

Survey Results Report

Sand Borrow Area S5M
UXO Avoidance Survey
Dutch Sector, North Sea

SAND BORROW AREA S5M UXO AVOIDANCE SURVEY

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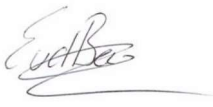


SURVEY RESULTS REPORT

SAND BORROW AREA S5M

UXO AVOIDANCE SURVEY

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1 INTRODUCTION

Rohde Nielsen A/S (hereafter Rohde Nielsen) has been awarded the contract by Rijkswaterstaat for sand nourishment operations at three locations along the Dutch North Sea coast/beaches. The three areas designated for beach and foreshore nourishment are:

- Goeree Noordwest beach (S3E)
- Schouwen Westkop beach (S5M)
- Vlieland Midden foreshore (L12O)

To meet the requirements Rohde Nielsen plans to dredge in the sand borrow areas S3E, S5M and L12O in 2021. Deep B.V. (hereafter Deep) has been contracted by Rohde Nielsen to carry out various UXO survey activities prior to the dredging operations. The scope consists of multibeam echo sounder (MBES), side-scan sonar (SSS) and magnetometer (MAG) measurements.

NjordIC B.V. (hereafter NjordIC) has been contracted by Rohde Nielsen to deliver UXO consultancy services and to cooperate with Deep during the preparations, execution, and reporting phases of the UXO risk mitigation campaign.

The UXO mitigation measures need to be compliant with the Netherlands Explosives Law (CS-000)¹. Consequently, all activities need to be executed and supervised by a CS-000 certified company. It is therefore that Freyr Trade & Services B.V. (hereafter Freyr) – as a partner company of NjordIC - is involved in this project. Freyr was responsible for the supervision, and where necessary execution of the UXO geophysical survey according to CS-000 requirements.

This report contains the UXO survey results for S5M only. The UXO survey results of the UXO surveys of sand borrow areas L12O and S3E are reported separately.

1.1 OBJECTIVE OF THE UXO GEOPHYSICAL SURVEY

The objective of the UXO geophysical survey was to identify all ferrous objects within the area of investigation that meet the minimum applicable UXO threshold criteria of 20kg ferrous mass for water depths <20m LAT and 50kg ferrous mass for water depths >20m LAT. The UXO survey results will be used to provide Rohde Nielsen with a UXO ALARP Clearance Certificate according to CS-000 legislation and to further design the UXO risk mitigation strategy for the sand borrow activities to be executed by Rohde Nielsen.

1.2 REFERENCES

This survey results report is based on the following information:

- Studies & reports
 - o Vooronderzoek CE – zandwinkvak S5M (REASeuro), reference RO-180176, versie 2.0, date 07 september 2018.
 - o Projectgebonden Risico Analyse Ontwerpfase zandwinkvak S5M (NjordIC), reference 2018.04.067/UP0-78, date April 18, 2019.
- Project documentation of client
 - o 31147146 Bestek en Voorwaarden (Rijkswaterstaat), v1.0.
 - o ALG_Proces RIE-CE Uitvoeringsfase (Rijkswaterstaat).

¹ CS-000: Netherlands Certification Scheme – Detection and Clearance of Explosive Remnants of War, replaces WSCS-OCE as of 01-01-2021.

- ALG_Proces Conventionele Explosieven v2.0 (Rijkswaterstaat Kustlijnzorg), date September 20, 2018.
- Informatiepakket CE, v1.0, reference RO-180223 (NjordIC/REASeuro), date September 14, 2018.
- Operational documentation
 - CS-000 project plan
Project plan UXO Avoidance Survey (Freyr), reference FR2020_OPS_045_EXT_046 v2.0, date January 21, 2021.
 - Project Execution Plan UXO Survey L120, S3E, S5M (Deep), reference P3803_PEP_R00, Deep BV, date December 30, 2020.
 - P-3802 Mobilisation / Calibration Report MV Breaker R01 (Deep), date January 12, 2021.
 - P3802_SIT_REP_BREAKER_R01 (Deep), date January 12, 2021 (SIT report 50kg).
 - P3803_S5M_FO_REP_R00 (Deep), date 09-03-2021.

