Oil & Natural Gas Technology

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Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities

Principal Author:
John T. Balczewski
Chevron Energy Technology Company
6001 Bollinger Canyon Road, CHVPKD
San Ramon, CA 94583

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ABSTRACT

In 2000, Chevron began a project to learn how to characterize the natural gas hydrate deposits in the deepwater portions of the Gulf of Mexico. A Joint Industry Participation (JIP) group formed in 2001, and a project partially funded by the U.S. Department of Energy (DOE) began in October 2001. The **primary objective** of this project is to develop technology and data to assist in the characterization of naturally occurring gas hydrates in the deep water Gulf of Mexico (GOM). These naturally occurring gas hydrates can cause problems relating to drilling and production of oil and gas, as well as building and operating pipelines. Other objectives of this project are to better understand how natural gas hydrates can affect seafloor stability, to gather data that can be used to study climate change, and to determine how the results of this project can be used to assess if, and how gas hydrates act as a trapping mechanism for shallow oil, or gas reservoirs.

During October 2010 – March 2011 JIP activities:

- **JIP activities remain significantly impacted by continuing developments and uncertainty in the wake of the Gulf of Mexico Drilling Moratorium. JIP Leg III preparations during this period have focused on a comprehensive Chevron assessment of all aspects of Leg III to ensure it fully meets all new safety standards. Additional staff have been retained to assist in carrying out these assessments.**

- **Executive Board meeting: A Gulf of Mexico Hydrate JIP Executive Board meeting was held in November to discuss the current Gulf of Mexico situation, the Leg III assessment, potential implications and to approve the 2011 plan and budget. The board approved use of 'industry style' coring practices that help manage risk by minimizing the number of people and equipment used offshore and conducting the maximum amount of core analysis in suitable onshore locations. The board also approved addition of two non-drilling science efforts in 2011: 1) advertising and allowing broader access to Leg II 2009 LWD data to researchers worldwide; and 2) soliciting larger blocks of seismic data in blocks surrounding WR 313 and GC 955**

locations and allowing access to this data to a larger group of JIP researchers.

- **Investigation of suitable onshore locations for core analysis: Lists of potential candidate locations were generated and shortlist sites were investigated and in most cases visited. Selection criteria included appropriate safety and security arrangements and site/zoning permits, emergency response capability, logistical access for equipment and science team members, and sufficient work space including protected work areas for core processing and parking room for equipment vans. The new Weatherford core analysis and storage facility in north Houston has been selected as the best location and negotiations are commencing to secure this location for the JIP.**

- **Leg II final results publication: The JIP was notified that our proposal to the Journal of Marine and Petroleum Geology for a special thematic volume dealing with the scientific results of the GOM JIP Leg II expedition has been accepted. The science team is currently working on papers for this special volume.**

- **New contract negotiations: Expected support, studies and equipment likely required for Leg III continue to be negotiated but will not be signed until the assessment is completed, any required changes made to the Leg III plan are approved by the JIP board, and any changes reflected through to associated contracts.**

- **Work under existing JIP contracts: work is continuing with a few exceptions (for example production holds on interface subassemblies that may require alteration pending outcomes of the assessment).**

More information is available on the JIP website: http://gomhydratejip.ucsd.edu/

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1.0 Introduction

In 2000, Chevron Petroleum Technology Company began a project to learn how to characterize the natural gas hydrate deposits in the deepwater portion of the Gulf of Mexico. Chevron is an active explorer and operator in the Gulf of Mexico, and is aware that natural gas hydrates need to be understood to operate safely in deep water. In August 2000, Chevron working closely with the National Energy Technology Laboratory (NETL) of the United States Department of Energy (DOE) held a workshop in Houston, Texas, to define issues concerning the characterization of natural gas hydrate deposits. Specifically, the workshop was meant to clearly show where research, the development of new technologies, and new information sources would be of benefit to the DOE and to the oil and gas industry in defining issues and solving gas hydrate problems in deep water.

Based on the workshop held in August 2000, Chevron formed a Joint Industry Project (JIP) to write a proposal and conduct research concerning natural gas hydrate deposits in the deepwater portion of the Gulf of Mexico. The proposal was submitted to NETL on April 24, 2001, and Chevron was awarded a contract based on the proposal.

