Guidelines for the conduct of offshore drilling hazard site surveys

Report No. 373-18-1

April 2013

Version 1.2

International Association of Oil & Gas Producers

Publications

Global experience

The International Association of Oil & Gas Producers has access to a wealth of technical knowledge and experience with its members operating around the world in many different terrains. We collate and distil this valuable knowledge for the industry to use as guidelines for good practice by individual members.

Consistent high quality database and guidelines

Our overall aim is to ensure a consistent approach to training, management and best practice throughout the world.

The oil and gas exploration and production industry recognises the need to develop consistent databases and records in certain fields. The OGP's members are encouraged to use the guidelines as a starting point for their operations or to supplement their own policies and regulations which may apply locally.

Internationally recognised source of industry information

Many of our guidelines have been recognised and used by international authorities and safety and environmental bodies. Requests come from governments and non-government organisations around the world as well as from non-member companies.

International Association of Oil & Gas Producers

Geomatics
Guidance note 18–1

Guidelines for the conduct of offshore drilling hazard site surveys

Revision history

Version	Date	Amendments
1	April 2011	Initial publication
1.2	April 2013	Minor amendment to *Section 2.3* and introduction of *Section 5.2.5*

Acknowledgements

This guideline was produced by The International Association for Oil & Gas Producers' Geomatics Committee

Table of contents

1 Introduction

This document provides guidance for the conduct of offshore drilling hazard site surveys (hereafter referred to as Site Surveys). The guidelines address the conduct of geophysical and hydrographic site surveys of proposed offshore well locations and the use of exploration 3D seismic data to enhance, or to replace, acquisition of a site survey.

The document does not set out to provide guidance on geotechnical engineering requirements for design of anchoring systems, the analysis of jack-up rig foundation or platform foundation design, neither does it address detailed guidance on environmental survey requirements. Such works require expert guidance and involvement of geotechnical or structural engineers or environmental scientists who are conversant in the application of appropriate industry codes for these tasks.

The document replaces the former UKOOA *Guidelines for conduct of mobile drilling rig site surveys, version 1.2*, and *Guidelines for conduct of mobile drilling rig site investigations in deepwater, version 1*, previously published under the auspices of the former UK Offshore Operators Association (UKOOA), now Oil & Gas UK.

These guidelines describe oilfield good practice in this subject area in support of meeting country specific regulatory requirements. While the document sets out oilfield good practice, it is impossible for the document to address all the varying regulatory requirements that are in place in different countries around the world.

Operators should make themselves aware of the local regulatory requirements that apply to marine site surveys. It is recommended that operators compare local requirements to these guidelines and where there are differences apply the higher of the two sets of standards.

The document explains the requirements that different types of offshore drilling units have on a site survey. The document also emphasises the differing site survey requirements of shelf and deep-water environments.

The techniques described in this document can also be applied to other types of seabed surveys, such as pipeline or cable route surveys, *etc*. While this document does not set out to directly address planning and delivery of such projects, it will be recognised that the same general thought processes and practices will be applicable to such projects.

A companion OGP document *Guideline for the conduct of drilling hazard site surveys – technical notes* (hereafter "The Technical Notes"), Report № 373-18-2, will be published in due course[1] and will provide supporting technical information and background theory on the various phases of a site survey project outlined in this document.

1 *Provisionally slated for some time before the end of 2012.*

2 Objectives of site surveys

2.1 General

Site surveys are performed to minimise the risk of harm to personnel and equipment, and to protect the natural environment. The objective of any site survey is to identify all possible constraints and hazards from man-made, natural and geological features which may affect the operational or environmental integrity of a proposed drilling operation, and to allow appropriate operational practices to be put in place to mitigate any risks identified. In addition, the proposed site survey area should be of adequate coverage to plan any potential relief well locations, and provide sufficient data to fully assess potential top-hole drilling hazards at these locations.

A properly conducted site survey for an offshore drilling location will require the input of a number of different professionals who should be suitably qualified and experienced in their respective disciplines. Overall project management of a site survey should be assigned to an individual who has a thorough understanding of the reasons for delivery of a site survey, an intimate knowledge of how the results will be applied, and first hand experience of collecting and presenting those results.

The quality of any dataset selected for use in a site survey should be directly related to the types of conditions expected to exist within the area of interest.

The interplay of the physical environment with the type of intended operation has a fundamental impact on the scope and content of a site survey.

2.2 Physical Environment

Depending on the physical environment and the intended operation, a site survey may need to review any, or all, of the following:

Table 1: conditions to be addressed by a marine site survey

Man-made features	Natural seabed features	Subsurface geological features
• Platforms: active, abandoned, or toppled • Pipelines: on or buried below the seabed • Power and umbilical lines • Communications cables • Wellheads and abandoned well locations • Manifolds and templates • Pipeline terminations, valves and protection frames • Subsea isolation valves • Rock dumps • Scour protection material • Jack-up rig footprints • Non oil & gas infrastructure such as navigation buoys, wind turbines etc. • Shipwrecks • Ordnance and chemical dumping grounds • Archaeological remains • Miscellaneous debris	• Seabed topography and relief • Seafloor sediments • Sand: banks, waves, and mega-ripples • Mud: flows, gullies, volcanoes, lumps, lobes • Fault escarpments • Diapiric structures • Gas vents and pockmarks • Unstable slopes • Slumps • Collapse features • Fluid expulsion features • Chemosynthetic communities • Gas hydrate mounds • Rock outcrops, pinnacles and boulders • Reefs • Hardgrounds • Seabed channels and scours	• Sedimentary sequences • Stratigraphy • Shallow gas charged intervals • Gas chimneys • Shallow water flow zones • Over-pressure zones • Buried infilled channels • Boulder beds • Buried slumps and mass transport complexes • Gas Hydrate zones and hydrated soils • Faults • Erosion and truncation surfaces • Salt or mud diapirs and diatremes

2.3 Planning fundamentals

In planning a site survey programme, the interplay of rig type and its specification, the different conditions that might be expected in the planned area of operations, and well control response contingencies must be carefully taken into account. This must be considered as a first step in the planning stage of any site survey programme.

The site survey project manager should be advised of the proposed outline drilling programme and/or the conceptual field layout by the project engineer planning the well or development. This should be taken into account in setting the data needs of the project.

The tables in Appendix 1 review conditions and areas of concern for the three rig type groupings. The appropriate columns should be considered during the planning stage of a site survey programme.

Sufficient time must be allowed in delivery of a site survey programme to ensure the results are available in time:

- to ensure all local regulatory permitting requirements are met ahead of the of the proposed well spud date
- to ensure the drilling project team can include them, and properly mitigate any risk of hazards identified from them, in the final well design

Figure 1: Site clearance – timing guidance

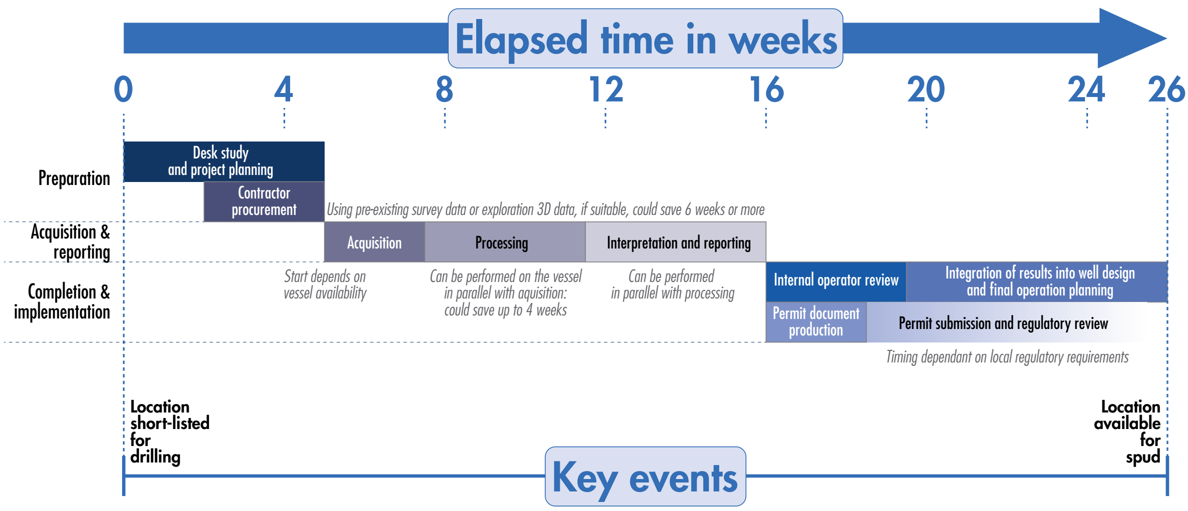


Figure 1 shows a conceptual time line. The permitting period will be country specific.

Generally it is recommended that a site survey programme should start six months prior to, and no less than three months ahead of, the proposed well's spud date.

2.4 Scope

Any site survey must include a review of all seafloor conditions and geology to a depth at least 200m below the preferred setting depth of the first pressure containment string, or to a depth of 1000m below seabed, whichever is greater.

The identification and assessment of all relevant geological features should be performed within the context of a geological model that takes into account depositional and post-depositional processes.

The site survey report should include a discussion of all relevant geological and/or man-made features that have a direct bearing on operational risk.

