CANADA'S OIL & NATURAL GAS PRODUCERS

BEST PRACTICE

Source Control in Well Planning for Subsea Wells

February 2023

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1 Introduction

In January 2019, the International Association of Oil & Gas Producers (IOGP) published a guidance document on Source Control Emergency Response Planning for Subsea Wells (SCERP-SW) - IOGP Report 594. Motivated by the contents of this report, a joint effort in the Atlantic Canada region between the offshore petroleum industry Operators and the respective Regulators was undertaken to develop a best practice document with specific focus on source control related tasks which are addressed in the well planning phase.

The objective of this document is to capture best practices regarding source control related tasks and considerations in the well planning / well design phase as set forth by recognized industry groups and common Operator practices. IOGP Report 594 is referenced and incorporated where practical.

The intended use of the document is to establish a common understanding and facilitate discussion between the Operators and the respective Regulators on what is considered industry best practice regarding source control considerations in well planning for subsea wells. The document is intended for use in the Atlantic Canada Offshore Petroleum Area and is applicable for subsea wells. This document does not replace or supersede any applicable regulations or Operator-specific requirements (management system or otherwise) to which Operators must comply. Local regulatory requirements for offshore Atlantic Canada identify expectations related to well integrity, contingency planning and emergency response. While it is intended to give broad coverage of recognized best practices regarding source control considerations in well planning it is not all inclusive and not intended to be used as requirements. This document only covers the subject matter identified in Section 2.0 and does not focus on source control related content such as spill response. Adherence solely to the best practices highlighted in this document may not be sufficient to ensure compliance with all applicable regulations.

Note: As stated, the document is intended to establish a common understanding between the Operators and the respective Regulators. If new technology or methods uncommon to the jurisdiction are being contemplated, early engagement with the Regulator is recommended.

2 Scope

The scope of this document was inspired by the contents of IOGP Report 594 “Source Control Emergency Response Planning Guide for Subsea Wells”. While IOGP Report 594 covers source control emergency response planning for subsea wells including engineering support tasks, this document focuses exclusively on engineering tasks which are commonly completed in the well planning phase in support of source control plans. It also considers local practices and considerations where appropriate.

This document captures best practices related to the following common well planning engineering activities:

1. Worst Case Discharge (WCD) Analysis
2. Blowout & Kill Rate Simulation Study
3. Casing Design for Blowout Load Case
4. Well Integrity Considerations in Source Control
5. Structural Integrity Analysis
6. Plume Evaluation
7. Computational Fluid Dynamics (CFD) of Uplift Forces
8. Capping Considerations
9. Relief Well Planning and Interfacing with Source Control

Note: The scope of this document is limited to well planning activities which interface with and support source control plans. It is not intended to cover other standard well design considerations addressed in well planning or any other contingency plans associated with the well planning process.

3 Document Format

The individual sections in this document pertaining to well planning engineering activities were prepared by reviewing relevant industry references and Operator best practices. Each section is built as follows:

- Best Practices – Direct quotations or section references from relevant industry references considered to capture best practices regarding source control related tasks and considerations in the well planning phase.

  Note: Direct references are used to ensure information from the selected industry references is not miscommunicated. While some best practices may contain prescriptive language (e.g., "shall"), the best practices should not be considered prescriptive.
- Reference Standard – Reference to where the best practice is sourced.
- Comments – Additional information / clarity regarding best practices. Includes for example elements considered best practice in the Atlantic Canada region or elements commonly considered best practice amongst the Operator group.

4 Definitions

FOR THE PURPOSES OF THIS BEST PRACTICE DOCUMENT, THE FOLLOWING DEFINITIONS APPLY:

Atlantic Canada Offshore Petroleum Area: refers to the combined offshore area regulated by the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) and the Canada- Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB)

Operator: the holder of an authorization to conduct petroleum activities in the offshore area [5]

Regulator: refers to the CNSOPB or C-NLOPB as applicable.

