DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2010/49

Laesoe Offshore Cable

Geophysical and geotechnical works for Laesoe Offshore Cable

Niels Nørgaard-Pedersen, Sara Borre,
Zyad Al-Hamdani & Steen Lomholt

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Client: Energinet.dk

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1. Introduction

In connection with the power cable project between northern Jutland and the island of Laesoe in Kattegat sea, GEUS has performed marine geophysical and geotechnical investigations for Energinet.dk. The survey took place ultimo April-primo May 2010 from the survey vessel M/V Madog.

The purpose of the investigations was to locate any objects, wrecks, cables etc. present in the investigation area. Furthermore, determination of the seabed type, and shallow geology shall enable an evaluation of the possible jetting and/or trenching for excavation of cable trenches.

The geophysical and geotechnical investigations consisted of:

- Dual frequency side-scan sonar to provide full coverage with the purpose of seabed classification and object localisation
- High-frequency 'chirp' shallow seismic profiling with the purpose of mapping the geology in the near-surface sediments
- Shallow seismic profiling by sparker in order to evaluate the relationship between deeper structures and the top sediment geology
- Magnetometry in order to scan the area for any iron objects, wrecks, cables, etc.
- Multibeam bathymetric mapping to provide full coverage of the seafloor bathymetry
- Vibrocoring as a supplement for the geophysical and geological interpretation, and for preliminary geotechnical data for excavation of cable trenches
- Laboratory tests on sediment samples in order to provide information about the soil stratification, geological classification and the strength parameters of the soil

2. Field work

2.1 Survey area

The survey corridor across Laesoe Rende (trench) follows the alignment of the northernmost part of the cable zone indicated on the navigation map (Fig. 1). The about 200 m wide and 15 km long survey corridor consists of two straight lines which meet at an angle point about 600 m north of Laesoe Rende light house. The western limit of the survey area is the restricted zone margin at about 2.0 km from the shore. The eastern limit is the 6 m depth contour about 2.3 km WSW of Laesoe.

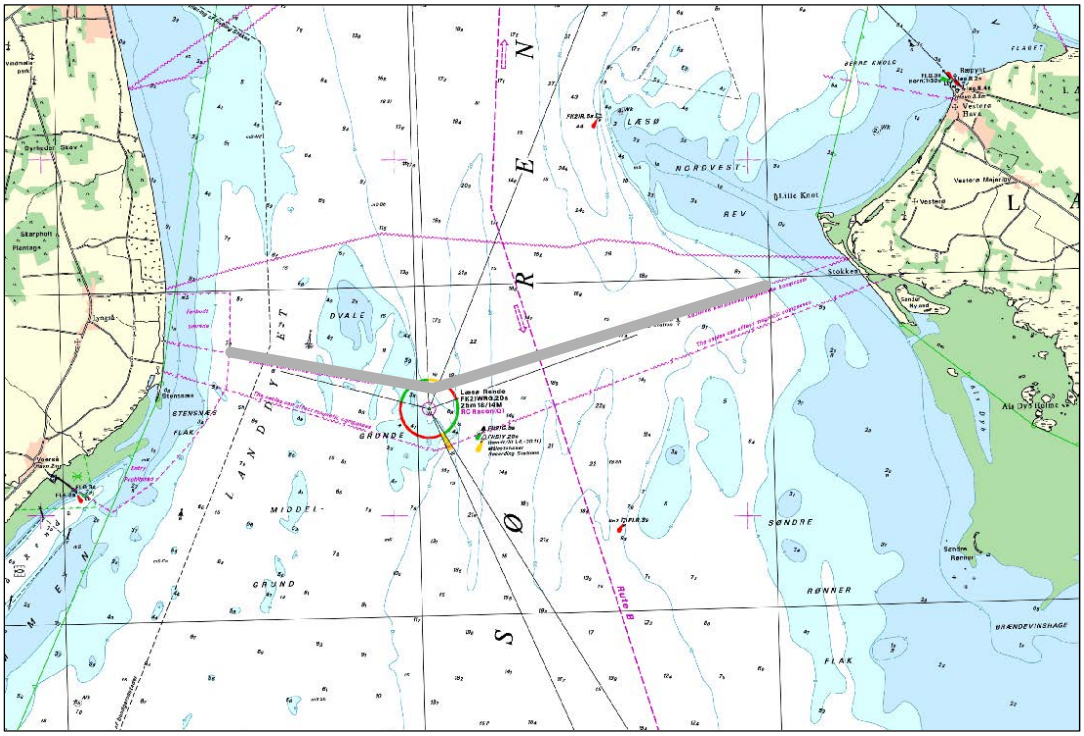


Figure 1. Laesoe Rende area. The thick grey line indicates the c. 15 km long and 200 m wide survey area along the northern limit of the existing cable corridor indicated by dotted pink lines.

2.2 Survey vessel M/V Madog

M/V Madog chartered from Nordmarine DK ApS Shipping was used as survey vessel (Fig. 2). Her ability to provide a stable platform in rough sea makes her very suitable for geophysical acquisition / bottom sampling /sediment coring survey projects. Her 66 m^2 spacious aft-deck with 2 cranes 1x 5 TM support crane and 1 x 10 TM which reaches out over the stern makes her a multi-functional work platform for various tasks. Her large survey room with direct access and view over the work deck can accommodate up to 6

technicians working at the same time. M/V Madog has a passenger insurance which covers 12 scientists / technicians / operators. For further details, see Appendix A.

Figure 2. M/V Madog 2009.

2.3 Mobilisation

Field work took place ultimo April-primo May, 2010. Mobilisation on M/V Madog took place from Rødby Harbour, 28th April, 2010. Hereafter the vessel sailed to Grenå Habour for dry dock mounting of the multibeam system. During the transit time all other necessary measurement equipment and computers on the vessel were coupled to the existing onboard systems and tested. After mounting of the multibeam system and fixation of cables along the ship's bow, the vessel sailed toward the Laesoe survey area where calibration and patch tests for the multibeam system were performed during the 30th of April.

2.4 Survey

Energinet.dk's representative arrived to the ship in Frederikshavn early the 1st of May, and the geophysical survey was acquired during the day until 2:20 AM, 2nd of May. A continuous acquisition of raw data from Sparker, Sub-bottom profiler, Magnetometer, Side-scan sonar, Echo sounder and Multibeam system with a coupled motion sensor, was carried out throughout the survey. This data served as base for later processing and mapping. A RTK GPS land base station was pre-installed in Sæby before

commencement of the survey. Five parallel lines with a distance of 40 m in between and a length of app. 15 km were surveyed. During the survey, periodical malfunction of the motion sensor was noticed, and this became worse toward the end of the survey. It was therefore decided that the multibeam acquisition should be repeated with a new motion sensor in the following week. Five vibrocoring sites were chosen along the center line, and during the 2nd of May, duplicate set of cores with a length of 1.5-2.5 m from each site were retrieved successfully. Hereafter the vessel sailed to Grenå Harbour for disembarkment of parts of the crew and Energinet.dk's representative. The multibeam survey was repeated during the 10th of May, 2010, from M/V Madog; this time with the RTK base station mounted in Frederikshavn.

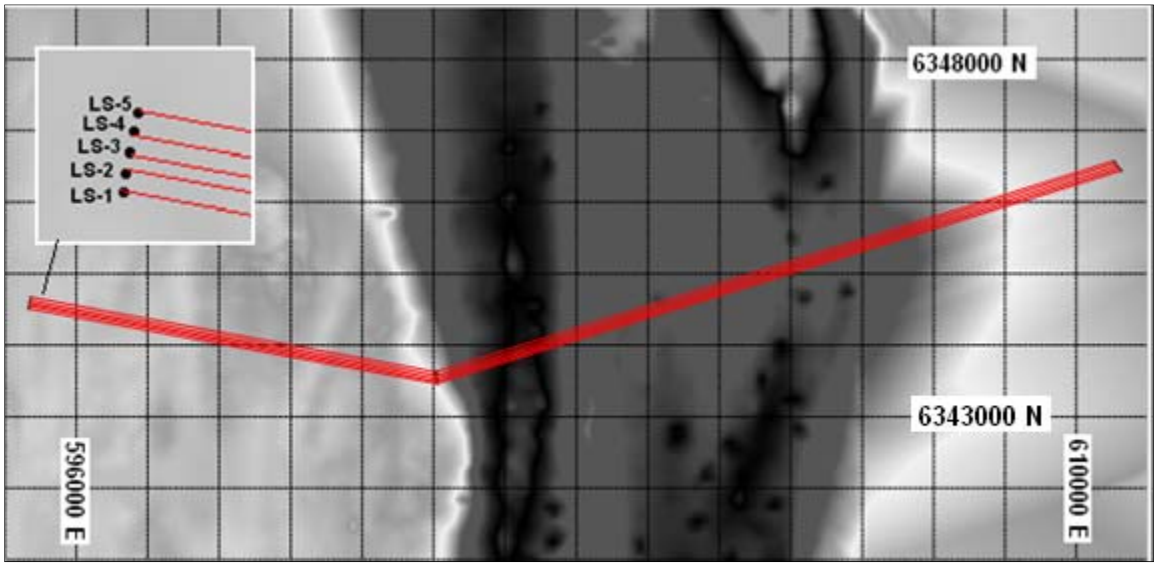


Figure 3. Five main survey lines (red) numbered LS-1 – LS-5. Coordinate grid in UTM Zone 32 N.

2.5 Geophysical and geological crew

Crew from GEUS included Niels Nørgaard-Pedersen (geologist, project manager), Sara Borre (geophysicist, seismic interpreter), Jacob Geltzer (technician) and Lars-Georg Rödel (technician, test phase only). Rune Bert Jørgensen (geologist, Rambøll) was chartered as additional geophysical surveyor. Subcontractor Bjerregaard Montage, ApS, (Johnny Bjerregaard Jørgensen) was responsible for vibro coring. The multibeam survey was performed by Scansurvey (Jesper Højdal assisted by Micky Højdal), and the RTK installation on land was performed by Subcontractor John Dahl. Energinet.dk's representative was Stig Marstal.

2.6 Weather conditions

During the survey period, weather conditions were fine with light to moderate winds (< 8 m/s), wave heights generally less than 0.5 m and moderate currents only.

3. Methods and equipment

In the following, the methods and equipment used are described in detail. Further equipment specifications are listed in Appendix A.

3.1 Positioning

The vessel position was verified by the RTK GPS system measured in correspondence to Euref89, UTM zone 32 and DVR90. For the survey a Jarvad Triumph-1 RTK GPS was used. This GPS supports RTK positioning plus GPS L1/L2/L2C/L5 and GLONASS L1/L2 tracking. This unit has a 216 channel receiver with a refresh rate of up to 100 Hz. It also contains a build-in UHF receiver and radio-modem for communicating with base station. RTK (OTF) accuracy is 1 cm horizontally and 1.5 cm vertically. A RTK GPS system was set up in correspondence to a fixed base station in Sæby plus a known control point on the harbor. For the later repetition of the multibeam survey, the RTK base station was mounted in Frederikshavn. This setup was verified by a land surveyor. The specifications for the RTK stations are listed in Appendix A. Positions of measuring equipment was calculated dynamically and precisely by the navigation computer in relation to the ships position and movement.

3.2 Multibeam

For detailed bathymetry, a Kongsberg Multibeam EM 3002 dual head seabed mapping system was used. It is an advanced multibeam echosounder with extremely high resolution and dynamically focused beams. Each head delivers a 1.5° beam for transmission and reception, where the swath coverage of the dual head system can reach up to 10 times the water depth. In the high density mode of operation each head acquires up to 254 soundings per ping. The operating frequencies are 293 and 307 kHz to avoid interference between the two heads. It is suited for detailed seafloor mapping and inspection in water depths between 0.5 and 150 meters. Due to its electronic pitch compensation system and roll stabilized beams the system performance is stable even in foul weather conditions. A Kongsberg MRU 5 Motionsensor was used. An AML Micro SV was used as multibeam sound velocity sensor and an AML SV Plus as sound velocity profiler. A detailed description of the multibeam equipment is given in Appendix A.

3.3 Side-scan Sonar / chirped sub-bottom profiler

As side-scan sonar the Teledyne 1625 combined side-scan sonar and chirp sub-buttom profiler was used. This is a dual frequency side-scan sonar operating at 100 and 400 kHz simultaneously, with selectable swath from 25 to 500 meters. The maximum resolution of the side-scan is 4.5 cm. The instrument also contains a build in sub-buttom profiler which operates within the 1 to 10 kHz range. This will be used in cooperation with the Geo-Source 200 system. A detailed description is given in Appendix A.

To further improve the accuracy of the side-scan and magnetometer data, the position of the fish relative to the tow point is monitored by an Ore Trackpoint 3 USBL system. For further description of the system see the datasheet in Appendix A.

3.4 Sub-bottom profiling

A combination of the Benthos Teledyne side-scan sonar/ chirped sub-bottom profiler and the Geo-Source 200 sparker was used. The Benthos is used to map fine grained near surface sediment layers and the Geo-Source 200 is used for deeper penetration.

The Geo-Source 200 is a high resolution Multi-tip sparker system designed for use with the Geo-Spark 1000 pulsed power supply and the Geo-Resources single channel 8 sensors mini-streamer. The sparker has an effective seabed penetration of approximately 30 meters below seabed with c. 30 cm resolution, and operates with a 200 tip array pulsed at between 50 and 1000 joule per ping. A detailed description of the seismic equipment is given in Appendix A.

3.5 Magnetometer

A Geometrics G-882 marine magnetometer was used. The magnetometer has automatic hemisphere switching, capable of operating down to a depth of 2750 m. The operating range is 20,000 to 100,000 nT. The absolute accuracy <3 nT throughout range. The system features include very high sensitivity measurements of total field and gradient combined with rapid sampling.

Ideally the magnetometer shall be towed as far away from the vessel as possible in order to reduce magnetic noise from the vessel. However, in shallower water (<10 m) lay back has to be reduced in order to prevent bottom contact and potential damage of the equipment. The magnetometer was preferably positioned about 50 m behind the vessel at water depths >10 m. The lay back was controlled through remote steering of the cable winch. The position of the fish relative to the tow point was monitored by an Ore Trackpoint 3 USBL system. For further description of the system, see the datasheet in Appendix A.

3.6 Vibrocoring

GEUS' vibrocorer W. Schmidt VKG 6/3 was used with a core barrel length of 3 m (Appendix D). The VKG is an electrically driven vibrocorer system, vibrating at around 28 Hz, coring bottom samples in up to 100 m water depth. PVC core liners with an inner diameter of 106 mm were used.

3.7 Laboratory tests

This outlines the details for the offshore and onshore sediment core/sample testing.

A duplicate set of cores (A and B) were taken from each core site. Core liners with samples were cleaned, cut into one-meter lengths and labeled. In the bottom sections containing clayey sediments, vane shear test were performed with a Geonor H-60 hand-held Vane Tester, capable of measuring shear strengths up to 200 kPa.

Subsamples were taken from the bottom of each core section (A cores only) and from the core top. Hereafter the core sections were sealed with core liner tubes and durable tape and placed carefully in transport boxes.

After return to the GEUS sediment laboratory, the 'A' cores were slapped into two halves, for a detailed core description and further sampling of representative sediment types. Laboratory analyses performed included water content, organic content, hydrometer and sieve analyses. The 'B' cores were preserved whole in the core barrel liner for the possibility later to perform advanced geotechnical tests such as compressibility and triaxial tests.

Results from the laboratory testing aim at providing information about:

- Soil stratification and the geological classification of the soil layer
- Classification and identification parameters
- Strength and deformation parameters of the soils

The classification is based on:

- Geological visual description incl. colour, continuously performed
- Grain size analyses, sieve and/or hydrometer, wet and dry unit weight, water content, organic matter content, vane shear test results

Water content determination
The water content is determined in percentage of natural condition sample weight. The samples are dried at 105° C to constant weight. The analyses are carried out partly to the standard DS 405.11 and partly to DS 204 (see references).

Loss on ignition determination
The organic content and the content of chemically-bonded water are determined with the loss on ignition analysis. The loss on ignition is determined in weight % of material dried at 105° C. The analyses are carried out partly to the standard DS 405 and partly to DS 204 (see references).

Grain size distribution
For well-sorted sandy samples, the grain size distribution was determined by sieve analysis. For samples with a larger amount of clay and silt, hydrometer analysis was used in supplement to sieve analysis.

The total sample was dried and washed through a 0,063 mm sieve. The resulting sediment was sieved through a sieve column from 16 mm to 0,063 mm with ½ phi intervals, which corresponds to 15 sieves. The method is adapted in relation to the

standards DS405.9, DS/EN 933-1, as more sieves than described in this standard have been used.

The particle size distribution of grain size fractions smaller than 0.063 mm was determined with Hydrometer analysis based on Stokes law using gravity sedimentation in 0,002 M Sodium Pyrophosphate ($Na_4P_2O_7$ .10 H_2O). The total particle size distribution was obtained by combining the Hydrometer analysis with the sieve analysis.

4. Data Acquisition and Processing

4.1 Data Handling

Survey data was acquired online and saved on the acquisition computer in a Raid 1 Hard disc setup. As an extra precaution, daily external backups were taken of each acquisition computer. This external backup served as transport media along with the data stored on the computer itself. Raw data were finally stored in our resident database at GEUS. The raw data is in XTF and SEGY formats.

4.2 NaviPac

The integrated navigation and data acquisition software NaviPac was used. It records the antenna position and distributes offset corrected navigation data for the individual instruments. NaviPac allows for survey planning through creation of survey area and survey lines. More details on NaviPac are found in Appendix A.

4.3 Triton Isis Side-scan Acquisition Software

Triton ISIS side scan software was used for recording, Triton Perspective for processing, and presenting side scan data as single line data and as mosaics. The interpretation of side scan and chirp data were performed by Isis® Sonar™ and TEI's Triton-Map™ software. Triton offers a wealth of display options to ensure high data quality. Typical windows for monitoring raw sensor information include a waterfall display for the sonar imagery, a signal voltage display for each incoming ping, and a parameter display for navigation, motion sensor, etc., and file storage. More details on Triton Isis are found in Appendix A.

4.4 Magnetometer

The raw data recorded by the Geometrics G-882 marine magnetometer were cleaned for noise by the use of *GeoSOFT Oasis montaj 6.0* software. Only minor processing was applied to data. A b-spline function was used to remove minor electrical noise from data.The magnetic data were plotted line through line and closely examined for characteristic anomaly spikes.

4.5 Multibeam

The multibeam data recording were performed in *QinSi 8.0*, and the post-processing were performed in *Qloud 2.1* software from Reson. Detailed information on patch testing and calibration before and after the survey are given in the data DVD attached to this report.

5. General physiography and geology of the area

5.1 Physiography

Laesoe Rende (Laesoe Trench) in the northern Kattegat is aligned N-S with depths to about 25 m and several shallow areas of 6-9 m depths. Two parallel trenches are divided by a shallower elongated ridge (here called' Laesoe Rende Ridge'). However, the eastern trench appears to be near filled up with sediment in the area of the planned cable alignment. The sea bottom surface sediment distribution in the area is dominated by sandy deposits. In the deeper trenches, however more muddy sediments are found. (Fig. 4).

The survey corridor across Laesoe Rende follows the alignment of the northernmost part of the cable zone indicated on the navigation map (Figs. 1, 3). The about 200 m wide and 15 km long survey corridor shows a characteristic angle point at about 600 m north of Laesoe Rende light house. The western limit of the survey area is the restricted zone margin at about 2.0 km from the Lyngså shore, Jutland. The eastern limit is the 6 m depth contour about 2.3 km WSW of Laesoe.

In general, the hydrography of Northern Kattegat is characterised by a northward brackish water (16-21 psu) current in the upper water column and a southward more saline current (30-31 psu) following the deeper trenches. Changes in the westerly vs. easterly wind regime, can lead to a reversal of the general circulation pattern. The tidal amplitude is limited to about 10-30 cm.

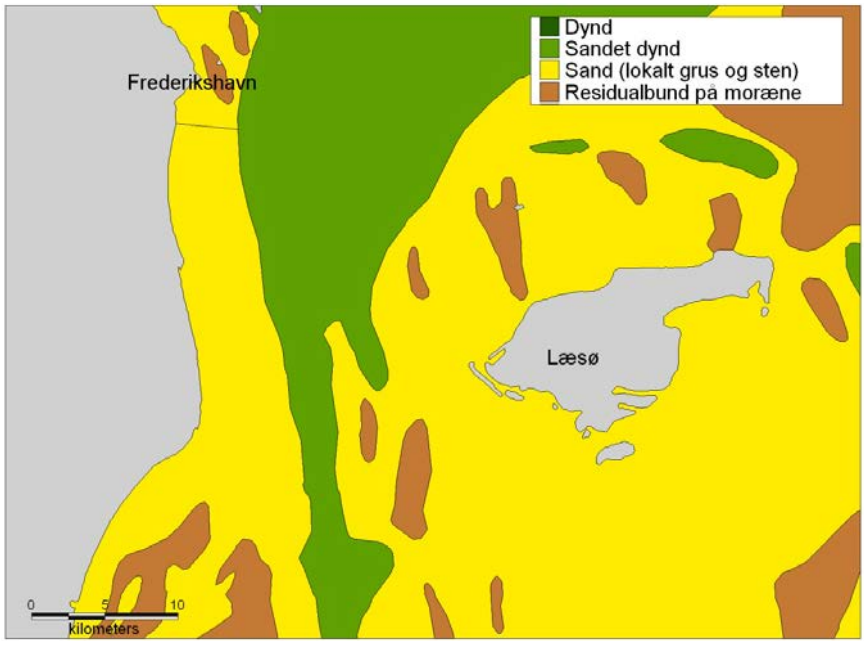


Figure. 4. Sea bed sediment distribution in the northern Kattegat area (source: J.O. Leth, GEUS).

5.2 Geology

The near surface geology in the area between North Jutland and Laesoe is dominated by last glacial (Weichselian) marine deposits, the so-called Older Yoldia Clay, above which late glacial Younger Yoldia Clay, and Holocene marine deposits are found (Figs. 5, 6). A hiatus, representing the 'Continental Period' (Danish: Fastlandstiden) from about 12-10 thousand years BP during which the land was exposed, separates the late glacial deposits from the postglacial Holocene marine sediments deposited as the sea transgressed the area. Widespread occurrences of gas surfacing through porous sediments and fissures have been related to a source from deeper organic rich, interglacial deposits (Skærumhedeserie). A younger gas type is related to thicker accumulation of organic-rich Holocene sediments in deeper basin areas.

Skærumhede Serie (Interglacial)
Organic rich, marine deposits from the last interglacial period, the Eemian, belong to the so-called 'Skærumhedeserie'. Occurrences of deeper gas have been related to a source from the interglacial deposits.

Older Yoldia Clay (Glacial)
The glacio-marine 'Older Yoldia Clay' consists of clayey sediments with a scattered content of dropstones and some sandy-gravelly layers. Glaciotectonics during the Weichselian glacial period at about 30 ka BP have deformed the Yoldia Clay into imbricated thrusted slices.

Younger Yoldia Clay (Late Glacial)
Late glacial 'Younger Yoldia Clay' has not been loaded by glacial ice and is often found horizontally deposited between higher standing thrust slices of glacial Older Yoldia Clay.

Postglacial deposits (Holocene)
Postglacial deposits are dominated by sandy and relatively fine-grained marine sediments with local occurrences of coarser gravely and stony deposits in areas where glacial deposits have been exposed during the early Holocene period of exposure. During the early Holocene, Laesoe Rende contained a river system flowing from south to the sea in the north.

In northern Kattegat off Frederikshavn and around Laesoe, scattered carbonate-cemented sandstone structures or socalled 'bubbling reefs' are well known (cf. Jensen *et al.*, 1992). The structures formed subsurface over methane seeps in sandy sediments. Subsequent erosion of the surrounding unconsolidated sediment led to exposure of the cemented sandstone structures. The formations are interspersed with gas vents that intermittently release methane gas originating primarily from microbial decomposition of organic material deposited during the Eemian and early Weichselian periods (Skærumhedeserie). The sandstone structures may consist of pavements, complex formations of slab-type layers, and pillars up to 4 m high and >100 m^2 in area.

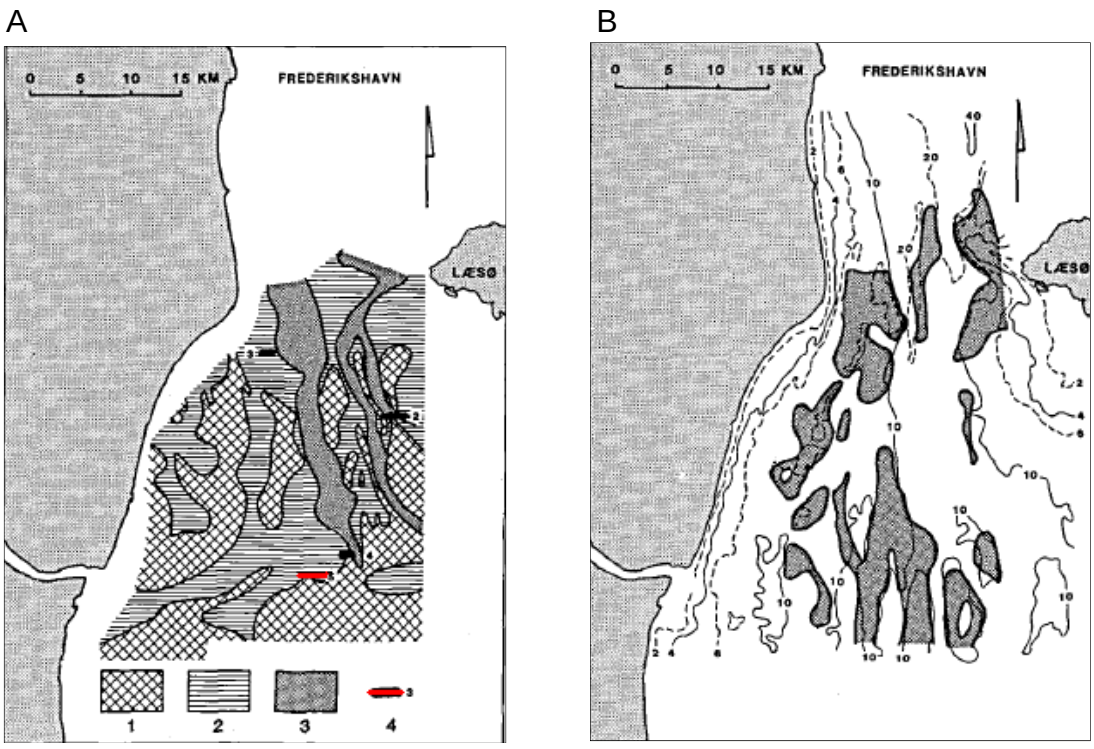


Fig. 5. A. Distribution of glacial and late glacial formations below the Flandrian (early Holocene) abrasion surface south of Læsø Rende. 1: Glacial deposits; 2: Late glacial deposits; 3. Postglacial valleys; 4: Location of seismic profile shown in Fig. 5. B. Major occurrences of post-glacial, marine sand; curves indicate sea depths in meters (from Larsen et al., 1985).

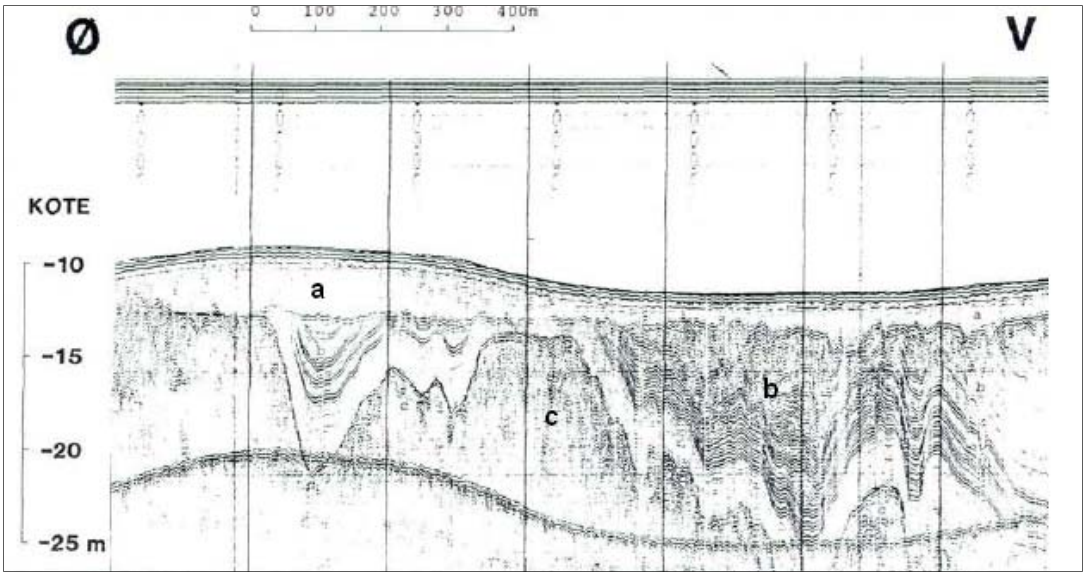


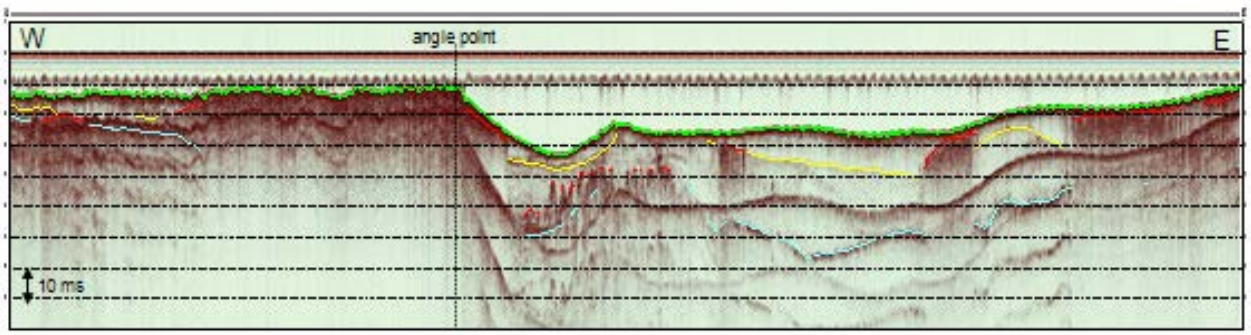
Fig. 6. Penetration echosounder profile from the southern part of Læsø Rende (Location shown in Fig. 5A). Vertical exaggeration c. 30x. a: Postglacial (Holocene) marine sand; b: Late glacial marine clay/silt/sand; c: Glacial deposits (from Larsen et al., 1985).

