5'	DEBRIS (VK-75)	1,269,563'	10,865,775'
36	182.00	183.40	1000+	500	DIPOLE	4'	ENRON 6" PIPELINE		
37	77.50	79.10	8	200	DIPOLE	15'	DEBRIS (VK-207)	1,274,517'	10,815,268'
37	77.90	79.50	9	250	DIPOLE	15'	DEBRIS (VK-207)	1,274,495'	10,815,465'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
37	83.80	84.60	30	100	DIPOLE	13'	DEBRIS (VK-207)	1,274,199'	10,817,957'
37	85.20	86.80	10	200	DIPOLE	12'	DEBRIS (VK-163)	1,274,082'	10,819,034'
37	92.30	93.90	16	250	DIPOLE	11'	DEBRIS (VK-163)	1,273,675'	10,822,506'
37	125.90	127.50	120	150	DIPOLE	4'	DEBRIS (VK-119)	1,271,742'	10,838,924'
37	147.80	149.20	7	180	DIPOLE	4'	DEBRIS (VK-119)	1,270,493'	10,849,532'
37	170.70	172.10	6	100	DIPOLE	2'	DEBRIS (VK-75)	1,269,162'	10,860,722'
37	174.00	175.40	9	60	DIPOLE	3'	DEBRIS (VK-75)	1,268,985'	10,862,336'
37	179.50	180.90	190	300	DIPOLE	4'	ENRON 6" PIPELINE		
37	180.50	181.90	25	60	DIPOLE	4'	DEBRIS (VK-75)	1,268,604'	10,865,509'
38	2.30	1.30	11	125	DIPOLE	1'	DEBRIS (MO-910)	1,261,566'	10,925,267'
38	4.80	3.80	8	40	MONOPOLE	2'	DEBRIS (MO-910)	1,261,712'	10,924,048'
38	7.90	6.90	200+	100	DIPOLE	4'	DEBRIS (MO-910)	1,261,897'	10,922,531'
38	15.70	14.70	7	20	MONOPOLE	4'	DEBRIS (MO-910)	1,262,341'	10,918,722'
38	16.10	15.10	17	20	MONOPOLE	4'	DEBRIS (MO-910)	1,262,366'	10,918,526'
38	20.40	19.40	4	40	MONOPOLE	5'	DEBRIS (MO-910)	1,262,611'	10,916,423'
38	39.30	38.30	9	50	DIPOLE	14'	DEBRIS (MO-954)	1,263,684'	10,907,185'
38	50.20	49.20	1000+	550	DIPOLE	17'	DAUPHIN 12" PIPELINE		
38	51.80	50.80	200	125	DIPOLE	17'	DEBRIS (MO-954)	1,264,410'	10,901,079'
38	56.70	55.70	67	150	DIPOLE	19'	MURPHY 6" PIPELINE		
38	70.20	69.00	9	45	DIPOLE	24'	DEBRIS (MO-998)	1,265,469'	10,892,187'
38	80.60	79.40	20	50	DIPOLE	29'	DEBRIS (MO-998)	1,266,058'	10,887,100'
38	89.10	87.90	8	40	MONOPOLE	32'	DEBRIS (MO-998)	1,266,546'	10,882,947'
38	100.30	98.90	8	50	DIPOLE	38'	DEBRIS (VK-30)	1,267,187'	10,877,571'
39	4.30	5.20	10	25	MONOPOLE	2'	DEBRIS (MO-910)	1,261,957'	10,923,381'
39	9.20	10.20	73	40	DIPOLE	4'	DEBRIS (MO-910)	1,262,240'	10,920,941'
39	13.00	14.00	25	50	DIPOLE	10'	DEBRIS (MO-910)	1,262,485'	10,919,081'
39	15.60	16.60	10	100	DIPOLE	10'	DEBRIS (MO-910)	1,262,622'	10,917,809'
39	20.20	21.20	6	10	MONOPOLE	8'	DEBRIS (MO-910)	1,262,868'	10,915,566'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
40	101.10	99.70	68	25	MONOPOLE	25'	DEBRIS (VK-31)	1,267,560'	10,877,216'
40	103.50	102.10	14	1000	MONOPOLE	26'	VK-31, WELL # 1		
41	4.50	5.50	5	150	DIPOLE	1'	DEBRIS (MO-910)	1,262,297'	10,923,274'
41	19.90	20.90	8	50	DIPOLE	3'	DEBRIS (MO-910)	1,263,184'	10,915,756'
41	27.50	28.50	19	50	MONOPOLE	12'	DEBRIS (MO-954)	1,263,616'	10,912,034'
41	40.30	41.30	7	50	MONOPOLE	13'	DEBRIS (MO-954)	1,264,359'	10,905,777'
41	49.70	50.70	1000+	400	DIPOLE	16'	DAUPHIN 12" PIPELINE		
41	50.60	51.60	8	50	MONOPOLE	16'	DEBRIS (MO-954)	1,264,949'	10,900,740'
41	51.80	52.80	22	75	MONOPOLE	16'	DEBRIS (MO-954)	1,265,024'	10,900,157'
41	55.50	56.50	80	200	MONOPOLE	17'	MURPHY 6" PIPELINE		
41	73.00	74.00	5	20	MONOPOLE	9'	DEBRIS (MO-998)	1,266,251'	10,889,798'
41	73.60	74.60	63	40	DIPOLE	9'	DEBRIS (MO-998)	1,266,280'	10,889,505'
41	76.10	77.10	12	25	DIPOLE	8'	DEBRIS (MO-998)	1,266,417'	10,888,282'
41	113.40	114.80	210	50	DIPOLE	5'	DEBRIS (VK-31)	1,268,595'	10,869,855'
41	122.00	123.40	200+	400	DIPOLE	6'	ENRON 6" PIPELINE		
42	37.40	36.40	5	10	MONOPOLE	9'	DEBRIS (MO-954)	1,263,878'	10,911,356'
42	44.80	43.80	20	40	MONOPOLE	10'	DEBRIS (MO-954)	1,264,227'	10,908,402'
42	46.10	45.10	6	50	MONOPOLE	11'	DEBRIS (MO-954)	1,264,283'	10,907,885'
42	54.50	53.50	80	75	DIPOLE	1'	DEBRIS (MO-954)	1,264,674'	10,904,527'
42	63.70	62.70	1000+	550	DIPOLE	3'	DAUPHIN 12" PIPELINE		
42	70.20	69.20	65	250	DIPOLE	4'	MURPHY 6" PIPELINE		
42	74.80	73.60	150	50	DIPOLE	5'	DEBRIS (MO-998)	1,265,611'	10,896,498'
42	78.60	77.40	5	40	MONOPOLE	8'	DEBRIS (MO-998)	1,265,787'	10,894,983'
42	83.40	82.20	7	60	MONOPOLE	10'	DEBRIS (MO-998)	1,266,028'	10,893,066'
42	96.90	95.70	14	100	MONOPOLE	16'	DEBRIS (MO-998)	1,266,648'	10,887,672'
42	97.10	95.90	17	100	DIPOLE	16'	DEBRIS (MO-998)	1,266,654'	10,887,591'
43	40.50	41.70	35	75	DIPOLE	29'	DEBRIS (MO-954)	1,264,725'	10,905,620'
43	40.70	41.90	14	75	DIPOLE	29'	DEBRIS (MO-954)	1,264,742'	10,905,521'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
43	42.20	43.40	340	60	DIPOLE	29'	DEBRIS (MO-954)	1,264,823'	10,904,794'
43	48.30	49.50	15	60	DIPOLE	30'	DEBRIS (MO-954)	1,265,176'	10,901,810'
43	50.60	51.80	1000+	600	DIPOLE	31'	DAUPHIN 12" PIPELINE		
43	53.50	54.70	61	75	DIPOLE	32'	DEBRIS (MO-954)	1,265,441'	10,899,263'
43	55.50	56.70	55	75	MONOPOLE	32'	MURPHY 6" PIPELINE		
43	61.00	62.20	25	50	MONOPOLE	34'	DEBRIS (MO-998)	1,265,884'	10,895,600'
43	62.30	63.50	8	60	DIPOLE	35'	DEBRIS (MO-998)	1,265,969'	10,894,965'
43	70.90	72.10	16	60	DIPOLE	19'	DEBRIS (MO-998)	1,266,478'	10,890,763'
43	72.40	73.60	19	100	DIPOLE	20'	DEBRIS (MO-998)	1,266,570'	10,890,035'
43	80.60	82.00	7	50	MONOPOLE	22'	DEBRIS (MO-998)	1,267,029'	10,885,922'
43	87.90	89.30	9	100	DIPOLE	26'	DEBRIS (MO-999)	1,267,399'	10,882,350'
43	100.80	102.20	100	900	MONOPOLE	32'	VK-31, WELL # 1		
43	121.40	122.80	1000+	750	DIPOLE	35'	ENRON 6" PIPELINE		
44	5.30	4.30	840	100	DIPOLE	7'	DEBRIS (MO-910)	1,262,714'	10,923,916'
44	5.60	4.60	660	100	DIPOLE	7'	DEBRIS (MO-910)	1,262,726'	10,923,771'
44	5.90	4.90	22	50	DIPOLE	7'	DEBRIS (MO-910)	1,262,737'	10,923,625'
44	14.30	13.30	7	50	DIPOLE	2'	DEBRIS (MO-910)	1,263,252'	10,919,523'
44	23.20	22.20	35	25	DIPOLE	7'	DEBRIS (MO-910)	1,263,752'	10,915,171'
44	37.80	36.80	7	25	MONOPOLE	11'	DEBRIS (MO-954)	1,264,584'	10,908,037'
44	38.20	37.20	30	100	DIPOLE	11'	DEBRIS (MO-954)	1,264,609'	10,907,841'
44	44.20	43.20	40	75	MONOPOLE	14'	DEBRIS (MO-954)	1,264,957'	10,904,910'
44	49.20	48.20	70	90	DIPOLE	4'	DEBRIS (MO-954)	1,265,237'	10,902,460'
44	53.20	52.20	1000+	600	DIPOLE	4'	DAUPHIN 12" PIPELINE		
44	57.70	56.70	34	300	DIPOLE	2'	MURPHY 6" PIPELINE		
44	62.70	61.70	19	125	DIPOLE	20'	DEBRIS (MO-998)	1,266,034'	10,895,868'
44	76.90	75.60	8	50	MONOPOLE	7'	DEBRIS (MO-998)	1,266,813'	10,889,071'
44	78.70	77.40	8	40	MONOPOLE	2'	DEBRIS (MO-998)	1,266,924'	10,888,195'
44	84.80	83.50	38	60	DIPOLE	2'	DEBRIS (MO-999)	1,267,279'	10,885,212'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
44	101.50	100.20	5	50	MONOPOLE	11'	DEBRIS (VK-31)	1,268,238'	10,877,050'
44	103.50	102.20	30	750	MONOPOLE	13'	VK-31, WELL # 1		
44	109.00	107.70	50	50	DIPOLE	14'	DEBRIS (VK-31)	1,268,667'	10,873,384'
44	123.50	122.20	195	500	DIPOLE	16'	ENRON 6" PIPELINE		
45	7.40	8.30	10	50	DIPOLE	8'	DEBRIS (MO-910)	1,263,109'	10,921,982'
45	7.50	8.40	6	25	MONOPOLE	8'	DEBRIS (MO-910)	1,263,114'	10,921,933'
45	7.60	8.50	14	50	MONOPOLE	11'	DEBRIS (MO-910)	1,263,120'	10,921,884'
45	9.50	10.40	23	25	MONOPOLE	9'	DEBRIS (MO-910)	1,263,233'	10,920,957'
45	10.00	10.90	6	25	MONOPOLE	6'	DEBRIS (MO-910)	1,263,266'	10,920,718'
45	27.00	28.00	22	50	MONOPOLE	13'	DEBRIS (MO-954)	1,264,247'	10,912,357'
45	42.10	43.10	59	50	DIPOLE	15'	DEBRIS (MO-954)	1,265,112'	10,904,969'
45	46.30	47.30	9	50	MONOPOLE	16'	DEBRIS (MO-954)	1,265,365'	10,902,920'
45	52.00	53.00	460	550	DIPOLE	16'	DAUPHIN 12" PIPELINE		
45	55.80	56.80	35	100	DIPOLE	18'	MURPHY 6" PIPELINE		
45	57.50	58.50	7	40	MONOPOLE	18'	DEBRIS (MO-998)	1,265,994'	10,897,445'
45	65.30	66.50	14	25	DIPOLE	22'	DEBRIS (MO-998)	1,266,468'	10,893,540'
45	67.00	68.20	75	25	DIPOLE	23'	DEBRIS (MO-998)	1,266,564'	10,892,708'
45	72.60	73.80	8	50	DIPOLE	25'	DEBRIS (MO-998)	1,266,873'	10,889,970'
45	73.50	74.70	30	50	DIPOLE	26'	DEBRIS (MO-998)	1,266,927'	10,889,528'
45	74.00	75.20	8	50	MONOPOLE	26'	DEBRIS (MO-998)	1,266,959'	10,889,284'
45	76.70	77.90	29	60	DIPOLE	11'	DEBRIS (MO-998)	1,267,120'	10,887,962'
45	104.90	106.10	30	100	DIPOLE	24'	DEBRIS (VK-31)	1,268,745'	10,874,185'
45	120.70	121.90	275	400	DIPOLE	25'	ENRON 6" PIPELINE		
46	7.00	6.10	29	40	DIPOLE	3	DEBRIS (MO-910)	1,263,148'	10,923,069'
46	8.20	7.30	12	10	DIPOLE	3'	DEBRIS (MO-910)	1,263,209'	10,922,493'
46	8.30	7.40	13	10	MONOPOLE	3'	DEBRIS (MO-910)	1,263,216'	10,922,444'
46	39.30	38.30	5	40	MONOPOLE	9'	DEBRIS (MO-954)	1,265,000'	10,907,340'
46	50.80	49.80	6	50	MONOPOLE	3'	DEBRIS (MO-954)	1,265,663'	10,901,719'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
46	54.20	53.20	1000+	600	DIPOLE	3'	DAUPHIN 12" PIPELINE		
46	57.70	56.70	210	150	MONOPOLE	4'	MURPHY 6" PIPELINE		
46	74.30	73.30	34	60	DIPOLE	12'	DEBRIS (MO-998)	1,267,001'	10,890,236'
46	84.90	83.90	7	40	MONOPOLE	15'	DEBRIS (MO-999)	1,267,628'	10,885,051'
46	108.00	106.30	6	25	DIPOLE	7'	DEBRIS (VK-31)	1,268,930'	10,874,109'
46	113.60	112.40	7	40	DIPOLE	8'	DEBRIS (VK-31)	1,269,280'	10,871,126'
46	123.00	121.80	390	500	DIPOLE	9'	ENRON 6" PIPELINE		
47	18.90	17.90	11	60	MONOPOLE	11'	DEBRIS (MO-910)	1,263,992'	10,917,328'
47	24.50	23.50	8	25	MONOPOLE	9'	DEBRIS (MO-910)	1,264,305'	10,914,595'
47	43.60	42.60	41	100	DIPOLE	13'	DEBRIS (MO-954)	1,265,408'	10,905,259'
47	43.70	42.70	38	75	MONOPOLE	13'	DEBRIS (MO-954)	1,265,414'	10,905,211'
47	54.80	53.80	400+	500	DIPOLE	17'	DAUPHIN 12" PIPELINE		
47	57.70	56.70	185	200	MONOPOLE	17'	MURPHY 6" PIPELINE		
47	66.70	65.70	6	70	MONOPOLE	21'	DEBRIS (MO-998)	1,266,752'	10,893,968'
47	72.80	71.80	10	100	DIPOLE	24'	DEBRIS (MO-998)	1,267,100'	10,890,989'
47	79.70	78.50	19	75	DIPOLE	10'	DEBRIS (MO-999)	1,267,481'	10,887,710'
47	105.40	104.00	27	40	DIPOLE	8'	DEBRIS (VK-31)	1,268,943'	10,875,248'
47	105.90	104.50	5	50	DIPOLE	6'	DEBRIS (VK-31)	1,268,974'	10,875,006'
47	106.10	104.70	60	50	MONOPOLE	8'	DEBRIS (VK-31)	1,268,986'	10,874,909'
47	120.60	119.20	7	50	MONOPOLE	8'	DEBRIS (VK-31)	1,269,814'	10,867,822'
47	122.40	121.00	250	300	MONOPOLE	8'	ENRON 6" PIPELINE		
48	5.00	6.00	7	60	DIPOLE	9'	DEBRIS (MO-910)	1,263,465'	10,923,160'
48	20.60	21.60	6	500	MONOPOLE	8'	DEBRIS (MO-910)	1,264,369'	10,915,536'
48	22.30	23.30	24	40	DIPOLE	8'	DEBRIS (MO-910)	1,264,468'	10,914,710'
48	23.70	24.70	4	25	MONOPOLE	13'	DEBRIS (MO-910)	1,264,551'	10,914,022'
48	26.90	27.90	8	20	DIPOLE	15'	DEBRIS (MO-954)	1,264,742'	10,912,458'
48	34.50	35.50	37	50	DIPOLE	14'	DEBRIS (MO-954)	1,265,169'	10,908,746'
48	53.40	54.40	560	500	DIPOLE	19'	DAUPHIN 12" PIPELINE		

