Deepwater Exploration
Offshore Drilling

19-February 2013

Tim Tirlia – International Exploration Drilling Manager

AGENDA – *Offshore Drilling*

1) Introduction – Anadarko International Deepwater Drilling
2) Types of MODUs and Specialized Equipment
3) Planning and Preparation
4) Mobilization
5) Execution
6) Demobilization
7) Treatment and disposal of Drilling Fluids

Introduction - Anadarko International Deepwater Drilling

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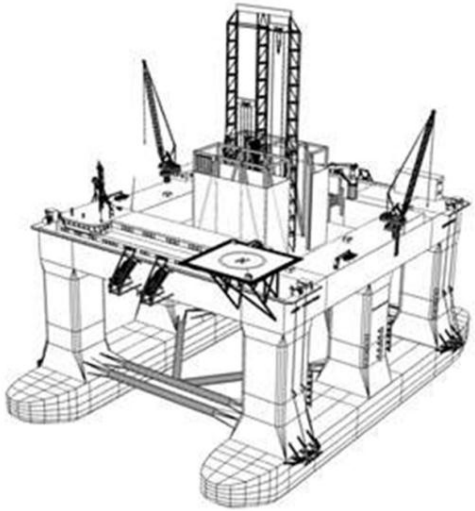
TYPES OF Mobile Offshore Drilling Units (MODU)

- **Bottom Supported MODU**
  - *Jack-up*
  - *Submersible*
  - *Maximum water depth ±190m for Ultra-Premium Jackups*
- **Floating MODU**
  - *Semi-submersible*
  - *Drill ship*
  - *Either can be moored (anchored) or dynamically positioned (DP)*
  - *Water depths to 4,000m*



Key Elements

- **Self-contained for extended periods**
- **Includes drilling package, cranes, material storage, crew accommodations, heliport, power generation**
- **Requires Vessel Support to Supply**

TYPES OF MODU's - JACKUP

Bottom Supported MODU - Jackup

- Towed to location with barge afloat
- Movable legs lowered to seafloor
- Pre-load required prior to "jacking up" into position
  - *Reduce the risk of "punch through"*
- Barge is raised out of water by jacking against the legs
- Provides very stable platform
  - *No Movement in Work Platform*
- Drilling depths to 12,000m
- Maximum water depth ±150m

TYPES OF MODU's – Floating Rigs

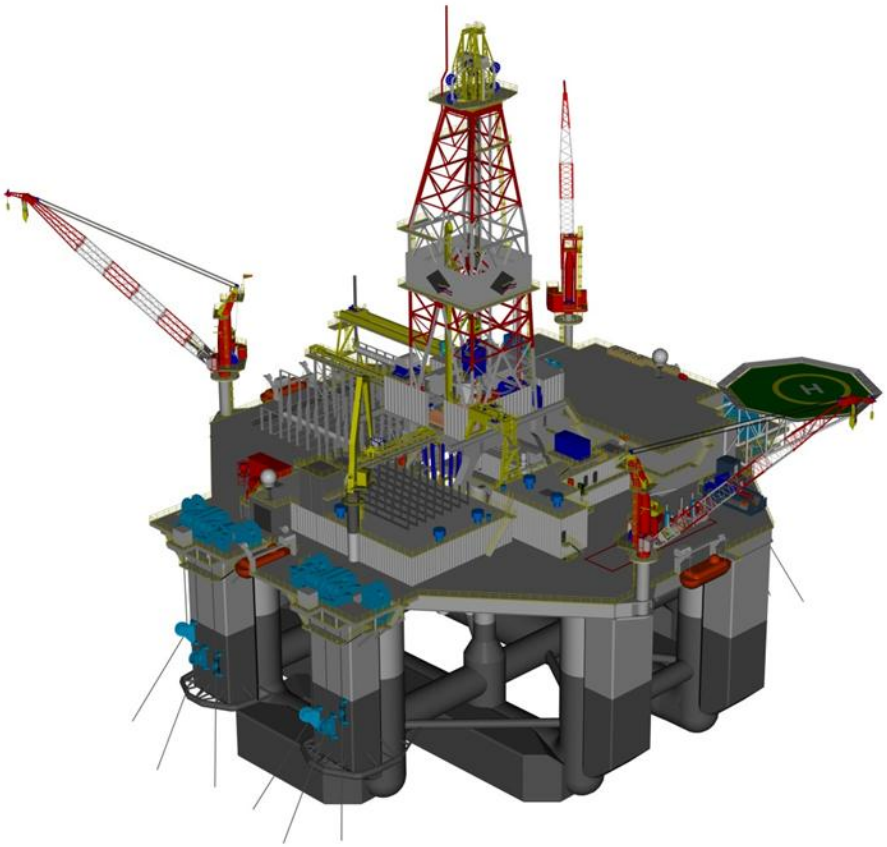
- **Typically, in water depths >150m, bottom supported rigs become impractical, and the industry uses floating rigs in water depths exceeding 150m**
- **Floating MODU types**
  - ***Semi-submersible barge***
  - ***Drill ship***
- **Floating rigs can be moored (anchored) subject to limitations of anchor chain-cable and winch systems or dynamically positioned (DP)**
- **Additional equipment is required to accommodate vessel movement (heave, pitch and roll)**
  - ***Motion compensation system***
  - ***Subsea blowout preventers (BOP) & Controls***
  - ***Marine riser system***
  - ***Remotely operated vehicle (ROV)***

TYPES OF MODU's – Moored vs. DP

- **Moored – is practical to water depth limits of ±1,500m**
  - *Material storage is limited by buoyancy & deck space, ± 4,000 MT*
  - *Weight & storage volume of mooring wire & chain require large/ heavy duty winching systems*
- **DP – is practical to water depth limits of ±3,658m**
  - *Ship shape designs have much more deck/hold area than semisubmersibles*
  - *Load capacity often exceeds 20,000 MT for late generation drill ships*
  - *Limiting factor is ability to hold top tension on the marine riser*
  - *Seafloor transponders & GPS are used to establish well location and maintain position*
  - *Multiple DP thrusters operate 24hr/day to maintain the ships position over the well*
  - *The MODU's stability is maintained by the transfer of sea water into dedicated ballast storage compartments.*

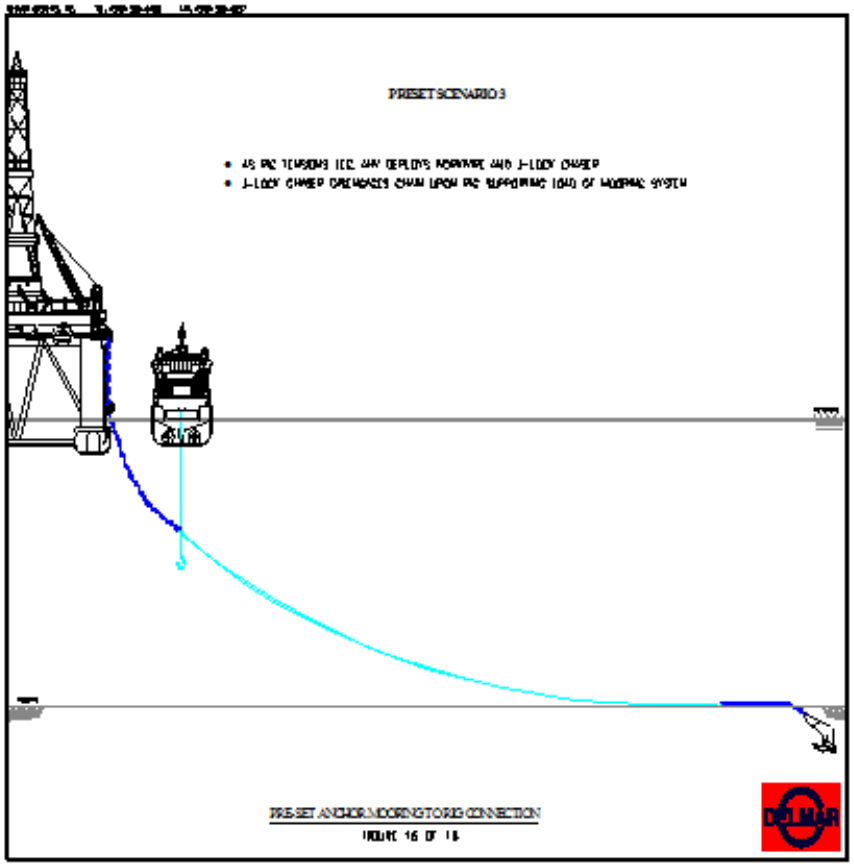
TYPES OF MODU's - Moored Semi-submersible

- **Towed to drill site at shallow draft**
- **At drill site, the mooring system is deployed (utilizing AHV), and the MODU is held in place w/ anchor & chain**
- **After mooring, the hull is ballasted down to provide stability and lower the COG.**
- **This design offers better motion characteristics than early drill ship designs**
  - ***Smaller water plane profile & lower center of gravity minimizes vessel motion***



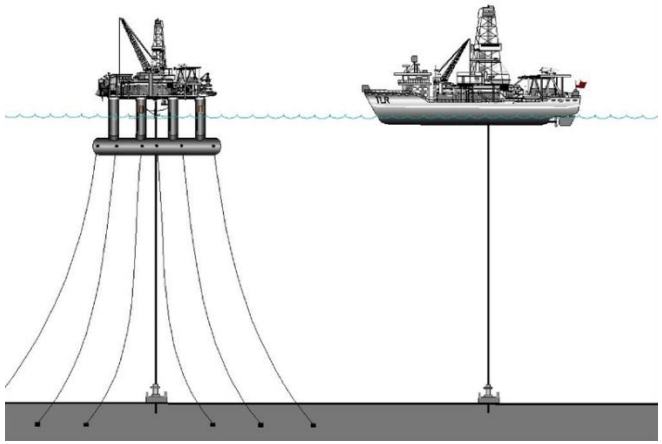
TYPES OF MODU's - Mooring Operations

- Anchor mooring & recovery may require up to 6-8 days
- Anchor setting is further complicated by too soft, too hard, or uneven seafloor conditions
- Requires very specialized, high HP vessels, winches & crews to safely place anchors in the desired pattern



TYPES OF MODU's - Dynamically Positioned Drill Ship

- **Vessel sails to site under its own power**
- **Vessel remains on station using 'dynamic positioning' (DP)**
- **DP set up is much faster, since mooring is not required (6-18hr vs 6 days) and transponder retrieval is also faster**
- **Multiple DP thrusters operate 24hr/day to maintain the ships position over the well**
  - ***The MODU's stability is maintained by the transfer of sea water into dedicated ballast storage compartments.***
- **Higher fuel usage due to significant power required to operate thrusters 24hr/day**



TYPES OF MODU's - Dynamic Positioning

- Initial position established by global positioning system (GPS)
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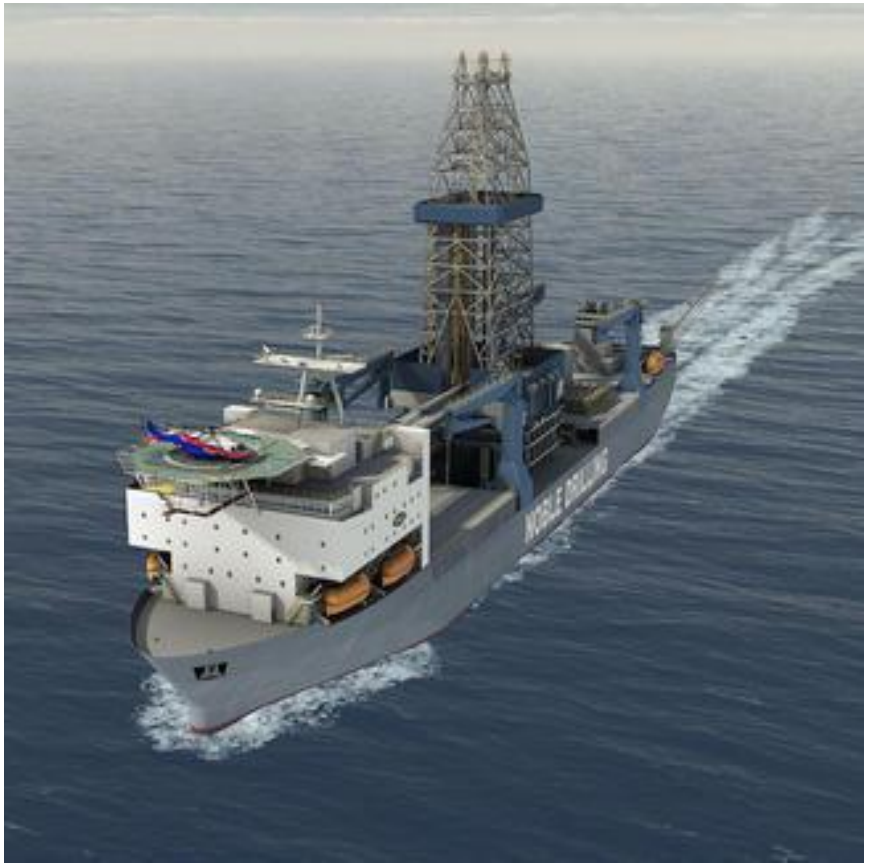
- Absolute position is continuously received from the vessel's GPS system
- Vessel's acoustic transceiver regularly queries the seabed transponders to determine relative position
- Computer processes inputs and adjusts power & azimuth of thrusters to hold the rigs position

