RRD-GAS-005

MULTIPHASE FLOW GAS AND SOIL DATA

RECOMMENDED REQUIREMENTS DOCUMENT

Subject: **Multiphase Flow Gas and Soil Data**

1.0 Background

The Blue Ribbon Commission Gas Group has agreed to recommend that reducing and maintaining methane gas formation pressures in the Mississippi River Alluvial Aquifer (MRAA) to equal to hydrostatic pressure across the Bayou Corne gas area is necessary in order to lift the mandatory evacuation order (**Figure 1**). This Recommended Requirements Document (RRD) defines the technical requirements for obtaining ORW operational data to address this overall objective. The intent of this RRD is to provide recommended requirements for use by the appropriate state agencies when directing the development of a comprehensive work plan for addressing the RRD objective.

This RRD for collecting multiphase gas and soil parameter data has been prepared with consideration of the following site conditions and factors:

1. The gas formation pressures at the top of the MRAA are at least 10 pounds per square inch (psi) greater than hydrostatic. While it would be preferable for the borings to be in the gas area, it has proven to be difficult and hazardous to collect continuous soil cores because of the gas pressures encountered. Therefore, these borings have been located outside where the gas is believed to be present at pressures greater than hydrostatic. Because the area of gas is not currently well defined, appropriate health and safety protocols must be in place in the event that gas is encountered.

2. The gas has been encountered at pressures greater than hydrostatic in several geologic zones at the top of the MRAA and the overlying clay aquitard.

3. Multiphase flow gas and soil characteristics of these zones are necessary for analysis and modeling of the gas migration and mitigation.

4. Technically, the gas pressure in the MRAA only has to be reduced to a pressure that is less than the pressure required for the gas to flow through the aquitard to the surface. However, determining a value for this pressure requires substantial characterization of subsurface geologic conditions and multiphase gas flow parameters. Such characterization is not presently available so hydrostatic pressure was defined by the BRC as the appropriate benchmark pressure. As the mitigation and characterization efforts progress and a multiphase gas flow numerical model is developed based on site conditions, it may be possible to define a MRAA gas pressure greater than hydrostatic pressure that is an appropriate benchmark to protect human health and the environment.

This RRD has been prepared as part of the overall GAS-07 BRC task. This BRC task addresses the need for multiphase flow soil characteristics from the MRAA and overlying aquitard for use in quantitative evaluations of gas migration and mitigation. This RRD establishes the procedures and equipment required to collect these data.

2.0 Objective

The objective of this RRD is to define the multiphase flow characteristics of the subsurface soils and gas in the MRAA gas area. These properties are critical for migration and mitigation analysis and modeling of the Bayou Corne gas. The specific laboratory and testing programs shall be specified in the work plan.

3.0 Requirements

The requirements of this RRD for multiphase flow soil data are:

1. Collect several representative gas and groundwater samples from selected Observation Relief Wells (ORWs) and submit to a qualified laboratory for measurement of interfacial tension (surface tension) between the gas and MRAA groundwater.
2. Drill and sample five or six soil borings outside the perimeter of the gas impacted area. **Figure 1** presents the preliminary locations of the boreholes. Alternative locations can be specified in the work plan.
    a. Install a CPT boring at each location to define lithology and pore pressures prior to drilling.
    b. Collect undisturbed intact soil cores from selected aquitard and MRAA intervals to a depth of 150 feet.
    c. Install groundwater monitoring wells in the boreholes.
3. The soil samples should be tested at a qualified geotechnical laboratory experienced in in the following testing:
    a. The core in the acetate liner shall be cryogenically cut using a diamond segmented bandsaw (API RP40) and photographed using ASTM D5079 digital core photography requirements including full-scale white light core photographs. The core photos will be sent to the project geologist for determination of the intervals from each core that will be analyzed for laboratory testing.
    b. A professional geologist selects the test intervals based on the data needs for this RRD.
    c. Each selected core interval shall be analyzed for the following laboratory parameters:
        i. Grain size analysis by the laser method (ASTM D4464) or sieve analysis (ASTM D442) procedures. Laser method is used on finer-grained materials up to medium-grained sand. Sieve analysis is used on coarser-grained material of medium sand and larger.
        ii. Capillary parameters by ASTM D6836 and API RP40 procedures

1. Air/water drainage (air displacing water) including fluid production vs. capillary pressure and air/water drainage capillary pressure curve
2. Air permeability
3. Hydraulic conductivity to water
4. Total porosity
5. Dry bulk density

iii. Calculation of van Genuchten parameters and relative permeability curves from the air-water drainage curve data.

4. Based on site geology currently defined from geophysical and CPT logs, the following are the minimum core intervals for multiphase flow laboratory parameter testing (**Figure 2**):
   a. The clay above the upper fine-grained sand in the aquitard.
   b. The upper fine-grained sand in the aquitard. This fine-grained sand is observed at depths between 20 and 50 feet across the gas area.
   c. The base of the aquitard, the top of the principal gas accumulation interval, is nominally at a depth of between 95 and 100 feet in the gas area but has been encountered at 110 feet at some locations. Based on the CPT log results, continuous core samples will be collected starting five feet above the bottom of the aquitard continuing down to a depth of 150 feet. The test intervals for this core will be selected by a professional geologist after the core photographs are received from the laboratory.
   d. The sand/gravel in the upper part of the MRAA.