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
48	55.70	56.70	28	100	MONOPOLE	19'	MURPHY 6" PIPELINE		
48	65.60	66.90	80	50	DIPOLE	24'	DEBRIS (MO-998)	1,266,981'	10,893,400'
48	69.50	70.80	8	50	MONOPOLE	4'	DEBRIS (MO-999)	1,267,200'	10,891,492'
48	77.00	78.30	100	14	DIPOLE	8'	DEBRIS (MO-999)	1,267,634'	10,887,825'
48	82.90	84.20	10	50	DIPOLE	10'	DEBRIS (MO-999)	1,267,970'	10,884,947'
48	119.40	120.30	60	250	DIPOLE	22'	ENRON 6" PIPELINE		
49	5.90	5.00	9	50	DIPOLE	13'	DEBRIS (MO-910)	1,263,571'	10,923,670'
49	8.00	7.10	3	50	MONOPOLE	13'	DEBRIS (MO-910)	1,263,699'	10,922,649'
49	17.50	16.60	24	50	DIPOLE	9'	DEBRIS (MO-910)	1,264,243'	10,918,003'
49	22.70	21.60	6	850	MONOPOLE	15'	DEBRIS (MO-910)	1,264,516'	10,915,560'
49	37.90	36.90	7	40	DIPOLE	4'	DEBRIS (MO-954)	1,265,416'	10,908,086'
49	56.10	55.10	378	900	DIPOLE	1'	DAUPHIN 12" PIPELINE		
49	57.60	56.60	170	75	MONOPOLE	2'	MURPHY 6" PIPELINE		
49	72.70	71.30	18	80	DIPOLE	8'	DEBRIS (MO-999)	1,267,393'	10,891,269'
49	76.80	75.40	23	60	DIPOLE	10'	DEBRIS (MO-999)	1,267,627'	10,889,268'
49	82.20	80.80	5	50	MONOPOLE	12'	DEBRIS (MO-999)	1,267,926'	10,886,622'
49	121.70	120.30	275	300	DIPOLE	25'	ENRON 6" PIPELINE		
50	3.90	2.90	90	50	DIPOLE	3'	DEBRIS (MO-910)	1,263,608'	10,924,717'
50	7.20	6.20	22	50	MONOPOLE	16'	DEBRIS (MO-910)	1,263,802'	10,923,101'
50	23.10	22.10	4	500	MONOPOLE	17'	DEBRIS (MO-910)	1,264,708'	10,915,330'
50	57.20	56.20	1000+	400	DIPOLE	2'	DAUPHIN 12" PIPELINE		
50	57.70	56.70	26	300	DIPOLE	2'	MURPHY 6" PIPELINE		
50	71.90	70.70	9	100	DIPOLE	4'	DEBRIS (MO-999)	1,267,501'	10,891,580'
50	85.20	84.00	24	50	DIPOLE	9'	DEBRIS (MO-999)	1,268,284'	10,885,085'
50	89.40	88.20	21	50	MONOPOLE	11'	DEBRIS (MO-999)	1,268,532'	10,883,032'
50	121.20	120.00	135	300	DIPOLE	22'	ENRON 6" PIPELINE		
51	8.70	9.60	16	54	MONOPOLE	14'	DEBRIS (MO-910)	1,264,173'	10,921,463'
51	15.50	16.90	5	25	MONOPOLE	17'	DEBRIS (MO-910)	1,264,570'	10,917,892'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
51	21.50	22.50	5	450	MONOPOLE	14'	DEBRIS (MO-910)	1,264,891'	10,915,155'
51	37.00	38.00	5	60	MONOPOLE	23'	DEBRIS (MO-954)	1,265,809'	10,907,584'
51	40.80	41.80	420	80	DIPOLE	24'	DEBRIS (MO-954)	1,266,015'	10,905,722'
51	44.70	45.70	220	100	DIPOLE	25'	DEBRIS (MO-954)	1,266,244'	10,903,815'
51	55.40	56.60	650	100	DIPOLE	28'	MURPHY 6" PIPELINE		
51	56.50	57.70	1000+	1000	DIPOLE	28'	DAUPHIN 12" PIPELINE		
51	82.30	83.50	23	60	DIPOLE	39'	DEBRIS (MO-999)	1,268,423'	10,885,344'
51	83.50	84.70	40	70	DIPOLE	39'	DEBRIS (MO-999)	1,268,481'	10,884,755'
51	98.00	99.40	17	50	DIPOLE	47'	DEBRIS (VK-31)	1,269,338'	10,877,573'
51	106.60	108.00	92	40	DIPOLE	49'	DEBRIS (VK-31)	1,269,827'	10,873,379'
51	108.50	109.90	29	50	DIPOLE	14'	DEBRIS (VK-31)	1,269,935'	10,872,443'
51	118.10	119.50	370	250	DIPOLE	15'	ENRON 6" PIPELINE		
52	17.10	16.10	19	30	DIPOLE	3'	DEBRIS (MO-910)	1,264,702'	10,918,305'
52	21.80	20.80	11	50	DIPOLE	11'	DEBRIS (MO-910)	1,264,980'	10,916,007'
52	22.20	21.20	9	90	MONOPOLE	11'	DEBRIS (MO-910)	1,265,005'	10,915,813'
52	23.50	22.50	6	500	MONOPOLE	6'	DEBRIS (MO-910)	1,265,074'	10,915,180'
52	42.45	41.45	107	125	DIPOLE	16'	DEBRIS (MO-954)	1,266,165'	10,905,917'
52	42.60	41.60	120	125	DIPOLE	16'	DEBRIS (MO-954)	1,266,172'	10,905,843'
52	60.50	59.50	1000+	500	DIPOLE	22'	DAUPHIN 12" PIPELINE		
52	67.20	66.00	8	50	MONOPOLE	9'	DEBRIS (MO-999)	1,267,578'	10,893,920'
52	71.30	70.10	5	25	MONOPOLE	11'	DEBRIS (MO-999)	1,267,811'	10,891,913'
52	73.00	71.80	8	90	DIPOLE	7'	DEBRIS (MO-999)	1,267,914'	10,891,082'
52	75.50	74.30	9	40	MONOPOLE	8'	DEBRIS (MO-999)	1,268,056'	10,889,862'
52	79.20	78.00	6	50	DIPOLE	9'	DEBRIS (MO-999)	1,268,270'	10,888,055'
52	81.60	80.40	6	50	MONOPOLE	10'	DEBRIS (MO-999)	1,268,407'	10,886,881'
52	86.20	85.00	76	60	MONOPOLE	12'	DEBRIS (MO-999)	1,268,668'	10,884,631'
52	103.30	102.10	42	110	DIPOLE	20'	DEBRIS (VK-31)	1,269,637'	10,876,274'
52	120.50	119.10	140	250	MONOPOLE	10'	ENRON 6" PIPELINE		

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
52	121.20	119.80	5	60	MONOPOLE	10'	DEBRIS (VK-31)	1,270,673'	10,867,621'
52	122.00	120.60	4	30	MONOPOLE	10'	DEBRIS (VK-31)	1,270,728'	10,867,233'
53	18.30	19.30	24	25	DIPOLE	6'	DEBRIS (MO-910)	1,265,043'	10,916,760'
53	27.30	28.30	23	30	MONOPOLE	12'	DEBRIS (MO-954)	1,265,562'	10,912,359'
53	39.50	40.50	13	40	MONOPOLE	11'	DEBRIS (MO-954)	1,266,272'	10,906,400'
53	39.60	40.60	8	30	MONOPOLE	11'	DEBRIS (MO-954)	1,266,276'	10,906,352'
53	40.30	41.30	180	100	DIPOLE	11'	DEBRIS (MO-954)	1,266,311'	10,906,011'
53	47.60	48.60	6	100	MONOPOLE	13'	DEBRIS (MO-954)	1,266,726'	10,902,441'
53	55.50	56.50	25	200	DIPOLE	17'	MURPHY 6" PIPELINE		
53	59.90	61.10	1000+	1600	DIPOLE	19'	DAUPHIN 12" PIPELINE		
53	63.10	64.30	4	50	MONOPOLE	19'	DEBRIS (MO-999)	1,267,628'	10,894,765'
53	69.00	70.20	6	15	MONOPOLE	23'	DEBRIS (MO-999)	1,267,979'	10,891,885'
53	71.00	72.20	5	15	MONOPOLE	23'	DEBRIS (MO-999)	1,268,100'	10,890,907'
53	74.70	75.90	20	50	DIPOLE	25'	DEBRIS (MO-999)	1,268,315'	10,889,097'
53	86.80	88.00	6	50	MONOPOLE	15'	DEBRIS (MO-999)	1,269,011'	10,883,180'
53	117.60	118.80	95	170	MONOPOLE	23'	ENRON 6" PIPELINE		
54	16.60	17.60	29	50	MONOPOLE	11'	DEBRIS (MO-910)	1,265,128'	10,917,608'
54	21.10	22.10	9	50	MONOPOLE	11'	DEBRIS (MO-910)	1,265,373'	10,915,419'
54	21.70	22.70	6	800	DIPOLE	8'	DEBRIS (MO-910)	1,265,407'	10,915,120'
54	34.30	35.30	37	40	MONOPOLE	7'	DEBRIS (MO-954)	1,266,134'	10,908,958'
54	40.00	41.00	340	100	DIPOLE	9'	DEBRIS (MO-954)	1,266,461'	10,906,174'
54	50.80	51.80	7	25	MONOPOLE	12'	DEBRIS (MO-954)	1,267,089'	10,900,894'
54	55.50	56.50	125	100	MONOPOLE	13'	MURPHY 6" PIPELINE		
54	61.50	62.50	154	1500	DIPOLE	15'	DAUPHIN 12" PIPELINE		
54	62.50	63.50	12	50	DIPOLE	15'	DEBRIS (MO-999)	1,267,752'	10,895,176'
54	63.50	64.50	7	75	DIPOLE	16'	DEBRIS (MO-999)	1,267,809'	10,894,685'
54	100.20	101.40	7	60	DIPOLE	16'	DEBRIS (VK-31)	1,269,935'	10,876,651'
54	117.20	118.40	80	100	MONOPOLE	19'	ENRON 6" PIPELINE		

