# Flambouyant-02 P&A Overview
# BP Trinidad & Tobago LLC

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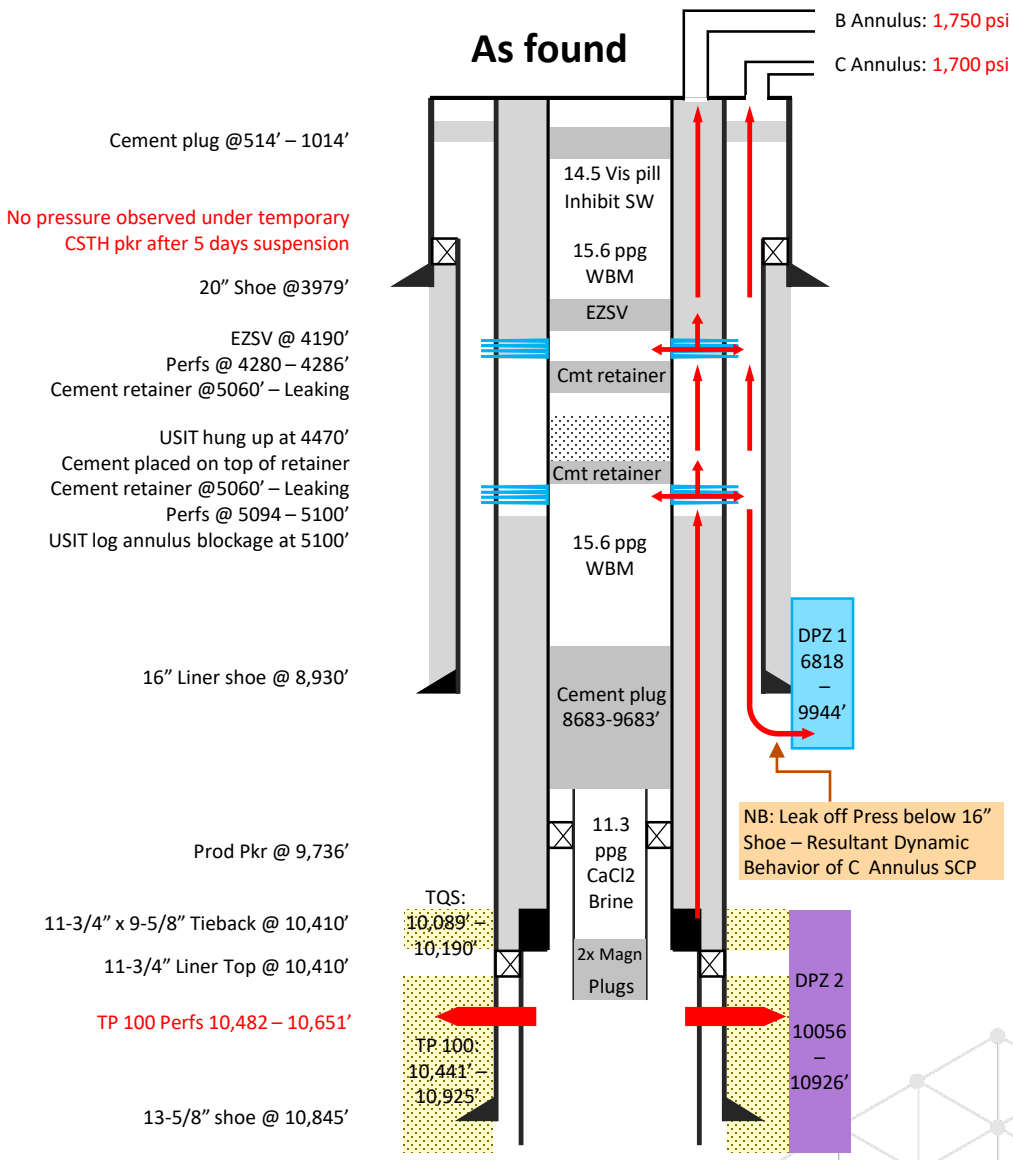
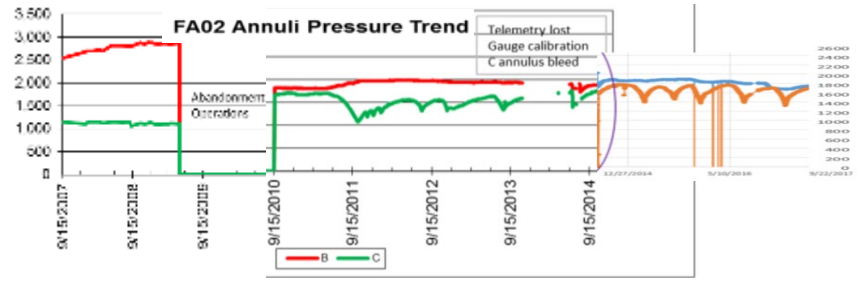
# Flam-02 P&A - Problem Definition