5. Laboratory testing to measure the interfacial energy (surface tension) using formation groundwater and gas.

6. The following reporting is recommended for this RRD. The work plan shall specify the reporting dates.
   a. The CPT logs with recommended sample interval shall be provided to the BRC and Louisiana Department of Natural Resources (LDNR) in Excel and PDF format for review and comment prior to start of the drilling program.
   b. Field boring, well construction, sampling, and daily activity logs are to be provided to LDNR as soon as the borings and wells are completed.
   c. The core photographs with the selected test intervals should be provided to the BRC and LDNR for review and comment prior to start of the laboratory geotechnical testing program.
   d. All laboratory test results shall be reported to the BRC and LNDR in both PDF and electronic data format. It is requested that the data be reported in Excel but the work plan can specify an alternate generally accepted electronic data reporting format.
   e. A summary report summarizing all of the data with appendices containing the laboratory reports, CPT, boring and well construction logs shall be submitted to the BRC and LDNR.

Appendix 1 presents suggested procedures for data collection to meet the above objective and requirements. These procedures can be modified or replaced as appropriate to meet the objectives and requirements.

APPENDIX 1

SUGGESTED PROCEDURES

1.0 Introduction

This appendix is intended for use as a procedural reference for obtaining the data required in the RRD. The procedures in this section have been used by one or more Blue Ribbon Commissioners to obtain or generate the data specified in Section 3.0 of the RRD. In preparing the work plan to address this RRD, other procedures can be used provided the objectives and data requirements in Sections 2 and 3 are met.

The following technical references are applicable to this appendix.

- Crain's Petrophysical Handbook (Crain, 2013), http://www.spec2000.net/09-cappres.htm
- Dense Chlorinated Solvents and other DNAPLS in Groundwater (Pankow and J.A. Cherry, 1996)
- LNAPL Distribution and Recovery Model Volumes 1 and 2 (LDRM) (Charbeneau, 2007)
- Louisiana Department of Environmental Quality (LDEQ)/Louisiana Department of Transportation and Development's (LDOTD) *Handbook for Construction of Geotechnical Boreholes and Groundwater Monitoring Systems, December 2000*
- Models for Design of Free-Product Recovery Systems for Petroleum Hydrocarbon Liquids (Charbeneau, 2003)
- PTS Core Handling Recommendations (Attachment 1)
- PTS Core Shipping Recommendations (Attachment 2)
- Standard Practice for Field Pneumatic Slug (Instantaneous Change in Head) Tests to Determine Hydraulic Properties of Aquifers with Direct Push Groundwater Samplers (ASTM, 2006)

2.0 Contract Services

2.1 CPT Contractor and Louisiana Licensed Drilling Contractor (Hollow-Stem Auger Drill Rig)

A CPT rig and hollow-stem auger drill rig will be required to obtain the subsurface data and collect the soil cores recommended in this RRD. All boring and wells shall comply with the applicable regulations. All wells shall be registered by the drilling contractor.

2.2 Multiphase Gas and Core Analysis Services Laboratory

Laboratory analysis of gas samples and soil cores for multiphase flow physical properties will be required. PTS Laboratories in California is a commercial laboratory that is equipped to conduct the required testing on the gas and soil cores. Certain academic and government laboratories are equipped to conduct the testing but they do not do commercial work. There may be other commercial geotechnical laboratories equipped and experienced in the required testing procedures but no other United States commercial laboratory has been identified to conduct the testing required by the RRD.

3.0 Definitions

The following definitions are applicable to this appendix:

- *Capillary pressure*—Capillary pressure is the pressure across the interface between two immiscible fluids such as water and air or oil and water. Capillary pressure is defined as the pressure across the interface between the non-wetting phase and the wetting phase. In the Bayou Corne gas area, the wetting phase is the groundwater in the MRAA and aquitard and the non-wetting phase is the gas.

- *Capillary pressure curve*—A capillary pressure curve defines the relationship between the water saturation in a porous media such as sand and the associated capillary pressure. For example, a sand 100% saturated with water and no gas will have a gas-water capillary pressure of zero. As the gas pressure is increased, there is a corresponding increase in capillary pressure. When the capillary pressure reaches a critical pressure termed the **entry or displacement pressure**, gas will enter the pore space displacing water**.** The capillary pressure is increased until no further reduction in water saturation is measured. The resulting end-point water saturation is termed the **residual saturation**. The capillary pressure curve is a function the grain-size and other physical characteristics of porous media, and fluid properties such as interfacial energy (surface tension).

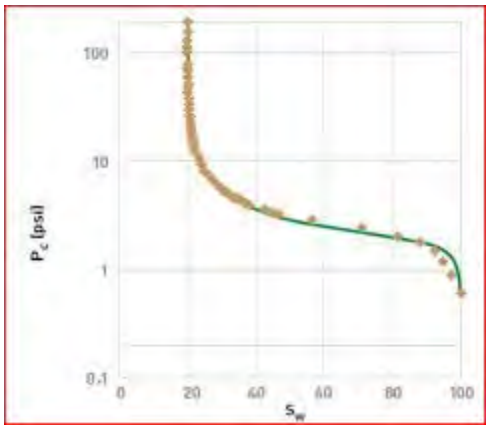


Figure 1. Example capillary curve
(from http://fesaus.org/temp/?task=view_event&event_id=1)

- *CPT*—Cone penetrometer testing (CPT). A direct-push method for obtaining detailed subsurface geologic and hydrogeologic data by pushing an instrumented cone into the soils using hydraulic rams and high-strength steel rods. At the Bayou Corne site, CPT has been successfully used to depths of 150 feet into the top of the MRAA. Once the coarser-grained sands of the MRAA are encountered, the CPT cone can no longer be advanced.

- *Interfacial tension (interfacial energy, surface tension)*—A property of the interface between two immiscible phases. When the phases are both liquid, it is termed interfacial tension; when one of the phases is air or a gas, it is termed surface tension. Interfacial tension is the Gibbs free energy per unit area of interface at fixed temperature and pressure. Interfacial tension occurs because a molecule near an interface has different molecular interactions than an equivalent molecule within the bulk fluid.