The title of the project is **"Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities".**

1.2 Objectives

The **primary objective** of this project is to develop technology and data to assist in the characterization of naturally occurring gas hydrates in the deep water Gulf of Mexico (GOM). These naturally occurring gas hydrates can cause problems relating to drilling and production of oil and gas, as well as building and operating pipelines. Other objectives of this project are to better understand how natural gas hydrates can affect seafloor stability, to gather data that can be used to study climate change, and to determine how the results of this project can be used to assess if and how gas hydrates act as a trapping mechanism for shallow oil or gas reservoirs.

1.3 Project Phases

The project is divided into phases. **Phase I** of the project is devoted to gathering existing data, generating new data, and writing protocols that will help the research team determine the location of existing gas hydrate deposits. During **Phase II** of the project, Chevron will drill at least three data collection wells to improve the technologies required to characterize gas hydrate deposits in the deepwater GOM using seismic, core and logging data. **Phase III** of the project began in September of 2007 and will focus on obtaining logs and cores of hydrate bearing sands in the GOM.

1.4 Research Participants

In 2001, Chevron organized a Joint Industry Participation (JIP) group to plan and conduct the tasks necessary for accomplishing the objectives of this research project. As of March 2010, the members of the JIP were Chevron, Schlumberger, ConocoPhillips, Halliburton, the Minerals Management Service (MMS), Total, JOGMEC, Reliance Industries Limited, The Korean National Oil Company (KNOC), and Statoil.

1.5 Research Activities

The research activities began officially on October 1, 2001. However, very little activity occurred during 2001 because of the paperwork involved in getting the JIP formed and the contract between DOE and Chevron in place. Several Semi-Annual and Topical Reports have been written that cover the activity of the JIP through September 2010.

1.6 Purpose of This Report

The purpose of this report is to document the activities of the JIP during October 2010 – March 2011. It is not possible to put everything into this Semi-Annual report, however, many of the important results are included and references to the JIP website, http://gomhydratejip.ucsd.edu/, are used to point the reader to more detailed information concerning various aspects of the project. The discussion of the work performed during this report period is organized by task and subtask for easy reference to the technical proposal and the DOE contract documents.

2.0 Executive Summary

Chevron formed a Joint Industry Participation (JIP) group to write a proposal and conduct research concerning natural gas hydrate deposits in the deepwater portion of the Gulf of Mexico. The proposal was submitted to NETL on April 24, 2001, and Chevron was awarded a contract based on the proposal.

The title of the project is **"Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities".**

The **primary objective** of this project is to develop technology and data to assist in the characterization of naturally occurring gas hydrates in the deep water Gulf of Mexico (GOM). **Other objectives** of this project are to better understand how natural gas hydrates can affect seafloor stability, to gather data that can be used to study climate change, and to determine how the results of this project can be used to assess if and how gas hydrates act as a trapping mechanism for shallow oil or gas reservoirs.

The project is divided into phases. **Phase I** of the project is devoted to gathering existing data, generating new data, and writing protocols that will help the research team determine the location of existing gas hydrate deposits. During **Phase II** of the project, Chevron drilled wells to obtain data for improving technologies required to characterize gas hydrate deposits in the deepwater GOM using seismic, core and logging data. **Phase III** of the project (the current phase) has an objective of collecting and analyzing data on hydrate bearing sands. Both logging and coring operations are planned in Phase III.

Phase III is roughly divided into two parts. Phase IIIA centered on a LWD drilling expedition (completed in 2009) to test methodologies to predict the locations and hydrate saturations of large, coarse-grained deepwater geobodies located in the hydrate stability zone. Phase IIIB will focus on retrieval and analysis of pressure cores from such geobodies, as well as wireline logging and (if possible) wireline formation tests. The end

of Phase IIIB will also include preparation and release of Final Integrated Reporting for the entire project.

3.0 Phase III A (Leg II) Activities

During the 2009 LWD leg, ongoing third party operations at one of the target drilling locations required that the Leg II expedition shift to an alternative site at a nearby block (AC21). LWD data at AC21 was successfully retrieved, and subsequent to completion of Leg II the JIP science team recommended that (for the sake of completeness) a pre-drill estimate should be made of this location. The estimate was done the same way as the pre-drill estimates at GC 955 and WR 313. Seismic inversion work in support of this objective was completed during this reporting period. As noted in the previous report, reading in the pre-stack seismic data took more time than anticipated because the tapes containing the seismic gathers are fairly old and problematic. Post-drill updates were completed by year's end.