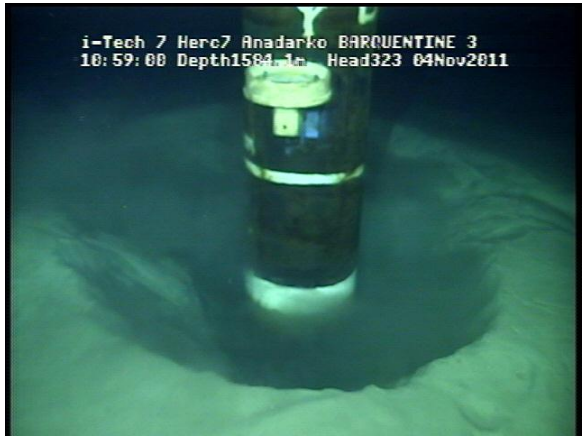
Bolette Dolphin

- Construction: HHI at Ulsan S. Korea
- Design: MSC P10000 Drillship
- Dimensions: 752’ x 118’/229 m x 36 m
- Dual Derrick: (NOV)
- Water Depth: 12,000’/3658 m
- Drilling Depth: 40,000’/ 12,192 m
- Variable Deck Load: 20,000 m-tonnes
- Quarters: 210 beds
- Thrusters: 6 x 5500 kw x 1.35 (44,500 hp)
- Power Generation: 6 x 8000 kw x 1.35 (64,800 hp)
- 2 BOP / LMRP Stacks

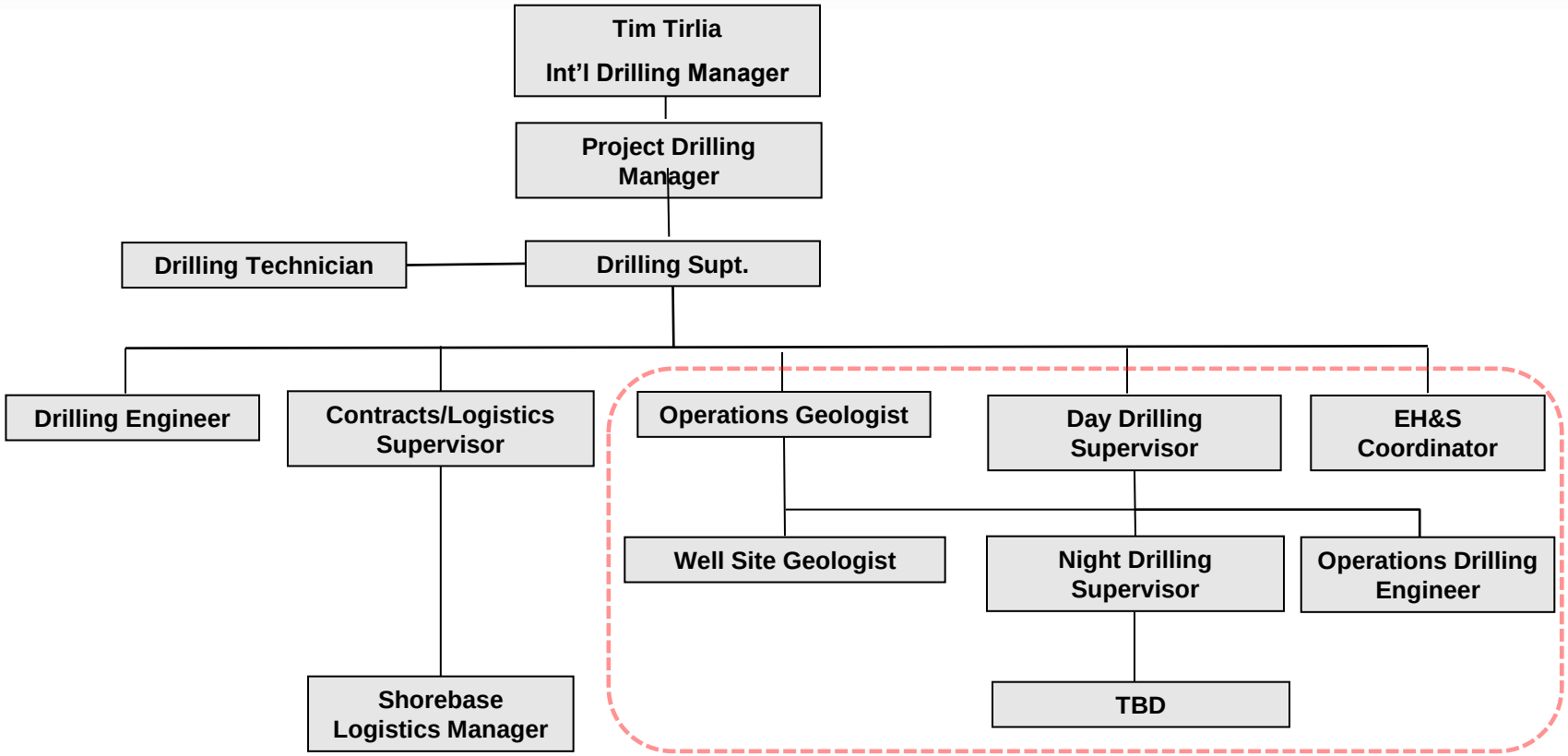


Remotely Operated Vehicle (ROV)

- Provide subsea monitoring & intervention capability
  - High resolution video
  - Manipulation of simple tools &/or BOP controls
- Perform seafloor surveys
- Placement of seabed transponders
- Visual operation of riserless operations
- Inspection of wellhead, riser and BOP



Planning and Preparation: Developing a Team



Support – Key Contact

- Country Manager
- Government Relations
- Security

Houston Support – Key Contact

- GoM & International Drilling Manager
- Reservoir Engineering
- Exploration Team
- WW Geological Operations
- Legal Team
- EH&S /Regs / Permitting

Planning and Preparation: Plan for the Unknowns

International Drilling Campaigns – Deep Water

- Early Commitment to Drilling Schedule
- Work Scope / Cost Creep
- Rig & Equipment Importation/Exportation
- Managing FCPA
- Staffing from Exploration to Development
- Managing Expectations
- Managing the Unknowns
- Performance on first attempt
- Security Protection
  - Law Enforcement/Military Relations
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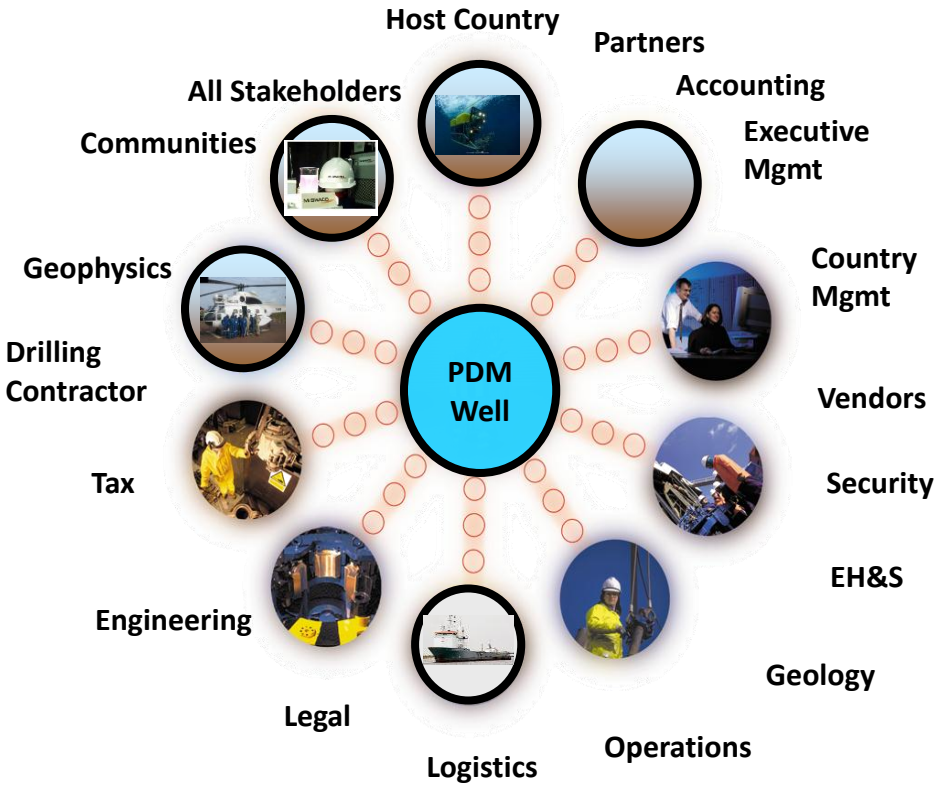
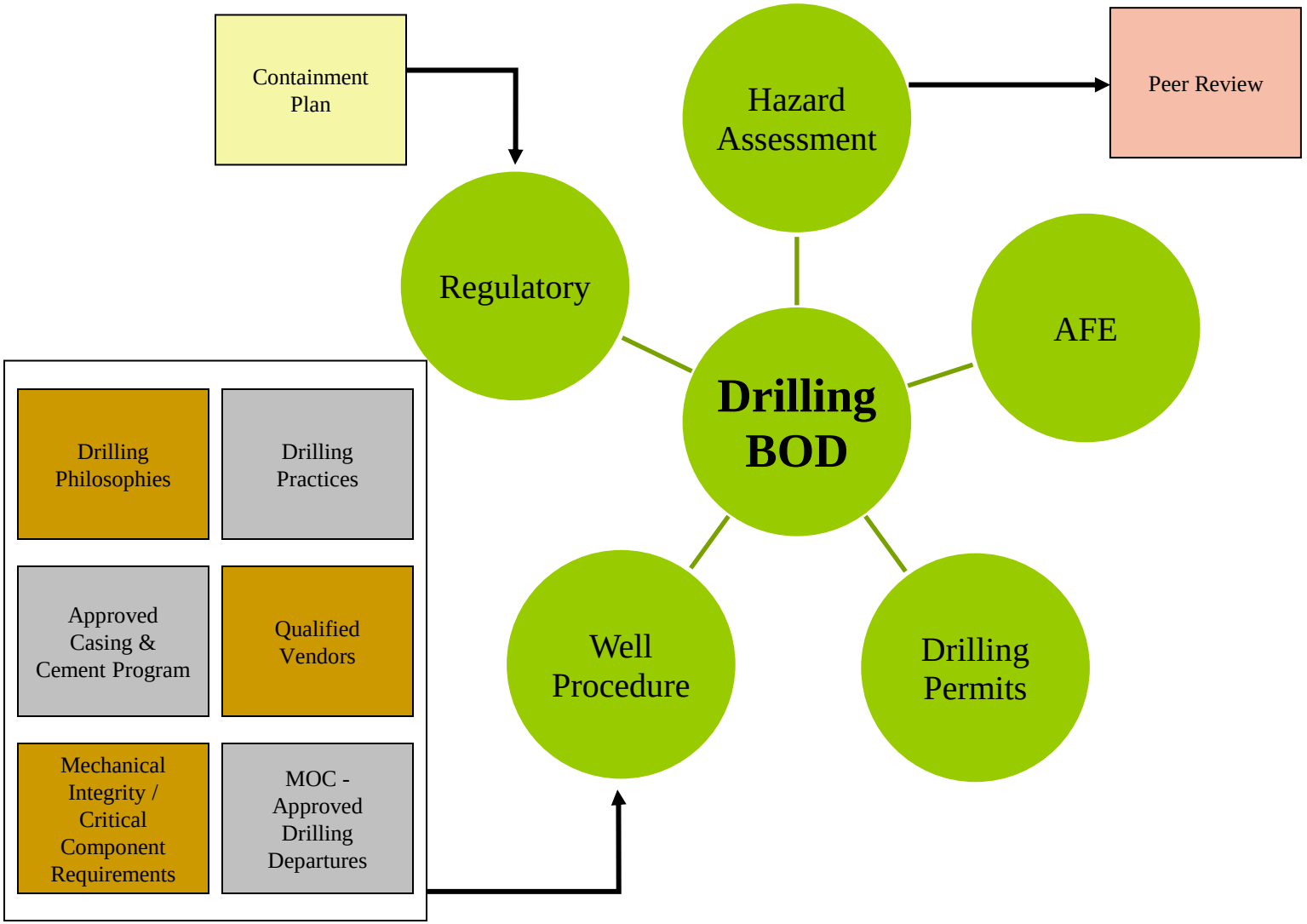
  - Piracy Plan