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
55	21.30	20.30	19	50	MONOPOLE	7'	DEBRIS (MO-910)	1,265,436'	10,916,309'
55	23.70	22.70	6	350	DIPOLE	10'	DEBRIS (MO-910)	1,265,576'	10,915,138'
55	52.00	51.00	6	60	MONOPOLE	13'	DEBRIS (MO-954)	1,267,201'	10,901,304'
55	55.30	54.30	5	50	MONOPOLE	14'	DEBRIS (MO-955)	1,267,389'	10,899,692'
55	57.40	56.40	140	300	DIPOLE	14'	MURPHY 6" PIPELINE		
55	65.30	64.10	1000+	1700	DIPOLE	7'	DAUPHIN 12" PIPELINE		
55	70.30	69.10	40	160	MONOPOLE	5'	DEBRIS (MO-999)	1,268,244'	10,892,458'
55	81.20	80.00	9	60	MONOPOLE	3'	DEBRIS (MO-999)	1,268,865'	10,887,133'
55	103.60	102.20	10	60	MONOPOLE	11'	DEBRIS (VK-31)	1,270,146'	10,876,283'
55	104.00	102.60	4	30	DIPOLE	11'	DEBRIS (VK-31)	1,270,165'	10,876,087'
55	109.70	108.30	5	50	DIPOLE	12'	DEBRIS (VK-31)	1,270,507'	10,873,301'
55	119.30	117.90	165	200	MONOPOLE	13'	ENRON 6" PIPELINE		
56	5.20	6.20	33	40	DIPOLE	6'	DEBRIS (MO-910)	1,264,789'	10,923,222'
56	6.90	7.90	100	50	DIPOLE	7'	DEBRIS (MO-910)	1,264,876'	10,922,388'
56	7.40	8.40	9	40	MONOPOLE	7'	DEBRIS (MO-910)	1,264,903'	10,922,145'
56	9.00	10.00	7	25	MONOPOLE	7'	DEBRIS (MO-910)	1,265,005'	10,921,361'
56	21.60	22.60	8	600	DIPOLE	9'	DEBRIS (MO-910)	1,265,729'	10,915,205'
56	23.00	24.00	175	50	MONOPOLE	6'	DEBRIS (MO-910)	1,265,816'	10,914,519'
56	25.10	26.10	50	30	MONOPOLE	10'	DEBRIS (MO-954)	1,265,934'	10,913,494'
56	27.60	28.60	5	50	MONOPOLE	13'	DEBRIS (MO-954)	1,266,078'	10,912,272'
56	39.60	40.60	61	100	DIPOLE	14'	DEBRIS (MO-954)	1,266,760'	10,906,406'
56	43.50	44.50	6	40	MONOPOLE	15'	DEBRIS (MO-954)	1,266,985'	10,904,500'
56	48.10	49.10	15	60	DIPOLE	17'	DEBRIS (MO-955)	1,267,256'	10,902,255'
56	48.70	49.70	9	40	MONOPOLE	17'	DEBRIS (MO-955)	1,267,288'	10,901,958'
56	55.50	56.50	110	150	MONOPOLE	19'	MURPHY 6" PIPELINE		
56	64.50	65.50	1000+	1600	DIPOLE	23'	DAUPHIN 12" PIPELINE		
56	68.90	69.10	7	40	MONOPOLE	8'	DEBRIS (MO-999)	1,268,397'	10,892,473'
56	71.90	72.10	6	50	DIPOLE	9'	DEBRIS (MO-999)	1,268,587'	10,891,012'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
56	80.30	81.50	16	100	DIPOLE	13'	DEBRIS (MO-999)	1,269,108'	10,886,422'
56	116.20	117.60	95	250	DIPOLE	11'	ENRON 6" PIPELINE		
56	118.10	119.50	9	50	MONOPOLE	12'	DEBRIS (VK-31)	1,271,307'	10,867,845'
56	122.90	124.30	5	50	DIPOLE	12'	DEBRIS (VK-75)	1,271,577'	10,865,498'
57	3.70	2.70	5	50	MONOPOLE	1'	DEBRIS (MO-910)	1,264,743'	10,924,951'
57	23.60	22.60	8	1150	DIPOLE	9'	DEBRIS (MO-910)	1,265,889'	10,915,227'
57	28.00	27.00	7	20	MONOPOLE	7'	DEBRIS (MO-954)	1,266,151'	10,913,076'
57	43.10	42.10	6	25	MONOPOLE	13'	DEBRIS (MO-954)	1,266,997'	10,905,696'
57	49.90	48.90	36	50	DIPOLE	15'	DEBRIS (MO-955)	1,267,403'	10,902,369'
57	51.90	50.90	31	56	DIPOLE	15'	DEBRIS (MO-955)	1,267,509'	10,901,395'
57	52.80	51.80	12	50	DIPOLE	16'	DEBRIS (MO-955)	1,267,567'	10,900,955'
57	55.00	54.00	70	75	DIPOLE	12'	DEBRIS (MO-955)	1,267,709'	10,899,884'
57	57.50	56.50	215	200	MONOPOLE	13'	MURPHY 6" PIPELINE		
57	62.00	61.00	6	25	DIPOLE	14'	DEBRIS (MO-999)	1,268,097'	10,896,457'
57	63.70	62.70	25	50	MONOPOLE	4'	DEBRIS (MO-999)	1,268,205'	10,895,626'
57	68.30	67.30	1000+	1600	DIPOLE	6'	DAUPHIN 12" PIPELINE		
57	104.80	103.60	30	70	MONOPOLE	15'	DEBRIS (VK-31)	1,270,554'	10,875,638'
57	118.40	117.20	100	220	DIPOLE	17'	ENRON 6" PIPELINE		
58	21.50	22.50	5	950	DIPOLE	9'	DEBRIS (MO-910)	1,266,044'	10,915,295'
58	22.10	23.10	5	50	MONOPOLE	9'	DEBRIS (MO-910)	1,266,079'	10,915,000'
58	22.30	23.30	5	40	MONOPOLE	9'	DEBRIS (MO-910)	1,266,091'	10,914,902'
58	29.30	30.30	10	30	MONOPOLE	10'	DEBRIS (MO-954)	1,266,511'	10,911,480'
58	43.10	44.10	10	50	MONOPOLE	14'	DEBRIS (MO-955)	1,267,284'	10,904,733'
58	54.40	55.40	6	40	MONOPOLE	17'	DEBRIS (MO-955)	1,267,948'	10,899,212'
58	55.50	56.50	90	300	DIPOLE	18'	MURPHY 6" PIPELINE		
58	57.50	58.50	4	50	MONOPOLE	18'	DEBRIS (MO-999)	1,268,118'	10,897,694'
58	65.80	67.00	13	40	MONOPOLE	7'	DEBRIS (MO-999)	1,268,603'	10,893,540'
58	68.00	69.20	1000+	1800	DIPOLE	8'	DAUPHIN 12" PIPELINE		

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
58	84.40	85.60	7	60	DIPOLE	14'	DEBRIS (MO-999)	1,269,678'	10,884,452'
58	85.50	86.70	6	50	MONOPOLE	15'	DEBRIS (MO-999)	1,269,739'	10,883,914'
58	107.50	108.90	31	50	DIPOLE	24'	DEBRIS (VK-31)	1,271,014'	10,873,059'
58	110.60	112.00	15	20	MONOPOLE	25'	DEBRIS (VK-31)	1,271,201'	10,871,545'
58	115.40	116.80	345	100	MONOPOLE	13'	ENRON 6" PIPELINE		
58	118.30	119.70	35	50	MONOPOLE	14'	DEBRIS (VK-31)	1,271,639'	10,867,785'
58	119.70	121.10	50	150	DIPOLE	14'	DEBRIS (VK-31)	1,271,718'	10,867,099'
59	18.60	17.70	10	50	DIPOLE	17'	DEBRIS (MO-910)	1,265,936'	10,917,660'
59	23.40	22.40	5	600	DIPOLE	16'	DEBRIS (MO-910)	1,266,202'	10,915,361'
59	40.80	39.90	9	50	DIPOLE	9'	DEBRIS (MO-954)	1,267,208'	10,906,811'
59	57.30	56.40	41	250	MONOPOLE	5'	MURPHY 6" PIPELINE		
59	65.00	64.10	8	75	MONOPOLE	2'	DEBRIS (MO-999)	1,268,610'	10,894,979'
59	71.40	70.50	1000+	1600	DIPOLE	1'	DAUPHIN 12" PIPELINE		
59	77.90	76.70	9	40	DIPOLE	4'	DEBRIS (MO-999)	1,269,322'	10,888,821'
59	117.60	116.40	30	200	MONOPOLE	19'	ENRON 6" PIPELINE		
60	6.50	7.50	10	90	DIPOLE	3'	DEBRIS (MO-910)	1,265,514'	10,922,663'
60	21.50	22.50	4	1000	DIPOLE	8'	DEBRIS (MO-910)	1,266,382'	10,915,334'
60	27.20	28.20	7	25	MONOPOLE	9'	DEBRIS (MO-954)	1,266,700'	10,912,541'
60	38.70	39.70	53	75	MONOPOLE	13'	DEBRIS (MO-955)	1,267,364'	10,906,921'
60	55.20	56.40	40	130	DIPOLE	2'	MURPHY 6" PIPELINE		
60	63.10	64.30	44	25	DIPOLE	5'	DEBRIS (MO-999)	1,268,790'	10,894,900'
60	63.40	64.60	43	30	DIPOLE	6'	DEBRIS (MO-999)	1,268,814'	10,894,755'
60	64.90	65.10	86	50	DIPOLE	6'	DEBRIS (MO-999)	1,268,848'	10,894,511'
60	66.40	67.60	21	120	DIPOLE	7'	DEBRIS (MO-999)	1,268,963'	10,893,286'
60	71.40	72.60	1000+	1500	DIPOLE	9'	DAUPHIN 12" PIPELINE		
60	73.30	74.50	63	20	DIPOLE	11'	DEBRIS (MO-999)	1,269,382'	10,889,919'
60	74.80	76.00	9	100	DIPOLE	11'	DEBRIS (MO-999)	1,269,468'	10,889,186'
60	83.90	85.10	180	150	DIPOLE	14'	DEBRIS (MO-999)	1,269,980'	10,884,733'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
60	85.00	86.20	105	100	DIPOLE	14'	DEBRIS (MO-999)	1,270,047'	10,884,199'
60	103.70	104.90	45	150	DIPOLE	23'	DEBRIS (VK-31)	1,271,146'	10,875,063'
60	109.10	110.50	13	40	MONOPOLE	18'	DEBRIS (VK-31)	1,271,450'	10,872,319'
60	110.11	111.50	13	100	DIPOLE	18'	DEBRIS (VK-31)	1,271,509'	10,871,833'
60	114.60	116.10	75	250	DIPOLE	8'	ENRON 6" PIPELINE		
61	15.90	16.90	4	300	DIPOLE	8'	DEBRIS (MO-910)	1,266,220'	10,918,088'
61	22.00	23.00	135	100	DIPOLE	8'	DEBRIS (MO-910)	1,266,560'	10,915,102'
61	38.10	39.10	7	40	DIPOLE	14'	DEBRIS (MO-955)	1,267,496'	10,907,238'
61	38.15	39.15	7	40	DIPOLE	14'	DEBRIS (MO-955)	1,267,498'	10,907,213'
61	38.50	39.50	98	50	DIPOLE	14'	DEBRIS (MO-955)	1,267,515'	10,907,040'
61	42.60	43.60	37	75	DIPOLE	15'	DEBRIS (MO-955)	1,267,755'	10,905,033'
61	55.20	56.40	230	300	DIPOLE	18'	MURPHY 6" PIPELINE		
61	62.50	63.70	815	150	DIPOLE	4'	DEBRIS (MO-999)	1,268,902'	10,895,213'
61	65.20	66.40	210	60	DIPOLE	5'	DEBRIS (MO-999)	1,269,064'	10,893,890'
61	65.40	66.60	5	30	MONOPOLE	6'	DEBRIS (MO-999)	1,269,076'	10,893,792'
61	72.80	74.00	1000+	1350	DIPOLE	9'	DAUPHIN 12" PIPELINE		
61	74.20	75.40	15	30	MONOPOLE	9'	DEBRIS (MO-999)	1,269,574'	10,889,490'
61	74.70	75.90	18	40	MONOPOLE	10'	DEBRIS (MO-999)	1,269,605'	10,889,246'
61	101.30	102.70	20	40	MONOPOLE	9'	DEBRIS (VK-31)	1,271,159'	10,876,152'
61	114.10	115.50	140	200	DIPOLE	10'	ENRON 6" PIPELINE		
62	13.60	14.60	4	50	MONOPOLE	8'	DEBRIS (MO-910)	1,266,246'	10,919,229'
62	21.70	22.70	3	900	DIPOLE	8'	DEBRIS (MO-910)	1,266,712'	10,915,271'
62	29.30	30.30	65	100	MONOPOLE	11'	DEBRIS (MO-954)	1,267,143'	10,911,556'
62	40.60	41.60	11	60	DIPOLE	14'	DEBRIS (MO-955)	1,267,795'	10,906,035'
62	50.70	51.20	10	50	DIPOLE	17'	DEBRIS (MO-955)	1,268,346'	10,901,337'
62	52.60	53.60	35	90	DIPOLE	18'	DEBRIS (MO-955)	1,268,494'	10,900,166'
62	55.40	56.40	150	200	MONOPOLE	18'	MURPHY 6" PIPELINE		
62	74.60	75.80	1000+	1900	DIPOLE	23'	DAUPHIN 12" PIPELINE		