1.3 AREA OF INVESTIGATION

The area of investigation is located west of Schouwen Duiveland in the Dutch sector of the North Sea. The location of the S5M UXO area of investigation is shown in Figure 1. Water depths range from -6.1m LAT to -24.4m LAT.

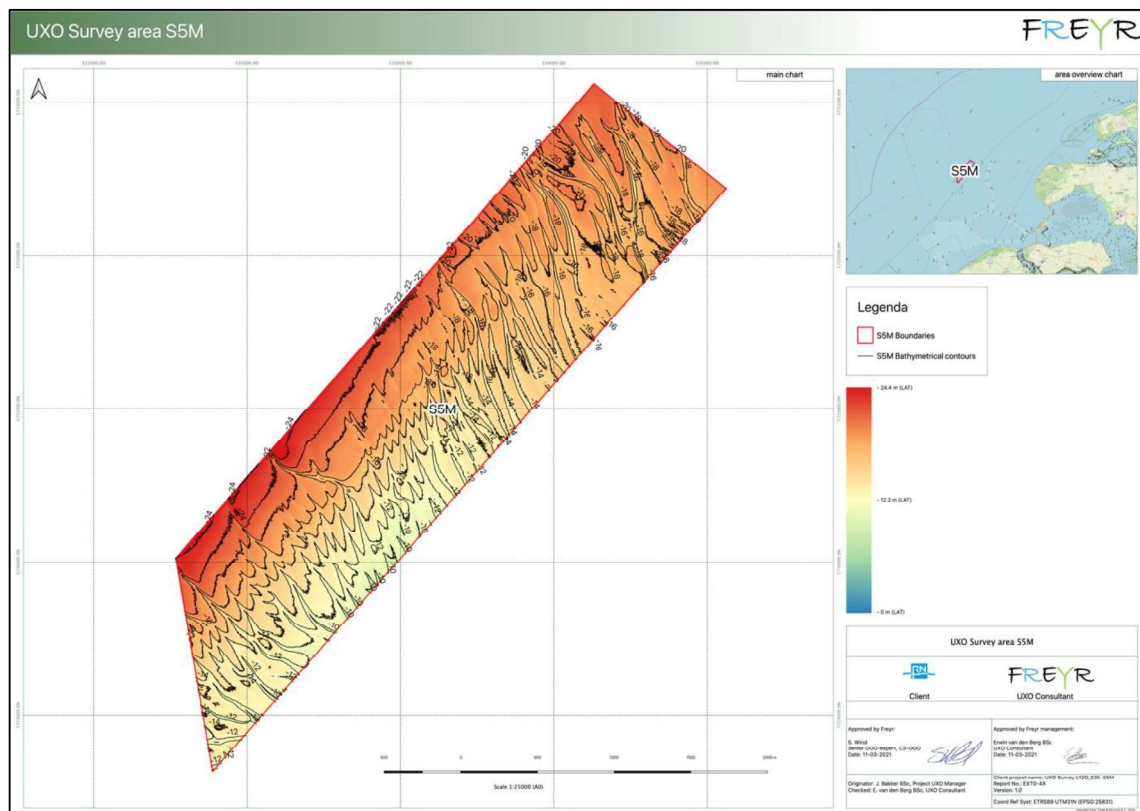


Figure 1: Area of investigation L5M.

1.4 UXO THRESHOLD AND DETECTION DEPTH

In the case of a UXO detonation due to sand borrow activities, the detonation effects pose an unacceptable risk to the safety of the staff involved. Mitigation measures are required to reduce the risks to a level that is considered ALARP.

To prevent an uncontrolled detonation during the dredging, the sand borrow area S5M was surveyed with the aim to avoid all objects that meet the applicable minimum ferrous threshold criteria (potential UXO) during the sand borrow activities.