- *Multiphase flow*—Multiphase flow is subsurface flow of two or more fluids through geologic units. At the Bayou Corne site, the primary fluids of interest for multiphase flow evaluations are methane gas and groundwater in the gas area.

4.0 Procedure

The coring and sampling activities should be performed consistent with the following recommendations. These recommendations have been successfully used to collect gas and soil cores for multiphase flow laboratory analyses at many sites.

4.1 Gas Sampling and Interfacial Tension (Energy) Testing

Contemporaneous gas and groundwater samples should be collected from selected ORW wells and submitted a laboratory for interfacial tension testing according to ASTM Method D971. It is recommended that gas-water pairs be tested from 10 ORWs.

4.2 CPT Boring to Define Lithology and Sample Intervals

A CPT boring is recommended to define the geologic units and potential presence of gas at each location before coring is initiated. Once the lithology is defined using the CPT log, the core intervals for laboratory testing are selected to focus the coring efforts. The CPT hole must be grouted using appropriate methods after completion.

Based on site geology currently defined from geophysical and CPT logs, the following are the minimum core intervals for multiphase flow laboratory parameter testing (**Figure 2**):

1. The clay above the upper fine-grained sand in the aquitard.

2. The upper fine-grained sand in the aquitard. This fine-grained sand is observed at depths between 20 and 50 feet across the gas area.

3. The base of the aquitard, the top of the principal gas accumulation interval, is nominally at a depth of between 95 and 100 feet in the gas area but has been encountered at 110 feet at some locations. Based on the CPT log results, continuous core samples will be collected starting five feet above the bottom of the aquitard continuing down to a depth of 150 feet. The test intervals for this core will be selected after the core photographs are received from the laboratory.

4. The sand/gravel units near the upper part of the MRAA.

Once the core intervals have been selected, soil core samples will be collected in acetate liners for subsequent laboratory testing.

4.3 Soil Core Sampling

4.3.1 Core Handling and Documentation

A professional geologist shall oversee the coring and log the soil types. All soil descriptions and field test results will be recorded on a field boring log and a separate record of all field activities shall be documented in a Field Log notebook or Daily Activity form.

The core samples will be collected using a 2-inch continuous core or similar soil core sampler equipped with an acetate liner. When the acetate liners are removed from the core barrel, they will be capped and tape sealed. As necessary, the liner will be saw-cut and capped and tape sealed to fit in the sample coolers. Each acetate liner containing the soil samples will be clearly labeled with the boring ID, depth interval and top and bottom of the soil core, and the sequence in the core run (**Attachment 1**). The liners will be capped and tape sealed. Each core interval will be photographed in the field with the labels clearly visible. After labeling and photography, the samples will be placed on dry ice in the coolers (**Attachment 2**).

4.3.2 Aquitard Sampling

In the aquitard, only two definite samples per borehole in the shallow sand and overlying clay are planned as described in Section 5.1. These samples can potentially be collected from one 5-foot core interval using the appropriate coring device.

One or more shallow water-bearing zones may be encountered in the aquitard. In this case, a surface casing (set to a minimum depth of 30 feet-bgs) may be required.

Between core intervals, the hollow-stem augers are advanced without coring or sampling. For well construction and sampling purposes, 6-inch or larger augers are recommended.

4.3.3 Base of Aquitard and MRAA Sampling

The well locations on **Figure 1** have been selected to be outside the area of known gas but prudent caution is recommended when drilling these boreholes. It is recommended that the drilling stop for a short time just above the base of the aquitard to check for gas using the air quality instruments and signs of gas pressure. To check for gas pressure, the contractor may elect to fill the inside of the augers with water and watch for visible bubbles inside the augers. In the event that adverse gas pressures are indicated or encountered, the borehole will be grouted from the bottom using Portland cement grout and bentonite as required by applicable regulations. If gas is indicated or encountered, no attempt needs to be made to drill deeper.

Beginning at 5 feet above the uppermost sandy interval to the total borehole depth of 150 feet, soil cores will be collected by advancing a continuous core sampling device using acetate liners. These samples will be processed and logged as described in Section 5.2.1. Because the MRAA contains unconsolidated sands, the appropriate coring equipment capable of sampling loose sand should be used.

4.4 Multiphase Soil Core Laboratory Analysis

Soil cores from each boring in the acetate liners shall be shipped to the laboratory for analysis. Following receipt at the lab, each core shall be tested according to the following procedure:

- The core in the liner shall be cryogenically cut using a diamond segmented bandsaw (API RP40 Proprietary) and photographed using digital core photography according to ASTM D5079 requirements including full-scale white light core photographs. The core photos will be sent to the respective party for determination of the intervals from each core that will be analyzed for multiphase flow soil testing.
- The responsible professional geologist will select the test intervals based on the data needs for evaluation and modeling of gas migration and mitigation consistent with the objective of this RRD.
- To cores will be stored frozen at the laboratory for at least 6 months after collection to allow for any subsequent testing required.

Each selected core intervals shall be analyzed for the following multiphase flow parameters:

- Grain size analysis by the laser method (ASTM D4464) or sieve analysis (ASTM D442) procedures. Laser method is used on finer-grained materials up to medium-grained sand. Sieve analysis is used on coarser-grained material of medium sand and larger.
- PTS Capillarity test package. This package includes air/water drainage (air displacing water) according to ASTM D6836 and API RP40 procedures, air/water drainage capillary pressure curve, air permeability and hydraulic conductivity; includes fluid production vs. capillary pressure, total porosity, and dry bulk density.
- Calculation of van Genuchten parameters and relative permeability curves.

