PL038 D Status Report Surrender

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Approved:	OKEA SVP Subsurface & Wells

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1 License history

General license information

PL038D with the Grevling discovery is located in the Ling Depression in the western part of Norwegian North Sea, 17 km south of the Sleipner East in block 15/12. The discovery well 15/12-21, drilled by Talisman Energy Norge AS in 2009, proved 67 m net oil column in the Hugin, Bryne and upper Skagerrak Formations. In addition to the discovery wellbore, sidetrack 15/12-21 A and appraisal well 15/12-23 with side-track 15/12-23 A (2010) are drilled in the discovery. The license was awarded May 15th 2009 to a license group consisting of Talisman Energy Norge AS (operator 65 %), Petoro AS (35 %) and Det norske oljeselskap ASA (5 %). Through transactions the current interest group are OKEA ASA, Chrysaor Norge AS and Petoro AS. Fig. 1.1 show PL038D outline with the Grevling (and Storskrymten PL974) discovery outline. The license has fulfilled the work program with thorough geophysical, geological and technological studies forming the basis for a Concept Select decision (BOV/DG2).

Table 1.1 Key license information

PL038D	
Awarded	15.05.2009
Licence period	01.07.2022
Licence area	33 km^2
Licence group	OKEA ASA 35 % (operator) - Chrysaor Norge AS 35 % - Petoro AS 30 %

Fig. 1.1 PL 038D licence location map.

Work program

The initial work obligation was to conduct geophysical, geological and technological studies leading up to a PDO delivery within July 1st 2023.

Table 1.2 Work program overview and status

Work program	**Expiry date**	**Status**
Initial:		
Licence expiry	01.04.2021	Extended
Updated:		
Application to extend deadline	23.11.2020	

Approval new work program	18.08.2021	
BoV Decision to continue	01.07.2022	Dropped
PDO Submit plan for development	01.07.2023	Dropped
Licence expiry	31.12.2023	

License meetings

During the life of the license a number of meetings took place and were documented in L2S.

Table 1.3 License meetings overview (included and reported with PL974)

Date	**Meeting**	**Meeting topic**
2019-03-21	MC	
2019-04-12	**MC**	**Work Meeting**
2019-05-21	RC	IPE Workshop
2019-05-23	RC	Storskrymten status - Inversion study.
2019-06-12	M, RC and TC	Q2, GDP Status and Progress
2019-06-20	RC	Storskrymten Seismic interpretation Status
2019-07-01	RC	Input Static models
2019-09-02	MC, RC and TC	Q3, GDP Status and Progress
2019-09-19	RC	Storskrymten updated Geophysics / input to Geomodel
2019-10-09	RC	Grevling and Storskrymten reservoirs modelling
2019-10-15	TC	Process Hazard Analysis (PHA) Workshop
2019-10-22	TC	Working Environment Risk/layout Review
2019-10-23	TC	Design Review of Subsea Storage Tank Concept
2019-11-13	RC	Storskrymten In-Place Volume uncertainty
2019-11-19	MC	Work meeting
2019-12-04/05	MC, RC and TC	Q4, GDP Status and Progress
2020-01-29	TC	Work meeting: Topside process plant deign, ECIT design and System design of Storage tank
2020-02-12	RC	
2020-02-13	TC	Work meeting
2020-02-14	MC	Work meeting
2020-03-11	TC	Work meeting
2020-04-01	MC	Q1
2020-06-10	MC, RC and TC	Q2
2020-09-22	MC, RC and TC	Q3
2020-11-18	MC	Q4
2020-12-10	RC	Grevling profile update and forward scope
2021-04-09	MC	
2021-05-05	MC	Status Meeting
2021-05-20	MC	Licence Alignment Meeting
2021-05-28	TC	Work Meeting
2021-06-18	MC	
2021-06-23	TC	
2021-07-06	RC	Grevling
2021-08-25	MC	Joint meeting Vette & Grevling
2021-09-02	RC	DG2 Subsurface review
2021-09-06	RC	D&W licence work meeting
2021-09-07	TC	IPR meeting
2021-10-04	MC & TC	IPR meeting
2021-11-03	MC	

Relinquishment

The license group unanimously agreed to relinquish license because proven resources did not meet the commercial criteria for development.