Planning and Preparation



Planning and Preparation: Develop the well Basis of Design (BOD)



Planning and Preparation: Capping Stack

- **APC is a member of Wild Well Control**

➢ **with access to:**

- ***Debris Removal Equipment***
- ***Subsea Dispersal Materials & Equipment***
- ***Capping Stack***
- ***Technical Expertise (Planning & Execution)***

Planning and Preparation: Complexities of Deepwater Drilling

Drilling

- **Tight Margin Between Fracture Gradient & Pore Pressure**
- **Hydrate Formation during Well Control**
  - **Gas & Water at pressures Form Ice**
  - **Typically Use LTSBM (Non-water Based)**
- **Kick Detection**
  - ***Avoid Riser Evacuation***
  - ***Significant portion of circulating volume above BOPs***
  - ***15 bbl/9.2 ppg kick @ 3300 mtrs=34 bbls @ 1468 mtrs or 5300 bbls @ surface***
- **Variability of Temperature**
  - ***Surface Ambient***
  - ***Mudline 36-42°F***
  - ***Bottom Hole Temperature >150°F***
- **Operational Cost**
  - **±1MM US$/day**

Rig Related

- **Environmental, Health & Safety**
  - ***+/-160 Personnel onboard***
  - ***Maintaining Acceptable Culture***
- **Station Keeping**
- **Coordination between Departments**
  - ***Marine***
  - ***Mechanical***
  - ***Drilling***
- **Complexity of Systems**
  - ***BOP Control System***
  - ***Marine Systems***
- **Maintenance of Systems**
  - ***Offline Maintenance***
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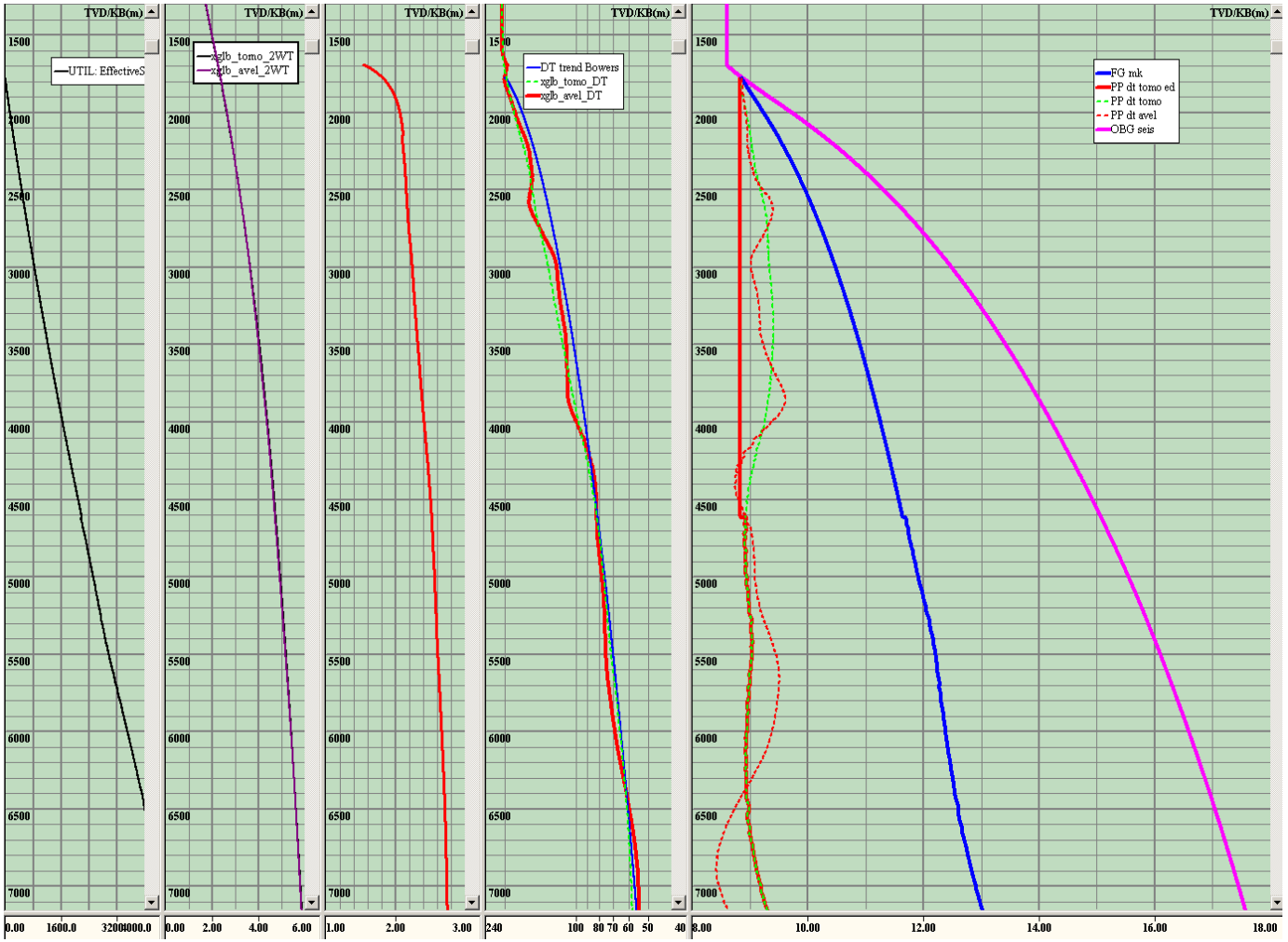
Planning and Preparation: Pore Pressure/Frac Gradient Curve



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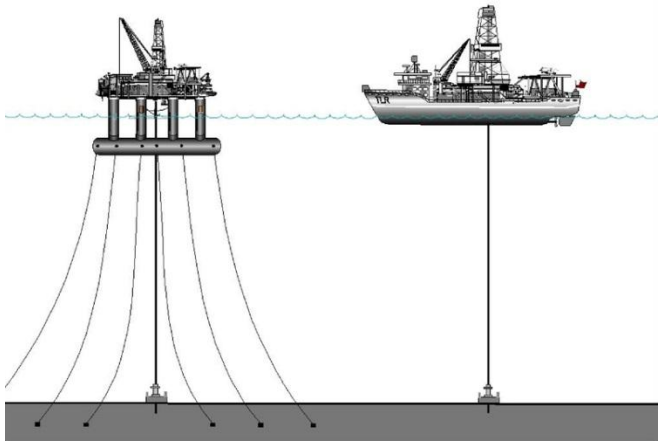

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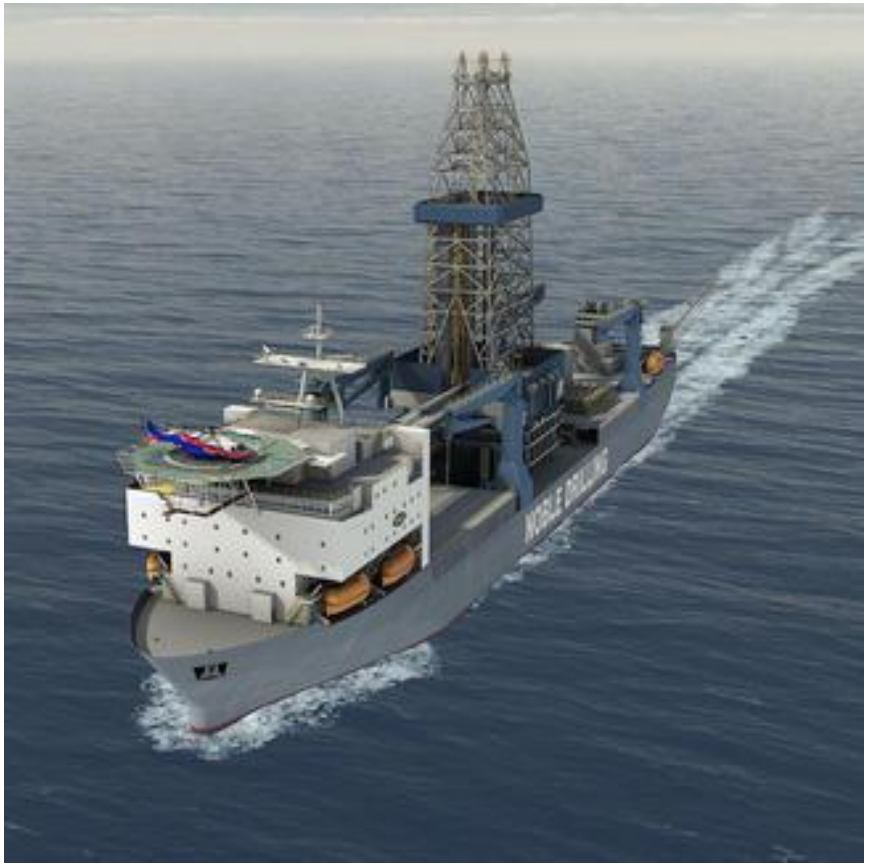

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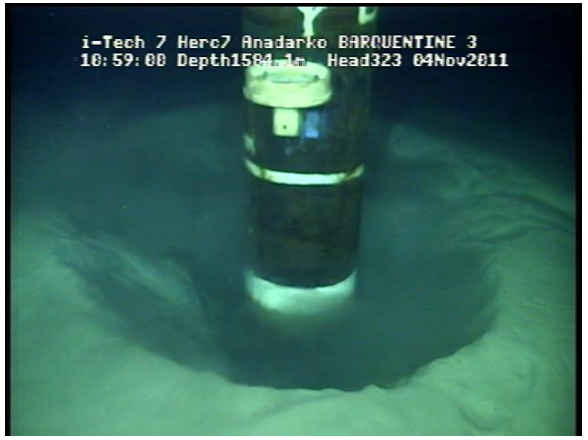

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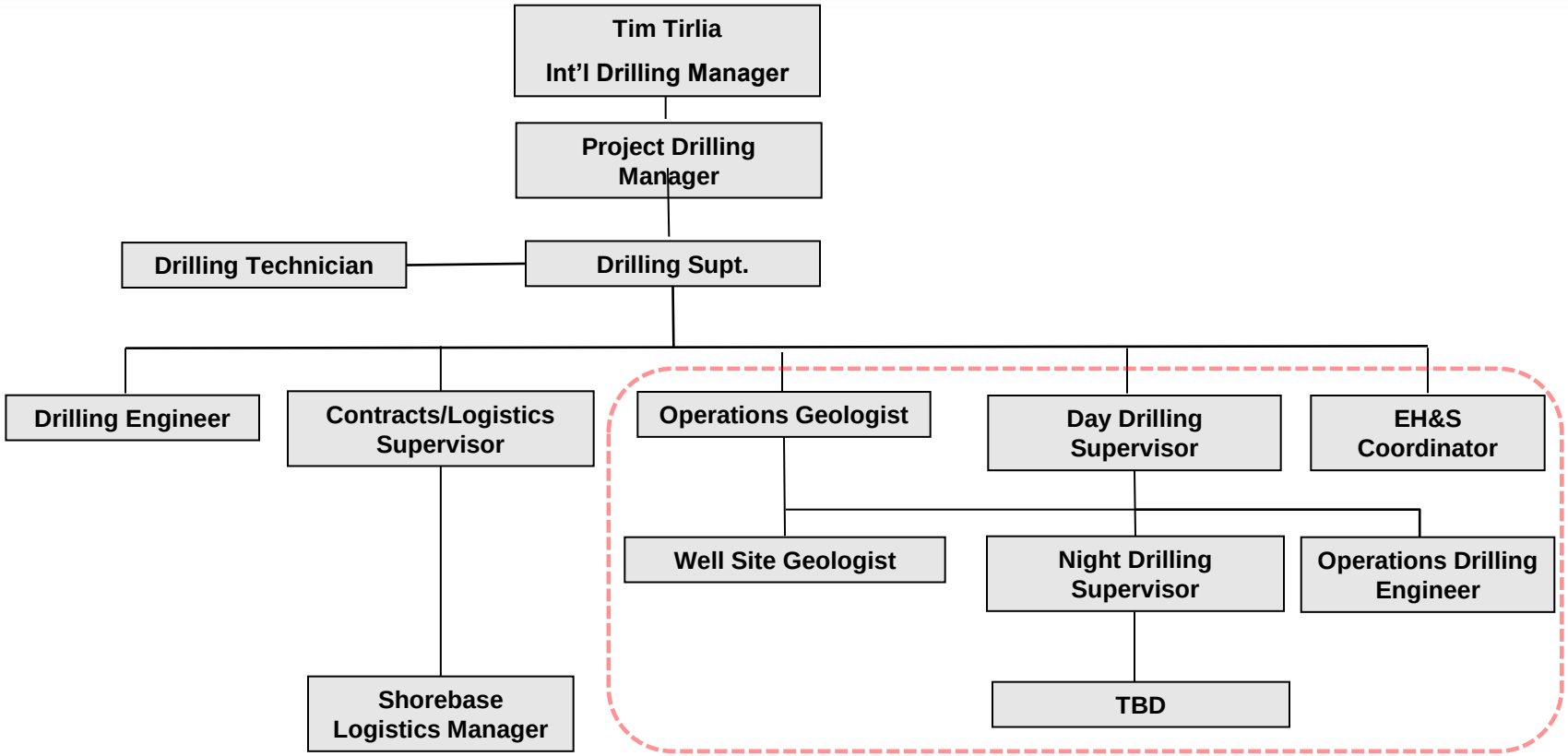