The original and fully processed GOM JIP Leg II well log database was loaded onto the Lamont-Doherty Earth Observatory web site: http://brg.ldeo.columbia.edu/ghp/. The web site includes original and processed data, in the same formats as GOM JIP Leg I. LDEO will add the processed MP3 shear-wave and PeriScope data when it is received from Schlumberger.

Expanded (non JIP) access to this database has been advertised in the DOE/NETL "Fire in the Ice" newsletter and one research request has been submitted to date and approved.

The JIP was notified that our proposal to the Journal of Marine and Petroleum Geology for a special thematic volume dealing with the scientific results of the GOM JIP Leg II expedition has been accepted. The science team is currently working on papers for this special volume. Special thanks go to Tim Collett and Ray Boswell (Co-Chief Scientists) for leading this effort.

4.0 PHASE III B (LEG III) ACTIVITIES

Phase III B work was significantly impacted by the Gulf of Mexico drilling moratorium that was announced in late May 2010. Prior to the moratorium the project team had been ramping up preparations for planned 2011 coring expedition. Shortly after the moratorium was announced JIP Leg III preparations were put on hold in order to wait for lifting of the moratorium and to get subsequent post-moratorium clarification and assessment of regulatory, legislative, permitting, operational and commercial changes in the Gulf of Mexico.

New rules and regulations were put in place changing both the methodology and process used for permitting wells, regulating drilling and defining the roles and responsibilities in all aspects of deepwater operations. The new process utilizes a safety case process, relying heavily on the permitee to have a comprehensive and all inclusive safety and emergency management system in place. It is uncertain how much of this applies to our coring program, but at a minimum we can expect a much higher degree of scrutiny, a greater requirement for risk identification and management, a robust technical and mechanical integrity program, and preparation of a detailed operational program with a formal management of change procedure. These need to be formalized as a part of our ongoing program.

Work under existing commitments has continued with manufacture of key components of the pressure core barrel. Additional technical help has been added to the program to begin formulating a detailed basis of design and schedule for the entire program before any additional contracts are issued.

Details:

- JIP activities remain significantly impacted by continuing developments and uncertainty in the wake of the Gulf of Mexico Drilling Moratorium. JIP Leg III

preparations during this period have focused on a comprehensive assessment of all aspects of Leg III to ensure it fully meets all new safety standards. Additional staff have been retained to assist in carrying out these assessments.

- A Gulf of Mexico Hydrate JIP Executive Board meeting was held in November 2010 to discuss the situation in the Gulf of Mexico, Leg III assessment and potential implications and approve the 2011 plan and budget. The board approved use of 'industry style' coring practices that help manage risk by minimizing the number of people and equipment used offshore and conducting the maximum amount of core analysis in suitable onshore locations.
- Investigations of suitable onshore locations for core analysis were undertaken. Lists of candidate locations around the Gulf of Mexico were generated and shortlist sites were investigated and in most cases visited. Selection criteria included appropriate safety and security arrangements and site/zoning permits, emergency response capability, logistical access for equipment and science team members, and sufficient work space including protected work areas for core processing and parking room for equipment vans. The new Weatherford core analysis and storage facility in north Houston has been selected as the best location and negotiations are commencing to secure this location for the JIP.
- The board also approved addition of two non-drilling science efforts in 2011: 1) advertising and allowing broader access to Leg II 2009 LWD data to researchers worldwide; and 2) soliciting larger blocks of seismic data in blocks surrounding WR 313 and GC 955 locations and allowing access to this data to a larger group of JIP researchers. Item 1) has been completed (as reported in section 3.0). Item 2) has been progressed with Schlumberger/WesternGeco generously making the additional seismic data available. Currently contracts and legal agreements are under review.

- New contract negotiations: expected support, studies and equipment likely required for Leg III continue to be negotiated but will not be signed until the assessment is completed, any required changes made to the Leg III plan are

approved by the JIP board, and any changes are reflected through to associated contracts.

