Gulf of Mexico Gas Hydrate Joint Industry Project Leg II:
Green Canyon 781 Site Selection

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Introduction

The Gulf of Mexico Gas Hydrates Joint Industry Project (JIP) was formed to conduct scientific analyses of gas hydrate deposits in the Gulf of Mexico to better understand their hazard to conventional drilling and their resource potential. When the logging-while-drilling (LWD) program was delayed in summer, 2008, until spring, 2009, the JIP site selection team decided to use the additional available time to consider other potential drilling sites in the northern Gulf of Mexico. The Green Canyon 781 site was chosen in October, 2008, after considering ~30 sites proposed by the Minerals Management Service (MMS) as part of their on-going geological and geophysical analyses in the Gulf of Mexico related to the MMS gas hydrate assessment. This site is located close to and on the landward side of the Sigsbee Escarpment (Figures F1A and F1B). The preliminary geological indicators that made this site favorable were a laterally discontinuous, but bright reflection in the middle of an otherwise interpreted muddy section, indications of phase reversal as this reflection crossed the inferred base of gas hydrate stability (BGHS), a nearby well (GC737 #001, Table T1) that penetrated deeper gas, proximity to the producing deep-water Mad Dog prospect, and a possible tie of the bright reflection to an inferred sand unit in the well, although the inferred sand was thin and pinching out at the well location.

Although the GC 781 site has many geological similarities to the other sites considered for gas-hydrate drilling (Walker Ridge 313 and Green Canyon 955, Figure F1A), it was ranked in priority below the WR 313 and GC 955 sites. The site selection team recommended against full seismic inversions of the data for quantitative gas-hydrate saturation measurements. Unlike the other sites, where multiple analyses of the data prior to target selection were completed by participants in the site selection team (e.g., independent well log analysis by U.S. Geological Survey (USGS) seismic data inversion by Western Geco, and geologic interpretation by MMS), the targets in this site were chosen based primarily on the geological interpretation and amplitude analysis of the original seismic data. AOA Geophysics, Inc. subsequently performed an inversion of the data for gas hydrate occurrence while preparing the hazards report.

This report summarizes the geologic framework of the GC 781 site and the information about the four selected drilling targets (Figure F2). These targets were chosen to test a geological model for which the only compelling interpretation is gas hydrate near the base of the gas hydrate stability zone in a coarse-grained unit. The four drilling targets are in the vicinity of a sea-floor fault scarp, at locations free from indications of free gas on the seismic

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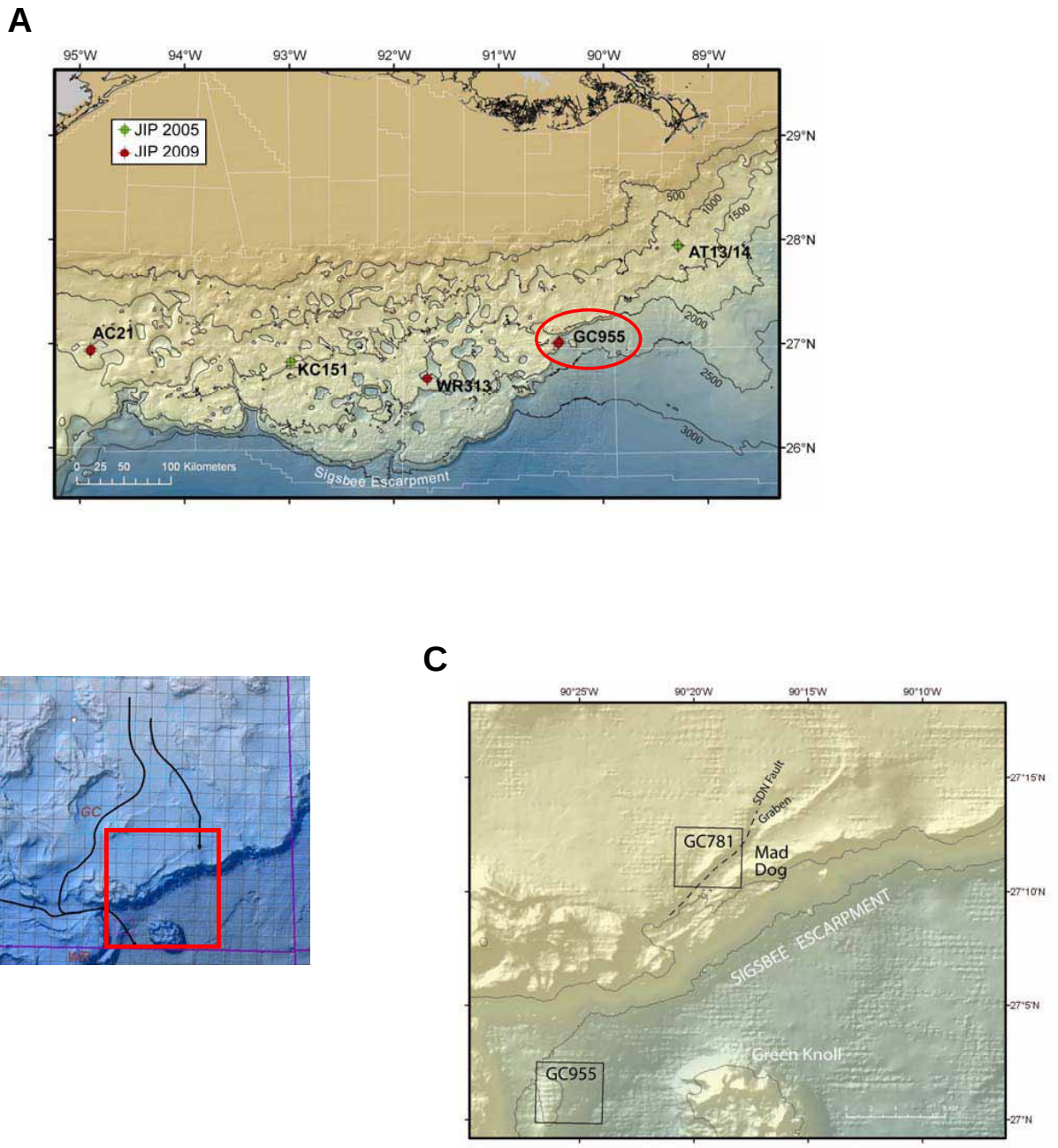

Figure F1: *(A) Location map of the northern Gulf of Mexico showing the proposed 2009 JIP sites (red) and 2005 JIP drilling locations (green). Red oval surrounds location of GC 955. (B) Map of the Green Canyon protraction area showing Green Canyon drainage. Box outlined in red shows location of enlargement shown in B. (Source: AOA ppt, March 27, 2008). (C) Location map of the GC 781 area using NOAA Coastal Relief Model shaded relief bathymetry. SDN: Seaward Dipping Normal fault through the GC 781 lease block (it is also associated with a bathymetric scarp). Mad Dog: Location of the hydrocarbon production system known as Mad Dog.*

Lease Block No.	GC737
Well Name	GC737#1
Water Depth (ft)	4415
Base of gas hydrate stability	Not identified
Seafloor to base of gas hydrate stability	Not identified
Thermal gradient (mK/m)	Not estimated
Target Facies sampled at the well	Ponded sheet sands, levee, and overbank deposits

Table T1: GC 737 #001 well information

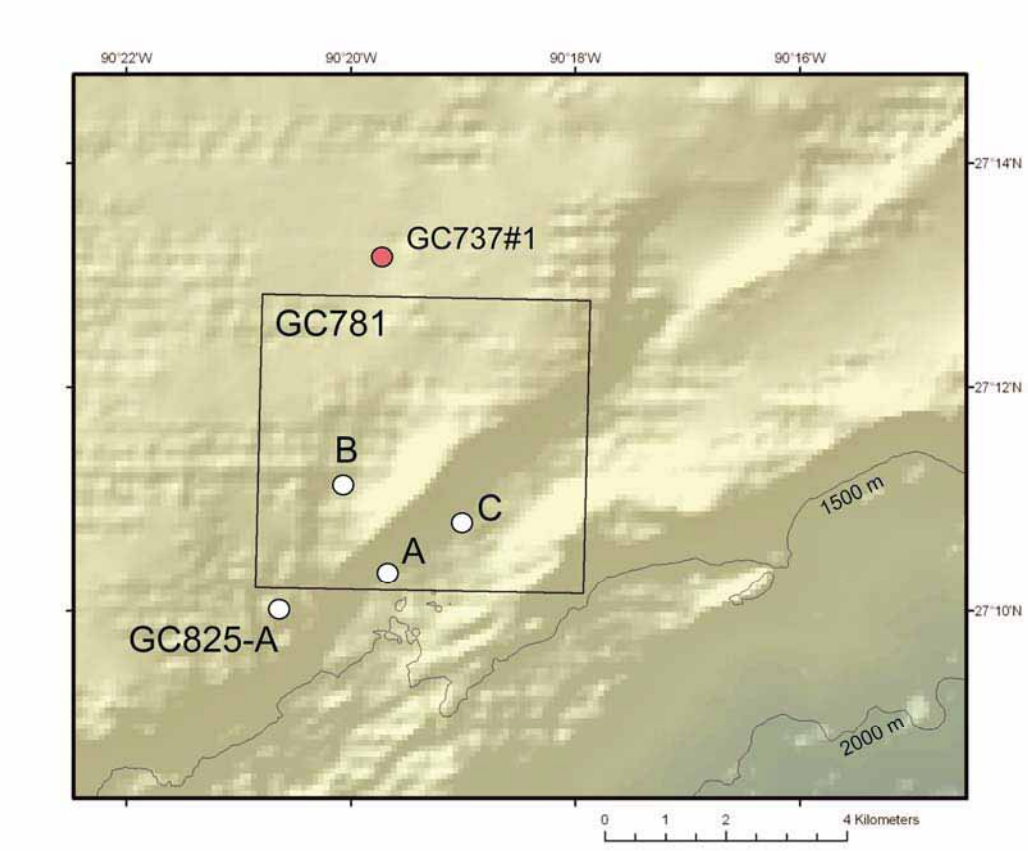

Figure F2: *Permitted locations in GC 781 and GC 825 together with location of GC 737 #001 well. Sites GC 781-A and GC 781-C are on the hanging wall of SDN fault (shown by the shaded escarpment that crosses block GC781 from southwest to northeast) and below its associated escarpment. GC 781-B and GC 825-A are both on the foot wall and above the escarpment associated with the fault.*

data. One of the four targets is in lease block GC 825 south of GC 781. For simplicity in terminology, this target is assumed to be included in references to GC 781 unless explicitly stated otherwise. One of the other 2009 JIP proposed drilling sites, GC 955, is about four lease blocks to the south, southwest of GC 781.