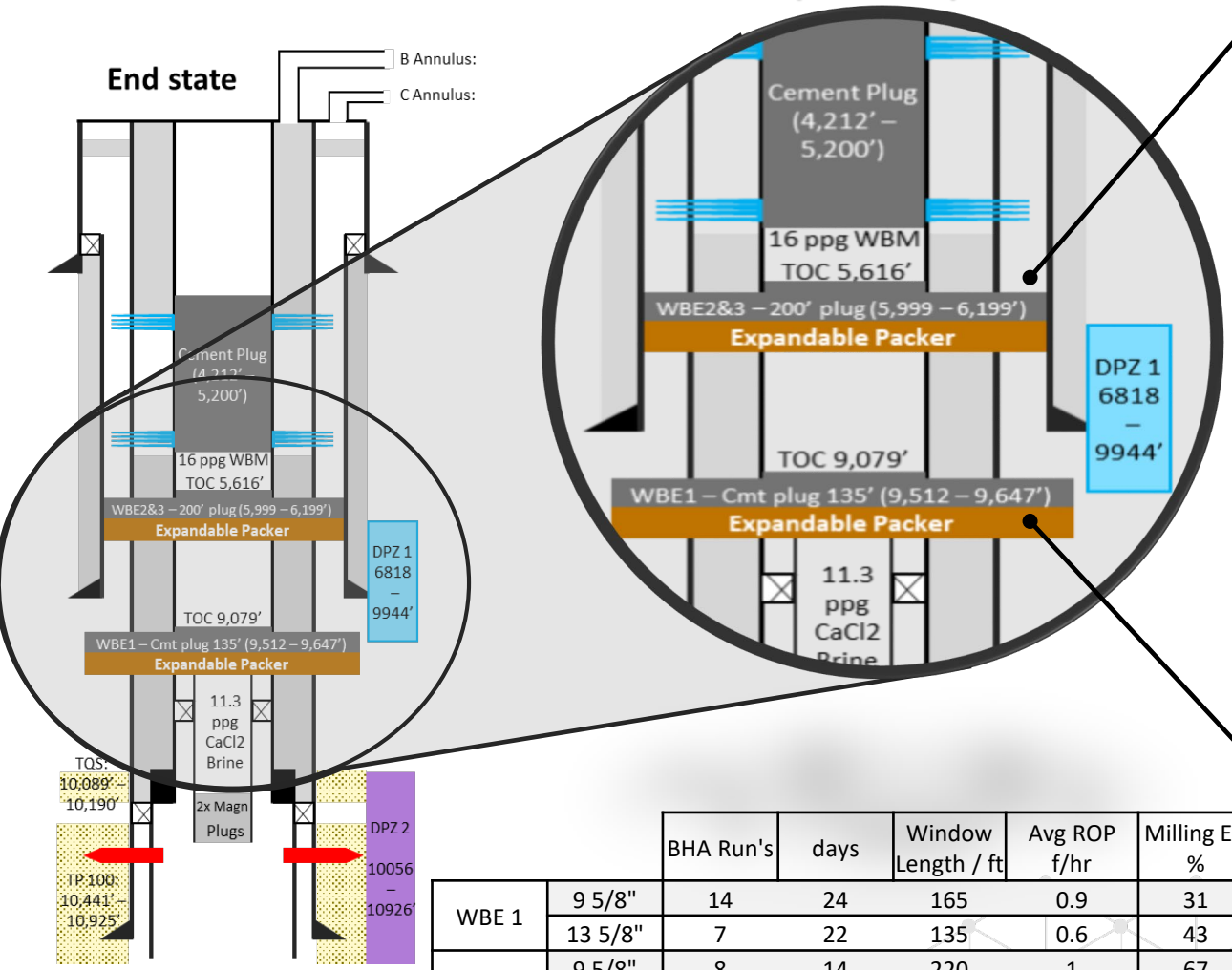

- Flambouyant Gas and Condensate Field, discovered in 1993 was developed with 5 wells.
- The Flambouyant A-02 (FA02) well exhibited sustained casing pressure (SCP) on two of the well's annuli
- An attempt in 2009 was made to abandon the well, but the annuli's SCP returned and now appeared to be in communication with one another
- The 2018 P&A required innovative approaches to isolate the plausible / multiple flow paths and maximum possible pressures to surface