6. Survey data

6.1 Seismic reflectors and geological units

Three major seismic reflectors have been identified in the seismic sections: 'Top Glacial', 'Top Late Glacial', and 'Sea Bottom' (mostly top Holocene) (Fig. 7). Moreover the characteristic reflection pattern from 'Gas' has been indicated. Examples of interpreted Chirp and Sparker seismic records are given in Figs. 8-11 (shown from West toward East), and all records are shown in large scale on the accompanying Data CD.

A.



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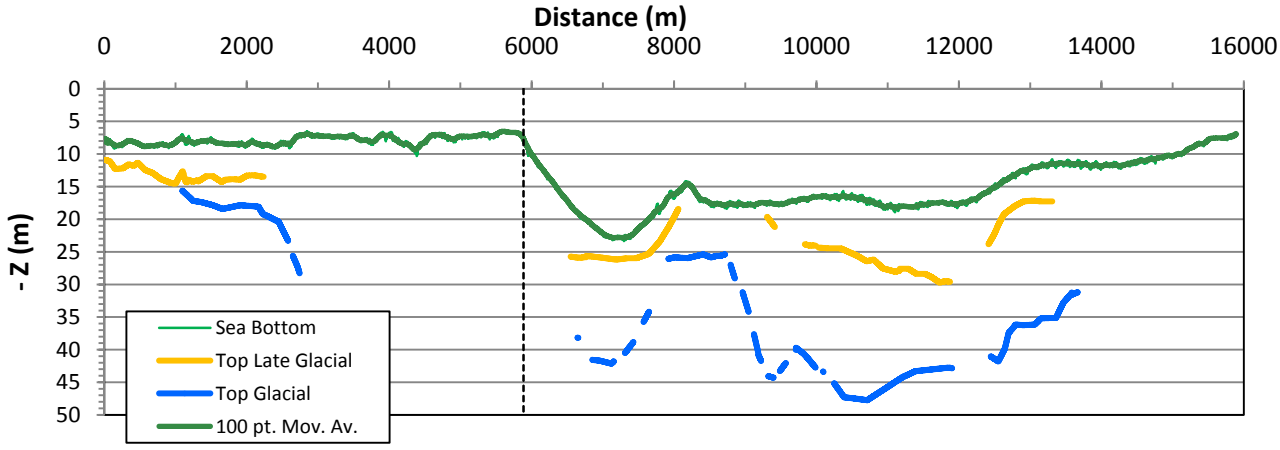


Figure 7. (A) seismic line LS3 (sparker) showing identified seismic reflectors and 'gas curtains'. 'Top glacial' reflector (blue); 'Top Late-glacial' (yellow); top of gas curtains (red); sea bottom (green). (B) Depth of identified seismic horizons plotted vs. distance along center line 3.

'Top Glacial'

A strong reflector observed west of 'Laesoe Rende Ridge' (Figs.7, 9) at a sub-bottom depth of 15-30 m (20-40 ms) is interpreted as the top of the glacial surface; i.e the

transition from the glacially loaded and probably tectonised Older Yoldia Clay to the late glacial and normally consolidated Younger Yoldia Clay. The reflector rises toward the central part of the profiles. Further westward it probably descent under the deep Laesoe Rende, where a thicker section of stratified late glacial sediment is found. The widespread occurrence of columnar 'old gas' features here probably indicates the occurrence of Older Yoldia Clay directly below.

In no parts of the profiles, glacial and possibly over-consolidated 'Older Yoldia Clay' appears to occur closer than 10 ms (about 7-8 m) from the sea bottom. The areas where Older Yoldia Clay possibly is found closest to sea bottom are in the more shallow western and eastern parts of the profile and under the Laesoe Rende Ridge. The occurrence under the 'Laesoe Rende Ridge' is supported by the occurrence of columnar older gas (Eemian?), which leaks through fissures in the Older Yoldia Clay (cf. Laier and Jensen, 2007).

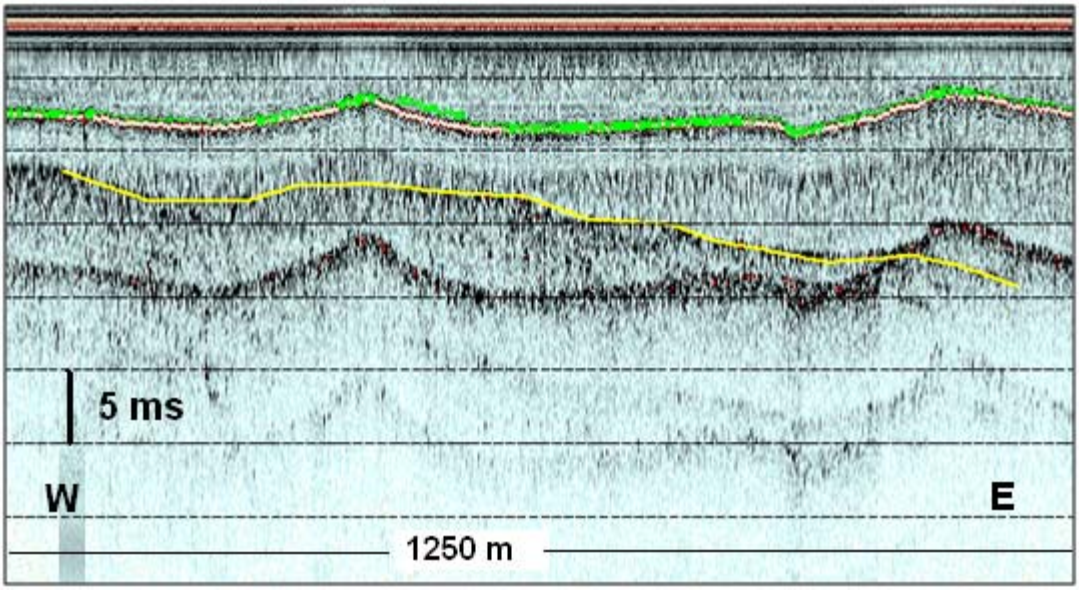
'Top Late Glacial'
Late glacial sediments appear to be located close to the sea bottom (<1m?) in the westernmost part of the seismic sections (Figs. 7, 8). The 'Top Late Glacial' surface descends to a depth of 3-8 ms (ca. 2-5 m) under 'Landedybet' a few km further eastward.

A distinct near horizontal reflector is found a few meters below the sea floor in the deep Laesoe Rende (Fig. 9). It separates an at least 15-20 m thick, highly stratified, undulating section of Younger Yoldia sediments from horizontal, more crudely stratified Holocene sediments. This 'Top Late Glacial' surface marks the 'Continental Period' period of sea regression and emergence from about 12-10 ka BP. Late glacial sediments with only a thin Holocene sediment cover or lag on top appear along an about 2 km long section east of the deep channel. East from here, the 'Top Late Glacial' surface dips slightly towards the east, where it becomes near horizontal at about 7-10 m subbottom depth. Internal eastward dipping reflectors in the Late Glacial sediment unit below support an in-fill history with progradational units building out toward the east. Further to the east, the 'Top Late Glacial' reflector approaches the sea bottom again.

Holocene
Holocene sediment occurs as thicker accumulations a few kilometres eastward of the western limit of the survey area, in the so-called 'Landdybet' (Figs. 7, 8). The Holocene fill in the deep Laesoe Rende channel appear only to be a few metres thick. The internal near-horizontal reflectors appear to be cut by the present channel bottom surface, and it is possible that the fine-grained clayey mud found here (core LS3) is of earlier Holocene age. The western side of the deep channel is characterised by a gas curtain masking sub-bottom reflections. However, the gas occurrence supports the existence of a Holocene organic-rich sediment fill several meters thick. The eastern side of the deep channel, in the depth range 18-15 m, is characterised by large sand waves, easily visible on the multibeam and side scan sonar mosaic maps. The sand waves have a wave length of c. 150 m, are up to 3 meters high with curved crests and stoss sides directed toward southwest-southeast. These bed forms probably migrate actively toward the North over time (unknown velocity). The sand waves are superimposed on an elongated N-S trending ridge, about 15 km long and a few km wide. The ridge may represent a Late Glacial structure, modified during the Holocene.

Shallow gas occurs in all seismic profiles in the Holocene section under the western side of Laesoe Rende, and under the easternmost part of the profiles. It occurs as broad bands that totally blank out structures below it, making interpretations of the geological conditions difficult. Quite different gas signatures, so called ‘plume gas’ or old gas are seen in the glacial to late glacial section under the deepest part of Laesoe Rende and the ‘Laesoe Rende Ridge’. In some of these plumes, sediment structures may locally be acoustically accentuated. Gas in the sediment limits the information for a larger quite shallow area west of the deep Laesoe Rende. The vibrocore LS2 taken from here contains Holocene sandy sediments to at least 1.5 m below bottom. Earlier investigations and coring near Laesoe Rende Lighthouse reveal a thick series of postglacial sediments here (Laesoe Rende Ressourceundersøgelser, 1983). The core data reveal that the upper 5 m are composed of fine sandy Holocene sediments.

A



B

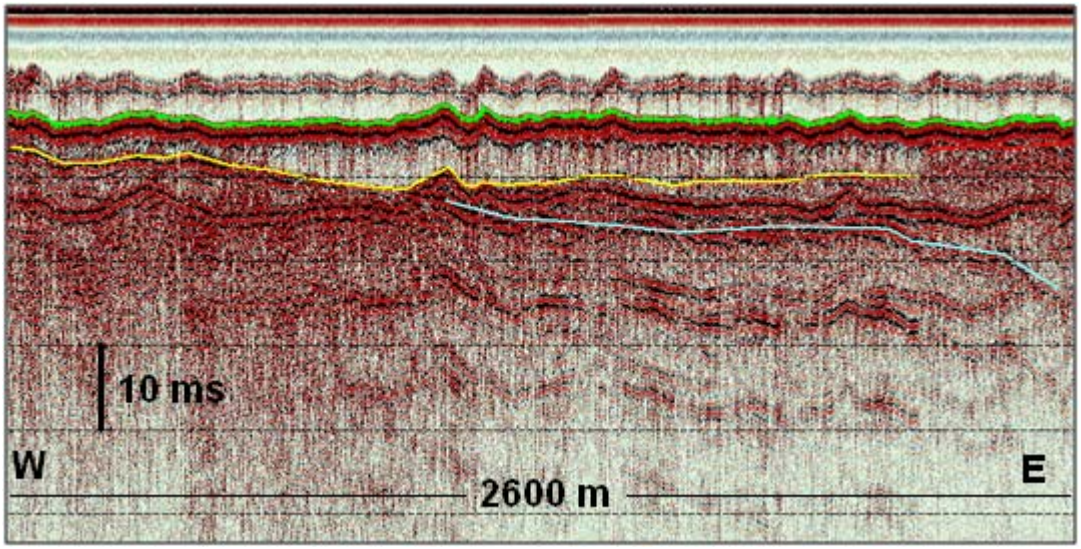
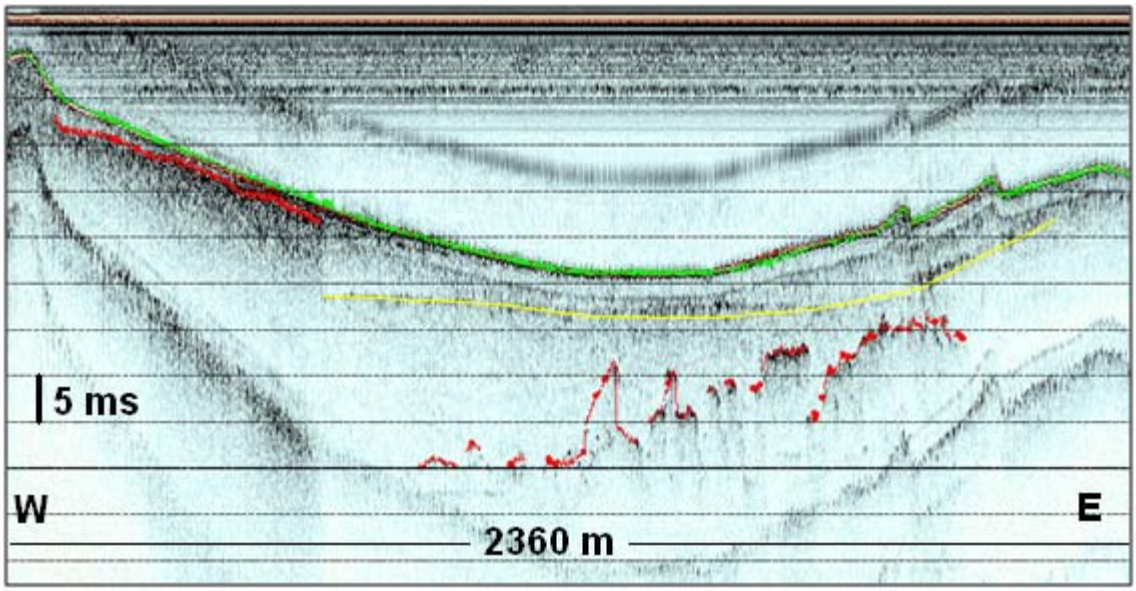


Figure 8. Example of Chirp (A) and Sparker (B) seismic profiles (Line 3) from the westernmost part of the survey area (Landdybet). Interpretation of main seismic reflectors: 'Top Glacial' (blue), 'Top Late Glacial' (yellow), 'Gas' (red) and Sea Bottom (Green). Two way seismic travel time (TWT) in ms.

A



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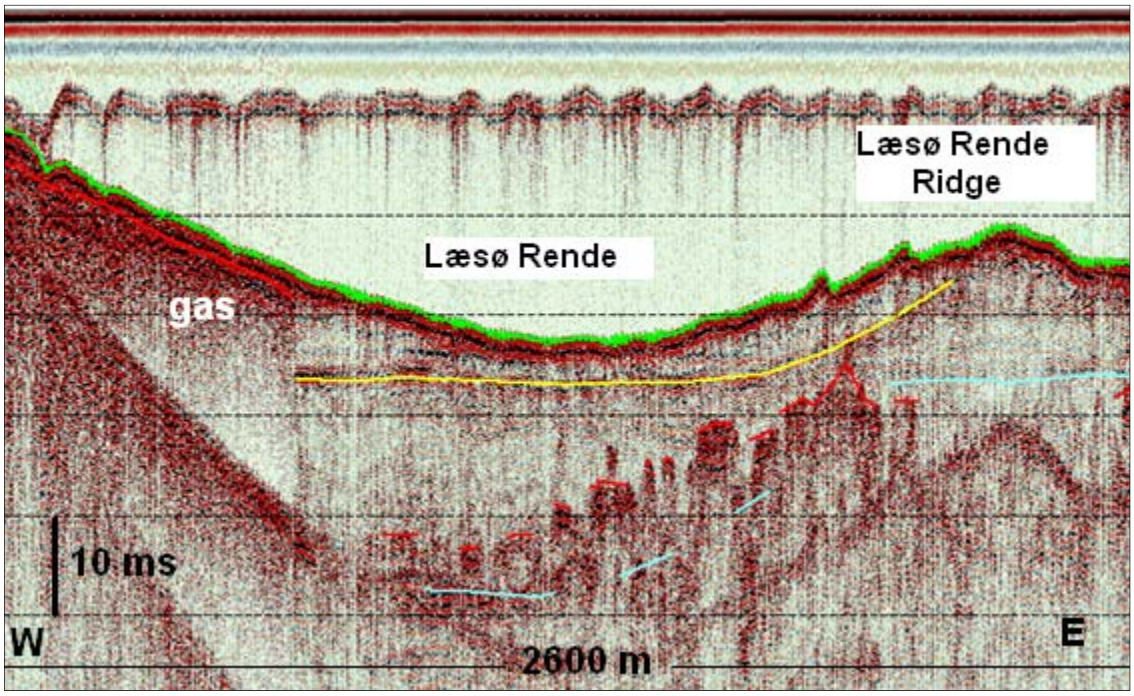
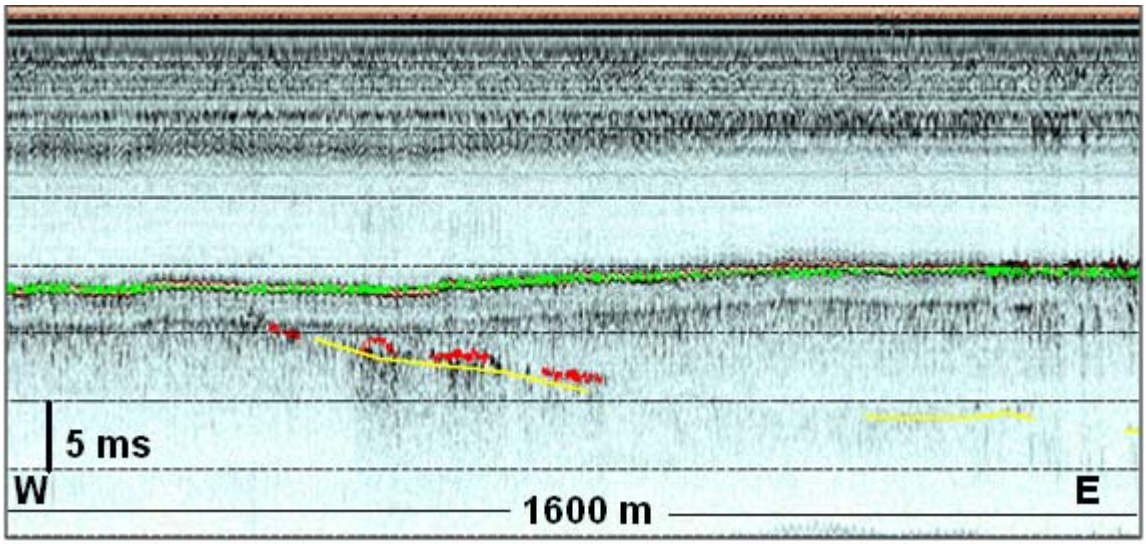


Figure 9. Example of Chirp (A) and Sparker (B) seismic profiles (Line 3) from the deep channel of Laesoe Rende. Interpretation of main seismic reflectors: 'Top Glacial' (blue), 'Top Late Glacial' (yellow), 'Gas' (red) and Sea Bottom (Green). Two way seismic travel time (TWT) in ms.

A



B

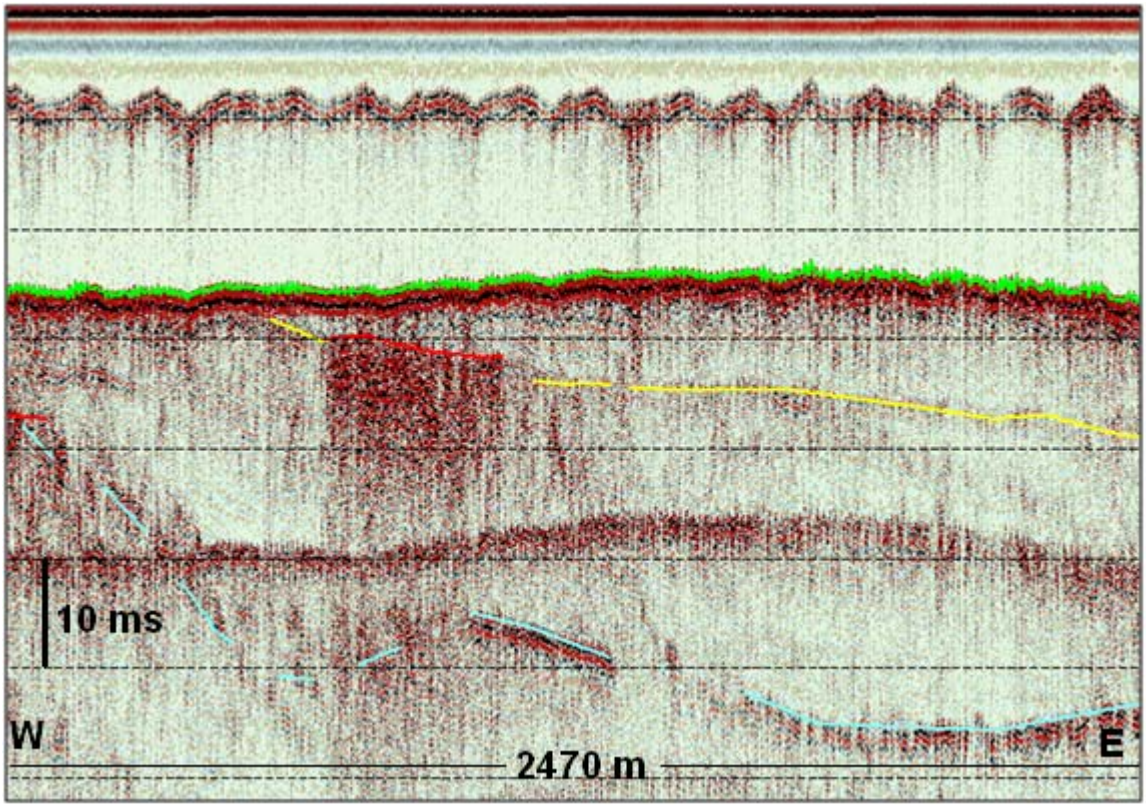
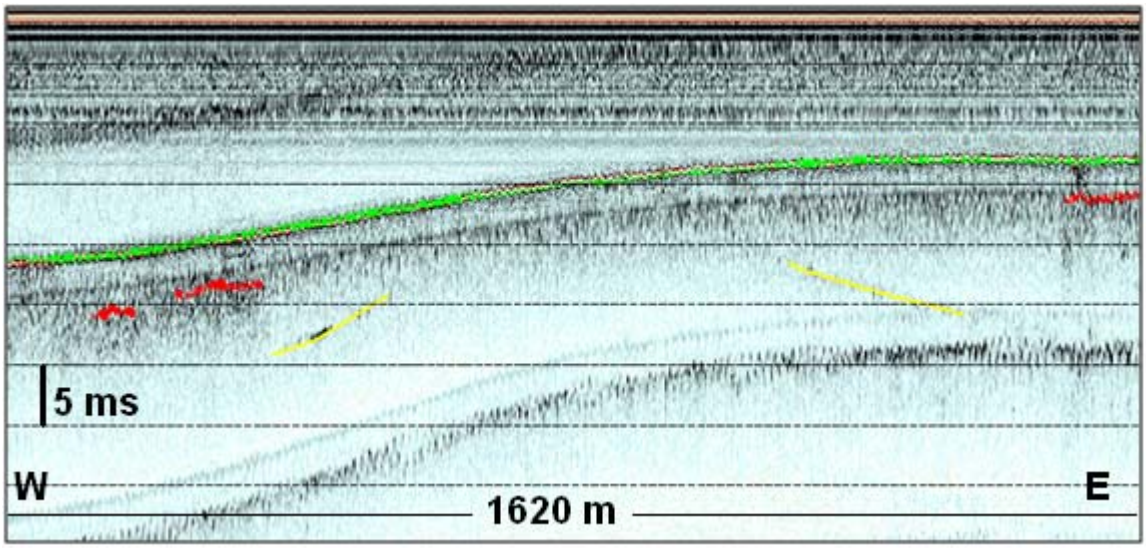


Figure 10. Example of Chirp (A) and Sparker (B) seismic profiles (Line 3) from east of the deep channel. Interpretation of main seismic reflectors: 'Top Glacial' (blue), 'Top Late Glacial' (yellow), 'Gas' (red) and Sea Bottom (Green). Two way seismic travel time (TWT) in ms.

A



B

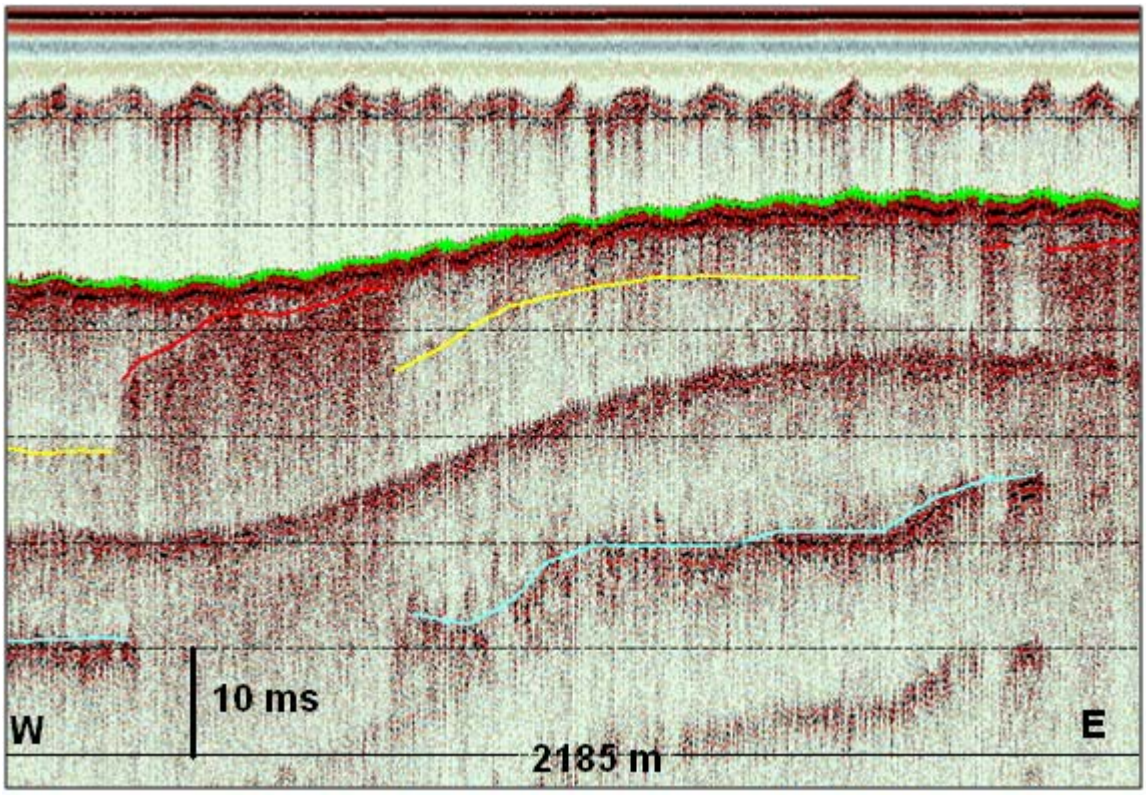


Figure 11. Example of Chirp (A) and Sparker (B) seismic profiles (Line 3) from the eastern part of the survey area. Interpretation of main seismic reflectors: 'Top Glacial' (blue), 'Top Late Glacial' (yellow), 'Gas' (red) and Sea Bottom (Green). Two way seismic travel time (TWT) in ms.

6.2 Vibrocore results

Five sediment cores, 1.5 to 2.7 m in length, were taken close to the middle seismic line LS3 (Fig. 12) and they all recovered unconsolidated sandy to muddy sediments of probably Holocene age. In Table 1, a short core description is given. Detailed core descriptions are found in Appendix B and detailed grains size data are presented on the accompanying Data CD.

Core No.	Recovery (m)	Position UTM 32N	Water Depth (m)	General description
LS1 -A	2,65	595718 E 6344538 N	8	Coarse silt with fine sand and marine shell fragments
LS2-A	1,50	600417 E 6343666 N	7	Sand with numerous marine shells
LS3-A	2,70	602444 E 6343977 N	22	Sandy mud with few marine shells
LS4-A	1,69	603338 E 6344261 N	18	Medium to coarse sand with gravel and many marine shells
LS5-A	1,50	606241 E 6345165 N	15	Medium sand with few marine shell fragments

Table 1. List of vibrocores LS 1A-5A retrieved along seismic line LS3.

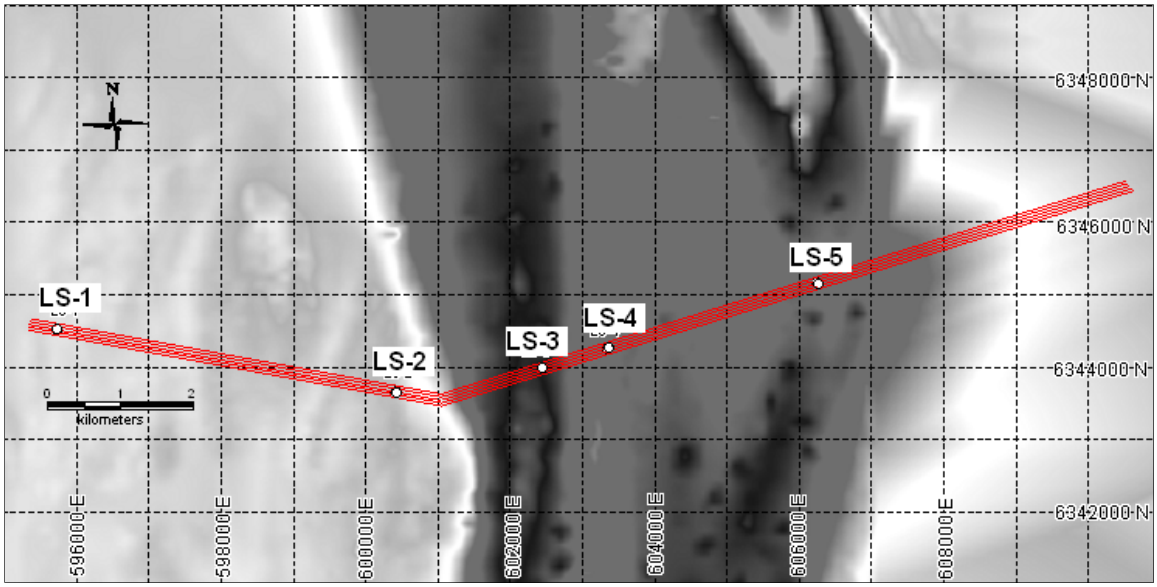


Fig. 12. Coring sites LS-1 to LS-5 positioned along the central survey line.

6.3 Multibeam sea bottom map

The bathymetry map produced for the cable corridor (Fig. 13) reveals that most of the sea bottom is dominated by medium-sized sand ripples (Fig. 14). Larger sand waves up to 2-3 m high with wave lengths of about 150 m are found on the ridge just east of the deep channel (Fig. 15).