In the UXO risk assessment ² the threshold required for safe sand borrow operations was assessed to be:

- 50kg ferrous mass for water depths > 20m LAT.
- 20kg ferrous mass for water depths < 20m LAT.

These thresholds were applied for the design of the UXO geophysical survey and the evaluation of the survey data. The required detection depth was set at 2.5m below seabed level.

1.5 HORIZONTAL AND VERTICAL REFERENCE

The horizontal and vertical reference for the survey data is as follows:

Datum:	European Terrestrial Reference System 1989 (ETRS89)
Ellipsoid:	GRS 1980 (corrected for epoch 2021)
Projection:	Universal Transverse Mercator zone 31N (UTM 31N)
Vertical reference:	LAT via GEONZ97 (Noordzee) and LAT2006

1.5.1 Horizontal Control

All geographical and projection co-ordinates used during the operational work, reporting and charting are based on local datum ETRS89. Projection co-ordinates are expressed in Universal Transverse Mercator (UTM) grid, Zone 31, Northern Hemisphere (EPSG code: 25831).

The primary satellite navigation and positioning system was operating in ETRS89 using RTK corrections. When RTK was not available the secondary system, using Fugro Marinestar corrections, automatically took over. Positions obtained using Marinestar are in ITRF2014 (WGS84) and were transformed to ETRS89 using a time-dependent transformation.

1.5.2 Vertical Control

The vertical datum for all depth and/or height measurements is Lowest Astronomical Tide (LAT). Reduction from ETRS89 based ellipsoid heights to LAT referenced geoid heights was done by using MSL model GEONZ97 (Noordzee) and LAT model LAT2006.

1.6 SURROGATE ITEM TRIAL

The CS-OOO requires proof/demonstration of:

- the functionality of the equipment/sensors,
- the detectability of threshold ferrous-mass items,
- the accuracy of positioning, and,
- the quality of the survey data.

² Projectgebonden Risico Analyse Ontwerpfase zandwinvak S5M (NjordIC), reference 2018.04.067/UP0-78, date April 18, 2019.

To demonstrate suitability of the survey equipment an equipment verification test (EVT) was conducted prior to the survey. This test included Surrogate Item Trials (SITs). Based on these trials several key survey parameters were calculated, such as the maximum detection range based on dynamic range, the optimal survey line spacing and maximum gap allowance.

The SIT was performed onboard the MS Breaker. Results of the SIT data and report ³ (ref: P3802_SIT_REP_BREAKER_R01, date 12-01-2021) were used by Freyr for data QC of the operational UXO survey data.

1.6.1 Determination of the maximum detection range

50kg ferrous mass threshold

The results of the 50kg SIT showed the observed signal values of all magnetometer measurements in the vicinity of the SIT object in relation of their distance to it. From the scatterplot it could be observed that data points with a signal value around 5nT to the SIT object had a total distance to the SIT item of more than 9m. Given that real UXO are unlikely to produce the idealized anomaly that is produced by the SIT object, it was advised by NjordIC/Freyr to include a safety factor of 1m.

Considering the accuracies of positioning and to keep a safe approach it was decided to take the minimum observed distance of 9m as maximum detection range. Subsequently the safety factor was deducted from this distance resulting in a maximum survey altitude of 8.0m. This is the maximum distance between a threshold size object and the sensors.

20kg ferrous mass threshold

The results of the 20kg SIT showed the observed signal values of all magnetometer measurements in the vicinity of the SIT object in relation of their distance to it. From the scatterplot it could be observed that data points with a signal value around 1.5nT to the SIT object had a total distance to the SIT item of more than 7m. Given that real UXO are unlikely to produce the idealized anomaly that is produced by the SIT object, it was advised by NjordIC/Freyr to include a safety factor of 1m.

Considering the accuracies of positioning and to keep a safe approach it was decided to take the minimum observed distance of 7m as maximum detection range. Subsequently the safety factor was deducted from this distance resulting in a maximum survey altitude of 6.0m. This is the maximum distance between a threshold size object and the sensors.