4.5 Monitoring Well Installation

Upon completion of soil sample collection to the required depth of 150 feet, a groundwater monitoring well shall be installed in each boring. The wells shall be installed and developed in accordance with the LDEQ/LDOTD *Handbook for Construction of Geotechnical Boreholes and Groundwater Monitoring Systems, (December 2000).* Each well will consist of 2-inch diameter PVC casing and 10 feet of 0.010-inch slotted PVC screen. Each well shall be completed with a graded-silica sand filter pack, bentonite seal, and cement-bentonite grout installed via tremie method. The surface will be completed with a flush-mounted bolt-down cover and concrete pad. The well will be developed until free of soil particles and has stable field parameters.

4.6 Slug Testing

Pneumatic slug tests are recommended according to ASTM procedures (ASTM, 2006) with necessary modifications for monitoring wells (Butler, 1997). The slug test data should be analyzed by the most applicable method (Dufield, 2013).

4.7 Monitoring Well Survey

The vertical (ground surface and top of casing) and horizontal position of each completed monitoring well shall be surveyed by a Louisiana licensed Professional Land Surveyor.

4.8 Monitoring

At this point in time, it is not anticipated that the monitoring wells will be sampled for water quality. If the wells are sampled, then normal groundwater purge and sample procedures shall be followed.

Because the groundwater flow gradients and fluctuations are poorly defined at the site, it is recommended that water levels in the wells be measured monthly and two of the wells be instrumented with recording, vented pressure transducers. The transducer wells should have manual water levels measured at least monthly and the transducer data adjusted accordingly.

4.9 Submittal of Data

All CPT, coring, slug testing, surveying, and monitoring data shall be documented and reported to LDNR in an electronic format once per week or as specified by LDNR directives. All CPT logs shall be submitted in PDF and Excel or similar electronic data transfer format.

5.0 Attachments

- ***Attachment 1***— PTS Core Handling Recommendations
- ***Attachment 2***—PTS Core Shipping Recommendations

6.0 FORMS

Soil Boring Log

Field Activity Daily Log

Well Construction Log

7.0 References

ASTM, 2006, Standard Practice for Field Pneumatic Slug (Instantaneous Change in Head) Tests to Determine Hydraulic Properties of Aquifers with Direct Push Groundwater Samplers, ASTM D7242-06, ASTM International, West Conshohocken, Pennsylvania.

Butler, J. J., 1997, The Design, Performance, and Analysis of Slug Tests, CRC Press, 262 p.:

Charbeneau, R., 2003, Models for Design of Free-Product Recovery Systems for Petroleum Hydrocarbon Liquids, API, 86 p.:

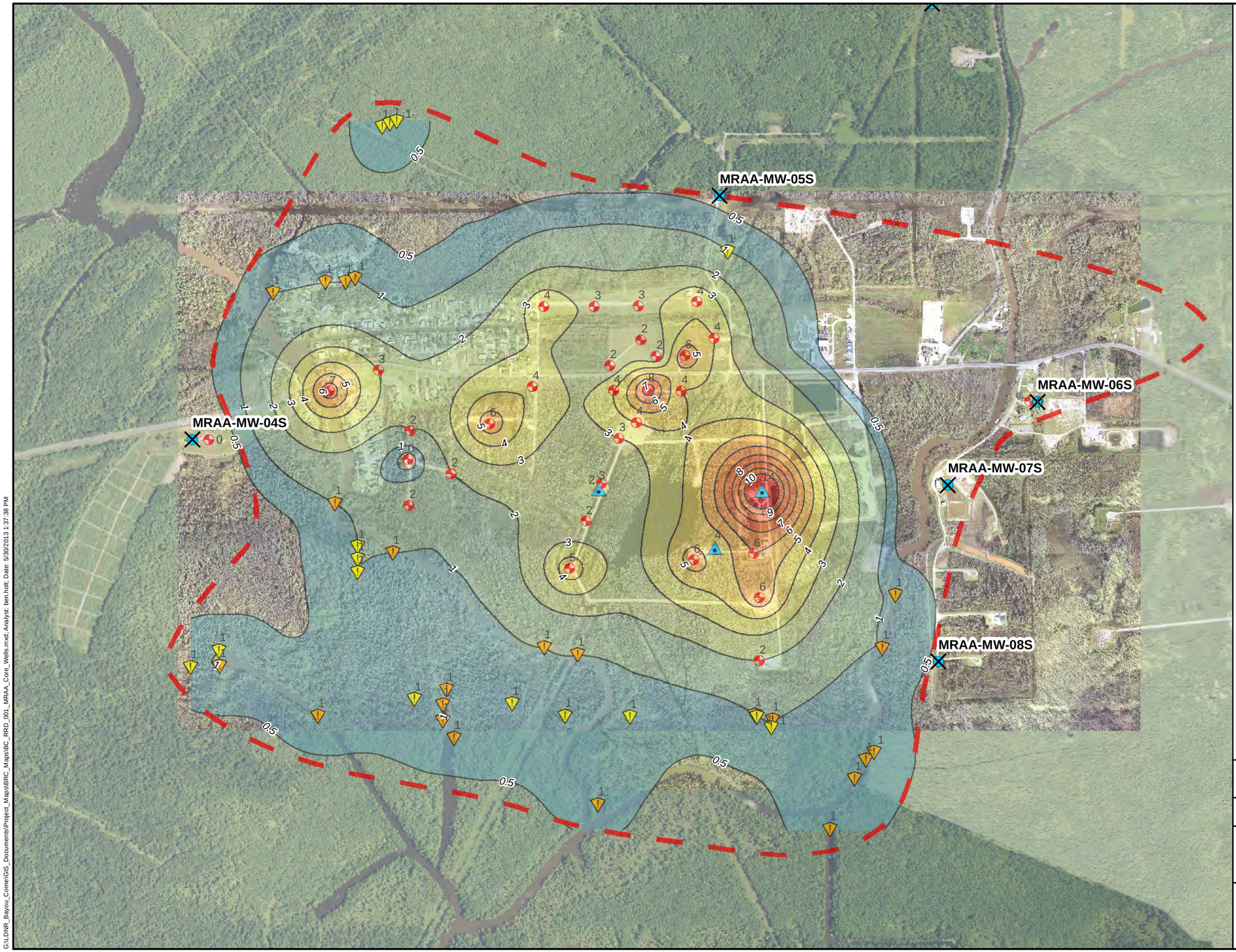
-, 2007, LNAPL Distribution and Recovery Model (LDRM), Volume 1: Distribution and Recovery of Petroleum Hydrocarbon Liquids in Porous Media, API.