Geologic Setting

The GC 781 site is on the landward edge of the Sigsbee Escarpment (Figure F1). Salt underlying the region is both shallow and intact and controls the morphology and structure of the nearby Sigsbee Escarpment (Peel *et al*., 1995). At this location, the Sigsbee Escarpment has about 750 m (2500 ft) relief (Nibbelink, 1999). GC 781 lies near the western end of the deepwater Mississippi fan-fold belt, which is a buried set of basinward-verging anticlines associated with thrust faults representing a short period of contraction that ended by Late Miocene time (Hall, 2002).

The adjacent lease block to the east (GC 782) contains development of the Mad Dog petroleum field (Figure F1B), which produces subsalt oil and gas from a multiple well system (Offshore, 2009). Proximity to the Mad Dog field gives some added confidence in the interpretation of adequate gas charge to form gas hydrate at GC 781.

The most prominent feature in the seafloor at GC 781 is a large escarpment associated with a seaward-dipping normal feature that trends northeast (labeled SDN fault, Figure F1B). Relief on this fault is large, about .18 ms (440 ft; 135 m), indicating relatively recent fault movement. At its northeast extension, this fault merges into a sea-floor graben structure subparallel to the Sigsbee Escarpment (Orange *et al*., 2004). The change from a fault structure to a graben structure coincides with the southwest limit of a diapir-cored ridge, indicating the importance of salt in controlling local structure and morphology (Orange *et al*., 2004). High-resolution bathymetric maps of the Sigsbee Escarpment show prominent slumping and toe thrusts along the Sigsbee Escarpment (Orange *et al*., 2004).

As in the WR 313 site, the GC 781 site has a series of steeply dipping sub-parallel reflections that cross the base of gas hydrate stability (BGHS). This site is also similar to WR 313 in that the minibasin structure results from both salt withdrawal and ponding of sediment behind the topographically uplifted rim of the Sigsbee Escarpment. This interpretation, like that of WR 313, is consistent with the occurrence of sheet sand deposition in the minibasin (Nibbelink, 1999).

The GC 781 site differs from WR 313, however, in that the controlling salt flow is outward towards the Sigsbee Escarpment, resulting in extensional structures within the basin (Nibbelink, 1999). Interactions amongst salt movement and sedimentation result in over steepening of the Sigsbeen escarpment, slumping, faulting, and extension, resulting in many of the features seen in the seismic data (Figure F3).

Three marker horizons have been mapped at GC 781 (Figure F3, Horizons A, B, and C). Based on seismic character, the gas hydrate targets are interpreted as sand-prone deposits yielding peak positive amplitudes. The positive anomalies occur between and near horizons B and C. Coarse-grained deposits are associated with horizons B and C and the intervening Unit 3 based on well correlation to GC 737 #001. An amoeboid shaped zone of high attenuation can be mapped in the hanging wall of the SDN fault at the site of GC 825-A, and is attributed to highly fractured sediments. Sediments near the sea floor are interpreted as normal marine clays containing mass movement deposits that have acted as a potential seal for gas migration.

Anomalously-terminated high amplitude events provide an indication of the position of the BGHS and the presence of free gas trapped by overlying gas hydrate. Phase reversals across the inferred BGHS are further indications of gas hydrate occurrence. At the nearby GC 737 #001 well, gas occurred at 10,520 ft, and sand occurred below 10,040 ft. These sands would be downdip of the units interpreted at the GC 781 site.

The GC 781 site is interpreted to have the components of a petroleum system: potential coarse grained reservoir (sands), and indicators of source/charge (high amplitudes and gas in nearby lease blocks).

Pressure-Temperature Conditions

The BGHS is interpreted to be nearly 0.4 s below the seafloor, or very deep compared to the other sites considered for JIP drilling. Consequently, the estimated thermal gradients from the seafloor to BGHS are generally low. Pressure-temperature conditions at the proposed drill holes are summarized in Table T2. The high gradient value for GC 781-A remains anomalous. If BGHS were closer to ~2700

JIP	SF (ft)	BGHS (ft) relative to seafloor	SF-BGHS (ft)	P[1] (MPa)	T_{eq} (ºC) at BGHS[2]	dT/dz (ºC/km) for BWT=2 ºC	dT/dz (ºC/km) for BWT=4 ºC
GC781-A	4841	6619	1778	20.3	18.1	31.4	35.8
GC781-B	4501	6683	2182	20.5	18.2	20.1	22.9
GC781-C	4763	6664	1901	20.4	18.1	23.6	26.9
GC825-A	4563	6733	2170	20.6	18.2	22.1	25.2

Table T2: *Estimated Pressure-Temperature Conditions for proposed drill holes at GC 781. (SF=Seafloor, BGHS=Base of gas hydrate stability, P=Pressure, T_{eq}= equilibrium temperature, dT/dZ=temperature gradient, BWT=bottom water temperature) [1] Hydrostatic pressure calculated at the BGHS. [2] Calculated using 3.3% NaCl pore waters and methane-only gas hydrate.*

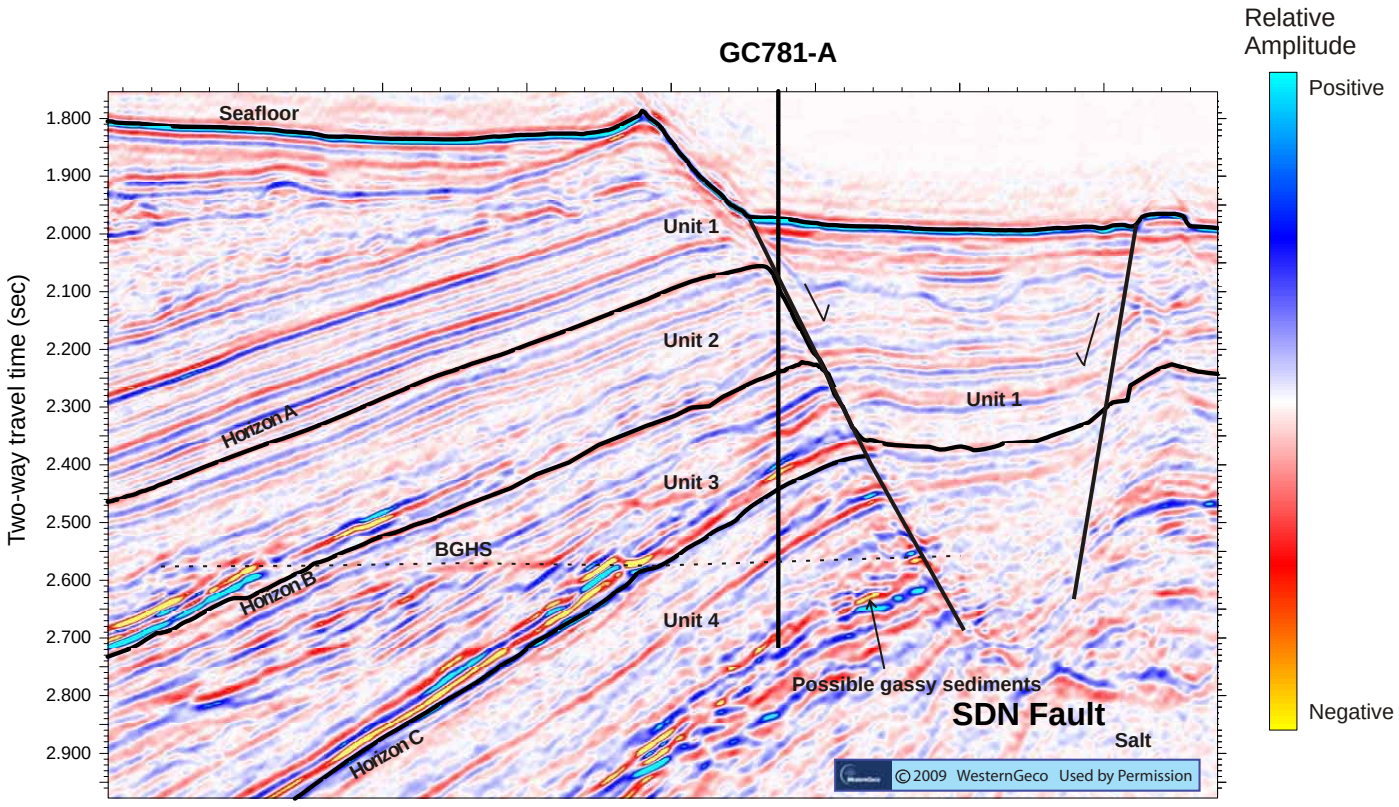

Figure F3: *Interpretation of horizons A, B, and C, and units 1, 2, and 3 in the vicinity of proposed drill hole GC 781-A on the hanging wall of SDN fault. BGHS is shown by dotted line. Seismic image provided by WesternGeco.*

m (Figure F3), where there are a series of bright reflections and a possible phase reversal, then the gradient would be lower and more consistent with the other estimated values for the site.

Gas Hydrate Saturation

Gas hydrate saturations were estimated from seismic data using the methodology of Dai *et al*. (2008a). The five-step process utilizes seismic reprocessing for highest possible resolution, detailed geological (lithological) interpretation to identify possible gas hydrate-bearing zones, seismic attribute analysis to refine the extent of the gas-hydrate-bearing zones, seismic inversion to estimate elastic parameters in the gas-hydrate-bearing zones, and quantifying gas hydrate saturation using elastic parameters and rock physics models. Gas hydrate saturation (S_{gh}) is given as a percent of pore volume. This model was used to predict S_{gh} at two sites drilled for gas hydrates in the Gulf of Mexico by the JIP in 2005, with encouraging success (Dai *et al*., 2008b).

Drilling Targets

Drilling is expected to penetrate the three mapped stratigraphic units (horizons A, B, and C), the SDN fault, and the zone of low reflectivity. Unit 3, which is between horizons B and C, contains interpreted sand-prone deposits inferred to have high or moderate saturations of gas hydrate. The four sites were chosen to avoid the escarpment associated with the SDN fault and have two locations each above and below the escarpment:

- Above the escarpment: GC 781-B and GC 825-A
- Below the escarpment: GC 781-A and GC 781-C

Consensus recommendation: The site selection group felt that the size of the amplitude and inversion anomalies together with the phase reversals gave us greatest confidence on the hanging wall hole in GC 781-A, although the lower overpressure concerns make the foot wall hole (GC 781-B) very attractive and similar. In addition to testing prospective amplitude anomalies near the BGHS, the hole proposed for GC 825-A would sample a wipe-out anomaly that has no obvious explanation and could be associated with slumping, shallow water flow, or the occurrence of gas hydrate. With these ideas, the consensus targets to drill are summarized in Table T3.