5 Worst-case Discharge Analysis

Worst-case discharge (WCD) is the maximum rate a well will flow during an uncontrolled event [1][3]. It is a single value for the expected flow rate calculated under worst-case wellbore conditions using known or expected reservoir properties [3]. Estimation of WCD is most commonly the result of an inflow/outflow assessment using a numerical reservoir simulator [3]. The output is used for engineering studies such as casing design, blowout & kill rate simulation studies, CFD analysis and plume evaluation [1].

SPE Technical Report 174705 Rev. 1 [3] is referenced in IOGP Report 594 [1] and is a suggested reference regarding calculation of worst-case discharge. Table 1 highlights the main areas considered as best practice within the associated reference standard.

<table>
<tr><th colspan="3">Table 1: Best Practices – Calculation of Worst-Case Discharge</th></tr>
<tr><th>Best Practices</th><th>Reference Standard</th><th>Comments</th></tr>
<tr><td colspan="3">Uncontrolled Flow Rate Calculation [3]*</td></tr>
<tr><td>See “Wellbore Configuration” in SPE Technical Report 174705 [3]</td><td rowspan="4">SPE Technical Report 174705 Rev. 1 [3]</td><td>Wellbore configuration should be worst-case (i.e., no restrictions in the flow path).</td></tr>
<tr><td>See “Subsurface Characterization” in SPE Technical Report 174705 [3]

- Identification of Zones Capable of Flow
- Selection of Analog Data
- Rock Properties
- Fluid Properties
- Drainage Area and Drive Mechanism
- Wellbore Conditions Affecting Inflow Performance</td><td>Blockage of the open hole by formation collapse, solids inflow or other wellbore fill should not be considered.</td></tr>
<tr><td>See “Inflow Modelling” in SPE Technical Report 174705 [3]

- Effect of High Drawdown on Fluid Properties
- Well Deliverability Impairment Caused by Gas Breakout
- Coning and Cusping of Water and Gas
- Impairment Caused by Condensate Dropout
- Naturally Fractured Reservoirs</td><td></td></tr>
<tr><td>See “Outflow Modelling” in SPE Technical Report 174705 [3]

- Flow Correlations
- Wellbore Temperature
- Fluid PVT Correlations
- Frictional Pressure Losses in Well Outflow Calculations
- Casing Roughness
- Open hole Roughness
- Pressure Loss Between Zones & Within a Zone
- Crossflow
- Sonic Velocity Limitation
- Sand Bridging, Hydrates, Washouts</td><td>No restrictions in the flow path should be assumed.</td></tr>
<tr><td colspan="3">*Note: Reservoir properties should be selected as best technical estimates (or “success case”) for calculation of WCD. Best technical estimates should represent values of properties as measured in nearby analogous well penetrations. In general, these values should not represent the extremes of the uncertainty ranges for the WCD well; although, in some cases, the highest or lowest analog value may be the best technical estimate. The data and values used in the WCD calculation should be no different than those used in the decision to drill the well and to design the casing, tubing, completion, facilities, etc. [3]</td></tr>
</table>

5.1 Blowout and Kill Rate Simulation Study

Worst-case discharge is used as an input to the blowout and kill rate simulation study which supports relief well planning, see Section 12.

NORSOK D-010:2021 [2] is a suggested reference related to blowout and kill rate simulation studies. Table 2 highlights the main areas considered as best practice within the associated reference standard.

Table 2: Best Practices – Blowout and Kill Rate Simulation Study		
Best Practices	**Reference Standard**	**Comments**
Blowout and Kill Rate Simulation Study		
A blowout simulation study shall be performed for the well design expected to give the highest blowout rates. A corresponding kill rate simulation shall be performed for a relief well targeting the casing shoe above the blowing reservoir [1].		Every well should be covered by a representative blowout and kill rate simulation study. A study should be performed for well design(s) expected to give the highest blowout and kill rates in a field and for every exploration well. Use of analogue studies (e.g., similar well design, reservoir conditions, external factors) can in some instances also be considered.
The following blowout scenarios should be covered for penetrated reservoirs: - through open hole/casing - through drillpipe or tubing - through drillpipe/casing or casing/casing annulus - for subsea wells: release to seabed. The likelihood of release to surface through the riser should be considered [1]	NORSOK D-010:2021 [2]	At minimum, the worst-case scenario should be evaluated and represented in the simulation study. It is up to the Operator to assess the worst-case scenario for the well(s) in the study.
The following data and assumptions should be used for blowout and kill simulations: - Expected values for reservoir parameters (pore pressure, permeability, porosity, net-gross pay, etc.) - Expected top of reservoir depth - Expected productivity index/transient productivity index - Expected fluid type parameters, if oil is expected, but gas cannot be disregarded both cases shall be simulated - Mechanical skin is zero - No restrictions in the flow path - Planned well design (hole size, casing setting depth, etc.) [1]		