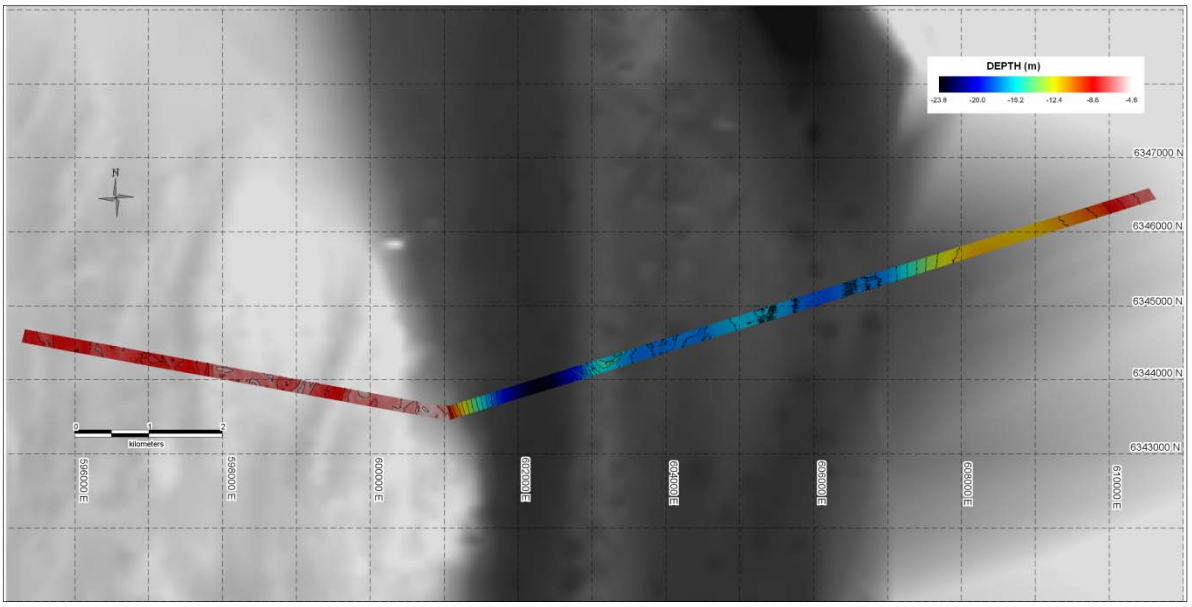


Figure 13. Overview of multibeam depth contour map. High-resolution data and maps are found on the accompanying data CD, and close-up images are shown on the following Figs. 14-16. Background relief from the Danish Maritime Safety Administration.

An irregular structure >10 m in diameter, protruding c. 2-3 m above the surrounding flat sea bottom has been identified on the multibeam and side scan sonar maps as well as the sparker and chirp profiles along Line 5b at a position 603970.4 E, 6344546.9 N (UTM) (Fig. 16). In addition, smaller point-like structures protruding <1 m from the sea bottom can be seen on the multibeam map at the position 603751.6, E 6344463.6 N. The structures occur above the Holocene sandy unit and it is therefore very unlikely that they represent very large stones / glacial erratics. More likely, it could be sandstone structures formed by methane degassing of older interglacial formations and local carbonate cementation of Holocene sand (socalled ‘bubbling-reef structure’). According to ‘Det Kulturhistoriske Centralregister’ (http://www.dkconline.dk/), Denmark, there is no known registered wrecks at this exact position. A few hundred meters to the north of the above position a few wrecks have been registered.

Apart from the above mentioned positions in a relatively small area, no marked structures protruding above the sea bottom have been identified on the side scan and multibeam mosaic maps.

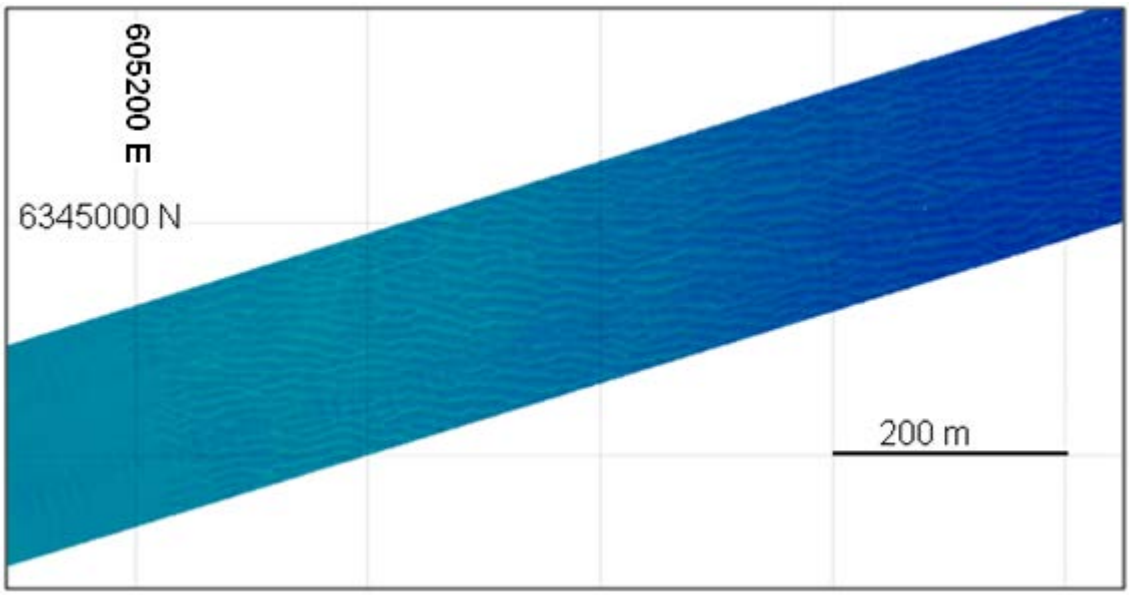


Figure 14. Multibeam map showing large ripples on the sea bottom. The ripples are app. 10 m apart, with crests heights of a few decimetres.

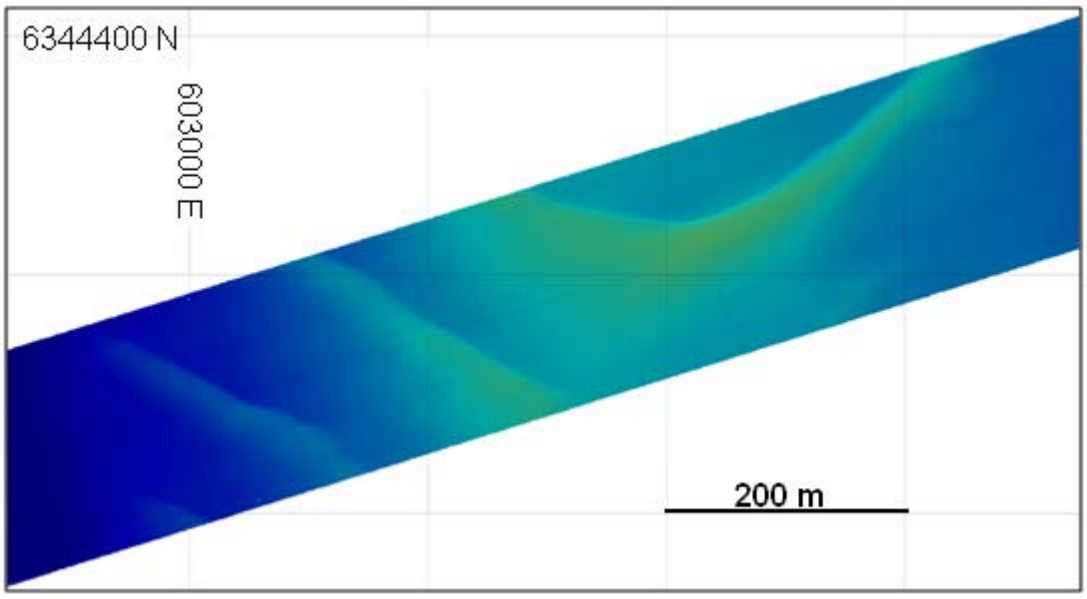
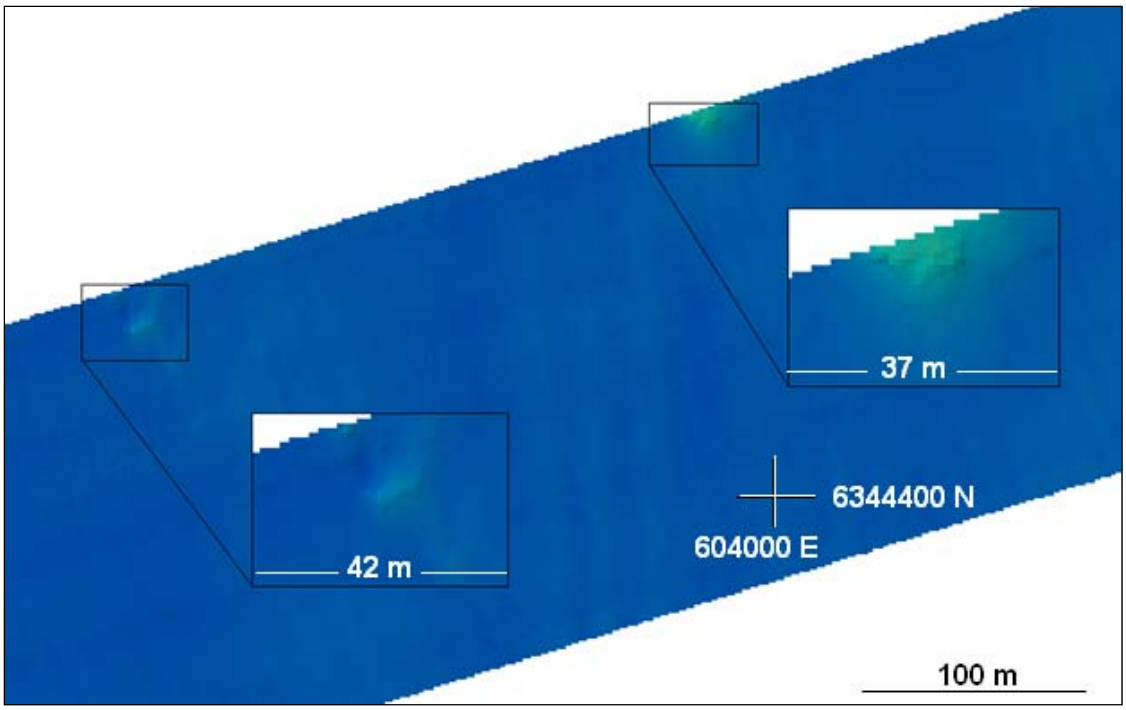


Figure 15. Multibeam map showing large sand waves on the sea bottom. The sand waves are app. 150 m apart, with crests heights up to 2-3 m.

A.



B.

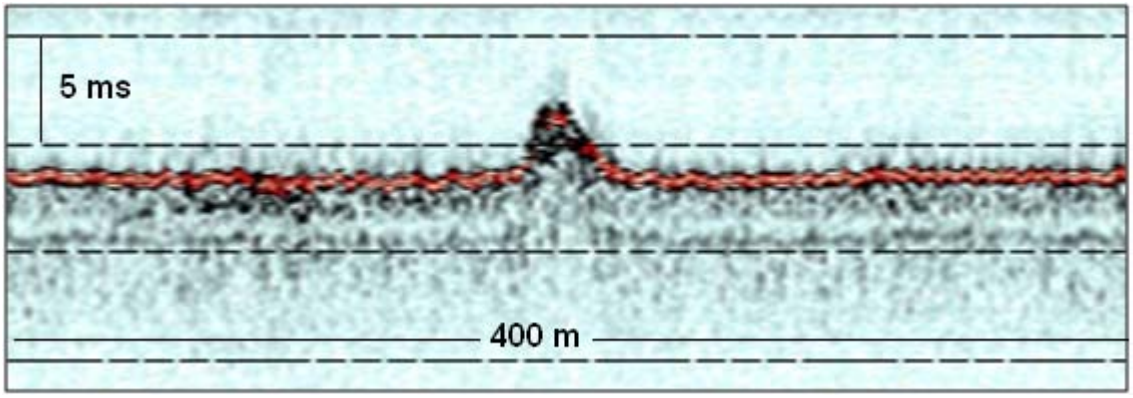


Figure 16. (A) Two sites with structures (possibly harder material) rising 2-3 m from the sea bottom as seen on the multibeam map, and (B) the chirp profile from seismic line 5 which crosses the structure to the Northeast in A. More details and exact position are given in text.

6.4 Side Scan sonar mosaic map

The side scan mosaic map reveals - as the multibeam data - a clear dominance of ripple structures on the sea bottom in the cable corridor (Fig. 17). Some stretches without clear ripple structures show a very limited contrast. The high degree of similarity in side scan and multibeam mosaic map changes observed (with respect to the observation of ripple structures cf. Figs. 14 and 17) confirm the true nature of the low contrast areas. The area characterised by sand waves is shown in Fig. 18. No larger stones or areas characterised by stone concentrations have been identified. The two sites with elevated structures on the multibeam map (Fig. 16) can be seen on the side-scan map in Fig. 19.

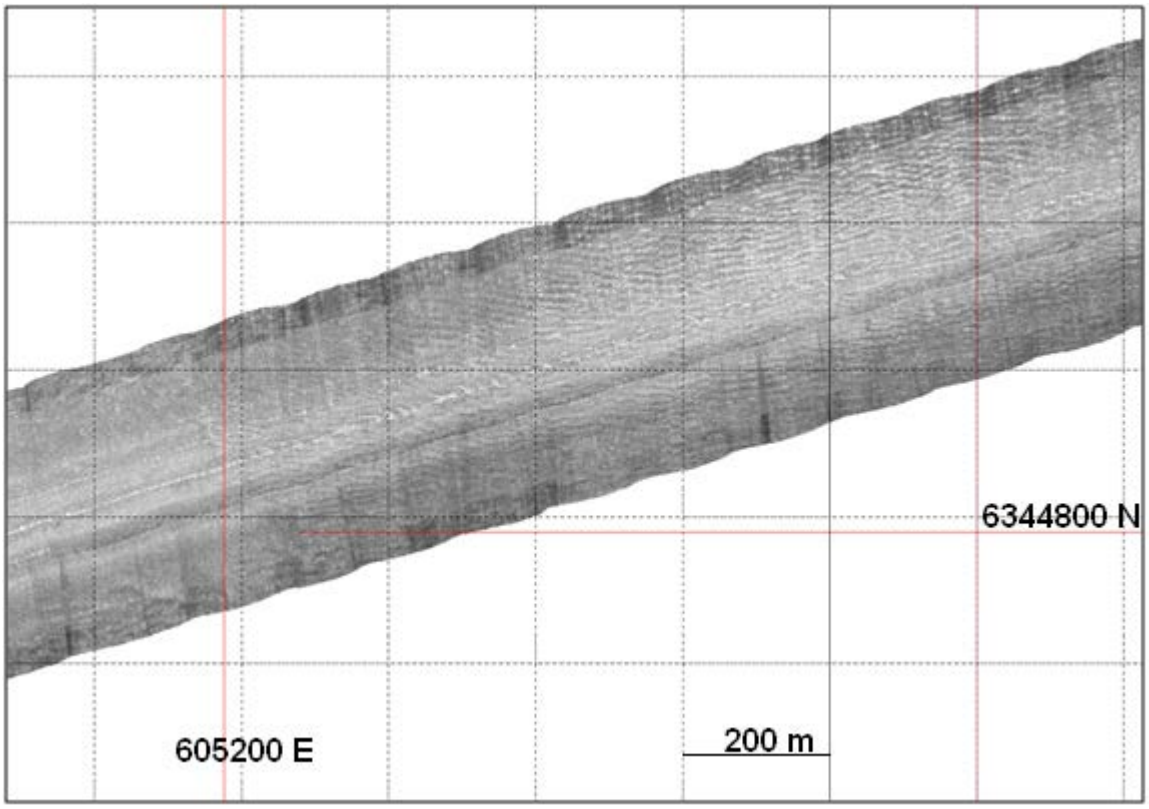


Figure 17. Side-scan sonar mosaic of the transition between a clearly rippled sea bottom to the east and a more featureless bottom in the westernmost part of the image (left side).

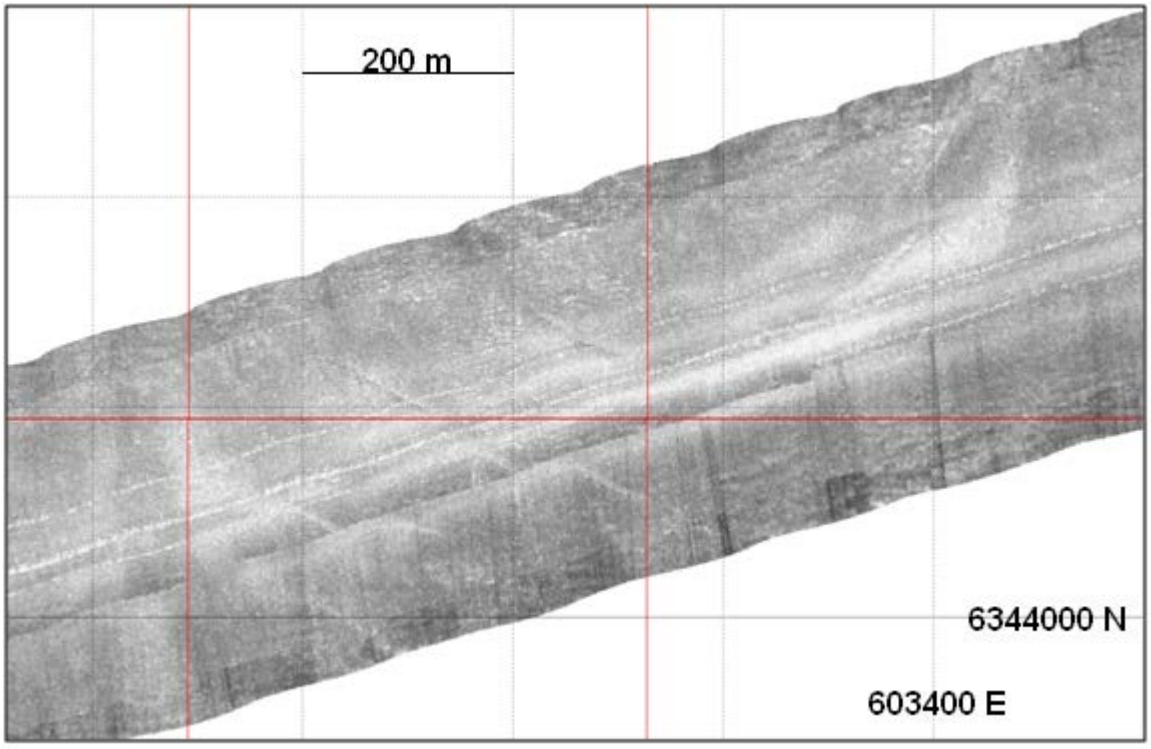


Figure 18. Side-scan sonar mosaic of area characterised by curved-crest large sand waves. The sand waves are 2-3 m high with a wave length of about 150 m.

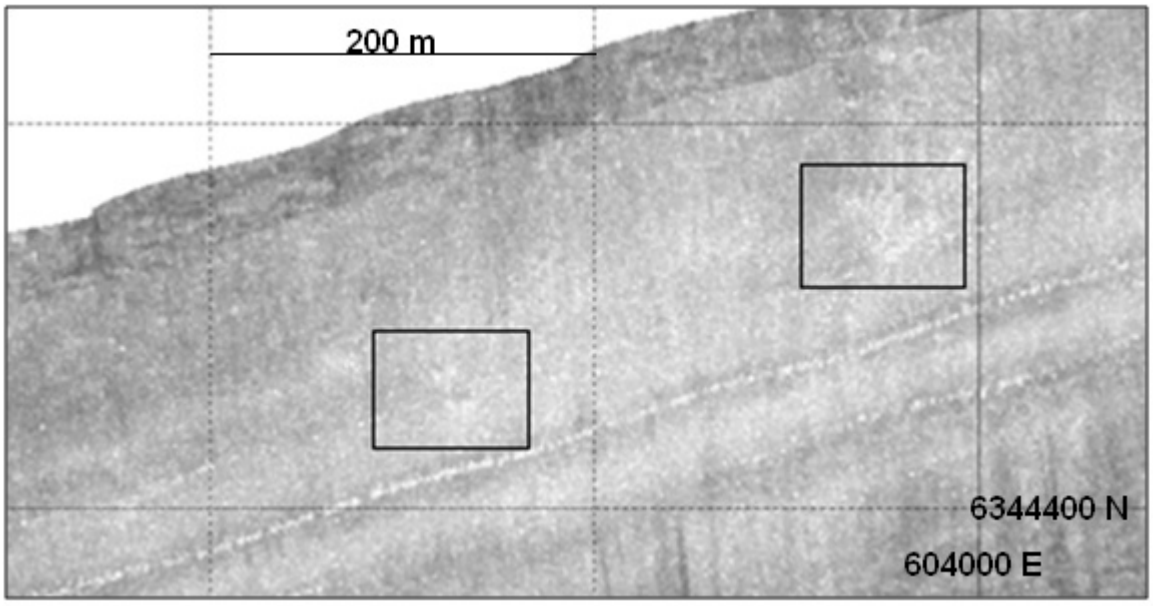


Figure 19. Side-scan sonar mosaic of areas (framed) characterised by structures rising above the surrounding relatively flat sea bottom as identified in the multibeam map and seismic line 5 (cf. Fig. 16).

6.5 Magnetic data

The raw data recorded by the Geometrics G-882 marine magnetometer were cleaned for noise by the use of *GeoSOFT Oasis montaj 6.0* software. Only minor processing was applied to data. A b-spline function was used to remove minor electrical noise from data. Original data from Line no. 2 is presented in Figure 20 and a processed version after removal of minor noise is presented in Figure 21.

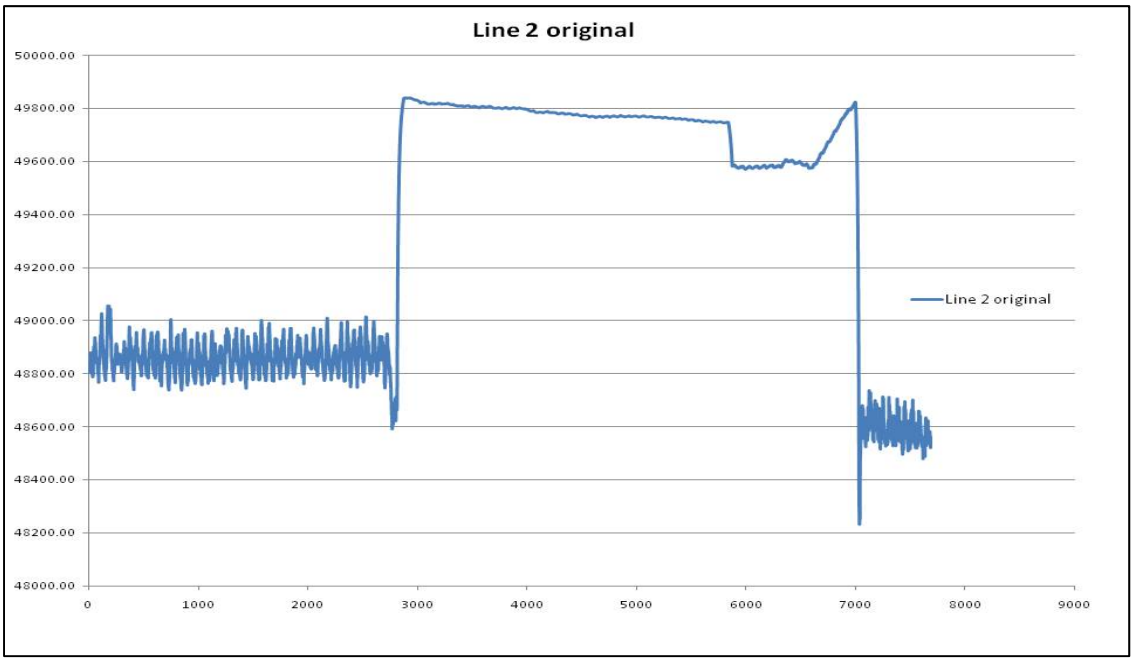


Figure 20. Original Magnetic data, Line no 2.

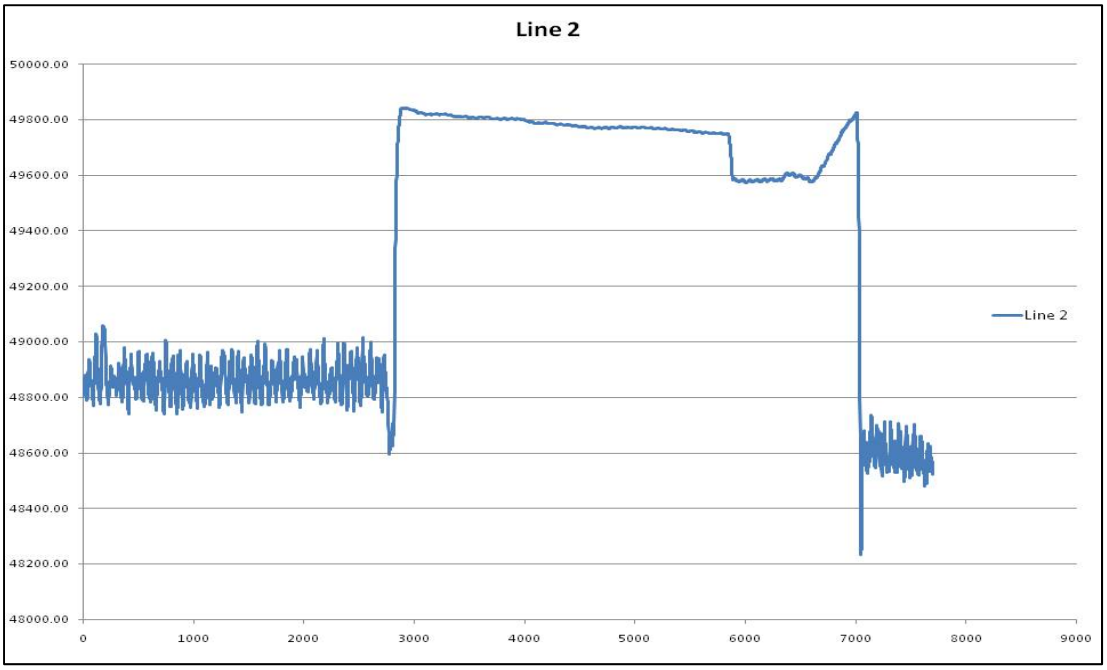


Figure 21. Processed magnetic data, Line no 2.

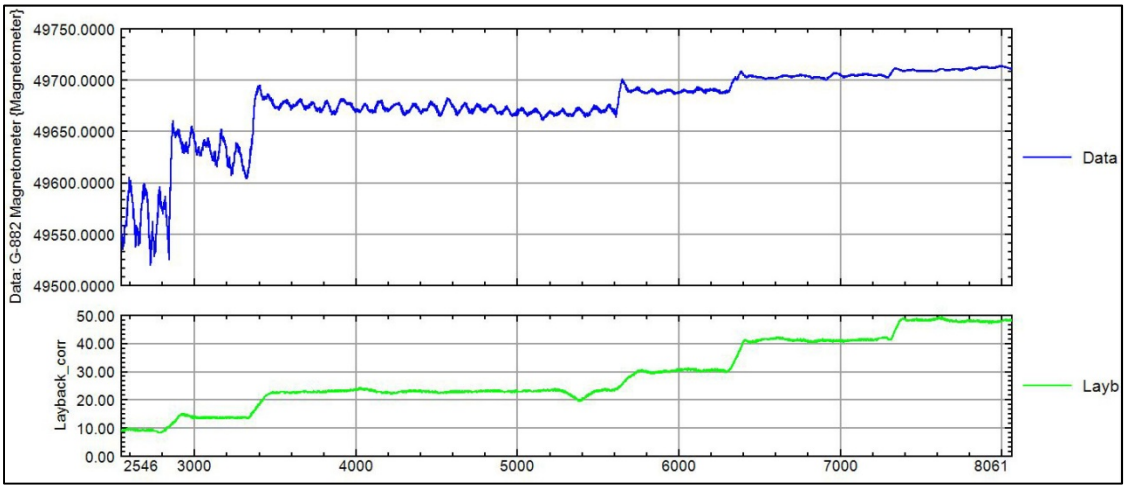


Figure 22. Magnetic data and lay back acquired at M/V Madog.

As it can be seen on figs. 20 and 21 more noisy data are acquired in shallow waters in the beginning and at the end of the line data. This noise was caused by shorter distance between ship and magnetometer in shallow water, which was done to avoid bottom contact and potential damage of the equipment. An example on data quality compared to lay-back can be seen in figure 22.

It is obvious that the distance from ship to magnetometer, has to be more than 40 m, before acquired data are unaffected by ship noise. Data are still valid to evaluate

magnetic anomalies, despite of noise influence on data quality. The only example of a magnetic anomaly from the Laesoe survey is shown in Figure 23 and 24.

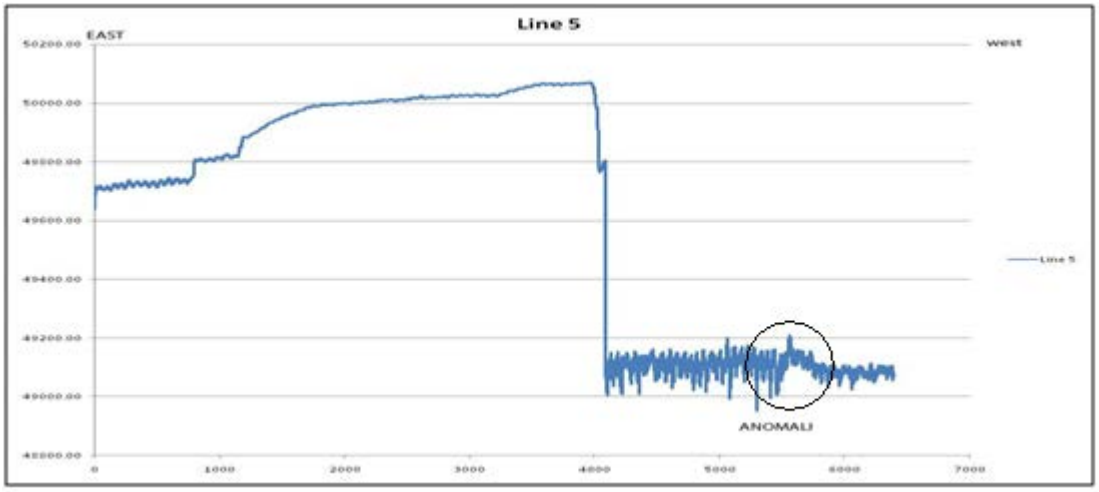


Figure 23. Magnetic data, line 5, with anomaly marked.