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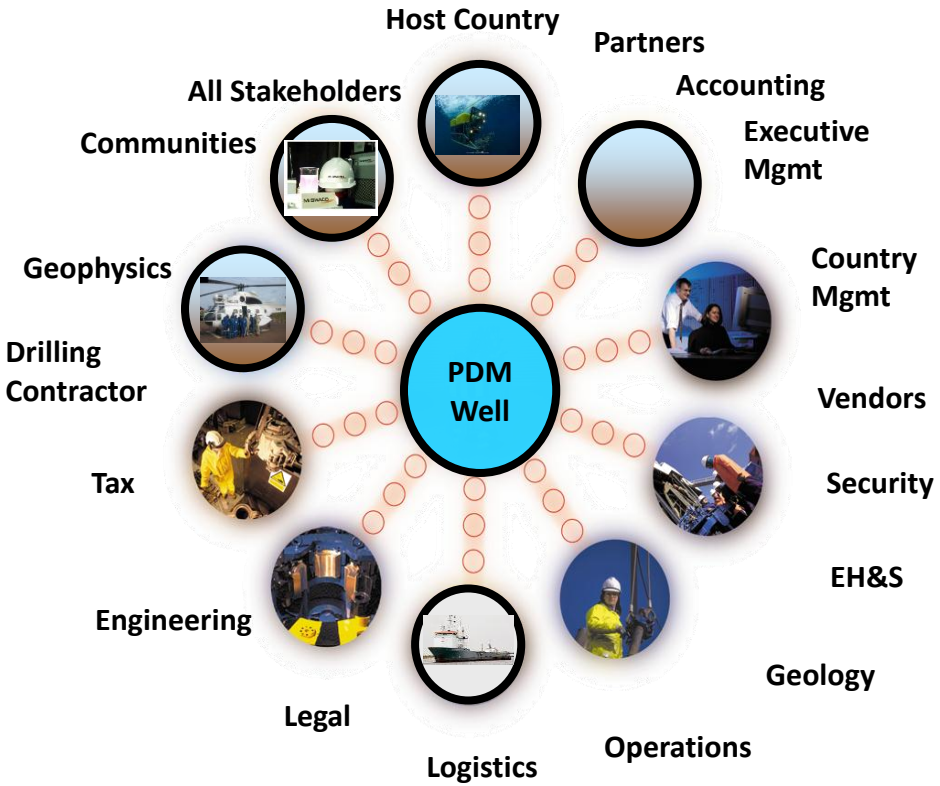

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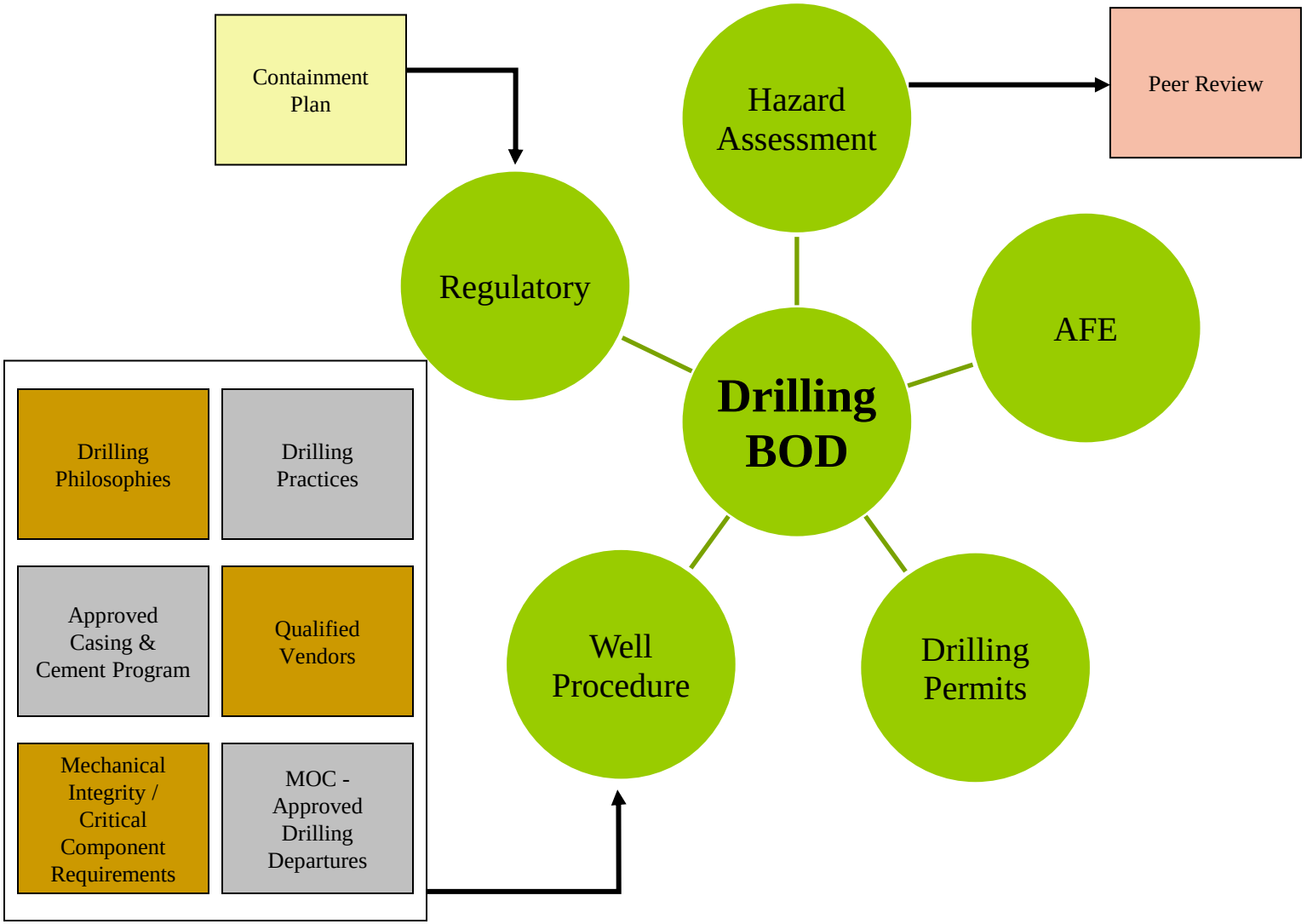

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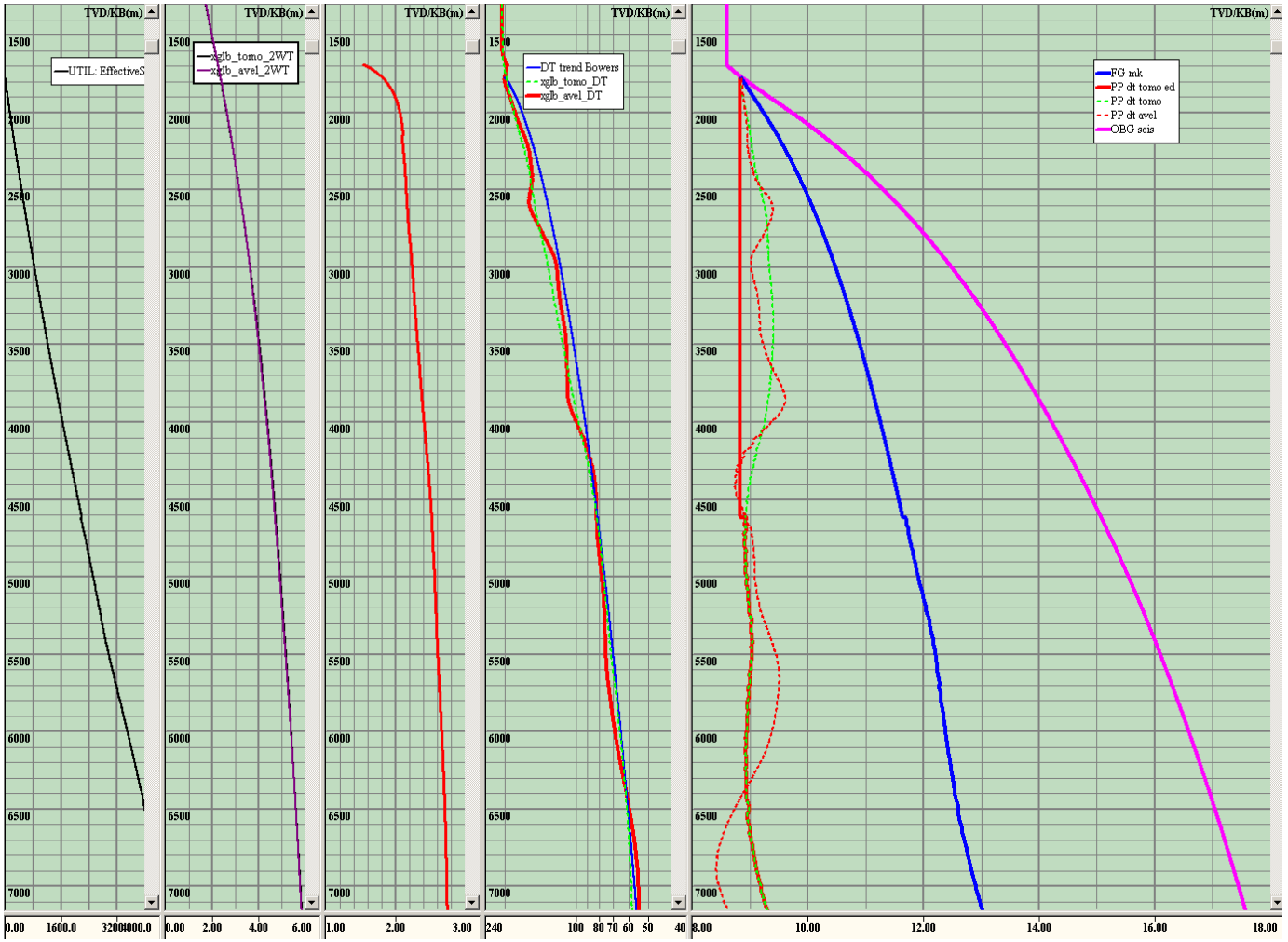
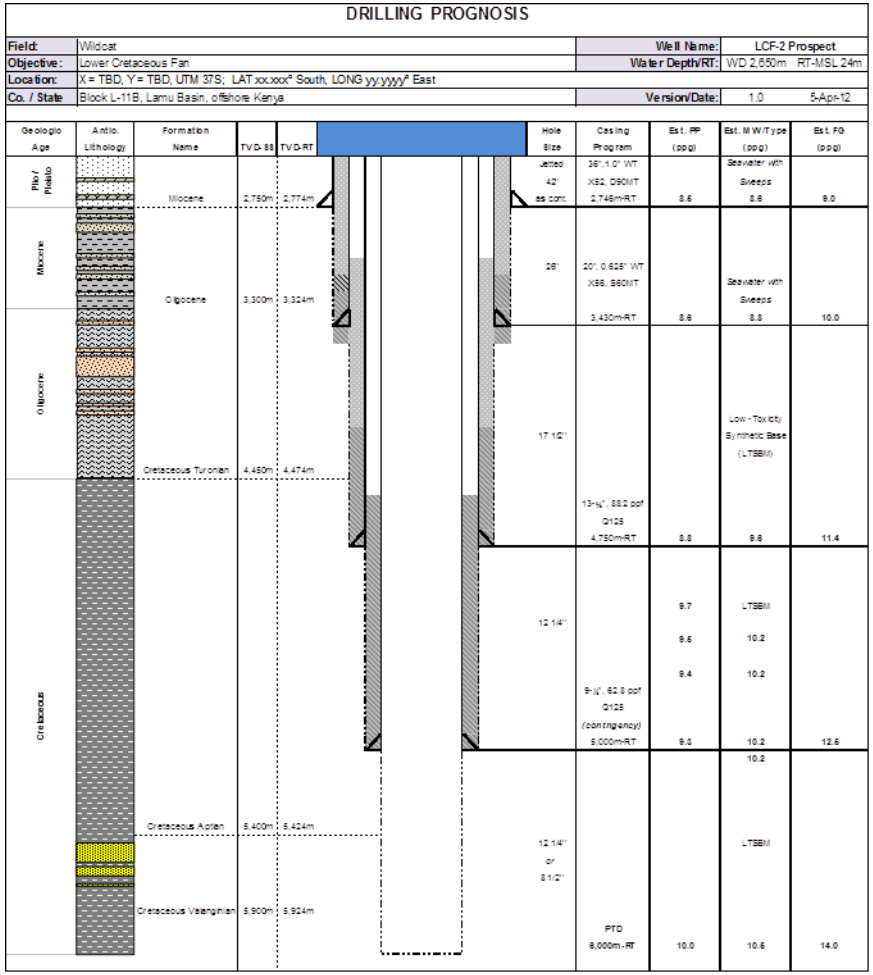