Crain, E. R., 2013, Crain's Petrophysical Handbook (http://www.spec2000.net/01-index.htm).

Dufield, G. M., 2013, AQTESOLV for Windows, HydroSOLVE, Inc.

Pankow, J. F., and J.A. Cherry, e., 1996, Dense Chlorinated Solvents and other DNAPLS in Groundwater, Portland, OR, Waterloo Press, 522 p.:

FIGURES



Legend

Well with Core Samples

Gas Thickness Points

Observation relief vent well

Monitoring Well

Surface bubble site

Seismic shothole bubble site

Known Gas Area

Initial Gas Thickness (ft)

0.0 - 0.5

0.6 - 1.0

1.1 - 2.0

2.1 - 3.0

3.1 - 4.0

4.1 - 5.0

5.1 - 6.0

6.1 - 7.0

7.1 - 10.0

10.1 - 13.8

N

1,000 500 0 1,000

Feet

LOUISIANA DEPARTMENT OF NATURAL RESOURCES

BAYOU CORNE/NAPOLEONVILLE SALT DOME EMERGENCY RESPONSE

FIGURE NUMBER 1

PROPOSED MRAA MONITOR WELLS WITH MULITPHASE CORE SOIL SAMPLES

Shaw Environmental & Infrastructure, Inc.
A CB&I Company
4171 ESSEN LANE
BATON ROUGE, LOUISIANA 70809
www.CBI.com

G:\LDNR_Bayou_Corne\GIS_Documents\Project_Maps\BRC_Maps\BC_RRD_001_MRAA_Core_Wells.mxd: Analyst: ben holt: Date: 5/30/2013 1:37:38 PM