Drill Site (permit name)	Comment
GC781-A	Consensus #1
GC781-B	Similar to GC781-A, but less risk.
GC825-A	Preferred over GC781-C

Table T3: *Recommendations for site GC 781.*

The proposed holes fulfill JIP objectives of (a) expecting to find high saturation gas hydrate for future coring; and (b) testing the petroleum system of hydrate formation. The GC 781 site does not have quantitative gas-hydrate saturation predictions from Schlumberger, but the data have been inverted for impedance contrast. In as much as impedance contrast can be used as an indicator of higher gas hydrate saturations, then this location will test predictions of gas-hydrate saturation from seismic interpretations. Details about each of the holes are given in Appendix 1.

Concerns about GC 781

The three primary concerns about the GC 781 site are (1) finding a flat sea floor around the drill holes, avoiding chemosynthetic communities that may be on the seafloor near the SDN fault (suggested by enhanced seafloor reflection amplitudes mapped using three-dimensional seismic data), and (3) avoiding zones of possible overpressure.

Because this site and proposed holes have not been discussed within the site selection group as thoroughly as the GC 955 and WR 313 sites, the site selection group has focused on the geology, faulting, potential overpressured shallow-water flow and other features (e.g., amplitudes) of interest and relevance.

The four proposed holes sample two geologic settings: the hanging wall and foot wall of a large seaward dipping normal fault, although the target gas hydrate horizons would be penetrated only in the footwall. Anomalies and phase reversals are somewhat better developed on one of the two hanging wall sites (at the base of the escarpment) but these also may have the greatest risk of overpressure because of the large burial differential associated with relief along the SDN fault escarpment where the horizons extend downdip to the west. One of the foot wall sites has a sub-seafloor wipe out zone above the drilling targets. Seafloor amplitude anomalies at GC 781 could represent carbonate hardgrounds or chemosynthetic communities.

References

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Peel, F.J., Travis, C.J., and Hossack, J.R., 1995. Genetic structural provinces and salt tectonics of the Cenozoic offshore U.S. Gulf of Mexico: a preliminary analysis, in Jackson, M.P.A., Roberts, D.G., and Snelson, S., eds., Salt Tectonics: a Global Perspective: AAPG Memoir 65, p. 153-175.

Appendix 1: Site and Target Summaries

The following pages provide detailed summaries of each drilling target with four tables of factual information and four figures (tophole prognosis chart [from MMS permitting], map showing the existing well and proposed targets, inline seismic section and crossline seismic section).

Explanation of Terms:

Site Name	the name used during permitting (generally GC 781-letter) and the name developed during the site selection process (generally JIP-name)
NAD27	datum used for latitude/longitude values (North America Datum 1927)
BSS	below sea surface
BML	below mud line
TGHO	top of gas hydrate occurrence
BGHS	base of gas hydrate stability
BSR	bottom simulating reflection

Target GC781-A
Drilling Target Documentation

Table 1: Background Information

General Site Objective	*Sand prone sediments in a minibasin with gas charge below GHSZ*
Drilling target and Specific Hole Objective	*Primary target is a strong peak-trough amplitude at 1317 ft BML (6158 ft BSS, 2408 ms), mapped as turquoise unit by MMS. Secondary target is a shallower, smaller peak-trough amplitude (1040 ft BML, 5881 ft BSS). Good phase reversal at BGHS.*
Other Drilling in Vicinity	GC737#1

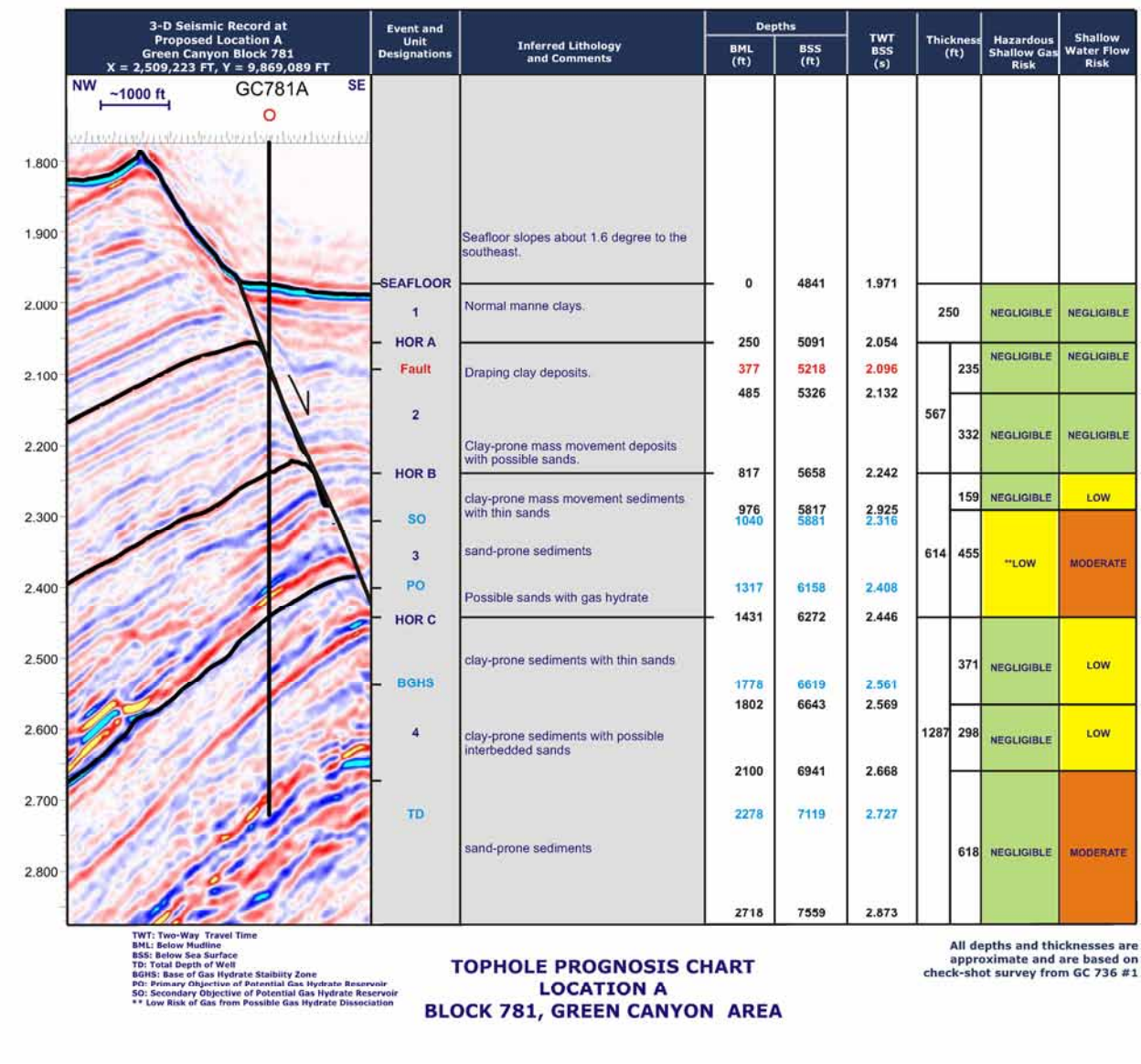
Table 2: Proposed Hole General Information

Site Name	GC781-A JIP
General Area	*Minibasin is north of Green Canyon, just upslope from the Sigsbee escarpment; Top of salt is rising towards the Sigsbee beneath the target horizons; clear phase reversal exists at BGHS*
Location	Latitude: *27.17168071 ^{o}N* Longitude: *-90.32747323 ^{o}W*
Coordinate Datum	*NAD27*
Water Depth	*4841 ft BSS (1971 ms)*
OPD/Lease Block	*GC781*
Seismic lines at hole	*Inline 6252, 4115 crossline (Seismic survey L96_057A)*

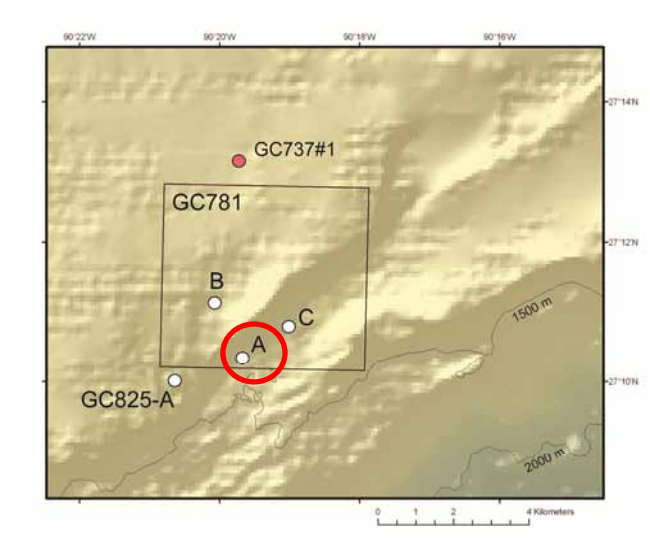
Table 3: Proposed Hole Drilling Information

Proposed penetration	*2278 BML 7119 ft BSS*
Seafloor slope	
Expected lithologies and thicknesses	*1040 ft – sea floor to secondary objective (modern muds??)* *277 ft secondary target to primary target (muds and sand-prone sediments)* *461 ft – primary target to base GH stability (muds and sand-prone sediments)* *500 ft – base GHS to base of hole*
Expected ages/section	*PlioPleistocene*
Estimated depth to TGHO	*1040 ft BML 5881 ft BSS (2316 ms) assumed at secondary target*
Estimated depth to BGHZ	*1778 ft BML 6619 ft BSS (2561 ms)*
Estimated GH interval	*738 ft thick*
Estimated GH saturation	
Anomalous conditions?	*Primary target is a gas sand horizon traced from GC737#1; hole penetrates a fault trace at 377 ft BML (5218 ft BSS, 2096 ms); large normal fault truncates the minibasin seds; it forms a scarp at the seafloor dipping towards the Sigsbee Escarpment; sea floor seeps can be identified along strike at the base of the fault scarp*
Other relevant information	*Drill hole is at foot of the fault scarp*
Source of Information	*AOA Tophole Chart from ppt dated 2/25/09*