Planning and Preparation: Pre-Drill Planning

- **Four casing strings typical**
  - ***Isolation of perceived / potential pressure regimes***
  - ***Well control requirements***
  - ***Hole sizes compatible with evaluation program***
  - ***Common international program***
- **Low toxicity, synthetic base mud (LTSBM) selected to avoid formation of gas hydrates during possible well control events**



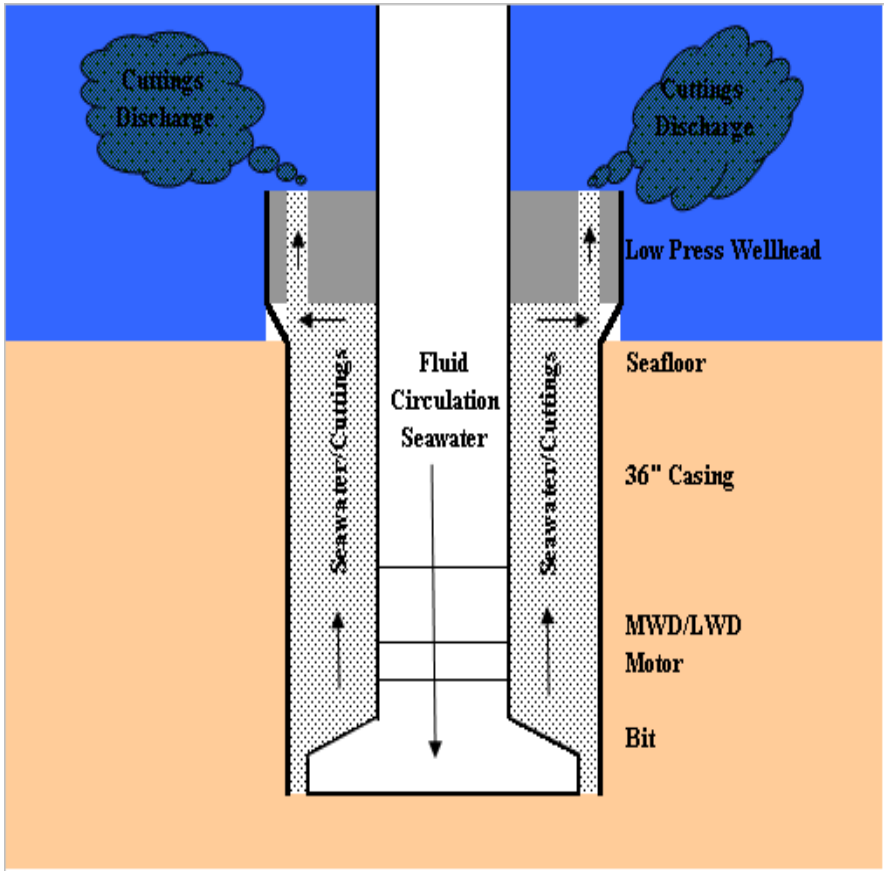
Planning & Preparation: Typical Formation Evaluation Objectives

	26” Hole	17-1/2” Hole	12-1/4” Hole	8-1/2” Hole
Samples	-N.A.-	10m	10m 3m during show	10m 3m during show
Mud Log	-N.A.-	Drilling Parameter Mud Gas Lithology	Drilling Parameter Mud Gas Lithology	Drilling Parameter Mud Gas Lithology
Geochemistry	-N.A.-	Post-Drill	Post-Drill	Post-Drill
Biostratigraphy	-N.A.-	Post-Drill	Post-Drill	While Drilling
LWD	Gamma Ray Resistivity Sonic	Gamma Ray Resistivity Sonic	Gamma Ray Resistivity Sonic	Gamma Ray Resistivity Sonic
Open Hole Logs	-N.A.-	-N.A.-	Gamma Ray Induction Resistivity Density Neutron Sonic Micro-Imager Magnetic Borehole Siesmic Formation Pressure Fluid Sample	Gamma Ray Induction Resistivity Density Neutron Sonic Micro-Imager Magnetic Borehole Siesmic Formation Pressure Fluid Sample

Mobilization

- Rig scheduled to be mobilized from it's last work location (West Africa) to Columbia → ± 1 month
- Upon arriving in country it will go through immigration & customs clearance and undergo any required inspections at location
- The rig will be resupplied with required goods
- Upon arriving on location, the rig will set out DP beacons or deploy anchors depending on water depth & rig type
- ROV will performs a site survey of the well area prior to beginning operations

Execution: (1) Jet-in the Structural Casing



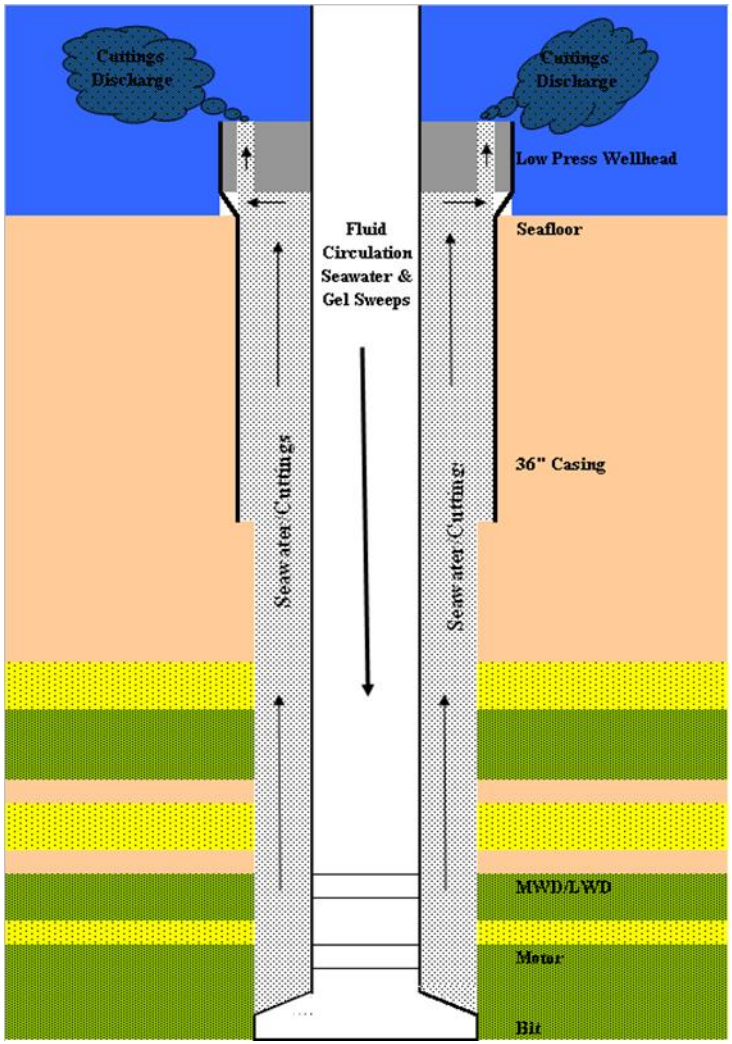
Purpose

- Primary Support for H/P wellhead & subsequent casing strings
- Relies on Sediment to Pipe Friction

Procedure

- Make up 36” casing string & L/P WH
- Run 26’ bit & drill pipe inside 36”, with WH running tool
- Engage L/P WH w/ running tools
- Run 36” casing to seafloor on drill pipe
- Begin pumping seawater down drill pipe to wash out sediments
- Lower 36” to desired penetration
- Shut down pumps and allow sediments to relax and hold 36” via skin friction

Execution: (2) Drill 26” Hole to Conductor Casing Depth



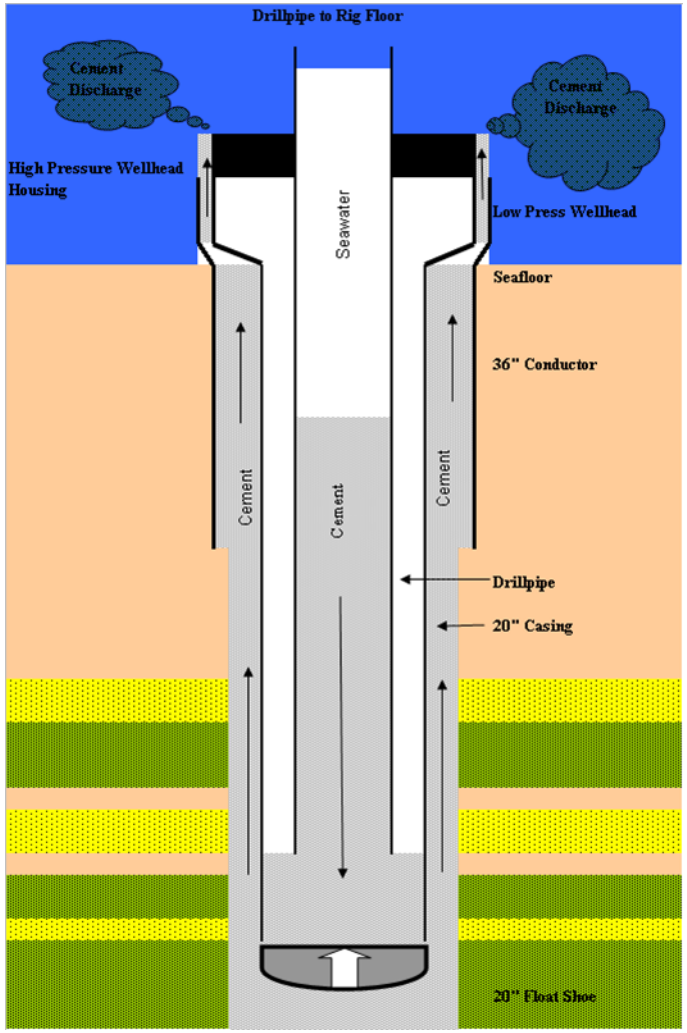
Purpose

- Provide Adequate Formation Strength
  - *Achieve Returns to Surface*
  - *Support Mud Column*
  - *Provide for Ability to control well*
- Typically 500-1200m bML