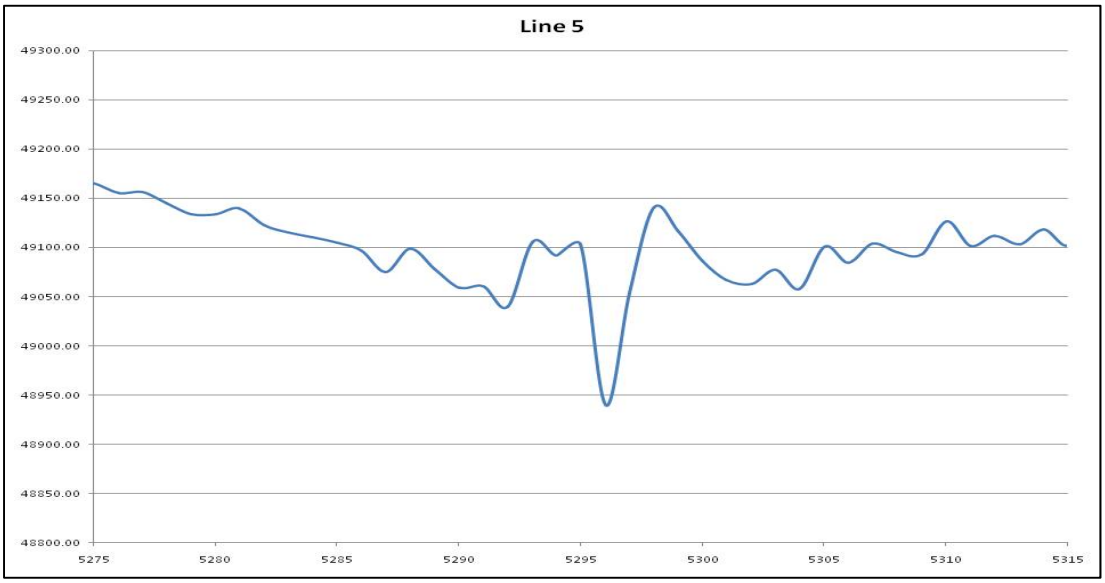


Figure 24. Details on Magnetic data anomaly line 5.

The anomaly is more than 100 nT and it is located on line 5 at a position 10.627244° East, 57.229784° North (UTM 6 344 137.975 N, 598 236.101 E).

7. Alignment sheet data presentation

Overlapping ‘Alignment Sheets’ with a parallel presentation of bathymetry, side-scan sonar bed type classification, seismic profiles, and vibrocore profiles along the surveyed cable corridors A and B have been produced in AutoCad with Rambøll A/S as subcontractor (example in Fig. 25). The charts for the investigated cable corridors are in A3 paper size scale 1:5000. The alignment sheets are presented in Appendix C, and pdf files and DWG format data are included in the Data CD accompanying this report.

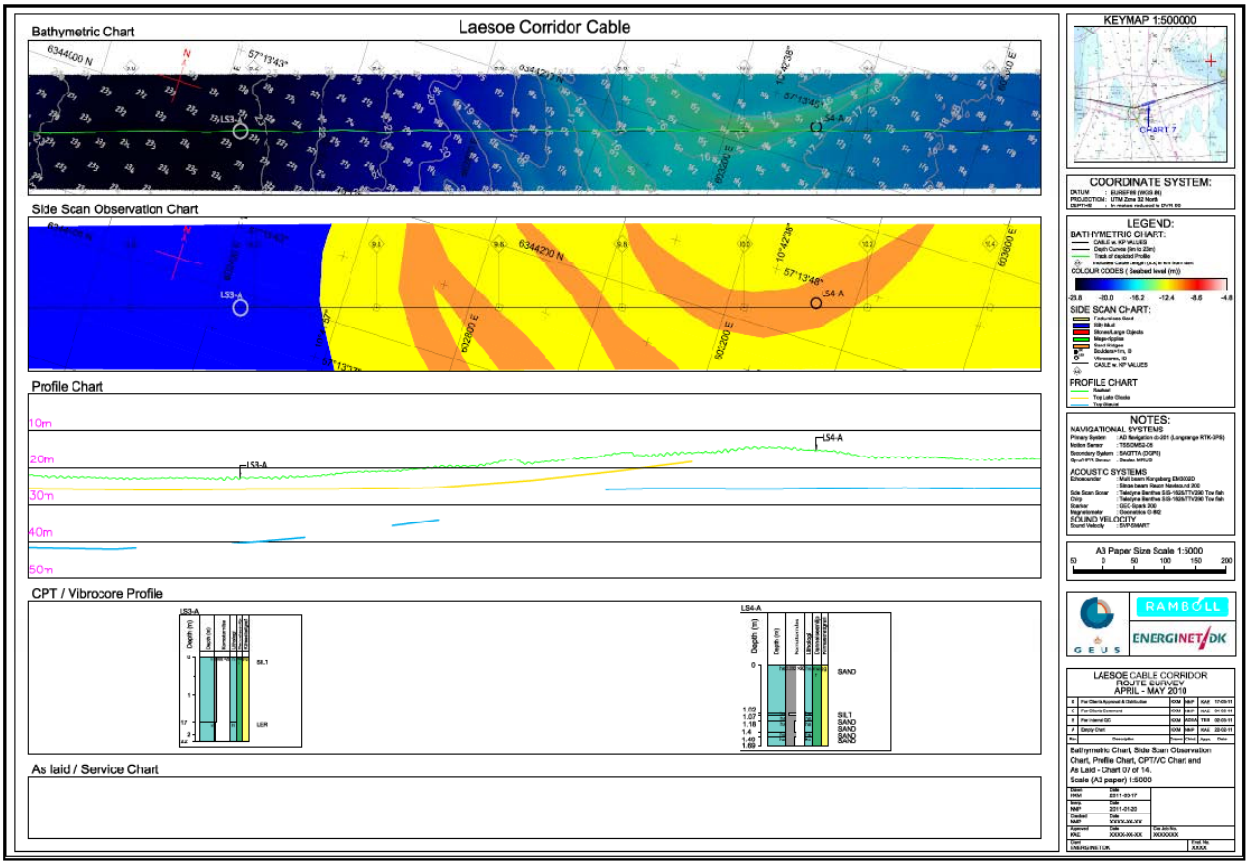


Fig. 25. Example of ‘Alignment Sheet’ (Chart 07 of 14) from the central part of the survey corridor.

8. Geological model based on the geophysical, geological, and geotechnical results

The five parallel seismic profiles (sparker and chirp) along the planned cable alignment all show a very similar pattern. This reflects both that the survey lines are very close (40 m apart) and that they are aligned near perpendicular to the Laesoe Rende structural feature. Due to the sandy and seismic relatively 'hard' nature of the sea bottom in the area, reflections in the uppermost 2-3 m (3-4 ms) of the seismic profiles are masked, and in most cases the geological interpretation given is based on the trend of the deeper subsurface seismic reflection pattern, as well as information from vibrocores, sea bottom surface structures (side scan and multibeam mapping), and existing knowledge on the regional geology of the area. Moreover, gas in the sediments masks specific parts of the profiles, and in these parts the character of the surface near sediment layers can be characterised with less confidence.

The investigated corridor is characterised by a cover of Holocene sandy sediments to a depth of at least 2-3 m subbottom (Fig. 26). Only the deepest part of Laesoe Rende is characterised by silty to clayey sediments. Late glacial sediments (Younger Yoldia Clay) that occasionally may contain larger dropstones appear close to the sea bottom in (1) the western most part of the transect, (2) under the deep Laesoe Rende, (3) east of the elevated ridge in the central part of Laesoe Rende, and (4) further east where a shallowing of water depths take place. Glacial sediments that may be critically over-consolidated and stony, appear typically at >10-30 m subbottom depth. However, it cannot be ruled out that glacial deposits occur close to the sea bottom in the western and easternmost part of the profiles and the adjacent non-surveyed shallower coast areas.

Possibly hard structures, protruding 2-3 m above the otherwise relatively even sea-bottom (about 18 m depth), occur in a limited area in the central Laesoe Rende. The structures rise from the Holocene sandy unit few hundred meters east of the area where the Late Glacial unit approaches the sea bed. It is possible that the structures represent local occurrences of carbonate–cemented sandstone (active or non-active bubbling reefs). Such features are well known offshore Frederikshavn and in areas around Laesoe. Apart from this limited area in central Laesoe Rende, the geophysical investigations along the cable corridor indicate no other occurrences of hard structures or large objects on the sea bottom.

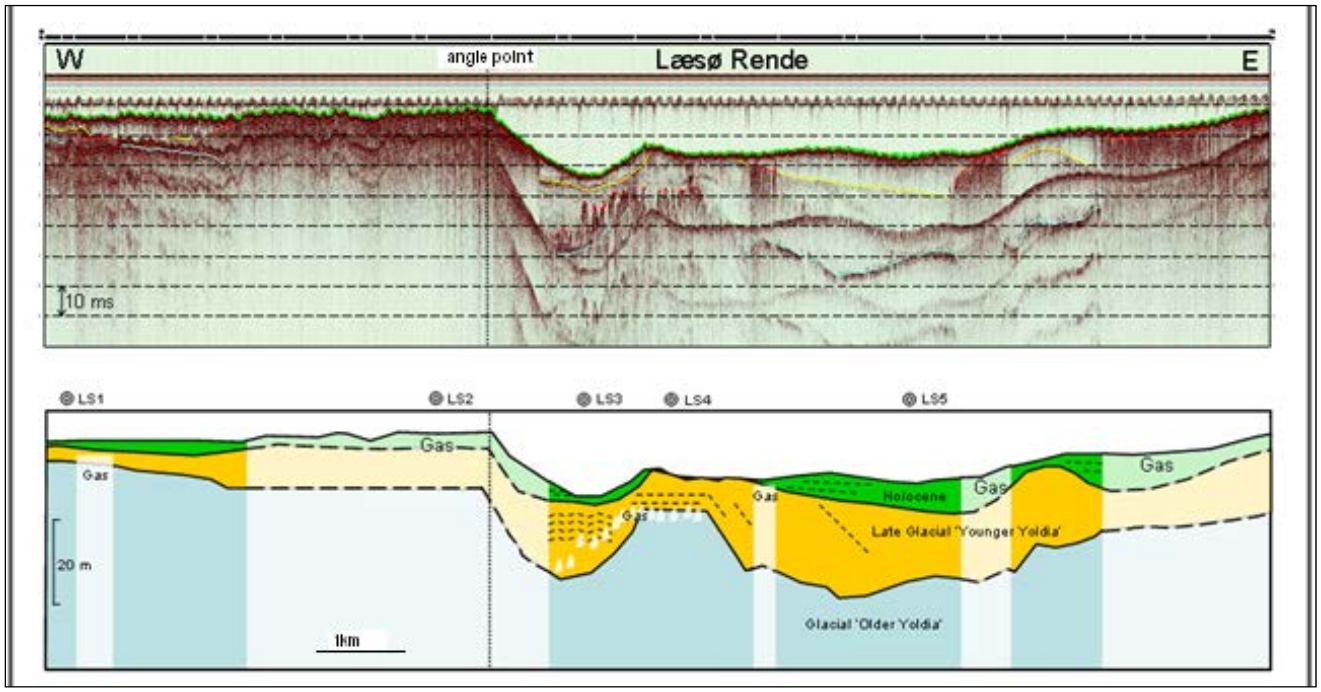


Figure 26. Geological model of the 15 km long profile across Laesoe Rende based on the seismic profiles and five vibrocores LS1 -LS5. Holocene sand (green) dominate the upper 2-10 meter of the sub-bottom transect. The occurrence of gas complicates the geological interpretation in the areas indicated by whitish 'curtains'.

9. Evaluation of the possibilities for jetting and need for trenching

The geophysical data, sediment core data, and interpretation of the surface-near geological conditions along the planned cable alignment reveal that the upper few meters of the sea bottom is dominated by Holocene sand, ideal for jetting excavation. The deepest part of Laesoe Rende contains unconsolidated muddy and clayey sediment to at least 2-3 meter depth below sea bottom. This material should as well be relatively easy to excavate by jetting.

In the central part of the profile, east of the deep trench, scattered occurrences of gravel or stones cannot be ruled out. However, the absence of larger stone concentrations on the sediment surface indicates that the frequency of random stones in this area might be low.

In order to prevent exposure of cable sections over time, a deeper cable excavation (> 2m?) is recommended in the area of the large sand waves on the elongated ridge just east of the deep trench (UTM East 603000-603700). As these large bed forms migrate (apparently to the north), the sea bed morphology is expected to change over time in the area.

The protruding objects, identified on the multibeam map and seismic profile in a limited area in Laesoe Rende, appear to be of a hard nature. It is possible that these structures represent sandstone columns from earlier (or still?) active bubbling reefs, and these specific positions should be investigated by ROV or diving. As the structures are positioned in the northern part of the 200 m wide survey band, it is a possibility to position cables to the south of the critical positions. Apart from these findings, the geophysical investigations along the survey corridor indicate no other occurrences of structures or large objects above the sea bottom.

10. References

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Appendix A

- Equipment specifications

Survey Vessel M/V Madog

M/V Madog is originally build to fit the science and research programmes for Bangor University in the UK, working mainly in the English Channel and the Irish Sea. M/V Madog has proved to be seaworthy enough to work with ROV and survey in the North Sea 60 to 100 Nautical miles offshore in winds up to 10 to 14 meters per second. Her ability to provide a stable platform in rough sea makes her very suitable for research projects / larger scale diving operations / Bottom sampling. Vibro core / CBT and survey projects

Her live aboard facilities, fuel and water capacities allows journeys with endurances up to + 14 days working around the clock.

M/V Madog is rigged with 4 point morring-handeling-winches which make her ideal for diving - sample -ROV works. Her 66 M/ 2 spacious aft-deck with 2 cranes 1x 5 TM support crane and 1 x 10 TM which reaches out over the stern makes her a multi functional work platform for various tasks. Her large survey room with direct access and view over the aft-deck can accommodate up to 6 technicians working at the time.

With regards to fuel consumption, M/V Madog is one of the most cost-effective ships available on market despite her large size as she only consumes around 33 liters per hour, running at 5 knots survey speed or 75 on cruising speed.

M/V Madog has a passenger insurance which covers 12 scientists / technicians / operators

Madog M/V, 2009

Trade area
GMDSS A2 trade permit North Europe

Insurance
Everads hull Machinery and full P&I 4x4 RDS
Ships Particulars
Madog: V4DR
Flag: St. Kitt & Navis
Owner's operators: Nord-Marine DK ApS Denmark
Nominated Crew: 5: 2. officers. 2 A/B´s 1 Professional Cook.
LOA 29,65 Meter
Beam 7,00 Meter
Draft 3.20 to 3.80 Meter

Cruising speed 10,00 Knots
Fuel capacity 26 CBM
Freshwater 26 CBM
Ballast water 35 CBM
Sewage tank 3 CBM
toilet tank 2 CBM
Sluge Oil tank 2 CBM

Fuel consumption cruising 75 lt. per hours 5 knots or while working on site 35 lt. per hours

Engine and deck
1 x 442 KW Lister – Blackstone low speed engine
1 x Deutz 200 AMP + hydraulik pump 130lt/min 240bar
1 x MVM 35 KWA 380
1 x back-up Hydraulic station 70 lt./min 200 bar
1 x back up Hydraulic pump main- engine 60 lt./min 180 bar
1 x 1/1 - 4 blade pitch propel
1 x 64KW bow- thrusters

Deck Arrangement
1 x 66 M/2 free aft deck
2 x 2 Hydraulic split-winch rigged for 4 point Anchoring
1 x 33 TM EFFER Crane with cable winch rigged with 80 meters carbon fiber wire SWL 3 tons Lifting height 25 meter above sea level
1 x 6 TM Hiab Crane lifting height 10 meter above sea level
3/4 “hydraulic snap connection for underwater tools on deck
Cargo hold 10 CBM

Accommodation
Accommodation for 12 passengers
Live- aboard: 4 persons in double-cabins and persons 4 in single cabins
Recommended for live-aboard 8 guests then all in single cabins
1 Technicians / survey room
1 Salon
3 toilets
2 showers
Laundry facilities
TV-DVD in cabins and saloons

Navigational aids
2 x daylight ARPA radars
1 x Gyro
1x A-AIS
1 x Max-sea Commander digital chart systems with AIS messenger system incorporated
R/D GPS solution for RTK
3 x VHF
5 x portable VHF PELTOR-Headset system
1 x NAVTEX
Inmarsat Fleetbroad band 250 (E-mail- Internet – Satphone)

Radio station licence GMDSS A2
Conventional Email Address: info@nord-marine.dk
Inmarsat: rv.madog@amosconnect.com
Sat- phone: 870773152383

NaviSound 200 Series

PRODUCT SPECIFICATION

PORTABLE HYDROGRAPHIC SINGLE-BEAM ECHOSOUNDERS

- ***Portable, highly compact, lightweight unit***
- ***Broadband frequency agile***
- ***Multiple bottom digitizing with single frequency for sediment and vegetation surveys***
- ***Supports single or alternating channel operations***
- ***High-performance, easy-to-operate, and very reliable***

RESON's NaviSound 200 Series are highly portable, single-beam echosounders that offer a range of high-performance features. With a selection of models, the NaviSound 200 Series supports a wide range of hydrographic survey applications.

NaviSound 200 echosounders provide reliable depth measurements in a convenient, easy-to-operate unit. Advanced features include multiple bottom digitizing with a single frequency for sediment and vegetation surveys. Besides its compact size and low weight, the NaviSound 200 enclosure provides the highest possible water resistance.

An affordable side-looking sonar (SLS) option that records dual-sided imagery is also available for selected NaviSound 200 models.

Individual NaviSound 200 models are as follows:

- **NaviSound 215:** Enhanced single-beam echosounder that uses one receiver channel to operate two transducers in true real-time, alternating frequency operation
- **NaviSound 210:** Basic, one-channel, single-beam echosounder for hydrographic survey operations
- **NaviSound 205:** One-channel single-beam echosounder for light surveying

RESON A/S · DENMARK
Tel +45 47 38 00 22
Fax +45 47 38 00 66
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RESON, INC. · USA
Tel +1 805 964 6260
Fax +1 805 964 7537
Email: sales@reson.com

RESON OFFSHORE · UK
Tel +44 1224 709 900
Fax +44 1224 709 910
Email: sales@reson.co.uk

RESON, GmbH · GERMANY
Tel +49 431 720 7180
Fax +49 431 720 7181
Email: reson@reson-gmbh.de

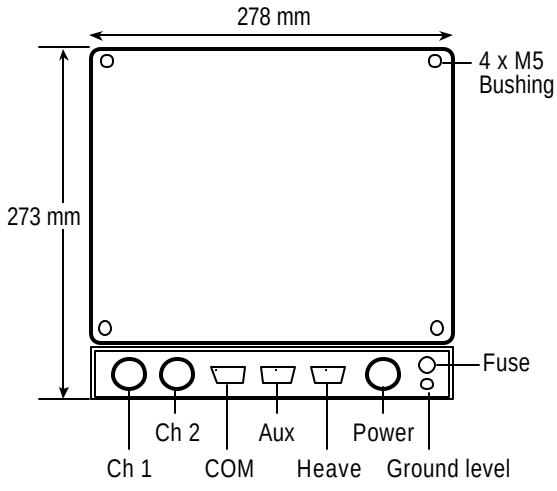
www.reson.com

NaviSound 200 Series System Specifications

TECHNICAL DETAILS

Frequencies:	User-selectable frequencies from 15-600 kHz. Standard 28-35 and 190-225 kHz
Impedance:	100 Ohm (others on request)
Max power:	300 W
Power control:	Manual or automatic
Pulse length:	Manual, 5 steps
Units:	Meters & feet
Resolution:	1 cm (210 & 215) 1 dm (205)
Accuracy:	1 cm at 210 kHz (1 sigma), 7 cm at 33 kHz (1 sigma) (assuming correct sound velocity, transducer draft)
TVC detection level:	20 Log (depth)
Additional feature:	Built-in barcheck utility
Sound velocity calibration:	1350 - 1600 m/sec in 1 m/sec step
Transducer draft comp:	0 - 99.99m
Graphics:	
Recording:	11 cm wide thermal paper recorder
Resolution:	800 pixels (gray shades)
Transfer speed:	20 lines/sec
Serial interfaces:	1: Communication 2: Heave input 3: Auxiliary input (DGPS) 4: Repeater output
Dimensions:	273 x 278 x 115 millimeters (11 x 11 x 4.5 inches)
Weight:	5.5 kg (12 lbs)
Supply voltage:	10 - 28 VDC (external AC converter available)
EMC radio noise:	CE approved

REAR VIEW



MODEL COMPARISON

NaviSound	205	210	215
Output resolution:	dm	cm	cm
Depth Range:	0.5-100m	0.2-600m	0.2-600m
Channels/Transducers:	1/1	1/1	1/2
Max. sounding rate (PRF):	5 Hz	20 Hz	20/10 Hz
Heave input:	-	✓	✓
NMEA output:	✓	✓	✓
DESOxx output protocol:	-	✓	✓
Supports SLS option	-	✓	✓
AC Converter Option	✓	✓	✓

Scope of delivery: NaviSound 200 Series User's Manual, DC power cable, RS-232C communication cable for PC, spare paper, transducer connector(s), and fuses & thermal head cleaning kit

RESON

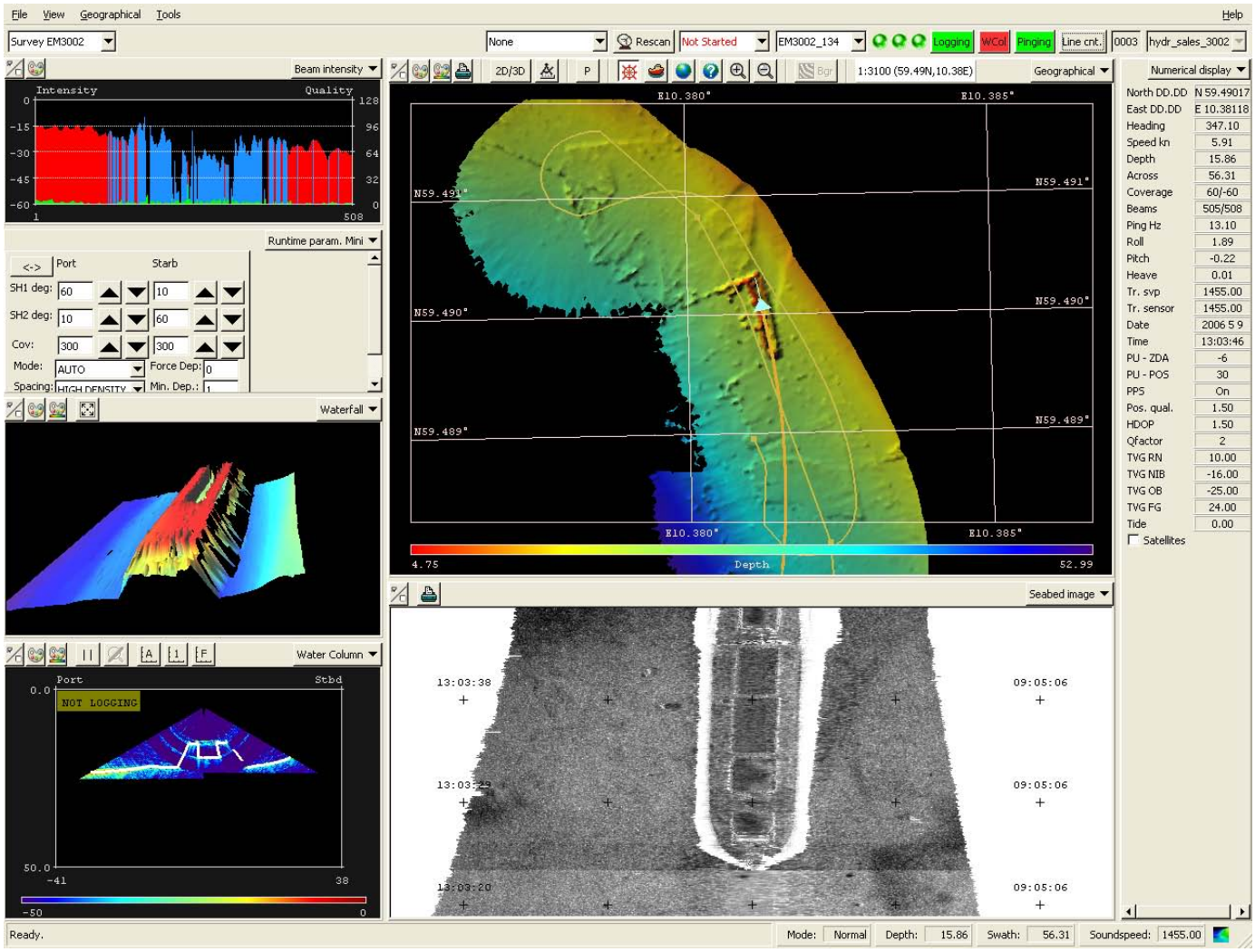
Version: B42-PDF-0202

EM 3002

KONGSBERG

Multibeam echo sounder

The new generation high performance shallow water multibeam



(855-164771 / Rev.E / 20.06.2006)

Key facts

The **EM 3002** is a new advanced multibeam echo sounder with extremely high resolution and dynamically focused beams. It is very well suited for detailed seafloor mapping and inspection with water depths from less than 1 meter up to typically 200 meters in cold oceanic conditions. Maximum depth capability is strongly dependant on water temperature and salinity - up to 300 meters is possible under favorable conditions. Due to its electronic pitch compensation system and roll stabilized beams, the system performance is stable also in foul weather conditions.

The spacing between soundings as well as the acoustic footprints can be set nearly constant over the swath in order to provide a uniform and high detection and mapping performance. Dynamic focusing of all receive beams optimizes the system performance and resolution for short range applications such as underwater inspections.

Typical applications

- Mapping of harbours, inland waterways and shipping channels with critical keel clearance
- Inspection of underwater infrastructure
- Detection and mapping of debris and other underwater objects
- Detailed surveys related to underwater construction work or dredging
- Environmental seabed and habitat mapping
- Mapping of biomass in the water column

Features

The EM 3002 system uses frequencies in the 300 kHz band. This is an ideal frequency for shallow water applications, as the high frequency ensures narrow beams with small physical dimensions. At the same time, 300 kHz secures a high maximum range capability and robustness under conditions with high contents of particles in the water.

EM 3002 uses a powerful sonar processor unit in combination with 1 or 2 compact sonar heads. The high computing power of the EM 3002 sonar processor makes it possible to apply sophisticated and exact signal processing algorithms for beamforming, beam stabilisation, and bottom detection. In High Density processing mode the system has close to uniform acoustic footprints and resolution over the whole swath width, and therefore a much improved capability to detect objects and other details on the bottom.

EM 3002 will in addition to bathymetric soundings, produce an acoustic image of the seabed. The image is obtained by combining the acoustic return signals inside each beam, thus improving signal to noise ratio considerably, as well as eliminating several artifacts related to conventional sidescan sonars. The acoustic image is compensated for the transmission source level, receiver sensitivity and signal attenuation in the water column, so that reliable bottom backscatter levels in dB are obtained. The image is also compensated for acoustic ray bending, and thus completely geo-referenced, so that preparation of a sonar mosaic for a survey area based upon data from several survey lines is easy. Objects observed on the seabed image are correctly located and their positions can be readily derived.

List of options

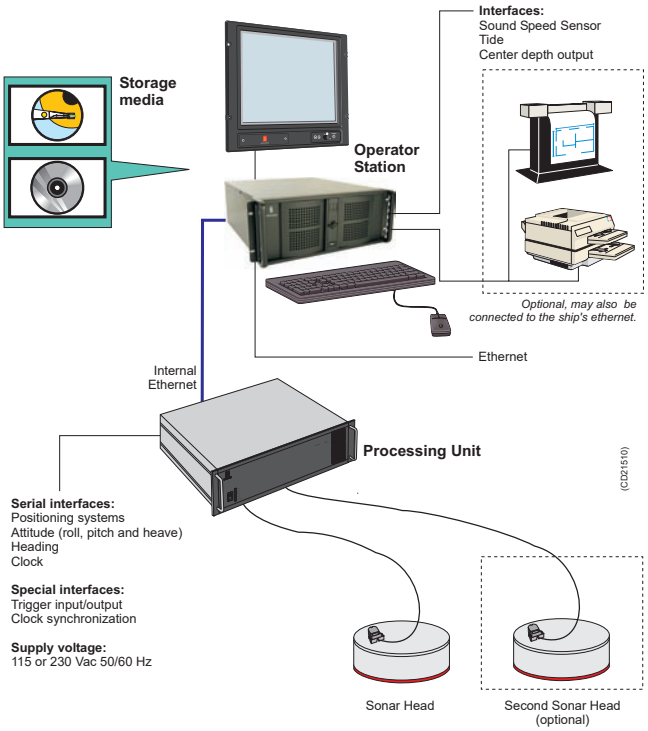
- Dual sonar heads - EM 3002D
- Logging of water column data
- Software for Automatic Calibration
- CUBE terrain modeling SW
- Extended depth raiting for transducer(s): 1500 m
- Extended length of transducer cable: 30 or 45 m
- Bracket for portable mounting of sonar head(s)
- Flight case for safe transportation of 1 sonar head w/cable
- Flight case for processing unit and operators workstation

- Full swath width accuracy to the latest IHO standard
- Swath width up to 10 x water depth (EM 3002D) or 200 m (cold oceanic water)
- Depth range from < 1 meter to > 200 meters
- Bottom detection by phase or amplitude
- 100% bottom coverage even at more than 10 knots vessel speed
- Real-time ray bending and attitude compensation
- Seabed image (sidescan) data output
- Sonar heads for 500 or 1500 meters depth rating
- Water column data display window + logging (optional)

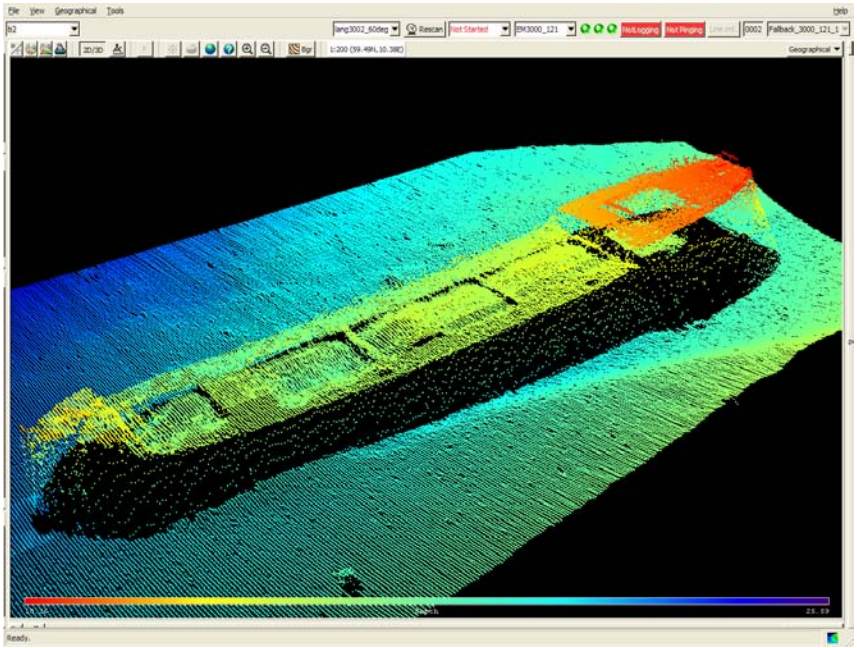
Operator Station

The Operator Station is a rugged zed PC workstation running on either Linux® or Microsoft Windows XP®. The Operator Station software, SIS, has extensive functionality such as 3D graphics, real-time data cleaning and electronic map background.