For offshore wells, the well design should enable killing a blowout with one (1) relief well. If two (2) relief wells are required, it shall be documented that such an activity is feasible with respect to logistics, weather criteria and availability of rigs. The feasibility should be supported by a risk assessment demonstrating that the proposed solution involving more than one relief well is achievable. An offshore well design that requires more than two (2) relief wells is not acceptable.[1]		The well design should, as far as possible, enable killing a blowout with one relief well. In the NL/NS jurisdiction this is considered best practice. As such, well plans where more than one relief well is needed would be considered an uncommon approach (see introduction). If a relief well requires additional kill rate other solutions may be considered (e.g., rig upgrade, kill spool), but still with relevant documentation with respect to fatigue, logistics, weather criteria, availability of equipment and rigs.
1 NORSOK D-010:2021 Section 5.8.1 p. 32-33		

6 Casing Design for Blowout Load Case

This section highlights best practices in well planning for assessing casing design loads associated with a blowout scenario, including the impact of Annular Fluid Expansion (AFE)/Annular Pressure Build-up (APB) on multiple casing strings due to heating and reduced internal casing pressure due to flow. The blowout and kill rate simulation study discussed in Section 5.1 is a key input for evaluating casing loads during a blowout as it provides relevant input parameters such as pressures, temperatures and fluid densities. The potential impact of the loads on well integrity and the ability to shut in the well are covered in the Section 7.

IOGP Report 594 [1] and NORSOK D-010:2021 [2] are suggested references for this topic. Table 3 highlights the main areas considered as best practice within the associated reference standards.

Table 3: Best Practices - Casing Design for Blowout Load Case		
Best Practices	**Reference Standard**	**Comments**
Casing Design for Blowout Load Case		
Casing shall be designed to withstand all planned and/or expected loads and stresses including those induced during potential well control situations.[2]	NORSOK D-010:2021 [2]	
See "Casing Design for WCD & Displacement to Hydrocarbon (Blowout Load Case)" in IOGP Report 594 [1]	IOGP Report 594 [1]	Identification of applicable blowout load cases for the well design is the responsibility of the Operator. However, IOGP Report 594 provides guidance on key considerations and typical load cases that may be evaluated. These may include: Burst - Pressure exerted by blowout flow - Shut-in of blowout - Potential for annulus pressure build-up / annulus fluid expansion Collapse - Potential for increased annulus pressure due to heating combined with reduced internal casing pressure due to flow
2 NORSOK D-010:2021 Section 6.6.4 p. 43		

7 Well Integrity Considerations in Source Control

This section highlights best practices in well planning for assessing whether a well can be shut in (by capping, possible re-activation of the BOP by ROV or other) and impact on source control. Understanding formation strength and the results of casing design work are key inputs to this assessment.

IOGP Report 594 [1] and NORSOK D-010:2021 [2] are suggested references for this topic. Table 4 highlights the main areas considered as best practice within the associated reference standards.