# Flam-02 Technology Deployed

- **Snubbing Unit:**
  - Wellbore pressure management during well re-entry and wellbore access - P&A cement and mechanical bridge plugs mill out while applying back pressure via a dedicated downstream choke manifold.
- **Bleed Off Package:**
  - Casing annulus fluid handling through a controlled flow back package with flaring capability
- **Distributed Acoustic Sensing (DAS):**
  - To assist with identification of the source of flow behind casing strings and with external annuli barrier verification.
- **Dual casing section milling:**
  - Milling the inner 9-5/8" casing without compromising the outer 13-5/8" casing and milling the outer 13-5/8" casing passing through the 9-5/8" window in an under-reamed stabilized fashion. A total of ~720' window milled.
- **Swarf Management:**
  - To facilitate metal swarf removal from the mud system through a diverted flow return system
- **Expandable Packers:**
  - To provide a full bore reliable base for the cement plugs. Ran through the 9-5/8" casing and expanding to set in ~17-1/2" open hole or 16" casing ID.
- **Cementing Spray Valve:**
  - To improve fluid displacement & cement placement efficiencies laterally across the milled window section.

# Dual Casing Section Milling

## Well Barrier Elements (WBEs)




| | | BHA Run's | days | Window Length / ft | Avg ROP f/hr | Milling Eff % |
|---|---|---|---|---|---|---|
| WBE 1 | 9 5/8" | 14 | 24 | 165 | 0.9 | 31 |
| | 13 5/8" | 7 | 22 | 135 | 0.6 | 43 |
| WBE 2&3 | 9 5/8" | 8 | 14 | 220 | 1 | 67 |
| | 13 5/8" | 4 | 11 | 200 | 1 | 78 |

### 9-5/8" Inner Casing

- **Casing Cut out Run:** Milling Vendor 7.750" OD CSM dressed for 9-5/8" Casing Cut out (~ 4 ft)
- **Casing Sect Mill Run:** Milling Vendor 5.5" OD CSM dressed for 9-5/8" casing milling
- **Casing Scraper Run:** Milling Vendor 7.750" OD Medusa Tool dressed to clean the ID of 13-5/8" Casing

### 13-5/8" Outer Casing

- **Casing Cut out Run:** Milling Vendor 7.750 OD Medusa Tool dressed to provide $13^5/_8$" Casing Cut out (~ 4 ft)
- **Casing Sect Mill Run:** Milling Vendor 7.750 OD Medusa Tool for 13-5/8" Casing Section Milling Run
- **17" Open Hole Under-reamer Run:** Milling Vendor 17.750" OD Milling Vendor CSM Assembly with Under Ream Blades for a maximum opening diameter of 17" for Under-Reaming the Shale.

### WBE #2/3 Interval:

- $9^5/_8$", 53.5 lb/ft, P110, Seal Lock HC Couplings
  - IBC log showed some standoff between $9^5/_8$" to $13^5/_8$"casing
  - No recorded centralizers
- $13^5/_8$" 88.2 lb/ft, Q125, NJO connections
  - 16" , 84 lb/ft, N80, XLF, Casing on external of $13^5/_8$"
  - No recorded centralizers

### WBE #1 Interval:

- $9^5/_8$", 53.5 lb/ft, P-110, NJO connections
  - IBC log showed some areas of tight $9^5/_8$" to $13^5/_8$" proximity
  - No recorded centralizers
- $13^5/_8$" 88.2 lb/ft, Q125, NJO connections
  - TQ 18 Shale and TQ 17 Sand on the external of the 13 $^5/_8$" Casing
  - No recorded centralizers

### Highlights:

•1st BP deployment of dual string section milling and 1st global deployment of 13-5/8" Q-125 dual string section milling

•Able to save 3 trips by using milling tool to scrub casing at end of milling run (lower 13 5/8" scrub, upper 13 5/8" scrub and upper 16" scrub)