- Work under existing JIP contracts: work is continuing with a few exceptions (for example production holds on interface subassemblies that may require alteration pending outcomes of the assessment). Specifically:

HPTC

- Following an extensive design stage, the decision was made in Nov of 2010 to award construction of the high pressure core barrel (HPTC) to Aumann & Associates. Early into the program, detailed reviews were undertaken by specialists in the field and several changes were made to the original design. Among these were:
    - Based on Leg II drilling location parameters, the capability of the HPTC design was increased to allow cores to be cut in total depths exceeding 11,000 ft at pressures up to 5,500 psi.
    - To permit additional shielding and provide greater clearances the coring assembly was designed to fit in 7-5/8" OD drilling tubulars. Use of this larger OD and inside diameter tubular also has operational and budgetary benefits because it allows standard wireline electrical logging tools to be used in a "log through the bit" procedure without having to retrieve the entire coring string and running new wireline-dimensioned tubulars, saving valuable rig time.
    - The optional use of Fugro pressure coring tools in the same assembly was eliminated as a cost saving measure.
    - Decision was made to utilize an industry standard outer core barrels with minor modifications to handle the Aumann internal core system. This allows the usage of a better selection of standard core head designs for both the inner and outer systems, saving considerable custom design and machine work.

- Use of standard outer barrels preserved the ability of the bottom hole assembly to also take 30 ft conventional non pressured cores within the same tubular and bottom hole system to increase utility and flexibility.
- A center bit option was added to allow conventional drilling with the core system between core points.

- In summary the JIP committed to construct a wire line retrievable core bbl with associated tools and spares, which will allow: 1) Conventional drilling with the center plug installed; 2) Conventional wireline retrievable non pressured cores in lengths of up to 30 ft; 3) Wireline retrievable pressure coring in 11.5 ft core lengths at in-situ pressures up to 5,500 psi; and 4) Conventional wireline logging through the bit. This coring system design has been achieved using a hybrid system of industry proven core and bit technology and current state of the art wire line hydrate pressure core equipment and techniques. Currently we expect delivery of the core system equipment in the second quarter of 2011. Figures below show the new HPTC tool under fabrication.

HPTC tool under fabrication. Top panel: latch assembly components. Bottom panel: assembled latch assembly.

(Photos courtesy of Aumann & Associates Inc.)

HPTC tool under fabrication. Top panel: ball valve components. Bottom panel: ball valve sub assembly.
(Photos courtesy of Aumann & Associates Inc.)

Core Bits:

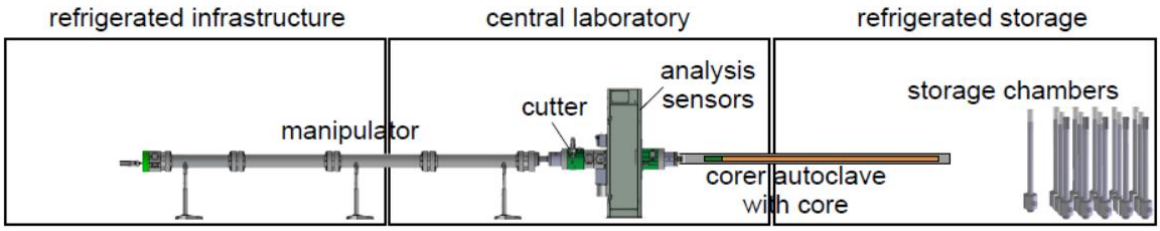
- In coordination with Aumann & Associates work has been undertaken by the Baker Hughes to design the composite bits needed for this work. The outer barrel has a bit sized to provide necessary drilling clearance. The hole in the center allows either a plug to be run for conventional drilling as shown in the lower left, or with an internal core head allowing continuous coring to be performed, as shown on the right. *(Renderings courtesy of Baker)*

Outer Core Barrel:

- The bit is designed to be attached to the outer core barrel, which will be the industry proven Baker Hughes HT 40 Coring System with minor modifications to accommodate the Aumann internal coring sub-system.

Surface Handling (PCATS):

- On surface the core is transferred under pressure to special handling unit allowing handling investigation and analysis while under pressure to preserve the hydrates. Work has been ongoing with the major vendor to update and upgrade the pressure core handling and transfer system (PCATS) to handle the higher pressure longer cores. Geotek PCATS: Status Update:
    - Modified PCATS for JIP/HPTC including increasing of pressure rating to 3.5 MPa and lengthen to handle 3.5 m pressurized cores: Work is complete with most functions tested in an offshore hydrate coring program in Korea in 2010. The PCATS is ready for interface/field test with HPTC.