2.5 Operations type

The type of rig to be used has a direct effect on the required scope of a site investigation. The full breadth of these effects is detailed in the table in Appendix 1 of this document. This table should be used by a project manager to sense check that all potential concerns for the placement of a rig at a proposed location are being, or have been, addressed as part of the site survey programme.

2.5.1 Bottom founded and platform based rigs

These rigs only directly impact the seafloor over a small area immediately around the wellbore. The site survey can therefore be focused directly upon the well location, the corridor of approach onto location, and any possible stand-off locations.

The style of top-hole drilling used by these rigs is different to the other two generic rig groupings. Fundamentally the risk to the rig from a shallow gas blowout is greater.

The risk to the rig's integrity through loss of seabed support makes review of the shallow section for these rigs critical.

The analysis of jack-up rig foundation, or platform foundation design, requires dedicated intrusive geotechnical soil investigations. The investigations require expert guidance and the direct involvement of geotechnical or structural engineers who are conversant in the application of appropriate industry codes for these tasks. Minimum requirements to geotechnical soil investigations are covered in industry guidelines and standards, *eg* The Society of Naval Architects and Marine Engineers (SNAME), Technical & Research Bulletin 5-5A, Site Specific Assessment of Mobile Jack-up Units and ISO 19905-1, Petroleum and natural gas industries, Site-specific assessment of mobile offshore units, Part 1: Jack-ups (in development, target publication date September 2011).

2.5.2 Anchored rigs

These rigs impact a large area of the seabed and as a result a site survey will need to be performed over a larger area of the seafloor to assess anchoring conditions.

These rigs encounter a number of different concerns not applicable to bottom founded rigs (*see* Appendix 1).

2.5.3 Dynamically positioned (DP) rigs

These rigs impact a small area of the seabed, and therefore the site survey can be focused directly upon the well location and its immediate surroundings. However, their use in predominantly deep to ultra deep water brings special requirements for a site survey programme (see Appendix 1).

3 Site survey process

A site survey project process can be considered to consist of four phases.

3.1 Desk study and project planning

A project should start with a desk study that should be considered as an integral part of the planning process. During this phase, a decision will be made as to whether new data – and which types of data – must be acquired.

In deep water areas, the desk study and any ensuing acquisition may need to address a semi-regional scope to consider topographic or geological issues that may be a threat to operations from outside of the direct area of proposed operations.

3.2 Data acquisition

The second phase is the acquisition of new data coverage, if such is required.

3.3 Data processing, interpretation and integration

All existing and new data are then processed, or reprocessed to improve their value, and interpreted to produce an integrated geological model of the seabed and subsurface conditions.

3.4 Reporting

The final stage of any site survey is the production of an integrated report that describes the conditions and operational risks identified across the site and – specifically – at the proposed drilling location.

4 Desk studies and project planning

As the first stage in survey planning a desk study – or review – of pre-existing data should be performed to gain an understanding of the area and to highlight matters of particular concern that need to be addressed by the investigation.

4.1 Use of existing geoscience data

Use of exploration 3D or 2D seismic data, offset well data (logs, operations reports, industry databases, *etc*), geotechnical boreholes, offset site surveys and any other relevant public domain data in an integrated fashion will allow an initial geological model of the seabed and shallow section to be developed. This can be used to design a survey programme appropriate to the location and rig.

In some cases, exploration 3D data covering the prospect area may provide sufficient information to produce a site report such that new survey data will not be required (Section 5.6 below). Otherwise the data will – as a minimum – provide a good guide to definition of line direction, line spacing, and the areas of uncertainty that the new site survey needs to clarify.

4.2 Pre-existing and proposed operations

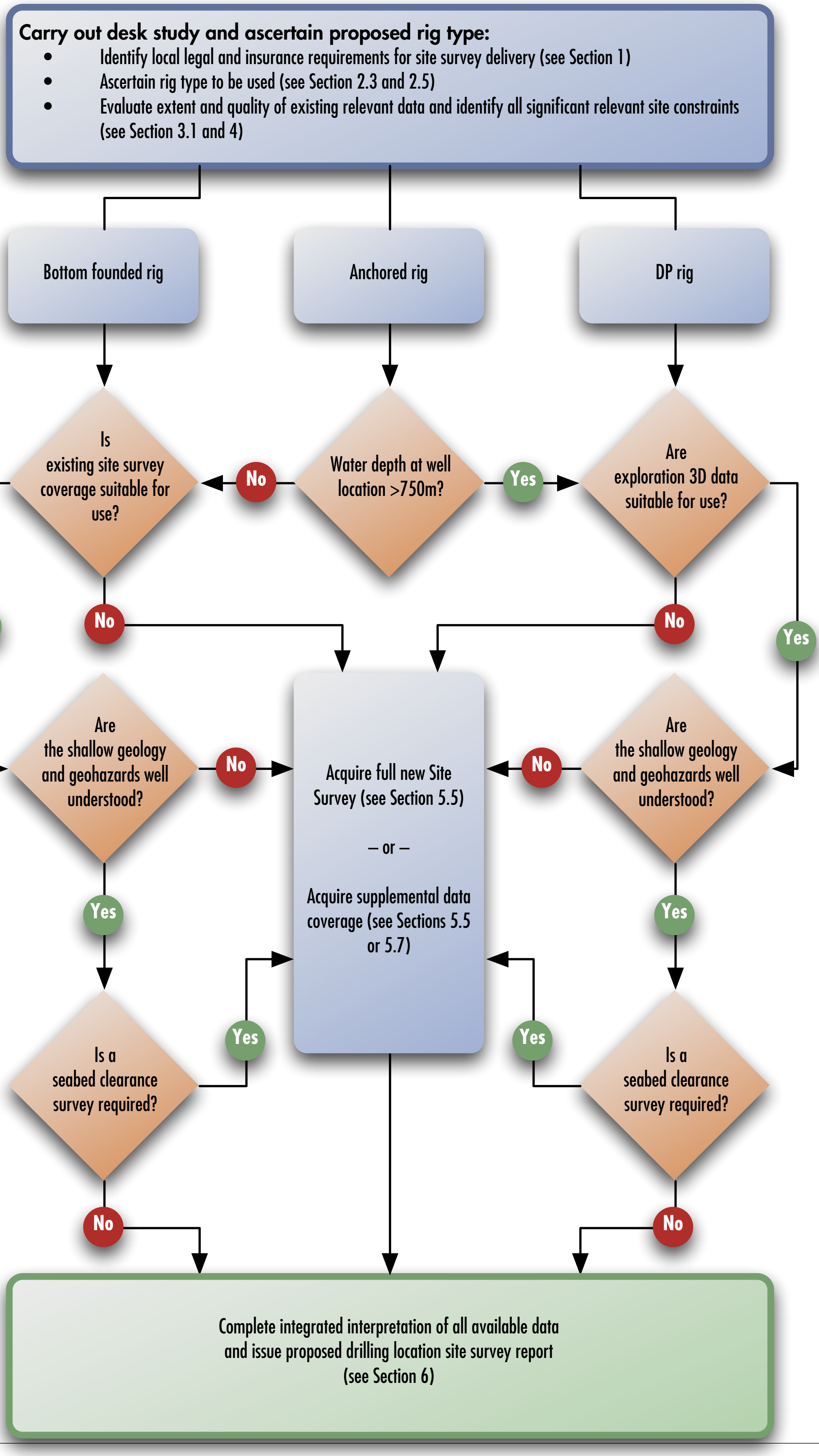
An up-to-date database of offshore facilities: wells, platforms, pipelines, *etc* that impact upon the operational area should be reviewed during the planning phase.

A check should also be made of any proposed third party exploration or development activities in the area that may impact the proposed operations.

4.3 Wrecks, submarine cables, sites of special interest

Local regulatory announcements, databases and nautical charts should be reviewed for the likely presence of wrecks, submarine cables and sites of special interest: archaeological, environmental, *etc*.

Figure 2 – site survey decision tree



5 Data requirements

5.1 General

Figure 2 presents a simple process for assessing the data needs of a project.

Four general areas of practice are common within the industry:

- Use of pre-existing site survey data.
- Use of an exploration 3D seismic dataset.
- Use of an exploration 3D seismic dataset combined with limited site survey data acquisition.
- Use of a newly acquired site survey.

Whatever generic approach is followed, the data made available for interpretation must allow for analysis of the conditions and hazards listed in Section 2.2 and detailed in Appendix 1 to be properly addressed for the type of rig in use.

5.2 Area of study

Any site survey study should address the total area likely to be impacted by drilling or development related activity. The area should include any potential relief well locations.

5.2.1 Bottom founded rigs and platform based rigs

Due to the physical nature of operations with this type of rig and the water depths in which these rigs operate, data requirements must be applied more rigorously to assure operational integrity.

Data coverage should provide full cover to a minimum distance of 500m around the drilling location and the immediate line of approach onto location.

Data should allow proper study of any obstructions that might be present on the seabed during the final transit of the rig on to location and the commencement of leg pinning activity for a jack-up rig.

Tieline data should be acquired to existing geotechnical boreholes and offset wells in the vicinity that show similar soil stratigraphy and that allow unambiguous interpretive correlation of conditions back to the proposed location.

5.2.2 Anchored rigs

Data coverage should provide full cover to a distance of 250m beyond the maximum likely anchor radius at the proposed drilling location.

