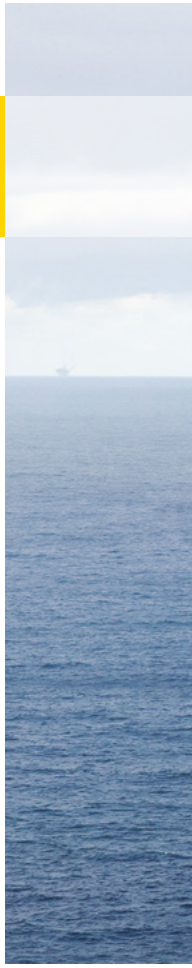
DECOMMISSIONING THE BRENT FIELD

The Brent oil and gas field lies off the north-east coast of Scotland, midway between the Shetland Islands and Norway. It is one of the largest fields in the North Sea and has four large platforms called **Alpha, Bravo, Charlie and Delta.**



When the Brent Field was discovered in 1971, it was one of the most significant oil and gas finds made in the UK sector of the North Sea. It helped to keep the lights on when energy was in short supply during the energy crisis of the 1970s.

Brent has been a cornerstone of the UK's hugely successful oil and gas industry for almost 40 years. It has created and sustained thousands of jobs, contributed more than £20 billion in tax revenue, and provided the UK with a substantial amount of its oil and gas. At its peak in 1982 the field was producing more than half a million barrels a day. Its production that year would have met the annual energy needs of around half of all UK homes.

At the time of its discovery, the expected life span of the field was 25 years. Continuous investment and a redevelopment in the 1990s by the field's equal partners, Shell and Esso Exploration and Production UK (Esso), extended the life of the field well beyond its original expectations. The 40th anniversary of production is in November 2016.

RETIRING BRENT

Now, after many years of service to the UK, the Brent Field has reached the stage where almost all the economically recoverable reserves of oil and gas have been extracted. The next step in the life cycle of Brent is to retire or "decommission" the field's four platforms and their related infrastructure.

This is a complex, major engineering project and is likely to take another decade to complete. It follows the decommissioning of other operators' platforms in the North Sea, with around 40 programmes submitted to the government's Department for Business, Energy and Industrial Strategy (BEIS) so far.

However, decommissioning the Brent Field does not signal the end of the UK's oil and gas production. Oil and Gas UK estimated in 2016 that there are up to 20 billion barrels of oil and gas still to recover.

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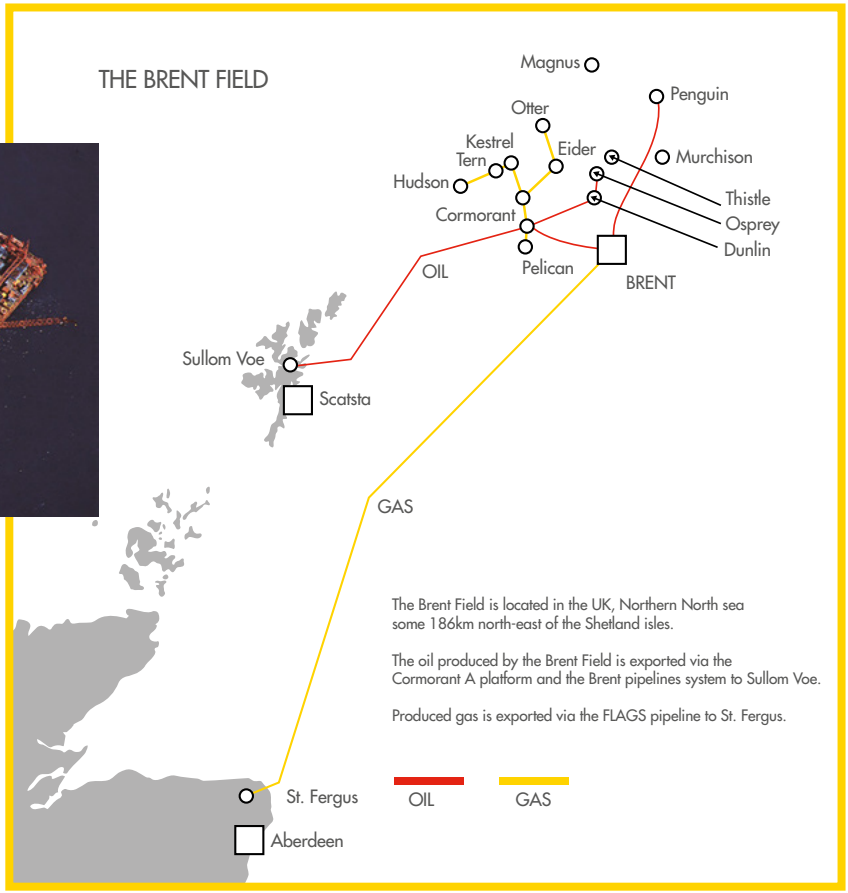
THE BRENT FIELD



The Brent Field is located in the UK, Northern North sea some 186km north-east of the Shetland isles.