2 Database overviews

2.1 Seismic data

The 3D seismic database used for mapping the Grevling discovery consists of the GRVLIN2012 and the GRVLIN2018 surveys. The underlying data were acquired in 2010 by PGS. The survey was fully reprocessed in 2012 (GRVLIN2012), and a subset of GRVLIN2012 was further post-migration conditioned in 2018. Fig. 2.1 shows the outline of available seismic datasets. Table 2.1 provides a complete list of surveys in the common database.

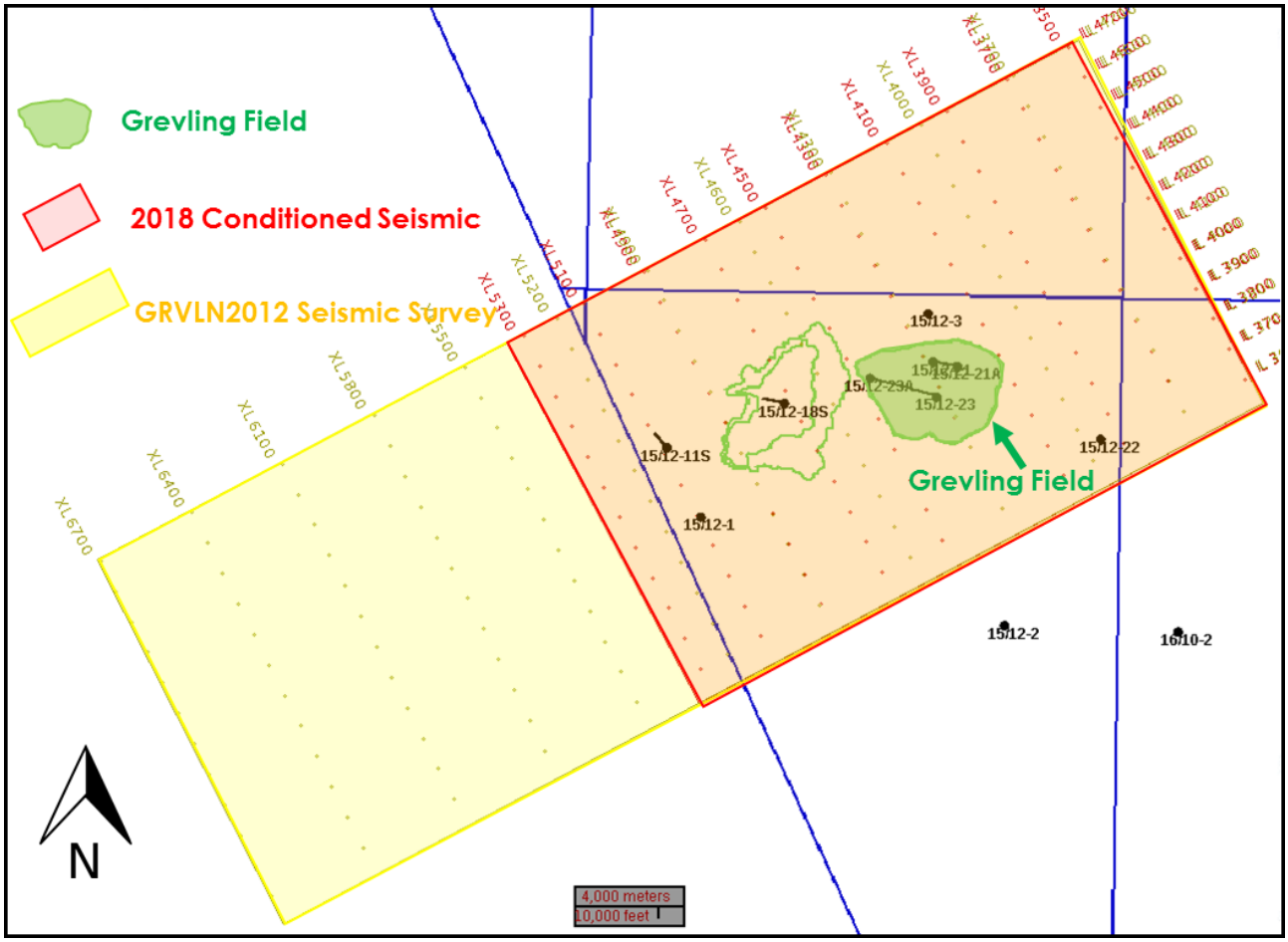

Fig. 2.1 Outline 3D seismic surveys PL038 D.
Seismic data availability in Grevling Field area. The yellow rectangular is the outline of GRVLIN2012 seismic survey, the 2018 conditioned seismic data is highlighted in the red box.

Table 2.1 List of seismic surveys in the common database for PL038D.