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
62	77.60	78.80	8	50	MONOPOLE	24'	DEBRIS (MO-999)	1,269,948'	10,887,853'
62	112.00	113.20	10	1800	MONOPOLE	37'	"A" STRUCTURE		
62	114.00	115.20	95	200	DIPOLE	37'	ENRON 6" PIPELINE		
63	9.00	8.10	170	100	DIPOLE	18'	DEBRIS (MO-910)	1,266,025'	10,922,428'
63	19.40	18.40	13	100	DIPOLE	11'	DEBRIS (MO-910)	1,266,626'	10,917,395'
63	23.50	22.50	5	1000	DIPOLE	11'	DEBRIS (MO-910)	1,266,860'	10,915,390'
63	40.10	39.10	14	80	MONOPOLE	8'	DEBRIS (MO-955)	1,267,799'	10,907,272'
63	50.90	49.70	13	25	MONOPOLE	5'	DEBRIS (MO-955)	1,268,430'	10,902,098'
63	54.00	52.80	8	50	DIPOLE	5'	DEBRIS (MO-955)	1,268,607'	10,900,580'
63	55.00	53.80	24	25	DIPOLE	5'	DEBRIS (MO-955)	1,268,666'	10,900,089'
63	57.50	56.30	75	100	MONOPOLE	6'	MURPHY 6" PIPELINE		
63	61.30	60.10	21	40	DIPOLE	7'	DEBRIS (MO-999)	1,269,032'	10,897,012'
63	61.50	60.30	19	20	MONOPOLE	7'	DEBRIS (MO-999)	1,269,042'	10,896,913'
63	70.40	69.60	54	70	DIPOLE	9'	DEBRIS (MO-999)	1,269,566'	10,892,368'
63	78.30	77.10	1000+	2000	DIPOLE	12'	DAUPHIN 12" PIPELINE		
63	92.30	91.10	8	60	DIPOLE	7'	DEBRIS (VK-31)	1,270,805'	10,881,858'
63	107.60	106.20	11	50	MONOPOLE	9'	DEBRIS (VK-31)	1,271,684'	10,874,483'
63	114.50	113.10	30	1500	MONOPOLE	10'	"A" STRUCTURE		
63	116.20	114.80	140	150	MONOPOLE	10'	ENRON 6" PIPELINE		
63	123.80	122.40	9	40	DIPOLE	11'	DEBRIS (VK-31)	1,272,622'	10,866,564'
63	124.30	122.90	5	40	MONOPOLE	11'	DEBRIS (VK-31)	1,272,648'	10,866,322'
64	8.90	7.90	12	30	MONOPOLE	16'	DEBRIS (MO-910)	1,266,184'	10,922,542'
64	9.10	8.10	6	50	MONOPOLE	16'	DEBRIS (MO-910)	1,266,195'	10,922,446'
64	24.30	23.30	16	25	DIPOLE	11'	DEBRIS (MO-910)	1,267,068'	10,915,016'
64	39.80	38.80	65	60	DIPOLE	7'	DEBRIS (MO-955)	1,267,955'	10,907,441'
64	43.00	42.00	8	100	MONOPOLE	6'	DEBRIS (MO-955)	1,268,168'	10,905,872'
64	48.20	47.20	8	50	DIPOLE	4'	DEBRIS (MO-955)	1,268,459'	10,903,341'
64	51.90	50.90	5	50	MONOPOLE	3'	DEBRIS (MO-955)	1,268,646'	10,901,524'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
64	57.30	56.30	85	200	MONOPOLE	3'	MURPHY 6" PIPELINE		
64	63.60	62.60	9	50	DIPOLE	3	DEBRIS (MO-999)	1,269,347'	10,895,811'
64	68.40	67.20	10	50	DIPOLE	2'	DEBRIS (MO-999)	1,269,607'	10,893,563'
64	69.80	68.60	14	50	DIPOLE	3'	DEBRIS (MO-999)	1,269,694'	10,892,882'
64	71.50	70.30	12	50	MONOPOLE	3'	DEBRIS (MO-999)	1,269,759'	10,892,046'
64	75.50	74.30	9	40	DIPOLE	5'	DEBRIS (MO-999)	1,270,012'	10,890,092'
64	75.70	74.50	5	25	MONOPOLE	6'	DEBRIS (MO-999)	1,270,026'	10,889,994'
64	78.70	77.50	13	30	MONOPOLE	7'	DEBRIS (MO-999)	1,270,181'	10,888,525'
64	78.90	77.70	20	50	DIPOLE	7'	DEBRIS (MO-999)	1,270,195'	10,888,428'
64	80.20	79.00	1000+	1750	DIPOLE	7'	DAUPHIN 12" PIPELINE		
64	84.10	82.90	24	60	MONOPOLE	9'	DEBRIS (MO-999)	1,270,508'	10,885,889'
64	104.40	103.20	19	100	DIPOLE	18'	DEBRIS (VK-31)	1,271,652'	10,875,964'
64	105.70	104.50	4	50	MONOPOLE	18'	DEBRIS (VK-31)	1,271,751'	10,875,333'
64	114.40	113.20	60	2250	MONOPOLE	20'	"A" STRUCTURE		
64	115.50	114.30	185	200	DIPOLE	20'	ENRON 6" PIPELINE		
65	6.10	5.10	45	100	DIPOLE	16'	DEBRIS (MO-910)	1,266,179'	10,923,932'
65	8.70	7.70	310	50	DIPOLE	16'	DEBRIS (MO-910)	1,266,341'	10,922,654'
65	9.20	8.20	35	50	MONOPOLE	16'	DEBRIS (MO-910)	1,266,370'	10,922,409'
65	23.30	22.30	16	100	DIPOLE	11'	DEBRIS (MO-910)	1,267,168'	10,915,524'
65	26.80	25.80	85	40	DIPOLE	13'	DEBRIS (MO-911)	1,267,376'	10,913,815'
65	28.80	27.80	13	100	MONOPOLE	12'	DEBRIS (MO-955)	1,267,503'	10,912,837'
65	38.70	37.70	5	40	MONOPOLE	7'	DEBRIS (MO-955)	1,268,068'	10,907,999'
65	38.80	37.80	5	40	MONOPOLE	7'	DEBRIS (MO-955)	1,268,073'	10,907,951'
65	54.40	53.40	12	70	MONOPOLE	3'	DEBRIS (MO-955)	1,268,961'	10,900,326'
65	57.30	56.30	80	100	MONOPOLE	3'	MURPHY 6" PIPELINE		
65	60.30	59.30	6	50	DIPOLE	3'	DEBRIS (MO-999)	1,269,299'	10,897,443'
65	72.80	71.60	42	50	DIPOLE	4'	DEBRIS (MO-999)	1,270,016'	10,891,431'
65	78.40	77.20	11	40	DIPOLE	6'	DEBRIS (MO-999)	1,270,330'	10,888,692'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
65	81.60	80.40	1000+	1500	DIPOLE	8'	DAUPHIN 12" PIPELINE		
65	97.40	96.20	6	50	DIPOLE	15'	DEBRIS (VK-31)	1,271,429'	10,879,406'
65	103.90	102.70	5	50	DIPOLE	18'	DEBRIS (VK-31)	1,271,818'	10,876,233'
65	114.20	113.00	108	2000	MONOPOLE	20'	"A" STRUCTURE		
65	115.20	114.00	150	150	MONOPOLE	20'	ENRON 6" PIPELINE		
66	9.20	8.20	10	25	DIPOLE	3'	DEBRIS (MO-910)	1,266,518'	10,922,436'
66	14.70	13.70	16	25	DIPOLE	5'	DEBRIS (MO-910)	1,266,850'	10,919,744'
66	21.90	20.90	15	200	DIPOLE	8'	DEBRIS (MO-911)	1,267,272'	10,916,227'
66	22.60	21.60	11	100	DIPOLE	8'	DEBRIS (MO-911)	1,267,306'	10,915,888'
66	27.50	26.50	22	40	DIPOLE	5'	DEBRIS (MO-911)	1,267,586'	10,913,489'
66	35.80	34.80	47	90	DIPOLE	3'	DEBRIS (MO-955)	1,268,051'	10,909,437'
66	39.40	38.40	95	100	DIPOLE	2'	DEBRIS (MO-955)	1,268,262'	10,907,674'
66	41.70	40.70	5	60	MONOPOLE	2'	DEBRIS (MO-955)	1,268,402'	10,906,553'
66	47.60	46.60	11	50	DIPOLE	1'	DEBRIS (MO-955)	1,268,737'	10,903,669'
66	57.30	56.30	59	250	DIPOLE	4'	MURPHY 6" PIPELINE		
66	61.00	60.00	14	100	DIPOLE	5'	DEBRIS (MO-999)	1,269,489'	10,897,115'
66	68.90	67.90	30	50	DIPOLE	8'	DEBRIS (MO-999)	1,269,975'	10,893,260'
66	82.90	81.70	1000+	2000	DIPOLE	14'	DAUPHIN 12" PIPELINE		
66	85.50	84.30	7	60	DIPOLE	15'	DEBRIS (MO-999)	1,270,925'	10,885,245'
66	104.00	102.80	6	40	MONOPOLE	22'	DEBRIS (VK-31)	1,271,959'	10,876,200'
66	114.30	113.10	300	1750	MONOPOLE	19'	"A" STRUCTURE		
66	114.90	113.70	60	50	MONOPOLE	19'	ENRON 6" PIPELINE		
67	6.50	7.40	11	50	DIPOLE	8'	DEBRIS (MO-910)	1,266,644'	10,922,847'
67	7.30	8.20	8	40	MONOPOLE	8'	DEBRIS (MO-910)	1,266,692'	10,922,462'
67	12.70	13.60	7	50	DIPOLE	6'	DEBRIS (MO-910)	1,267,003'	10,919,822'
67	20.40	21.30	13	60	MONOPOLE	4'	DEBRIS (MO-911)	1,267,438'	10,916,050'
67	24.20	25.10	5	60	DIPOLE	4'	DEBRIS (MO-911)	1,267,663'	10,914,193'
67	25.80	26.70	22	86	DIPOLE	6'	DEBRIS (MO-955)	1,267,743'	10,913,409'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
67	33.80	34.70	3	25	MONOPOLE	3'	DEBRIS (MO-955)	1,268,217'	10,909,501'
67	35.00	35.90	5	80	MONOPOLE	3'	DEBRIS (MO-955)	1,268,285'	10,908,915'
67	37.00	37.90	7	60	MONOPOLE	1'	DEBRIS (MO-955)	1,268,393'	10,907,934'
67	55.40	56.30	40	110	MONOPOLE	6'	MURPHY 6" PIPELINE		
67	67.00	68.20	16	20	DIPOLE	11'	DEBRIS (MO-999)	1,270,154'	10,893,126'
67	67.50	68.70	38	40	DIPOLE	11'	DEBRIS (MO-999)	1,270,180'	10,892,883'
67	69.60	70.80	15	40	MONOPOLE	12'	DEBRIS (MO-999)	1,270,287'	10,891,857'
67	71.70	72.90	46	60	MONOPOLE	13'	DEBRIS (MO-999)	1,270,408'	10,890,832'
67	72.70	73.90	20	50	DIPOLE	13'	DEBRIS (MO-999)	1,270,466'	10,890,344'
67	73.40	74.60	8	30	MONOPOLE	14'	DEBRIS (MO-999)	1,270,510'	10,890,000'
67	77.80	79.00	155	350	DIPOLE	15'	DEBRIS (MO-999)	1,270,770'	10,887,851'
67	82.60	83.80	1000+	1850	DIPOLE	17'	DAUPHIN 12" PIPELINE		
67	90.50	91.70	14	150	MONOPOLE	22'	DEBRIS (VK-31)	1,271,498'	10,881,719'
67	104.10	105.30	98	100	DIPOLE	21'	SHIPWRECK		
67	111.90	113.10	925	2800	MONOPOLE	23'	"A" STRUCTURE		
68	14.90	13.90	11	20	MONOPOLE	7'	DEBRIS (MO-910)	1,267,181'	10,919,686'
68	43.00	42.00	9	60	MONOPOLE	15'	DEBRIS (MO-955)	1,268,797'	10,905,954'
68	114.10	112.90	1000+	3000	MONOPOLE	8'	"A" STRUCTURE		
68	49.20	48.20	7	25	MONOPOLE	15'	DEBRIS (MO-955)	1,269,170'	10,902,927'
68	56.10	55.10	5	50	DIPOLE	17'	DEBRIS (MO-955)	1,269,535'	10,899,551'
68	57.20	56.20	105	150	MONOPOLE	17'	MURPHY 6" PIPELINE		
68	80.10	78.90	55	300	DIPOLE	11'	DEBRIS (MO-955)	1,270,910'	10,887,921'
68	86.20	85.00	1000+	1500	DIPOLE	13'	DAUPHIN 12" PIPELINE		
68	106.30	105.10	275	300	DIPOLE	17'	SHIPWRECK		
68	120.30	119.10	6	75	MONOPOLE	19'	DEBRIS (VK-31)	1,273,237'	10,868,276'
69	15.60	16.60	8	25	MONOPOLE	13'	DEBRIS (MO-911)	1,267,501'	10,918,384'
69	26.50	27.50	4	50	DIPOLE	13'	DEBRIS (MO-955)	1,268,136'	10,913,060'
69	53.80	54.80	16	75	DIPOLE	3'	DEBRIS (MO-955)	1,269,703'	10,899,718'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
69	55.30	56.30	1000+	250	DIPOLE	3'	MURPHY 6" PIPELINE		
69	79.00	80.20	7	30	DIPOLE	6'	DEBRIS (MO-999)	1,271,158'	10,887,301'
69	85.90	87.10	1000+	1750	DIPOLE	9'	DAUPHIN 12" PIPELINE		
69	89.10	90.30	8	40	DIPOLE	11'	DEBRIS (MO-999)	1,271,747'	10,882,366'
69	89.90	91.10	13	100	MONOPOLE	11'	DEBRIS (VK-31)	1,271,791'	10,881,975'
69	105.40	106.60	1000+	750	DIPOLE	18'	SHIPWRECK		
69	113.10	114.30	1000+	3000	MONOPOLE	20'	"A" STRUCTURE		
70	7.40	8.40	6	40	MONOPOLE	8'	DEBRIS (MO-910)	1,267,182'	10,922,413'
70	40.80	41.80	45	50	DIPOLE	15'	DEBRIS (MO-955)	1,269,128'	10,906,092'
70	55.05	56.05	292	250	DIPOLE	19'	MURPHY 6" PIPELINE		
70	71.20	72.40	38	25	DIPOLE	25'	DEBRIS (MO-999)	1,270,875'	10,891,132'
70	72.70	73.90	400	50	DIPOLE	26'	DEBRIS (MO-999)	1,270,955'	10,890,397'
70	73.90	75.10	90	30	MONOPOLE	26'	DEBRIS (MO-999)	1,271,023'	10,889,814'
70	85.10	86.30	11	40	MONOPOLE	30'	DEBRIS (MO-999)	1,271,687'	10,884,339'
70	87.30	88.50	1000+	1650	DIPOLE	12'	DAUPHIN 12" PIPELINE		
70	103.80	105.00	45	40	DIPOLE	20'	DEBRIS FROM SHIPWRECK	1,272,746'	10,875,201'
70	104.20	105.40	250	300	MONOPOLE	20'	SHIPWRECK		
70	111.70	112.90	430	1500	MONOPOLE	21'	DAUPHIN 8" PIPELINE & "A" STRUCTURE		
70	113.00	114.20	325	300	DIPOLE	22'	(2) ENRON 6" PIPELINES & SANTA FE 6" PIPELINE		
71	5.60	6.50	25	100	DIPOLE	10'	DEBRIS (MO-911)	1,267,250'	10,923,362'
71	18.80	19.70	5	40	MONOPOLE	15'	DEBRIS (MO-911)	1,268,000'	10,916,906'
71	29.90	30.90	4	25	MONOPOLE	17'	DEBRIS (MO-955)	1,268,661'	10,911,436'
71	35.50	36.50	7	25	MONOPOLE	18'	DEBRIS (MO-955)	1,268,989'	10,908,699'
71	35.70	36.70	5	25	MONOPOLE	18'	DEBRIS (MO-955)	1,268,999'	10,908,602'
71	40.50	41.50	21	50	MONOPOLE	20'	DEBRIS (MO-955)	1,269,271'	10,906,256'
71	44.50	45.50	16	50	DIPOLE	21'	DEBRIS (MO-955)	1,269,476'	10,904,297'
71	54.40	55.40	7	50	MONOPOLE	16'	DEBRIS (MO-955)	1,270,055'	10,899,458'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
71	55.30	56.30	9	150	MONOPOLE	16'	MURPHY 6" PIPELINE		
71	56.50	57.50	8	50	DIPOLE	16'	DEBRIS (MO-955)	1,270,191'	10,898,436'
71	64.90	66.10	4	50	MONOPOLE	19'	DEBRIS (MO-999)	1,270,682'	10,894,233'
71	73.60	74.80	29	50	DIPOLE	23'	DEBRIS (MO-999)	1,271,191'	10,889,982'
71	76.60	77.80	6	40	DIPOLE	24'	DEBRIS (MO-999)	1,271,347'	10,888,513'
71	79.00	80.20	7	50	MONOPOLE	11'	DEBRIS (MO-999)	1,271,498'	10,887,340'
71	79.80	81.00	12	50	DIPOLE	12'	DEBRIS (MO-999)	1,271,530'	10,886,950'
71	89.00	90.20	1000	1500	DIPOLE	16'	DAUPHIN 12" PIPELINE		
71	91.20	92.40	6	40	DIPOLE	17'	DEBRIS (VK-31)	1,272,174'	10,881,373'
71	104.30	105.50	25	400	MONOPOLE	23'	SHIPWRECK		
71	111.70	112.90	430	1500	MONOPOLE	24'	DAUPHIN 8" PIPELINE, "A" STRUCTURE		
71	112.00	113.00	96	1600	MONOPOLE	24'	"A" STRUCTURE		
71	113.20	114.40	1000	150	DIPOLE	24'	(2) ENRON 6" PIPELINES		
71	113.50	114.70	120	150	MONOPOLE	24'	SANTA FE 6" PIPELINE		
71	122.60	123.80	15	150	DIPOLE	26'	DEBRIS (MO-75)	1,274,013'	10,866,031'
72	5.80	6.80	16	40	DIPOLE	7'	DEBRIS (MO-911)	1,267,416'	10,923,230'
72	26.30	27.30	9	50	DIPOLE	11'	DEBRIS (MO-955)	1,268,611'	10,913,213'
72	28.60	29.60	5	50	MONOPOLE	13'	DEBRIS (MO-955)	1,268,732'	10,912,091'
72	55.20	56.20	110	100	MONOPOLE	20'	MURPHY 6" PIPELINE		
72	67.30	68.50	4	50	MONOPOLE	17'	DEBRIS (MO-999)	1,270,984'	10,893,080'
72	69.50	70.70	17	100	DIPOLE	26'	DEBRIS (MO-999)	1,271,097'	10,892,001'
72	72.20	73.40	10	25	MONOPOLE	27'	DEBRIS (MO-999)	1,271,267'	10,890,683'
72	73.30	74.50	6	25	DIPOLE	27'	DEBRIS (MO-999)	1,271,336'	10,890,145'
72	90.60	91.80	1000+	1500	DIPOLE	16'	DAUPHIN 12" PIPELINE		
72	104.50	105.70	7	500	MONOPOLE	21'	SHIPWRECK		
72	111.50	112.70	28	75	DIPOLE	23'	DAUPHIN 8" PIPELINE		
72	112.00	113.00	65	1000	MONOPOLE	23'	"A" STRUCTURE		