The oil produced by the Brent Field is exported via the Cormorant A platform and the Brent pipelines system to Sullom Voe.

Produced gas is exported via the FLAGS pipeline to St. Fergus.

WHY DECOMMISSION?

The decision to decommission Brent is a natural step in the life cycle for the field. Having extended the field life for as long as possible, and before considering decommissioning options, Shell explored potential ways to reuse the platforms. This ranged from using the field for carbon capture and storage facilities to wind farms.

After a thorough review, Shell concluded that reuse was not a credible option, due to the age of the infrastructure, its distance from shore, the lack of demand for reuse and the cost of modernising the facilities. It was clear that decommissioning the field was the only viable option.

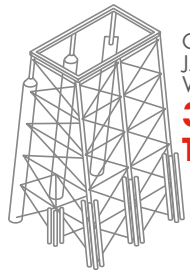
Brent will be one of the largest decommissioning projects undertaken in the North Sea and offers the opportunity to develop specialist skills and gain expertise that could be exported worldwide. Following competitive tendering processes, several major contracts have been awarded to UK companies and more than 80% of the project's supply chain is in the UK.

Shell has been working for more than 10 years on the long-term planning necessary to stop production and then decommission the Brent Field. This has involved in-depth work with government and interested stakeholders. The Brent platforms will cease producing at different times, which adds a further layer of complexity to decommissioning plans: Brent Delta stopped in December 2011; Alpha and Bravo in November 2014; and production on Charlie is expected to cease within the next few years.

DECOMMISSIONING CHALLENGES

The decommissioning of the Brent platforms is unprecedented in size and scale. The age and design of the infrastructure adds to its complexity. At the time of their construction, decommissioning was not at the forefront of people's minds. But since then, legislation and technology have changed, and offshore installations built in the north-east Atlantic after 1999 are now designed to be completely removed. Additional challenges are the field's distance from shore at 186 km and the harsh conditions of the North Sea.

THE BRENT FIELD INFRASTRUCTURE HAS:



ONE STEEL JACKET WEIGHING **31,500 TONNES**

103km **OF PIPELINES**

64 OIL STORAGE TANKS – each taller than Nelson's Column

Four "topsides" that house the accommodation block, helipad, drilling and other operational areas with a combined weight of more than **100,000 tonnes**

Three concrete "gravity base structures" (GBS), weighing more than **300,000 tonnes** each, used to anchor the topsides to the sea bed

154 WELLS

The complexity of decommissioning Brent requires advanced engineering and significant investment.

The complexity involved in decommissioning Brent requires ingenuity, innovative engineering and significant investment. Yet, already, these engineering challenges are leading to the deployment of new technologies, such as lifting the Brent Delta topside in one piece. This will be carried out by a new vessel named the 'Pioneering Spirit' that has been designed and constructed by Allseas, a Swiss-based company.

Each option for decommissioning the different parts of the infrastructure involves weighing up the risks, challenges and benefits. In preparing for decommissioning, Shell has maintained an unrelenting focus on safety and the environment, and carried out an extensive and thorough process of stakeholder engagement with a wide range of interested parties.

WHAT SHELL IS REQUIRED TO DO

Decommissioning follows a tightly defined regulatory process that is stipulated in the UK's Petroleum Act 1998 and regulated by BEIS. As the operator of the Brent Field, Shell must submit a Decommissioning Programme to BEIS for review, followed by public consultation.

This will include Shell's recommendations for closing down and making safe the four platforms, the wells and the subsea infrastructure. These recommendations are the result of 10 years of research involving engineering studies, expert input, consultations and scientific assessments.

The OSPAR Convention provides the framework for protecting and conserving the north-east Atlantic (including the North Sea). Within OSPAR, 15 governments and the EU co-operate to protect the marine environment of the North-East Atlantic.

