Hurricane’s journey so far

- **Hurricane founded**
- **2004**
  - Whirlwind 205/21a-5
- **2009**
  - Lancaster 205/21a-4Z
- **2010**
  - Lancaster 205/21a-4
  - Lincoln 205/26b-12
- **2011**
  - Halifax 205/23-3A
  - Warwick Crestal 205/26b-B
- **2012**
  - GWA farm-out
  - Warwick Deep 205/26b-13Z
  - Lincoln Crestal 205/26b-A
  - 5 wells drilled to date, 2 on production
- **2013**
  - Lancaster 205/21a-6
  - Lancaster EPS First Oil
- **2014**
  - Lancaster EPS FID / FDP-approval
- **2015**
  - Lancaster 205/21a-7
- **2016**
  - Lancaster 205/21a-7Z
- **2017**
  - 204/30b-A
- **2018**
  - 2017
- **2019**
  - 2018

**Barcelona forum**
**Paris forum**
**Monaco forum**

- Spirit deal significantly accelerated GWA portion of portfolio
- Clear momentum towards full field development
Hurricane-Schlumberger Collaboration

- **Formation evaluation**
  - Conventional wireline tools
  - Electrical image logs
  - Acoustic image logs
  - Production logging tool

- **Production technology**
  - Well test isolation valves
  - Electric submersible pumps

- **Seismic interpretation**
  - Ant tracking

- **Petrophysical interpretation**
  - Techlog

- **Static modelling**
  - Petrel

- **Dynamic modelling**
  - Intersect

- **Production data**
  - Avocet

- **Geo database**
  - Studio

Good working relationships with the right people
The Lancaster Field
Fractured Basement

- Basement is the igneous or metamorphic rock underlying the sedimentary cover
- Often found as ‘buried hill’ structures
- This is an outcrop analogue for Lancaster on the Isle of Lewis (on a surprisingly dunny day)
Fractured Basement

- Fractured basement is a Type 1 Naturally Fractured Reservoir (NFR)
- All porosity and permeability is associated with fractures
Fracture Imaging

- Hurricane use Schlumberger wireline tools
  - FMI (electrical image log)
  - UBI (acoustic image log)

- Currently evaluating Schlumberger LWD image logs for use in horizontal wells where wireline is not practical

- Fractures typically categorised as discrete Joints or non-discrete Microfractures
Flowing Joints

- Schlumberger FSI production logging tool
- Wide aperture joints dominate inflow on PLT, though smaller joints flow too
Well Test Responses

- Highly productive discrete fractures (joints) dominate early time after storage response
- Supportive non-discrete fractures (microfractures) cause a dual porosity response
Modelling Lancaster
Fault Identification

- Ant Tracking in Petrel used to support manual seismic interpretation of faults

- Good correlation with log-derived fault interpretation
  - Indicates faults are largely near-vertical as Ant Tracking displayed on Top Basement surface
Lancaster Fault Model

- Roughly 740 modelled faults
- All modelled vertically – acceptable approximation and makes pillar gridding and simulation easier
Fault Zone Variation

- Constructing detailed fault model and maintaining 10m x 10m grid spacing enables Fault Zone widths to be varied stochastically using Distance to Fault property.
Intersect Simulation

- With Schlumberger’s assistance, Hurricane was an early adopter of Intersect

- Intersect allows Hurricane to model this large and complex field at geological resolution (10m x 10m grid cells)

- Uncertainty cases constructed – how will the EPS performance compare to these modelled cases?
  - It is still too early to say, at least 6 months of stable production is required
Moving Forwards with the Simulation Model

There are two main elements to address in the simulation model:

1. **Simulation Performance**
   - Intersect can handle large models, hardware can be a constraint
   - Working with Schlumberger on some solutions – combination of optimising the model and assessing hardware requirements

2. **New Data**
   - EPS is providing significant high quality dynamic data to incorporate into the simulation model
Simulation Performance
Layering Improvements

• Overcoming legacy issues with modelling aquifers and constraining zones to OWC cases in the next iteration of the model
Layering Improvements

• Performance negatively affected by unintended thin layer – effect of zone / layer control

• Problem becomes more noticeable when introducing other complexities to the model

• Rebuilding model from ground up
Simulation Well Paths

As-drilled trajectories

Simulation trajectories

- As-drilled trajectories not perfectly horizontal
- Causes performance issues as they cross layers
Simulation Well Paths

• Simplifying the trajectories has a marked improvement in simulation performance and almost no impact on the simulation results