5.2.3 Dynamically Positioned (DP) rigs

Data coverage should provide full cover to a distance of 500m beyond the maximum likely diameter of the seabed acoustic array used to maintain the rig's position on location.

5.2.4 Location uncertainty

If the proposed well location has not been finalised at the time of planning, the survey area should be designed to take into account the full positional uncertainty of the final surface location of the well and to meet the requirements set out above (Sections 5.2.1 to 5.2.3 inclusive).

5.2.5 Relief Wells

In responding to a well control incident, no relief well should be spudded until new site survey data have been acquired, processed and analysed for the final agreed relief well location(s) to fully assess the presence of any changes in post-event seabed and subsurface conditions that might be encountered during relief well drilling as a result of the incident.

5.3 Total Depth of Study

The total depth of study below seabed should be to a depth at least 200m below the preferred setting depth of the first pressure containment string, or to a depth of 1000m below seabed, whichever is greater, irrespective of rig type.

The combined dataset to be used must therefore be capable of properly imaging geological conditions to this depth.

5.4 Use of a pre-existing site survey

Pre-existing site survey data should be re-used whenever possible. The quality and validity of these data should be carefully assessed prior to committing to their use in producing a report for a new drilling location.

If the pre-existing survey fails to cover the full project scope required, either spatially or in depth, it will need to be supplemented by data from another source.

Subject to local operator policy, regulatory or insurance requirements, for guidance purposes the maximum age validity of pre-existing hydrographic and geophysical site survey data can be considered as:

Table 2: pre-existing data validity guidance

Activity Condition	Seabed Data	Subsurface Data
No Activity	5 years	10 years
Engineering Activity	1 year	10 years
Well Control Incident	Invalid	Invalid

Subject to local conditions, in a prospect area where there has been no drilling or engineering (pipe-lay, *etc*) activity since acquisition of a pre-existing survey, the validity of seabed clearance data should be considered to be five years and subsurface data should be considered to have a ten year validity.

In a prospect area where there has been drilling or engineering activity since a pre-existing survey was acquired, validity of the data should be one year for seabed clearance data and ten years for subsurface data.

If the pre-existing data do not meet these requirements then a new survey should be acquired.

At locations where a jack-up rig will be operating in close proximity to existing installations, an additional seabed survey should be carried out immediately prior to the jack-up rig installation.

If it is known that a rig has been installed more recently than the existing site survey data new data should be acquired.

If a well control incident (an uncontrolled underground or surface flow) has taken place on the prospect, field or in an immediately adjacent area since acquisition of a pre-existing survey, any existing seabed and subsurface data shall be considered invalid. In such a case a new survey is always required.

5.5 Acquisition of a new site survey

When a new site survey is considered necessary, the survey should be designed to specifically address the expected operational requirement.

The following should be considered in survey design, specification, and delivery.

5.5.1 Standard site survey data types

A new site survey will involve gathering of all of the following standard data types except where specified in Section 5.5.2 below.

Positioning

Surface positioning of the survey vessel should be based on augmented global navigation satellite systems (GNSS), *eg* Differentially Corrected GPS (DGPS) or Clock and Orbit Corrected GPS (also referred to as SDGPS or Precise Point Positioning PPP) that typically yield sub-metre positioning accuracy. It is recommended that two fully independent surface positioning systems should be used.

The correct use of GNSS positioning is critical to the success of an offshore drilling hazard site survey. It is recommended that the GNSS are operated in line with the *Guidelines for GNSS Positioning in the Oil and Gas Industry,* issued jointly by OGP and IMCA. It describes good practice for the use of global satellite navigation systems (GNSS) in, among other, offshore survey and related activities for the oil and gas industry. The guideline will be published in the spring of 2011 and can be downloaded from www.ogp.org.uk or www.imca-int.com.

Except in shallow water depths of less than 25m where it may be impractical or where layback to the towed equipment is less than 50m, it is recommended that the position of towed sensors should be determined by vessel mounted acoustic positioning system, *eg* a tracking Ultra Short Baseline System (USBL) that, when properly calibrated, typically yield a relative positioning accuracy of better that 1% of slant range from vessel transducer to transponder on the tow fish.

Bathymetry

Bathymetry data should, as a preference, be acquired using a swathe bathymetry system to measure accurate water depths across the area.

Where swathe bathymetry data are acquired, it is recommended that backscatter values from the seabed returns are logged and processed for use in seabed characterisation to support and complement side scan sonar data.

As a minimum, however, bathymetric data should be obtained using a hull mounted, high-frequency, narrow, single beam hydrographic echo sounder. Data should be digitally recorded.

Single beam echo sounder data should be used to verify the results of swathe bathymetry data – if acquired – to check for gross error.

The bathymetry systems should be set up to accurately record data across the range of water depths expected in the survey area.

The bathymetry systems should be used in conjunction with an accurate motion sensor to compensate for vessel motion.

Water column sound velocity should be determined as a minimum at the start and end of each project by use of a CTD (Conductivity, Temperature and Depth probe) or direct reading sound velocity probe suitable for use in the maximum water depths expected within the survey area.

Water depths should be corrected for vessel draft, tidal level and referenced to an appropriate local vertical datum (LAT, MSL, *etc*).

The final processed digital terrain model (DTM) data cell size covering the entire survey area, without gaps, should preferably be less than 10x10m, and output in an appropriate digital format to allow further imaging and analysis of the data.

Side scan sonar

A dual channel, dual frequency, side scan sonar system should be used to provide acoustic seabed imagery to define man made and natural seabed features across the area.

Systems should be operated at no less than 100kHz.

Line spacing and display range should be designed to ensure a minimum of 200% coverage of the survey area in the prime survey line direction, with additional further orthogonal tie-lines.

For detailed inspection of contacts or inspection of pre-determined bottom-founded rig sites, extra lines should be run using a frequency of 400kHz or greater.

Data should be recorded digitally. Recorded data should be image processed to improve subsequent computer aided analysis and mosaicing of the data. Such mosaics should be output as geo-referenced, high resolution, digital models of the seabed for presentation in the final report.

Data may also be displayed on a graphic recorder in the field for quality control and to provide a hard copy back-up.

Sub-bottom profilers

A suite of sub-bottom acoustic profilers should be operated to provide a continuous and very high resolution image of the shallow geological conditions.

Subject to local soil conditions, the systems should be capable of achieving a resolution of 0.3m vertical bed separation in the upper 50m below seabed.

The systems chosen should be run simultaneously to provide imagery that penetrates to in excess of the foundational depth of interest. This can be considered to be equivalent to a depth equal to the greater of 30m or the anticipated spud-can penetration plus one-and-a-half times the spud-can diameter for a jack-up rig or the maximum expected anchor penetration for an anchored rig.

The data should be recorded digitally to allow signal processing to further improve data quality, final export to a workstation for integrated interpretation and mapping of the data, and ease of data retrieval of old datasets.

Data may also be displayed on a graphic recorder in the field for quality control and to provide a hard copy back-up.

Magnetometers and Gradiometers

A magnetometer can be used to measure total magnetic field strengths to investigate ferrous objects lying on – or buried immediately beneath – the seafloor, or to attempt to determine the position of cables, pipelines or abandoned wells that cannot be identified by acoustic means.

The system should be capable of a sampling rate of at least 1Hz and have a sensitivity of at least one nanotesla (1nT).

The sensor should be towed as close to the seabed as possible and sufficiently far away from the vessel to isolate the sensor from the magnetic field of the survey vessel.

As magnetometers measure total magnetic field strength they cannot be used in the vicinity of large infrastructure such as platforms, which swamp the magnetic signature of smaller features.

Use of a gradiometer system, which measures the magnetic gradient between two or more closely spaced magnetometers, should be considered for more precise results and surveys close to large structures such as platforms.

Data should be recorded digitally. Recorded data should be processed to allow subsequent computer aided analysis and modeling to be undertaken.

2D multi-channel high resolution seismic

A multi-channel High Resolution (HR) digital seismic survey should be conducted over proposed drilling locations to investigate top-hole geological conditions across the area. The exception to this is where the use of pre-existing exploration 3D seismic data is deemed an appropriate substitute (see Section 5.6 below).

The primary interest of such surveys is from the seabed to a depth at least 200m below the preferred setting depth of the first pressure containment string, or to a depth of 1000m below seabed, whichever is greater.

All HR seismic surveys should be designed on a site specific basis to take into account the varying conditions present and specific goals of the project, but in general will conform to the outline specifications below.

- *Source Type:* surveys should make use of a seismic source that delivers a simple, stable and repeatable source signature that is near to a minimum phase output and has a useable frequency content across at least the 20-250Hz band.
- *Tow Depths:* source and streamer tow depths should be specified to be no greater than 3m and preferably less.
- *Streamer Type:* use of digital solid streamers is preferred.
- *Recording System:* the recording system should record at no greater than a 1 millisecond sample interval. Field high-cut filters should be set no lower than 300Hz.
- *Fold of cover:* should generally not be less than 24 for 2D HR surveys in water depths less than 750m.
- *Offsets:* the maximum offset recorded should preferably be no less than the total depth of interest below mudline that the survey is attempting to image except in water depths greater than 750m. The minimum offset recorded should be no greater than half the water depth.
- *Record Length:* to an equivalent two-way time of at least 200m below the preferred surface casing setting depth or to a penetration of 1000m below seabed, whichever is greater.