### Challenges:

•Difficult application to un-centralized flush joint casing in full contact with outer casing

•Erosion issues with downhole tools

•Operational variables including milling fluids, hole cleaning/swarf removal and tuning of optimum parameters

•Departures from recommended best practices and/or operational procedures

# DAS Objectives & Scope

**Objective:**

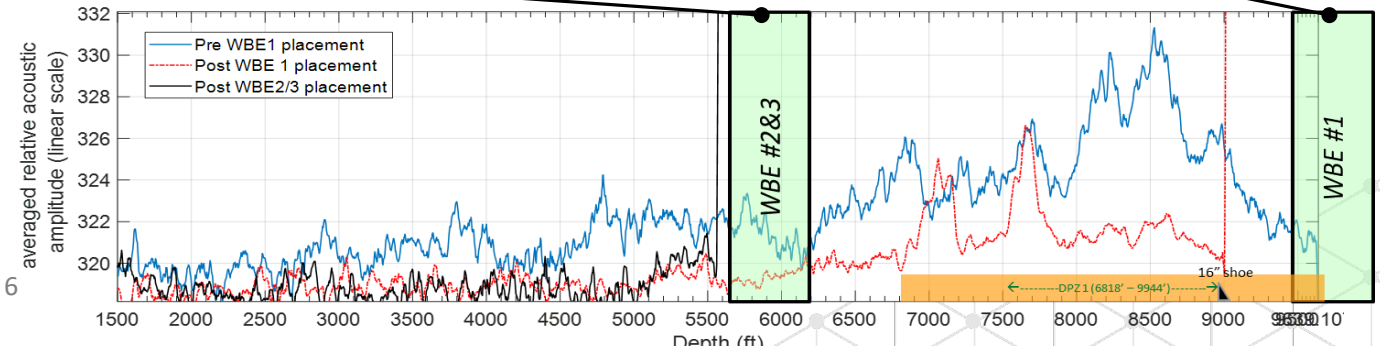
- To aid in the verification of the installed barriers on Flam-02, by comparing the pre and post placement of same via noise interpretation