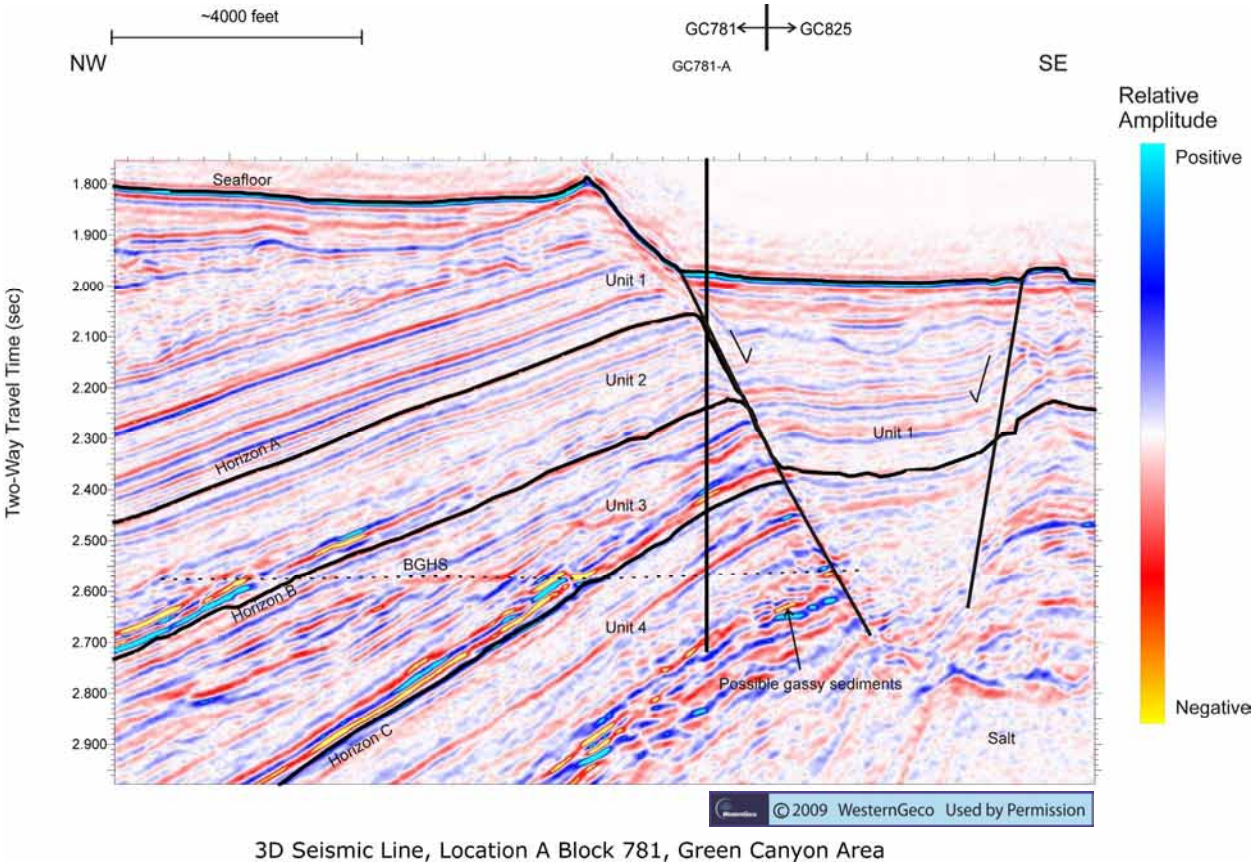
BML: Below Mud Line TGHO: Top of Gas Hydrate Occurrence
BSS: Below Sea Surface BGHZ: Base of Gas Hydrate stability Zone
Depth estimates: based on AOA analysis of check shot survey in GC737#1.



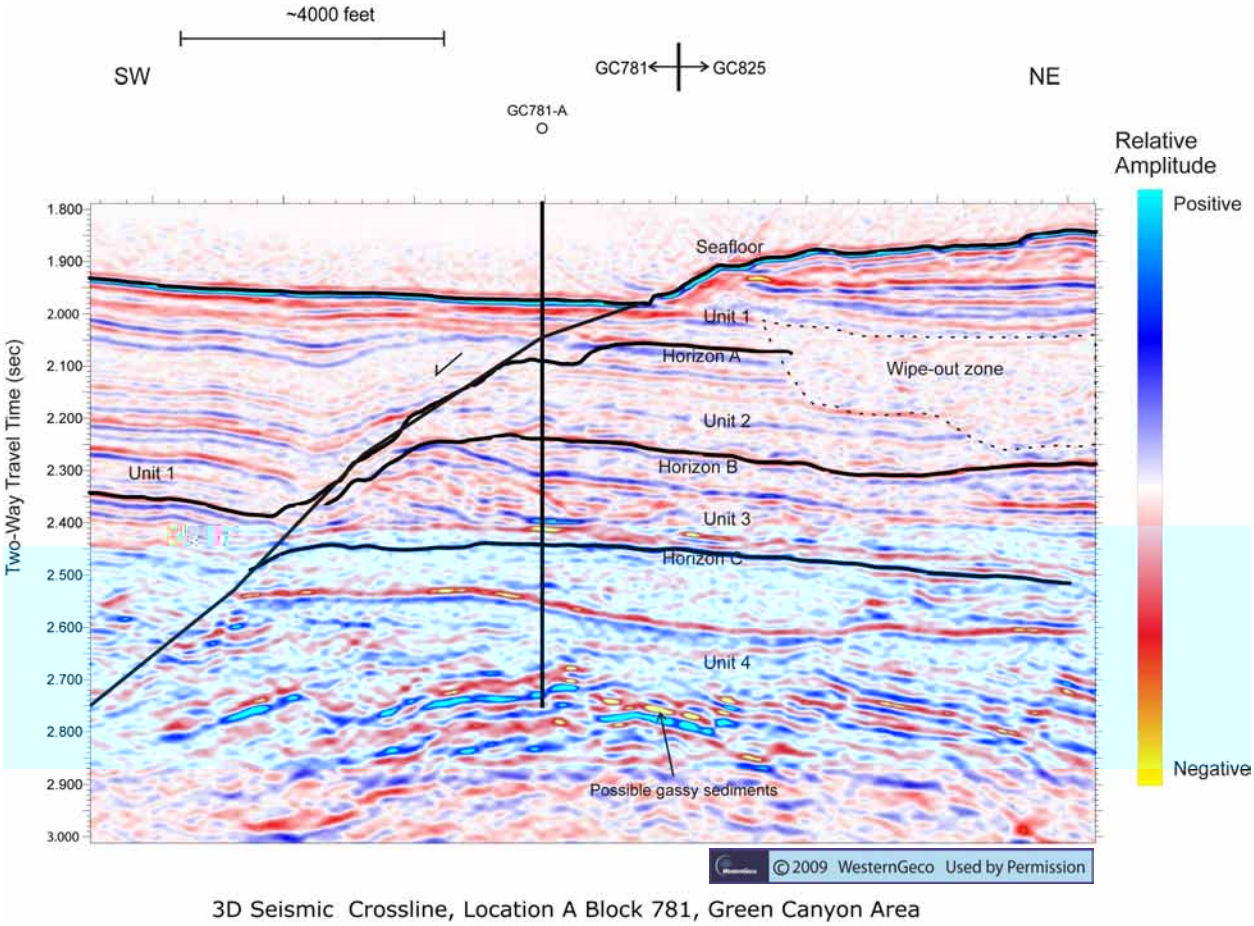
Appendix F1: *Stratigraphic interpretation, from AOA Geophysics; Seismic image provided by WesternGeco.*



Appendix F2: *Map showing location of proposed site GC781-A.*



Appendix F3: *Inline seismic profile across GC781-A. Seismic image courtesy of WesternGeco.*



Appendix F4: *Crossline seismic profile across GC781-A. Seismic image courtesy of WesternGeco.*

Target GC781-B
Drilling Target Documentation

Table 1: Background Information

General Site Objective	*Sand prone sediments in a minibasin with gas charge below GHSZ*
Drilling target and Specific Hole Objective	*Primary target is a strong peak-trough amplitude at 2069 ft BML (6577 ft BSS, 2483 ms), mapped as turquoise unit by MMS. Good phase reversal at BGHS.*
Other Drilling in Vicinity	GC737#1

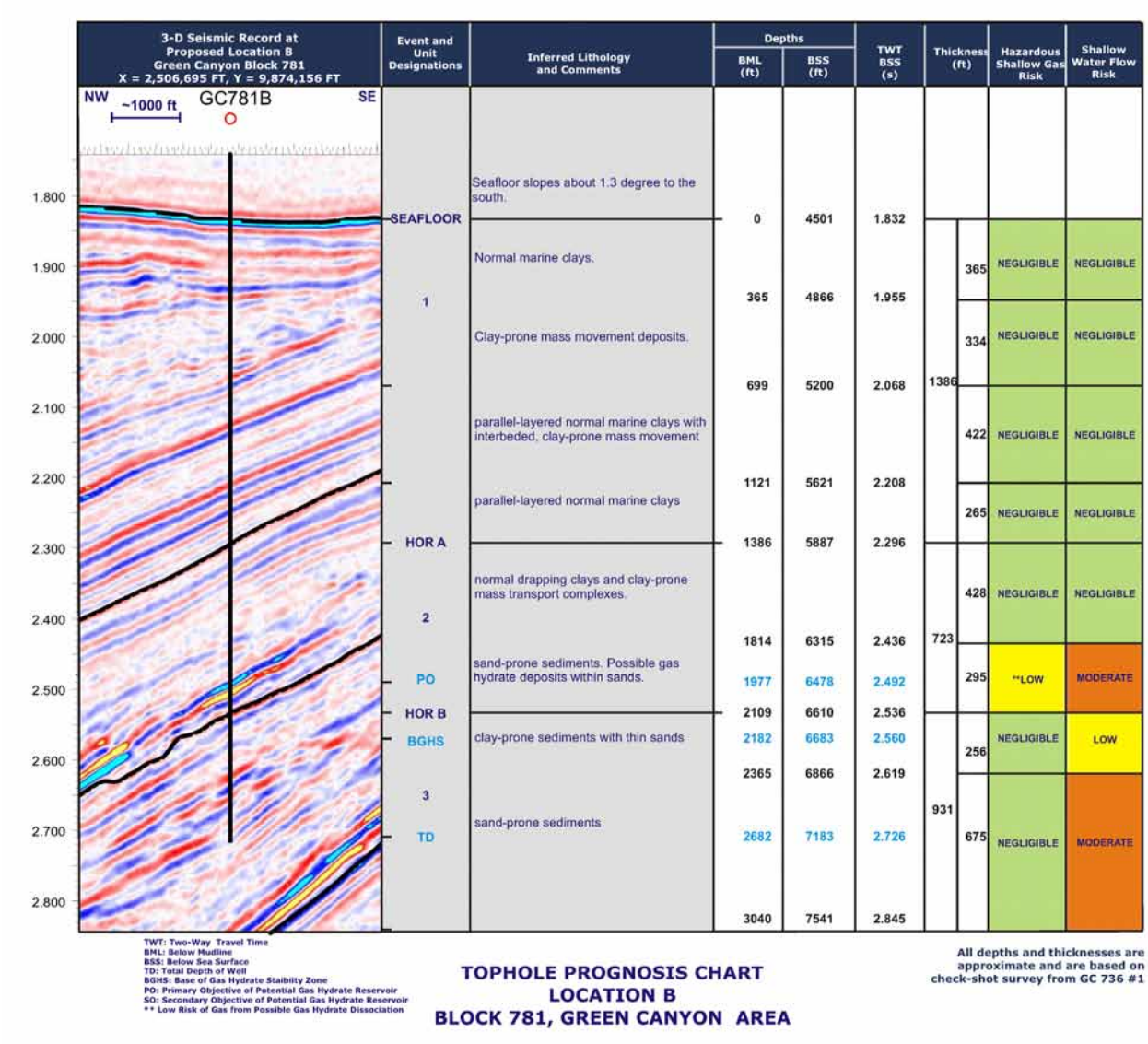
Table 2: Proposed Hole General Information