³ Ref: P3802_SIT_REP_BREAKER_R01 (Deep), date January 12, 2021 (SIT report 50kg).

2 RESULTS

In this chapter the results of the UXO survey are described. The UXO survey was executed by Deep under UXO supervision of Freyr to assure compliancy to the CS-OOO. The UXO survey field operations have been executed by the MV Breaker.

2.1 GENERAL

Deep has performed a safe and high quality UXO survey operation. This was accomplished by dividing the survey in two (2) phases. The first phase consisted of MBES and SSS measurements. Using these survey techniques, the area of investigation was mapped. This was done to ensure safe ROTV operations.

The results of the MBES and SSS survey were used to design the MAG survey (phase 2). The ROTV with the MAG array used by Deep was the “Iron Lady” developed by Deep. This array holds six (6) G882 Cs Vapour Magnetometers. The distance between the sensors was fixed at 1.5m, resulting in a minimum swath width of 7.5m. The frame has an automated bottom tracking function, allowing it to keep a fixed distance above the seabed or above a reference level. During the UXO survey the non-mobile reference level as detailed in paragraph 2.2 was used for setting the automated bottom tracking of the ROTV. A maximum altitude of 6m above the non-mobile reference level was set for the purpose of this survey.

2.2 DATA EVALUATION AND PUXO TARGET PICKING

The MAG data was processed and interpreted in Oasis Montaj by Deep, and targets were initially picked by Deep based on magnetometer data within sand borrow area S5M. This resulted in a Preliminary Master Target List (PMTL) with a total number of 342 targets. Amongst the targets selected by Deep all were classified with high confidence level. Ten (10) of these targets are monopole, and seven (7) linear anomalies have been detected within S5M. Furthermore, the north eastern part of the UXO survey data shows an area where – based on the likely presence of geological features – discrimination of individual pUXO targets appeared to be impossible. In the UXO ALARP Clearance Certificate (Annex A) this area is displayed with a red hatched exclusion area. See Figure 2 for a visualization of the survey results.