All seismic data acquired shall undergo full, multi-channel, digital signal processing to provide an optimally imaged dataset of migrated seismic data for output to, and analysis on, an interpretation workstation.

3D multi-channel high resolution seismic

Where initial review or offset drilling experience indicates that the complexity of the shallow section, or the perceived conditions are particularly complex, acquisition of a purpose designed HR 3D survey should be considered. Such surveys must be designed on a site specific basis.

Seabed samples

Samples should be acquired to ground truth seabed and shallow soil provinces that are defined during the site survey, or that have been pre-defined during the desk study.

For an anchored rig it may be necessary to acquire shallow seabed soil evaluation data using a suite of tools appropriate to the soil conditions (grab, box corer, piston corer, gravity corer, vibro-corer or CPT). Samples retrieved should be comprehensively logged and may need to be sent ashore for analysis.

If sampling is aimed at defining suspected sensitive environments, care should be taken to acquire a control sample away from the suspect target area.

Seabed photographs

Where appropriate, seabed photographs and/or video footage using equipment suited to the seabed type, tidal conditions and visibility expected in the area (drop camera, ROV or AUV mounted, towed sledge or fresh-water lens) may aid in ground truthing of acoustic data and allow investigation of discrete areas of concern that are identified during a survey.

Particular attention should be given to potential sensitive seabed environments including:

- unusual bedforms
- gas/fluid escape features
- shallow sand banks
- gravel beds or coarse gravel banks
- benthic communities

Seabed imagery may also be used to establish an absence of sensitive features or habitats prior to use of invasive sampling techniques.

5.5.2 Water depth control on acquisition parameters

Water depth affects the appropriateness of certain types of equipment and the way in which they are deployed. The acquisition scope should be modified accordingly:

- *Water depths less than 25m:* A full suite of data should be acquired using vessel mounted or towed equipment as detailed above.
- *Water depths of greater than 25m to 150m:* a full suite of data should be acquired using vessel mounted or towed equipment as detailed above. Towed sensors should always be positioned by acoustic means to allow accurate positioning of all data.

- *Water depths of greater than 150m to 750m:* a full suite of data should be acquired using vessel mounted or towed equipment as detailed above. Deep tow sensors should always be positioned by acoustic means to allow accurate positioning of all data. Consideration in water depths greater than 500m should be given towards use of Autonomous Underwater Vehicle (AUV) deployed sensors rather than towed systems.
- *Water depths of greater than 750m:* depending on operational type in these water depths a full suite of data may not need to be acquired; however, preference is for the use of AUV deployed swathe bathymetry, side scan sonar, and sub-bottom profiler systems over surface towed or hull mounted equipment.

5.5.3 Survey line spacing

Survey line spacing will depend on the type of programme being acquired. However, as a basic guide, main direction line spacing can be considered to be as follows:

Table 3: Main line spacing guidance

Data type	Water depth range			
	<25m	25m to 150m	150m to 750m	>750m
Swathe bahymetry	≤50m	50m – 150m	200m	150m (AUV)
Side scan sonar/profiler	50m	100m	200m 300m (Deep Tow)	150m (AUV)
2D HR seismic	25m – 50m	50m	50m – 100m	≥150m

Additional cross lines should be acquired normal to the main line direction at an increased spacing (as a guide three to five times the spacing of the main line direction spacing) to provide ties for interpretation and processing.

If the final drilling location is known at the time of the survey, thought should be given to acquiring closer line spacings either side of the location in both line directions.

Wherever possible, to support interpretation, tie line(s) should be acquired to relevant offset wells, geotechnical boreholes, or other data calibration points.

5.6 Use of exploration 3D seismic data on a standalone basis

The use of exploration 3D seismic data on a standalone basis as a replacement for acquisition of a site survey for deep water well locations is a generally acceptable practice within certain limits (Section 5.6.2 below) assuming data are appropriately processed, or reprocessed, for the purpose (Section 5.6.3 below). On this basis, exploration 3D seismic data can be used to derive bathymetric, geological and geohazards information.

Exploration 3D seismic data is not a substitute for side scan sonar data for the detection and mapping of objects and obstructions on the seabed that may interfere with anchoring. For this reason, special consideration will need to be given for anchored rigs in deep water where a side scan sonar survey, possibly acquired using an AUV, may be needed as a supplement to a study based on exploration 3D data.

Exploration 3D seismic data is not a substitute for sub bottom profiler data for the identification and mapping of shallow geology and hazards in the top 100m of the seabed and is not a replacement for a site survey when using a bottom founded drilling rig.

Not all exploration 3D seismic data lend themselves to this type of study and an acceptable dataset can be rendered unsuitable through trace or sample decimation, *etc.*

Data should be reviewed carefully at the outset of a project to study the complexity of the location's setting as part of a preliminary hazards severity assessment or desk study. The results of such a study might indicate:

- That the data clearly indicate that the setting of the study area is so complex as to require a supporting site survey.
- The data fail to meet minimum data acceptability criteria set out below and may require reprocessing, or replacement, or be supplemented by acquisition of a site survey that provides a better basis for study.
- The data are adequate for use as a site survey replacement and meet the minimum data acceptability criteria set out below.

5.6.1 Exploration 3D seismic data types

For site survey studies, generally only exploration 3D seismic data acquired using conventional tow methods are considered acceptable for studying the shallow section.

Other forms of exploration 3D seismic data, through their acquisition geometry, are less likely to provide an appropriate continuous image of the seabed or shallow section. For example, wide azimuth, ocean bottom cable and node based 3D seismic datasets are unlikely to be acceptable for site survey application.

5.6.2 Minimum exploration 3D seismic data acceptability criteria

Exploration 3D data to be used for site survey studies should be used at their optimum spatial, temporal, bit resolution and sampling interval.

Data shall be loaded to a workstation at no less than 16- and preferably 32-bit data resolution. Data should be unscaled.

The dataset to be used shall provide a sufficiently resolute image of the seabed and shallow section to allow an accurate analysis of conditions to be made.

A preliminary review of the exploration 3D dataset under consideration should indicate that it fulfils the following basic standards:

- *Frequency content:* The dataset should preferably possess a useable frequency content up to, and preferably beyond, 60Hz to the full depth of interest below seabed.
- *Seafloor reflection:* should be free of gaps and defined by a wavelet of stable shape and phase to allow auto-tracking of the seabed event with minimum user intervention and guidance.
- *Acquisition artifacts:* such as cross-line statics and/or amplitude striping, though possibly identifiable in the shallow section, should not detract from the overall interpretation of a picked event when mapped in time or amplitude. Similarly time slices, or windowed attribute extractions, should be devoid of or show minimal acquisition artifacts to the detriment of their interpretation.
- *Merge points:* between datasets of differing origin or vintage that cross a study area should be marked by minimal – and preferably no – time or phase shifts and amplitude changes across the joins that might otherwise be to the detriment of the interpretation.
- *Bin sizes:* processed bin sizes should preferably be less than 25m in both the inline and crossline direction.
- *Sample interval:* Processed output sample interval should preferably be 2 milliseconds and certainly be no more than 4 milliseconds. This may be achieved by extracting a near offset cube from the original volume.

- *Imaging:* Attention to definition of an accurate velocity model in the shallow section in processing shall have allowed optimum structural and stratigraphic resolution to have been achieved in the migrated volume. The shallow section shall show no indication of under, or over, migration artifacts.
- *Multiple energy:* shall either be unidentifiable or at a level that does not interfere with the analysis of the shallow section.
- *Data coverage:* the available exploration seismic data coverage shall fully meet the requirements for data coverage set out in Section 5.2 above.

In shallow water depths of less than 300 metres, the above criteria are generally not met because of the frequency content of the data and the long seismic recording offsets. Exploration 3D seismic data is therefore not a suitable replacement for a site survey when a jack-up or bottom founded rig is to be used, or when seabed clearance is required for an anchored rig.

Depending on data quality, exploration 3D seismic data may however still be adequate for the identification of deeper drilling hazards and may therefore in some cases, in these water depths, replace the acquisition of high resolution 2D multichannel seismic data to identify drilling hazards. This should, however, be decided on a case-by-case basis and only after detailed review of the 3D seismic data by geohazard and 3D seismic specialists.

5.6.3 Use of targeted exploration 3D seismic data reprocessing

Reprocessing of an exploration 3D volume, either through production of a near trace or short offset, cube or by simply spectral whitening of the original volume can deliver significant improvements in resolution and data quality. This should be considered especially if the original exploration 3D dataset fails to meet the minimum data acceptability criteria set out above.

5.7 Enhancing the value of an exploration 3D seismic dataset

Where review of exploration 3D seismic data leaves some uncertainty on site conditions, the acquisition of a focused survey programme to calibrate the results of the review of the exploration 3D seismic dataset can assist in reducing interpretational risk or uncertainty.

Such work may entail the acquisition of various types of data:

5.7.1 Seabed samples

These can be acquired to calibrate variation in exploration 3D seabed reflection amplitude or appearance to variation in shallow soils.