Table 4: Best Practices – Well Integrity Considerations in Source Control		
Best Practices	**Reference Standard**	**Comments**
Well Integrity Considerations in Source Control		
Well design screening that assesses whether the well can be shut-in after capping. A well should be able to be categorised into one of three below: 1. Full mechanical and geologic integrity 2. Mechanical or geologic integrity not intact, but consequence of failure is acceptable 3. Wellbore integrity does not exist and well cannot be shut-in without hydrocarbons escaping/broaching to sea [3]	IOGP Report 594 [1]	Appropriate well design screening methods to understand whether a well can be shut-in are the responsibility of the Operator. Ideally, full mechanical and geologic integrity is maintained (Category 1). If not, further assessment is needed on a case by case basis to determine if the consequence of failure is acceptable (e.g., ability to accommodate underground cross flow, sufficient strength at previous shoe to enable shut-in) (Category 2) or if sufficient wellbore integrity does not exist for shut-in (Category 3). Wells assessed as Category 2 or 3 are generally considered uncommon to the jurisdiction (see introduction). In any case, it will be important that the assessed category and proposed source control plans are aligned.
Depending on these evaluations and the actual incident scenario, the capping stack may be used as a measure to shut-in the well or assist in metering and/or restricting well flow during the Relief Well drilling and dynamic kill operations. [4]	NORSOK D-010:2021 [2]	Regardless of assessed ability to fully shut-in, the well design should ensure sufficient well integrity remains in a blowout situation to enable well kill through a relief well.
3 IOGP Report 594 Section 2.1 p. 19 4 NORSOK D-010:2021 Section 5.8.3 p. 34		

8 Structural Integrity Analysis

This section highlights best practices in well planning for assessing the impacts of a blowout on the structural integrity of a well, in particular the implications of landing out a capping stack.

IOGP Report 594 [1] is a suggested reference for this topic. Table 5 highlights the main areas considered as best practice within the associated reference standard.

Table 5: Best Practices – Structural Integrity Analysis		
Best Practices	**Reference Standard**	**Comments**
Structural Integrity Analysis		
The ability to land out a capping stack on the incident well should be considered during the conductor design phase.[5]	IOGP Report 594	The well planning phase should consider: - Assessing the additional loading on the conductor from the weight of the capping stack - Ensuring sufficient soil capacity around the selected conductor string
5 IOGP Report 594 Section 2.5 p. 22		

9 Plume Evaluation

This section highlights best practices in well planning related to plume evaluation. The objective of plume modelling is to establish the expected safe working areas at surface [1]. The modelling helps to establish whether gas is expected to reach the surface [7] and expected exclusion zone based on volatile organic compounds (VOC) and lower explosive limit (LEL) of gases present [1]. Surface release of gases such as H_2S, CO_2 and hydrocarbons can be hazardous for personnel and introduce risk for explosion [7]. This information can be input to capping stack deployment considerations, as is further discussed in Section 11, and surface location for relief wells, as is further discussed in Section 12.

IOGP Report 594 [1] is a suggested reference for this topic. Table 6 highlights the main areas considered as best practice within the associated reference standard.

Table 6: Best Practices – Plume Evaluation

Best Practices	Reference Standard	Comments
Plume Evaluation		
In-water plume and gas dispersion modelling should be considered as part of the oil spill response planning activities.[6]	IOGP Report 594 [1]	Plume modelling as part of well planning activities is more common for high discharge, high GOR wells in medium to shallow water with little current, where the probability for gas reaching the surface is increased. Planned relief well locations typically consider prevailing wind and current directions. The locations are typically out of wind and current paths and a sufficient distance from the incident wellhead to avoid expected surface gas concentrations [10] and encroaching on the safety zone of the incident well. Plume modelling is not necessarily a required input but can be done if there is uncertainty in the impact a potential plume could have on feasible relief well locations. Offset studies (e.g., existing studies with for example similar water depth, potential blowout rates, fluid types and metocean conditions) may also be used for this purpose.
Although the worst case discharge modelling may indicate that vertical access to the incident well is not feasible, it is still important to ensure equipment, resources and plans for a vertical capping operation are in place as the actual incident in practice may have a lower flow rates than modelled allowing for vertical access.[7]		When plume modelling is conducted in support of capping stack deployment considerations, such as assessing vertical access, the results are highly dependent on the inputs. It is considered best practice to have a plan for accessing capping equipment for vertical deployment such that, in the event of an incident, vertical capping can be done if feasible.