3D Seismic survey	Processing
GRV2010	PSTM
GRVLIN2012	PSTM
GRVLIN2018	PSTM + post migration conditioning with emphasis on Grevling reservoir

2.2 Well data

A list of all wells in the common database for PL038 D is provided in Table 2.2, and their location is seen in the map Fig. 2.2.

Table 2.2 Well in common database PL038D.

Well	NPDID	Year	Drilling operator	License	Result	TD (m MD)	TD stratigraphy	Comment
15/12-18 S	5607	2007	Det norske oljeselskap ASA	337	Oil	3520	Zechstein Gp	Deviated, max. inclination of 36^0
15/12-18 A	5608	2007	Det norske oljeselskap ASA	337	Oil	3036	Tor Fm	Deviated, max. inclination of 42^0
15/12-1	94	1975	Den norske statsoljeselskap a.s.	038	Oil shows	3269	Skagerrak Fm	Vertical
15/12-3	199	1980	Den norske statsoljeselskap a.s.	038	Dry	4450	Rotliegend Gp	Vertical, max. inclination of 3^0
15/9-23	6186	2010	Det norske oljeselskap ASA	408	Dry	3225	Skagerrak Fm	Vertical, max. inclination of 2.3^0
15/12-11 S	3074	1997	Saga Petroleum ASA	116	Dry	3597	Skagerrak Fm	Deviated, max. inclination of 26.7^0
15/12-21	6047	2009	Talisman Energy Norge AS	038 D	Oil	3310	Skagerrak Fm	Vertical, max. inclination of 1^0
15/12-21 A	6139	2009	Talisman Energy Norge AS	038 D	Oil	3702	Skagerrak Fm	Deviated, max. inclination of 50.4^0
15/12-23	6327	2010	Talisman Energy Norge AS	038 D	Oil	3485	Skagerrak Fm	Deviated, max. inclination of 9.9^0
15/12-23 A	6404	2010	Talisman Energy Norge AS	038 D	Oil	4772	Sleipner Fm	Deviated, max. inclination of 88.5^0
15/12-22	6326	2010	Det norske oljeselskap ASA	337	Dry	3085	Skagerrak Fm	Deviated, max. inclination of 26^0

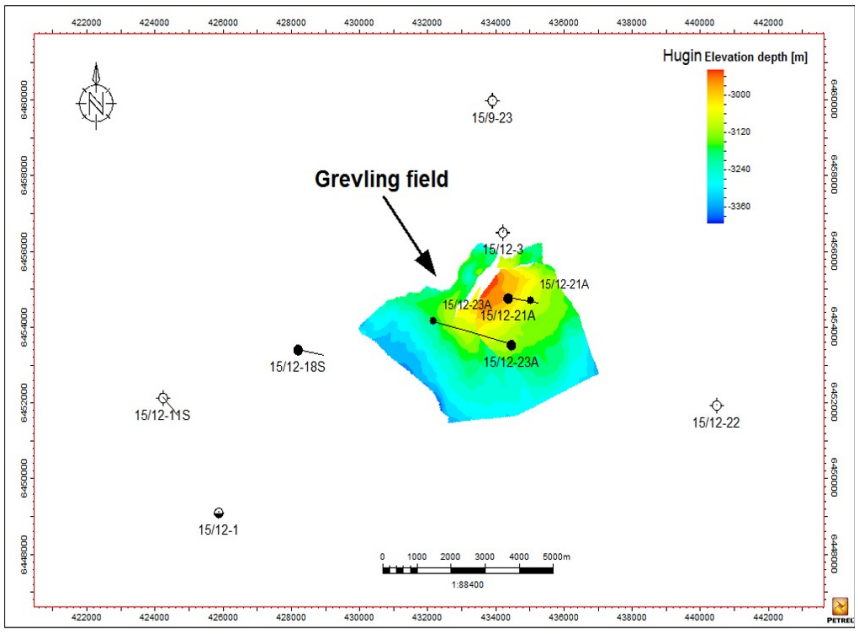

Fig. 2.2 Well database.

3 Results of geological and geophysical studies

Geolink Study, 2015.

Study objective was to extend the detailed sequence stratigraphic study of the Varg area, to the Grevling area and the southern Sleipner Terrace. Available results was used to produce detailed depositional facies maps to delineate reservoir distribution. The study achieved a consistent framework incorporating sedimentological interpretation, sequence stratigraphy, well log correlations, seismic and regional understanding.