The EM 3002 can be set up to use other operational software than SIS, for example “QINCy®” or Costal Oceanographics “HYPACK® Max”, and is also supported by software from Triton Elics International, EIVA and others.



Typical system configuration with desktop Operator Station, Processing Unit and one or two Sonar Heads.



The image of a sunken wreck at 20 m depth.

Note that Kongsberg Maritime AS does not take any responsibility for system malfunction caused by third-party software.

Advanced functions

- Bottom detection uses a combination of amplitude and phase processing in order to provide a high sounding accuracy over the whole swath width.
- All beams are stabilized for pitch and roll movements of the survey vessel, by electronically steering the transmit beam as well as the receive beams.
- Dynamic focusing of the receive beams is applied in order to obtain improved resolution inside the acoustic near-field of the transducer.
- Swath coverage with one sonar head reaches 130 degrees, but can be manually limited while still maintaining all beams inside the active swath. For deeper waters the swath width will be reduced due to reduced signal-to-noise margin. The system will automatically re-locate all beams to be within the active swath.
- With two sonar heads the swath width will reach 200 degrees to allow for inspection of constructions up to the water surface, as well as for efficient mapping of beaches, rivers and canals. On a flat shallow seabed the swath-width can be about 10 x depth.
- Operator controlled equidistant or equiangular beam spacing.

Operational specifications

Frequencies ..... 293, 300, 307 kHz
Number of soundings per ping:
Single sonar head ..... Max 254
Dual sonar heads ..... Max 508
Maximum ping rate ..... 40 Hz
Maximum angular coverage:
Single sonar head ..... 130 degrees
Dual sonar heads ..... 200 degrees
Pitch stabilisation ..... Yes
Roll stabilisation ..... Yes
Heave compensation ..... Yes
Pulse length ..... 150 µs
Range sampling rate ..... 14, 14.3, 14.6 kHz
Depth resolution ..... 1 cm
Transducer geometry ..... Mills cross
Beam spacing ..... Equidistant or equiangular
Beamforming:

- Time delay with shading
- Dynamically focused receive beams

Seabed image data

- Composed from beamformed signal amplitudes
- Range resolution 5 cm.
- Compensated for source level and receiver sensitivity, as well as attenuation and spherical spreading in the water column.
- Amplitude resolution: 0.5 dB.

External sensors

- Position
- Heading
- Motion sensor (Pitch, roll and heave)
- Sound velocity profile
- Sound velocity at transducer.
- Clock synchronisation (1 PPS)

Environmental and EMC specifications

The system meets all requirements of the IACS E10 specification.The Operator Station, LCD monitor and Processing Unit are all IP22 rated.

Dimensions and weights

Sonar head:
Shape ..... Cylindrical
Housing material ..... Titanium
Diameter ..... 332 mm
Height ..... 119 mm
Weight ..... 25 kg in air, 15 kg in water
Pressure rating ..... 500 m (1500 m option)
transducer cable length ..... 15 m

Sonar Processing Unit:
Width ..... 427 mm
Depth ..... 392 mm
Height ..... 177 mm
Weight ..... 14.5 kg

Operator Station:
Width ..... 427 mm
Depth ..... 480 mm
Height ..... 127 mm
Weight ..... 20 kg

19” industrial LCD monitor:
Width 483mm
Depth ..... 68 mm
Height ..... 444 mm
Weight ..... 12 kg
Resolution ..... 1280 x 1024 pixels

All surface units are rack mountable. Dimensions exclude handles and brackets.

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KONGSBERG

SIS-1625 Seafloor Imaging System

SIDE SCAN SONAR/ PROFILER

Combined Chirp/CW Side Scan Sonar/ Sub-bottom Profiling System

The SIS-1625 Seafloor Imaging System has quickly become the industry standard for shallow water (<2000M) seafloor survey operations. This field proven, highly versatile survey tool offers a fully digital platform capable of collecting high resolution chirp side scan/sub-bottom data, as well as a full suite of customer selected sensor data. The high resolution, extended range chirp data and multiple data sensor capability provide the surveyor with a significant savings in instrument cost and survey time.

One Workstation

Topside system consists of:

- Chirp DSP based side scan sonar, operating at 100/400 kHz simultaneously, allows a full 1000 meter swath, with resolution equivalent to much higher frequency systems.
- Chirp DSP/CW based sub-bottom profiling, operating in the 1 to 10 kHz region, allows maximum sediment penetration with greatly improved resolution.
- Gain, TVG, image correction, color palette, and other programmable parameters are under trackball control.
- Digital interface provided for thermal graphic recorders.

One Tow Vehicle—TTV-290

The TTV-290 is a fully digital platform with standard Chirp side scan/sub-bottom transducer arrays, digital multiplexor, subsea electronics, and RS-232 ports for optional sensors.

- Hydrodynamically stable tow vehicle includes pitch, roll and heading sensors, optional position responder/ transponder, and other customer selected sensors.
- 0.5° side scan sonar horizontal radiation pattern,combined with broad band Chirp DSP match filter processing, provides optimal cross-track and along track resolution.
- Tow vehicle operates in depths up to 2000 meters.

ACOUSTICS
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SIS-1625 Seafloor Imaging System

One Cable—CL-160 Communications Link

The comm link was designed through a program to develop a full ocean depth telemetry module for a multisensor seafloor mapping system.

- Two-way communication with tow vehicle over single coax with digital high speed multiplexor. Standard cable length—up to 10,000 meters.
- Digital multiplexor for single coaxial tow cables. Communication rates: sonar data—up to 5 megabit/sec; uplink status—9600 bits/sec; downlink command—9600 bits/sec.

SPECIFICATIONS

CL-160 Shipboard Sub-System

Chirp Processing:	Sonar/status control PC based workstation; 5-DSP based sonar matched filter processing channels.
Display:	High resolution video display.
Recording:	Large capacity hard drive, DVD writable, other..
Status Display:	Vehicle pitch, roll, heading (standard); speed, altitude, and depth (optional). Customer input ship position, vehicle position, event marks; all status data recorded.
Sonar Display:	Side scan port, starb; dual channel sub-bottom; all sonar data recorded.
Corrections:	Slant range and speed; beam angle/grazing angle.
Multiplexor:	Digital MUX for coaxial cables (ADSL).
Sonar Data:	up to 5 megabit/sec.
Uplink Status:	9600 bit/sec.
Downlink Command:	9600 bits/sec.
Power Supply:	110/220 VAC autosensing.

Side Scan

Side Scan Transducers:	Multi-element array, dual channel 100/400 kHz 0.5° horizontal beam; 60° vertical beam.
Frequency:	100/400 kHz band swept FM; 4.5 cm resolution.
Processing:	Calibrated transmit waveform stored in ROM; match filter FFT digital signal processing.
Swath Selection:	25 meters to ±500 meters.

Sub-Bottom

Transducer:	Transmit projector array; line array receiving hydrophone; 30° conical radiation pattern.
Frequency:	1 kHz to 10 kHz swept FM (4 KW output), synchronous with side scan.
Resolution:	5 cm.
Processing:	Calibrated transmit waveform stored in ROM; matched filter FFT digital signal processing.
Scale Selection:	25 meters to 500 meters full scale.

TTV-290 Tow Vehicle Sub-System

Depth rating:	2000 meters.
Vehicle Dimensions:	18 inches (45 cm) OD x 64 inches (162.6 cm) long.
Weight:	In air: 300 lbs (136 Kg); in water: 170 lbs (77 Kg).

TELEDYNE BENTHOS
A Teledyne Technologies Company

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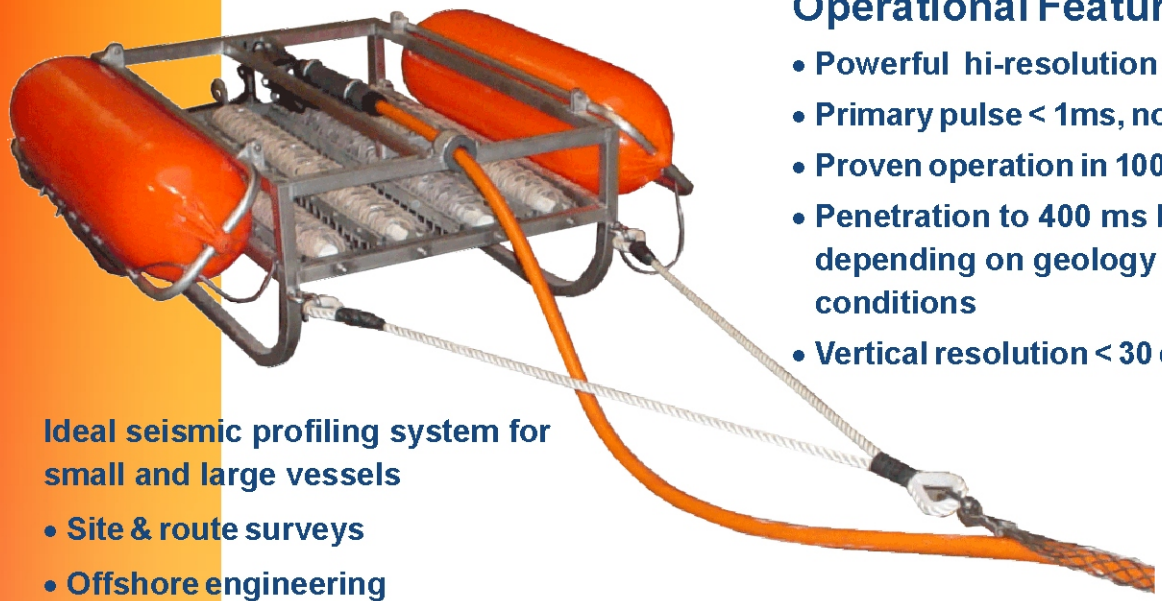
Geo-Source 200 - 400

Marine Multi-Tip Sparker System



Operational Features

- Powerful hi-resolution seismic source
- Primary pulse < 1ms, no ringing
- Proven operation in 1000 m water depth
- Penetration to 400 ms below seabed, depending on geology and survey conditions
- Vertical resolution < 30 cm

Ideal seismic profiling system for small and large vessels

- Site & route surveys
- Offshore engineering
- Mineral exploration
- Oceanographic research

INNOVATIVE Preserving Electrode Mode

The innovative Geo-Source 200 has been designed for operation with the Geo-Spark 1000 pulsed power supply (PPS) using the patented **Preserving Electrode Mode.** This mode uses a NEGATIVE electric discharge pulse instead of a positive pulse.

(Please note that this negative pulse is NOT the same as the simple reversal of the positive polarity of a 'standard' power supply.)

Maintenance free electrodes 5 year guarantee

The Preserving Electrode Mode **reduces the tip wear to practically zero**. You can shoot day after day, week after week, month after month with practically **NO tip maintenance.**

Always a stable acoustic pulse

Zero tip wear is essential for the **acoustic repeatability** of the pulse, which depends largely on a constant, unaltered electrode surface and tip insulation.

Efficient & Cost Effective

With the Geo-Spark HV power supplies you will save a lot of time and money, since the electrodes do NOT burn off like in all other systems.

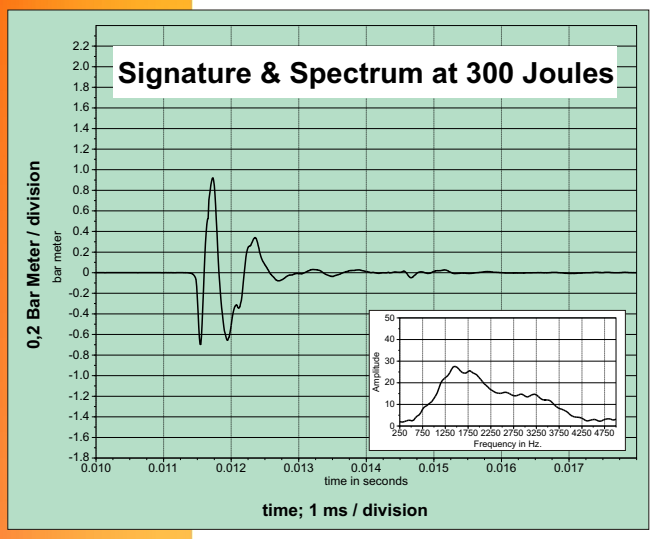
You don't need to trim tips during the survey. There is no need to have any stock of consumables.

Examples of Records

To see examples of our sparker records, please visit the 'Downloads' page on our website: ***www.geo-spark.com***

Geo-Source 200-400

Technical Specifications



Source Geometry

The electrode modules are evenly spaced in a planar array of 0.75 m x 1.00 m. This geometry not only enhances the downward projection of the acoustic energy, it also reduces the primary pulse length, since all tips are perfectly in phase.

Control of Source Parameters 400 tips

The advanced Geo-Source 200 design gives you total control of:

Source depth, Joules per tip, Number of tips in use, and Electrode configuration.

- Two floats provide a stable towing configuration and insure the proper depth of the electrode tips. This is critical to achieve constructive interference between the primary pulse and its own sea-surface reflection (surface ghost).
- Four individually powered electrode modules of 50 or 100 tips each allow you to distribute the energy from the Geo-Spark power supply over 50, 100....., up to 400 tips. (Each tip has an exposed surface area of 1.4 mm^2.)
- **200 tips,** the classic 200 tip configuration is normally used with the Geo-Spark 1000 PPS and consists of four 50-tip electrode modules. This configuration gives an excellent hi-res pulse over the 100 to 500 J power range.
- **400 tips,** for higher energies above 1000 J, and in particular with the Geo-Spark 2000, we recommend a 400 tip configuration with 4 x 100-tip electrode modules

Coaxial High Voltage (HV) Power/Tow Cable

The Geo-Source 200 is towed by a very high quality, Kevlar-reinforced, coaxial power/tow cable with stainless steel kellum grip. This dedicated high voltage (HV) cable contains **4 x 10 mm^2** inner cores (negative) plus a **40 mm^2** braiding (ground-referenced). It is designed to have a very low self-inductance to preserve the high dI/dt pulse output of the Geo-Spark 1000 PPS.

The coaxial structure of the HV cable reduces the electromagnetic interference to the absolute minimum.

The wet end of the cable is terminated with four special HV connectors to the electrode modules and a ground connector to the frame. Connecting or disconnecting the cable to the Geo-Source 200 takes only 10 minutes; so you can work on, or handle, the sparker and the HV cable as independent units.

The dry end of the cable is terminated at the Geo-Source 200 patch panel, which allows you to select the number of electrode arrays in use

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Geo-Spark 1000 - 1500 - 2000

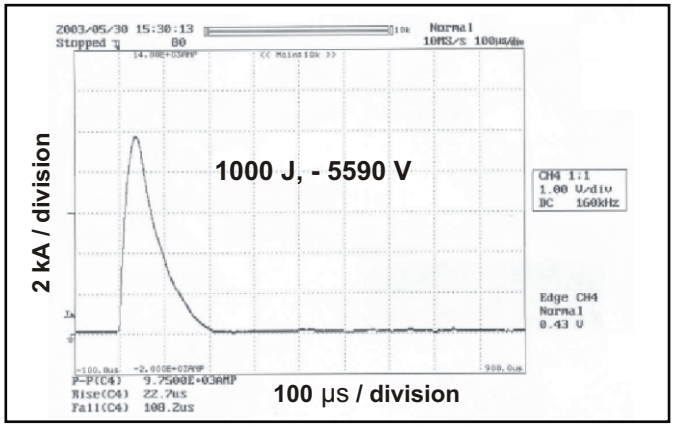
Solid State Pulsed Power Supplies

Operational Features

- 100 to 1000-1500-2000 J real power
- No electrical oscillations
- User-friendly & 100 % safe
- Modular internal design

Cutting-Edge Pulsed Power Technology

The Geo-Spark 1000 -1500 - 2000 are revolutionary high voltage (HV) power supplies based on cutting-edge 'pulsed power' technology. The systems use an extremely reliable, state-of-the-art thyristor switch that can generate very short (60 - 200 µs) high voltage pulses of up to 10 kA at -5.6 kV.



Applications

- Very high resolution seismic acquisition e.g. site & route surveys

Is typically combined with:

- Geo-Source 200-400-tip sparkers (marine and fresh water)
- Geo-Boomer 300-500 Joules
- Borehole Sparkers
- Pulsed power projects & research

100 % Safety Features

All possible features have been integrated into the systems to safeguard against potential human error.

- To open and gain access to the high voltage (HV) connection box, the 230 V mains CE-form connector must first be physically removed.
- High voltage can only be activated when the HV connection box is completely closed.
- If the HV connection box is opened, even partially, during operation, the HV will automatically switch off and the unit will generate a final trigger to discharge the capacitors.
- Similarly, when the HV is switched off normally by pushing the red stop button, an automatic final trigger will discharge the capacitors.
- When the HV connection box has been opened completely, both poles (zero and negative) will automatically be shorted.
- The systems contain internal bleed-off resistors to eliminate any possibility of unwanted charging effects.
- A power lock limits the output to Geo-Boomer to 300 J.

Preserving Electrode Mode

These pulsed power supplies are fundamentally different from any other HV power supplies. They have been designed specifically to power the Geo-Source range of multi-tip sparkers in our patented **'**Preserving Electrode Mode**'.** In this mode the electrodes have a negative potential with respect to the source frame (= ground), thereby reducing electrode wear to almost zero.

Negative Electric Discharge Pulse

There is no other unit commercially available that allows you to generate a negative high voltage pulse with such a high dI/dt ratio.

No Electrical Oscillations

The pulse output has NO electrical oscillations, which affect the acoustic signature. The integrated capacitor bank consists of two (1000 PPS), three (1500) or four (2000 PPS) indestructible 32 µF capacitors rated for more than 200 million (= 2 x 10^8) discharges. For example, a ¼ second discharge rate would give continuous work for 1½

Low Power Consumption

The Geo-Spark 1000 -1500 - 2000 PPS can be operated from an ordinary 230 V/16 A mains socket or from a portable 230 V/3.5 kVA generator.
The systems do not draw excessive peak currents.

Geo-Spark 1000 - 1500 - 2000

Solid State Pulsed Power Supplies

Safe and Intuitive Operation

All connections, command buttons, switches and status LEDs are front-mounted to ensure direct safe access and intuitive operation.

Flexible Energy Output

The systems feature a very flexible energy output, ranging from 100 to 2000 J (in steps of 100 J), that can be modified while online.

This is achieved by:

- varying the operating voltage (selectable from -2000 V to -5600 V);
- varying the capacitance (selectable from 32 µF to 64 or 128 µF).

Microprocessor Control

All internal initialising and safety procedures are microprocessor-controlled and the current system status can be monitored via a comprehensive series of LEDs. This provides an easy and straightforward system operation that is basically limited to the following actions:

- switching on/off the control unit (230 V/50-60 Hz single phase);
- selecting the capacitance and voltage;
- activating/deactivating the HV generation.

Triggering

Remote triggering of the unit is implemented by a TTL pulse, which is internally converted into a fibre-optic signal to the thyristor trigger device. There is no need for any external opto-isolator on the trigger line. During standby between survey lines, the unit will NOT trip - it will slowly bleed off but will remain ready for the next line.

USB connection on front

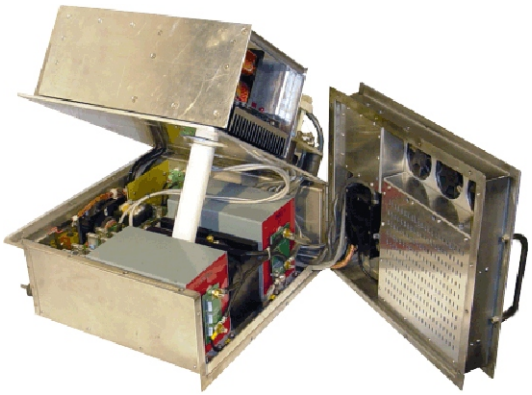
This new feature allows to connect a PC and provides direct access to the control software. You can check the usage data and the system functionality. It also allows customise the control software and internal configuration.

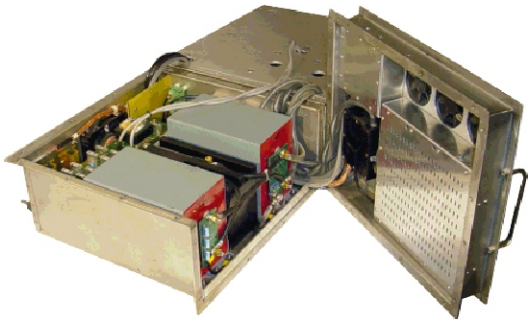
Modular Internal Architecture

The pictures below give an idea of the advanced modular architecture that allows the opening and inspection of the systems without disconnecting any units.

The internal construction comprises three main individual compartments:

- upper compartment with pulsed HV module, thyristor stack and relay/opto-control PCB;
- lower compartment with the pulse capacitors, capacitor switch, etc.
- front compartment with line filter, mains breaker, HV connection box, main control PCB and cooling fans.





Quality Built to Last

These pulsed power supplies are built to last, electronically and mechanically. Ten rubber shock absorbers in a sturdy, high quality polyester flight case support the compact inner housing that contains the actual unit.

Additionally, rubber shock absorbers support each vibration-sensitive component inside the inner housing.

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Geo-Sense Mini-Streamers

Single Channel Arrays of 8 to 24+ Elements

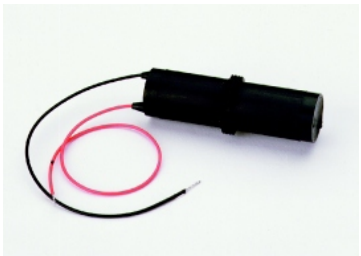
Applications

For use with our VHR single channel data acquisition systems: Geo-Trace, Mini-Trace, or any other recording system

- **Site and route surveys**
- **Sand searches**
- **Oceanographic research**

AQ-2000 Hydrophone

Geo-Sense streamers are equipped with the AQ-2000 hydrophones - the latest innovative acoustic sensor technology for both shallow and deep water exploration.



The AQ-2000 is well suited for applications that require stable performance over a wide range of water depths.

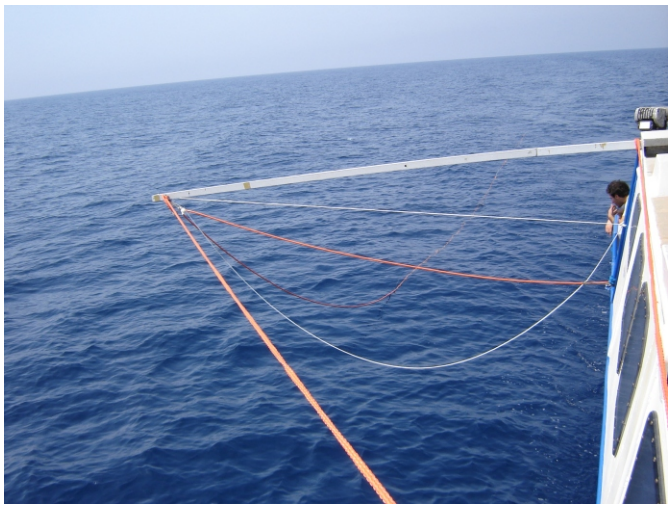
It has excellent acceleration-cancelling qualities and an exceptionally wide frequency bandwidth.

The AQ-2000 can be installed into standard array configurations or integrated into custom-moulded packages.

Every hydrophone is tested for sensitivity, capacitance and insulation to ensure the highest quality product for all very high resolution seismic operations.

Operational Features

- **Specifically designed for the high frequency spectrum emitted by VHR sources (sparkers, boomers, pingers)**
- **The short 8-element array has proven successful down to 4500 m water depths**
- **The active length and number of elements can be configured to your requirements**
- **Can be used with any Third Party recording system (in combination with the Geo-Sense Filter/Gain Interface)**



Tow Cable

Length:	Standard 50 m to 100 m
Diameter:	11 mm
Type:	3 x 2 x 24 AWG screened twisted pair
Insulation:	Polyurethane
Strain member:	Double reverse spiral Kevlar

Active Section & Jacket

Number of elements:	8 to 24+
Spacing of elements:	0.4 m standard
Length of active section:	2.8 m / 9.2 m (for 8 / 24elements)
Length of jacket:	4.8 m / 11.2 m (approx.)
Jacket size ID & OD:	20.5 mm & 26.5 mm
Jacket material:	Unreinforced polyurethane
Buoyancy:	Slightly negative
Array fluid:	Shell Sol T/ Isopar

Power to Preamplifier

For streamers other than Geo-Sense, a standard battery box of 12 V DC from penlight batteries can be used.

Geo-Sense Mini-Streamers
Technical Specifications

AQ-2000 Hydrophone

Electrical Specifications

Leads:	Two 28 AWG stranded conductors (red and black), Hytrel® insulation, 12.7 cm length each
Connector:	None
Polarity:	A positive increase in acoustic pressure generates a positive voltage on the red conductor
Capacitance:	4.5 nF +/- 25% at 20°C and 1 kHz
Resistance:	500 MΩ minimum across leads or to sea water at 20°C and
100%	relative humidity, 50 V DC
Dissipation:	0.02 typical

Performance

Sensitivity @ 100 Hz
Free-field voltage:
-201 dB re 1 V/µPa +/- 1.5 dB

Sensitivity Change
Versus frequency: +/- 0.25 dB from 1 Hz to 1 kHz
(+/-2.0 dB from 1 kHz to 10 kHz)
Versus depth : < 0.5 dB to 1000 m
Versus temperature: < 0.03 dB per 1°C change

Acceleration Sensitivity
Output is <1.5 mV/g due to acceleration in any of the three major axes at 20 Hz

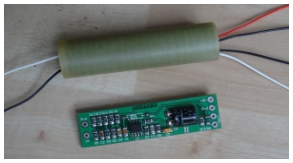
Mechanical
Resonance typically 20 kHz in water
Maximum operating depth of 2000 m
Destruction depth of more than 7000 m

Physical Specifications

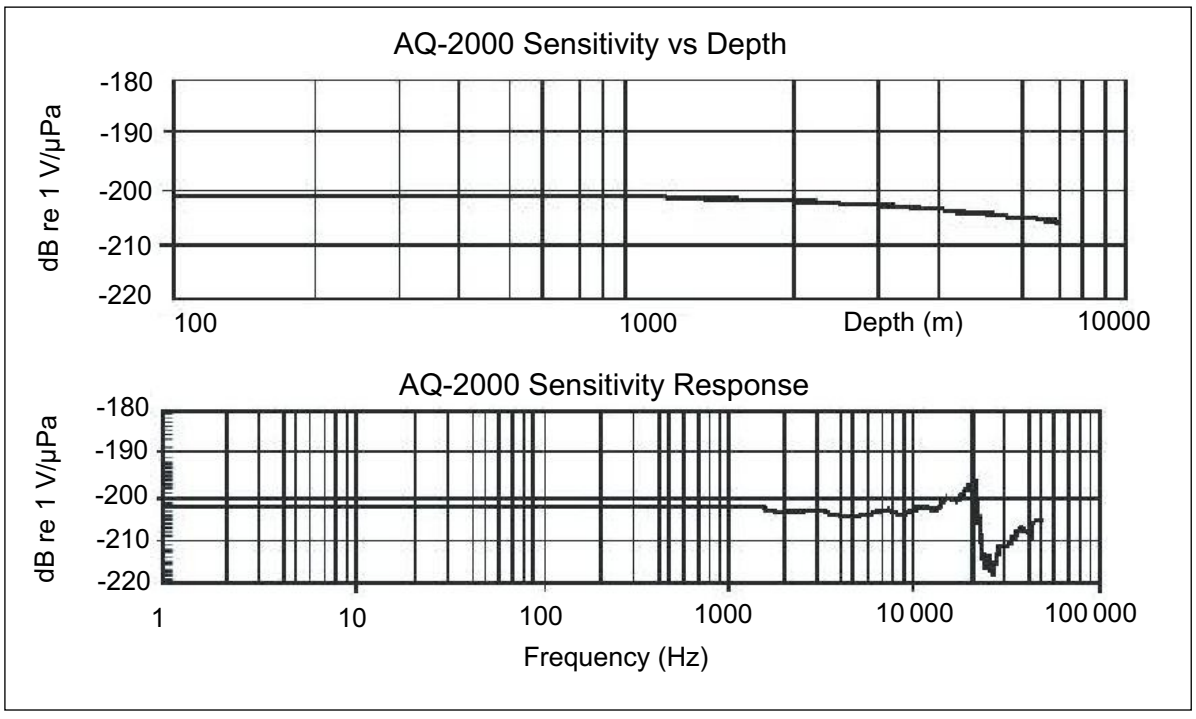
Materials:	Fluoroelastomer, high strength epoxy, Hytrel® insulated leads
Weight in air:	14 grams
Size:	4.56 cm long x 1.32 cm diameter
Displacement:	6.24 cc
Temperature:	Operating: -10°C to 50°C
	Storage: -40°C to 60°C

Pre-Amplifier

Size: 60 x 16 mm
Gain: 26 dB
Ground reference:
Single-ended



Power : 9 -12 V DC (polarity protected)
High-pass: -3 dB: 3 Hz
Low-pass: -3 dB:13 kHz
Output impedance: 60 Ω



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Website: www.geo-resources.com

Geo-Sense Filter/Gain Interface

Application & Functionality

- **Interfaces the Geo-Sense VHR single channel mini-streamers to any Third Party recording system**
- **Provides high quality analogue frequency filters and two-stage analogue gain**

Analogue Frequency Filtering

There are four settings for analogue filtering:

1) bandpass filter of 80 Hz - 2.5 kHz,

This is usually the best setting for the sparker spectrum. Other filter settings can be provided.

2) high-pass (low-cut) filter of 80 Hz

To remove low frequency noise, it is usually sufficient to filter only the low frequencies, which are difficult to remove digitally.