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
72	113.40	114.60	685	150	DIPOLE	23'	(2) ENRON 6" PIPELINES		
72	114.00	115.20	115	100	DIPOLE	23'	SANTA FE 6" PIPELINE		
73	19.10	18.10	12	25	MONOPOLE	9'	DEBRIS (MO-911)	1,268,245'	10,917,709'
73	20.30	19.30	5	40	MONOPOLE	9'	DEBRIS (MO-911)	1,268,303'	10,917,141'
73	22.50	21.50	65	35	MONOPOLE	9'	DEBRIS (MO-911)	1,268,442'	10,916,083'
73	28.10	27.10	5	35	MONOPOLE	9'	DEBRIS (MO-955)	1,268,757'	10,913,311'
73	37.90	36.90	75	100	DIPOLE	9'	DEBRIS (MO-955)	1,269,304'	10,908,572'
73	42.00	41.00	51	60	DIPOLE	9'	DEBRIS (MO-955)	1,269,566'	10,906,541'
73	56.20	55.20	5	40	MONOPOLE	9'	DEBRIS (MO-955)	1,270,373'	10,899,565'
73	57.10	56.10	22	100	MONOPOLE	9'	MURPHY 6" PIPELINE		
73	68.00	67.00	3	50	MONOPOLE	9'	DEBRIS (MO-999)	1,271,227'	10,892,365'
73	75.00	74.60	9	50	DIPOLE	9'	DEBRIS (MO-999)	1,271,492'	10,890,120'
73	75.40	75.00	6	25	DIPOLE	9'	DEBRIS (MO-999)	1,271,512'	10,889,923'
73	80.60	80.20	6	25	MONOPOLE	9'	DEBRIS (MO-999)	1,271,805'	10,887,378'
73	94.20	93.00	1000+	1100	DIPOLE	15'	DAUPHIN 12" PIPELINE		
73	98.80	97.60	21	150	MONOPOLE	17'	DEBRIS (VK-31)	1,272,815'	10,878,876'
73	99.00	97.90	8	60	DIPOLE	17'	DEBRIS (VK-31)	1,272,833'	10,878,730'
73	113.80	112.60	74	150	MONOPOLE	18'	DAUPHIN 8" PIPELINE		
73	114.30	113.10	42	1250	MONOPOLE	18'	"A" STRUCTURE		
73	115.80	114.60	400	30	DIPOLE	18'	(2) ENRON 6" PIPELINES		
73	116.90	115.70	27	250	DIPOLE	18'	SANTA FE 6" PIPELINE		
74	11.00	10.00	29	70	DIPOLE	9'	DEBRIS (MO-911)	1,267,929'	10,921,708'
74	57.30	56.10	650	200	DIPOLE	4'	MURPHY 6" PIPELINE		
74	58.00	56.80	208	50	DIPOLE	4'	DEBRIS (MO-955)	1,270,632'	10,898,838'
74	59.00	57.80	60	100	MONOPOLE	4'	DEBRIS (MO-955)	1,270,687'	10,898,348'
74	60.90	59.70	64	25	DIPOLE	5'	DEBRIS (MO-999)	1,270,795'	10,897,418'
74	61.00	59.80	28	25	DIPOLE	5'	DEBRIS (MO-999)	1,270,801'	10,897,370'
74	63.60	62.40	17	60	DIPOLE	6'	DEBRIS (MO-999)	1,270,946'	10,896,097'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
74	64.40	63.20	210	50	DIPOLE	6'	DEBRIS (MO-999)	1,270,984'	10,895,708'
74	65.10	63.90	14	30	DIPOLE	6'	DEBRIS (MO-999)	1,271,026'	10,895,364'
74	95.00	93.80	390	1100	DIPOLE	20'	DAUPHIN 12" PIPELINE		
74	98.20	97.00	6	75	MONOPOLE	21'	DEBRIS (VK-31)	1,272,941'	10,879,190'
74	98.40	97.20	9	60	MONOPOLE	21'	DEBRIS (VK-31)	1,272,951'	10,879,091'
74	113.70	112.50	75	100	MONOPOLE	26'	DAUPHIN 8" PIPELINE		
74	115.90	114.70	245	200	DIPOLE	26'	(2) ENRON 6" PIPELINES		
74	117.50	116.30	29	150	MONOPOLE	26'	SANTA FE 8" PIPELINE		
75	8.70	7.70	13	50	DIPOLE	9'	DEBRIS	1,258,173'	10,962,539'
75	23.50	22.50	1000+	2000	DIPOLE	12'	SIX PIPELINES & A-2 STRUCTURE		
75	87.70	86.70	14	300	DIPOLE	30'	DEBRIS (MO-910)	1,262,714'	10,923,931'
76	16.50	17.50	16	30	MONOPOLE	7'	DEBRIS (MO-822)	1,258,909'	10,957,766'
76	18.50	19.50	20	1000	MONOPOLE	8'	SATELLITE STRUCTURE		
76	19.90	20.90	250	110	DIPOLE	8'	OED 4" PIPELINE		
76	21.60	22.60	730	1500	MONOPOLE	9'	A-2 STRUCTURE		
76	22.10	23.10	540	100	DIPOLE	9'	DAUPHIN 20" PIPELINE		
76	25.40	26.40	10	50	DIPOLE	9'	DEBRIS (MO-822)	1,259,412'	10,953,413'
77	6.10	7.10	11	50	DIPOLE	5'	DEBRIS (MY-110)	1,258,475'	10,962,872'
77	13.60	14.60	9	45	MONOPOLE	7'	DEBRIS (MO-822)	1,258,893'	10,959,203'
77	18.70	19.70	55	1200	MONOPOLE	7'	SATELLITE STRUCTURE		
77	19.40	20.40	165	100	DIPOLE	7'	OED 4" PIPELINE		
77	22.10	23.10	140	2000	DIPOLE	8'	A-2 STRUCTURE		
77	22.30	23.30	1000+	200	DIPOLE	8'	DAUPHIN 20" PIPELINE		
78	1.20	2.20	9	60	DIPOLE	2'	DEBRIS (MY-91)	1,258,354'	10,965,281'
78	6.70	7.70	8	300	DIPOLE	2'	DEBRIS (MY-110)	1,258,677'	10,962,598'
78	18.80	19.80	220	1500	DIPOLE	5'	OED 4" PIPELINE		
78	21.70	22.70	78	100	MONOPOLE	6'	SATELLITE STRUCTURE		
78	22.40	23.40	860	100	DIPOLE	6'	DAUPHIN 20" PIPELINE		

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
78	57.50	58.50	20	150	MONOPOLE	19'	DEBRIS (MO-866)	1,261,573'	10,937,764'
79	16.50	15.50	6	50	MONOPOLE	4'	DEBRIS (MO-822)	1,259,276'	10,958,805'
79	20.60	19.60	730	1200	DIPOLE	3'	OED 4" PIPELINE & SATELLITE STRUCTURE		
79	23.60	22.60	85	2000	DIPOLE	2'	SATELLITE STRUCTURE		
79	24.40	23.40	850	100	DIPOLE	2'	DAUPHIN 20" PIPELINE		
79	39.30	38.30	815	200	DIPOLE	2'	DEBRIS (MO-822)	1,260,590'	10,947,661'
80	19.00	18.00	11	20	MONOPOLE	3'	DEBRIS (MO-822)	1,259,580'	10,957,600'
80	19.50	18.50	310	125	DIPOLE	4'	OED 4" PIPELINE		
80	20.80	19.80	350	900	MONOPOLE	4'	SATELLITE STRUCTURE		
80	22.70	21.70	60	40	DIPOLE	5'	DEBRIS (MO-822)	1,259,803'	10,955,796'
80	24.70	23.70	600	100	MONOPOLE	5'	DAUPHIN 20" PIPELINE		
80	38.80	37.80	6	75	MONOPOLE	9'	DEBRIS (MO-822)	1,260,707'	10,947,920'
81	4.40	5.40	7	60	MONOPOLE	2'	DEBRIS (MY-110)	1,259,079'	10,963,287'
81	6.70	7.70	60	40	DIPOLE	3'	DEBRIS (MY-110)	1,259,212'	10,962,160'
81	11.20	12.20	6	50	DIPOLE	4'	DEBRIS (MO-822)	1,259,470'	10,959,965'
81	15.80	16.80	975	250	DIPOLE	5'	OED 4" PIPELINE		
81	17.80	18.80	50	1400	MONOPOLE	5'	SATELLITE STRUCTURE		
81	23.00	24.00	345	300	DIPOLE	7'	DAUPHIN 20" PIPELINE		
82	1.30	2.30	15	45	MONOPOLE	3'	DEBRIS (MY-91)	1,259,007'	10,965,312'
82	9.00	10.00	5	40	DIPOLE	6'	DEBRIS (MY-110)	1,259,444'	10,961,545'
82	13.50	14.50	91	55	MONOPOLE	7'	DEBRIS (MO-822)	1,259,709'	10,959,348'
82	16.20	17.20	180	250	DIPOLE	8'	OED 4" PIPELINE		
82	18.80	19.80	20	1300	MONOPOLE	8'	SATELLITE STRUCTURE		
82	23.10	24.10	830	150	DIPOLE	10'	DAUPHIN 12" PIPELINE		
83	11.60	10.60	40	30	MONOPOLE	2'	DEBRIS (MY-110)	1,259,668'	10,961,274'
83	14.40	13.40	9	150	MONOPOLE	2'	DEBRIS (MO-822)	1,259,779'	10,959,904'
83	16.40	15.40	5	75	MONOPOLE	3'	DEBRIS (MO-822)	1,259,908'	10,958,930'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
83	17.50	16.50	230	150	DIPOLE	1'	OED 4" PIPELINE		
83	20.40	19.40	14	700	MONOPOLE	1'	SATELLITE STRUCTURE		
83	23.90	22.90	50	30	DIPOLE	2'	DEBRIS (MO-822)	1,260,343'	10,955,266'
83	25.20	24.20	900	300	DIPOLE	3'	DAUPHIN 20" PIPELINE		
83	25.80	24.80	9	25	MONOPOLE	3'	DEBRIS (MO-822)	1,260,454'	10,954,337'
83	30.40	29.40	19	15	MONOPOLE	4'	DEBRIS (MO-822)	1,260,717'	10,952,089'
83	40.70	39.70	7	25	MONOPOLE	7'	DEBRIS (MO-822)	1,261,320'	10,947,056'
83	41.70	40.70	22	40	MONOPOLE	8'	DEBRIS (MO-822)	1,261,380'	10,946,559'
83	79.60	78.60	8	150	MONOPOLE	18'	DEBRIS (MO-910)	1,263,547'	10,928,041'
84	2.00	1.10	14	40	MONOPOLE	3'	DEBRIS (MY-91)	1,259,259'	10,965,935'
84	5.70	4.80	14	50	DIPOLE	1'	DEBRIS (MY-110)	1,259,456'	10,964,124'
84	10.10	9.20	9	25	MONOPOLE	3'	DEBRIS (MY-110)	1,259,715'	10,961,978'
84	16.90	16.00	180	250	DIPOLE	4'	OED 4" PIPELINE		
84	17.50	16.60	9	20	DIPOLE	4'	DEBRIS (MO-822)	1,260,144'	10,958,362'
84	25.30	24.40	940	200	DIPOLE	6'	DAUPHIN 20" PIPELINE		
84	70.70	69.70	5	100	MONOPOLE	19'	DEBRIS (MO-866)	1,263,209'	10,932,412'
85	6.10	7.10	65	15	MONOPOLE	4'	DEBRIS (MY-110)	1,259,792'	10,963,023'
85	14.00	15.00	400	300	DIPOLE	5'	OED 4" PIPELINE		
85	23.80	24.80	780	400	DIPOLE	8'	DAUPHIN 20" PIPELINE		
85	24.00	25.00	70	50	DIPOLE	8'	DEBRIS (MO-822)	1,260,796'	10,954,270'
85	27.20	28.20	40	56	DIPOLE	9'	DEBRIS (MO-822)	1,260,979'	10,952,707'
85	32.20	33.20	6	40	MONOPOLE	10'	DEBRIS (MO-822)	1,261,265'	10,950,262'
85	70.60	71.60	12	300	DIPOLE	20'	DEBRIS (MO-866)	1,263,480'	10,931,496'
85	72.90	73.90	10	250	DIPOLE	20'	DEBRIS (MO-866)	1,263,618'	10,930,372'
86	15.60	14.60	260	300	DIPOLE	2'	OED 4" PIPELINE		
86	23.60	22.60	8	40	DIPOLE	3'	DEBRIS (MO-822)	1,260,822'	10,955,467'
86	25.80	24.80	930	250	DIPOLE	4'	DAUPHIN 20" PIPELINE		
87	11.00	12.00	10	60	DIPOLE	2'	DEBRIS (MY-110)	1,260,372'	10,960,664'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
87	12.80	13.80	340	110	DIPOLE	3'	OED 4" PIPELINE		
87	24.10	25.10	830	300	DIPOLE	3'	DAUPHIN 20" PIPELINE		
87	31.20	32.20	11	250	DIPOLE	5'	DEBRIS (MO-822)	1,261,552'	10,950,796'
87	36.60	37.60	8	100	MONOPOLE	7'	DEBRIS (MO-822)	1,261,848'	10,948,155'
87	37.40	38.40	40	50	DIPOLE	7'	DEBRIS (MO-822)	1,261,899'	10,947,763'
87	53.80	54.80	6	50	DIPOLE	14'	DEBRIS (MO-866)	1,262,834'	10,939,745'
87	61.80	62.80	8	50	MONOPOLE	17'	DEBRIS (MO-866)	1,263,305'	10,935,836'
87	72.80	73.80	8	100	MONOPOLE	18'	DEBRIS (MO-866)	1,263,937'	10,930,462'
88	3.50	4.50	7	50	DIPOLE	4'	DEBRIS (MY-110)	1,260,106'	10,964,350'
88	11.00	12.00	8	100	DIPOLE	6'	DEBRIS (MY-110)	1,260,537'	10,960,686'
88	12.20	13.20	140	200	DIPOLE	6'	OED 4" PIPELINE		
88	24.30	25.30	970	200	DIPOLE	9'	DAUPHIN 20" PIPELINE		
88	26.20	27.20	6	40	MONOPOLE	10'	DEBRIS (MO-822)	1,261,403'	10,953,256'
89	13.00	12.00	14	50	DIPOLE	3'	DEBRIS (MY-110)	1,260,708'	10,960,710'
89	13.60	12.60	970	300	DIPOLE	3'	OED 4" PIPELINE		
89	25.60	24.60	15	25	DIPOLE	6'	DEBRIS (MO-822)	1,261,419'	10,954,549'
89	26.40	25.40	500	250	DIPOLE	6'	DAUPHIN 20" PIPELINE		
89	30.20	29.20	30	40	DIPOLE	7'	DEBRIS (MO-822)	1,261,690'	10,952,297'
90	4.10	5.10	7	40	MONOPOLE	3'	DEBRIS (MY-110)	1,260,477'	10,964,096'
90	10.80	12.00	552	250	DIPOLE	5'	OED 4" PIPELINE		
90	11.20	12.20	7	50	MONOPOLE	5'	DEBRIS (MY-110)	1,260,878'	10,960,623'
90	24.50	25.50	500	250	DIPOLE	6'	DAUPHIN 20" PIPELINE		
90	52.50	53.50	5	90	MONOPOLE	16'	DEBRIS (MO-866)	1,263,249'	10,940,440'
90	65.80	66.80	7	100	MONOPOLE	21'	DEBRIS (MO-866)	1,264,014'	10,933,942'
91	10.10	11.10	165	350	DIPOLE	5'	OED 4" PIPELINE		
91	11.20	12.20	10	40	DIPOLE	5'	DEBRIS (MY-110)	1,261,041'	10,960,645'
91	16.90	17.90	110	45	DIPOLE	6'	DEBRIS (MO-822)	1,261,359'	10,957,855'
91	25.70	26.70	6	56	MONOPOLE	5'	DEBRIS (MO-822)	1,261,867'	10,953,555'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
91	35.40	36.40	50	150	DIPOLE	8'	DEBRIS (MO-822)	1,262,430'	10,948,816'
92	9.70	10.70	230	200	DIPOLE	5'	OED 4" PIPELINE		
92	11.20	12.20	11	60	DIPOLE	6'	DEBRIS (MY-110)	1,261,207'	10,960,663'
92	25.00	26.00	700	250	DIPOLE	9'	DAUPHIN 20" PIPELINE		
93	11.00	10.00	890	200	DIPOLE	1'	OED 4" PIPELINE		
93	13.20	12.20	15	90	DIPOLE	1'	DEBRIS (MY-110)	1,261,361'	10,960,685'
93	15.40	14.40	20	30	DIPOLE	1'	DEBRIS (MO-822)	1,261,493'	10,959,609'
93	27.00	26.10	900	100	DIPOLE	4'	DAUPHIN 20" PIPELINE		
93	36.90	35.90	24	30	MONOPOLE	6'	DEBRIS (MO-822)	1,262,721'	10,949,099'
93	71.70	70.70	9	100	MONOPOLE	18'	DEBRIS (MO-866)	1,264,732'	10,932,094'
94	5.60	4.70	16	75	DIPOLE	2'	DEBRIS (MY-110)	1,261,091'	10,964,367'
94	10.20	9.30	860	100	DIPOLE	3'	OED 4" PIPELINE		
94	10.60	9.70	8	25	DIPOLE	3'	DEBRIS (MY-110)	1,261,408'	10,961,929'
94	10.90	10.00	21	50	DIPOLE	3'	DEBRIS (MY-110)	1,261,430'	10,961,783'
94	13.00	12.10	17	55	DIPOLE	1'	DEBRIS (MY-110)	1,261,506'	10,960,753'
94	27.10	26.10	540	200	DIPOLE	3'	DAUPHIN 20" PIPELINE		
94	36.40	35.40	12	56	MONOPOLE	5'	DEBRIS (MO-822)	1,262,865'	10,949,369'
94	61.90	60.90	7	35	MONOPOLE	15'	DEBRIS (MO-866)	1,264,327'	10,936,903'
94	73.40	72.40	28	150	DIPOLE	12'	DEBRIS (MO-866)	1,264,992'	10,931,281'
95	9.70	8.70	130	150	DIPOLE	1'	OED 4" PIPELINE		
95	13.10	12.10	10	50	DIPOLE	1'	DEBRIS (MY-110)	1,261,689'	10,960,772'
95	27.40	26.40	815	250	DIPOLE	4'	DAUPHIN 20" PIPELINE		
95	35.90	34.90	20	30	MONOPOLE	7'	DEBRIS (MO-822)	1,262,997'	10,949,632'
96	6.90	7.80	400	150	DIPOLE	3'	OED 4" PIPELINE		
96	10.90	11.80	6	50	DIPOLE	1'	DEBRIS (MY-110)	1,261,825'	10,960,938'
96	16.80	17.70	145	100	DIPOLE	2'	DEBRIS (MO-822)	1,262,174'	10,958,053'
96	25.70	26.60	905	250	DIPOLE	4'	DAUPHIN 20" PIPELINE		
96	33.20	34.10	12	75	DIPOLE	6'	DEBRIS (MO-822)	1,263,100'	10,950,036'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
96	54.20	55.10	14	40	MONOPOLE	13'	DEBRIS (MO-866)	1,264,325'	10,939,771'
96	55.00	55.90	5	40	MONOPOLE	14'	DEBRIS (MO-866)	1,264,370'	10,939,383'
96	86.60	87.60	7	150	DIPOLE	22'	DEBRIS (MO-910)	1,266,207'	10,923,888'
97	6.30	7.30	1000+	200	DIPOLE	4'	OED 4" PIPELINE		
97	8.60	9.60	320	40	DIPOLE	5'	DEBRIS (MY-110)	1,261,866'	10,962,028'
97	8.70	9.70	16	20	DIPOLE	5'	DEBRIS (MY-110)	1,261,872'	10,961,979'
97	25.90	20.90	886	200	DIPOLE	7'	DAUPHIN 20" PIPELINE		
97	32.00	33.00	19	60	DIPOLE	10'	DEBRIS (MO-822)	1,263,211'	10,950,591'
97	49.40	50.40	7	50	DIPOLE	16'	DEBRIS (MO-866)	1,264,221'	10,942,090'
97	63.70	64.90	11	150	DIPOLE	22'	DEBRIS (MO-866)	1,265,042'	10,935,000'
97	65.40	66.40	15	200	DIPOLE	22'	DEBRIS (MO-866)	1,265,138'	10,934,269'
97	80.70	90.70	6	100	MONOPOLE	3'	DEBRIS (MO-910)	1,266,537'	10,922,392'
98	1.80	2.70	12	50	DIPOLE	2'	DEBRIS (MY-91)	1,261,629'	10,965,418'
98	5.10	5.00	8	40	MONOPOLE	2'	DEBRIS (MY-110)	1,261,769'	10,964,299'
98	5.80	6.70	185	150	DIPOLE	3'	OED 4" PIPELINE		
98	26.00	27.00	490	200	DIPOLE	8'	DAUPHIN 20" PIPELINE		
98	31.30	32.30	10	150	DIPOLE	7'	DEBRIS (MO-822)	1,263,340'	10,950,957'
98	36.00	37.00	12	50	DIPOLE	8'	DEBRIS (MO-822)	1,263,609'	10,948,660'
99	3.20	.2.20	8	50	DIPOLE	3'	DEBRIS (MY-91)	1,261,767'	10,965,688'
99	3.50	2.50	5	40	DIPOLE	3'	DEBRIS (MY-91)	1,261,776'	10,965,541'
99	7.00	6.00	700	200	DIPOLE	3'	OED 4" PIPELINE		
99	23.20	22.20	14	15	MONOPOLE	3'	DEBRIS (MO-822)	1,262,923'	10,955,916'
99	24.90	23.90	8	25	MONOPOLE	3'	DEBRIS (MO-822)	1,263,015'	10,955,082'
99	25.80	24.80	9	40	MONOPOLE	3'	DEBRIS (MO-822)	1,263,061'	10,954,639'
99	28.20	27.20	970	250	DIPOLE	3'	DAUPHIN 20" PIPELINE		
99	70.40	69.40	15	300	DIPOLE	3'	DEBRIS (MO-866)	1,265,630'	10,932,842'
100	2.00	1.00	56	150	DIPOLE	22'	OED 4" PIPELINE		
101	1.40	2.40	80	250	DIPOLE	19'	OED 4" PIPELINE		