Site Name	GC781-B JIP
General Area	*Minibasin is north of Green Canyon, just upslope from the Sigsbee escarpment; Top of salt is rising towards the Sigsbee beneath the target horizons; clear phase reversal exists at BGHS*
Location	Latitude: 27.18575768 ^{o}N Longitude: *90.33491166* ^{o}W
Coordinate Datum	*NAD27*
Water Depth	*4501 ft BSS (1832 ms)*
OPD/Lease Block	*GC781*
Seismic lines at hole	*Inline 6255, 4253 crossline (Seismic survey L96_057A)*

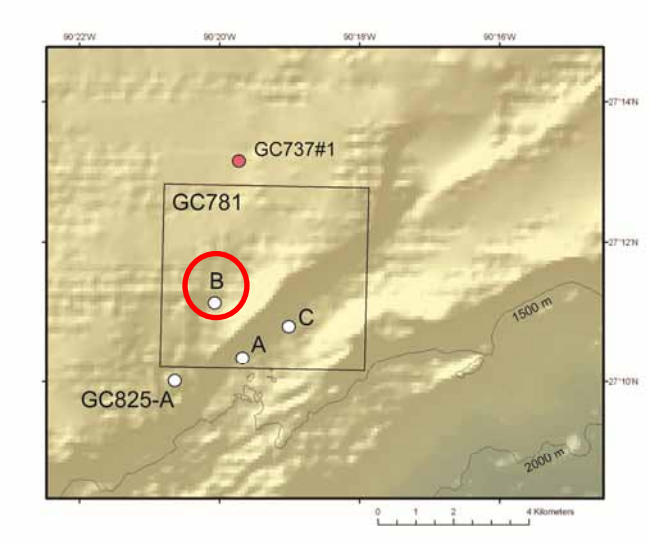
Table 3: Proposed Hole Drilling Information

Proposed penetration	*2682 BML 7183 ft BSS*
Seafloor slope	
Expected lithologies and thicknesses	*1977 ft – sea floor to primary objective (modern muds??)* *205 ft – primary target to base GH stability (muds and sand-prone sediments)* *500 ft – base GHS to base of hole*
Expected ages/section	*PlioPleistocene*
Estimated depth to TGHO	*Not given*
Estimated depth to BGHZ	*2182 ft BML 6683 ft BSS (2580 ms)*
Estimated GH interval	*>205 ft (primary object – BGHS)*
Estimated GH saturation	
Anomalous conditions?	*Primary target is a gas sand horizon traced from GC737#1; large normal fault truncates the minibasin seds; it forms a scarp at the seafloor dipping towards the Sigsbee Escarpment; sea floor seeps can be identified along strike at the base of the fault scarp*
Other relevant information	*Drill hole is at top of the fault scarp*
Source of Information	*AOA Tophole Chart from ppt dated 2/25/09*

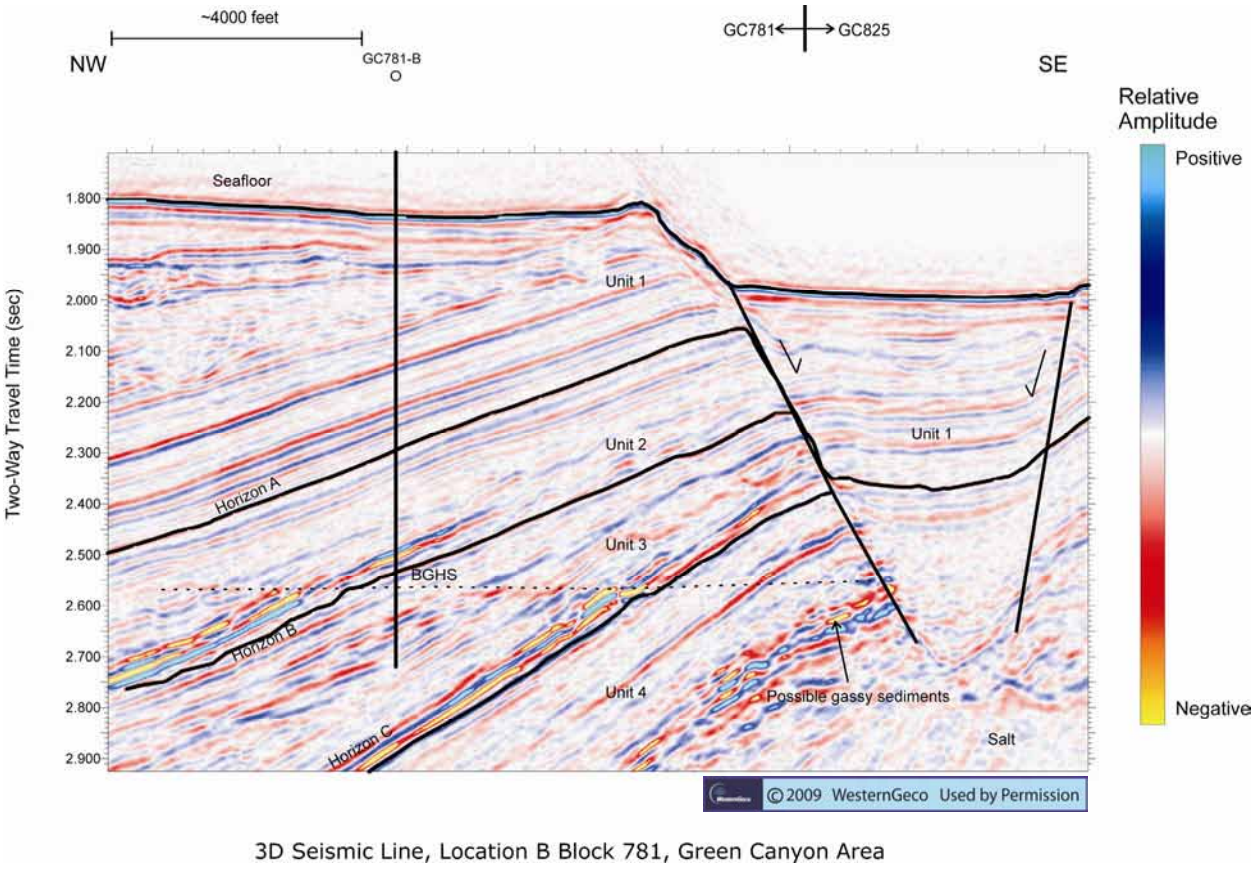
BML: Below Mud Line TGHO: Top of Gas Hydrate Occurrence
BSS: Below Sea Surface BGHZ: Base of Gas Hydrate stability Zone
Depth estimates: based on AOA analysis of check shot survey in GC737#1.



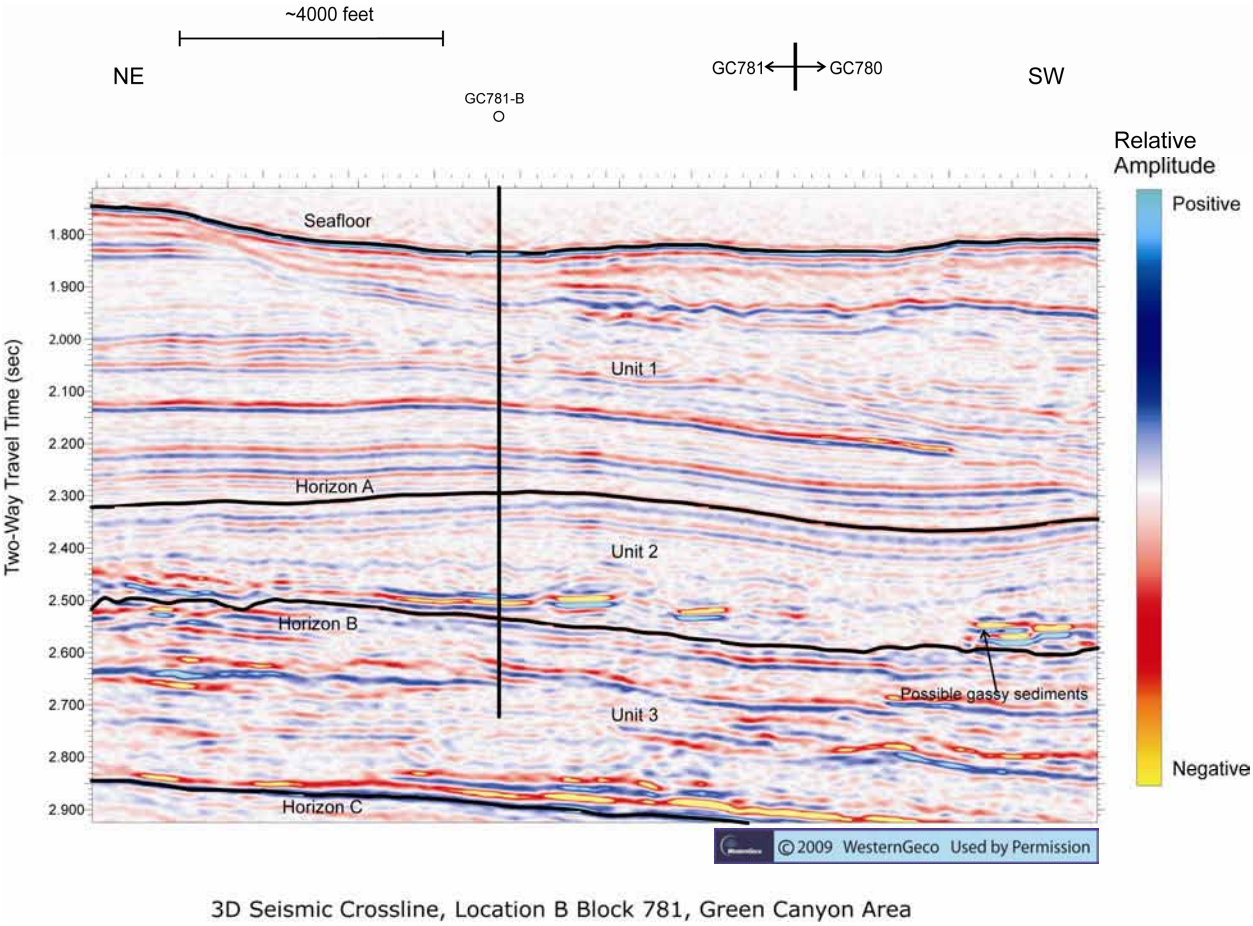
Appendix F5: *Stratigraphic interpretation, from AOA Geophysics; Seismic image provided by WesternGeco.*