5.7.2 Targeted 2D high resolution seismic data

The acquisition of a grid of tie-lines across particular features of interest, or to directly tie in the top-hole section of any available relevant offset wells to a proposed location, can significantly assist in confirming interpretation and improving analyses performed otherwise solely on the basis of exploration 3D data.

5.7.3 Side scan sonar data

If the exploration 3D data indicate the presence of potentially sensitive seabed conditions, or public information suggests the presence of existing infrastructure (submarine cables, *etc*), dumping grounds or wrecks in the area, the acquisition of side scan sonar data to ensure a clear seabed should be considered.

5.8 Use of exploration 3D seismic data in a development scenario

In the case of a field development, use of an exploration 3D dataset will normally provide an excellent basis for an initial field-wide desk study to support initial field layout concept screening.

Use of such data will also assist in design decisions for any subsequent engineering quality bathymetric and geophysical site investigation data acquisition campaign.

Therefore, use of exploration 3D datasets should be considered as an integral part in the phased development of an integrated geological model of the seabed and shallow subsurface for the field under development to complement, and fill in any gaps in, bathymetric or geophysical site survey data coverage.

However, field development project geohazard decisions should not be based solely on the use of standalone exploration 3D data. Acquisition of bathymetric and geophysical site survey data should always be acquired to ensure a clear site prior to installation, to affirm the long term integrity of the locations selected and to record the baseline seafloor environmental conditions in the area.

6 Geohazards analysis and reporting

Seismic interpretation, the identification and analysis of potential geohazards and the writing of technical reports to convey results to the end users should be performed by a qualified, experienced and skilled geoscientist who has specialised in high resolution geophysics.

6.1 Purpose of the report

The report's purpose is to describe and assess seafloor and top-hole geological conditions to help plan safe and efficient rig emplacement & drilling operations and to assist in identifying potentially sensitive seabed environments.

The report is the permanent record of the site investigation.

The site survey report for an offshore drilling location is the means by which information that has been collected and analysed is communicated to the end users through the provision of maps, cross-sections, figures, text, *etc*.

6.2 Scope of reporting

Site survey reports should provide an integrated assessment of all seafloor constraints upon the emplacement of the rig at the proposed location, and top-hole geological conditions to a depth at least 200m below the preferred setting depth of the first pressure containment string, or to a depth of 1000m, whichever is greater.

Constraints to the proposed drilling operations, including man made features, should be assessed and described.

It is recommended that a summary is provided at the start of the report in order to present the essential findings and conclusions about the site in an easily accessible form.

Reports should draw upon all relevant existing and newly acquired data for the site in question. This may include or make reference to:

- desk study reports
- pre-existing site survey reports
- exploration 2D or 3D seismic data
- top-hole logs from offset wells
- geotechnical soil investigation data
- information about man-made features such as existing wells, shipwrecks, and oil field infrastructure
- newly acquired hydrographic and geophysical data
- environmental data including benthic samples and seabed photographs

It is important that any links with environmental or geotechnical investigations are identified and there is consistency of results between the reports.

The content of the report should be carefully planned with the operational objectives in mind, and adjusted on the basis of the site conditions encountered during the survey.

Pre-drilling site survey reports should be concise, objective and user-friendly; they should be clearly understandable, regardless of the technical background of the reader.

A suggested table of contents for a site survey report is enclosed in the Technical Notes.

6.3 Identifying sources of risk

A key objective of a site survey is to assess geohazards and to enable the risk posed to drilling operations by the seabed and geological conditions to be managed and reduced.

The presence of hazards must be determined through rigorous and consistent analysis and clearly reported in the text, maps, and other graphics that make up the site survey report. For each hazard identified, hazard potential should be stated in terms of the likelihood that the particular condition exists at a specific locality.

The Technical Notes provide interpretation guidelines for the assessment of some key geohazards that may be identified during site survey.

6.4 Consideration by rig type

The site survey report should address three phases of the drilling operation:

- bringing the rig onto location and stabilising it before spudding-in
- spudding the well
- top-hole drilling to a depth at least 200m below the preferred setting depth of the first pressure containment string, or to a depth of 1000m below seabed, whichever is greater.

If the rig type is not known at the time the site survey report is prepared, the report should address concerns for all the rig types that could be used for the proposed drilling operation.

6.4.1 Bottom-founded rigs and platform based rigs

Reports for bottom-founded rigs should address the shallow foundation conditions for rig leg emplacement to whichever is greater: 30m below seabed or the expected leg penetration depth plus one-and-a-half times the diameter of the spud can. It should address the expected drilling conditions across the top-hole section to whichever is greater: 200m below the preferred setting depth of the first pressure containment string or to a depth of 1000m below seabed.

The report should also consider the seabed conditions within a 200m radius of the proposed wellsite or sites, along the approach route to location, and around any temporary stand-off locations.

6.4.2 Anchored rigs

Reports for anchored rigs should focus on the seafloor and shallow soil conditions to a distance 250m beyond the maximum likely anchor radius and the top-hole drilling conditions for the proposed location.

If anchor locations are known, special attention should be paid to the anchor and catenary touchdown area where the seafloor will be disturbed by anchor chain and/or wire rope. The expected type and strength of the seabed soils where the anchors will be set should be described.

For spud-in and top-hole drilling, the report should consider the seabed conditions in a 200m radius around the proposed wellsite and the expected drilling conditions across the top-hole section to 200m below the preferred setting depth of the first pressure containment string or to a depth of 1000m below seabed, whichever is greater.

6.4.3 Dynamically Positioned (DP) rigs

Reports for DP rigs should consider the expected drilling conditions across the top-hole section to 200m below the preferred setting depth of the first pressure containment string or to a depth of 1000m below seabed, whichever is greater.

Special attention should be paid to the immediate vicinity of the proposed wellsite within a radius of 200m or out to the maximum distance that the DP rig's seabed acoustic reference network shall be laid from the well.

6.5 Deliverables

Report deliverables can be provided in both digital media and paper forms.

Integrated digital methods of compiling, presenting and delivery of report information are encouraged. In particular, GIS and web-based methods allow ease of retrieval for future reference, results integration with other types of information and rapid archiving and retrieval.

OGP have published a Seabed Survey Data Model (SSDM) to define an industry standard GIS data model for seabed surveys. This model can be used as a deliverable standard between operators and survey contractors, as well as a data model for managing seabed survey data within operator companies. The SSDM was published as beta version late 2010 for testing and will be finalised in 2011. The SSDM documentation and supporting material can be downloaded from **www.ogp.org.uk**.

Glossary

2D multi-channel high resolution seismic

Seismic reflection data designed to image the shallow section and detect drilling hazards such as shallow gas.

3D migrated volume

The end product of a fully processed 3D seismic survey.

Acoustic seabed imagery

Images derived from acoustic reflection data processed to illustrate seabed: topography, features, and changes in texture.

Acquisition artefacts

Noise on seismic data that is a function of the data acquisition process rather than geology

Anchor radius of a semi-submersible rig

The radius of the smallest circle that includes all the seabed anchor positions for a semi-submersible rig.

Archaeological remains

Objects that are of historical interest. These may be man-made, for example shipwrecks, or human or animal remains of any age.

Auto-tracking

The process by which seismic horizons are automatically tracked in a seismic dataset by an interactive seismic interpretation system.

AUV

Autonomous Underwater Vehicle. A self propelled, untethered underwater vehicle that is able to be programmed to fly along a predefined survey track at a predefined height above the seabed to collect data from sensors installed on it.

Backscatter

The amplitude of the acoustic echo sounder energy reflected by the seabed that may be processed into maps that provide information about seabed features and texture.

Benthic samples

Seabed samples recovered by grabs, or corers, that are normally taken for environmental investigations.

Bottom founded rig

Mobile drilling rig such as a jack-up rig or a drilling barge that relies on a seabed foundation for stability during drilling.

Boulder beds

Accumulations of boulder sized material, greater than 10cm across, buried in sediments. Typically found in the base of buried channels or within glacial sediments.

Box corer

Seabed sampling system designed to recover a cube of seabed sediment. Generally used for soft seabed sediments.

Buried infilled channels

Ancient eroded channels that have subsequently been infilled and buried by sediment.

Buried slumps

Ancient submarine landslides that have been buried by sediment.

Chemosynthetic communities

Discrete life forms normally in the vicinity of the seabed that exist only because of specific, localized chemical conditions.

Clock and orbit corrected GPS

Corrections applied to the clock and orbit ephemerides data that has been uploaded to each GPS satellite. Corrections are broadcast at 1 Hz to the NASA GDGPS system.

Communications cables

Cables on or beneath the seabed laid either between continents and islands or to offshore installations.

Global Navigation Satellite Systems (GNSS)

Generic term for satellite based navigation systems like GPS, Glonass and others that provide autonomous global positioning of GNSS receivers.

CPT

Cone Penetration Test. In-situ soil strength testing device that makes real time measurements as it is pushed into the seabed by mechanical means.

Crossline direction

Azimuth bearing of subordinate lines in a marine survey

CTD

Conductivity, Temperature and Depth meter. Device for making real time measurements of conductivity, temperature against depth over the full water column to derive the speed of sound in water to calibrate e.g. echo sounder and USBL observations.

Desk study

Exercise to derive as much information as possible about the site conditions in an area from existing data and public domain information.

Diapiric structures

Positive geological structures formed by the deformation of plastic material, for example salt or clays. They can be associated with hydrocarbon accumulations and may also have a surface expression that in the marine case would result in a bathymetric high.