• Shows that it is worth returning to simulation models with fresh perspective

• There is still learning to do on how the model works
New Data – The Lancaster EPS
## EPS Objectives

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td><strong>Data</strong></td>
<td>To provide long term production data to enhance understanding of reservoir characteristics and associated full field development scenarios</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td><strong>Commence phased development</strong></td>
<td>Commence development of the resources in a phased manner with regard to managing uncertainties over reservoir characteristics and associated development risks</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td><strong>Financial return</strong></td>
<td>Deliver an acceptable return on investment</td>
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Average production rate of c. 14,400 bopd from First Oil to latest lifting on 17 August

1.2 million barrels of crude oil sold to date

High quality data obtained, opportunities for multi-rate interference tests and extended pressure build up periods to compare with DST results

Start-up phase objectives

- Ability to flow / shut-in the wells for longer than DST
- Ability to evaluate well interference for the first time
- Test flow assurance assumptions
Interference Data

- Proximity of the two wells allows for gathering of interference data, varying rates in one well and observing response in the other

- Wells are communicating with each other

- Analysis of this data is ongoing to try and determine dominant flow direction – do we need to model permeability anisotropy in our simulations?
205/21a-6 – 2014 vs. 2019

- PTA shows clear improvement in productivity index
- Late time data shows different reservoir behaviour away from wellbore
- 5 year shut-in has led to significant improvement in well productivity

<table>
<thead>
<tr>
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<th>DST 2014</th>
<th>EPS 2019</th>
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<tbody>
<tr>
<td>ESP flow (bopd)</td>
<td>9,800</td>
<td>n/a</td>
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<tr>
<td>Natural flow (bopd)</td>
<td>5,300</td>
<td>16,500</td>
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<tr>
<td>PI (stb/d/psi)</td>
<td>160</td>
<td>205</td>
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205/21a-7Z – 2016 vs. 2019

- PTA shows clear improvement in productivity index
- Late time PTA behaviour similar between DST and EPS
- 3 year shut-in has led to significant improvement in well productivity

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<thead>
<tr>
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<th>DST 2016</th>
<th>EPS 2019</th>
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<tr>
<td>ESP flow (bopd)</td>
<td>15,375</td>
<td>n/a</td>
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<tr>
<td>Natural flow (bopd)</td>
<td>6,520</td>
<td>16,500</td>
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<tr>
<td>PI (stb/d/psi)</td>
<td>147</td>
<td>190</td>
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205/21a-7Z Water Production

- Some water production has been observed from well 205/21a-7Z
- Hurricane’s assessment is that this represents trapped or perched water, stranded within the oil column
  - Drawdowns are low, unlikely to be lifting water from the aquifer
  - Behaviour does not appear to be a classic water cone
  - 205/21a-6 remains dry
- The presence of trapped water was expected by Hurricane
- We are looking at how we can model this in the future – it is a challenge to incorporate in the current simulation
Lancaster Reservoir Behaviour

• The Lancaster reservoir appears to be quite unique

• Both wells display improved performance compared to the well test results

• High quality data gathering remains the top priority for planning future development on the field

• Work continues with Schlumberger to help incorporate this new data into the simulation model
The Future
### Future Development Phases

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<th>2019</th>
<th>2020</th>
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<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
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<td><strong>Greater Lancaster Area</strong></td>
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<td>EPS development</td>
<td>Development</td>
<td>Host mods.</td>
<td>Throughput capacity increase</td>
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<td>Gas export</td>
<td>Gas export solution</td>
<td>First gas export</td>
<td>Gas production</td>
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<td>Full field development</td>
<td>Well planning</td>
<td>Additional Rona Ridge wells</td>
<td>FEED</td>
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<td><strong>Greater Warwick Area</strong></td>
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<td>Drilling</td>
<td>1x Lincoln HZ</td>
<td>Well Planning</td>
<td>3x Appraisal / prod. wells</td>
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<td>Preparation, LLs</td>
<td>Development</td>
<td>First Oil</td>
<td>GWA FFD FID</td>
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<td><strong>Whirlwind</strong></td>
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<tr>
<td>Appraisal</td>
<td>Concept studies</td>
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<td>TBD</td>
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</tbody>
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*Hurricane | The Lancaster EPS - SIS Global Forum 2019 | 17 September 2019*
The Future

- Hurricane intends to continue its plan to de-risk the fractured basement play West of Shetland

- Future developments on our neighbouring assets will benefit from data gathered from the Lancaster EPS

- Continued collaboration with select partners, such as Schlumberger, will continue to be crucial to Hurricane’s success