Procedure

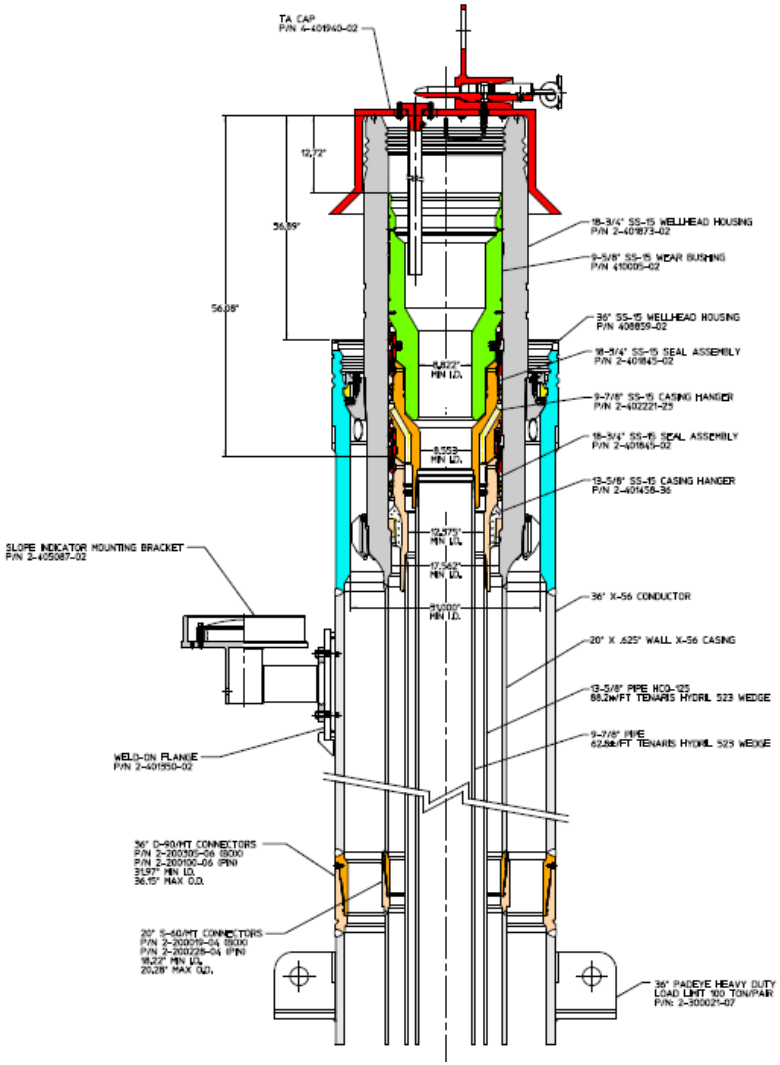
- After 36” is secured, release the wellhead running tools
- Resume pumping seawater and drill 26” hole
- Pump occasional sweeps of viscosified fluid (bentonite or guar gum) to clean cuttings from the hole
- Observe returns to the sea floor with the ROV’s video system
- At desired depth, displace the hole with viscosified mud to stabilize while drill pipe is removed and casing is run in the hole

Execution: (3) Run & Cement 20” Conductor Casing



- Make up 20” casing
- Run inner cementing string
- Make up H/P WH on top of inner string, and attach to 20”
- Pick up and run 20” casing on drill pipe
- Stab the 20” into the L/P WH using ROV video to position rig as required
- Lower the 20” and land HPWH in LPWH
- Pump cement from casing shoe to mud line
- Release running tools and remove inner string

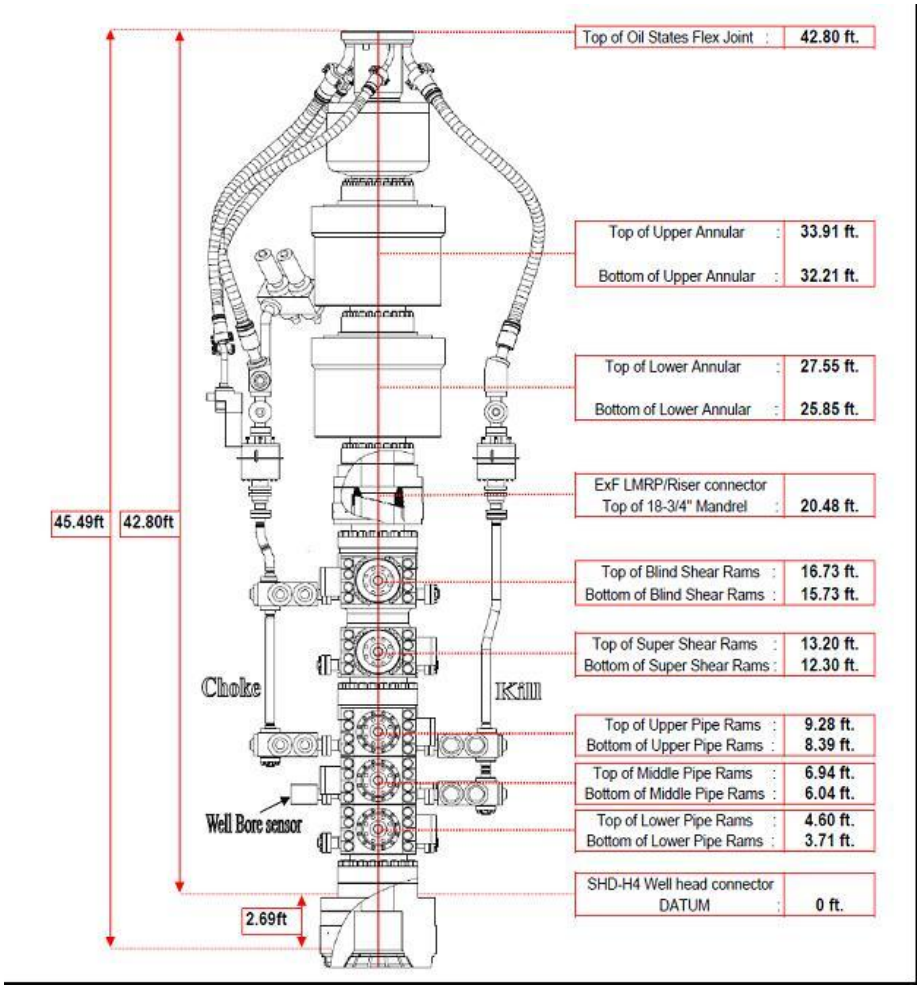
Execution – Subsea Wellhead



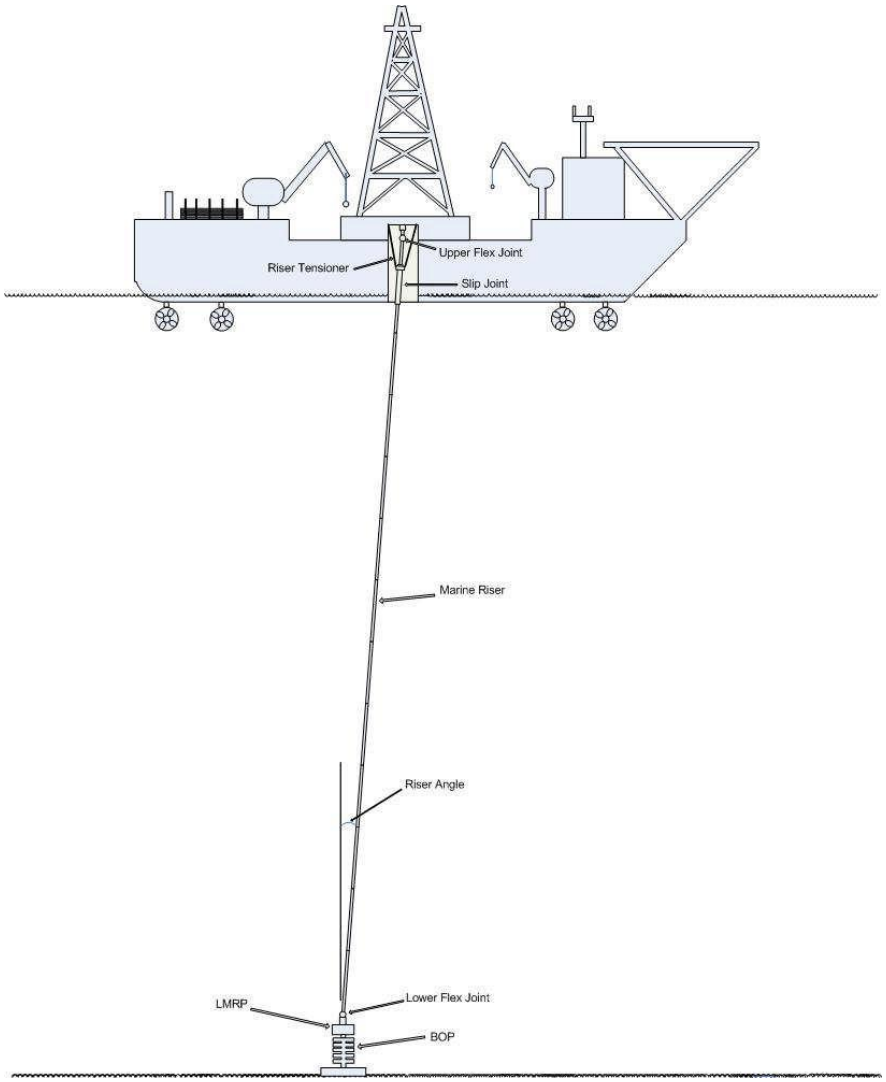
- **Low Pressure Housing**
  - Turquoise color
  - Provides landing profile for HPWH
  - Transfers loads into the 36” structural casing
- **High Pressure Housing**
  - Gray color
  - 15,000 psi pressure rating
  - Contains landing profiles for casing strings smaller than 20”
  - Provides profile to connect BOP and marine riser to wellhead
- **Casing Hangers and packoffs**
  - Orange & lime green colors
  - Supports casing string and seals annulus

Execution: Typical Subsea BOP

- 5 Ram Preventers
  - 18-3/4”, 15,000 psi WP
  - Super shear rams capable of severing tube of all drill pipe and HWDP in use
  - Blind shear rams capable of complete closure
  - Lower ram cavity utilized as test ram
- 2 Annular Preventers
  - 18-3/4”, 10,000 psi WP
- Functionality via
  - 3 surface control panel
  - Simrad acoustic system
  - ROV



Execution: Run Marine Riser & Subsea BOP

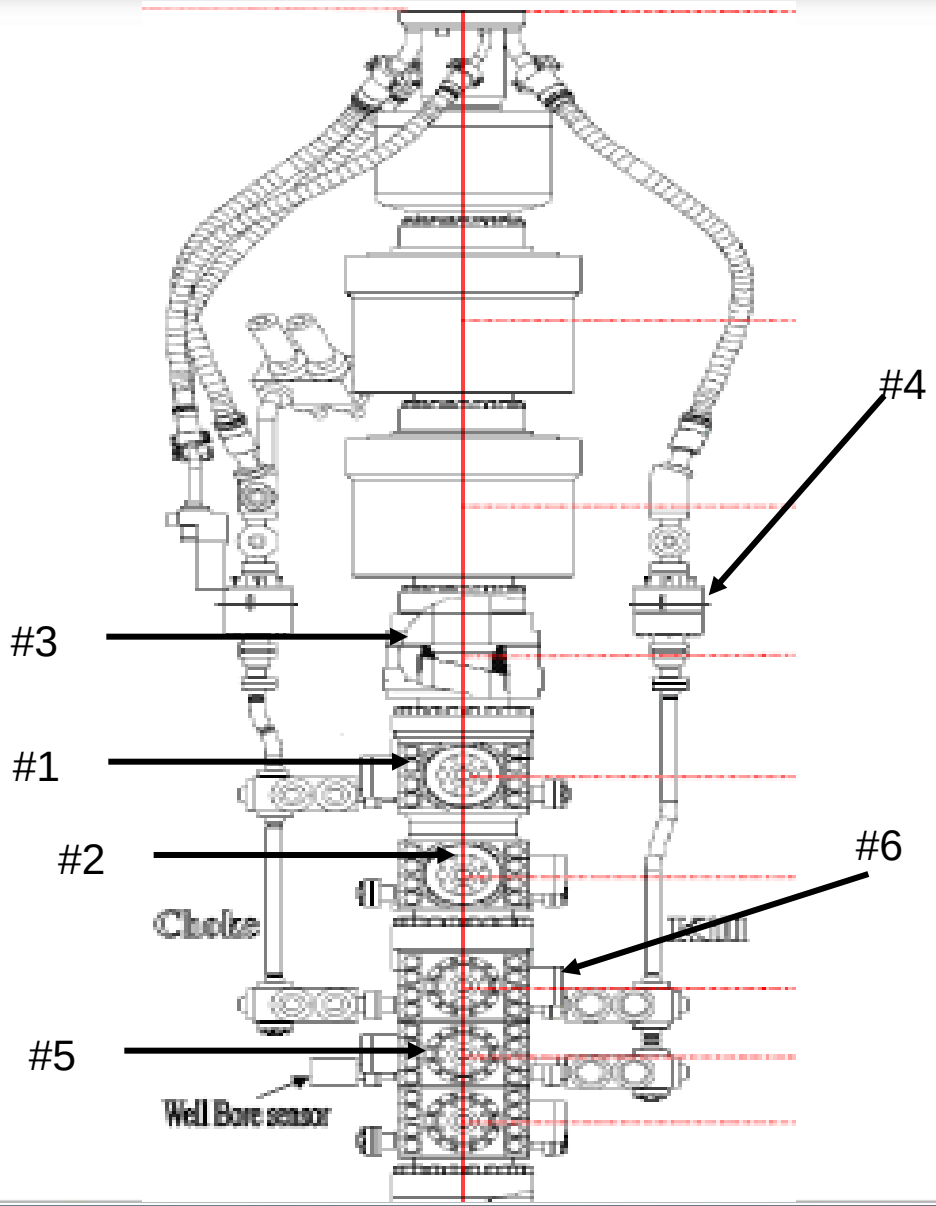


- **Large diameter, hydraulic conduit**
  - ***Allow fluids to transit from seafloor to vessel w/o contacting seawater***
- **Marine riser held motionless relative to seafloor**
  - ***Vessel heave accommodated by telescoping "slip joint"***
  - ***Vessel position & riser tension is managed to maintain low angles at top joint and BOP***