FIGURE 2

Napoleonville Salt Dome

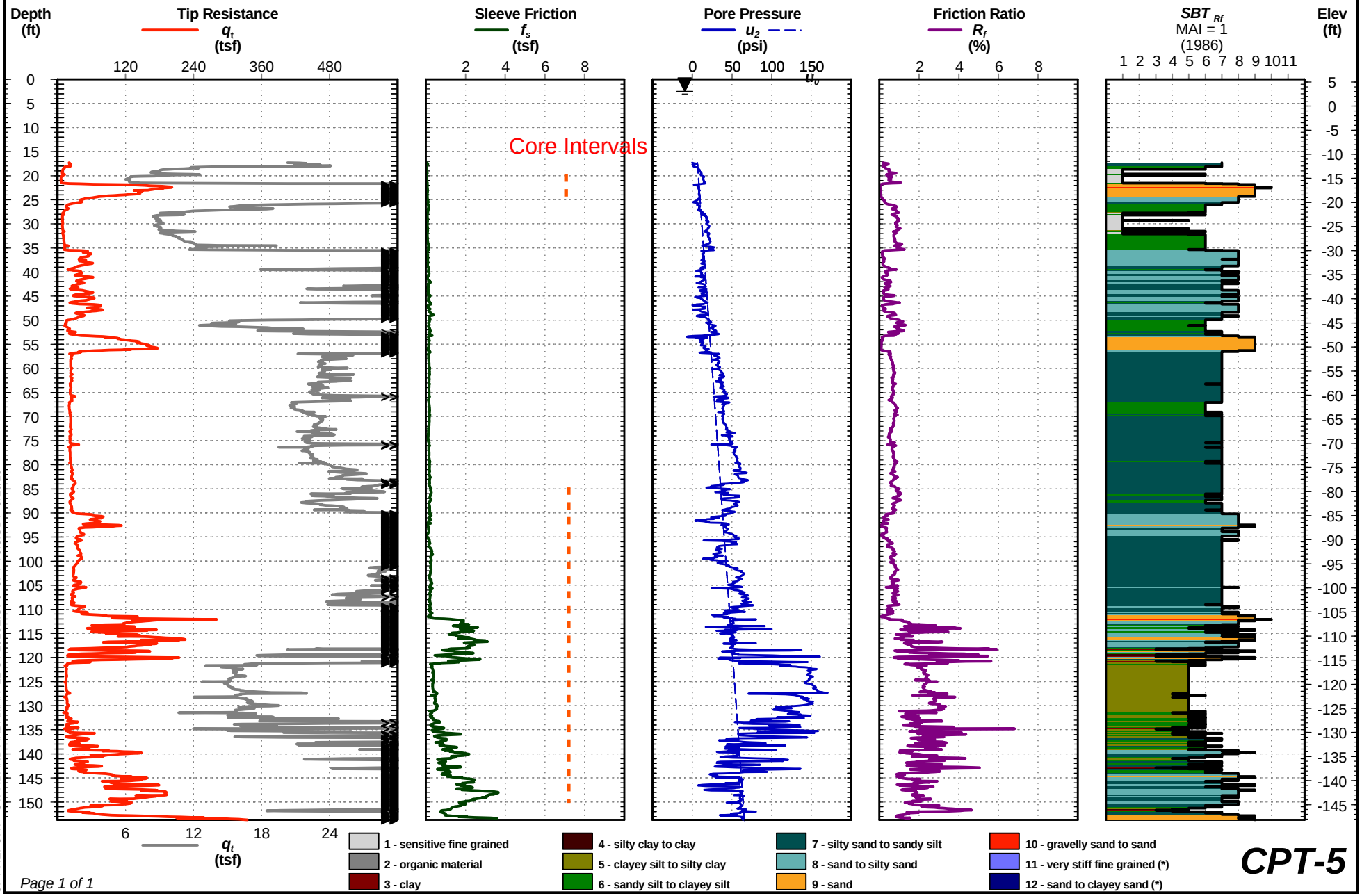
Cone Penetration Test

CPT-5

Project #: 12-84-2910E
Date: May. 14, 2013

Northing: 548040.7
Easting: 3342113.9

Elevation: 5.55
Total Depth: 153.7 ft



CPT-5

CPT REPORT - STANDARD ARDAMAN 12-84-2910E.GPJ CPT V3.0.GDT 5/20/13

ATTACHMENT 1

PTS CORE HANDLING RECOMMENDATIONS

PTS Laboratories

Geotechnical Services

8100 Secura Way • Santa Fe Springs, CA 90670
Phone (562) 907-3607 • FAX (562) 907-3610

Client: Environmental
Client Project ID: Core Recovery Project

PTS Quote No: 00-200
January 2002

Recommended Core Handling/Preservation Field Procedures

Introduction

Following are recommended field procedures for handling, preserving and shipping unconsolidated cores obtained from shallow borings. Coring methods are beyond the scope of these procedures, as every site will have it's own unique problems and those are best addressed by the consultant and coring companies involved.

The goal of any coring operation is to obtain representative, *undisturbed* samples. If the core is being submitted to a laboratory for petrophysical analysis, it is recommended that the laboratory be contacted in advance to discuss the test program and required core size. Often, a compromise must be met between what the laboratory requires and what is practical in the field. Generally a 2" diameter by 6" long sleeve is suitable for most basic tests; horizontal and vertical permeability, TOC, density, grain size, porosity and pore fluid saturations. If larger diameter/continuous coring equipment is available, then a more detailed lithological and petrophysical data profile can be generated.

Procedure

1. Remove sample from core sampler as soon as possible.
   a. If core is in sleeves, fill any void space with saran wrap to minimize core movement, then seal with Teflon film and tape on plastic end caps.
   b. If core is not in sleeves, slide gently from sampler on to split PVC core supports - contact PTS for details. Wrap with Saran and secure with clear box tape.
2. Label each core section with top and bottom depths. Fractions of a foot should be recorded in tenths. Additionally, label multiple sleeves sequentially with A, B, C... etc starting with A on the top (shallowest) sleeve.
3. Immediately place cores in a cooler containing dry ice and freeze to minimize migration of core fluids (alternative: pack core into an ice chest with frozen “Blue Ice” and foam packing/cushioning material).
4. Ship cores at the end of each day by overnight courier (FedEx or AirBorne Express, etc.) to PTS Laboratories. Contact PTS for labeling requirements.

Applicable ASTM Standards

D3550-84: Ring Lined Barrel Sampling of Soils; split spoon or one-piece sampling barrel.
D1587-83: Thin-Walled Tube Sampling of Soils; Pitcher/Shelby tubes.
D4220-89: Preserving and Transporting Soil Samples; basic, does not address contaminated samples.

•ATTACHMENT 2

PTS CORE SHIPPING RECOMMENDATIONS

Core Handling & Preservation

Freezing Core with Dry Ice

- Second fastest way to freeze core and preserve fluid saturations
- “Best” for most applications
- Longer freeze time results in little alteration of core physical properties
- Used when fluid saturations and physical properties are of equal importance
  - Preserves volatile and semivolatile hydrocarbons
  - Keeps fluids from migrating in high-permeance materials

Core Handling & Preservation

Freezing Core with Dry Ice

1. Dry Ice is available at most industrial gas supply companies (some supermarkets).
2. Large marine ice chests are used to freeze and transport core.
   a. Up to 72 quart coolers used for smaller core.
   b. Large marine coolers (94 quarts and greater) used for core over two feet long.
3. Place approximately 50 to 75 pounds of dry ice in the bottom of the ice chest.
4. Label core, attach end caps, and place core in ice chest.
   a. Close lid and core will freeze solid in 30 minutes.
   b. Each ice chest freezes up to 22.5 feet of core using 50-75 pounds of dry ice.
5. Caution - Do not put dry ice in an unventilated or enclosed space due to risk of death by asphyxiation!

PTS Laboratories

Core Handling & Preservation

- Place 50 to 75 pounds of dry ice in the bottom of the ice chest.
- Put core in ice chest and close lid. Core will freeze solid within 30 minutes.
- Continue adding core and dry ice as necessary.

Core Handling & Preservation

Transporting Frozen Core

1. Caution - Do not transport dry ice in passenger compartments due to risk of death by asphyxiation!
2. Large ice chests are used for transporting frozen core.
3. Place a layer of foam, bubble wrap, or “Styrofoam peanuts” in the bottom of ice chest to absorb shock during transport.
4. Place one layer of core on top of packing material.
5. Place a layer of dry ice over the core.
    a. Dry ice pellets can be used as a “packing material” to secure the core and fill any voids between cores.
    b. Block dry ice can also be used by breaking into smaller pieces and packing around core.
    c. Bubble wrap or styrofoam peanuts can be added to the core layers to cushion the core during transport.