Within its Decision 98/3, the OSPAR Convention recognises that there are difficulties in removing major installations, such as concrete gravity base structures and large steel jackets. In these instances, operators may make a case for exemption – called 'derogations' – from the general rule of complete removal from the sea. These have been granted to North Sea operators in the past to leave structures similar to parts of the Brent infrastructure, in place.

PREPARATION FOR DECOMMISSIONING

For more than 10 years, Shell has carried out a thorough, transparent and in-depth process of stakeholder engagement with interested parties in the decommissioning process. This involved discussing and informing stakeholders of the different risks, challenges and benefits of the various elements of decommissioning.

More than 180 organisations across Europe have been engaged. This has included non-governmental organisations such as environmental groups, government representatives and bodies, academics and professional institutes, fisheries organisations, oil and gas industry bodies and business associations, as well as media and community groups.

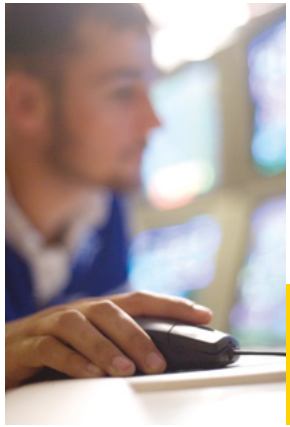
The discussions have enabled stakeholders to share their views and concerns, which Shell has taken into account when assessing different options. Their expertise and input have made a valuable contribution to the project. Shell has also maintained transparent and open engagement with stakeholders throughout the preparations. This has included individual visits to stakeholders and the hosting of larger stakeholder events, an online newsletter and a dedicated website.

In 2012, a specific stakeholder group, the Cell Management Stakeholder Task Group, was established, consisting of 15 stakeholders. They contributed to discussions on how best to decommission the contents of the large oil storage cells.

INDEPENDENTLY REVIEWED SCIENCE

When the Brent decommissioning work began in 2007, Shell and Esso asked Professor John Shepherd from Southampton University to head an Independent Review Group (IRG) for the project.

Professor Shepherd appointed a team of leading academics from across Europe, whose role has been to objectively review all the scientific and engineering assessments of the various decommissioning options proposed. The IRG validates the science which underpins Shell's conclusions.



DECOMMISSIONING THE BRENT FIELD: RECOMMENDATIONS

Decommissioning in the UK sector of the North Sea takes place under a mature regulatory process implemented by BEIS. Shell is preparing the following activities in line with these regulations:

- plugging and making safe all the wells in the Brent field;
- removing all four of the platform's topsides;
- recovering oil and gas debris; and
- removing the oil, known as 'attic oil', that is trapped at the top of some of the subsea storage cells.

For other parts of the field, regulations stipulate that an operator is required to complete a detailed process of comparative assessment to identify and examine the various options for decommissioning.

ELEMENTS DETERMINED BY REGULATION

DECOMMISSIONING THE WELLS

A significant proportion of decommissioning cost is incurred plugging and making safe the wells. There are 154 wells across the four platforms – some are 40 years old – and hundreds of wellbores across the field. Every well has to be sealed with cement barriers after the casings and well control equipment have been removed. This is done to ensure that the wells are isolated with appropriate seals to ensure no hydrocarbons are released.

The decommissioning of all wells on the Delta platform was completed by the end of 2014. Shell is now able to apply this knowledge to Bravo, Alpha and Charlie to make this process more efficient.

REMOVAL AND RECYCLING OF THE TOPSIDES

Each of the four platforms has a topside. This is the surface deck of a platform that contains equipment for drilling, producing and processing oil and gas, as well as the accommodation block and helipad. Each topside needs to be taken to shore for recycling and disposal.

The topside on the Brent Delta platform, weighing 24,200 tonnes, will be removed as one piece by the Pioneering Spirit. It is estimated that over 97% of the topsides will then be recycled once it is brought to shore.

REMOVING OIL AND GAS DEBRIS

The UK regulation and BEIS decommissioning guidelines requires removal of oil and gas debris from the seabed around the platform and along pipeline corridors. Remotely Operated Vehicles (ROVs) are being used to recover scaffold poles and other oil and gas debris into baskets, which are filled on the seabed, raised to the platform and shipped to shore for recycling or safe disposal.

REMOVAL OF "ATTIC OIL"

The quantity of oil trapped at the top dome of the storage cells is called "attic oil". This is unique to gravity base structures and this oil will be recovered using bespoke subsea technology.

On Brent Delta, this involves drilling a hole in each of its 16 cells and transferring the attic oil into one cell for shipping ashore. Safety is a key priority and using ROVs removes the need for divers to do the work.