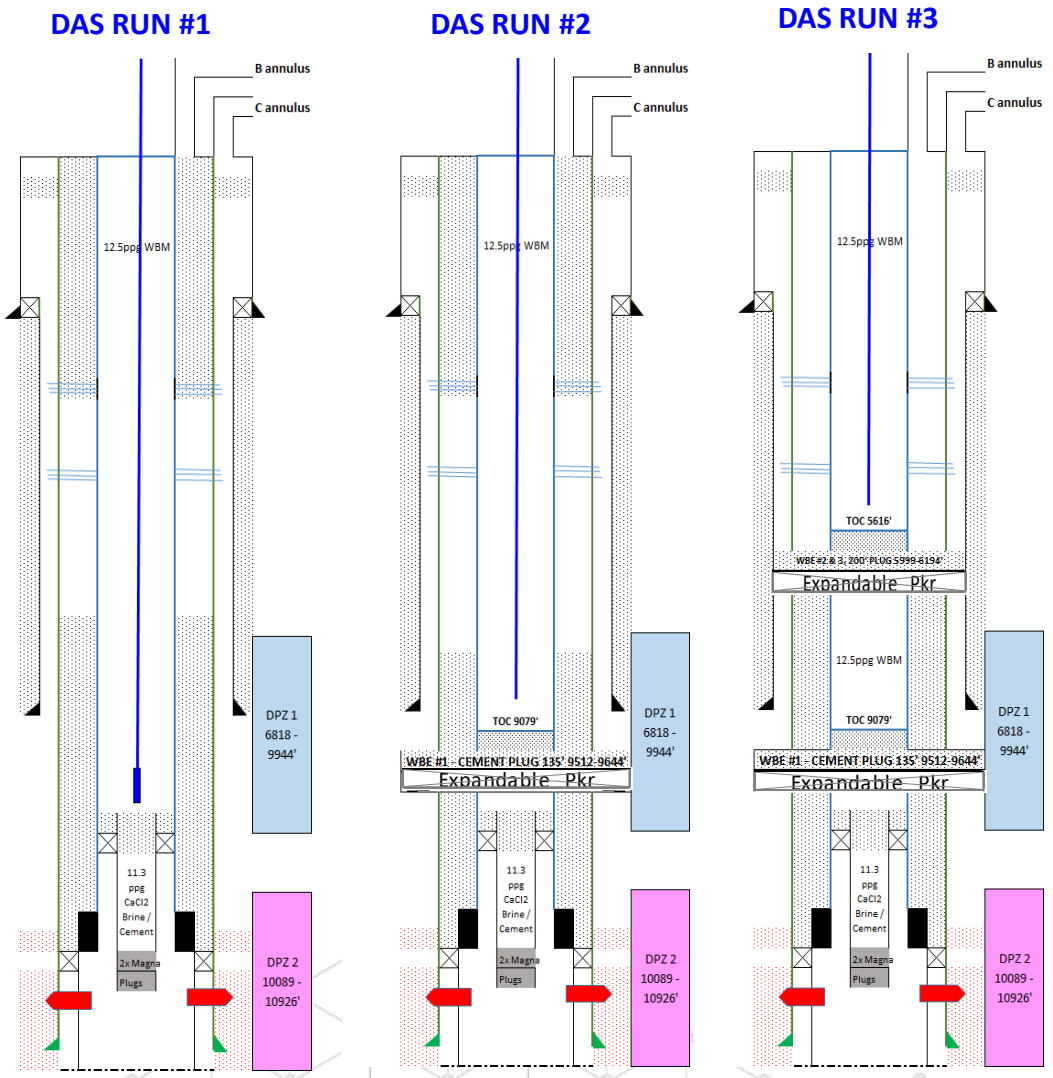
**Scope:**

- Deploy DAS log via Wireline Vendor "Hepta" cable which is designed to use wireline logging tools plus has two fiber optic cores within. This allowed IBC and DAS logging on the same logging run.
- Perform DAS logging 3 times:
  1. Baseline (pre Well Barrier Element (WBE) placement phase)
  2. Post WBE #1 placement
  3. Post WBE #2&3 placement
- Each DAS run comprised of 3 phases of 6 hours each:
  1. Baseline (no wellbore or annuli activity)
  2. Bleed C annulus (no other wellbore or annuli activity)
  3. Bleed B annulus (no other wellbore or annuli activity)

WBE #2&3 installed:
-Little / no acoustic noise captured in Run 3 in the baseline data post WBE #2&3 installation
-Similar behaviour observed in acoustic response in DAS Runs 2 and 3 in the baseline logs (as expected)
These observations indicate good barrier performance upon installation

WBE #1 installed:
-Run 2 indicated fluid movement behind 16" liner reduced significantly post WBE1 installation, indicating adequate isolation of leak pathway
-Acoustic flow noise captured above WBE1 indicates potential feed from perm zones (above WBE1)




Value to WBEs planning, placement and verification:
-WBE #1 Lateral Extension to Formation: DAS Run #1 showed noise trend indicating a communication adjacent to sealing shale behind the 13-5/8" casing. Recommendation to mill out 13-5/8" casing for WBE #1.
-WBE #2&3 Position: DAS Run #1 & #2 data showed evidence of flow outside of 16" casing within DPZ1, dropping to background noise at just below the TQ50 shale. Recommendation to move WBE #2&3 to a shallower interval from initially planned deeper interval (lateral placement across to 16 in Liner adjacent to shale).
-Verification of WBE #1 and WBE #2&3 isolation: Reduction in noise post WBE installation provided further support of adequate WBE placements

# Conclusion

Successful application of multiple technology enablers and enhancers to a complex well abandonment:

- **Snubbing Unit:**

  Risk of shallow wellbore pressure managed during well re-entry and wellbore access operation.

- **Bleed Off Package:**

  Casing annulus pressure and flow back of associated fluid managed over the abandonment operation

- **Distributed Acoustic Sensing (DAS):**

  DAS technology added significant value to the WBEs planning, placement and annular verification

- **Dual casing section milling:**

  Dual casing string section milling enabled the lateral access for installing WBEs through inner 9 5/8" and outer 13 5/8" Casing strings

- **Swarf Management:**

  Enabled metal swarf removal from the mud system through a diverted flow return system

- **Expandable Packers:**

  Successfully deployed through inner 9 5/8" and outer 13 5/8" Casing strings across to 17 ½" open hole and 16" Liner ID to provide a base for cement plugs.

- **Cementing Spray Valve:**

  Enabled improved fluid displacement and cement placement laterally across the milled window section windows.