Diatreme

A volcanic, or injective, feature piercing sedimentary strata.

Differentially Corrected GPS (DGPS)

A method of improving GPS solution for position in plan and height by applying corrections to satellite ranges. Corrections are calculated between observed and calculated ranges at reference station(s) of known position.

DTM

Digital Terrain Model. Digital representation of a mapped surface usually defined by xyz values for defined cells.

Dynamically Positioned (DP) rig

Mobile drilling rig that relies on thrusters automatically controlled by a dynamic positioning system for stability during drilling.

Engineering activity

Any construction or maintenance activity that could result in changes to facilities at the seabed, deformation of the seabed, or dropping of debris items.

Erosion and truncation surface

Geological interface that marks the lower limit of erosion and on which deposition has subsequently taken place. Erosion and truncation surfaces therefore mark unconformities in the sequence of geological deposition.

Exploration 3D seismic data

3D seismic reflection data collected for the purpose of exploring for oil and gas rather than studying geohazards and the shallow section.

Fault escarpments

Bathymetric ridges on the seabed aligned with underlying geological faults.

First pressure containment string

The first casing to be installed in a well that will enable the pressure inside the well to be controlled.

Fluid expulsion features

Seabed depressions such as pockmarks believed to have been caused by the expulsion of pore water or gas.

Fold of cover

The number of seismic traces, each recorded at a different source to receiver offset, that are combined together in multi-channel seismic reflection profiling

Foundational depth

The maximum depth below seabed of interest for foundation design and installation

Gas chimney

A zone within the sub-seabed section where the vertical migration of gas is taking place. This is often characterized by energy scattering and absorption on seismic reflection data and a lack of coherent reflectors.

Gas hydrate mounds

Accumulations or build ups of gas hydrate at seabed normally over a seabed seep in deep water or at high latitudes.

Gas hydrate zones

Parts of the sub-seabed section where gas hydrate is present.

Gas vents

See Fluid Expulsion Features

Geohazard

Geological condition that has the potential to cause harm to man or damage to property

Geological model

Computerised representation of subsurface geology

Geotechnical boreholes

Boreholes drilled into the seabed for the purposes of carrying out in-situ geotechnical testing, or to collect samples for geotechnical laboratory testing and analysis.

Geotechnical engineering

The branch of civil engineering concerned with the engineering behaviour of earth materials.

GIS

Geographic Information System. A system that captures, stores, analyzes, manages, and presents data that are directly linked to the coordinates of the data's origin.

Grab

Seabed sampling device

Gradiometers

A system which measures the magnetic gradient using two or more closely spaced magnetometers

Gravity corer

Seabed sampling device that penetrates the seabed using force exerted by its own weight of momentum

Ground truthing

Calibration of geological interfaces interpreted from seismic data using seabed samples

Habitat

An ecological or environmental area inhabited by a particular animal or plant species

Hardgrounds

Hard material, such as cemented sediment, coral or rock, at seabed

HR 3D survey

3D seismic reflection survey designed to image the shallow section in great detail by recording high frequencies

Inline direction

Azimuth bearing of primary lines in a marine survey

Jack-up rig foundation

The seabed conditions where a jack-up rig leg impacts the seabed

Jack-up rig footprint

Depression left on the seabed after a jack-up rig leg has been withdrawn

Layback to towed equipment

Horizontal distance from the survey vessel to a towed sensor

Local vertical datum

A vertical datum that has been chosen for a project where a standard datum such as LAT may not be appropriate; for example on a platform or jack-up rig superstructure

Magnetometer

An instrument used to measure the strength and / or direction of the magnetic field in the vicinity of the instrument

Manifolds and templates

Examples of facilities placed on the seabed for the purposes of drilling and / or production.

Mass transport complexes

MTCs, see Slump

Maximum offset

The maximum horizontal source to receiver offset in a multi-channel seismic survey.

Mega-ripples

Current ripples normally present on a sandy seabed having a wavelength of greater than 0.5 metre.

Minimum offset

The minimum horizontal source to receiver offset in a multi-channel seismic survey.

Minimum phase output

The output of a seismic source where the energy is front-end loaded in the first energy peak of the pulse and is not followed by a larger peak.

Mosaic

Compilation of side scan sonar records to form a geo-referenced seabed map.

Motion sensor

An instrument for measuring horizontal and vertical motion and attitude of for example a survey vessel. The information is needed to correct, *eg* multi or single beam echo sounder data and USBL data for vessel motion.

Mud volcano

Formations created by geo-excreted liquids and gases. See Diatreme.

Mudflow

See Slumping.

Mudline

Seabed. Term often used when the seabed is composed of particularly soft, water saturated sediment

Multi-beam echo sounder

See Swathe Bathymetry System

Multi-channel digital signal processing

The process by which field recordings from multi-channel seismic reflection surveys are enhanced and converted to interpretable sections or volumes

Multiple energy

Noise on seismic records caused by reverberations between strong reflecting interfaces, such as the seabed and the sea surface.

Near offset cube

A processed 3D seismic dataset that uses only traces recorded by the receivers positioned closest to the seismic source with most vertical incidence angle. The data will contain the highest frequencies and thus the best vertical resolution, but will be affected by noise especially in the deeper part of the section.

Ocean bottom cable

Seismic recording cable placed on the seabed with four component receivers that will have the capability to record S-waves as well as P-waves.

Offset well

Existing well from which information is available to tie back to and assist with making predictions about conditions at a proposed well location.

Offshore drilling unit

Facility from which offshore wells are drilled. For example a mobile drilling unit.

Operator

Company having responsibility for drilling an offshore well.

Over-pressure zone

Sub-seabed layer having a pressure above normal hydrostatic pressure.

Pinning up activity for a jack-up rig

Procedure by which jack-up rig legs are initially lowered to contact with the seabed to secure the rig to the seabed and make it resistant to lateral movement.

Piston corer

Seabed sampling device best suited to soft sediments where a piston helps draw sediment into the core barrel.

Platform based rig

Drilling rig mounted on a fixed platform

Project engineer

The Operator's Project Engineer responsible for overall well or development planning and interface to the Site Survey Project Manager

Project manager

Can refer to either or both of: the Operator staff member responsible for planning and delivery of the Site Survey, and the Contractor Representative responsible for actioning the Operator's plans.

Protection frames

Structure placed over a seabed installation normally to protect it from trawl nets or dropped objects

Record length

The length of time that seismic signals are recorded following the firing of a seismic source.

Recording system

Instrument for recording seismic signals

Reefs

Sedimentary features, built by the interaction of organisms and their environment, that have synoptic relief and whose biotic composition differs from that found on and beneath the surrounding sea floor, for example a coral reef.

Relief well

Well designed to provide intervention in the event of incurring a well control incident at depth.

Responder

Same as Transponder (see below). An electronic acoustic device that produces an acoustic response when it receives a trigger signal through an umbilical between e.g. a vessel and towed equipment.

Rock dump

Mound of rock or gravel placed on the seafloor for example to stabilise a pipeline or submarine cable.

Salt or mud diapirs

See Diapiric Structures and Diatremes

Sample decimation

Resampling of digital seismic data at a longer interval than originally used.

Sample interval

Time interval between successive samples in a digital seismic record.

Sandwave

Mobile submarine sand dune created by currents. Typically up to 10 metres high but occasionally higher.

Seabed acoustic array

A number of acoustic transponders strategically placed on the seabed to position either surface vessels, for example drilling rigs, or sub-sea installations.

Seabed characterisation

Classification of seabed topography and sediments through investigation.

Seabed clearance data

Dataset that enables objects and obstructions on the seabed to be located and identified.

Sedimentary sequence

Succession of sediments that makes up the geological sequence.

Seismic source

Source of controlled seismic energy that is used in reflection and refraction seismic surveys.

Seismic streamer

Receiving system for marine seismic surveys that is towed behind a survey vessel. Usually consists of a large number of hydrophones arranged in groups and may extend to several km in length.

Semi-regional

Area of study extending beyond a single well to include several wells, prospects or developments.

Shallow gas blowout

Uncontrolled egress of shallow gas from a well.

Shallow section

The geological section above the setting depth of the first pressure containment string in a well

Shallow water flow zone

Overpressured geological interval from which pore water flows into a well causing difficulties in well control and effective cementing of casing.

Side scan sonar

Instrument for scanning the seabed to either side of a survey line using acoustic pulses. Can detect objects on the seabed, and variations in seabed topography and seabed sediment type.

Single beam hydrographic echo sounder
Instrument for measuring water depth immediately below a survey vessel

Slump
Movement of a sediment mass under the influence of gravity. An example is the outflow of sediment from a seabed expulsion feature such as a mud volcano. Also known as Gravity Transport.

Source signature
Output wavelet, or waveshape, of a particular seismic source from which frequency, output power and phase may be determined

Spatial resolution
The lateral size of a feature that can be detected by the seismic method. Usually defined as the radius of the Fresnel zone at a particular depth. On migrated data the Fresnel zone radius is related to approximately one quarter of the signal wavelength.