6 IOGP Report 594 Section 2.6 p. 22
7 IOGP Report 594 Section 2.6 p. 23

10 Computational Fluid Dynamics (CFD) Analysis of Uplift Forces

This section highlights best practices when undertaking CFD analysis to model uplift forces during installation of a capping stack in a well blowout scenario [1]. Uplift forces exerted on the capping stack are a result of forces acting on the cross-sectional area of the capping stack as it enters the hydrocarbon jet stream [9]. CFD modelling will allow for a better understanding of the impact of flow on the capping stack during approach and landing [8]. Uplift forces may, in some cases, influence capping installation plans or equipment selection [1]. The output of the modelling can be input to capping stack landing analysis, as is further discussed in Section 11.

IOGP Report 594 [1] is a suggested reference for this topic. Table 7 highlights the main areas considered as best practice within the associated reference standard.

Table 7: Best Practices – Computational Fluid Dynamics (CFD) Analysis of Uplift Forces		
Best Practices	**Reference Standard**	**Comments**
Computational Fluid Dynamics (CFD) of Uplift Forces		
Depending on flow rates and fluid properties, it is recommended to perform Computational Fluid Dynamics (CFD) analysis of uplift forces during the installation of the Capping Stack.[8]	IOGP Report 594 [1]	CFD modelling of uplift forces, as input to capping stack landing analysis, is not required for every well. This decision is based on engineering judgement. IOGP Report 596 [9] provides some guidance on typical factors to assess. It is more commonly considered at the well planning stage for shallow water, high rate or high GOR wells where the forces may be higher [7] and may influence installation plans or equipment selection [1]. As such, CFD modelling of uplift forces should be done if there is uncertainty in installation plans or equipment selection. Modelling results will be dependent on the scenario inputs. Typical Items to take into consideration when conducting CFD analysis: ▪ Appropriate blowout rate sensitivities. ▪ Accurate capping stack information and engineering drawings. ▪ A range of wellhead inclinations to aid in understanding the impact this has on capping stack landing assumptions.
Note: IOGP Report 596 [9] provides a full range of considerations and guidance for CFD practitioners as it pertains to applications in subsea well response. This report was developed to share information on the modelling that is associated with capping stack landing analysis, plume analysis and gas dispersion analysis. 8 IOGP Report 594 Section 2.7 p. 23		

11 Capping Considerations

This section highlights best practices in the well planning phase to evaluate capping considerations including capping stack specifications and suitability for use, mechanical interface/clash checks, access to and mobilization of equipment and installation related considerations. The results of structural integrity analysis (Section 8), plume evaluation (Section 9) and CFD modeling (Section 10) can be used as inputs for some of these activities.

Some of the best practices noted typically apply to well specific planning activities while others typically apply to broader planning activities for a well program or well campaign. Below is a holistic list of considerations for capping.

IOGP Report 594 [1] is a suggested reference for this topic. Table 8 highlights the main areas considered as best practice within the associated reference standard.

Table 8: Best Practices – Capping Considerations		
Best Practices	**Reference Standard**	**Comments**
Capping Considerations – Well Specific Planning		
Ensure the proposed capping stack meets its intended requirements.[9]	IOGP Report 594 [1]	A list of typical considerations to assist in evaluating a proposed capping stack against intended requirements is provided in IOGP Report 594 Section 3.1.2. Section 2.7 includes erosion related considerations for capping stack requirements.
The worst-case scenario, that of an open-hole blowout (no drill string in the hole) with discharge to seabed, should be evaluated to confirm that the flowing well conditions are within Capping equipment specifications and that the equipment is suitable for use.[10]	IOGP Report 594 [1]	Available capping stacks have in general been designed considering a global evaluation of worst-case scenarios and covering the majority of needs. Many capping stacks have been assessed for additional capacity beyond their initial design brief. [8] If worst-case scenario is outside capping stack design limit (specification or additional assessed capacity), access to capping equipment is still recommended as actual scenario may be within. Wells where the worst-case scenario is outside capping stack specifications are generally considered uncommon to the jurisdiction (see introduction).
The SCERP should consider connection interface points.[11]	IOGP Report 594 [1]	A list of typical considerations for interface points is provided in IOGP Report 594 Section 3.1.7. It is considered best practice to ensure access to equipment (connectors) for capping at the primary (top BOP following LMRP removal) and secondary (wellhead) interface point. Additional interfaces may be considered based on engineering judgement.