COMPARATIVE ASSESSMENT

"Comparative assessment" is a detailed process that weighs up the pros and cons of various decommissioning options against key criteria identified by the regulator, BEIS.

Considerations for the comparative assessment include balancing the safety risks, the technical feasibility, societal impacts, the longer-term environmental impact and the cost.

Shell has conducted comparative assessments for the Alpha steel jacket, drill cuttings, pipelines, gravity base structures (GBS) and cell contents. The objective of these assessments is to show, on balance, which option provides the best solution.

ALPHA JACKET

Brent Alpha has a steel jacket platform that weighs around 31,500 tonnes. It was installed in 1976 and is the structure that supports the topside and anchors it to the seabed. Under UK regulations, the upper portion of the steel jacket must be removed.

However, a comparative assessment was carried out for the lower part, the footings. The difficulty in removing older structures weighing over 10,000 tonnes is recognised by OSPAR. After completing the comparative assessment, the recommendation will be to leave the steel jacket footings in place due to the engineering challenge and broader concerns associated with their removal. Leaving it in place will also allow the drill cuttings pile to be left to degrade naturally.

DRILL CUTTINGS

Drill cuttings are pieces of rock that are generated when a well is drilled. Up until the mid-1990s, discharge of cuttings to the seabed was permitted. The cuttings have formed piles on the seabed and also settled on and between some of the oil storage cells of the gravity base structures.

Over the years, legislation regarding the use and discharge of oil based muds has changed. Shell has to comply with OSPAR Recommendation 2006/5, which aims to reduce the impacts of oil and other substances from historic drill cuttings piles.

The drill cuttings have been surveyed and sampled since the late 1990s – most recently in 2015. Long-term fate modelling based upon the 2007 sample analysis has determined that the GBS seabed cuttings all fall below the OSPAR thresholds. Under OSPAR Recommendation 2006/5, they can be left in place to degrade naturally. A similar outcome was determined for the Delta and Bravo cell top cuttings.

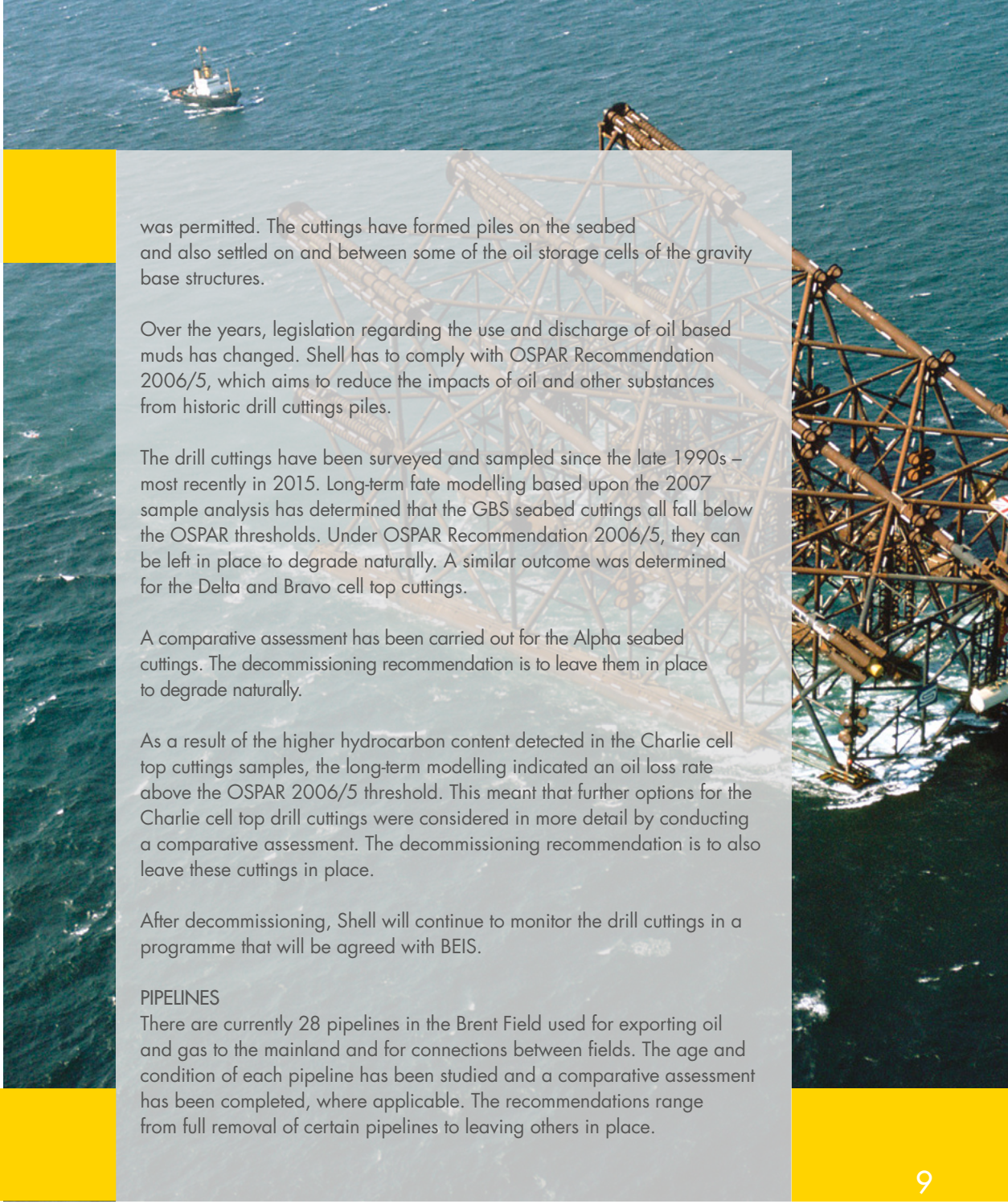
A comparative assessment has been carried out for the Alpha seabed cuttings. The decommissioning recommendation is to leave them in place to degrade naturally.