Spud can
Base of a jack-up rig leg

Stand-off location
Area of seabed that has been surveyed and established as a safe place for a rig to be placed while waiting to move onto an intended drilling location

Stratigraphy
A branch of geology that studies rock layers and layering (stratification) primarily used in the study of sedimentary rocks

Sub-bottom profiler
Seismic reflection instrument for investigating the upper few tens of metres of the sub-seabed with as high a vertical resolution as possible

Subsea isolation valves
Valves on submarine pipelines that automatically cut off the flow in the event of an emergency. They are often placed within a few hundred metres of a platform.

Subsurface data
Geophysical and geotechnical data for investigating sub-seabed geology.

Swathe bathymetry system
Instrument for measuring water depths within a defined swathe either side of a survey vessel track

Time slice
Horizontal section through a 3D seismic volume that displays information at the same two way reflection time

Top-hole drilling hazards
Geological conditions that impact on drilling operations in the top-hole section of a well.

Top-hole section
The shallow geological section above the setting depth of the first pressure containment string in a well

Topography
The study of Earth's surface shape and features.

Tow fish
Vehicle on which survey sensors are mounted that is towed behind a survey vessel.

Towed sensors
Survey sensors mounted on a tow fish and towed behind a survey vessel.

Trace decimation
Reducing the number of seismic traces in a seismic record in order to reduce its volume.

Transponder
An electronic acoustic device that produces an acoustic response when it receives an acoustic signal from e.g. a vessel mounted transducer or another transponder.

USBL
Ultra Short Baseline System: a subsea acoustic positioning system used to determine the position of towed or deployed sensors in the water column. A transponder or responder is mounted on the sensor to be positioned and interrogated from a transducer of known position.

Unscaled
A processed seismic section in which the magnitude of reflection amplitudes is preserved in a meaningful way, and may be used, for example, in the identification of shallow gas.

Unstable slopes
Submarine slopes that have the potential to fail.

UUV
Untethered Underwater Vehicle, see AUV.

Velocity model
The assignment of different seismic velocities to certain discrete geological or reflection time intervals.

Velocity probe
Instrument for making real time measurements of the speed of sound in water to calibrate echo sounder readings.

Vessel mounted acoustic positioning system

A subsea acoustic positioning system that is permanently installed on a vessel. This system can either determine the relative position of acoustic transponders or responders mounted on other equipment (*eg* tow fish) or absolute positions within a network of seabed acoustic transponders.

Vessel transducer

A transducer, to transmit and receive acoustic signals, that is either permanently installed in the hull of a vessel or deployed from the vessel for the acquisition of different data types; water depth (echo sounder), shallow geophysical data (sub bottom profiler), range and bearing to towed equipment (acoustic positioning system).

Vibro-corer

Seabed sampling device that penetrates the seabed using force exerted by a vibrating motor mounted on top of a coring barrel.

Wavelet

A seismic pulse usually consisting of one and a half to two cycles.

Wellhead

A general term used to describe the pressure containing component at the surface of an oil or gas well that provides the interface for drilling and production equipment.

Windowed attribute extractions

Analysis of the reflection amplitudes or other seismic attributes over a specific reflection time window carried out using an interactive seismic interpretation system.

Appendix 1 – Hazard impact tables

Constraint, hazard or concern	Impact on operations			Investigatory data requirement
	Bottom founded rig or platform	Anchored rig	Dynamically positioned rig	
Water depth	*Suitability of Rig:* • Barge draught • Barge freeboard • Leg length • Expected seabed penetration – relative to vessel draught or leg length • Achievable air gap	*Suitability of Rig:* • Maximum permissible draught (coastal waters) • Anchor system limitations (limb length and winch capacity) • Boat support needs for anchoring • Riser length available • Maximum useable mud weight (in deep water) • Amount of fatigue loading on riser	*Suitability of Rig:* • Riser length available • Maximum useable mud weight • Direction of departure in event of emergency disconnect, hanging off with riser fully deployed, or approaching back on to location to latch on to BOP.	Derived from results from a precise bathymetric survey using Swathe Bathymetry and single channel echo sounder systems (see section 5.5.1). For individual well locations in water depths greater than 750m, that are not related to a field development, use of a properly depth converted exploration 3D Seabed event may be an adequate replacement (see sections 5.5.2 and 5.6).
Natural seabed features • Seabed topography and relief • Seafloor sediments • Sand: banks, waves, and mega-ripples • Mud: flows, gullies, volcanoes, lumps, lobes • Fault escarpments • Diapiric structures • Gas vents and pockmarks • Unstable slopes • Slumps • Collapse features • Fluid expulsion features • Gas hydrate mounds • Rock outcrops, pinnacles and boulders • Reefs • Hardgrounds • Seabed channels and scours	*Choice of:* • Rig type (barge, mat or multi-leg jack up) • Well location *Impacts on:* • Risk of scou r • Rig stability • Spud can damage	*Choice of:* • Well location • Anchor locations • Catenary touchdown points *Impacts on:* • Anchor deployment and slippage • Requirement for piggy back anchors • Difficulty of spudding the well • Leveling of wellhead • Wellhead scour caused by current focusing.	*Choice of:* • Well location • Difficulty of spudding the well • Leveling of wellhead • Layout of seabed acoustic array • Wellhead scour caused by current focusing. • Direction of departure in event of emergency disconnect, hanging off with riser fully deployed, or approaching back on to location to latch on to BOP.	Mapped on the basis of an integrated use of: • Bathymetric data • Side scan sonar data • Profiler data See section 5.5.1. In some cases in shelf waters, where bottom founded rigs would operate, exploration 3D seismic imagery might assist an integrated study depending on 3D data quality. In water depths over 750m exploration 3D data can replace the need for bathymetry or side scan sonar data (see sections 5.5.2 and 5.6).
Man made features • Platforms: active, abandoned, or toppled • Pipelines: on or buried below the seabed • Power and umbilical lines • Communications cables • Wellheads and abandoned well locations • Manifolds and templates • Pipeline terminations, valves and protection frames • Subsea isolation valves • Rock dumps • Non oil and gas infrastructure such as navigation buoys, wind turbines etc. • Ordnance and chemical dumping grounds • Miscellaneous debris	*Choice of:* • Well location • Emergency transit locations • Stand-off location(s) • Direction of approach onto and departure from location • Positional tolerance • Anchor locations to aid in bringing rig onto location. *Can result in:* • Structural damage to rig or seabed facilities. • Spud can damage • Spills and emissions • Loss of Operator reputation.	*Choice of:* • Well location • Anchor Locations and appropriate offsets to identified features • Design of anchor catenary profile • Requirement for mid-line anchor line buoys. *Can result in:* • Damage to seabed facilities. • Spills and emissions • Loss of Operator reputation.	*Choice of:* • Well location • Direction to leave location when hanging off with riser fully deployed, or approaching back on to location to latch on to BOP. *Can result in:* • Damage to seabed facilities. • Spills and emissions • Loss of Operator reputation.	*Presence identified from a desk study review of:* • Nautical charts for the area • Communications cable databases • Published Pipeline and Cable route charts See Section 4. *Mapped from the integrated use of:* • Side scan sonar data • Towed magnetometer • data • Profiler data See Section 5.5.1. When the above data are not acquired in water depths greater than 750m, the well location should be visually inspected by the rig's ROV immediately prior to, and during spudding, of the well.

Constraint, hazard or concern	Impact on operations			Investigatory data requirement
	Bottom founded rig or platform	Anchored rig	Dynamically positioned rig	
Environmentally sensitive environments *To include but not be limited to:* • Marine Sanctuaries • Fish spawning grounds • Cold water corals • Chemosynthetic communities	*Choice of:* • Emergency transit locations • Stand-off Locations • Direction of approach onto and departure from location.	*Choice of an environmentally neutral:* • Location • Anchor Locations • Catenary touchdown points.	Choice of an environmentally neutral well location.	*Presence identified from a desk study review of:* • Local laws, regulations and public announcements • Nautical charts for the area See Section 1 and 4. Otherwise defined using similar methods to "Natural Seabed Features" above and in keeping with section 5.5.1.
Shipping and military training areas	*Choice of:* • Well location • Stand-off locations • Direction of approach onto and departure from location.	*Choice of:* • Well location • Anchor locations.	Choice of well location.	As defined on published nautical charts (see section 4).
Archaeological features *To include but not be limited to:* • Wrecks • War debris (mines etc.) • Possible submerged communities or human environments.	*Choice of:* • Well location • Stand-off locations • Direction of approach onto location.	*Choice of safe:* • Well location • Anchor locations and catenary touchdown points.	Choice of well location.	*Defined by:* • Local Laws and listings • Nautical charts See Section 1 and 4. *Mapped from the integrated use of:* • Side scan sonar data • Towed magnetometer • data • Profiler data See Section 5.5.1 When the above data are not acquired in water depths greater than 750m, the well location should be visually inspected by the rig's ROV immediately prior to, and during spudding, of the well.