Petroleum Systems Modelling for the Block 15/12 area, 2018, Petroleum System Consulting.

Measured and back-calculated source rock richness and quality. Based on measured TOC and HI in samples present-day potential and the initial TOC and HI has been back calculated from wells relevant for the drainage area.

Bryne Formation analogue study, 2019.

The analogue study aimed to establish a reasonable input range to model the fluvial part of the Bryne Formation based on the current understanding of depositional environment. To fully take advantage of available well data, object models both based on meandering and braided channels was established with the uncertainty ranges supported by the analogue study.

4 Prospect update report

The Grevling development project was matured to a DG2 level. In the following a summary of the key topics relevant for the understanding of the resources in PL038D.

The Grevling discovery is recognised as an up-thrown, salt induced structural closure, containing four main formations: Hugin, Sleipner (coal), Bryne and Skagerrak with the primary targets being Hugin, Bryne and Skagerrak, Fig. 4.1. The Skagerrak Formation contains two broad systems; an aeolian dune belt and a fluvial distributary system. The Bryne and Sleipner Formations were deposited after the middle Jurassic doming event and are onlapping onto the base Jurassic unconformity. Bryne Formation contains an early fluvial top a more shallow marine depositional systems. The Hugin Formation is recognized by a lower shoreface and transition sands. The reservoir sediments and their properties varies significantly.

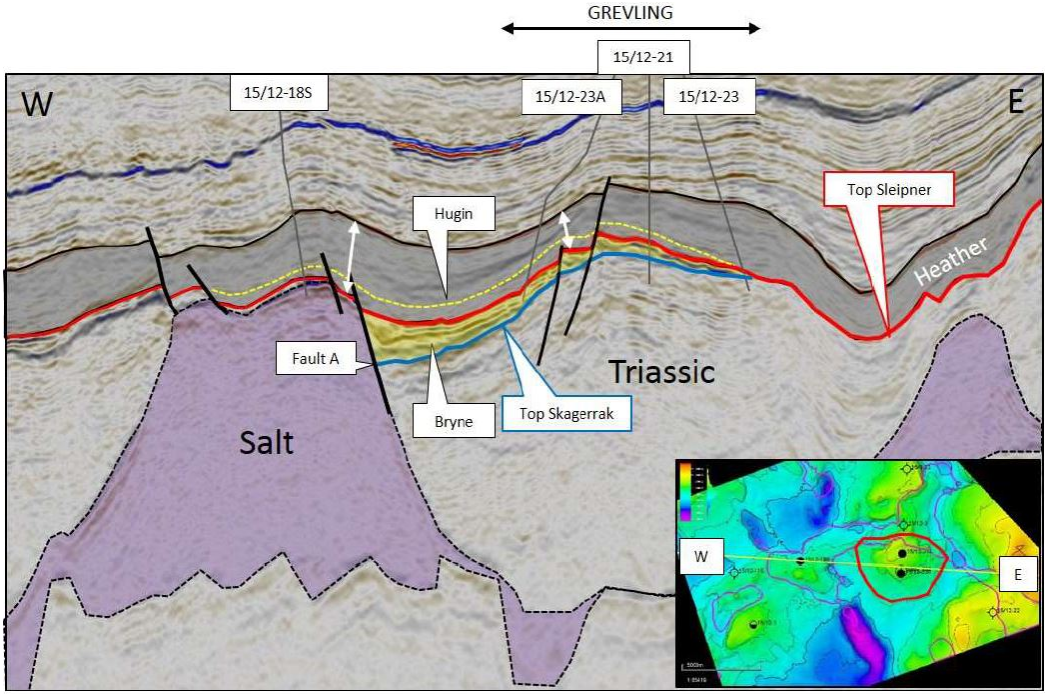

Fig. 4.1 E-W seismic section through Grevling.
Underlying seismic by courtesy of PGS.

The reservoir structure is formed by two dominant fault patterns, NW-SE and W-E trending faults, Fig. 4.2. To the west of a NW-SE trending fault zone, 15/12-23 A found oil in Bryne and Skagerrak Formations, while the overlaying Hugin Formation is water bearing. The free water level (FWL) is observed at 3301 m TVDSS. To the east of the fault zone, 15/12-21 and 15/12-21 A found oil in the Hugin, Bryne and Skagerrak Formations. In 15/12-23 oil was found in the Bryne and Skagerrak Formations with the Hugin Formation being absent. Hugin Formation oil water contact (OWC) in the east is interpret at 3094 m TVDSS, while the pressure data indicate a shallower FWL for Skagerrak Formation in the east compare to the west (3225.7 m TVDSS), Fig. 4.3. Oil samples were collected from wells located in the eastern segment shows a under-saturated oil with viscosity up to 2.2 cP in situ and low GOR of ~27 Sm^3/ Sm^3. Observed reservoirs pressure was ~377 bar in Skagerrak formation (FWL) and reservoir temperature up to 123°C (FWL).