Core Handling & Preservation

Transporting Frozen Core

6. Continue alternating layers of core, packing materials and dry ice. Do not exceed three layers of core.
7. Fill remaining space with dry ice.
8. Put Chain of Custody in a zip lock bag and tape inside lid.
9. Close lid and seal with tape to keep cold.
10. Attach Dry Ice Placards to ice chest.
11. Contact Overnight Courier for shipment to laboratory for next day delivery. Notify laboratory of shipment arrival time (tracking numbers).
12. Arrange shipment so core does not sit in hot warehouse or truck for days.

Core Handling & Preservation

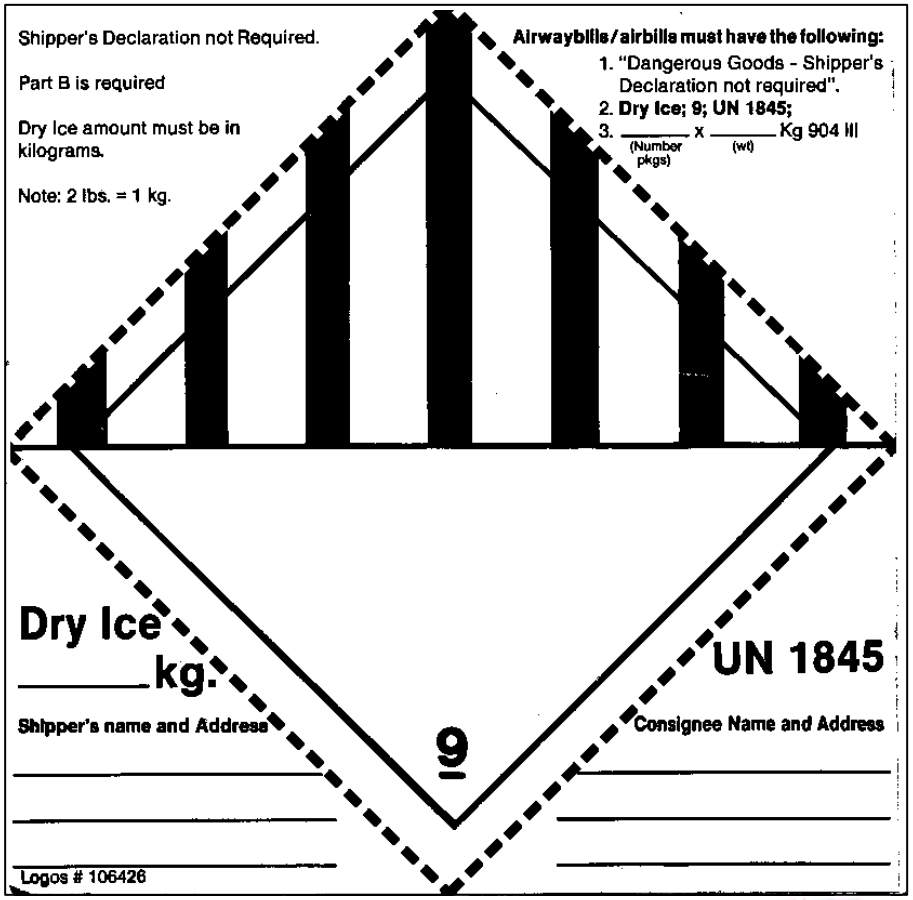
Transporting Frozen Core

- Ice chest filled with cores, dry ice, and packing material for cushioning.