3) low-pass (high-cut) filter of 2.5 kHz

To cut out the high frequencies.

4) no filter

Analogue Gain

To minimise distortion and to avoid saturation, the seismic signal is amplified in two stages:

1) 0-6-12-18 dB (four levels), the first stage gain is applied after the high- pass filter;

2) 0-6-12-18 dB (four levels), the second stage gain is applied after the low-pass filter.

By using the maximum gain setting for both stages, you can achieve a total amplification of 36 dB.

Operational Features

- **Dedicated 4-pin connection to power the pre-amplifier of the Geo-Sense streamer and to receive the signal**
- **Standard BNC connections for signal output to any seismic recorder and signal input from any Third Party streamer**
- **Audio output to headphone on front panel**
- **Mains power 110-230 V AC / 50-60 Hz**

General Features

The Geo-Sense filter/gain interface is designed to operate with the Geo-Sense mini-streamers and allows the Geo-Sense mini-streamers to be used with ANY digital recording system.

The interface is also designed to accept signal input, via BNC cable, from any other type of streamer.

It is a stand-alone unit that applies high quality, non-distorting analogue filters and two-stage gains to a single-channel seismic signal.

If you are working with a seismic recording system that has no suitable analogue front-end, then the Geo-Sense filter/gain interface would be an essential part of your system.

Audio Control

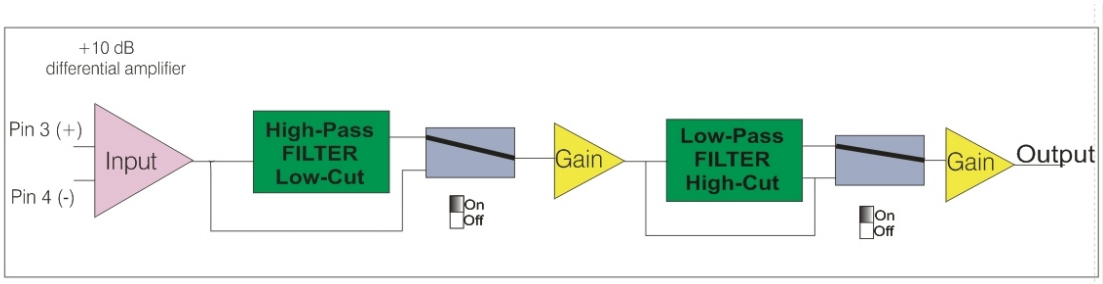
You can now listen to your streamer using a headphone connected to the audio socket on the front panel.

Geo-Sense Filter/Gain Interface

Technical Data & Schematics

Filter & Gain Parameters

First stage	Switchable high-pass (low-cut) filter / 80 Hz 4th order
Second stage	Switchable amplifier / 0-6-12-18 dB
Third stage	Switchable low-pass (high-cut) filter / 2.5 kHz 4th order
Fourth stage	Switchable amplifier / 0-6 -12-18 dB



Dedicated Geo-Sense Streamer Connection

The 4-pin connection is used for both the signal input from the streamer and the 12 V DC power supply to the streamer's internal pre-amplifier. This power supply replaces the standard battery box (which is normally also provided with the mini-streamer).

The four pins are assigned as follows:

- Pin 1 — +12 V DC power to pre-amplifier
- Pin 2 — Ground shield (earth)
- Pin 3 — Positive (+) signal from pre-amplifier
- Pin 4 — Ground signal from pre-amplifier

BNC Input and Output

The two BNC connections at the rear of the unit are for the single-ended input from the streamer, and the signal output to any digital recorder (with four settings for signal level voltage peak to peak of 0.3, 1, 3 and 10 V).

Optional Functions

- Customised filter settings are available on request.

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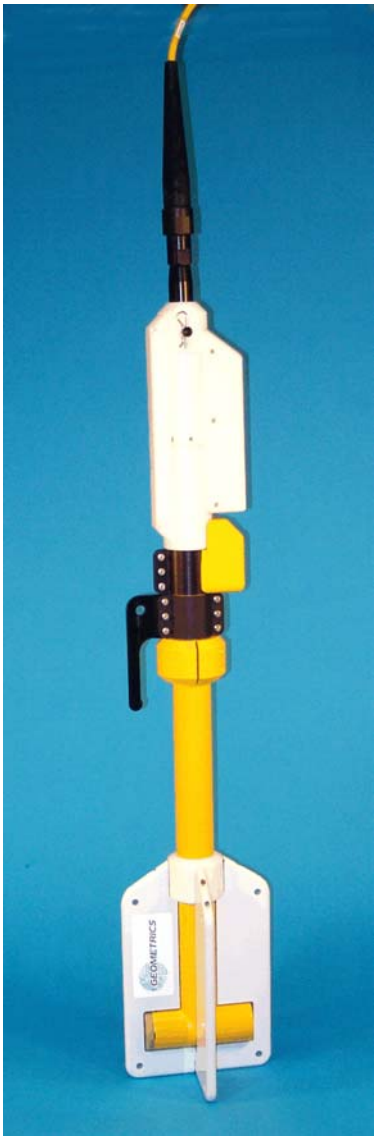
G-882 MARINE MAGNETOMETER

- ***CESIUM VAPOR HIGH PERFORMANCE – Highest detection range and probability of detecting all sized ferrous targets***
- ***NEW STREAMLINED DESIGN FOR TOW SAFETY – Low probability of fouling in lines or rocks***
- ***NEW QUICK CONVERSION FROM NOSE TOW TO CG TOW – Simply remove an aluminum locking pin, move tow point and reinsert. New built in easy carry handle!***
- ***NEW INTERNAL CM-221 COUNTER MODULE – Provides Flash Memory for storage of default parameters set by user***
- ***NEW ECHOSOUNDER / ALTIMETER OPTION***
- ***NEW DEPTH RATING – 4,000 psi !***
- ***HIGHEST SENSITIVITY IN THE INDUSTRY – 0.004 nT/Hz RMS with the internal CM-221 Mini-Counter***
- ***EASY PORTABILITY & HANDLING – no winch required, single man operation, only 44 lbs with 200 ft cable (without weights)***
- ***COMBINE TWO SYSTEMS FOR INCREASED COVERAGE – Internal CM-221 Mini-Counter provides multi-sensor data concatenation allowing side by side coverage which maximizes detection of small targets and reduces noise***



G-882 with Weight Collar Depth Option & Altimeter

Very high resolution Cesium Vapor performance is now available in a low cost, small size system for professional surveys in shallow or deep water. High sensitivity and sample rates are maintained for all applications. The well proven Cesium sensor is combined with a unique and new CM-221 Larmor counter and ruggedly packaged for small or large boat operation. Use your computer and standard printer with our MagLogLite™ software to log, display and print GPS position and magnetic field data. The G–882 is the lowest priced high performance full range marine magnetometer system ever offered.

The G-882 offers flexibility for operation from small boat, shallow water surveys as well as deep tow applications (4,000 psi rating, telemetry over steel coax available to 10Km). The G-882 also directly interfaces to all major Side Scan manufacturers for tandem tow configurations. Being small and lightweight (44 lbs net, without weights) it is easily deployed and operated by one person. But add several streamlined weight collars and the system can quickly weigh more than 100 lbs. for deep tow applications. Power may be supplied from a 24 to 30 VDC battery power or the included 110/220 VAC power supply. The tow cable employs high strength Kevlar strain member with a standard length of 200 ft (61 m) and optional cable length up to 500m with no telemetry required.

A rugged fiber-wound fiberglass housing is designed for operation is all parts of the world allowing sensor rotation for work in equatorial regions. The shipboard end of the tow cable is attached to an included junction box or optional on-board cable for quick and simple hookup to power and output of data into any Windows 98, ME, NT, 2000 or XP computer equipped with RS-232 serial ports.

The G-882 Cesium magnetometer provides the same operating sensitivity and sample rates as the larger deep tow model G-880. MagLogLite™ Logging Software is offered with each magnetometer and allows recording and display of data and position with Automatic Anomaly Detection and automatic anomaly printing on Windows™ printer! Additional options include: MagMap2000 plotting and contouring software and post acquisition processing software MagPick™ (free from our website.)

The G-882 system is particularly well suited for the detection and mapping of all sizes of ferrous objects. This includes anchors, chains, cables, pipelines, ballast stone and other scattered shipwreck debris, munitions of all sizes (UXO), aircraft, engines and any other object with magnetic expression. Objects as small as a 5 inch screwdriver are readily detected provided that the sensor is close to the seafloor and within practical detection range. (Refer to table at right).

The design of this high sensitivity G-882 marine unit is directed toward the largest number of user needs. It is intended to meet all marine requirements such as shallow survey, deep tow through long cables, integration with Side Scan Sonar systems and monitoring of fish depth and altitude.

Typical Detection Range For Common Objects

Ship 1000 tons	0.5 to 1 nT at 800 ft (244 m)
Anchor 20 tons	0.8 to 1.25 nT at 400 ft (120 m)
Automobile	1 to 2 nT at 100 ft (30 m)
Light Aircraft	0.5 to 2 nT at 40 ft (12 m)
Pipeline (12 inch)	1 to 2 nT at 200 ft (60 m)
Pipeline (6 inch)	1 to 2 nT at 100 ft (30 m)
100 KG of iron	1 to 2 nT at 50 ft (15 m)
100 lbs of iron	0.5 to 1 nT at 30 ft (9 m)
10 lbs of iron	0.5 to 1 nT at 20 ft (6 m)
1 lb of iron	0.5 to 1 nT at 10 ft (3 m)
Screwdriver 5 inch	0.5 to 2 nT at 12 ft (4 m)
1000 lb bomb	1 to 5 nT at 100 ft (30 m)
500 lb bomb	0.5 to 5 nT at 50 ft (16 m)
Grenade	0.5 to 2 nT at 10 ft (3 m)
20 mm shell	0.5 to 2 nT at 5 ft (1.8 m)

MODEL G-882 CESIUM MARINE MAGNETOMETER SYSTEM SPECIFICATIONS

OPERATING PRINCIPLE:	Self-oscillating split-beam Cesium Vapor (non-radioactive)
OPERATING RANGE:	20,000 to 100,000 nT
OPERATING ZONES:	The earth's field vector should be at an angle greater than 6° from the sensor's equator and greater than 6° away from the sensor's long axis. Automatic hemisphere switching.
CM-221 COUNTER SENSITIVITY:	<0.004 nT/ √Hz rms. Up to 20 samples per second
HEADING ERROR:	±1 nT (over entire 360° spin)
ABSOLUTE ACCURACY:	<2 nT throughout range
OUTPUT:	RS-232 at 1,200 to 19,200 Baud
MECHANICAL:	
Sensor Fish:	Body 2.75 in. (7 cm) dia., 4.5 ft (1.37 m) long with fin assembly (11 in. cross width), 40 lbs. (18 kg) Includes Sensor and Electronics and 1 main weight. Additional collar weights are 14lbs (6.4kg) each, total of 5 capable
Tow Cable:	Kevlar Reinforced multiconductor tow cable. Breaking strength 3,600 lbs, 0.48 in OD, 200 ft maximum. Weighs 17 lbs (7.7 kg) with terminations.
OPERATING TEMPERATURE:	-30°F to +122°F (-35°C to +50°C)
STORAGE TEMPERATURE:	-48°F to +158°F (-45°C to +70°C)
ALTITUDE:	Up to 30,000 ft (9,000 m)
WATER TIGHT:	O-Ring sealed for up to 4,000 psi (9000 ft or 2750 m) depth operation
POWER:	24 to 32 VDC, 0.75 amp at turn-on and 0.5 amp thereafter
ACCESSORIES:	
Standard:	View201 Utility Software operation manual and ship kit
Optional:	Telemetry to 10Km coax, gradiometer (longitudinal or transverse), reusable shipping case
MagLog Lite™ Software:	Logs, displays and prints Mag and GPS data at 10 Hz sample rate. Automatic anomaly detection and single sheet Windows printer support

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE ***12/03***

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#18 Chaoyangmenwai Dajie, Chaoyang District, Beijing, China 100020
10-6588-1126 (1127..1130), 10-6588-1132 Fax 010-6588-1162

MAGELLAN®
PROFESSIONAL

Sagitta™

The Turnkey RTK Receiver

Features

- Easy to use and lightweight GNSS receiver
- Real-time precision ranging from meter to centimeter
- Multi-application positioning sensor

Accurate, Easy To Use And Lightweight

The Sagitta receiver from Magellan is intended for small and medium-scale marine surveys for which position precision and ease of use are equally important. Sagitta offers real-time precision ranging from the meter to the centimeter level, depending on how it is operated (Operating modes available include: WAAS/EGNOS, DGPS, EDGPS, KART or LRK®).

Its fast 10-Hz (raw data) and 20-Hz (computed data) output rates make it the ideal tool for many types of kinematic applications such as bathymetry or coastal works, sea trials or trajectory. Surprisingly, for its size, Sagitta boosts levels of performance comparable to those of the most sophisticated equipment available today. Thanks to its low weight and small size, it can easily be carried from site to site.

Flexible

Sagitta comes in two versions: single-frequency and dual-frequency. Its 16-channel GNSS differential core is housed in a single, versatile unit that can be combined with additional optional software or hardware to meet a variety of requirements: screen & keypad (TRM100), UHF or HF/MF radio (U-Link or HM-Link transmitter/receiver), etc.

Benefiting from a high degree of flexibility in its design, Sagitta can also be used as a reference station. You just need to add a U-Link station kit to deliver UHF signals over distances of 40 km or more. To even more increase your project flexibility Sagitta is also compatible with several data format (RTCM, Magellan, CMR/CMR+).

Extended Performance

Sagitta now also offers a unique full BACKUP™ feature where a second position fix is computed to guarantee an extreme position availability. With our dual-frequency LRK kinematic processing technology - today a standard renowned for its outstanding performance – Sagitta provides fast, reliable, real-time centimeter-level positioning combined to a fully operational radio link up to 40 km. With LRK, you will be able to work at greater distances than conventional RTK.

Sagitta Technical Specifications

Applications

- High-Precision Positioning
- Marine Surveying
- Trajectory

Sagitta Configurations

	Standard Features	Firmware Options	Hardware Options
Sagitta-01	Compact-case receiver NAP 001 antenna with standard supply Firmware: DGPS, EDGPS, BACKUP	KART REFSTATION RELATIVE OTF	Rx 4812 U-Link Reception Module Rx 1635 HM-Link Reception Module (x1) Tx 4800 U-Link Transmission Module TRM100 keyboard & screen
Sagitta-02	Compact-case receiver NAP 002 antenna with standard supply Firmware: DGPS, EDGPS, BACKUP	KART LRK REFSTATION RELATIVE OTF	Rx 4812 U-Link Reception Module Rx 1635 HM-Link Reception Module (x1) Tx 4800 U-Link Transmission Module TRM100 keyboard & screen

Standard Supply List

- NAP 001 or NAP 002 geodetic antenna; Diameter: 143 mm (5.63"); Weight: 0.35 kg (0.77 lb)
- Power cable, RS232 serial cable (x 1)
- Receiver mounting kit

Performance Figures[1]

Real-Time Centimeter LRK Mode (L1/L2)

- Operating range up to 40 km (5 SVs or more) with OTF kinematic initialization
- OTF initialization time: 30 seconds, typical
- Precision:
  - In KR Fast Mode (20 Hz max. and 5-ms latency): 10 mm + 0.5 ppm, XY; 20 mm + 1.0 ppm, Z
  - In KA Synchronous Mode (1 Hz and 1-s latency): 5 mm + 0.5 ppm, XY; 10 mm + 1.0 ppm, Z

Real-Time Centimeter KART Mode (RTK L1)

- Operating range up to 12 km (5 SVs or more) with OTF kinematic initialization
- OTF initialization time: 10 minutes, typical
- Precision: same as LRK Mode

Real-Time Decimeter EDGPS Mode

- No operational limits of distance; U-LINK radio reception required
- Data convergence time: 2 minutes, typical
- Precision: 20 cm + 2 ppm, XYZ

Real-Time Metric WAAS/EGNOS Mode

- Service area as defined for the system of satellites used. The different systems available are: WAAS in North America, EGNOS in Europe and MSAS in Japan
- Precision: 1 to 2 meters, XY; 3 meters, Z

Technical Specifications

GPS/GNSS

- 16 x L1 channels - 12 x L2 channels (Sagitta-02 only)
- C/A code and L1 phase, P code and L2 phase with multi-path processing
- Differential modes: WAAS/EGNOS, Numeric RTCM Version 2.2, messages 1,3, 5, 9, 16, 18 & 19

Raw Data:

10 Hz output rate

Computed Data:

- 20 Hz output rate - Latency < 5 ms (0.005 s)
- User Coordinate System: -Local datum, projection, geoid model

Interface

- GPS and Radio Antenna connectors: all female TNC
- 3 two-way I/O ports (one RS232, two RS422) with baud rates from 1200 to 115200 bauds
- AUX port (1 PPS output, external event input, RTCM input on RS422, etc.)
- TRM100 display also available on VGA output
- NMEA 0183 messages: RTCM, Magellan format, CMR/CMR+
- User messages via ConfigPack™

Electrical

- Power source: 9 to 36V DC, floating input
- Consumption (mobile receiver): 7 to 15 W (Sagitta-01); 8 to 16 W (Sagitta-02)

Environmental

- IP 52 compliant, rigid aluminum case
- Operating temperature range: -20 to +55°C (antennas: -40 to +70°C)
- Storage temperature range: -40 to +70°C
- Vibration: EN 60945 & ETS 300 019 (Shocks)
- EMI: EN60945, Class B FCC Part15

Physical

- H x W x D: 65 x 265 x 215 mm (2.56 x 10.43 x 8.46")
- Weight: 2 kg (4.41 lb)

Radio Module Options

Tx 4800 U-Link UHF Transmission

- Transmission module operating in UHF band 410 to 470 MHz
- Data formats: LRK (RTK) and RTCM
- Modulation type: GMSK at 4800 bits/s
- Radiated power: 4W or 0.5W (according to local authorization)
- CXL-70 3 dB antenna
- Norm ETS 300-113 - Certified in Europe, the US and most other countries
- R & TTE 1999/5/CE
- EMI specifications: EN60945

Rx 4812 U-Link UHF Reception (built-in module)

- Reception module operating in UHF band 410 to 470 MHz
- Reception module designed to be integrated into the receiver
- Modulation type: GMSK 4800 bits/s or DQPSK 1200 bits/s (NDS 100 type)
- CXL-70 3 dB antenna

Rx 1635 HM-Link HF/MF Reception (1 built-in module)

- Reception module designed to be integrated into the receiver
- Dual-channel in HF band 1.6 to 3.5 MHz; BCPSK modulation (NDS 200 type)
- Dual-channel in MF band 270 to 330 kHz; MSK modulation
- DHM 5000 dual-band antenna - H x Diameter: 245 x 135 mm (9.64 x 5.31")

TRM100 Keyboard & Screen Option

- 1/4 VGA screen and keyboard terminal
- Dimensions (H x W x D): 125 x 255 x 40 mm (4.92 x 10.0 x 1.57")
- One-meter cable for connection of TRM100 unit to receiver
- TRM100 mounting kit

TRM 100 keyboard/screen terminal

[1] All performance figures are 1 RMS values based on test conducted in Nantes, France,in normal conditions of GPS receptions,(normal ionospheric activity, 5 SVs used and HDOP < 4) on a clear site.

[1] Tests in different locations under different conditions may produce different results.

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MAGELLAN® PROFESSIONAL

GEUS Vibrocorer

Vibrocorer: VKG (VibrationsKernGerät)

Technical data and crane requirements:	VKG-6	VKG-3
Height (operational)	7.4 m	4.7 m
Base (foot)	4.6 m	3.6 m
Weight inclusive drilling rod and 6 contraweight @ 50 kg.	850 kg.	550 kg
Same inclusive max sediment in the liner	1000 kg	700 kg
Coreliner PVC outside	110 mm	110 mm
Core diameter	106 mm	106 mm
Corelength max	6.0 m	3.0 m
Working area	6 x 9 m	5 x 6 m
Crane lifting capacity	2 ton	1 ton
Crane lifting height over rails	7.5 m	5.0 m
Crane boom length from shipsside to drillingpoint min.	2.5 m	3.5 m
Hoisting wire non-rotating	12 mm	12 mm

Working depth	0 – 100 m
Mooring:	Treepoint mooring
Power:	380 V 3 phase+ ground 50 Hz
Fuse:	Min 25 A
Electromotor	4 kW/2880 rpm
Working current	10 – 16 A (20 A short)
Vibro-frequency	28 Hz
Drilling force	30 kN

Personnal: One driller, one crane operator and two assistants

Navigations software - NaviPac

The NaviPac software is integrated navigation and data acquisition software specifically suited for applications like:

- General navigation
- Hydrographic & oceanographic surveying
- Geophysical & seismic surveying

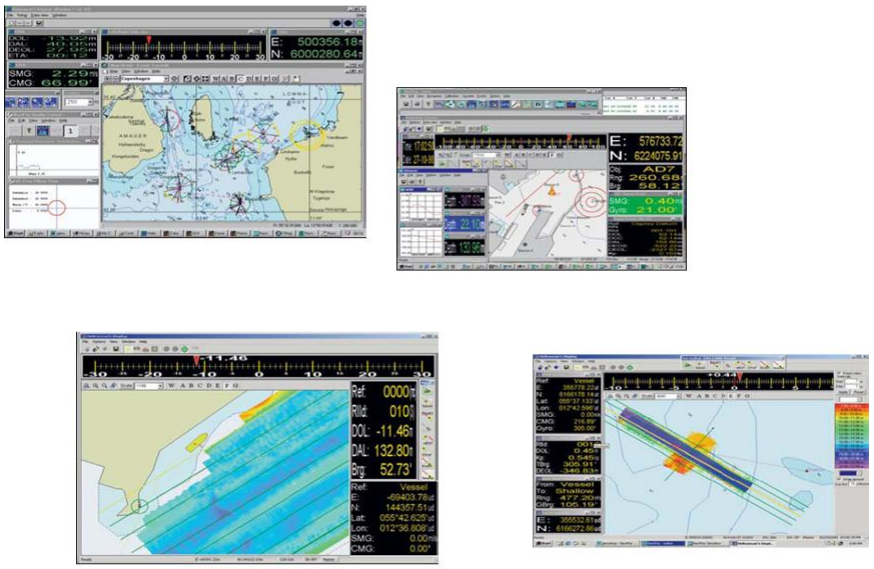
MODULARITY – NaviPac is modularity through use of multi tasking, multithreading and networking capabilities of the Windows NT, Windows 2000 and Windows XP operating system. The software is highly flexible and user configurable and the user interface adhere to The Microsoft Interface Guidelines making it very intuitive and easy to operate (figure 4).

NAVIGATION SET-UP – The NaviPac set-up module provides easy selection of geodetic parameters, navigation systems, devices, offsets and port settings.

DEVICE I/O DRIVERS – A vast number of field-tested device I/O drivers are provided for most available positioning systems, GPS/DGPS receivers, gyros, motion/attitude sensors, tide-gauges, single beam echosounders, magnetometers, dynamic positioning systems, autopilots, etc. Generic I/O drivers allow definition or customization of own device I/O drivers. Data is interfaced via RS232, a LAN or via a digital I/O interface

TIME SYNCHRONIZATION – Time stamping of sensor data, incoming as well as outgoing, can be done in two ways, either by the internal computer clock or by he PPS output available from most GPS receivers. Using the PPS output data are synchronized relative to the GPS/UTC time frame, resulting in an accuracy of a few milliseconds.

SURVEY PLANNING – NaviPac allows for survey planning through quickly creation of planned survey area and survey lines. A variety of methods for creation of survey lines is provided, e.g. by click-and-drag (of mouse/trackball), input of survey line coordinates, offset (parallel) survey lines, cross lines, circles, arcs etc. Survey lines can easily be adapted to fit a defined survey area. Creation of templates allows input of other data formats.



Figur 4. NaviPac skærmbilleder side scan sonar.

DELPH SEISMIC

SUB-BOTTOM IMAGERY ACQUISITION AND INTERPRETATION TOOL

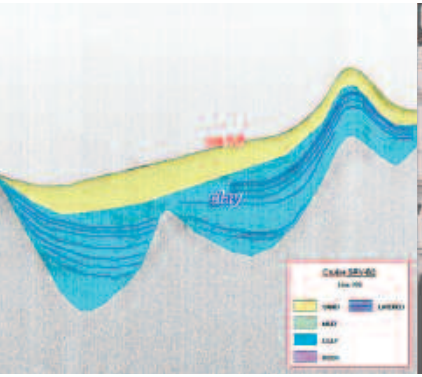
DELPH SEISMIC is a real-time and batch survey productivity tool, compatible with most digital and analog sub-bottom profilers. Beyond the traditional scrolling display, its global viewer mode and mapping tools provide advanced interpretation capabilities.

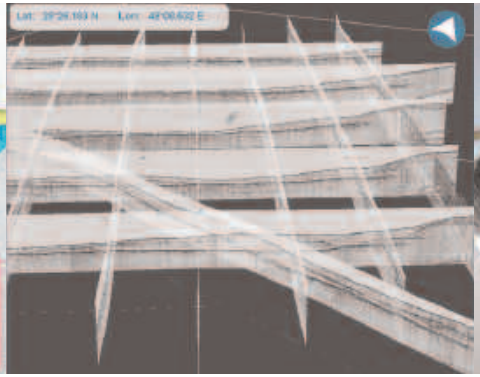
FEATURES

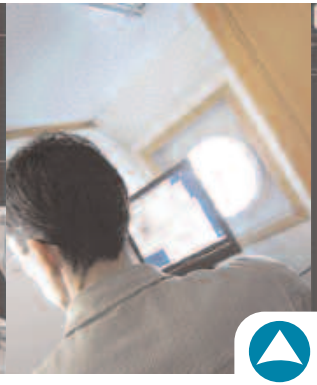
- One screen display of km-long survey lines
- Manual and automatic reflector identification
- On screen annotation and drawing tools
- Crossing profiles one click browsing
- 3D display of both imagery and interpretation

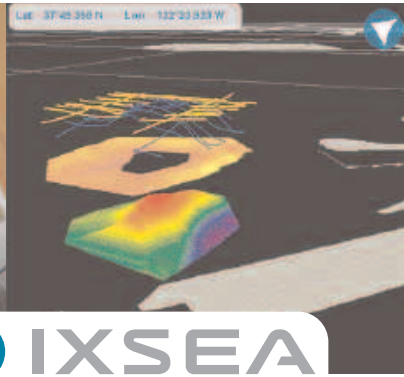
BENEFITS

- Improvement of the interpretation production line
- Interpretation productivity boost
- Ready to use imagery data
- Improve your understanding of the survey field
- Easy profiles correlation for interpretation









APPLICATIONS

- Offshore mining preparation
- Geotechnical, scientific and environmental investigation
- Pipe pre-laying and pre-dredging survey

DELPH SEISMIC INTERPRETATION

SUB-BOTTOM IMAGERY ACQUISITION AND INTERPRETATION TOOL

DETAILED FEATURES

Acquisition

IXSEA's ECHOES SBP interface with multi-ping capability
Interfaces with most digital and analog sources
24 Bits acquisition of 1 to 6 analog channels
Master and slave modes
Asynchronous acquisition of two analog systems
Industry standard XTF or SEGY format logging

Processing

Band pass and time varying filters
Automatic and time varying gain control
Horizontal stacking
Navigation filtering and speed correction
Topo correction with swell and heave compensation
Multiple removal and signature deconvolution

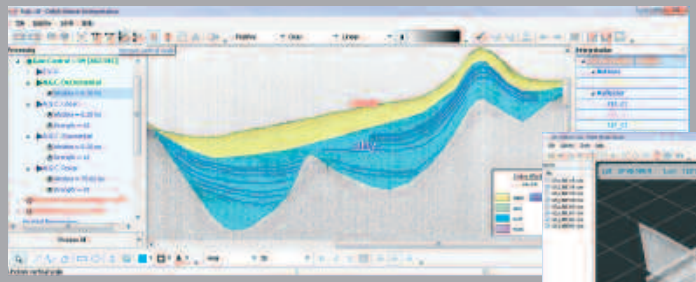
Interpretation

Manual and semi-automatic horizon picking and export
Thickness computation between two horizons
Crossing lines browsing and interpretation correlation
Annotation and drawing on the seismic profile
Outputs to industry standard formats

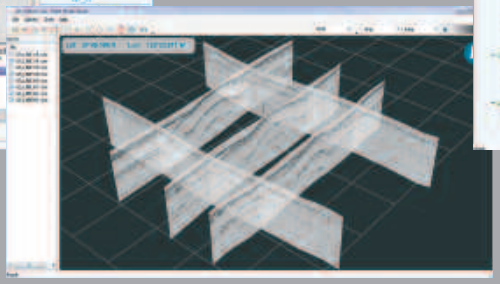
Mapping

DTM generation
Real-time and post processed seismic GeoSections
3D display of the DTMs with the interpretation vectors
3D display of GeoSections
Geographic correlation with other sensor data

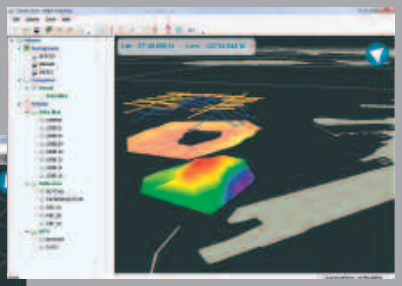
WORKSPACE OVERVIEW



Delph Seismic Interpretation



Delph Mosaic Viewer – GeoSection Display



Delph Road Map - DTM Display

REQUIREMENTS & COMPATIBILITY

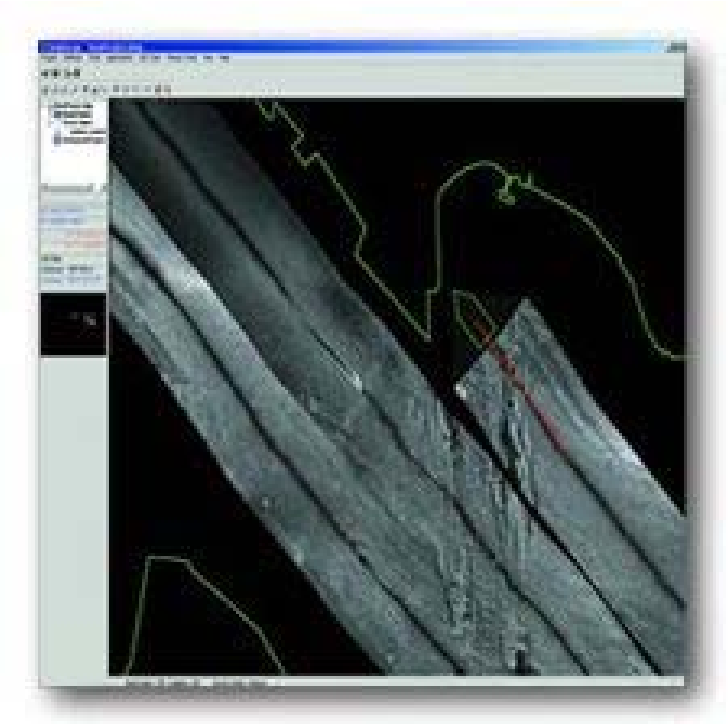
Minimum workstation configuration: Pentium IV, Windows XP

IXSEA : • EMEA : +33 (0)1 30 08 98 88 • AMERICAS : +1 (781) 937 8800 • ASIA : +65 6747 4912 • www.ixsea.com

2008-01-PS-DELSEI

Isis Sidescan Acquisition Software

This complete software suite has the options of logging the sidescan and the sub-bottom profiler data, process the data and produce a mosaic image of the seabed as shown in the figure. It has the ability to export these images in a geotiff format which can be read directly by any GIS software, like MapInfo.