Depiction of modified PCATS arrangement (three twenty-foot container units) required to handle the longer pressurized cores (above) and photos of two of those units lined up (next page).
(Image courtesy of Geotek)

USGS/Georgia Tech IPTC:

- Similar to the PCATS, the Instrumented Pressure Testing Chamber (IPTC) will require modifications to handle the longer pressure cores as well as design, fabrication and testing of various analytical devices such as a triaxial cell. An all-day meeting was held on February 10th at Georgia Tech to review interim results of the Leg III assessment and build consensus on the impacts to the IPTC modifications. Critical to the IPTC modification and analytical device design, fabrication and testing efforts will be input from the selected onshore site operator because these devices will be used in the sites under their control and responsibility and certain design standards and certifications may be required by local zoning and facility use agreements. Finalization of IPTC details is on hold pending selection of the onshore assessment site and results of the Leg III assessment.

Drill string:

- Due to the size of the coring system and diameter of the inner core barrel, the JIP decided to use a larger drilling tubular than standard 6-5/8" drill pipe. Work is ongoing to finalize the design and selection of this key component. We will utilize a pipe string which can withstand the harsh loads imposed by the ultra deep

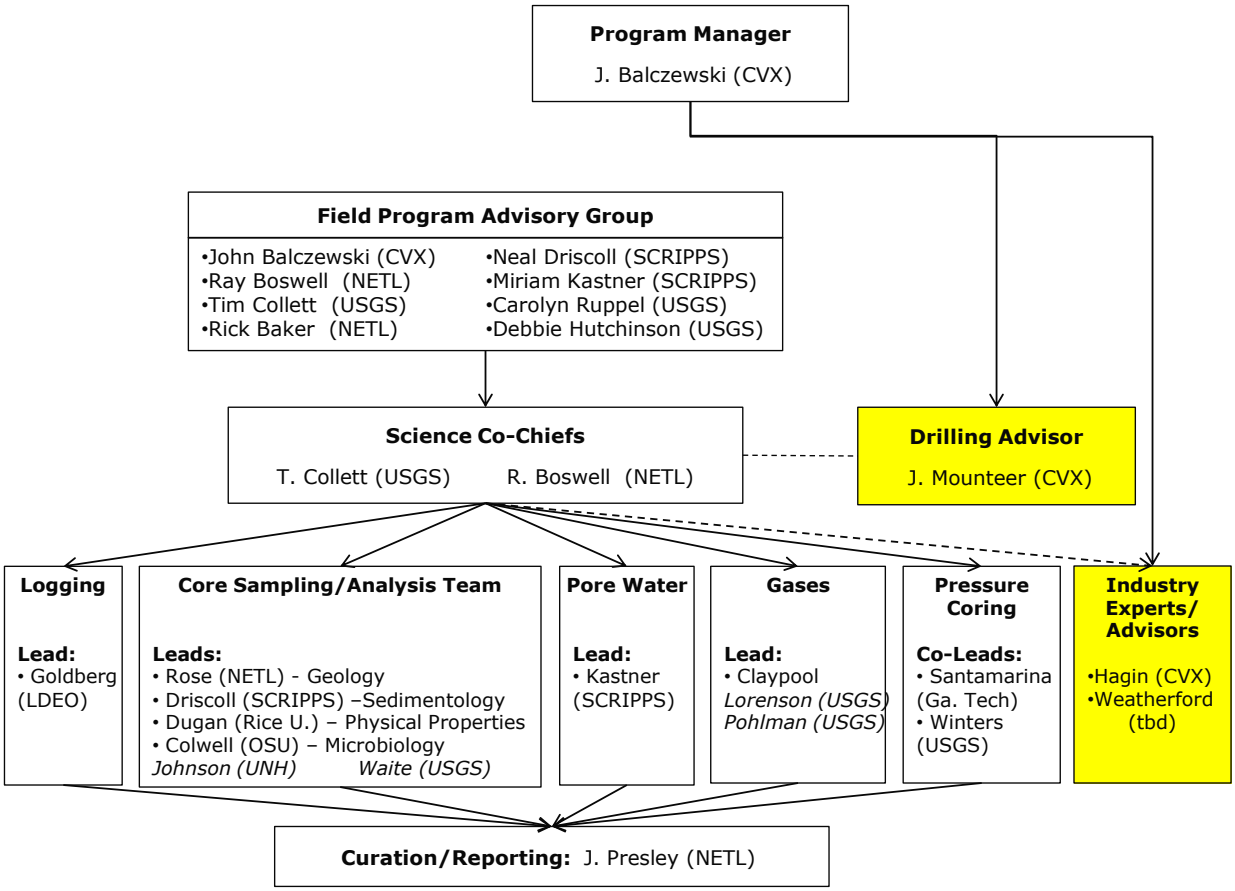
water, Gulf of Mexico environmental conditions and coring depths, while allowing it to be handled with conventional equipment found on deepwater drilling rigs.