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
101	25.70	24.70	29	40	DIPOLE	2'	DEBRIS (MY-91)	1,258,893'	10,975,404'
102	1.20	.20	24	250	DIPOLE	25'	OED 4" PIPELINE		
103	18.60	19.60	54	100	DIPOLE	7'	DEBRIS (MY-91)	1,259,232'	10,972,896'
104	25.50	24.50	18	40	MONOPOLE	6'	DEBRIS (MY-91)	1,258,446'	10,975,179'
105	9.00	8.00	4	150	MONOPOLE	18'	DEBRIS (MY-91)	1,260,399'	10,967,296'
105	27.50	26.50	7	400	MONOPOLE	2'	DEBRIS (MY-91)	1,258,095'	10,975,854'
106	9.00	8.00	5	200	MONOPOLE	17'	DEBRIS (MY-91)	1,260,251'	10,967,253'
106	10.50	9.50	4	250	MONOPOLE	16'	DEBRIS (MY-91)	1,260,052'	10,967,969'
106	27.60	26.50	3	250	MONOPOLE	3'	DEBRIS (MY-91)	1,257,931'	10,975,807'
107	8.50	9.50	7	400	DIPOLE	16'	DEBRIS (MY-91)	1,259,903'	10,967,931'
107	25.20	26.20	4	250	MONOPOLE	2'	DEBRIS (MY-91)	1,257,775'	10,975,766'
107	27.10	28.10	11	20	MONOPOLE	2'	DEBRIS (MY-91)	1,257,531'	10,976,720'
108	10.40	9.40	3	300	MONOPOLE	20'	DEBRIS (MY-91)	1,259,751'	10,967,836'
108	27.00	26.00	5	350	MONOPOLE	6'	DEBRIS (MY-91)	1,257,612'	10,975,718'
109	11.00	10.00	5	100	DIPOLE	18'	DEBRIS (MY-91)	1,259,516'	10,968,080'
109	22.70	21.70	160	100	DIPOLE	8'	DEBRIS (MY-91)	1,258,012'	10,973,637'
109	23.70	22.70	18	100	DIPOLE	7'	DEBRIS (MY-91)	1,257,881'	10,974,110'
109	27.00	26.00	5	450	MONOPOLE	4'	DEBRIS (MY-91)	1,257,456'	10,975,677'
110	11.80	10.80	5	56	MONOPOLE	18'	DEBRIS (MY-91)	1,259,248'	10,968,421'
110	23.20	24.20	85	45	MONOPOLE	8'	DEBRIS (MY-91)	1,257,535'	10,974,781'
110	23.80	22.80	5	40	MONOPOLE	8'	DEBRIS (MY-91)	1,257,723'	10,974,120'
110	27.00	26.00	6	500	MONOPOLE	5'	DEBRIS (MY-91)	1,257,317'	10,975,636'
111	24.80	25.80	5	400	MONOPOLE	5'	DEBRIS (MY-91)	1,257,187'	10,975,504'
112	19.20	18.20	23	60	DIPOLE	11'	DEBRIS (MY-91)	1,257,971'	10,971,839'
113	17.50	18.50	15	40	DIPOLE	13'	DEBRIS (MY-91)	1,257,793'	10,971,949'
114	19.30	20.30	10	50	DIPOLE	9'	DEBRIS (MY-91)	1,257,399'	10,972,757'
115	16.30	17.30	6	25	MONOPOLE	4'	DEBRIS (MY-91)	1,257,624'	10,971,292'
115	26.30	27.30	70	25	DIPOLE	5'	DEBRIS (MY-91)	1,256,387'	10,975,901'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
116	26.00	27.00	44	50	MONOPOLE	5'	DEBRIS (MY-91)	1,256,238'	10,975,859'
118	26.50	27.50	72	1850	DIPOLE	3'	DAUPHIN 12" PIPELINE		
119	25.00	26.00	1000+	3500	DIPOLE	7'	DAUPHIN 12" PIPELINE		
120	21.10	22.10	1000+	500	DIPOLE	11'	DAUPHIN 12" PIPELINE		
120	23.90	24.90	1000+	500	DIPOLE	8'	DAUPHIN 12" PIPELINE		
120	28.10	29.10	335	150	DIPOLE	4'	DAUPHIN 12" PIPELINE		
121	20.80	19.80	1000+	600	DIPOLE	10'	DAUPHIN 12" PIPELINE		
121	23.00	22.00	1000+	1000	DIPOLE	8'	DAUPHIN 12" PIPELINE		
122	15.70	16.70	1000+	600	DIPOLE	11'	DAUPHIN 12" PIPELINE		
122	18.80	19.80	1000+	950	DIPOLE	9'	DAUPHIN 12" PIPELINE		
122	20.70	21.70	28	40	MONOPOLE	7'	DEBRIS (MY-91)	1,255,960'	10,973,076'
122	27.80	28.80	180	200	DIPOLE	2'	DAUPHIN 12" PIPELINE		
123	10.20	11.20	1000+	3900	DIPOLE	13'	(2) 12" DAUPHIN PIPELINES		
123	12.80	13.80	1000+	1550	DIPOLE	11'	DAUPHIN 12" PIPELINE		
123	15.50	16.50	1000+	1600	DIPOLE	8'	DAUPHIN 12" PIPELINE		
123	27.30	28.30	750	200	DIPOLE	2'	DAUPHIN 12" PIPELINE		
124	10.00	11.00	1000+	1350	DIPOLE	15'	DAUPHIN 12" PIPELINE		
124	13.00	14.00	1000+	1600	DIPOLE	13'	DAUPHIN 12" PIPELINE		
124	27.10	28.10	1000+	150	DIPOLE	2'	DAUPHIN 12" PIPELINE		
124	28.30	28.20	1000+	200	DIPOLE	2'	DAUPHIN 12" PIPELINE		
173	44.00	41.20	28	2400	MONOPOLE	189'	WELL #1 (MP-247)		
173	58.95	56.15	27	250	MONOPOLE	151'	AMOCO 18" PIPELINE		
173	100.05	97.65	42	300	DIPOLE	88'	CENTANA 20" PIPELINE		
174	39.00	41.80	105	2100	MONOPOLE	191'	WELL #1 (MP-247)		
174	52.95	55.75	145	200	MONOPOLE	150'	AMOCO 18" PIPELINE		
174	97.05	99.05	75	250	DIPOLE	91'	CENTANA 20" PIPELINE		
175	19.75	22.55	4	400	DIPOLE	249'	SHELL 8" PIPELINE		
175	38.80	41.60	27	2500	MONOPOLE	233'	WELL #1 (MP-247)		

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
175	52.95	55.35	48	400	MONOPOLE	194'	AMOCO 18" PIPELINE		
175	98.85	100.85	16	250	DIPOLE	132'	CENTANA 20" PIPELINE		
175	161.40	163.40	7	100	DIPOLE	108'	DEBRIS (MP-191)	1,2 4,690'	10,719,239'
176	30.10	27.30	1008	1800	DIPOLE	241'	WELL #2 (MP-261)		
176	57.90	55.10	24	250	MONOPOLE	188'	AMOCO 18" PIPELINE		
176	103.15	100.75	230	250	DIPOLE	129'	DEBRIS (MP-216)	1,284,690'	10,688,399'
176	104.80	102.40	115	400	DIPOLE	127'	CENTANA 20" PIPELINE		
176	126.00	123.60	5	100	DIPOLE	116'	DEBRIS (MP-195)	1,284,338'	10,699,644'
177	24.45	21.65	5	250	MONOPOLE	242'	SHELL 8" PIPELINE		
177	57.50	54.70	38	175	MONOPOLE	181'	AMOCO 18" PIPELINE		
177	106.50	104.50	35	50	DIPOLE	119'	CENTANA 20" PIPELINE		
177	130.15	128.15	14	1000	MONOPOLE	109'	WELL #1 (MP-195)		
177	157.10	155.10	17	110	MONOPOLE	100'	DEBRIS (MP-191)	1,282,846'	10,715,102'
178	18.15	20.95	5	275	MONOPOLE	237'	SHELL 8" PIPELINE		
178	51.35	54.15	13	200	DIPOLE	182'	AMOCO 18" PIPELINE		
178	103.50	105.70	97	350	MONOPOLE	121'	CENTANA 20" PIPELINE		
178	116.40	118.60	5	200	MONOPOLE	113'	DEBRIS (MP-216)	1,282,403'	10,697,121'
179	51.20	53.80	19	225	DIPOLE	170'	AMOCO 18" PIPELINE		
179	105.60	107.40	25	275	MONOPOLE	112'	CENTANA 20" PIPELINE		
179	143.90	145.70	205	2000	DIPOLE	91'	WELL #2 (MP-195)		
400	4.60	3.60	47	150	MONOPOLE	35'	DAUPHIN 8" PIPELINE		
401	8.00	9.00	7	100	DIPOLE	36'	DEBRIS (VK-31)	1,270,531'	10,875,606'
402	2.80	1.80	37	150	MONOPOLE	34'	DAUPHIN 8" PIPELINE		
403	4.00	5.00	36	500	MONOPOLE	33'	SHIPWRECK		
404	5.50	6.50	1000+	500	DIPOLE	31'	SHIPWRECK		
405	6.20	5.20	1000+	600	DIPOLE	30'	SHIPWRECK		
1031	18.20	19.60	28	50	MONOPOLE	18'	DEBRIS (VK-296)	1,283,808'	10,786,882'
1031	64.40	65.80	6	75	DIPOLE	19'	DEBRIS (VK-207)	1,281,161'	10,809,460'

