Question 4 – Provide a vertical/section plan indicating the extent of the proppant squeeze.

Reason: The application refers to a various primary and secondary targets which are offset in the vertical axis. It is unclear which geological unit(s) the proppant will be undertaken in and how this relates to the estimated height of 40-80m. For example, the Kirkham Abbey Formation is described as a secondary target however there is >40m TVDS difference between this formation and the Primary Targets in the Carboniferous sandstones.

The plan should present, but not be limited to, the formations above and below the targeted horizons.

The Cloughton-1 well found gas bearing sandstones over a large column height. Gas was encountered over a distance of over 4000ft of measured section. There are multiple sands within the Carboniferous section with each sand being gas bearing. One large continuous gas column is not expected however as no large overpressure was noted in the Cloughton-1 well. Instead each sand is believed to be gas bearing and isolated from sands above and below. All sands within the Cloughton-1 well found a gas down to with the uncertainty on the actual Gas Water Contact providing some uncertainty on the volume of gas in place (stacked pay). The well was tested from 3 different zones with sands towards the top, middle and base of the hydrocarbon bearing section tested. The best zone was flowed from the base of the well at 20,000 Mscf/d. It should be noted that these were conventional tests (with no reservoir stimulation) with the flow rates proving gas in multiple levels but the sandstones had low porosity and permeability and commercial flow rates could not be achieved.

Mathematical models to design a hydraulic fracture treatment provide a very sophisticated model to predict fracture growth. It is standard practice to first design the treatment based on analogue data collected from previous wells.

Modelling of the Cloughton proppant squeeze operation has been performed by experts with significant experience in both hydraulic fracture modelling and operations across the world and have carried out proppant squeeze operations across the UK including at Europa's Wressle field in Lincolnshire without issue. This was in similar aged and quality rocks to those seen in Cloughton. A substantial uplift in flow rate was seen after the proppant squeeze in Carboniferous sandstones of the field.

For the proposed Cloughton-2 well the fracture stimulation design was based on the results of the Cloughton-1 well. Similar sands are expected within the Carboniferous section of the Cloughton-2 well. Fluvial sands are expected with similar ranges of thickness, porosity and permeability. A number of gas bearing sands from the Cloughton-1 well have been used to calculate the proppant squeeze conductivity. We have calculated a hydraulic fracture half length (horizontal distance) and a hydraulic fracture height within 4 possible targets at two conservative permeabilities (0.4 and 0.04mD) based on core date from the Cloughton 1 well. The derived fracture dimensions are used in the evaluation provided for the Cloughton-2 well.

Within the vertical model the suggested hydraulic height at the well has been used based on this modelling. The range of vertical height is between 65-80m depending on the sand quality and the thickness of the sand modelled. Please see the figure below.

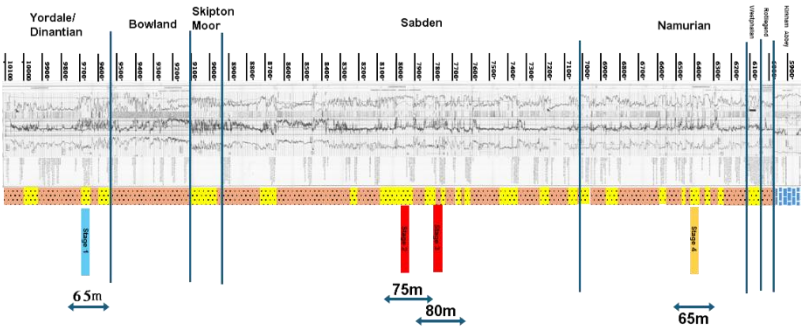
The left hand side of the diagram shows the Cloughton-1 well with the significant vertical gas bearing Carboniferous logged section (presented on it's side). The simplified stratigraphy is shown with sands (yellow) separated by intervening shales and coals (pink). These are individual sands with the shales acting as top and base seals for each sandstone. Four zones modelled are highlighted as Stage 1,2,3 and 4. The fracture height of each operation is shown. Only sands with a significant thickness, hydrocarbon saturation and reservoir quality will be viewed as potential proppant squeeze targets. As can be seen from the diagram each proppant squeeze will generally only affect the sand in question where the technique is applied, however where sand thickness is small the overlying and underlying sand may also be affected. Ultimately the proppant squeeze will die out in the over

and underlying shales. These shales are plastic in nature and impermeable so will resist fracture opening and heal in a much shorter time than the sandstones. It is this plastic and impermeable nature that has created the multiple stacked pays within the section and has held it in place for millions of years.

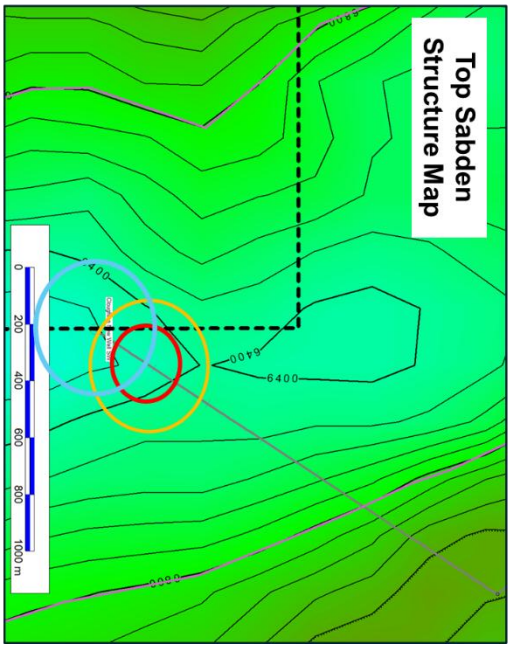
As can be seen from the diagram the overlying Kirkham Abbey formation is present above the Carboniferous section. This is often hydrocarbon bearing within the local area. Whilst a secondary target the Zechstein limestone (Brotherton and Kirkham Abbey) are often very low permeability and only flow at good rates where natural fractures are present. The secondary target will be ignored in this well if the primary target is successful given the propensity of the natural fractures in the limestone to produce water. Given the prognosed large number of potential sandstones that are available for a proppant squeeze within the Carboniferous there is no need to carry out a proppant squeeze within sands directly underlying the Zechstein formation. Any proppant squeeze in the Carboniferous sandstones directly in the vicinity of the limestones may compromise the performance of the well and will be avoided.

The fracture half-length was based on the reservoir characteristics of 4 sands. If similar sands are tested in the Cloughton-2 well then the frac half-length will be between 130-260m. For instance the deepest sand modelled within the Cloughton-1 well would have the largest half-length of 263m. Assuming the Cloughton-2 well has a similar sand distribution in the Carboniferous section the map **on the right hand side** shows the fracture length radius of invasion. NB the well is deviated which is why the centre of the circle “walks” down the well. The well bore is designed to fall back to vertical in the reservoir so if the proppant squeezes are carried out towards the base of the well they will overlie each other in an X/Y domain but will be separated from each other in the Z axis (depth).

Vertical Model
Offset Well Analogue. The Cloughton-2 well will drill a very similar section to the Cloughton-1 well except the Namurian section maybe thinner. The exact zones where a proppant squeeze will be attempted will be dependent on the result of the well. The thickest/best quality zones will be stimulated. As can be seen from Cloughton-1 there are more (gas bearing) sands than will be stimulated. Overlying each sand are shale packages and coals – the proppant squeeze will die out into these overlying and underlying formations. Sands directly underlying the Kirkham Abbey would be avoided.



Horizontal Model



Stage 1 Frac Half length = 250m

Stage 2 & 3 Frac Half length = 130m

Stage 4 Frac Half length = 263m