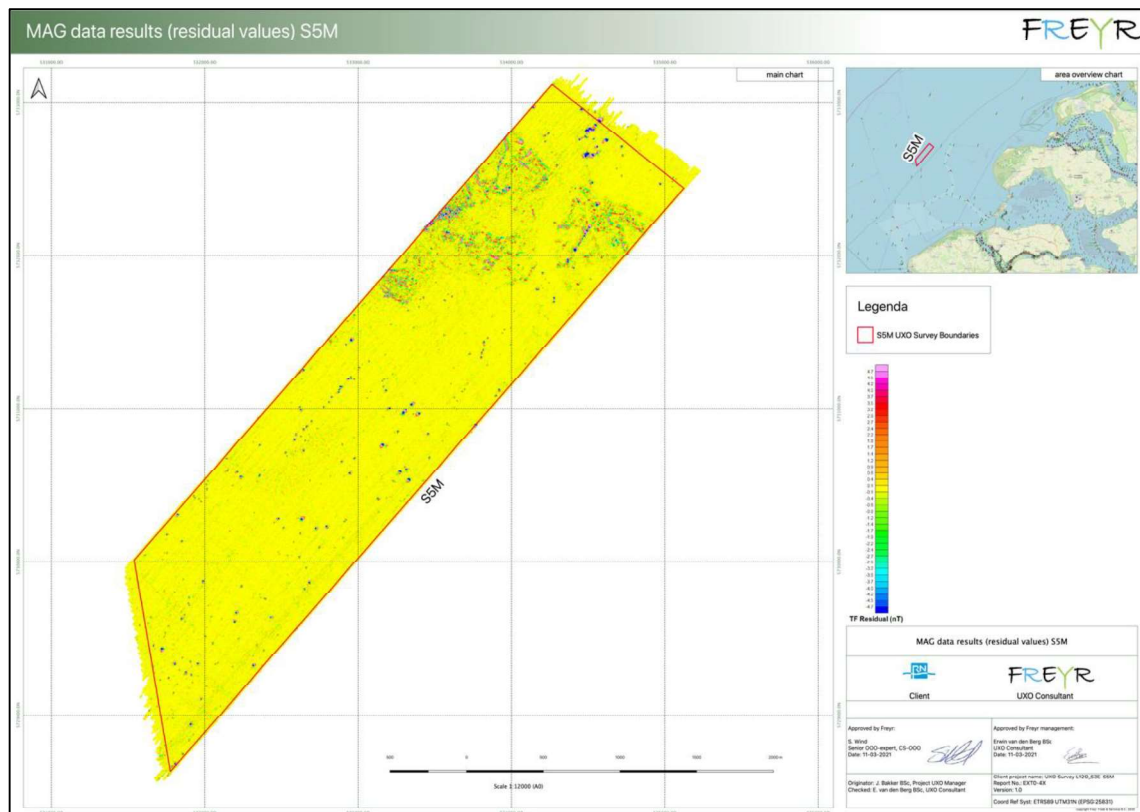


Figure 2: MAG data results S5M.

Further MAG data evaluation of the PMTL targets under CS-000 was done by Freyr. Final target picking by Freyr was executed by comparing the modelled magnetic moments with the data in Freyr's own UXO data base. Targets positions of pUXO were picked on the dipole positions where possible. Magnetic moment calculations seemed to be a bit unreliable sometimes. Some small pUXO targets have extremely large magnetic moments, and some large pUXO targets appear to have relatively small magnetic moments.

For example, in Annex B see pUXO targets:

- P3803_MAG_S5M_0174 Mag mom. 0.0
- P3803_MAG_S5M_0201 Mag mom. 1672.34
- P3803_MAG_S5M_0212 Mag mom. 2445481062.36
- P3803_MAG_S5M_0217 Mag mom. 29573.09
- P3803_MAG_S5M_0283 Mag mom. 1.07
- P3803_MAG_S5M_0302 Mag mom. 1.31

The final pUXO target picking by Freyr's Senior OOO-expert resulted in a total number of 227 pUXO targets.

The locations of all interpreted pUXO targets were further assessed using the available bathymetric data profiles, the assessed non-mobile reference layer, and the designed dredging profiles. For determination of the dredging profiles a safety margin of 0.5m to the 2m dredging depth has been applied by Freyr.

Figure 3 illustrates how pUXO targets were assessed against the bathymetrical data (red line), the estimated non mobile seabed layer (magenta line) and the dredging profile (blue line). The residual UXO risks at the locations where the dredging profile line is positioned above the estimated non-mobile seabed layer are assessed to be ALARP.

The rationale for this is that any UXO deployed during the war will have migrated down to the non-mobile reference layer because of sand wave migration. Objects located in post war sediments such as sand waves are therefore assessed to be of post war origin.

It is therefore that FMTL pUXO targets located in the green areas as per Figure 3 do not require avoidance. For information, they are listed on the Final Master Target List (FMTL) with the comment “No exclusion area needed based on the profile assessment” (see Annex B), but they are not shown on the chart (see Annex A).

If applicable, around all linear features and pUXO targets in the white areas in Figure 3 an avoidance radius of 15.6m was applied.⁴ The results of the assessment are reflected in the UXO ALARP Clearance Certificate as per Annex A.