MAGNETIC ANOMALY TABLE - STATE AND FEDERAL WATERS

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
1031	108.20	109.60	19	50	DIPOLE	16'	DEBRIS (VK-168)	1,278,636'	10,830,870'
1031	146.40	147.80	13	300	DIPOLE	19'	DEBRIS (VK-119)	1,276,432'	10,849,539'
1031	166.10	167.50	145	110	DIPOLE	11'	DEBRIS (VK-75)	1,275,303'	10,859,168'
1042	126.50	125.10	1000+	1000	DIPOLE	7'	VK-31, STRUCTURE 1		

MAGNETIC ANOMALY TABLE - MISSISSIPPI SOUND AREA

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
125	2.20	2.10	90	40	DIPOLE	1'	DEBRIS (MS-58)	1,247,930'	11,007,452'
125	3.30	3.20	1000+	250	DIPOLE	1'	ARCO 12" PIPELINE		
125	6.00	7.00	1000+	1000	DIPOLE	1'	OED 20" PIPELINE (PARALLEL)		
125	14.90	15.90	1000+	1000	DIPOLE	1'	OED 20" PIPELINE (PARALLEL)		
125	25.40	25.50	1000+	150	DIPOLE	1'	DAUPHIN 8" PIPELINE		
125	44.70	45.00	12	75	DIPOLE	1'	DEBRIS (MS-73)	1,253,516'	10,987,098'
125	44.90	45.20	90	100	DIPOLE	1'	DEBRIS (MS-73)	1,253,546'	10,987,004'
125	45.70	46.00	5	15	DIPOLE	1'	DEBRIS (MS-73)	1,253,663'	10,986,630'
125	47.00	47.30	720	200	DIPOLE	1'	DEBRIS (MS-73)	1,253,817'	10,986,004'
125	48.60	48.90	4	30	MONOPOLE	1'	DEBRIS (MS-73)	1,254,045'	10,985,252'
125	49.30	49.60	45	25	MONOPOLE	1'	DEBRIS (MS-73)	1,254,145'	10,984,921'
125	50.70	51.00	105	75	DIPOLE	1'	ARCO 6" PIPELINE		
125	51.10	52.00	60	50	DIPOLE	1'	ARCO 6" PIPELINE		
125	53.20	53.50	85	150	DIPOLE	1'	ARCO 6" PIPELINE		
125	59.80	59.70	3	40	MONOPOLE	1'	DEBRIS (MS-73)	1,255,525'	10,979,671'
126	3.30	3.60	1000+	1000	DIPOLE	1'	ARCO 12" PIPELINE		
126	9.50	10.00	1000+	1000	DIPOLE	1'	OED 20" PIPELINE (PARALLEL)		
126	25.70	25.40	880	150	DIPOLE	1'	DAUPHIN 8" PIPELINE		
126	28.00	28.40	25	10	MONOPOLE	1'	DEBRIS (MS-58)	1,251,582'	10,994,976'
126	43.30	43.00	45	40	DIPOLE	1'	DEBRIS (MS-73)	1,253,415'	10,988,095'
126	46.40	46.10	70	40	DIPOLE	1'	DEBRIS (MS-73)	1,253,815'	10,986,615'
126	46.90	46.60	165	100	DIPOLE	4'	DEBRIS (MS-73)	1,253,891'	10,986,382'
126	47.70	47.40	12	90	MONOPOLE	3'	DEBRIS (MS-73)	1,254,001'	10,986,002'
126	51.40	51.10	880	100	DIPOLE	1'	ARCO 6" PIPELINE		
126	51.80	51.50	135	60	DIPOLE	1'	ARCO 6" PIPELINE		
126	53.90	53.60	90	100	DIPOLE	1'	ARCO 6" PIPELINE		
127	.80	1.10	130	100	DIPOLE	1'	DEBRIS (MS-58)	1,248,101'	11,008,502'
127	3.00	3.30	165	150	DIPOLE	1'	ARCO 12" PIPELINE		

MAGNETIC ANOMALY TABLE - MISSISSIPPI SOUND AREA

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
127	4.80	5.10	1000+	500	DIPOLE	1'	OED 20" PIPELINE		
127	25.40	25.70	230	200	DIPOLE	1'	DAUPHIN 8" PIPELINE		
127	26.22	26.52	7	150	MONOPOLE	3'	DEBRIS (MS-58)	1,251,458'	10,995,976'
127	45.00	45.30	50	40	DIPOLE	1'	DEBRIS (MS-73)	1,253,883'	10,987,043'
127	46.00	46.30	11	80	DIPOLE	1'	DEBRIS (MS-73)	1,254,007'	10,986,568'
127	46.40	46.70	30	75	DIPOLE	3'	DEBRIS (MS-73)	1,254,056'	10,986,378'
127	47.00	47.30	86	50	DIPOLE	3'	DEBRIS (MS-73)	1,254,129'	10,986,092'
127	50.50	50.80	75	20	DIPOLE	3'	DEBRIS (MS-73)	1,254,581'	10,984,429'
127	50.80	51.10	900	100	DIPOLE	1'	ARCO 6" PIPELINE		
127	51.20	51.50	45	50	MONOPOLE	1'	ARCO 6" PIPELINE		
127	53.50	53.80	310	70	DIPOLE	1'	ARCO 6" PIPELINE		
127	55.30	55.60	16	40	DIPOLE	1'	DEBRIS (MS-73)	1,255,206'	10,982,148'
127	60.80	60.50	6	25	MONOPOLE	1'	DEBRIS (MS-73)	1,255,954'	10,979,370'
128	1.70	1.40	11	40	DIPOLE	1'	DEBRIS (MS-58)	1,248,396'	11,007,941'
128	2.00	1.70	40	25	DIPOLE	1'	DEBRIS (MS-58)	1,248,430'	11,007,795'
128	2.10	1.80	275	100	DIPOLE	1'	ARCO 12" PIPELINE		
128	3.40	3.10	1000+	300	DIPOLE	1'	OED 20" PIPELINE		
128	4.50	4.20	50	40	DIPOLE	1'	DEBRIS (MS-58)	1,248,815'	11,006,602'
128	25.90	25.60	300	150	DIPOLE	1'	DAUPHIN 8" PIPELINE		
128	26.56	26.26	7	125	MONOPOLE	3'	DEBRIS (MS-58)	1,251,566'	10,996,106'
128	43.90	43.60	220	100	DIPOLE	1'	DEBRIS (MS-73)	1,253,801'	10,987,889'
128	44.50	44.20	37	40	DIPOLE	1'	DEBRIS (MS-73)	1,253,878'	10,987,608'
128	45.20	44.90	22	40	MONOPOLE	1'	DEBRIS (MS-73)	1,253,982'	10,987,279'
128	45.30	45.00	18	100	DIPOLE	1'	DEBRIS (MS-73)	1,253,997'	10,987,233'
128	47.30	47.00	21	80	DIPOLE	3'	DEBRIS (MS-73)	1,254,261'	10,986,285'
128	51.10	50.80	440	60	DIPOLE	1'	DEBRIS (MS-73)	1,254,715'	10,984,464'
128	51.40	51.10	100	125	DIPOLE	1'	ARCO 6" PIPELINE		
128	51.90	51.60	105	150	DIPOLE	1'	ARCO 6" PIPELINE		

MAGNETIC ANOMALY TABLE - MISSISSIPPI SOUND AREA

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
128	54.30	54.60	106	150	DIPOLE	1'	ARCO 6" PIPELINE		
129	2.40	2.70	820	200	DIPOLE	1'	ARCO 12" PIPELINE		
129	3.60	3.90	1000+	250	DIPOLE	1'	OED 20" PIPELINE		
129	4.60	4.90	110	25	MONOPOLE	1'	DEBRIS (MS-58)	1,248,878'	11,006,743'
129	17.10	17.40	765	100	DIPOLE	1'	DEBRIS (MS-58)	1,250,631'	11,000,388'
129	25.50	25.80	750	110	DIPOLE	1'	DAUPHIN 8" PIPELINE		
129	30.30	30.70	330	50	DIPOLE	1'	DEBRIS (MS-72)	1,252,290'	10,994,056'
129	31.20	31.50	760	25	DIPOLE	1'	DEBRIS (MS-72)	1,252,394'	10,993,676'
129	43.11	43.70	830	60	DIPOLE	1'	DEBRIS (MS-72)	1,253,994'	10,987,889'
129	45.40	45.70	14	25	DIPOLE	2'	DEBRIS (MS-72)	1,254,236'	10,986,933'
129	46.00	46.30	6	25	MONOPOLE	1'	DEBRIS (MS-72)	1,254,307'	10,986,651'
129	47.00	47.30	11	40	MONOPOLE	3'	DEBRIS (MS-72)	1,254,433'	10,986,181'
129	50.30	50.60	30	25	MONOPOLE	1'	DEBRIS (MS-72)	1,254,879'	10,984,610'
129	50.90	51.20	210	100	MONOPOLE	1'	ARCO 6" PIPELINE		
129	51.10	51.40	45	10	DIPOLE	1'	DEBRIS (MS-72)	1,254,986'	10,984,232'
129	51.40	51.70	210	70	DIPOLE	1'	ARCO 6" PIPELINE		
129	51.70	52.00	25	40	DIPOLE	1'	DEBRIS (MS-72)	1,255,067'	10,983,949'
129	54.00	54.30	240	60	DIPOLE	1'	ARCO 6" PIPELINE		
129	58.00	58.30	300	40	DIPOLE	1'	DEBRIS (MS-72)	1,255,892'	10,980,974'
130	4.50	4.80	1000+	350	DIPOLE	1'	OED 20" PIPELINE		
130	8.50	8.80	90	30	MONOPOLE	1'	DEBRIS (MS-47)	1,254,515'	11,015,523'
130	10.30	10.60	40	45	DIPOLE	5'	DEBRIS (MS-47)	1,253,978'	11,014,799'
130	29.40	29.70	1000+	1250	DIPOLE	1'	ARCO 12" PIPELINE		
131	2.80	2.50	8	40	MONOPOLE	1'	DEBRIS (MS-47)	1,256,394'	11,017,747'
131	29.00	28.70	5	20	MONOPOLE	1'	DEBRIS (MS-58)	1,248,473'	11,007,312'
131	29.30	29.00	7	10	MONOPOLE	1'	DEBRIS (MS-58)	1,248,385'	11,007,189'
131	30.20	29.90	210	200	DIPOLE	1'	ARCO 12" PIPELINE		
133	2.00	2.30	15	150	DIPOLE	2'	DEBRIS (MS-47)	1,256,870'	11,017,814'

MAGNETIC ANOMALY TABLE - MISSISSIPPI SOUND AREA

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
133	2.80	3.10	90	80	DIPOLE	2'	DEBRIS (MS-47)	1,256,630'	11,017,493'
133	3.30	3.60	33	40	DIPOLE	3'	DEBRIS (MS-47)	1,256,475'	11,017,299'
133	4.00	4.30	3	30	MONOPOLE	3'	DEBRIS (MS-47)	1,256,255'	11,017,026'
133	4.20	4.50	3	30	MONOPOLE	3'	DEBRIS (MS-47)	1,256,191'	11,016,948'
133	8.40	8.70	5	25	DIPOLE	3'	DEBRIS (MS-47)	1,254,918'	11,015,273'
133	10.20	10.50	10	60	DIPOLE	1'	DEBRIS (MS-47)	1,254,394'	11,014,554'
133	12.30	12.60	19	120	DIPOLE	1'	DEBRIS (MS-47)	1,253,746'	11,013,721'
133	17.60	17.90	10	100	DIPOLE	1'	DEBRIS (MS-46)	1,252,129'	11,011,621'
133	20.30	20.60	75	50	DIPOLE	1'	DEBRIS (MS-46)	1,251,321'	11,010,535'
133	23.20	23.50	20	20	MONOPOLE	1'	DEBRIS (MS-46)	1,250,445'	11,009,382'
133	26.60	26.90	195	40	MONOPOLE	1'	DEBRIS (MS-58)	1,249,418'	11,008,031'
133	28.10	28.40	45	40	MONOPOLE	1'	DEBRIS (MS-58)	1,248,970'	11,007,428'
133	29.20	29.50	1000+	300	DIPOLE	1'	OED 20" PIPELINE		
133	31.00	31.30	1000+	150	DIPOLE	5'	ARCO 12" PIPELINE		
134	9.70	9.40	64	60	DIPOLE	1'	DEBRIS (MS-47)	1,254,696'	11,014,703'
134	13.90	13.60	8	50	DIPOLE	1'	DEBRIS (MS-47)	1,253,425'	11,013,028'
134	15.20	14.90	6	40	DIPOLE	1'	DEBRIS (MS-47)	1,253,025'	11,012,518'
134	20.20	19.90	95	50	DIPOLE	1'	DEBRIS (MS-46)	1,251,521'	11,010,521'
134	22.60	22.30	95	50	DIPOLE	1'	DEBRIS (MS-46)	1,250,794'	11,009,570'
134	23.50	23.20	7	25	MONOPOLE	1'	DEBRIS (MS-46)	1,250,516'	11,009,214'
134	25.30	25.00	95	40	DIPOLE	1'	DEBRIS (MS-58)	1,249,963'	11,008,506'
134	29.80	29.50	1000+	200	DIPOLE	1'	OED 20" PIPELINE		
134	31.00	30.70	1000+	150	DIPOLE	1'	ARCO 12" PIPELINE		
135	1.60	1.30	215	50	MONOPOLE	1'	ARCO 12" PIPELINE		
135	1.95	1.65	50	20	DIPOLE	2'	DEBRIS (MS-58)	1,248,728'	11,007,899'
135	2.50	2.20	970	150	DIPOLE	2'	OED 20" PIPELINE		
135	3.20	2.90	11	15	DIPOLE	1'	DEBRIS (MS-58)	1,248,918'	11,007,304'
136	1.10	1.40	1140	200	DIPOLE	3'	ARCO 12" PIPELINE		