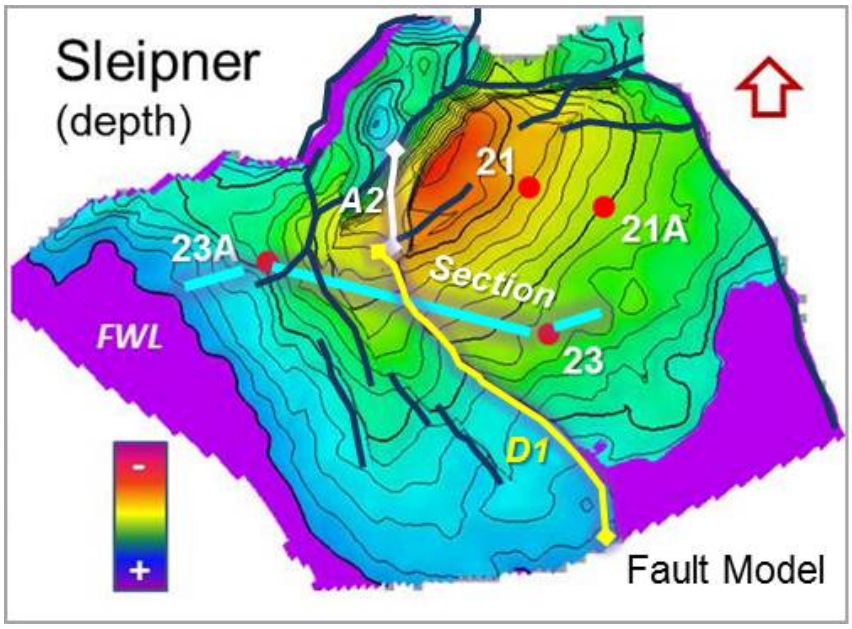

Fig. 4.2 Fault model displayed on top Sleipner depth map.
Underlying seismic by courtesy of PGS.

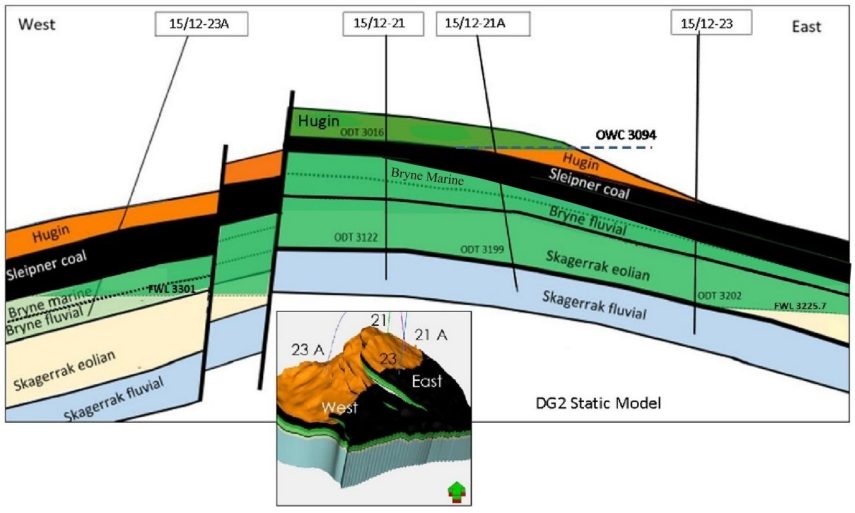

Fig. 4.3 E-W geological cross-section showing exploration well results.

For Grevling reservoirs, the upper Jurassic marine shales are the important petroleum source rocks. Draupne Formation holds the best source rock quality with an initial average TOC of 5.8% and HI of 431 mg HC/g TOC while Heather contains an initial average TOC of 4.1% and HI of 460 mg HC/g TOC. Migration direction would have been controlled by dip and permeability distribution of the carrier beds, and by the buoyancy of the hydrocarbon phase leading to a hydrocarbon charge in Hugin, Bryne, and Skagerrak Fms.