Appendix F6: *Map showing location of proposed site GC781-B.*



Appendix F7: *Inline seismic profile across GC781-B. Seismic image courtesy of WesternGeco.*



Appendix F8: *Crossline seismic profile across GC781-B. Seismic image courtesy of WesternGeco.*

Target GC781-C
Drilling Target Documentation

Table 1: Background Information

General Site Objective	*Sand prone sediments in a minibasin with gas charge below GHSZ*
Drilling target and Specific Hole Objective	*Primary target is a strong peak-trough amplitude at 1744 ft BML (6519 ft BSS, 2491 ms), mapped as turquoise unit by MMS. Good phase reversal at BGHS.*
Other Drilling in Vicinity	GC737#1

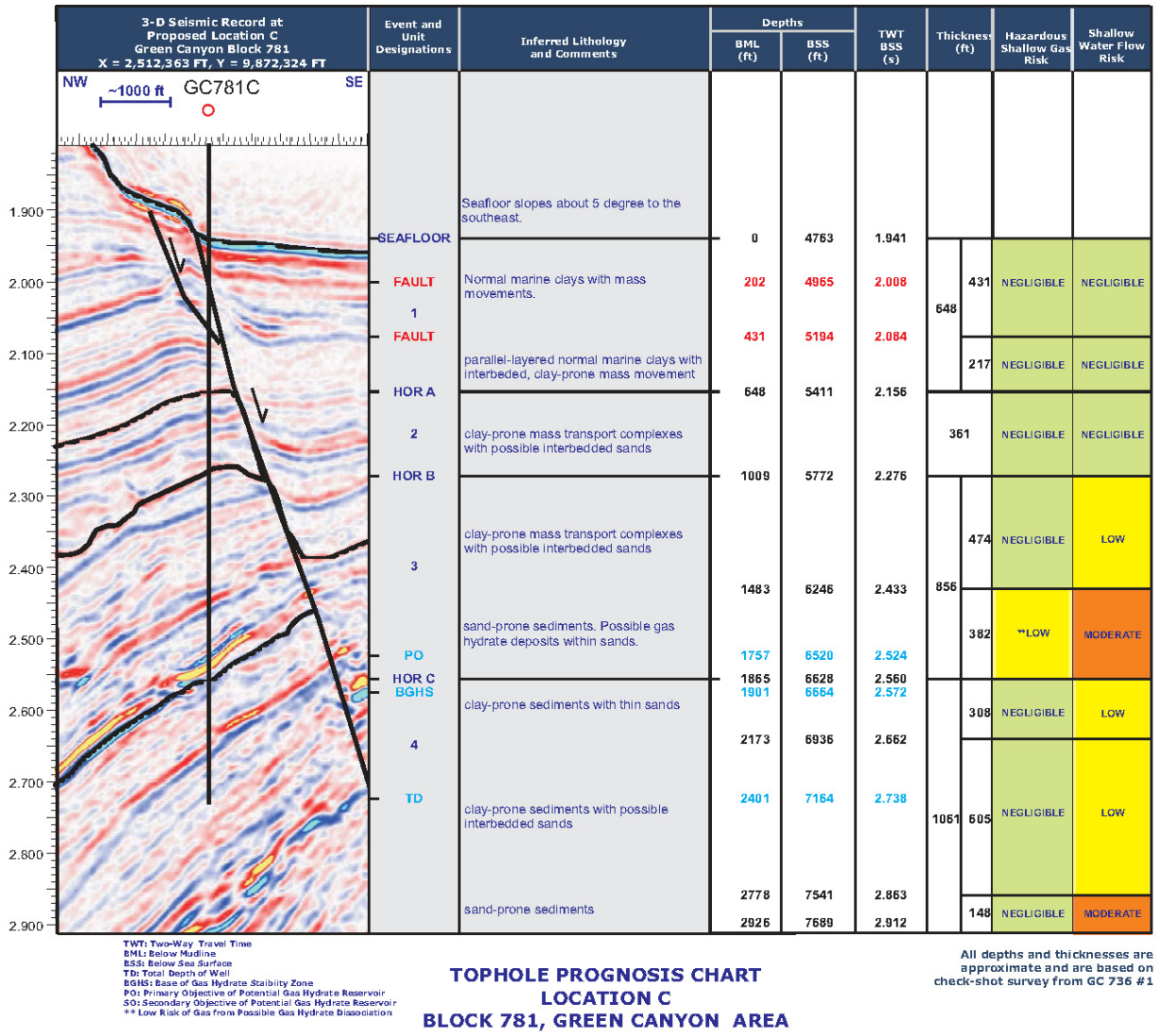
Table 2: Proposed Hole General Information

Site Name	GC781-C JIP
General Area	*Minibasin is north of Green Canyon, just upslope from the Sigsbee escarpment; Top of salt is rising towards the Sigsbee beneath the target horizons; clear phase reversal exists at BGHS*
Location	Latitude: 27.18038919 *^{o}N* Longitude: *90.31761010 ^{o}W*
Coordinate Datum	*NAD27*
Water Depth	*4763 ft BSS (1941 ms)*
OPD/Lease Block	*GC781*
Seismic lines at hole	*Inline 6188, 4155 crossline (Seismic survey L96_057A)*

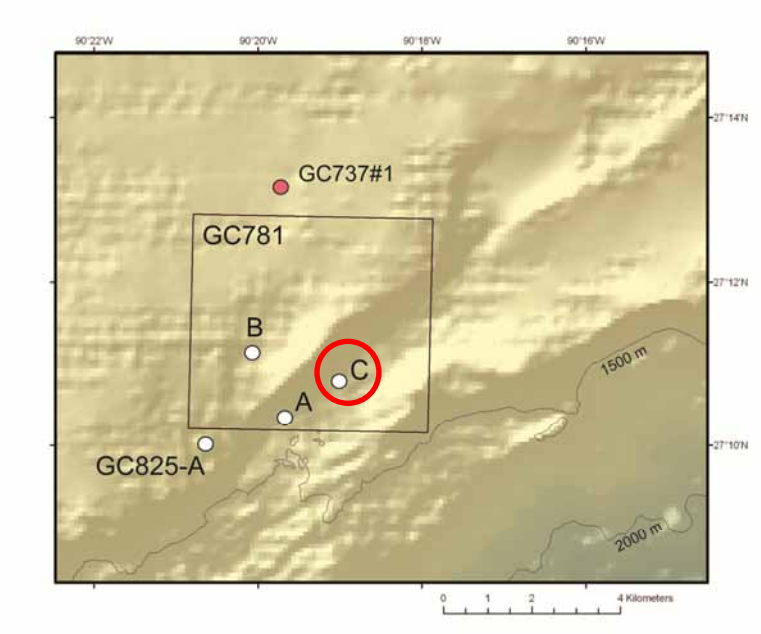
Table 3: Proposed Hole Drilling Information

Proposed penetration	*2401 BML 7164 ft BSS*
Seafloor slope	
Expected lithologies and thicknesses	*1757 ft – sea floor to primary objective (modern muds??)* *144 ft – primary target to base GH stability (muds and sand-prone sediments)* *500 ft – base GHS to base of hole*
Expected ages/section	*PlioPleistocene*
Estimated depth to TGHO	*Not given*
Estimated depth to BGHZ	*1901 ft BML 6664 ft BSS (2560 ms)*
Estimated GH interval	*>144 ft (primary object – BGHS)*
Estimated GH saturation	
Anomalous conditions?	*Primary target is a gas sand horizon traced from GC737#1; hole penetrates a fault trace at 202 ft BML, 4965 ft BSS, which truncates the minibasin seds and forms a scarp at the seafloor dipping towards the Sigsbee Escarpment; a smaller splay fault occurs at 431 ft BML, 5194 ft BSS; sea floor seeps can be identified along strike at the base of the fault scarp*
Other relevant information	*Drill hole is on foot-wall block (i.e., area at foot of the fault scarp);*
Source of Information	*AOA Tophole Chart from ppt dated 2/25/09*