Constraint, hazard or concern	Impact on operations			Investigatory data requirement
	Bottom founded rig or platform	Anchored rig	Dynamically positioned rig	
Shallow soils • Sediment type • Soil strengths • Strength inversions • Gas inclusions • Rockhead • Hardpan or Hard grounds • Calcareous soils • Coral	*Choice of:* • Rig type • Well location • Spud can or foundation type • Drive pipe/conductor setting depth relative to leg penetration. *Can impact upon:* • Foundation Stability • Spud can damage • Amount of leg penetration • Scour and differential rig settlement • Punch-through • Drive pipe/conductor driveability • Top-hole inclination.	*Choice of:* • Well location • Type of mooring system: all chain, all wire, or mixed wire and chain • Anchor type • Anchor fluke setting angle • Anchor and catenary touchdown placement • Requirement for piggy back anchors • Mud mat design due to wellhead instability • Length and strength of conductor • Conductor installation technique (drill and grout or jetting). *Can impact upon:* • BHA deflection, top-hole inclination and need to re-spud.	*Choice of:* • Well location • Mud mat design due to risk of wellhead instability • Length and strength of conductor • Conductor installation technique (drill and grout or jetting). *Can impact upon:* • BHA deflection, top-hole inclination and need to re-spud	*Defined on the basis of an integrated use of:* • Profiler data • Multi-Channel HR seismic data • Geotechnical soil data (where available) • Side scan sonar data • Offset well reports See section 4, 5.5.1 and 6.2. In shelf waters occasionally, but more normally in deep waters, exceeding 750m, integrated or standalone use of exploration 3D seismic seabed amplitude maps used with the data types listed above, where available, might assist, in assessing regional variability of seabed soils. See section 5.6 and 5.7.1.
Shallow faults	*Can result in:* • Lost Circulation • Flow to surface in event of underground blowout, seabed cratering, and resultant loss of rig. • BHA deflection • Stuck pipe and/or twist-offs • Casing hang-ups • Requirement for additional casing strings. • Casing collapse.	*Can result in:* • Lost Circulation • Broaching to surface in event of underground blowout leading to seabed cratering, loss of well and potential loss of rig stability in a gas plume. • BHA deflection • Stuck pipe and/or twist offs • Casing hang-ups • Requirement for additional casing strings • Casing collapse.	*Can result in:* • Lost Circulation • Broaching to surface in event of underground blowout leading to seabed cratering, loss of well and forced rig drive off. • BHA deflection • Stuck pipe and/or twist-off • Casing hang-up • Requirement for additional casing strings • Casing collapse.	*Defined on the basis of an integrated use of:* • Profiler data • Multi-Channel HR seismic data • Side scan sonar data See section 5.5.1. In shelf waters, but more normally in deep waters, exceeding 750m, integrated or standalone use of exploration 3D seismic data depending on quality (see section 5.6.2) can be used in assessing the presence and geometry of shallow faulting.

Constraint, hazard or concern	Impact on operations			Investigatory data requirement
	Bottom founded rig or platform	Anchored rig	Dynamically positioned rig	
Shallow gas charged intervals	*Risk of:* • Minor gas flow at seabed or to rig floor • Hydrate formation in polar latitudes • Gas kick • Blowout • Uncontrolled flow to seabed • Seabed cratering • Loss of rig *Has direct impact on choice of:* • Rig type • Well location • Design(ed use) of diverter system • Setting depth of surface casing string • Shallow casing plan • Mud weight choice	*Can lead to:* • Minor gas flow at seabed or to rig floor • Hydrate formation on wellhead (in water depths greater than 600m or in Polar latitudes) • Gas kick • Blowout • Loss of well • Loss of vessel buoyancy in a gas plume • Uncontrolled environmental emissions *Has direct impact on choice of:* • Well Location • Setting depth of surface casing string. • Need for additional casing strings • Riser or riserless drilling approach • Mud weight choice • Mud use (e.g. "pump and dump") • Drilling and cementing practices.	*Can lead to:* • Minor gas flow • Hydrate formation on wellhead (water depths greater than ~600m) • Gas kick • Blowout • Loss of well • Loss of vessel buoyancy in a gas plume • Uncontrolled environmental emissions *Has direct impact on choice of:* • Well location • Setting depth of surface casing string • Need for additional casing strings • Riser or riserless drilling approach • Mud weight • Mud use (e.g. "pump and dump") • Drilling and cementing practices.	Shallow gas is defined as any gas pocket encountered above the setting depth of the first pressure containment string. *Defined on the basis of an integrated use of:* • Multi-channel HR seismic data • Offset well data • Profiler data In deep waters, exceeding 750m, integrated or standalone use of exploration 3D seismic data depending on quality (see section 5.6.2) can be used in assessing the presence of shallow gas and possible migration routes from depth.
Shallow water flow	*Can lead to:* • Uncontrolled artesian flow • Formation fracture and flow to surface outside casing/conductor. • Uncontrolled flow to seabed and cratering • Loss of foundation support to wellhead or rig foundations • Problem cementing surface casing string • Loss of integrity to surface casing string • Casing collapse • Loss of well. *Has direct impact on:* • Setting depth, and number, of shallow casing points. • Shallow drilling practices • Choice of mud weights • Cementing practices.	*Can lead to:* • Uncontrolled artesian flow • Formation fracture and flow to surface outside casing/conductor. • Uncontrolled flow to seabed and cratering • Loss of foundation support to wellhead • Problem cementing surface casing string • Loss of integrity to surface casing string • Casing collapse • Loss of well. *Has direct impact on:* • Setting depth, and number, of shallow casing points. • Shallow drilling practices ("pump and dump") • Choice of mud weights • Cementing practices.	*Can lead to:* • Uncontrolled artesian flow • Formation fracture and flow to surface outside casing/conductor. • Uncontrolled flow to seabed and cratering • Loss of foundation support to wellhead • Problem cementing surface casing string • Loss of integrity to surface casing string • Casing collapse • Loss of well *Has direct impact on:* • Setting depth, and number, of shallow casing points. • Shallow drilling practices ("pump and dump") • Choice of mud weights • Cementing practices.	Shallow water flow is defined as a water flow from an overpressured aquifer at a depth above the setting depth of the surface casing. This is generally an issue of concern where the recent rate of shallow deposition has consistently exceeded 450m per million years. *Predicted on the basis of an integrated use of:* • Multi-channel HR seismic data • Offset well data and reports In deep waters, exceeding 750m, integrated or standalone use of exploration 3D seismic data depending on quality (see section 5.6.2) can be used in assessing the presence of intervals that may be prone to shallow water flow.

Constraint, hazard or concern	Impact on operations			Investigatory data requirement
	Bottom founded rig or platform	Anchored rig	Dynamically positioned rig	
Gas hydrate or hydrated soils	Generally not an issue in shallow water except at Polar latitudes. *Formation of hydrate can lead to:* • Loss of circulation • Underground blowout • Destabilization of natural hydrated conditions could lead to: • Loss of formation integrity • Loss of foundation support leading to well and rig collapse.	*Formation of hydrate can lead to difficulty with:* • Emergency disconnect • Temporary and final well abandonment. • Loss of circulation • Underground blowout *Destabilization of natural hydrated conditions could lead to:* • Loss of formation integrity • Loss of foundation support leading to wellhead sinking and loss of well • Seabed (slope) failure.\	*Formation of hydrate can lead to difficulty with:* • Emergency disconnect in a drive-off situation • Temporary and final well abandonment • Loss of circulation • Underground blowout *Destabilization of natural hydrated conditions could lead to:* • Loss of formation integrity • Loss of foundation support leading to wellhead sinking and loss of well • Seabed (slope) failure.	Gas hydrate or hydrated soils may be considered to be a potential issue in Polar latitudes or deep water. *Predicted on the basis of an integrated use of:* • Water temperature probe data • Gross water depths • Side scan sonar data • Profiler data • Multi-channel HR seismic data • Offset well data and reports In deep water, exceeding 750m, integrated or standalone use of exploration 3D seismic data depending on quality (see section 5.6.2) can be used in assessing indirect evidence for the presence of a hydrated shallow section.
Top-hole geology • Sedimentary sequences: sand, mud, clay, swelling clays or gumbo, marl, carbonates, salt, etc. • Stratigraphy • Buried infilled channels • Boulder beds • Buried slumps and mass transport complexes • Loose formations • Salt or mud diapirs and diatremes • Erosion and truncation surfaces • Dip angle	*Impacts upon choice of:* • Length of drive pipe/conductor • Setting depth of first pressure containment string and subsequent casing strings • Drilling and cementing practices.	*Impacts upon choice of:* • Length and strength of conductor • Conductor installation technique (drill and grout or jetting). • Casing point(s) • Setting depth of surface casing string • Drilling and cementing practices.	*Impacts upon choice of:* • Length and strength of conductor • Conductor installation technique (drill and grout or jetting) • Setting depth of surface casing string • Casing point(s) • Drilling and cementing practices.	*Defined on the basis of an integrated use of:* • Profiler data. • Multi-channel HR seismic data • Offset well and geotechnical borehole data In shelf waters, but more normally in deep waters, exceeding 750m, integrated or standalone use of exploration 3D seismic data depending on quality (see section 5.6.2) can be used in assessing the top-hole geology.

For further information and publications,
please visit our website at

www.ogp.org.uk

International
Association
of Oil & Gas
Producers

209-215 Blackfriars Road
London SE1 8NL
United Kingdom
Telephone: +44 (0)20 7633 0272
Fax: +44 (0)20 7633 2350

165 Bd du Souverain
4th Floor
B-1160 Brussels, Belgium
Telephone: +32 (0)2 566 9150
Fax: +32 (0)2 566 9159

Internet site: www.ogp.org.uk
e-mail: reception@ogp.org.uk