ISIS online mosaic screenshot.

ISIS continues to be the most advanced sidescan sonar acquisition system available today. Isis® Sonar™ is the tool of choice for a variety of applications including: mine-hunting, hydrography, archaeology, environmental studies, oilfield engineering, civil engineering, oceanography, and law enforcement.

Real-time Sensor Quality Control

ISIS offers a wealth of display options to ensure high data quality. Typical windows for monitoring raw sensor information include a waterfall display for the sonar imagery, a signal voltage display for each incoming ping, and a parameter display for navigation, motion sensor, etc., and file storage. A real-time link with TEI TritonMap™ provides for on-line mosaic production, an invaluable tool for assessing seabed coverage and the quality of geo-referencing between adjacent lines (figure 6).

Reliable, Precise Sonar Data Acquisition

ISIS systems are active throughout the world, incorporating over 20 years of field experience in hardware and software design. Incoming sidescan sonar and ancillary sensor data are time-stamped to

millisecond accuracy, thereby ensuring the final data products can be properly corrected during processing. Wide Compatibility,

Compatible with All Sidescan Sonars
ISIS interfaces with any sidescan sonar available today. Analogue or digital, regardless of the manufacturer -- we offer a custom interface that is intuitive to set up and is designed around the sonar's communication requirements. All data are stored in TEI's open XTF (eXtended Triton Format), an industry-standard, non-proprietary format.

Comprehensive Data Correction & Analysis
Numerous tools exist within ISIS for correcting and analyzing data and generating reports. Bottom-tracking, time-varying gain, slant range correction, and layback may all be applied to the imagery on-screen without affecting the raw data being logged. Events, scale lines, and notes can be associated with the imagery. A powerful ASCII report tool allows practically any information stored in the XTF file to be extracted in user-defined formats.

GIS Mosaicing
A mosaicing link exists between Isis® Sonar™ and TEI's TritonMap™ GIS product. These mosaics may be overlain on navigation charts or other background information. Contours, navigation hazards, or contacts may be overlain on the mosaics as they are being built.

SonarWiz.MAP+SBP

SonarWiz.MAP+SBP: the fastest, friendliest acoustic mapping package available now includes a sub-bottom profiler acquisition and processing module.

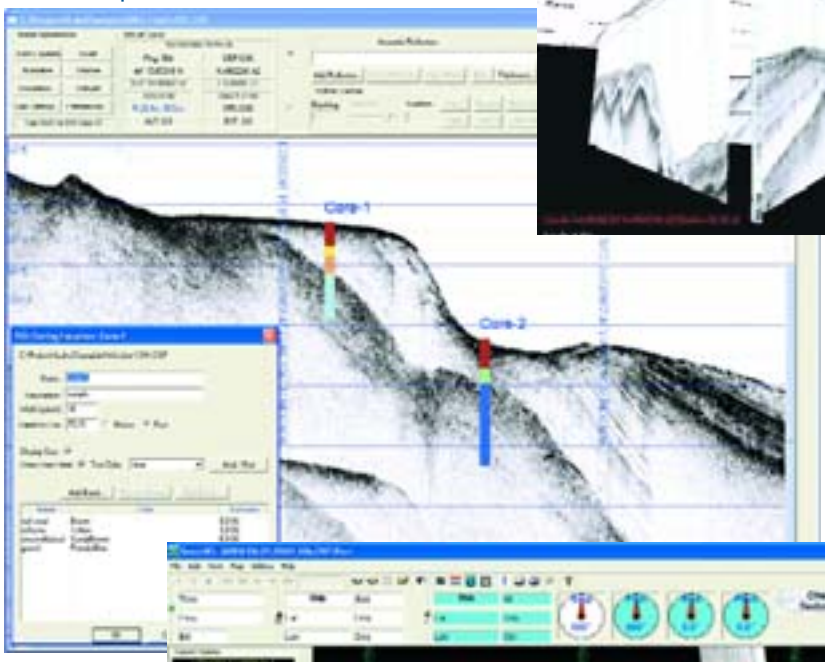
SonarWiz.MAP+SBP produces real-time and post-processed mosaics and SBP profiles at any resolution and size, quickly and on-the-fly.

In real-time acquisition mode, it supports most sonar systems, in addition to navigation, fathometer and magnetometer input.

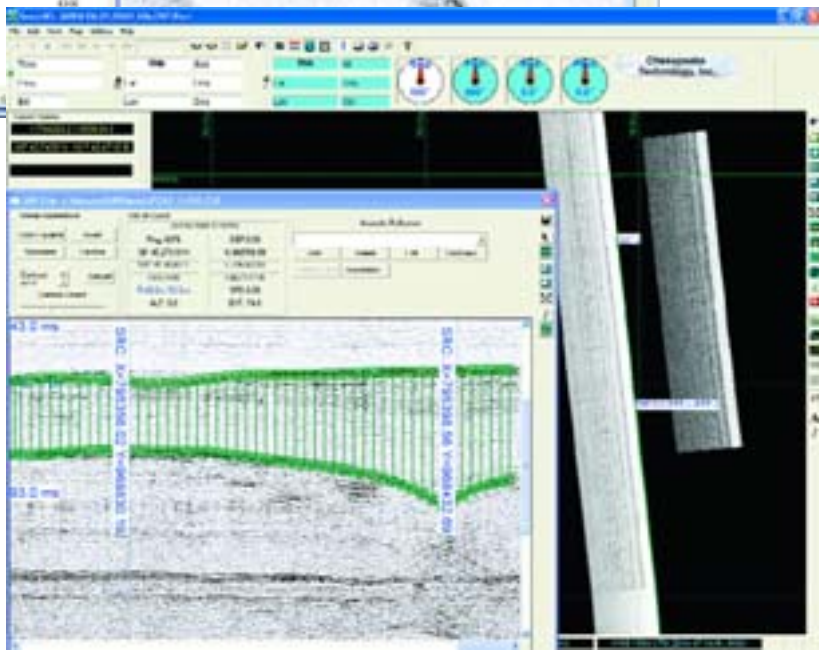
In post-processing mode, it will handle most of the common sidescan and sub-bottom data file types as well as S-57, VPF, BSB, GeoTiff and many more charting, GIS and CAD formats.

Runs on Windows 2000, XP, Vista and later

Core Sample

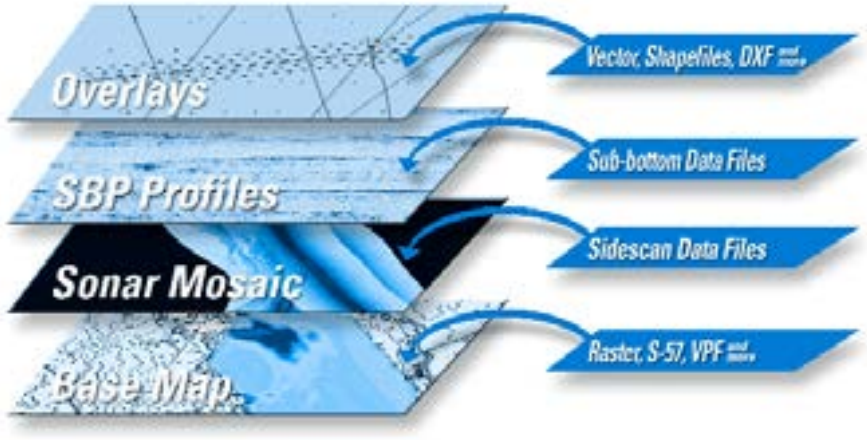


3-D Video



Reflector Digitizing with Thickness Computation

SonarWiz.MAP+SBP Display Capabilities



Chesapeake Technology Inc.

650.967.2045

www.chesapeaketech.com

SonarWiz.MAP+SBP

SonarWiz.MAP+SBP: Interactive visualization tools such as zoom, pan, measure and on-the-fly image scaling make SonarWiz.MAP+SBP an indispensable tool for sonar mosaic production and sub-bottom profile interpretation.

Contact identification and feature digitizing tools allow features to be located and classified on the mosaic during or after data acquisition. Graphic, tabular and application specific files (HTML, MS Word, ESRI Shapefiles) provide multiple data export routes. Export SBP profile sections with custom annotations and scale lines.

Sub-Bottom Profiler Module Features…

- **Broad File Type Support**—XTF, SEG-Y, CODA (.COD and .CDA), Edgetech JSF, Tritech SBP V4Log and Syqwest StrataBox data file formats are currently supported with more formats on the way.
- **Intuitive Mapping**—The SBP Option maps your sub-bottom data in a 2D plan view by rotating the vertical trace 90 degree into the map surface providing a plan view of your data. Individual files may be moved, trimmed, split, image enhanced just by a simple right-click in the map view.
- **Classical Profile Views**—In addition to a plan view of all of your SBP data files, SonarWiz.MAP+SBP also provides multiple profile views of your SBP files that are "cursor-linked" with the map view. The profile views allow infinite scroll and pan over the entire SBP data file and complete customization of the vertical and horizontal scale lines and event marking.
- **Acoustic Reflector Generation**—SonarWiz.MAP+SBP profile view provides a simple interface for digitizing acoustic reflectors in the profile. Reflectors are displayed in the map view and on the profile view as they are digitized. SonarWiz.MAP+SBP includes a complete export tool that will save the digitized reflectors in CAD, GIS and ASCII formats.
- **Isopach and Thickness Tool**—SonarWiz.MAP+SBP thickness tool compares any pair of reflectors and automatically generates the thickness vector for the area of intersection of the reflectors. This is a huge time saving feature.
- **3D Viewer**—Included with all SonarWiz.MAP products is a 3D visualization package that displays mosaics, maps and SBP profiles in an interactive 3D display. Exports movie files and JPEG images.
- **Core Processing**—Show your interpretations right on the SBP profile using the new Core mapping tool.

SonarWiz.MAP Features…

- Real time data acquisition and display: supports most sonar systems, plus navigation, fathometer and magnetometer input.
- Real-time and post processed sonar mosaic production.
- Real-time survey-line generator, editor and steering indicator makes line following a breeze.
- Real-time QC-sonar waterfall display.
- Interactive and on-the-fly scaling.
- Sonar file importing: supports most sonar file formats.
- Comprehensive selection of pre-defined geodetic datums, coordinate systems and map projections, plus support for user defined datums and projections.
- Support for basemaps and overlays includes BSB, S-57, VPF/VMAP, ECW, DXF, Shapefiles, GeoTiff and much more.
- Bottom Tracker: manual and automatic modes.
- Comprehensive signal processing and gain control including Beam Angle Correction, Destriping, Non-linear per-channel TVG, AGC, layback.
- On-screen feature digitizing and attribution.
- Target capture and reporting.
- On-screen tools simplify difficult tasks such as adjusting survey lines.
- Printed output to any Windows supported printer or plotter.
- Output mosaics to GeoTiff (TIF/TFW) with user specified resolution.
- Output digitized features and reports to ESRI shapefiles, AutoCAD DXF, and simple ASCII files.
- Full online HTML help system, unmatched customer support and a yearly maintenance agreement available for extended upgrade and support options.

Chesapeake Technology Inc.

Chesapeake Technology, Inc.
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Mountain View, CA 94040 USA
voice: 650.967.2045
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sales@chesapeaketech.com
www.chesapeaketech.com

GeoGraphix

SOFTWARE OVERVIEW

GeoGraphix® software delivers a unique blend of geoscience, engineering and economic decision support capabilities on Windows®.

Visit us at: www.geographix.com

Integrated GeoscienceSuites

By tightly integrating our best-in-class geophysical and geologic technologies with powerful data management and mapping tools we have created the ultimate geoscience solution suites that increase asset understanding and provide the highest quality products.

Discovery™
The Discovery™ suite is a Windows®-based geologic and geophysical interpretation system that combines industry-leading technologies supported by a common data and project architecture. Geoscientists use this tightly integrated system to easily interpret reservoirs, support field development and exploit mature assets. The Discovery suite is the ultimate integrated collaborative environment for geologists and geophysicists to develop highly accurate interpretations of their assets or exploration plays.

Discovery™ on OpenWorks®
GeoGraphix Discovery™ technology now directly accesses OpenWorks® and SeisWorks® data and projects without data transfer or replication. Discovery on OpenWorks technology directly links to Landmark's OpenWorks system, the most widely used project data-management application in the exploration and production (E&P) industry. For geoscience professionals, this means that they can choose between any Landmark or Discovery application to support their interpretation process without complicating their project environment.

Utilities

Efficient data management is critical to any oil and gas company, providing an environment where your technical staff is interpreting and not searching for or validating data. Our data management utilities reduce effort and streamline data sharing.

SDE Connect
GeoGraphix's SDE Connect utility enables a direct connection to Oracle® spatial data engines so that you can display lease and cultural information on our mapping tools without exporting, importing and duplicating data. Because this connection is live, you can be confident that your maps are always current with the latest data available. Even create SDE layers as virtual snapshots of your data for when connections to the SDE server are not available or when you take your projects on the road.

SeisXchange™
We realize that many of our customers operate their geoscience IT technologies in a hybrid Unix/PC environment. SeisXchange™ technology reduces the effort to transfer geophysical 2-D and 3-D horizon picks, faults and seismic attributes between Discovery™ and Landmark's Unix-based interpretation tools.

WellXchange™
Want to use both GeoGraphix and Landmark geoscience environments yet are tired of manipulating data between these systems? GeoGraphix's WellXchange™ utility allows you to manually transfer or set up scheduled synchronizations between the Discovery™ GXDB and OpenWorks® databases. Well header, formations, log curves, fault data and production data are a few of the data types handled by this efficient data-transfer utility.

Engineering

GeoGraphix's engineering technologies help reservoir and production engineers maximize your asset's financial performance. Proactively and easily analyze and identify opportunities to optimize production and reservoir recovery.

Dynamic Surveillance System™ (DSS™)
Integrates all the information necessary for engineers to manage their assets. Monitoring all well and operations data enables engineers to proactively identify opportunities to increase production across an asset, while at the same time reducing downtime. By replacing spreadsheets with a dedicated surveillance tool, one engineer can easily manage an asset with more than 500 wells.

Economics Technologies

Designed for companies around the globe, our economic solutions accurately support your wide range of financial decisions, assess and report your company's reserves and help you manage a portfolio of projects all within one integrated system.

Economics Evaluation

ARIES™ System
ARIES™ System combines superior well and project management, sophisticated graphical analysis, and a robust economics engine to forecast production, economics, and reserves for all types of properties and assets. Designed to accurately support financial decisions across your company and forms the foundation for the reserve management and decision support tools described below.

ARIES™ International
Extends the power of ARIES™ technology so you can accurately model complex international fiscal contracts. Easily combines domestic and international results into the reserves and portfolio management systems, saving time and preserving accuracy.

Reserve Management

ARIES™ Reserves Management System (RMS)
Improves evaluation, approval, reconciliation and reporting of reserve values. Increases the accuracy, speed and your control of the results. Built-in government and corporate reports save additional time and effort. With the extra time, companies can easily update and report reserves throughout the fiscal year.

Decision Support

ARIES™ Decision Suite™
Enhances the risk analysis of ARIES™ software through graphical decision-tree analyses that support evaluations of individual economic cases and expected value summaries. Also enables Monte Carlo simulations through links from economic data to Crystal Ball® technology.

ARIES™ Portfolio
Supports capital allocation decisions. It aggregates all the inputs – property type, cash flows, capital expenditure, time frames and more – that managers consider when allocating capital for a project. With all the relevant data in one place, managers can easily create reports that help evaluate the impact a particular project will have on the company's bottom line.

ARIES™ Optimizer
Automates rigorous economic and financial analysis that is cumbersome to do manually. It quickly identifies the most effective combinations in the portfolio data set within the context of your corporate objectives. It helps produce insights which, when combined with your judgment, can produce better strategic decisions and value for your company.

Land Solutions

Because land management is such an integral part of exploration and exploitation of your assets, GeoGraphix has tightly integrated mineral interest and leasehold technology into our mapping system providing the complete picture.

LeaseMap®
GeoGraphix's LeaseMap® application is a powerful yet easy to use land-management tool that provides a complete understanding of any region's mineral interest and leasehold situation. Using industry standard reports and interactive maps, LeaseMap software helps you identify the details and status of mineral and lease holdings across your assets or in an area of interest. The lease information can be integrated with our mapping tools displaying geologic, geophysical and engineering data.

Geology Solutions

GeoGraphix's high-performance geology solutions are tightly integrated into either one of the two bundled mapping systems or geologic interpretation systems – four systems total, all designed to support basic and advanced geologic workflows.

Advanced Well Log Correlation
Whether you are trying to understand a regional trend or identify subtle unconformities in a complex reservoir across hundreds of wells, our advanced well log interpretation tools provide powerful interpretation workflows.

smartSECTION®
smartSECTION® technology specializes in high-performance well log correlation and advanced geologic interpretation by working with digital or raster logs and simulating paper-based log correlation workflows. Unique fault gapping tools are used to interpret structural relationships plus sequence stratigraphy tools allow geologists to accurately correlate large volumes of wells, interpret reservoir facies, build maps and identify drilling opportunities more efficiently than ever before.

Geologic Interpretation Systems
By combining our industry-leading geologic interpretation technologies into systems, we've made it easier for you to purchase the right components to support your most common interpretation workflows.

Basic Geologic Interpretation System
The Basic Geologic Interpretation System is composed of all of the basic geological interpretation applications that the petroleum geologist needs to interpret and map subsurface data. It combines our Mapping System with the Xsection™ application to extend the subsurface interpretation functionality. It is designed for the geoscientist who works primarily with well data and does not have the need to incorporate geophysics or well log analysis into the interpretation.

Geologic Interpretation System
The Geologic Interpretation System is our high-performance geologic application encompassing everything from gridding, contouring, cross sectioning and log analysis to production mapping, basemapping and well data management. Advancing beyond the Basic Interpretation System, we added PRIZM™ to include petrophysical analysis functionality to create the industry's leading product of its kind. Companies around the world use GeoGraphix's Geologic Interpretation System to improve the quality of their interpretations.

Mapping Systems
Whether you are creating base maps or need to display reservoir characteristics, our integrated mapping systems include the right combination of technologies to support your demanding mapping needs.

Base Map System
The Base Map System gives you everything you need to create powerful, informative base maps that derive maximum value from your data. It combines the DataManager™, GeoAtlas™ and LandNet components to deliver comprehensive base map and data management functionality plus basic gridding and contouring for a quick look at regional structure and trends.

Mapping System
The Mapping System takes the components of the Base Map System and adds more sophisticated gridding and contouring capabilities with the IsoMap® module. This system gives geologists a range of tools to address every possible geologic mapping challenge for a solid understanding of the subsurface structural, stratigraphic and reservoir configurations. From more efficient data management to presentation-quality output the first time around, this package delivers everything you need to put your data into context and communicate it effectively.

Geophysical Solutions

From comprehensive seismic interpretation to seismic modeling, GeoGraphix offers the geoscientist all the geophysical tools needed to gain true insight into reservoir opportunities and make the most of the information at hand.

Seismic Interpretation Systems
By combining our advanced data management and mapping systems with our full-featured seismic interpretation and analysis tools, we have created the ultimate environment for the geophysicist to produce high-quality prospects in a fraction of the time.

Seismic Interpretation System
Whether your play involves complex structural problems or subtle stratigraphic traps, having an integrated seismic tool that is sophisticated provides you with the power to accurately interpret your seismic data with confidence. GeoGraphix's Seismic Interpretation System combines the power of DataManager™ with the seismic interpretation capabilities of SeisVision™ 2D/3D to meet your mainstream geophysical needs.

Seismic Interpretation System with Advanced Mapping
The Advanced Mapping version of the Seismic Interpretation System adds the powerful gridding and contouring capabilities of IsoMap®, as well as the superior display capabilities of GeoAtlas™, to provide the ultimate geophysical tool set. Empower geoscientists to work on the same project with GeoGraphix's unique data management tools and common database.

Seismic Modeling
Interpreting seismic data sometimes is not enough to accurately pick well locations. Building seismic models to create synthetic traces correlated to well data is essential to increasing the quality of complex depositional environments.

LogM™ Advanced Synthetics
LogM™ Advanced Synthetics, running on either UNIX or Windows® desktops, allows you to tie the trace data with synthetics in real time. For added accuracy, the wavelet of the seismic can be extracted, and applied to the synthetic using WavX. 1-D modeling can be accomplished with AVO/AVA synthetics or fluid substitution. The result? More confidence in your interpretation accuracy.

LogM™ Modeling
LogM™ Modeling is an interactive add-on to the LogM Advanced Synthetics application and is available for both UNIX and Windows® desktops. It includes the industry standard for 2-D stratigraphic or structural modeling to predict seismic responses for stratigraphic changes or in highly structured areas where steeply dipping reflectors and complex velocity problems mask true bed geometry. As with LogM Advanced Synthetics, you can display the models directly in SeisVision™ to enhance the accuracy and confidence of your geophysical interpretation.

Seismic Processing
Are you dissatisfied with your seismic data? Instead of sending seismic data back to the processor for reprocessing, GeoGraphix provides you with the tools to perform post-stack processing right from your desktop.

SCAN™
SCAN™ technology is an add-on to the processing module, pSTAx®. With SCAN, the geoscientist can readily identify subtle discontinuities in the seismic data that may be related to geologic features. Based on Landmark's PostStack ESPTM™ technology, this tool provides a cost-effective alternative to outsourcing these types of projects.

pStaX
pSTAx® technology eliminates the need to send seismic data back to the processor for reprocessing. Instead, your geoscientists can perform post-stack processing flows directly from the desktop. Integrated with the SeisVision™ interpretation application, we've included all the mainstream post-stack processing functions, such as amplitude scaling, correlations, convolution, filtering, phase rotation and more, to create the ultimate desktop environment for evaluating the effects of new processing flows quickly and easily.

Our Strategy

Our vision is to help our customers optimize production and maximize their return on investment by providing the most comprehensive software solutions on a windows-based platform.

GeoGraphix is built upon these main objectives:

1. Price/Performance	To provide industry leading performance at a cost-effective price point.
2. Integration	Offer a complete integrated and flexible solution where all G&G workflows and project teams can access/leverage the same data.
3. Portability	Abilty to access and interpret data anywhere.

Best printed on legal size paper. | October 24, 2006

Client: **GEUS**
Lars Rödel
(Mail: lagr@geus.dk)

Læsø cable
RTK: Reference station.

Positioning Systems

Ref: Læaø-1
Date: 01-05-2010
Version: final_1

Prepared by John Dahl
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DK-3550 Slangerup
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Phone +45 45354585

TABLE OF CONTENTS

1. INTRODUCTION

GEUS hired in Dansurvey to install and operate one base station for RTK positioning during the pre-investigation survey at the power cable route.

The base station is placed at the roof of the Nordmark factory in the harbour of Sæby
The building is placed in the absolute southern part of the area, and by this free view to the entire cable route. The baseline is between 10-21km

The GNSS antenna and control point alongside is measured by certified surveyor using Trimble VRS rover, with an expected accuracy at +/- 2cm.

The UHF antenna used in omnidirectinal and placed 10m above sealevel.
Assuming a antenna height on 10m at vessel, the line of sight is 26km.
The frequency is 449.100Mhz, sending at 5watt ERP.

For additional information, report malfunctioning etc.
Please contact Dansurvey.
Phone +45 45354585.
Mail info@dansurvey.com

2. GEODETIC PARAMETERS.

Geodetic Parameters:	UTM-EUREF-89. Zone 32N
Vertical reference	DVR-90 (MSL)

3. GNSS EQUIPMENT AND ACCURACY

The supplied GNSS equipment (both rover and reference station) is AD-Navigation DC201.
Antenna type is Javad MARANT-1

Specification
GPS L1/L2, GLONASS
Accuracy 1.5cm + 1.5ppm (XYZ)

Working at the actual baseline up to 21km the accuracy is < 5cm (XYZ)

4. COORDINATES, BASESTAIONS AND CONTROLE STATION.

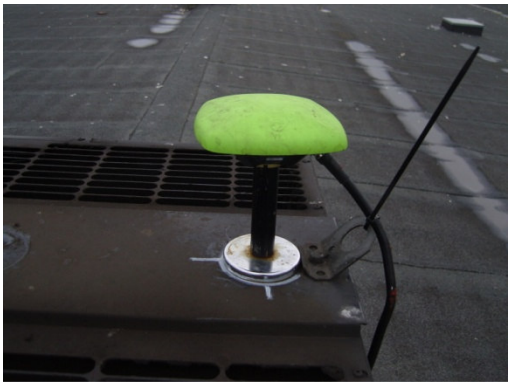
a.) GNSS antenna (APC)
Lat 57°19 53.06897, Lon 10°31'59.32367, h48.881m

b.) Control station on roof
Lat 57°19'52.93557, Lon 10°32'00.03735, h48.184m

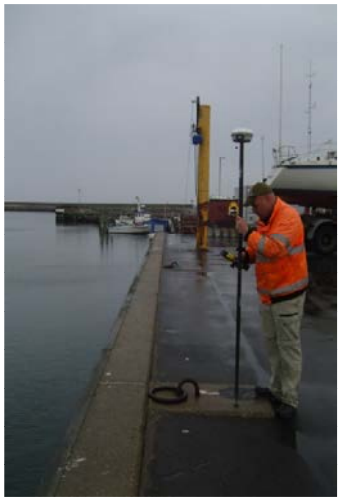
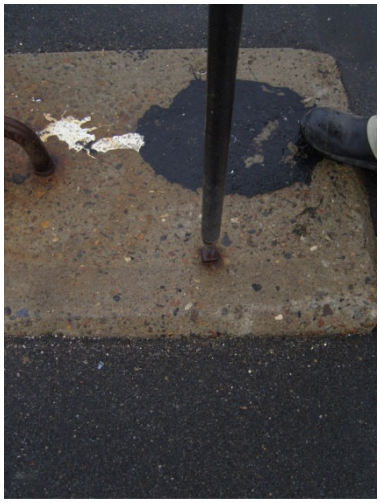
c.) Control station at the keyside
Lat 57°19'56.65105, Lon 10°31'57.92794, h39.544 m

Note: ellipsoid heights, Geoid separation in Sæby is 38.079m

GNSS antenna on magnetic stand. Coordinates measured is end of 10cm upright.

Control point at the key side, note the yellow mastcrane. (2' pollard north direction)

5. SÆBY: RTK. REFERENCE, SPECIFICATION.

I12 Reference Station: GEUS-Sæby	
Station Name	**Station ID No: 1** Short ID: GEUS Long ID: N/A
Reference Station co-ordinates. Geo_EUref 89 (WGS84)	Lat 57°19 53.06897 Lon 10°31'59.32367 Ellipsoid h = 48.881 Entered value APC = 48.9416
Reference Station co-ordinates. EUref 89 UTM Zone 32N	N 6355317.360 E 592301.284m DVR-90 h = 10.801m + 0.0601 (ant APC)
GNSS RTK receiver.	AD-Navigation model DC201B. L1/L2 GPS/GLONASS RTK receiver.
Measurements sent.	CMR format. (Glonass message 3) (Reference coordinates = Antenna APC) GPS CA/L1,P/L2, GLONASS L1 Update rate 1hz.
TX UHF radio specifications.	Telemetry: Satel 3AS Epic **Frequency 449.1000 Mhz** TX Addressing, off TX power 5watt. Baud rate (Air) 19200. Omni-Directional antenna. (3db) TX beam in 10.4 m above MSL.
Rover telemetry: RX UHF Radio. (Recommended)	Telemetry: Satel 3AS Epic. Space diversity (Two antennas recommend) **Frequency 449.100 Mhz**, . TX Addressing, Off, Baudrate (RS232) 19200. Programmable. RS232 Connector DB9-F. RXd pin2.GND pin5.

Note

UHF antenna mounted with free view to Frederikshavn, Læsø and the cable entry point 10km south of Sæby.