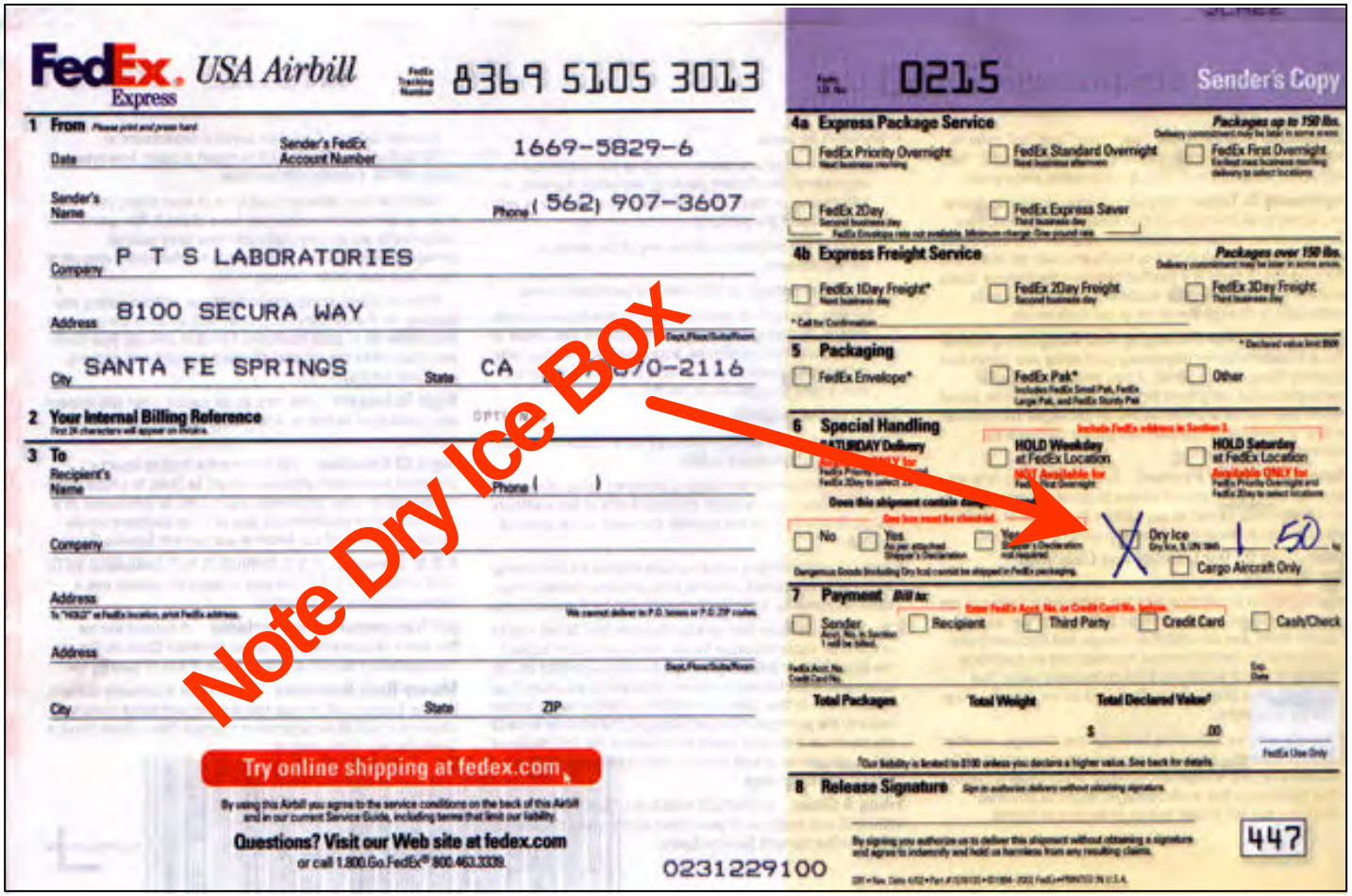
Core Handling & Preservation

Transporting Frozen Core

Dry Ice Placard: Overnight couriers can supply the placard stickers.

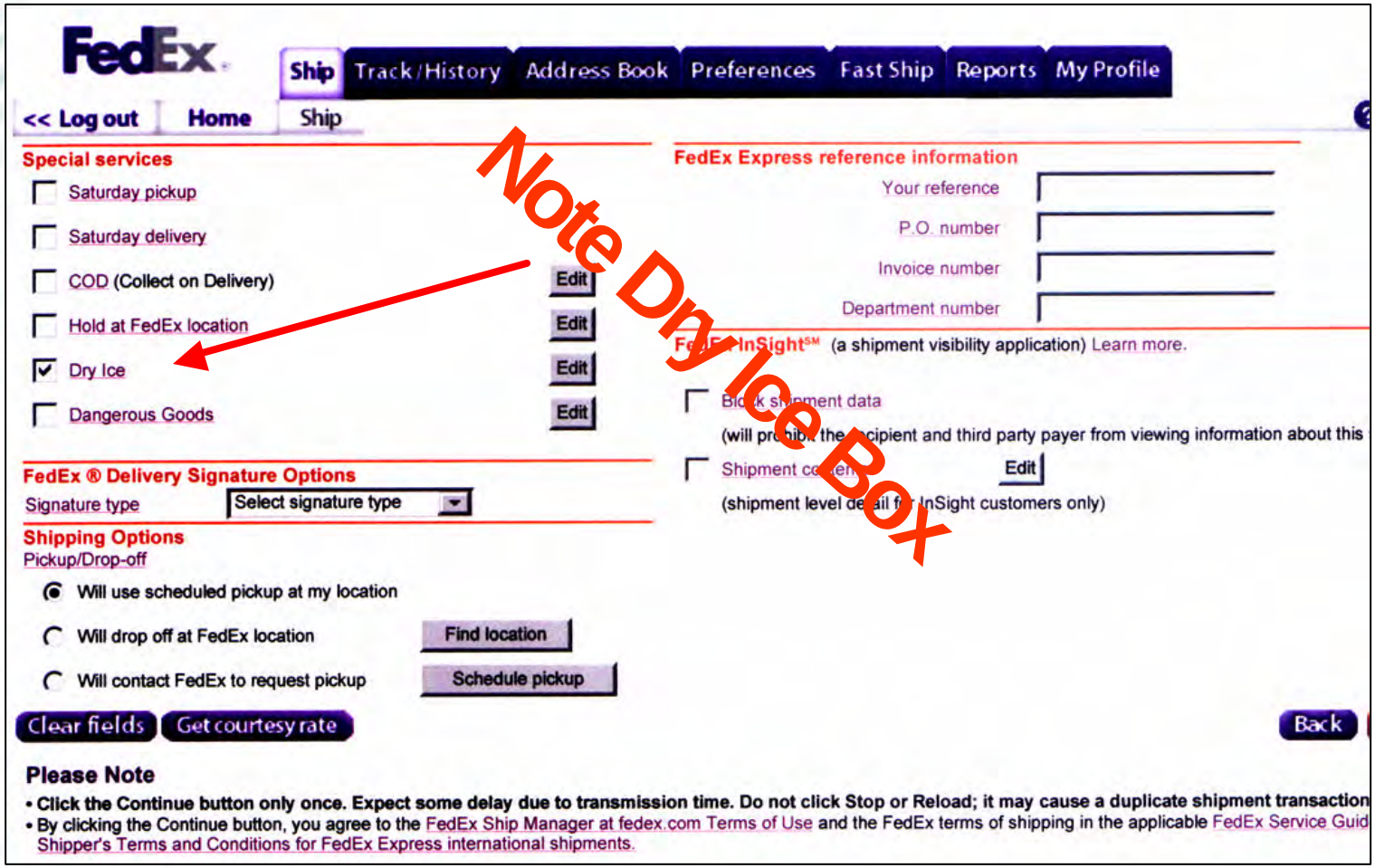


Core Handling & Preservation



Paper Shipping Label: FedEx is the easiest to ship with, they routinely handle dry ice shipments.

Core Handling & Preservation



Electronic Shipping: FedEx is the easiest to ship with, they routinely handle dry ice shipments.