

# Specialist Technical Services Key to Successful Pipeline Design

Until now, the UK has been self-sufficient in gas, thanks largely to abundant supplies from gas fields, predominantly in the North Sea. However, offshore gas production is decreasing at the same time as demand for gas is rising, and analysis shows that the UK will become increasingly dependent on imported gas.

To meet the demand, two new terminals to import Liquefied Natural Gas (LNG) are being constructed at Milford Haven. National Grid has an obligation to connect this supply to the National Gas Transmission System to ensure that it is safely and economically delivered to homes and industry. To achieve this, National Grid intends to construct a new 1220mm diameter high pressure gas transmission pipeline from Felindre, near Swansea, to a point near Tirley, between Newent and Tewkesbury in Gloucestershire, in addition to the Milford Haven to Aberdulais section currently under construction.

When completed, the new pipeline will have the capacity to carry 20% of the UK's natural gas supply. As such, the whole project is of vital strategic importance for the future of the UK economy.

Murphy Pipelines Ltd has been awarded a contract by National Grid to construct a 107 km long section of the pipeline from Brecon to Tirley. The pipeline route, selected after extensive consultations, will initially pass north of Brecon over the Garthbreny and the Llandyfalle hills, before turning south past Myynydd Ffrosset as it heads towards Llyswen. The route then follows the valley of the River Wye to Hay-on-Wye, before turning southward again along the Golden Valley to Peterstow. From Peterstow, the route continues to head eastwards, to the north of Ross on Wye, crossing the M50 motorway and River Leadon before terminating at Tirley. STATS Limited was contracted to provide



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specialist technical services to the project. Initially, this involved the design, procurement, management and supervision of the ground and groundwater investigation of the proposed route, post investigation analysis of the collected data and the submission of appropriate recommendations with respect to design, construction and the final choice of route. In order to achieve this, STATS has employed expertise from both within its specialist divisions and from key sub-contractors.

The project has a value to STATS exceeding £1m, representing one of the largest projects ever undertaken by the company. The next phase of investigation and analysis is well underway and it is anticipated that there will be considerable ongoing work.

The main ground investigation provided considerable challenges due to the often remote locations and the rugged terrain in the foothills of the Brecon Beacons. Due to the environmentally sensitive location, National Grid were especially concerned that this phase of the work was carried out to the highest standards with minimal impact on the land, both during and after drilling. STATS therefore elected to deploy crawler mounted Pioneer drilling rigs provided by Geotechnical Engineering Ltd. These rigs are clean, modern, highly mobile and ideally suited to the soil profile. Ground conditions along the route generally comprised a veneer of Glacial Till overlying weathered rock, with competent rock, usually Devonian sandstone and mudstone, at shallow depth. River alluvium and more extensive glacial deposits were encountered along the river valleys. Cable percussion techniques would have refused on rockhead whilst rotary coring often results in poor recovery of the superficial deposits. The Pioneer drill is capable of dynamic soil sampling in the superficial deposits in order to obtain near-

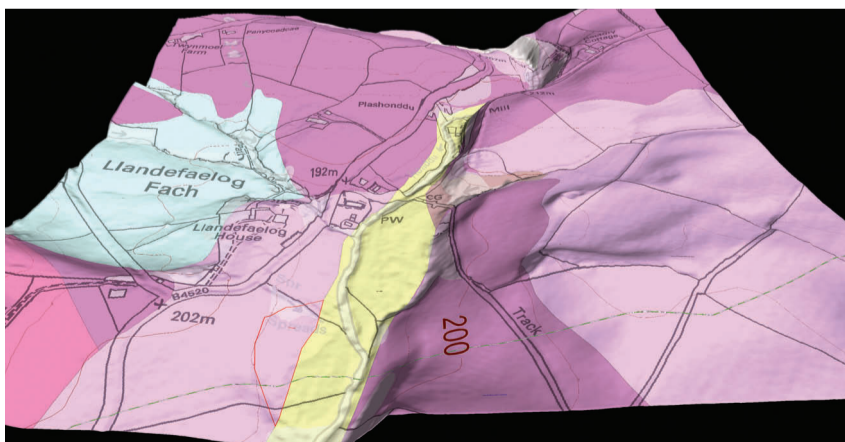
undisturbed continuous samples up to 112mm diameter retained in a plastic liner. On encountering rockhead, the rig can readily switch to rotary coring mode using a water flush, recovering high quality cores at up to 116mm in diameter.

In excess of 270 boreholes have been drilled to date, however, even this represents a relatively low frequency per kilometre, and in some of the remoter areas even the Pioneer rigs could not gain access. To overcome this problem, STATS in house geophysics team, led by Dr George Tuckwell, developed the concept of 'virtual trial pits' to investigate the soil characteristics and rockhead profile beneath localities which were inaccessible or inappropriate for intrusive surveys. The virtual trial pits involved the use of the seismic refraction technique, which is based on the propagation of seismic waves through the subsurface, and their refraction at interfaces across which there is a sufficient increased contrast in acoustic velocity. Seismic energy is generated using multiple hammer blows to a hammer plate. Analysis of the time taken for the seismic energy to travel from the shot point to an array of distances from the source can provide information on the geometry, depth and elastic properties of subsurface materials, which can be related to geology.

A total of 17 locations were investigated using this technique. At each site, two orthogonal spreads of geophones, each some 48m long were deployed. After processing, the resulting data allowed imaging to a depth of up to 5m into bedrock. Check drilling at two locations confirmed the ability of the virtual trial pits to identify rockhead to an accuracy of +/-50mm.

Geophysical techniques such as EM and Magnetics have also been utilised to delimit the extent of features such as areas of landfill in addition to underground tunnels and shafts associated with the former Hereford to Gloucester Canal at Oxenhall.