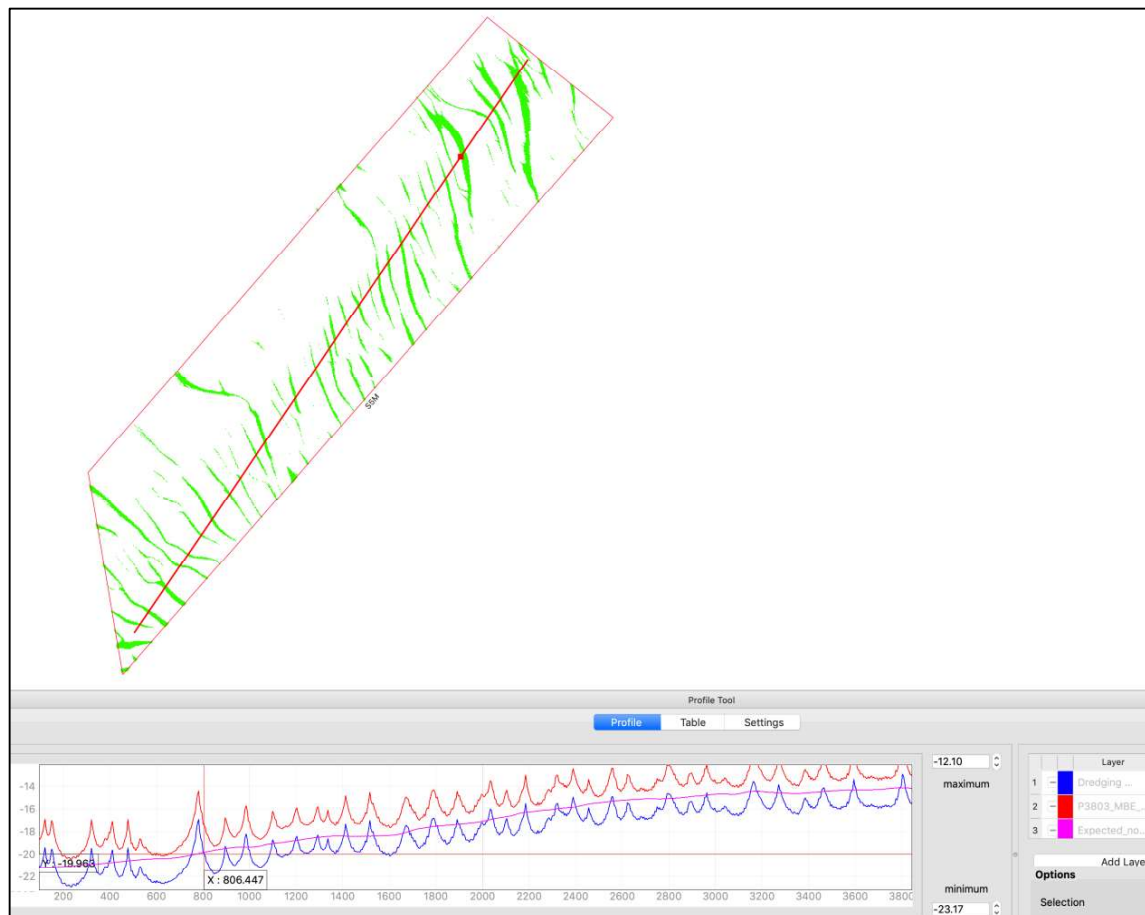


Figure 3: Representation of extractable sand in post-war sediments (top in green). Longitudinal profile sand borrow area S5M (below: current seabed level: red, dredging depth: blue, non-mobile reference level: magenta).

⁴ See paragraph 7.1.2. of report ‘Projectgebonden Risico Analyse Ontwerpfase zandwinvak S5M’ (NjordIC), reference 2018.04.067/UP0-78, date April 18, 2019.

One of the pUXO targets correlates with the SSS contact/object P3803_MAG_S5M_0293. All detected anomalies are stated in the target list (see: Annex B). Please note that Annex B includes PMTL results from Deep and the FMTL targets picked by Freyr (red cells in the Threshold column stating “pUXO / avoidance required”).

For further, more detailed results of the MBES and SSS survey reference is made to the report: P3803_S5M_FO_REP_R00, Deep BV, date 09-03-2021.

2.3 UXO ALARP CLEARANCE CERTIFICATION





Annex B: PMTL and FMTL (red cells)

Delivered as separate file to this report.

MAG data results (residual values) S5M

FREYR

area overview chart

S5M UXO Survey Boundaries

Legend

TF Residual (nT)

main chart

S5M

Scale 1:12000 (A0)

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Client
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UXO Consultant

Approved by Freyr management:
Einar von Gentling BSc
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