MAGNETIC ANOMALY TABLE - MISSISSIPPI SOUND AREA

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
136	1.80	2.10	1000+	200	DIPOLE	1'	OED 12" PIPELINE		
139	1.10	.80	11	250	DIPOLE	1'	ARCO 12" PIPELINE		
139	2.20	1.90	1000+	300	DIPOLE	1'	OED 20" PIPELINE		
139	3.00	2.70	60	25	DIPOLE	1'	DEBRIS (MS-58)	1,248,655'	11,005,635'
139	3.70	3.40	60	40	MONOPOLE	1'	DEBRIS (MS-58)	1,248,723'	11,005,979'
139	5.30	5.00	8	40	MONOPOLE	1'	DEBRIS (MS-58)	1,248,849'	11,006,770'
139	8.00	7.70	1000+	500	DIPOLE	1'	OED 20" PIPELINE		
139	9.00	8.70	1000+	250	DIPOLE	1	ARCO 12" PIPELINE		
143	7.25	7.55	9	50	DIPOLE	1'	DEBRIS (MS-47)	1,256,354'	11,021,025'
143	7.47	7.77	5	30	MONOPOLE	1'	DEBRIS (MS-47)	1,256,356'	11,020,914'
143	8.10	8.43	125	60	DIPOLE	1'	MARKER STICK OR POST		
143	11.20	11.50	29	30	DIPOLE	1'	DEBRIS (MS-47)	1,256,380'	11,019,059'
143	14.60	14.90	25	6	MONOPOLE	1'	DEBRIS (MS-47)	1,256,462'	11,017,353'
143	15.40	15.70	23	40	DIPOLE	1'	DEBRIS (MS-47)	1,256,486'	11,016,963'
144	9.20	9.50	56	50	DIPOLE	1'	DEBRIS (MS-47)	1,256,564'	11,020,074'
144	9.50	9.80	9	30	DIPOLE	1'	DEBRIS (MS-47)	1,256,566'	11,019,937'
144	10.10	10.40	41	45	DIPOLE	1'	DEBRIS (MS-47)	1,256,564	11,019,600'
144	15.40	15.70	19	50	DIPOLE	1'	DEBRIS (MS-47)	1,256,614'	11,016,994'
144	16.00	16.30	70	50	DIPOLE	1'	DEBRIS (MS-47)	1,256,623'	11,016,644'
145	4.10	3.80	1000+	2700	DIPOLE	1'	ARCO 12" PIPELINE		
145	6.50	6.21	12	40	DIPOLE	1'	DEBRIS (MS-47)	1,255,786'	11,016,639'
146	3.50	3.20	1000+	200	DIPOLE	4'	OED 20" PIPELINE		
147	1.60	1.30	64	50	DIPOLE	1'	DEBRIS (MS-47)	1,255,362'	11,015,431'
147	4.40	4.10	36	40	DIPOLE	1'	DEBRIS (MS-47)	1,255,836'	11,016,752'
147	7.40	7.10	48	50	DIPOLE	3'	DEBRIS (MS-47)	1,256,359'	11,018,157'
147	8.00	7.70	45	25	DIPOLE	3'	DEBRIS (MS-47)	1,256,453'	11,018,443'
148	3.60	3.90	25	20	MONOPOLE	3'	DEBRIS (MS-73)	1,254,397'	10,986,812'
149	1.60	1.30	240	200	DIPOLE	3'	OED 20" PIPELINE		

MAGNETIC ANOMALY TABLE - MISSISSIPPI SOUND AREA

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
152	1.00	1.30	315	150	DIPOLE	3'	ARCO 12" PIPELINE		
152	1.80	2.10	900	150	DIPOLE	3'	OED 20" PIPELINE		
152	4.10	4.40	5	50	MONOPOLE	3'	DEBRIS (MS-58)	1,251,484'	10,998,521'
153	1.80	1.50	880	100	DIPOLE	3'	ARCO 12" PIPELINE		
153	2.60	2.30	475	200	MONOPOLE	3'	OED 20" PIPELINE		
154	1.70	2.00	960	60	DIPOLE	3'	ARCO 12" PIPELINE		
154	1.90	2.20	15	40	DIPOLE	3'	DEBRIS (MS-58)	1,248,868'	11,003,971'
154	2.50	2.80	945	115	DIPOLE	3'	OED 20" PIPELINE		
155	1.70	2.00	115	70	MONOPOLE	3'	DEBRIS (MS-58)	1,249,950'	11,006,508'
155	4.50	4.80	210	150	DIPOLE	3'	OED 20" PIPELINE		
155	5.60	5.90	395	100	MONOPOLE	3'	ARCO 12" PIPELINE		
163	1.90	2.20	920	120	DIPOLE	3'	ARCO 12" PIPELINE		
163	2.40	2.70	220	150	MONOPOLE	3'	OED 20" PIPELINE		
163	3.20	3.50	6	20	MONOPOLE	3'	DEBRIS (MS-47)	1,253,659'	11,013,477'
167	2.10	1.80	405	150	DIPOLE	3'	ARCO 12" PIPELINE		
167	3.00	2.70	66	40	DIPOLE	3'	DEBRIS (MS-47)	1,255,774'	11,016,870'
167	3.70	2.40	410	125	DIPOLE	3'	OED 20" PIPELINE		
172	2.20	2.80	1000+	150	DIPOLE	3'	OED 20" PIPELINE		
172	2.50	2.50	1000+	100	DIPOLE	3'	ARCO 12" PIPELINE		
172	3.20	3.20	14	20	MONOPOLE	3'	DEBRIS (MS-47)	1,256,267'	11,022,713'
172	4.00	4.00	8	25	MONOPOLE	3'	DEBRIS (MS-47)	1,256,665'	11,022,720'
1137	2.30	2.00	20	50	DIPOLE	3'	DEBRIS (MS-47)	1,257,204'	11,017,793'
1137	2.70	2.40	9	25	DIPOLE	3'	DEBRIS (MS-47)	1,257,089'	11,017,577'
1137	11.30	11.00	40	40	DIPOLE	3'	DEBRIS (MS-47)	1,254,531'	11,014,148'
1137	19.20	18.90	70	50	DIPOLE	3'	DEBRIS (MS-46)	1,252,128'	11,010,997'
1137	25.40	25.10	7	10	MONOPOLE	3'	DEBRIS (MS-58)	1,250,242'	11,008,536'
1137	27.90	27.60	16	20	MONOPOLE	3'	DEBRIS (MS-58)	1,249,488'	11,007,553'
1137	29.30	29.00	10	30	MONOPOLE	3'	DEBRIS (MS-58)	1,249,019'	11,007,057'

MAGNETIC ANOMALY TABLE - MISSISSIPPI SOUND AREA

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
1137	30.60	30.30	1000+	150	DIPOLE	3'	OED 20" PIPELINE		
1137	31.60	31.30	1000+	250	DIPOLE	3'	ARCO 12" PIPELINE		
1138	10.30	10.00	14	25	DIPOLE	3'	DEBRIS (MS-47)	1,254,748'	11,014,289'
1138	11.37	11.07	33	100	DIPOLE	3'	DEBRIS (MS-47)	1,254,443'	11,013,840'
1138	24.60	24.30	7	51	DIPOLE	3'	DEBRIS (MS-58)	1,250,453'	11,008,571'
1138	30.57	30.27	46	50	MONOPOLE	3'	DEBRIS (MS-58)	1,248,671'	11,006,174'
1138	30.83	30.53	1000	200	DIPOLE	3'	OED 20" PIPELINE		
1138	31.62	31.32	500	350	DIPOLE	3'	ARCO 12" PIPELINE		
1142	4.60	4.90	5	25	MONOPOLE	3'	DEBRIS (MS-47)	1,256,228'	11,022,350'
1142	4.70	5.00	42	100	DIPOLE	3'	DEBRIS (MS-47)	1,256,228'	11,022,299'
1142	4.75	5.05	7	25	DIPOLE	3'	DEBRIS (MS-47)	1,256,227'	11,022,274'
1142	6.73	7.03	28	60	DIPOLE	3'	CRAB TRAP		
1142	8.12	8.42	180	50	DIPOLE	3'	MARKER STICK OR POST		
1142	8.59	8.89	80	55	DIPOLE	3'	CRAB TRAP		
1142	14.95	15.25	6	40	DIPOLE	3'	DEBRIS (MS-47)	1,256,317'	11,017,178'
1142	15.10	15.40	12	50	DIPOLE	3'	DEBRIS (MS-47)	1,256,316'	11,017,102'
1142	15.29	15.59	5	50	MONOPOLE	3'	DEBRIS (MS-47)	1,256,314'	11,017,007'
1142	15.42	15.72	8	55	MONOPOLE	3'	DEBRIS (MS-47)	1,256,314'	11,016,942'
1142	15.71	16.01	125	52	DIPOLE	3'	DEBRIS (MS-47)	1,256,312'	11,016,796'
1143	8.20	8.50	18	40	DIPOLE	3'	DEBRIS (MS-47)	1,256,685'	11,020,559'
1143	8.30	8.60	5	10	MONOPOLE	3'	DEBRIS (MS-47)	1,256,688'	11,020,509'
1143	8.90	9.20	16	30	DIPOLE	3'	DEBRIS (MS-47)	1,256,697'	11,020,208'
1143	9.20	9.50	11	40	DIPOLE	3'	DEBRIS (MS-47)	1,256,694'	11,020,056'
1143	10.80	11.10	10	40	DIPOLE	3'	DEBRIS (MS-47)	1,256,719'	11,019,254'
1143	12.50	12.80	17	50	DIPOLE	3'	DEBRIS (MS-47)	1,256,712'	11,018,408'
1143	14.91	15.21	11	50	DIPOLE	3'	DEBRIS (MS-47)	1,256,746'	11,017,199'
1143	16.10	16.40	42	50	DIPOLE	3'	DEBRIS (MS-47)	1,256,754'	11,016,606'
1143	16.40	16.70	23	20	DIPOLE	3'	DEBRIS (MS-47)	1,256,749'	11,016,456'

MAGNETIC ANOMALY TABLE - MISSISSIPPI SOUND AREA

LINE NO.	RECORDED POSITION	CORRECTED POSITION	AMPLITUDE (GAMMAS)	WIDTH (FEET)	DIPOLE/ MONOPOLE	HEIGHT OFF BOTTOM	DESCRIPTION	"X" COORDINATE	"Y" COORDINATE
1144	7.11	7.70	9	50	MONOPOLE	3'	DEBRIS (MS-47)	1,256,843'	11,020,964'
1144	7.80	8.10	16	25	MONOPOLE	3'	DEBRIS (MS-47)	1,256,845'	11,020,762'
1144	8.70	9.00	150	50	DIPOLE	3'	DEBRIS (MS-47)	1,256,842'	11,020,308'
1144	8.90	9.20	38	45	DIPOLE	3'	DEBRIS (MS-47)	1,256,850'	11,020,208'
1144	13.10	13.40	30	40	DIPOLE	3'	DEBRIS (MS-47)	1,256,910'	11,018,113'
1144	13.80	14.10	110	150	DIPOLE	3'	DEBRIS (MS-47)	1,256,922'	11,017,761'
1144	15.90	16.20	25	25	DIPOLE	3'	DEBRIS (MS-47)	1,256,951'	11,016,712'
1147	2.20	1.90	6	60	DIPOLE	3'	DEBRIS (MS-73)	1,254,431'	10,982,798'
1147	3.40	3.10	118	200	MONOPOLE	3'	ARCO 6" PIPELINE		
2132	1.30	1.00	35	45	DIPOLE	3'	DEBRIS (MS-47)	1,257,063'	11,018,177'
2132	2.00	1.70	17	40	MONOPOLE	3'	DEBRIS (MS-47)	1,256,833'	11,017,913'
2132	3.10	2.80	4	20	MONOPOLE	3'	DEBRIS (MS-47)	1,256,504'	11,017,471'
2132	3.60	3.20	5	10	DIPOLE	3'	DEBRIS (MS-47)	1,256,385'	11,017,312'
2132	4.60	4.30	52	50	DIPOLE	3'	DEBRIS (MS-47)	1,256,035'	11,016,891'
2132	5.20	4.90	7	20	MONOPOLE	3'	DEBRIS (MS-47)	1,255,829'	11,016,672'
2132	7.20	6.90	5	10	MONOPOLE	3'	DEBRIS (MS-47)	1,255,250'	11,015,852'
2132	7.80	7.50	18	40	DIPOLE	3'	DEBRIS (MS-47)	1,255,059'	11,015,620'
2132	8.50	8.20	6	30	DIPOLE	3'	DEBRIS (MS-47)	1,254,842'	11,015,344'
2132	8.70	8.40	5	20	MONOPOLE	3'	DEBRIS (MS-47)	1,254,784'	11,015,263'
2132	10.30	10.00	7	50	DIPOLE	3'	DEBRIS (MS-47)	1,254,293'	11,014,633'
2132	10.90	10.60	7	40	MONOPOLE	3'	DEBRIS (MS-47)	1,254,103'	11,014,397'
2132	12.10	11.80	6	150	MONOPOLE	3'	DEBRIS (MS-47)	1,253,741'	11,013,912'
2132	17.40	17.10	12	125	MONOPOLE	3'	DEBRIS (MS-46)	1,252,133'	11,011,819'
2132	25.90	25.60	28	25	MONOPOLE	3'	DEBRIS (MS-58)	1,249,571'	11,008,413'
2132	26.50	26.20	65	40	DIPOLE	3'	DEBRIS (MS-58)	1,249,387'	11,008,175'
2132	28.80	28.50	1000+	500	DIPOLE	3'	OED 20" PIPELINE		
2132	30.60	30.30	650	250	DIPOLE	3'	ARCO 12" PIPELINE		

C & C MAGNETIC ANOMALY TABLE

Line Number	Recorded Shot Point	Corrected Shot Point	Amplitude (Gammas)	Monopole/ Dipole	Duration (ft)	Sensor Ht (ft)	Description	Coordinates	
								X	Y
200	2.14	2.74	56	M	300	5	Chevron 10"Pipeline		
200	11.52	12.12	2	D	225	8	DEBRIS MO822	1259884	10946632
200	44.65	45.25	10	M	250	17	DEBRIS MO866	1261783	10930442
200	45.32	45.92	7	M	200	17	DEBRIS MO866	1261817	10930115
200	47.43	48.03	7	D	375	17	DEBRIS MO822	1261954	10929087
201	3.40	2.80	154	M	240	5	Chevron 10" Pipeline		
202	2.38	2.98	216	M	275	6	Chevron 10" Pipeline		
202	16.50	17.10	3	M	120	9	DEBRIS MO866	1259833	10944159
202	31.50	32.10	6	M	100	5	DEBRIS MO866	1260697	10936834
203	3.48	2.88	266	M	280	5	Chevron 10"Pipeline		
203	6.30	5.70	39	D	100	6	DEBRIS MO822	1259014	10949711
204	2.30	2.90	92	D	150	6	Chevron 10" Pipeline		
204	3.90	4.50	5	D	60	6	DEBRIS MO822	1258870	10950287
204	30.57	31.17	10	D	225	15	DEBRIS MO866	1260451	10937256
205	3.55	2.95	70	D	170	7	Chevron 10" Pipeline		
205	22.62	22.02	5	D	450	11	DEBRIS MO866	1259629	10941692
206	16.58	17.18	3	M	150	10	DEBRIS MO866	1259185	10944044
206	21.08	21.68	5	D	210	12	DEBRIS MO866	1259445	10941847
206	24.10	24.70	4	D	750	13	DEBRIS MO866	1259605	10940368
206	54.80	55.40	3	D	350	17	DEBRIS MO910	1261396	10925367
206	59.90	60.50	10	D	200	17	DEBRIS MO910	1261678	10922872
206	65.05	65.65	2	M	500	15	DEBRIS MO910	1261962	10920356
207	24.20	23.60	4	D	325	13	DEBRIS MO866	1259403	10940882
207	39.40	38.80	3	D	450	17	DEBRIS MO866	1260262	10933456
208	25.76	26.36	2	M	40	14	DEBRIS MO866	1259393	10939520
209	35.52	34.92	6	D	160	15	DEBRIS MO866	1259735	10935312
210	35.36	35.96	3	D	60	15	DEBRIS MO866	1259621	10934792
210	46.13	46.73	12	M	400	17	DEBRIS MO910	1260244	10929528