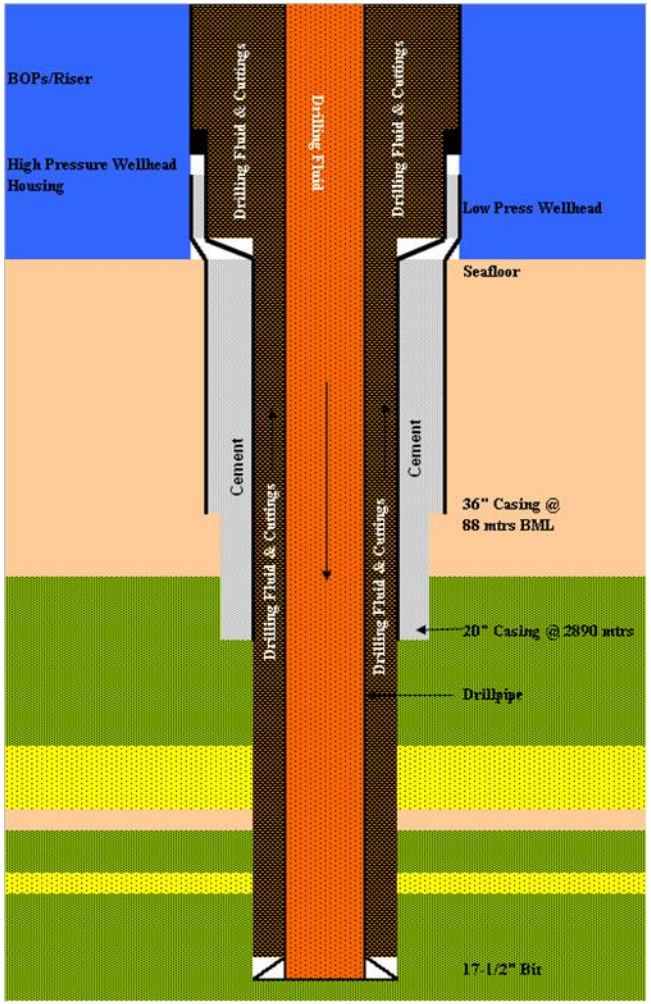
Subsea BOP – Emergency Disconnect

- **Manual initiation**
- **Automatic functionality**

1) **Blind Shear Rams close**
2) **Super Shear Rams close**
3) **Riser connector unlock**
4) **Collet connectors unlock**
5) **Middle Pipe Rams close**
6) **Upper Pipe Rams close**



Execution: (4) Drill 17-½" Hole to Surface Casing Depth



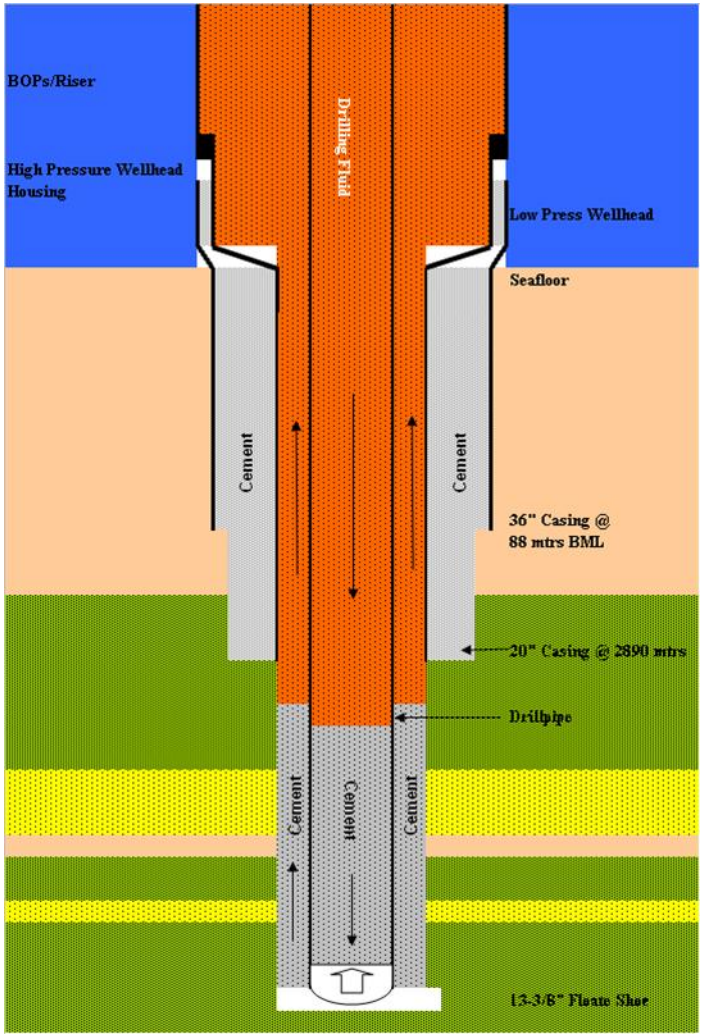
Purpose

- **Provide Formation Integrity to reach Objectives**
  - *Support Mud Column*
  - *Provide for Ability to control well*
  - *Not Conducive to Logging (large hole)*
- **Typically set above first Well Objective**

Procedure

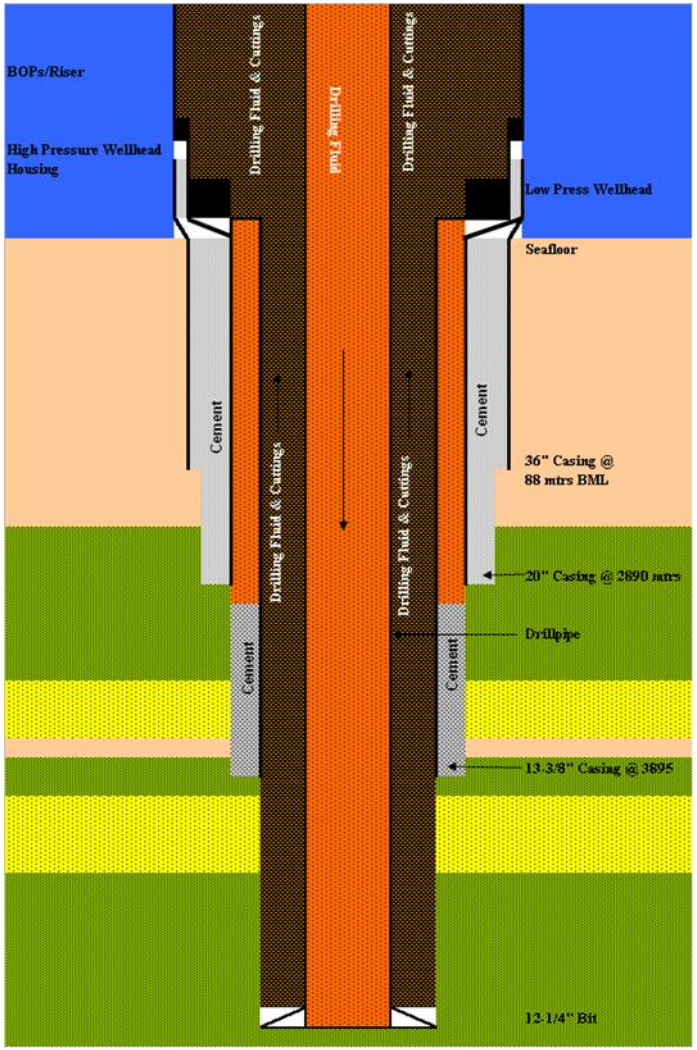
- **Makeup and run the 17-½" drilling assembly**
  - *Bit*
  - *Logging While Drilling Tools / lWT*
  - *Drill collars & stabilizers*
- **Displace well to Low Toxicity Synthetic Base Mud (LTSBM)**
  - *Effectively Inhibits Hydrate Formation*
  - *Stabilizes reactive formations*
  - *Minimizes Hole Problems relative to Water Based Mud*
- **Drill 20" shoe track, perform Leak-off Test (LOT)**
- **Drill to casing point & condition mud**
- **Trip out of hole for casing**

Execution: (5) Run & Cement 13-3/8” Surface Casing



- Make up 13⅝” casing, casing hanger and packoff
- Run 13⅝” casing on drill pipe
- Lower the 13⅝” and land the casing hanger in the HPWH
- Pump cement
- Release running tools
- Set & pressure test annular packoff
- Remove landing string

Execution: (6) Drill 12-¼" Hole



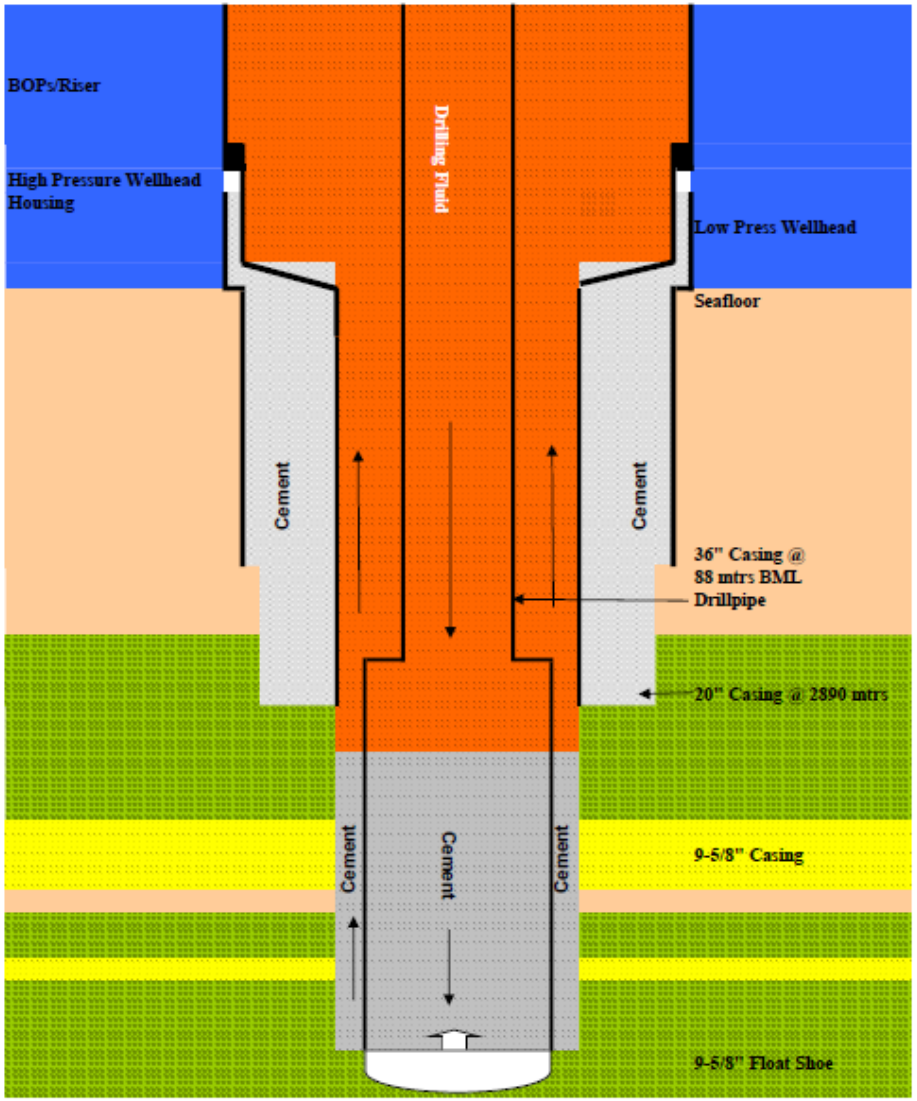
Purpose

- Provide Formation Integrity to reach Objectives
  - *Support Mud Column*
  - *Provide for Ability to control well*
  - *Conducive to Logging*
- Typically TD Hole Size
  - *Full Wireline Evaluation Capability*