As a result of the higher hydrocarbon content detected in the Charlie cell top cuttings samples, the long-term modelling indicated an oil loss rate above the OSPAR 2006/5 threshold. This meant that further options for the Charlie cell top drill cuttings were considered in more detail by conducting a comparative assessment. The decommissioning recommendation is to also leave these cuttings in place.

After decommissioning, Shell will continue to monitor the drill cuttings in a programme that will be agreed with BEIS.

PIPELINES

There are currently 28 pipelines in the Brent Field used for exporting oil and gas to the mainland and for connections between fields. The age and condition of each pipeline has been studied and a comparative assessment has been completed, where applicable. The recommendations range from full removal of certain pipelines to leaving others in place.



BRENT ELEMENTS

THE GRAVITY BASE STRUCTURES

Gravity Base Structures (GBS) are composed of giant concrete "legs" and oil storage cells at the base that support the topsides above the surface of the sea. Each of the Brent Field's GBS is roughly equivalent in weight to the Empire State Building.

Most GBS in the North Sea were built when decommissioning was not a design consideration or a regulatory requirement. They were not intended to be removed once they had been installed on the seabed. The Brent's structures have either three or four concrete legs each, around 18m in diameter and up to165m tall. The full height of the platforms – from the seabed to the top of the structure – is equivalent to the Eiffel Tower.

There are considerable engineering challenges and safety risks associated with cutting through, lifting and transporting the reinforced concrete legs for removal. OSPAR recognises the difficulty in removing these concrete installations and has granted exemptions from removal to other operators of similar structures in the North Sea. In the last decade, Shell has thoroughly examined the options for decommissioning the GBS.

Comparative assessments were conducted for the GBS to analyse options for the legs, such as partially removing them or leaving them in place. Studies also investigated the potential ways that the GBS structures could collapse and possible long-term effects. Many options presented specific technical challenges.

On balance, the recommendation is that the safest and most responsible solution is to leave the GBS legs and oil storage cells in place, marked with a navigation aid and on the FishSAFE database. This recommendation is consistent with what other operators have recommended and had approved.

It is difficult to predict with accuracy how and when these structures will eventually collapse. Studies reveal that the visible part of the legs is expected to remain in place for 150 to 250 years. Once parts above sea level have degraded, the section of the legs under the sea is expected to last for another 300 to 500 years. The oil storage cells are also expected to remain largely intact for at least 1,000 years.