The SCERP should consider how the capping stack will be landed and what equipment is required to facilitate the land out.[12]	IOGP Report 594 [1]	As discussed in Section 9, plume modelling can be done if there is uncertainty with respect to vertical access for capping stack deployment. This is more common for high discharge, high GOR wells in medium to shallow water with little current, where the probability for gas reaching the surface is increased. As discussed in Section 10, CFD modelling of uplift forces can be done if there is uncertainty as to whether the selected capping stack can be landed. This is more common for shallow water, high rate or high GOR wells where the forces may be higher. Use of a weighted blowout rate* can be helpful to evaluate the likelihood of vertical access or landing challenges in support of considering appropriate installation plans for the operating environment. Considerations for tooling, spares and operability assessments are provided in IOGP Report 594 Section 3.3. A significant percentage of regional activity is conducted in shallow water. However, the Atlantic Canada region also includes deepwater environments which may impact capping stack deployment strategies. Key considerations specific to deepwater deployment are provided in IOGP Report 594 Section 3.4.2.
Capping Considerations – Well Program or Well Campaign Planning		
The well Operator is responsible for developing and implementing plans for capping operations.[10]	IOGP Report 594 [1]	

In evaluating which capping stack system to make use of, consideration should be given for how that system will be mobilised.[13]	IOGP Report 594 [1]	A list of typical considerations for mobilization and pre-deployment is provided in IOGP Report 594 Section 3.1.3. Due to the relative remoteness of Atlantic Canada compared to other jurisdictions there should be a heightened focus on developing credible logistics plans and associated mobilization timelines for equipment identified for the capping operation. In this context it is important to consider the robustness and complexity of plans when considering air freight vs. vessel mobilization.
ROV interface points need to consider the type of ROV functions that are on the capping stack and how the ROV will interface with same.[14]	IOGP Report 594 [1]	
Consideration should be given toward the closing method of the capping stack which may be closed mechanically, hydraulically, or both. Consideration should be given to what equipment is needed to enable alternate or contingent actuation possibilities without having to recover the stack.[15]	IOGP Report 594 [1]	
*Note: Evaluation of likelihood of vertical access may be performed based on NOROG "Guidance on calculating blowout rates and duration for use in environmental risk analyses" [4] definition of expected value (average of possible outcomes, weighted by their respective probabilities). Per NOROG [4], uncertainty related to blowout rate must be specifically assessed and be expressed as probability distributions. Historical data of relevance for such assessments are found in the SINTEF database (referenced in NOROG [4]). Results from the calculations at scenario level are weighted with the probabilities for the occurrence of the various scenarios assuming a blowout. NOROG [4] provides guidance on defining blowout scenarios to assess. 9 IOGP Report 594 Section 3.1.2 p. 30 10 IOGP Report 594 Appendix 2 A2.5 p.54 11 IOGP Report 594 Section 3.1.7 p. 31 12 IOGP Report 594 Section 3.1.8 p. 32 13 IOGP Report 594 Section 3.1.3 p. 30 14 IOGP Report 594 Section 3.1.4 p. 31 15 IOGP Report 594 Section 3.1.5 p. 31		

12 Relief Well Planning and Interfacing with Source Control

This section highlights best practices in well planning related to relief well planning and highlights how relief well plans should be integrated into source control plans. A relief well is a directionally drilled well designed to locate, intercept and hydraulically communicate with a target well in order to suppress a blowout. Source control has a close relationship with relief well planning [1]. Relief well drilling and kill operations are a method of achieving source control.

Section 5.1 highlights key considerations related to blowout & kill rate simulation studies which are typically conducted in support of relief well planning. Section 7 highlights key considerations related to well integrity considerations in source control including relief well kill operations. If available, results from a plume evaluation should be considered when selecting relief well locations. Refer to Section 9.