Procedure

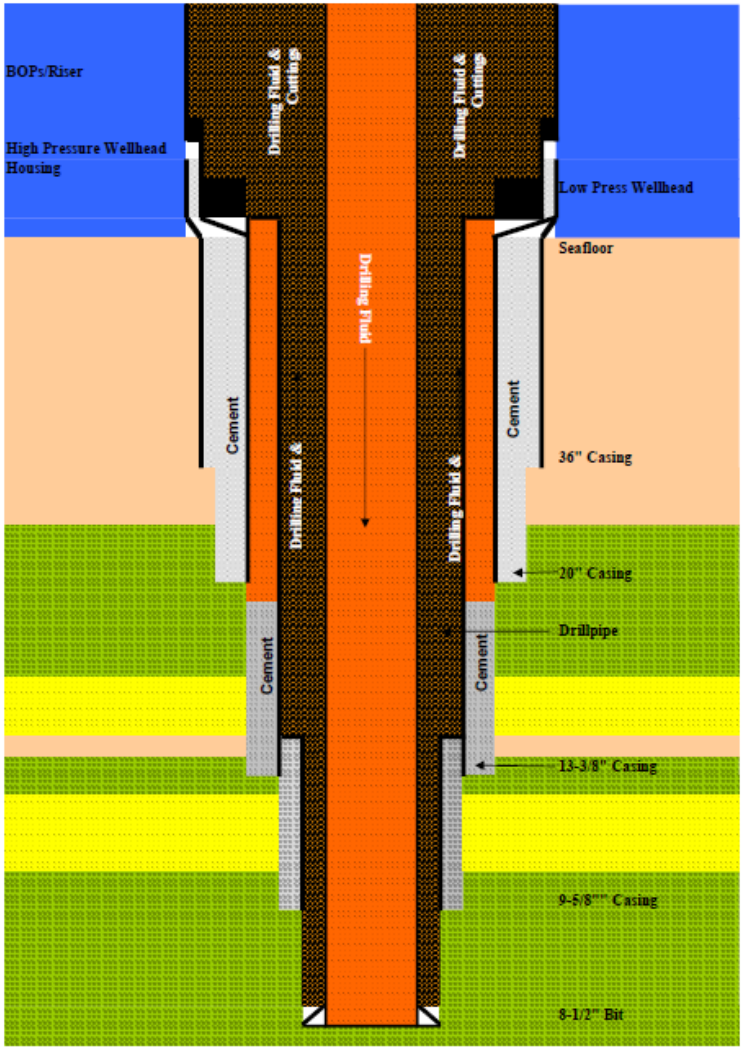
- Makeup and run the 12¼" drilling assembly
  - *Bit*
  - *Logging While Drilling Tools*
  - *Drill collars & stabilizers*
- Drill 13-3/8" float equipment
- Test BOP if required
- Perform LOT to ascertain good cement job and formation integrity
- Drill to next casing point
- Circulate and condition mud
- Trip out of hole for formation evaluation logs

Execution: (7) Run & Cement 9-5/8” Liner



- **Setting Depth Based on Pore Pressure/Fracture Gradient**
- **Drilled with LTSBM**
  - ***Full Wireline Evaluation Capability***
- **Full Well Control Capability**
- **Top of Cement to Liner Top**

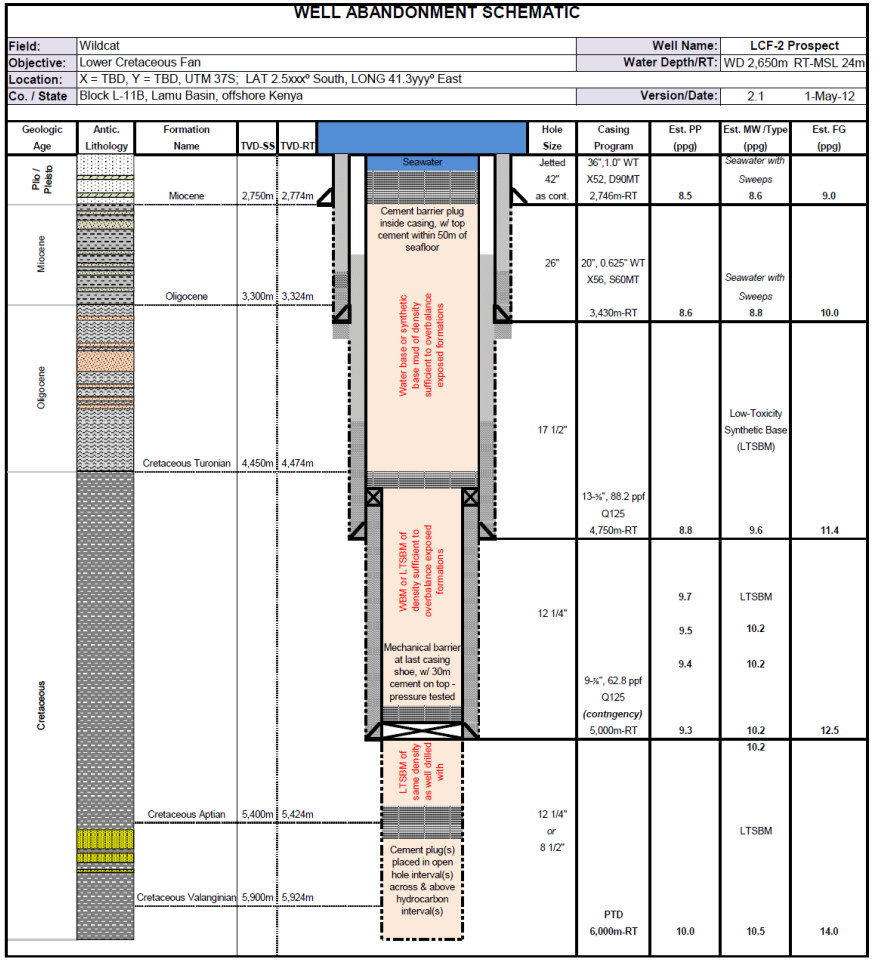
Execution: (7) 8-1/2” Production Hole (If Required)



- Total Depth based on Exploration Objectives
- Full Wireline Capability
- Full Well Control Capability
- 7” Liner Material Available if Justified
- Ideally used as a Contingency hole section in order to “Manage the Unknowns”

Execution: (8) Abandonment

- **Isolate exposed formations in the well bore with tested mechanical barriers**
  - *Utilize cement plugs (gray) in open hole – placed opposite and above hydrocarbon intervals, leaving -*
  - *'Void' intervals filled with drilling fluid of sufficient density to overbalance exposed formation after the riser is removed*
  - *Utilize a combination of cement and mechanical plugs inside casing*

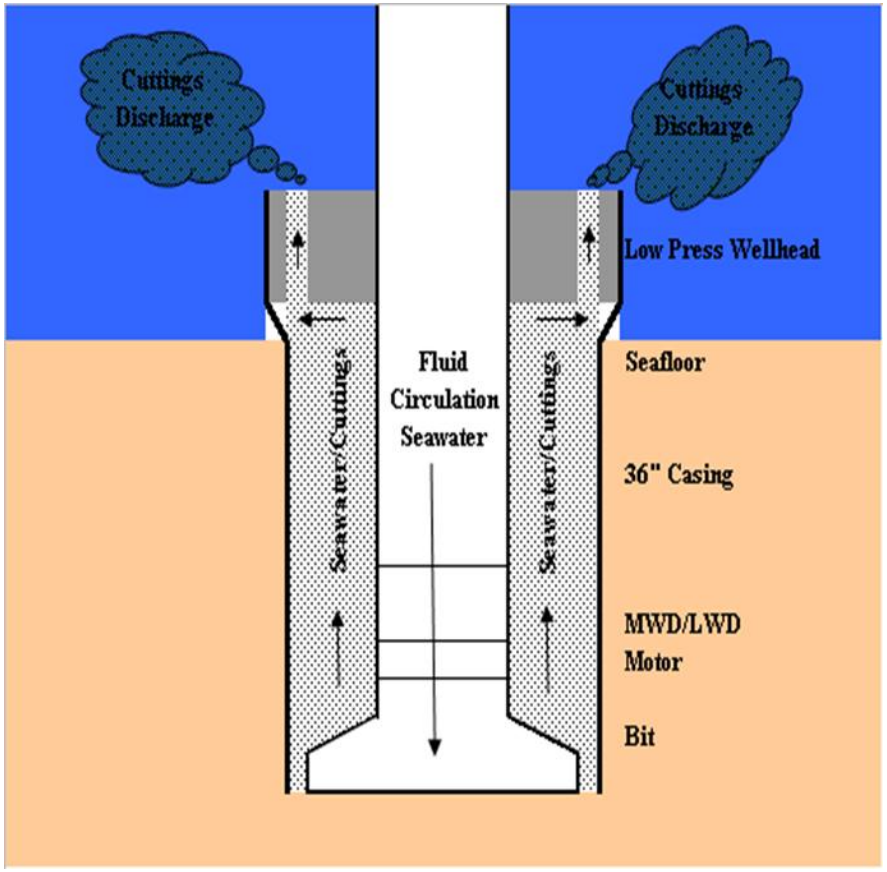


DeMobilization

- ROV performs a site survey prior to departure from location to ensure the seafloor is clear
- Rig will recover DP beacons or anchors depending on rig type
- Rig will then travels to it's next location either in Columbia or exit the country

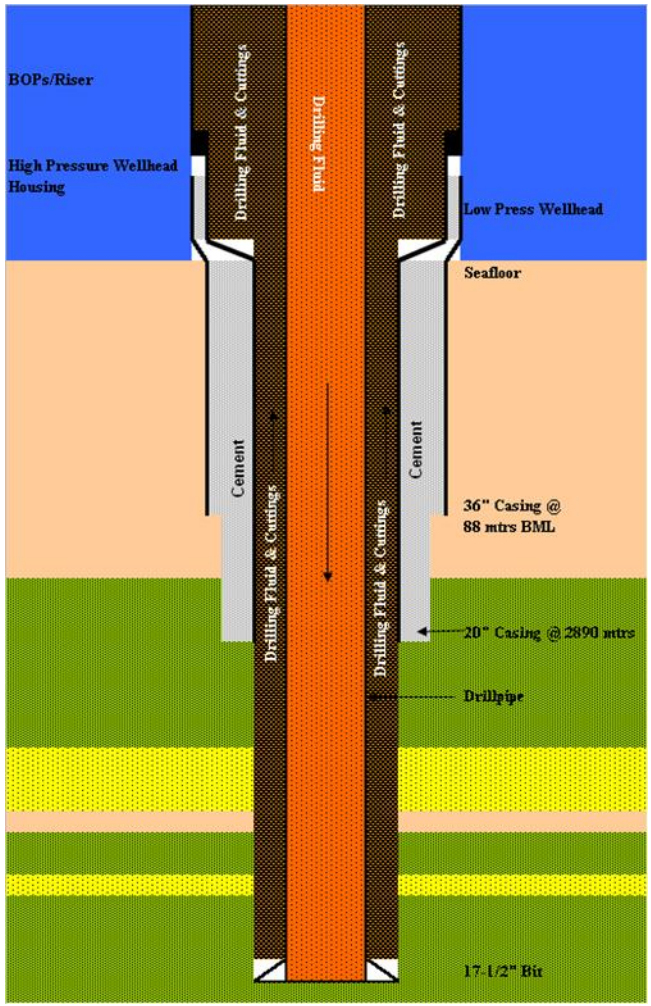
Treatment and Disposal of Drilling Fluid

- **Top Hole**
  - *Seawater is used to drill the top hole sections and is circulated back into the ocean*
  - *There is no riser connected at this point, therefore the cuttings settle to the seafloor naturally*
  - *The seawater is not treated but occasional non-toxic viscosified sweeps are pumped to flush the cuttings from the wellbore*
  - *Before running the casing string, water based mud is pumped into the hole to provide hole stability until the casing is in place*



Treatment and Disposal of Drilling Fluid

- **Intermediate and Production Hole Sections**
  - *LTSBM is used to drill these sections to prevent hydrates and to prevent hole stability issues from sensitive formations.*
  - *The mud and cuttings are circulated back to the rig through the riser were the cuttings are separated through a series of equipment.*
  - *After separation, the mud is cleaned and re-conditioned and the formation drill cuttings are disposed of in the ocean.*
  - *At the end of the well, all LTSBM is either re-injected or sent back to shore to be recycled or disposed of at dedicated waste treatment facilities.*



Drilling Fluid Circulating System