Additional Work Underway:

- Once all downhole equipment has been completed qualified, tested and accepted for delivery, a trial run will be undertaken in a controlled test well environment. This 'dry run" will be key in ensuring proper interface between all major systems and sub systems, as well as a good test into the utility and workability of the entire pressure core system. Selection and safety review of test facilities, as well a development of the test program and protocols is underway. This work will be completed and results incorporated into final plans and revisions prior to commencement of actual offshore core operations.

Organization:

- The Leg III Science Field Organization was revised to add the benefit of industry experience and subject matter expertise on oil industry standard coring practices to critical areas related to offshore and onshore operations including pressure core retrieval, transport and analysis (refer to the diagram below). In addition to helping improve scientific results, these enhancements are also expected to increase safety and reduce risks by ensuring excellent communications between industry and scientific community members at all levels.



7.0 Conclusions

The Gulf of Mexico Drilling Moratorium and related developments have significantly impacted timing and work requirements for the Phase III B work plan, adding significantly to the time and potentially the costs for the Leg III expedition. The work progress during the moratorium shutdown has been focused on preparation of a detailed description for all work flows and equipment requirements. These will be key components in subsequent risk assessments, design, procurement and risk management processes.

Project resources have been redirected toward a review of all plans and development of alternative proposals to minimize the risk in terms of safety and protection of the environment while preserving best cost efficiency possible in the current Gulf of Mexico offshore operating environment.

It is anticipated that by the end of the next reporting cycle, the JIP will have a detailed plan and firm timing for the completion of this phase of the hydrates coring program.

8.0 References

No external references were used for this report.

9.0 Appendix A – Project Timeline

Notional Plan Leg III

	2010	2011				2012				2013			
	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
Pressure Corer Development Program													
Pressure Corer/BHA- Final Design	X												
Pressure Corer/BHA- Fabrication	XX	XXX	X??										
Pressure Corer/BHA- Onshore Drilling Test				(drilling test requirements and schedule tbd*)									
Pressure Corer/BHA- Post-test Adjustments					tbd*								
Pressure Corer/BHA- Deployment								tbd*					
Pressure Corer/BHA- Demob / Refurbish									tbd*				
Pressure Corer - Inventory & DOE Turnover												tbd*	
Onshore Drilling Test Program													
Test Site Assess, Inspect				(drilling test requirements and schedule tbd*)									
Test Site Award													
Test Preparation (HSE, Technical)													
Onshore Drilling Test													
Pressure Core Laboratory Tools Program													
Design	XX	XXX											
Fabrication			tbd*										
Calibration				tbd*									
Mock Field Trial					tbd*								
Deployment								tbd*					
Demob / Refurbish									tbd*				
Inventory and DOE Turnover												tbd*	
PCATS Deployment													
Onshore Test				(requirements and schedule tbd*)									
Leg III								tbd*					
Leg III Offshore Drilling Program													
Drilling Assessment Study	XXX	XXX	XXX										
Drill Rig Tender, Inspect, Award				tbd*									
Drilling Permit Applications					tbd*								
Pre-spud Safety Meeting							tbd*						
Leg III Expedition (~16 days incl mob/demob)								tbd*					
Science Program													
Program Development and Management	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
Science Team Meeting - Finalize Science Plan				tbd*									
Science Team Deployment								tbd*					
Post-cruise Studies									tbd*	tbd*			
Reporting													
Leg III Initial Results Workshop										tbd*			
Leg III Initial Results Publication											tbd*		
Leg I-III Final Reports												tbd*	
DOE/JIP Project Close-out												tbd*	
*tbd pending results of the Chevron drilling assessment													

Notional Schedule is contingent on Gulf of Mexico offshore drilling legislative, regulatory and commercial impacts and the Chevron drilling assessment.

National Energy Technology Laboratory

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880

One West Third Street, Suite 1400
Tulsa, OK 74103-3519

1450 Queen Avenue SW
Albany, OR 97321-2198

2175 University Ave. South
Suite 201
Fairbanks, AK 99709

Visit the NETL website at:
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1-800-553-7681