Oil & Gas UK (OGUK) Guidelines on Relief Well Planning for Offshore Wells and NORSOK D-010:2021 are suggested references for this topic. Table 9 highlights the main areas considered as best practice within the associated reference standards.

Table 9: Best Practices – Relief Well Planning and Interfacing with Source Control		
Best Practices	**Reference Standard**	**Comments**
Relief Well Planning and Interfacing With Source Control		
The required level of planning depends on the complexity of the potential relief well.[16]	OGUK Guidelines on Relief Well Planning for Offshore Wells [10]	It is the Operator's responsibility to determine the level of relief well planning required to ensure a relief well(s) is feasible. The reference standard suggests factors that should be considered when evaluating the complexity of a potential relief well. It is not necessary to generate a detailed relief well plan in all cases. However, a plan covering the main points should be in place, which commonly include: - High level relief well directional plan, including seabed location (which considers seabed, shallow hazard and seismic data if available) and point of intersection. - Surface location for rig with due consideration to predominant weather conditions (wind and current directions) and proximity to the incident well. - Relief well schematic detailing items such as casing setting depths and sizes (which may be the same as the original / blowout well) - Identification of available / suitable relief well rig(s) and their location(s), with due consideration to the relative remoteness of Atlantic Canada compared to other jurisdictions and mobilization requirements. - Identification of available long lead relief well equipment . Note, mutual aid can be an acceptable source of long lead relief well equipment.

Site survey data is useful for the initial selection of relief well seabed locations, but is not essential. [17]	OGUK Guidelines on Relief Well Planning for Offshore Wells [10]	The reference standard suggests factors that should be considered when selecting potential relief well locations. When developing relief well directional plan(s) and selecting seabed locations, shallow hazard, seabed and seismic data should be considered if available.
In order to prepare relief well directional plans it is necessary to identify the preferred interception point. [18]	OGUK Guidelines on Relief Well Planning for Offshore Wells [10]	In every relief well there are several possibilities for interception targets including: • The top of the reservoir (assuming drill string or casing is across the intercept point). • The casing shoe above the blowout zone (assuming there is open hole, and the drill string is either out of the hole or above the casing shoe when the blowout occurs). It is the Operator's responsibility to determine the appropriate interception point when developing relief well directional plans.
The plan shall contain minimum two (2) suitable rig locations including anchoring assessment (only applicable for anchored rigs) for the two relief well locations. If blowout and kill simulations show the need for two relief wells, minimum three relief well locations shall be in place. [19]	NORSOK D-010:2021 [2]	Refer to Section 5 regarding number of relief wells.
16 OGUK Guidelines on Relief Well Planning Section 2 p. 2 17 OGUK Guidelines on Relief Well Planning Section 4.1 p. 10 18 OGUK Guidelines on Relief Well Planning Section 4.2 p. 15 19 NORSOK D-010:2021 Section 5.8.2 p. 33		

13 Industry References

- IOGP Report 594: Source Control Emergency Response Planning Guide for Subsea Wells Version 1.0 January 2019 [1]
- NORSOK D-010:2021: Well Integrity in drilling and well operations [2]
- SPE Technical Report 174705: Calculation of Worst-Case Discharge (WCD) September 2016 Rev. 1 [3]

- NOROG: Guidance on calculating blowout rates and duration for use in environmental risk analyses, 2021 [4]

  Note: An amendment to NOROG "Recommendations on blowout scenario modelling for environmental risk analysis of exploration wells" has also been published.

- C-NLOPB Glossary [5]
- C-NLOPB Drilling and Production Guidelines August 2017 [6]
- SPE-181393-MS: How to Develop a Well Specific Blowout Contingency Plan that Covers Engineering Analysis of the Deployment, Installation, and Soft Shut-In of a Subsea Capping Operation 2016 [7]
- IOGP Report 595: Subsea Capping Stack Design and Operability Assessment Version 1.0 February 2020 [8]
- IOGP Report 596: Guidance for computational fluid dynamics in subsea well response applications Version 1.0 December 2021 [9]
- OGUK Guidelines on Relief Well Planning for Offshore Wells Issue 2 March 2013 [10]