Commenting on the main site investigation works, STATS Project Manager, Jon Bassett said "although we have used innovative and unusual approaches to gathering ground investigation data, we have tried to not lose sight of the use to which the



*The vast quantity of gathered data is brought together using the latest GIS software. As the data is presented in a spatial context, it is possible to produce 3D drapes of aerial photography, OS maps and geology. Using additional software, STATS has been able to assess slope angles and hence slope stability using the digital terrain model*





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information will be put. The whole of STATS site based team worked closely with the designers, construction crews and the quantity surveyors to develop new ways with which to make the borehole and laboratory test data, timely, relevant and meaningful. One outcome of this was that the interpretative report has very little text, with most of the analysis of the engineering properties of the soils, rocks and groundwater data, and our assessment of construction issues such as trench stability, trafficability etc., presented as a series of "traffic light" colour coded bars along the base of A3 size long sections. As a result, the non specialist members of the project team can easily identify potentially problematic areas and an intuitive cross referencing system provides simple access to greater detail within the factual report. We have been pleased to discover that these books of long sections have become widely used throughout the project team, and that the QS's in particular, have enthusiastically welcomed this approach."

The pipeline route will also cross an aquifer, 6 rivers and more than 30 ditches, and STATS has provided an assessment of the likely affects on surface groundwater resources, including flood risk assessments wherever the route crosses the floodplain.

The aquifer was of particular concern and as such it is vitally important that pipeline construction does not affect water quality or yield.

Following a detailed site investigation, the British Geological Survey, led by Dr Nick Robins, was commissioned by STATS to construct a numerical groundwater flow model using the state of the art, object oriented ZOOMQ3D package which was jointly developed by the BGS, Environment Agency and Birmingham University. After running numerous 'what if?' scenarios the modelling has predicted that dewatering during construction will have a small but acceptable impact on the aquifer and that any turbidity will be lost during the 100 day travel time. The impact of the completed pipeline on the groundwater flow and groundwater heads has also been shown to be minimal. The conclusions from the modelling work are due to be tested during a full-scale well point dewatering test.

STATS has also provided the scope of work for surface water monitoring to be carried out prior to, during and for four years post construction.

A mining and quarrying hazard assessment has been undertaken to provide a basis for evaluating the presence and likely zones of influence from historic, current and planned

mining, together with an assessment of potentially economic mineral reserves that could be mined in the future. This assessment has involved both desk studies and ground investigation. The work has facilitated the creation of a generic model of geological and related potential mineral resources versus historical, contemporary and possible future mineral extraction patterns, from which a pipeline route-specific matrix of potential mineral resources versus generic and the more detailed regionally-customised, methods of extraction has been developed for all of the possible types of mineral resources present. All forms of hazard were assessed including the traditional hazards such as ground subsidence, void migration and shaft collapse, as well as less common hazards such as gas emissions, aggressive mine waters and biological hazards from diseased animals and waste.

The resulting data set has been assessed using a qualitative risk assessment approach with four risk categories, very low to high, assigned to each actual or potential occurrence. For each moderate to high risk rating, mitigation measures have been proposed. These range from complete excavation and recompaction of loose backfill to a shallow former stone quarry, to in-trench clay barriers where the pipeline passes close to an animal burial site.



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A landslide hazard assessment has been undertaken by STATS in order to assess the pipeline corridor for areas of potential slope instability. This work has been undertaken under the supervision of STATS Director Dr Shon Williams, with peer review by Professor Eddie Bromhead of Kingston University. The initial screening process used an advanced geographical information system (GIS) based approach to integrate LIDAR digital elevation data with BGS digital geology maps and air photographs. Maximum safe slope angles were allocated to each geological unit and where the LIDAR data indicated that these angles had been exceeded, further investigation was undertaken. The output from the GIS comprised slope angle summary maps with colour coded zoning of slope angle. Commenting on the project, STATS Dr Williams noted "the approach we used, whilst common in the US, is practically unique in the UK. The high tech GIS based analysis saved weeks of conventional walk over survey work, but when it came down to it, the only way to properly investigate the high risk areas identified



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by the GIS was to get our boots on!"

STATS also employed further investigation works which incorporated more innovative use of technology, including downhole optical and acoustic scanning to provide high resolution, true colour images of the borehole wall that will be used for detecting bedding, fractures and discontinuities. These data can be automatically analysed to provide computer generated rose diagrams and stereonet depictions of dip and dip azimuth, in conjunction with conventional core logging and more detailed slope stability analysis.

Tony O'Sullivan, Project Manger for Murphy Pipelines, says "STATS were awarded the contract because of the high quality work that they provided on a similar project in Scotland and because they possess the resources and technical expertise necessary on a project of this scale. We have been pleased to note that STATS has been able to recruit the very highest calibre of partners in order to provide some of the specialist expertise that this project has necessitated"

Commenting on progress to date, STATS Director Paul Stearns says "This has been a fascinating project which has allowed STATS to use our full range of specialist technical services to assist Murphy Pipelines and National Grid to deliver the project to very tight time constraints. The integrated team approach favoured by Murphy allows specialist consultants to work closely alongside the commercial, design and construction teams so that the information we provide is accurate, timely, and relevant. We strive to achieve the highest technical standards without losing sight of the commercial aspects of our work and we are always trying to think of new and innovative ways of investigating a problem as well as making the results and conclusions accessible to the whole of the project team, not just a few experts. Our biggest challenge has been to find the resources to manage the project and the unsung heroes have been the field engineers who have worked unbelievable hard over many months to produce top quality ground investigation data, without which the specialist expert reports could not have been produced.

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