THE CONTENTS OF THE CELLS

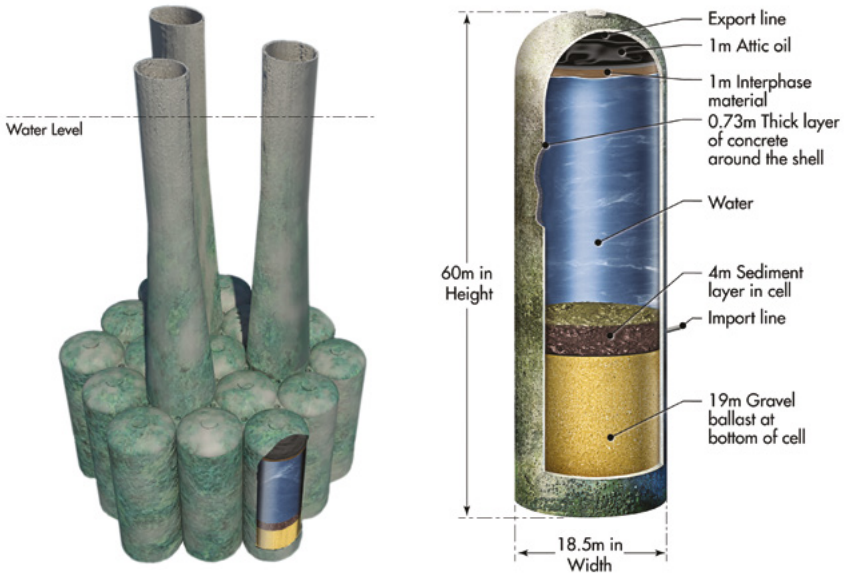
There are 64 storage cells in the Brent Field which sit around the legs anchoring the GBS to the seabed. Over the years, 42 of the cells have been used for oil storage and separation. These cells are each over 60m high and almost 20m wide – taller than Nelson's Column. The cells are made of almost 1m thick concrete and reinforced with steel. Inside, they contain a mixture of attic oil, water, and a layer of sediment which has settled at the base.

Shell made a commitment to stakeholders that a sample of the sediment would be obtained prior to submitting the Decommissioning Programme to validate modelling assumptions. In 2014, after several attempts over the previous years, sediment from three of the cells was obtained. The collection of the samples was independently witnessed, verified and analysed before the findings were shared with stakeholders.

The sediment in the cells is a sticky layer made up of a combination of hydrocarbons, sand and water. It was deposited as a result of operational activities during the latter part of the platform's production life.

Although not a regulatory requirement, Shell carried out a comparative assessment for the cell contents to ensure there was consistency in the process. The assessment determined what, on balance, would be the best solution for the cell contents. The recommendation is that the cell contents be left in place. Shell believes that this is the best solution based on robust modelling and data. The technical difficulties, safety issues and cost of the cell sediment removal, along with treatment and disposal, would be disproportionate to any benefit of removal. The studies show that leaving the cell content in place does not present a significant environmental hazard.

CROSS SECTIONS OF DELTA LEGS AND CELL



Over time, even as the legs slowly degrade, the GBS will contain the cell sediment. Modelling shows that any exposed cell sediment will disperse very slowly into the marine environment and not extend further than the existing drilling cuttings piles. This will not have a significant effect on marine organisms or people.

In agreement with BEIS, Shell will implement a monitoring programme for the Brent Field.

COLLABORATING WITH NASA

Since 2010, Shell has been working with NASA to develop a technique to access the cells to gain images of the content. NASA specially designed "sonar spheres" – a bowling ball-sized satellite – to access the cell through existing pipework.

The sphere took sonar images of the cell sediment so that Shell could identify its physical characterisation. Images were successfully obtained from Brent Bravo in May 2016.

The North Sea is an extremely harsh marine environment of strong winds and rough, cold seas. It is a challenging place to work, and decommissioning the enormous Brent structures will require advanced engineering and significant investment.

WHERE WE ARE NOW

Shell is planning to submit its recommendations for the decommissioning of the Brent Field to the Department for Business, Energy and Industrial Strategy.

The Decommissioning Programme will consist of a series of technical documents. The final recommendations contained in them are the result of 10 years of exhaustive studies, the completion of the detailed comparative assessment process, extensive stakeholder engagements and ongoing discussions with the regulator. The recommendations include leaving the gravity base structures, Brent Alpha footings, drill cuttings and cell contents in place. If approved, the next step will be for BEIS to apply to OSPAR on Shell's behalf for an exemption to leave these in place.

At the request of stakeholders, Shell has doubled the public consultation process from the standard 30 days to 60 days to enable people to fully review the documentation. Anybody who has an interest in the proposals will be able to comment. Shell is confident that the proposals are safe, technically achievable, financially and socially responsible, and environmentally sound.

Regular updates can be found on our website: www.shell.co.uk/brentdecomm