A thick Heather Formation shale sequence forms the overall cap-rock to the Grevling structure. Coals and clays in Sleipner Formation form an intra reservoir seal between Bryne and Hugin Formations, and an unconformity with an erosional base between Bryne and Skagerrak Fms. is present although its sealing capacity is unclear.

The Sleipner Fm. coal provides a high-confidence event for the overall structure, however suppresses the expectedly more subtle events from intra reservoir zones.

The initial well placement was based on long horizontal oil producer at the crest combined with a similar down-flank water injector for Hugin and Skagerrak east Fms., while the Bryne Fm. east and the western block were both drained by a long horizontal oil producer each.

Static and dynamic parameters for uncertainty study were identified and evaluated. Highest ranking uncertainty in terms of highest impact is STOIIP and connectivity related i.e. SW, PHIE, NTG. The impact of other parameters such as fluid viscosity, contacts formation compressibility, permeability multipliers, Kv/Kh ratio is to much lager extend mitigated by drainage strategy. Based on present understanding, the main subsurface risks for Grevling is related to recoverable volume rather than hydrocarbon in place. Key risks to oil recovery of the Grevling development is identified as parameters affecting reservoir connectivity and lateral communication.

To achieve an economic development, water injection and artificial lift (gas lift) is essential to achieve required hydrocarbon volumes and rate. Volumetric uncertainty result is summarized in Table 4.1.

Table 4.1 Grevling resources and recoverable volumes results from combined stocastic uncertainty analysis.

	Reservoir segment	STOIIP [MSm³]	Cumulative production [MSm³]
P50	**FIELD TOTAL**	**28**	8
	Hugin East	3	1
	Bryne East	9	3
	Skagerrak East	8	2
	Bryne & Skagerrak West	8	2
P90 - P10	**FIELD TOTAL**	**19 - 39**	**5 - 11**
	Hugin East	2 - 4	1 - 1
	Bryne East	6 - 10	2 - 4
	Skagerrak East	5 - 13	1 - 4
	Bryne & Skagerrak West	6 - 12	1 - 3

5 Technical assessment

Various field development scenarios were assessed during Grevling's concept evaluation. These included a range of subsea tie-back options to existing infrastructure, a subsea field development option to a retrofitted FPSO and an option to connect wells to a new-built jack-up or FPSO unit. The use of artificial lift like downhole ESPs or gas-lift in the producers was also studied in conjunction with the review of the field development options. Use of existing infrastructure require a costly and technical challenging long distance multiphase flowline and/or subsea separation. A stand alone unit was selected and planned developed in cooperation with other discoveries like Storskrymten (PL974) and Vette (PL972), and prospects in Licence 973.

The selected unit featured:

- Dry well-heads
- Possibility for intervention derrick (Work-over, coiled-tubing, wireline etc.)
- Flexibility to process plant design
- Dual inlet separator with single well routing configuration (test separator)

Produced oil was planned to be processed to export specifications and stored before being shuttled. The gas was planned suitably treated and used for gas lift and fuel. Excess gas was planned injected back to the reservoir.

The base case drainage strategy consists of 7 horizontal oil producers and 5 horizontal water injectors: 5 producers and 4 injectors targeting Hugin, Bryne and Skagerrak Fms. in the east segment, and 2 oil producers and one water injector targeting Bryne/Skagerrak Fms. in the west segment.

The base case well designs for all, except one, oil producers and water injector is horizontal wells with 3 casing string and then a horizontal 8.5” open hole approximately 2000 m in length. One of the wells in west segment was planned drilled and completed as a multilateral. The well design is a 4 string casing design with 9-5/8” casing at least 60 m in the reservoir section to help build the junction for the multilateral. The main bore for the multilateral was planned drilled as 8-1/2" hole.

6 Conclusion

The studies, maturation of data and modelling resulted in an updated volume range for the Grevling discovery. This volume range in combination with the development cost basis pre-DG2 illustrate low robustness. Extensive work and resources were deployed to de-risk and improve the project economy through a larger area stand-alone development together with the PL974 Storskrymten discovery and exploration well in licence PL973. The project was then put hold in early 2020, and late 2020 the concept serial production of PL972 Vette and Grevling to FPSO was established.

The work program for PL038 D is fulfilled with a thorough Concept Select (DG2) evaluation. No new wells were drilled in the license. Based on the an overall assessment of the Grevling discovery, it is decided not to forward PL038 D towards a PDO. The economics are not sufficiently robust, and the licence partnership has decided to surrender the licence.