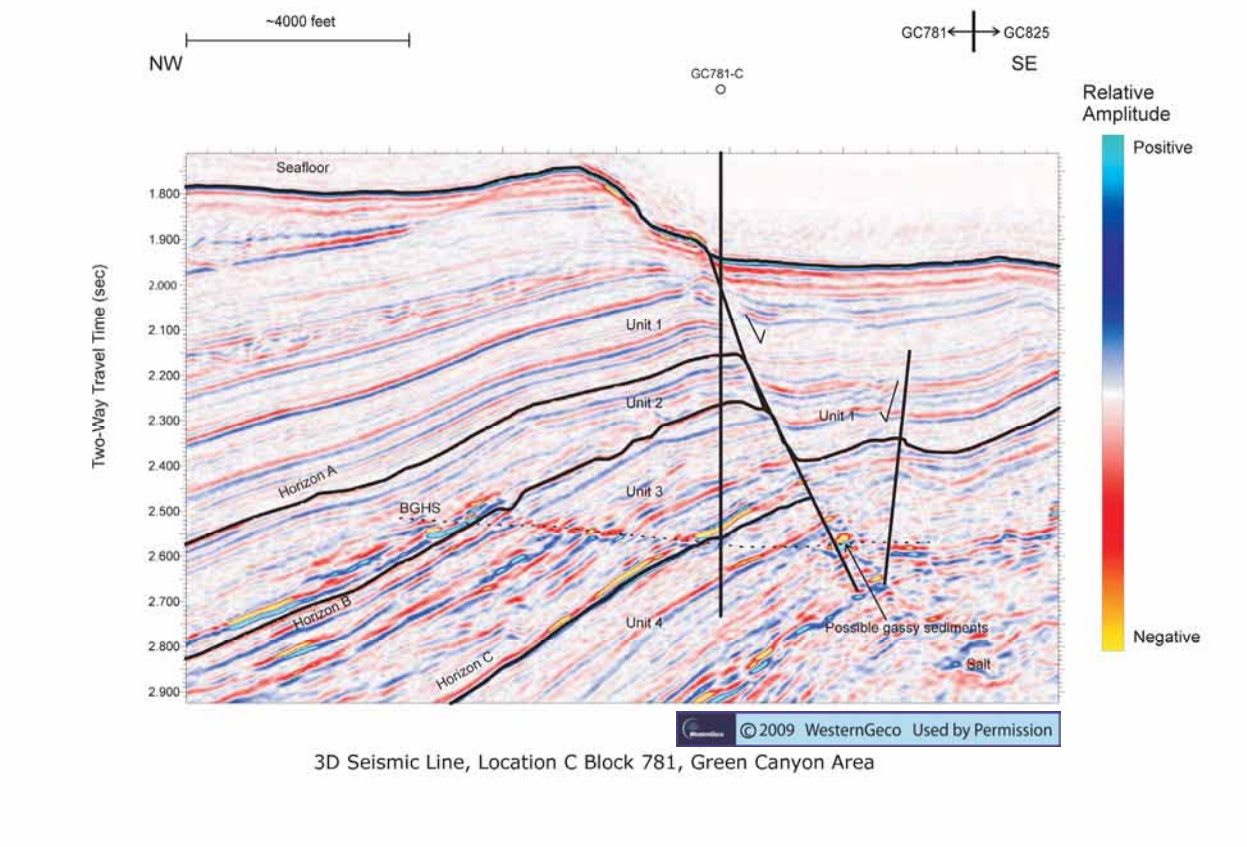
BML: Below Mud Line TGHO: Top of Gas Hydrate Occurrence
BSS: Below Sea Surface BGHZ: Base of Gas Hydrate stability Zone
Depth estimates: based on AOA analysis of check shot survey in GC737#1.



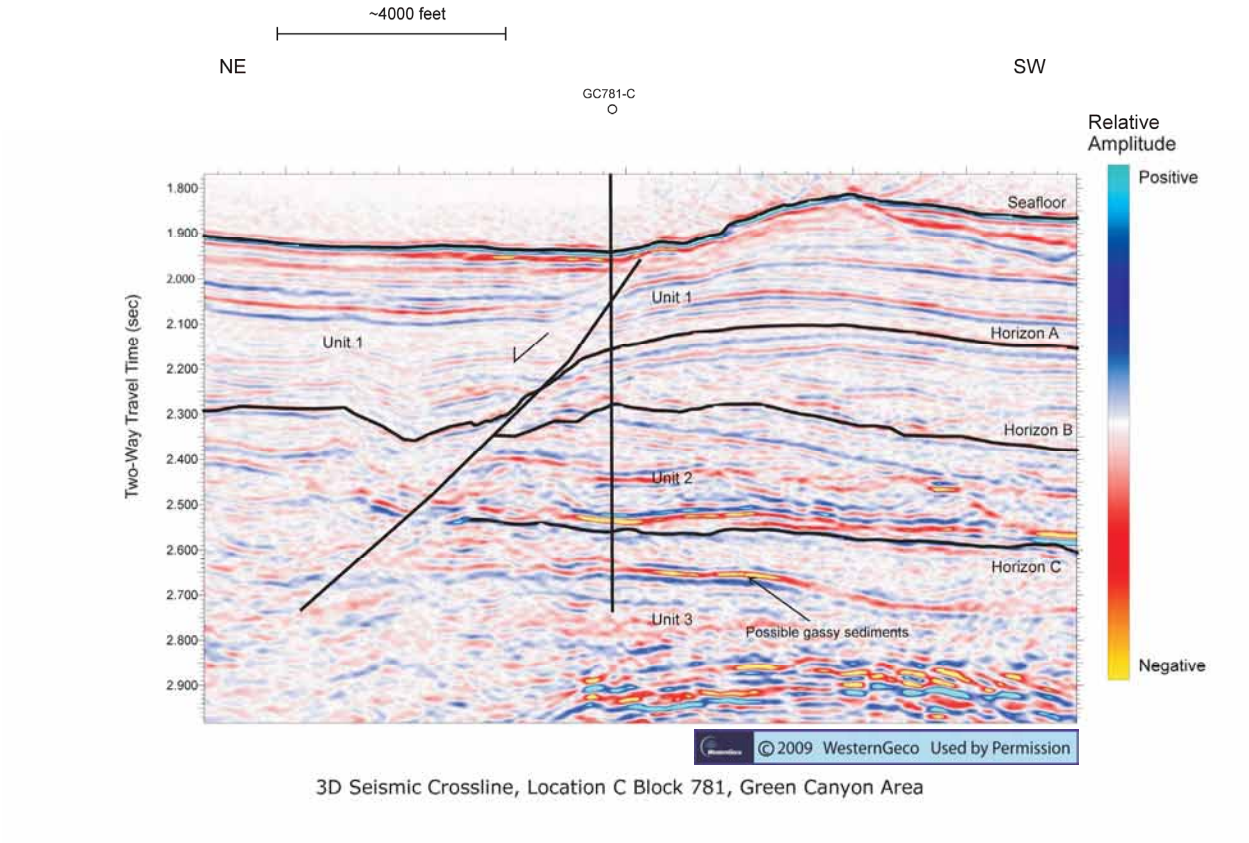
Appendix F9: *Stratigraphic interpretation, from AOA Geophysics; Seismic image provided by WesternGeco.*



Appendix F10: *Map showing location of proposed site GC781-C.*



Appendix F11: *Inline seismic profile across GC781-C. Seismic image courtesy of WesternGeco.*



Appendix F12: *Crossline seismic profile across GC781-C. Seismic image courtesy of WesternGeco.*

Target GC825-A
Drilling Target Documentation

Table 1: Background Information

General Site Objective	*Sand prone sediments in a minibasin with gas charge below GHSZ*
Drilling target and Specific Hole Objective	*Primary target is a strong peak-trough amplitude at 1904 ft BML (6467 ft BSS, 2492 ms, mapped as turquoise unit by MMS. Good phase reversal at BGHS.*
Other Drilling in Vicinity	GC737#1

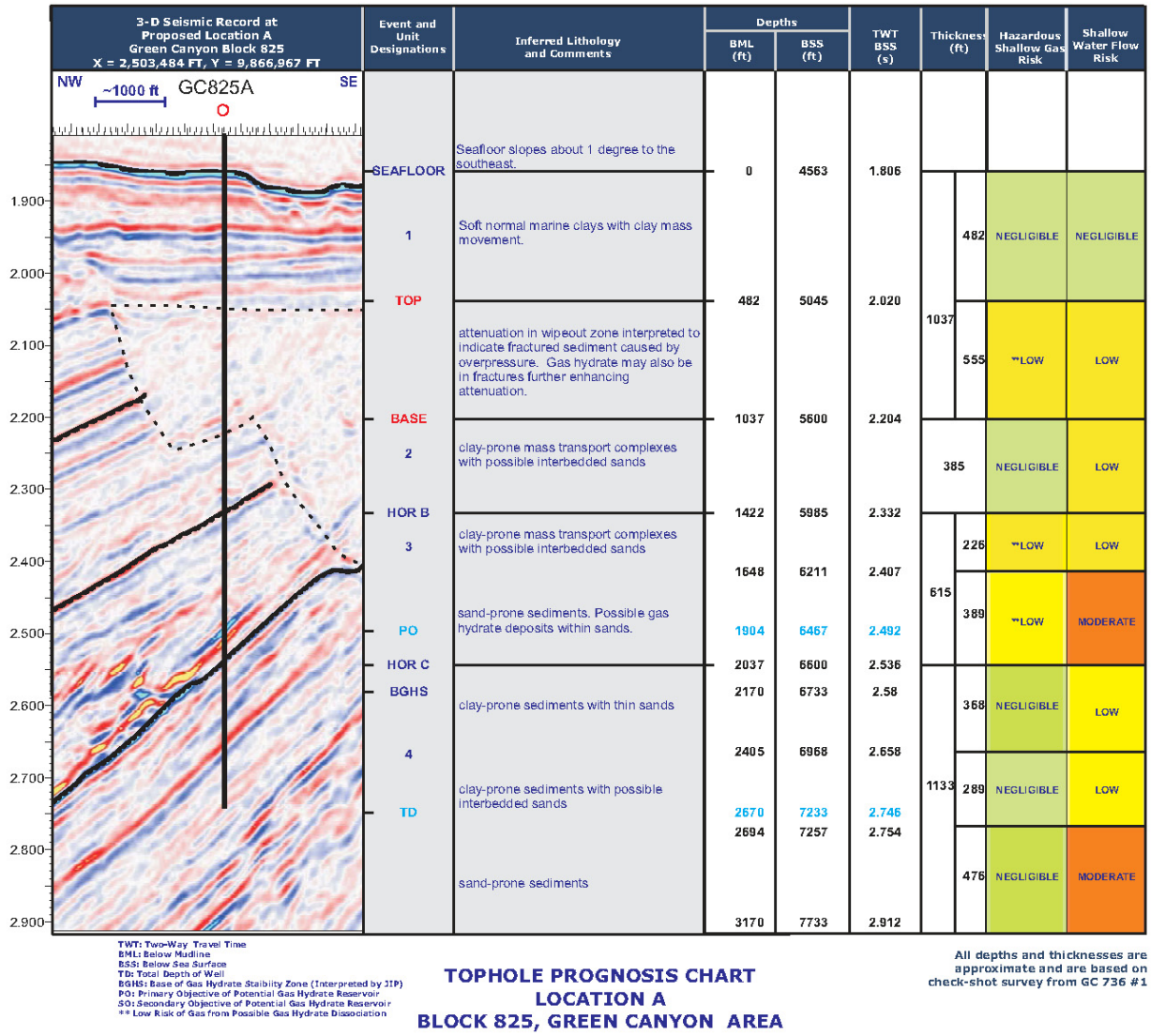
Table 2: Proposed Hole General Information

Site Name	GC825-A JIP
General Area	*Minibasin is north of Green Canyon, just upslope from the Sigsbee escarpment; Top of salt is rising towards the Sigsbee beneath the target horizons; clear phase reversal exists at BGHS*
Location	Latitude: *27.16618251 ^{o}N* Longitude: *90.34524962 ^{o}W*
Coordinate Datum	*NAD27*
Water Depth	*4563 ft BSS (1806 ms)*
OPD/Lease Block	*GC825*
Seismic lines at hole	*Inline 6345, 4126 crossline (Seismic survey L96_057A)*

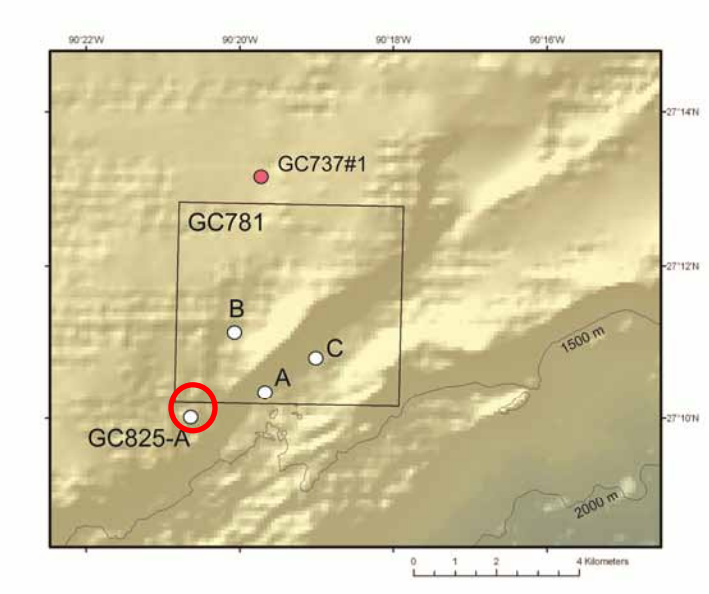
Table 3: Proposed Hole Drilling Information

Proposed penetration	*2670 ft BML 7233 ft BSS*
Seafloor slope	
Expected lithologies and thicknesses	*482 ft sea floor to top of chaotic unit (modern muds??)* *555 ft chaotic unit – slump or channel (opague zone, probably muds)* *867 ft Base chaotic unit to top primary target clay prone mass transit with sands)* *266 ft primary target to BGHS (clay-prone sediments with thin sands)* *500 ft base GHS to base of hole*
Expected ages/section	*PlioPleistocene*
Estimated depth to TGHO	*Not given*
Estimated depth to BGHZ	*2170 ft BML 6733 ft BSS (2529 ms)*
Estimated GH interval	*>266 ft thick (primary object – BGHS)*
Estimated GH saturation	
Anomalous conditions?	*Primary target is a gas sand horizon traced from the well at GC737; normal fault truncatesg the minibasin seds and chaotic unit; it forms a scarp at the seafloor dipping towards the Sigsbee Escarpment; sea floor seeps can be identified along strike at the base of the fault scarp*
Other relevant information	*Drill hole is above the fault scarp*
Source of Information	*AOA Tophole Chart from ppt dated 2/25/09*

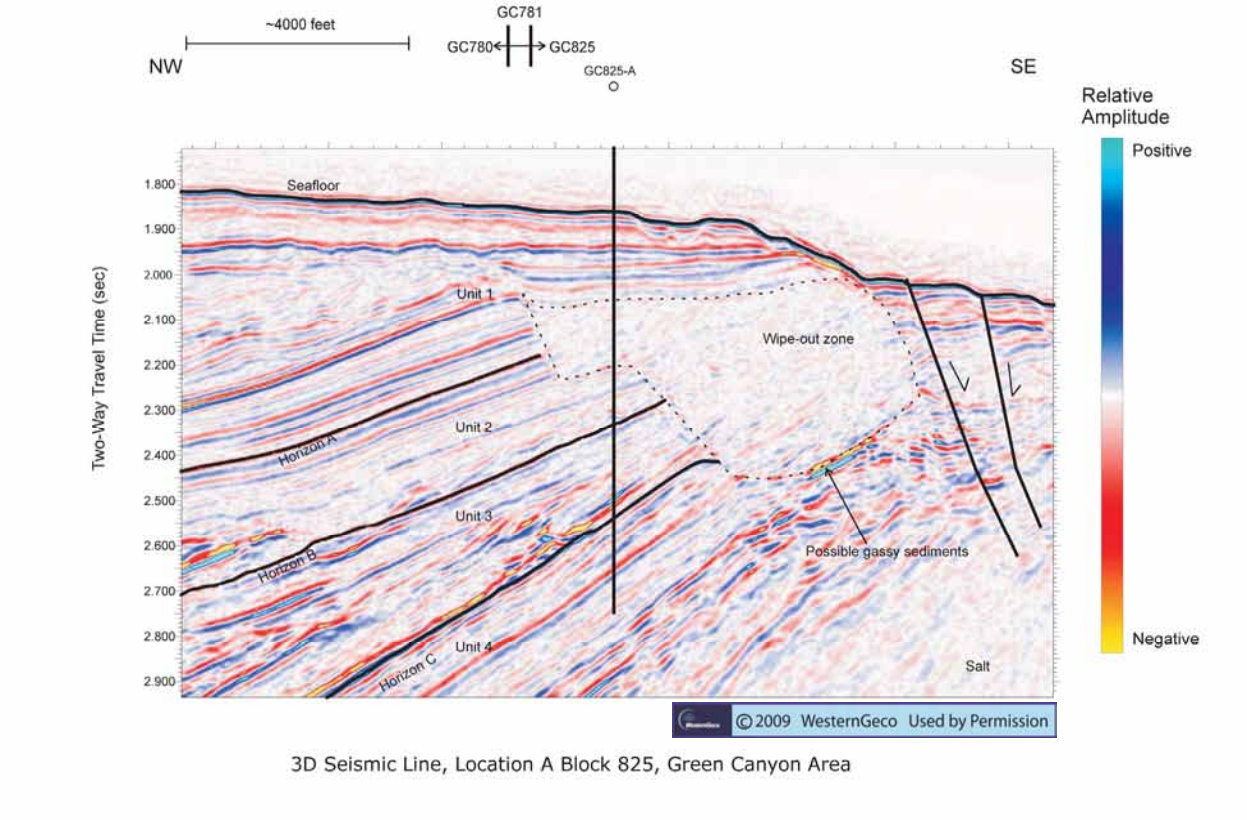
BML: Below Mud Line TGHO: Top of Gas Hydrate Occurrence
BSS: Below Sea Surface BGHZ: Base of Gas Hydrate stability Zone
Depth estimates: based on AOA analysis of check shot survey in GC737#1.



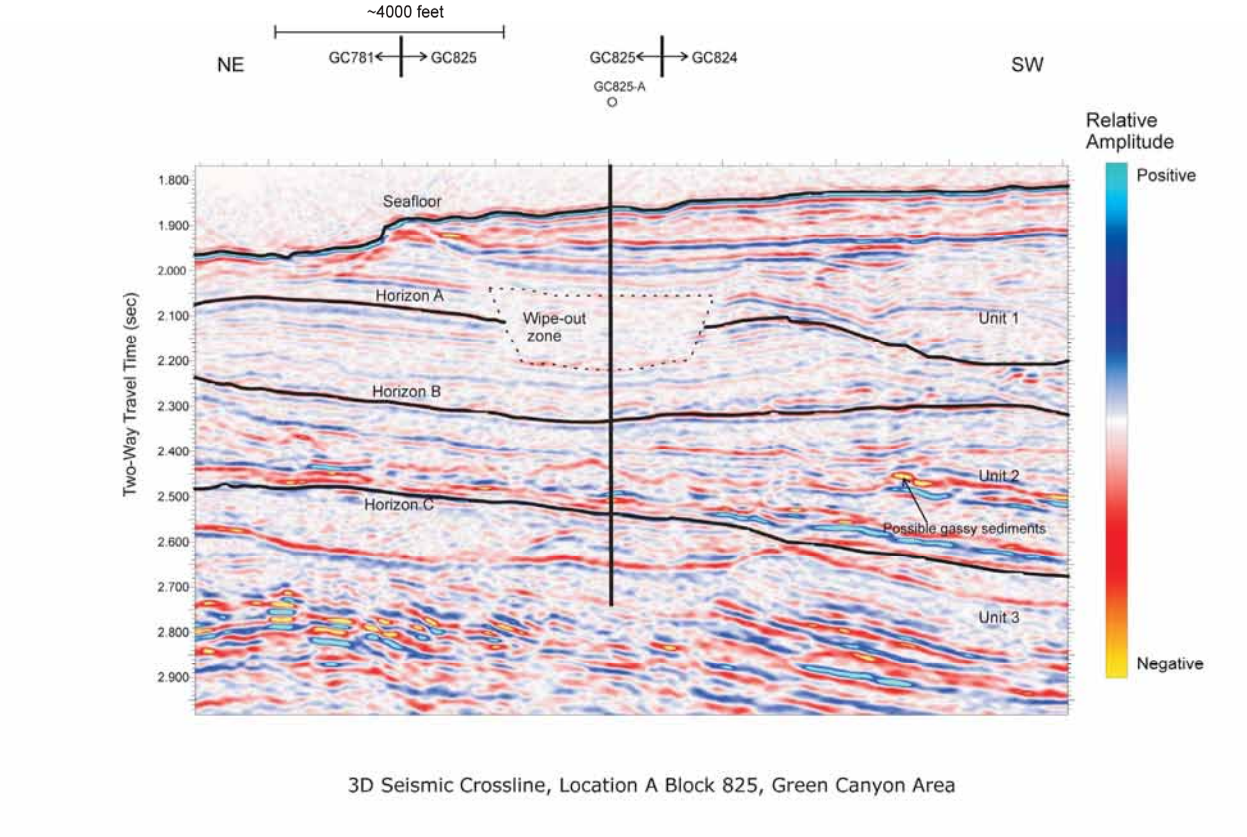
Appendix F13: *Stratigraphic interpretation, from AOA Geophysics; Seismic image provided by WesternGeco.*



Appendix F14: *Map showing location of proposed site GC825-A.*



Appendix F15: *Inline seismic profile across GC825-A. Seismic image courtesy of WesternGeco.*



Appendix F16: *Crossline seismic profile across GC825-A. Seismic image courtesy of WesternGeco.*