Appendix B

- VVibrocore descriptions

Signatures and abbreviations in core description

Explanation in Danish/English

hl	Postglacial saltvandsler / Postglacial marine clay
hi	Postglacial saltvandssilt /Postglacial marine silt
hs	Postglacial saltvandssand / Postglacial marine sand
hg	Postglacial saltvandsgrus / Postglacial marine gravel
hp	Postglacial saltvandsgytje (ink. Diatomégytje) / Postglacial marine gytja (incl. Diatomégytja)
ft	Postglacial ferskvandstørv/ Postglacial freshwater peat
ml	Glacial moræneler / Glacial clayey till
mi	Glacial moræne silt / Glacial silty till
ll	Eocæn ler, Lillebælt ler, plastisk ler/ Eocene Clay, Lillebælt Clay, Plastic Clay
s	Grus, Sand & Grus / Gravel, Sand & Gravel
g	Grus / Gravel

BORERAPPORT DGU arkivnr: 571027. 33

Borested : Kattegat, Læsø Rende

Projekt Nr.: 10229

Kommune :
Region :

Boringsdato : 2/5 2010 **Boringsdybde** : 2,65 meter **Terrænkote** : 8 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LS1A

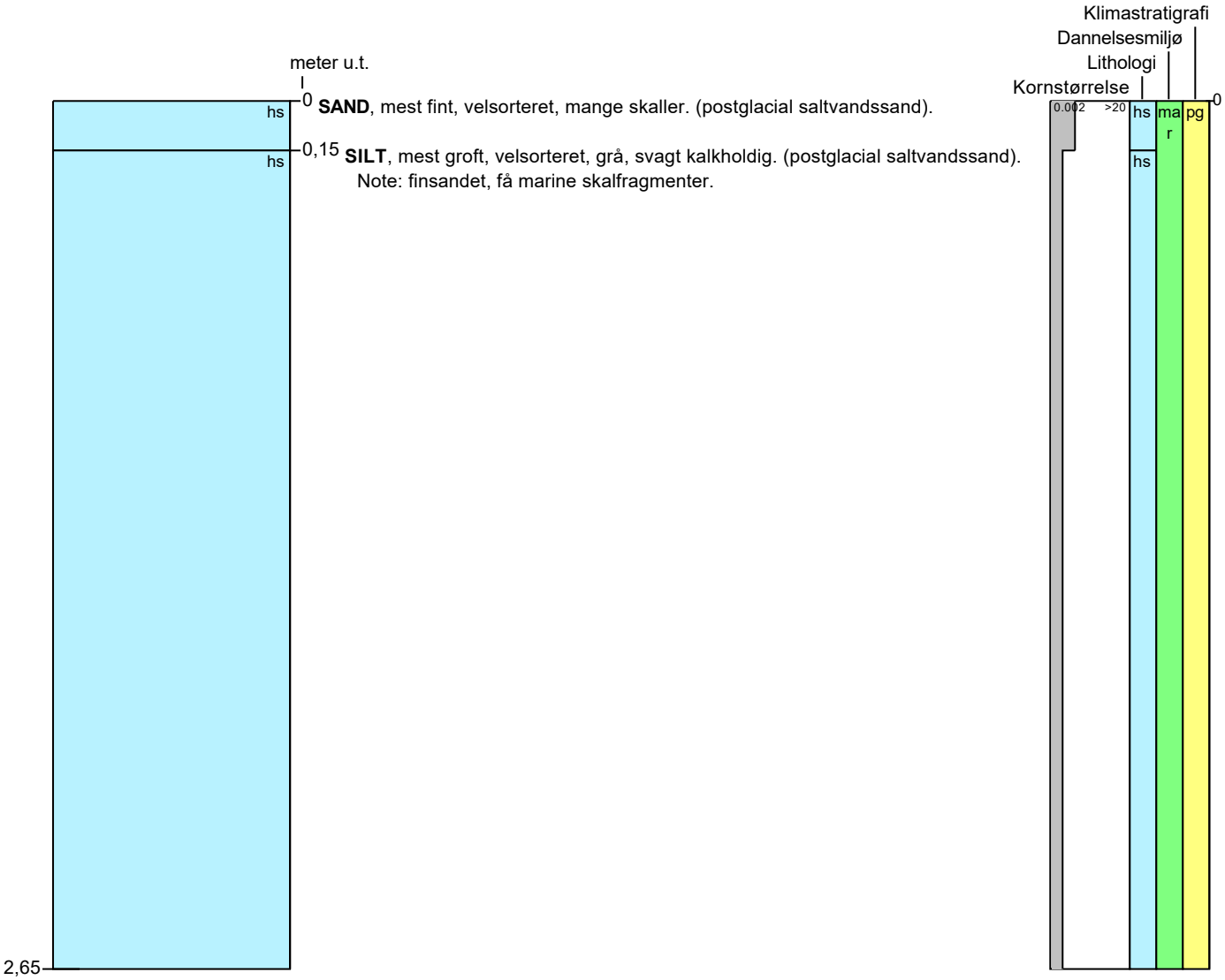
Prøver
- modtaget :
- beskrevet : 18/5 2010
- antal gemt : 0

Formål :
Anvendelse :
Boremetode :

Kortblad : 1317 ISV
UTM-zone : 32
UTM-koord. : 595718, 6344538

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Boringen er beskrevet af Birger Larsen - GEUS



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.

0 - 2,65 marin - postglacial

BORERAPPORT DGU arkivnr: 571027. 34

Borested : Kattegat, Læsø Rende

Projekt Nr.: 10229

Kommune :
Region :

Boringsdato : 2/5 2010 **Boringsdybde** : 1,5 meter **Terrænkote** : 7 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LS2A

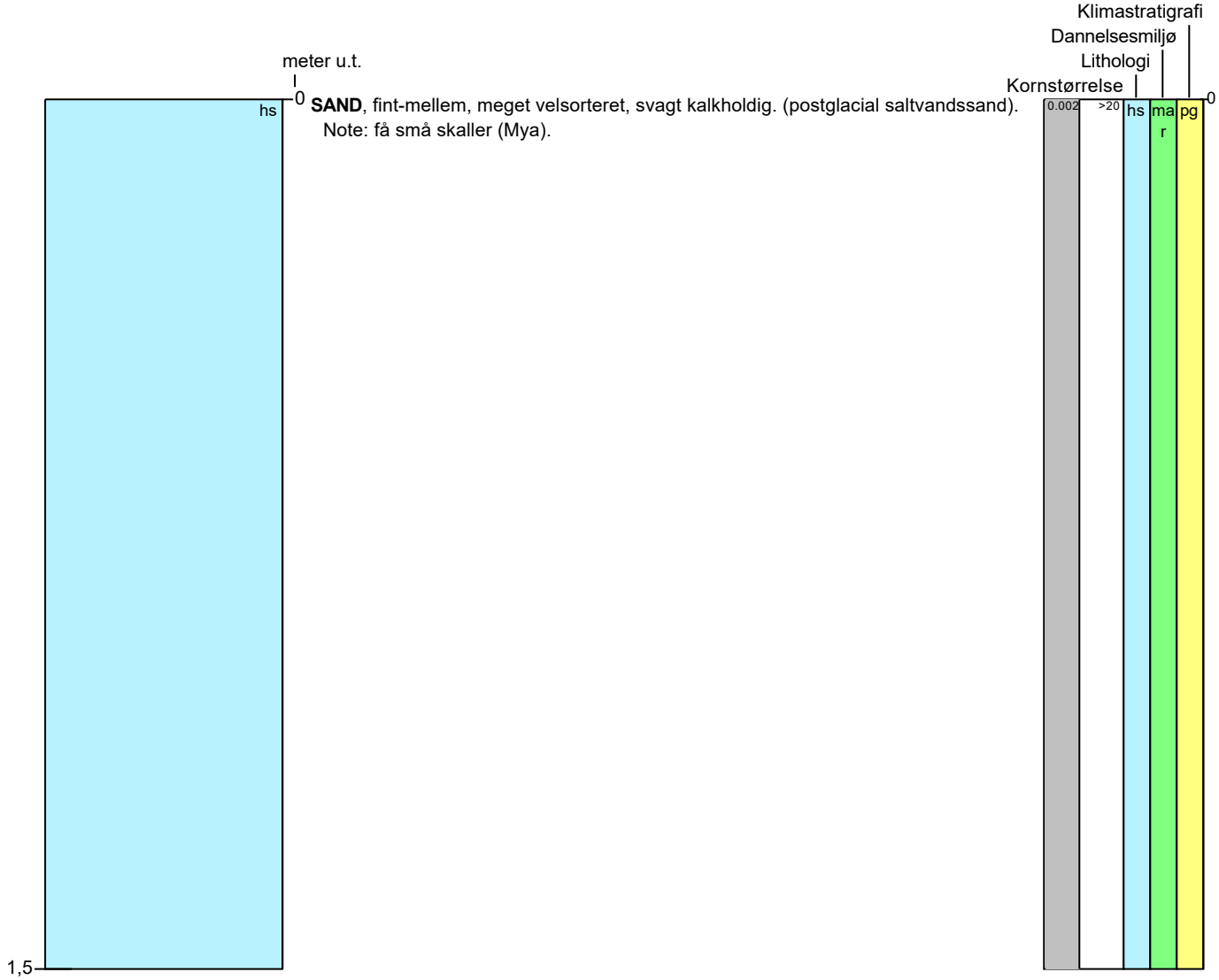
Prøver
- modtaget :
- beskrevet : 18/5 2010
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode :

Kortblad : 1317 IINØ
UTM-zone : 32
UTM-koord. : 600417, 6343666

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Boringen er beskrevet af Birger Larsen - GEUS



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.

0 - 1,5 marin - postglacial

BORERAPPORT

DGU arkivnr: 571027. 35

Borested : Kattegat, Læsø Rende

Projekt Nr.: 10229

Kommune :
Region :

Boringsdato : 2/5 2010 **Boringsdybde** : 2,2 meter **Terrænkote** : 22 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LS3A

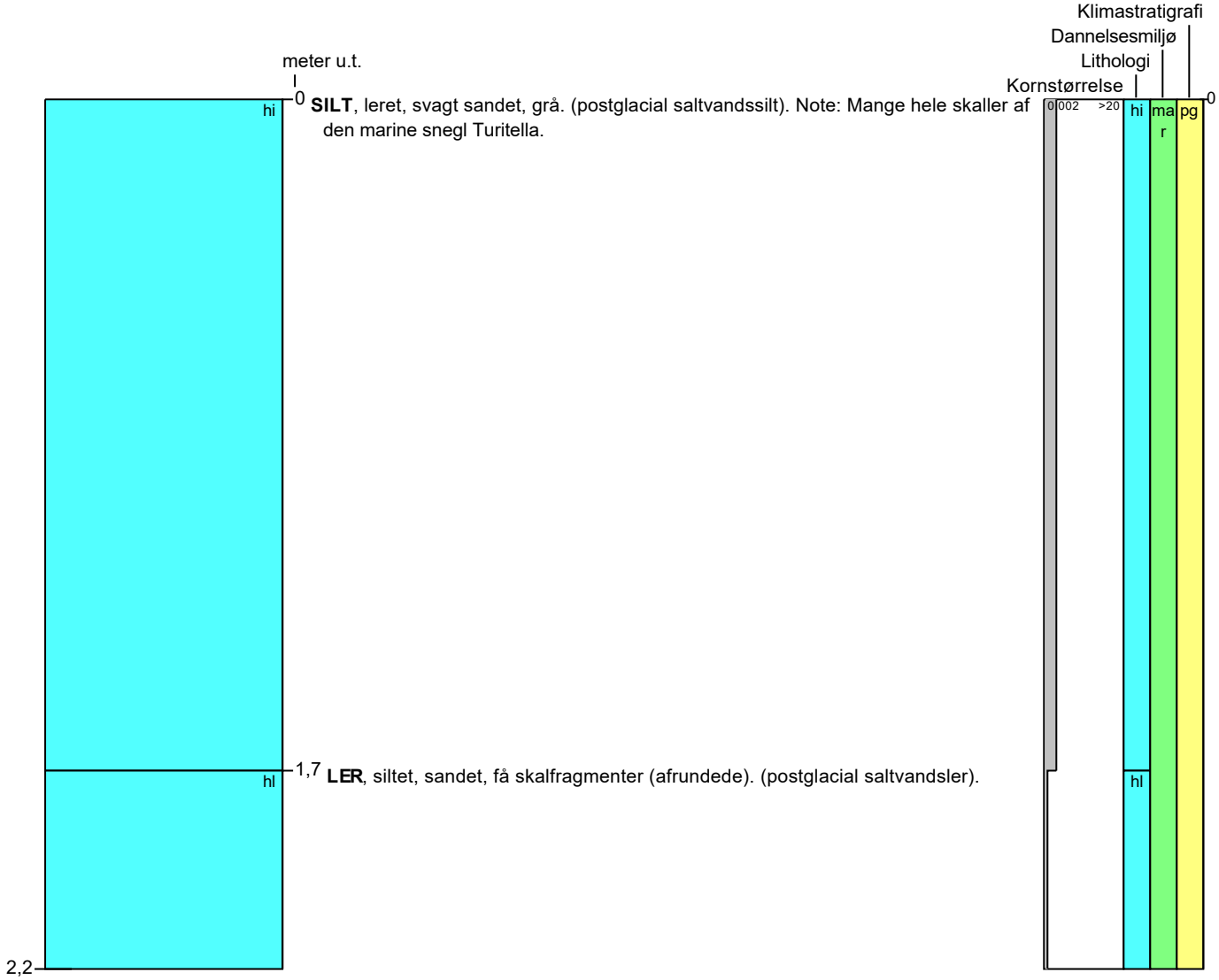
Prøver
- modtaget :
- beskrevet : 18/5 2010
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode :

Kortblad : 1317 IINØ
UTM-zone : 32
UTM-koord. : 602444, 6343977

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Boringen er beskrevet af Birger Larsen - GEUS



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.			
0	-	2,2	marin - postglacial

BORERAPPORT DGU arkivnr: 571027. 36

Borested : Kattegat, Læsø Rende
Projekt Nr.: 10229

Kommune :
Region :

Boringsdato : 2/5 2010 **Boringsdybde** : 1,69 meter **Terrænkote** : 18 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LS4A

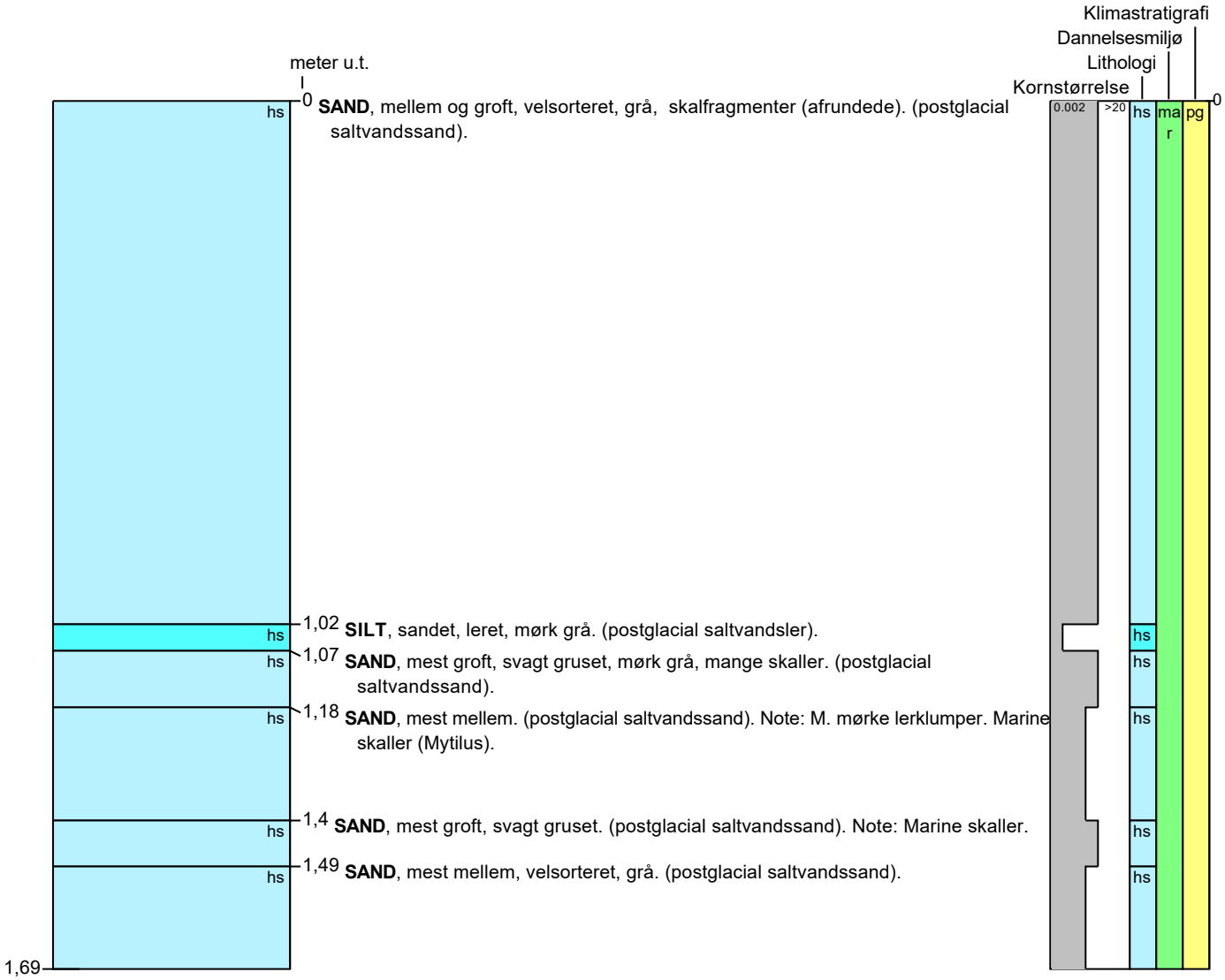
Prøver
- modtaget :
- beskrevet : 18/5 2010
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode :

Kortblad : 1317 IINØ
UTM-zone : 32
UTM-koord. : 603338, 6344261

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Boringen er beskrevet af Birger Larsen - GEUS



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

meter u.t.
0 - 1,69 marin - postglacial

BORERAPPORT DGU arkivnr: 571028. 18

Borested : Kattegat, Læsø Rende

Projekt Nr.: 10229

Kommune :
Region :

Boringsdato : 2/5 2010 **Boringsdybde** : 1,5 meter **Terrænkote** : 15 meter u. DNN

Brøndborer : Danmarks Geologiske Undersøgelse
MOB-nr :
BB-journr :
BB-bornr : LS5A

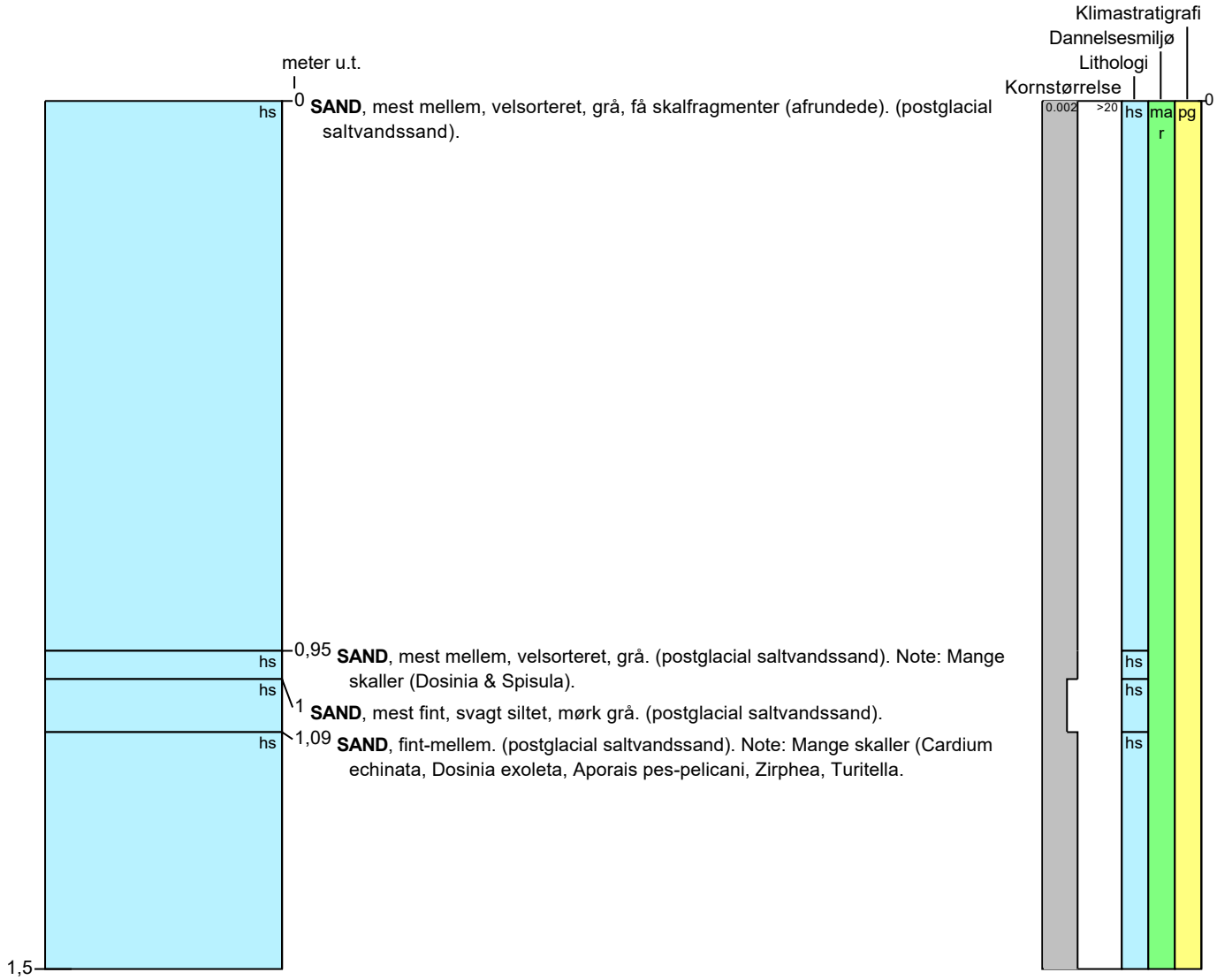
Prøver
- modtaget :
- beskrevet : 18/5 2010
- antal gemt : 0

Formål : Marin geoteknisk
Anvendelse :
Boremetode :

Kortblad : 1317 ISØ
UTM-zone : 32
UTM-koord. : 606241, 6345165

Datum : WGS84
Koordinatkilde : GEUS
Koordinatmetode :

Notater : Boringen er beskrevet af Birger Larsen - GEUS



Aflejringsmiljø - Alder **(klima-, krono-, litho-, biostratigrafi)**

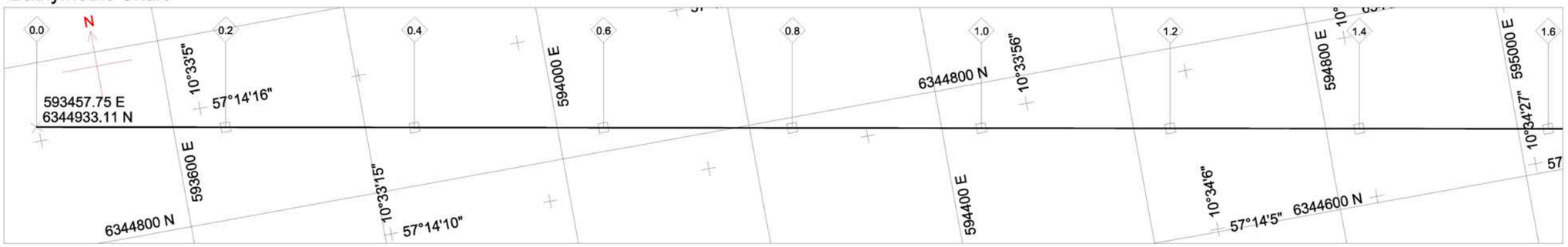
meter u.t.			
0	-	1,5	marin - postglacial

Appendix C

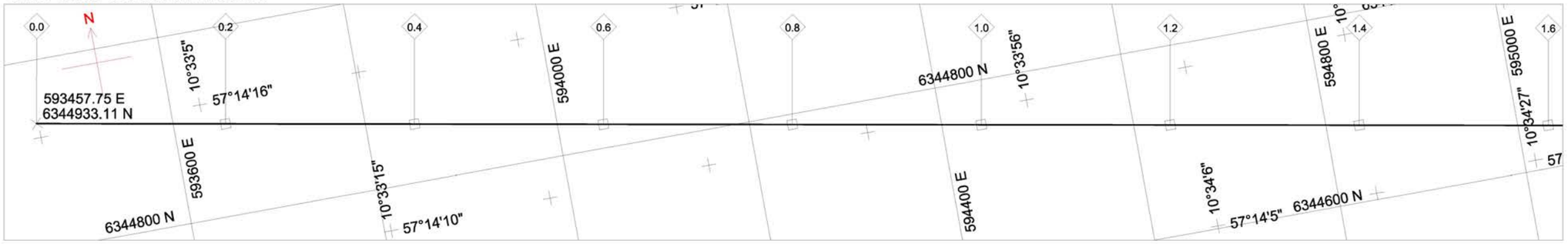
- Alignment sheets

Laesoe Corridor Cable

Bathymetric Chart



Side Scan Observation Chart



Profile Chart

10m

20m

30m

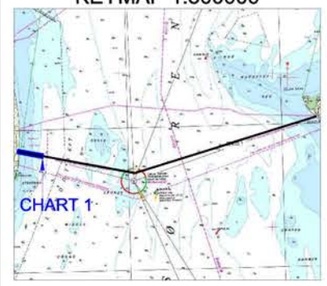
40m

50m

CPT / Vibrocore Profile

As laid / Service Chart

KEYMAP 1:500000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth Curves (5m to 23m)
- Track of depicted Profile
- (x.x) Indicates Cable Length (x.x) in km from start

COLOUR CODES (Seabed level (m))

-23.8 -20.0 -16.2 -12.4 -8.6 -4.8

SIDE SCAN CHART:
- Featureless Sand
- Silty Mud
- Stones/Large Objects
- Mega-ripples
- Sand Ridges
- Boulders>1m, ID
- Vibrocores, ID
- CABLE w. KP VALUES
- (x.x) Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Late Glacial
- Top Glacial

NOTES:

NAVIGATIONAL SYSTEMS

Primary System : AD Navigation dc-201 (Long range RTK-GPS)
Motion Sensor : TSS DMS2-05
Secondary System : SAGITTA (DGPS)
Gyro/HPR Sensor : Seatex MRUS

ACOUSTIC SYSTEMS

Echosounder : Multi beam Kongsberg EM3002D
: Single beam Reson Navisound 200
Side Scan Sonar : Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp : Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker : GEO-Spark 200
Magnetometer : Geometrics G-882

SOUND VELOCITY

Sound Velocity : SVP-SMART

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LAESOE CABLE CORRIDOR
ROUTE SURVEY
APRIL - MAY 2010

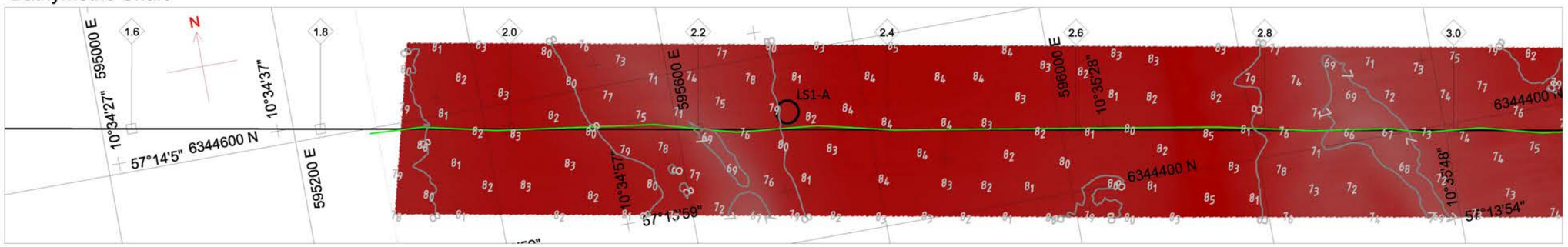
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	For Clients Approval & Distribution	KXM	NNP	KAE	17-03-11
C	For Clients Comment	KXM	NNP	KAE	04-03-11
B	For Internal QC	KXM	ADEA	TEB	02-03-11
A	Empty Chart	KXM	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation Chart, Profile Chart, CPT/VC Chart and As Laid - Chart 01 of 14.
Scale (A3 paper) 1:5000

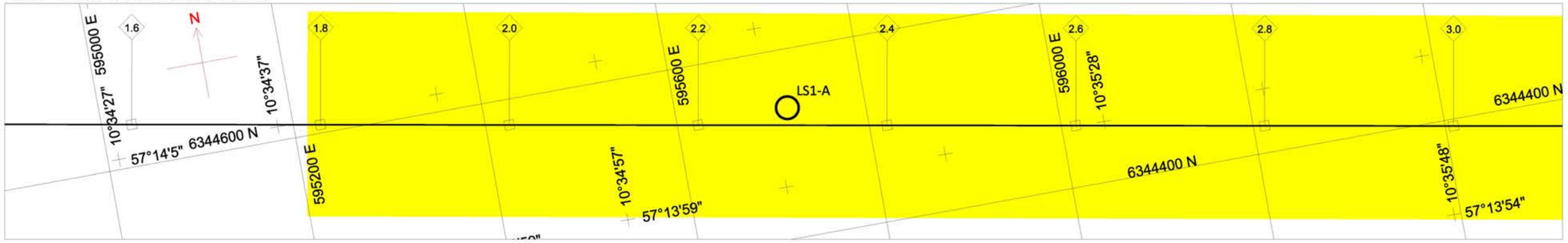
Drawn KXM	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Laesoe Corridor Cable

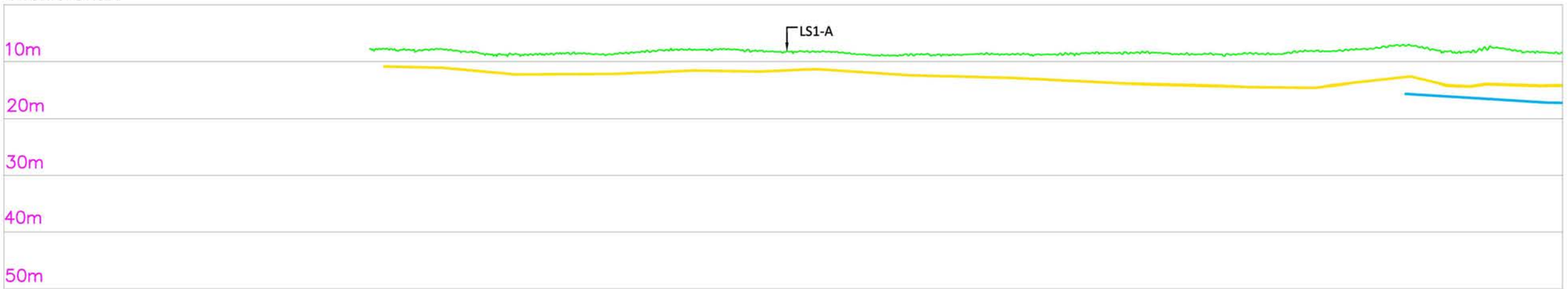
Bathymetric Chart



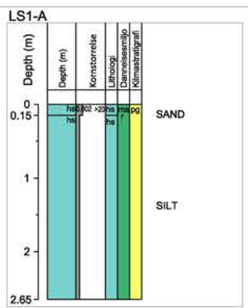
Side Scan Observation Chart



Profile Chart



CPT / Vibrocore Profile



As laid / Service Chart

KEYMAP 1:500000

COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth Curves (5m to 23m)
- Track of depicted Profile
- (x.x) Indicates Cable Length (x.x) in km from start

COLOUR CODES (Seabed level (m))

-23.8 -20.0 -16.2 -12.4 -8.6 -4.8

SIDE SCAN CHART:
- Featureless Sand
- Silty Mud
- Stones/Large Objects
- Mega-ripples
- Sand Ridges
- Boulders>1m, ID
- Vibrocores, ID
- CABLE w. KP VALUES
- (x.x) Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Late Glacial
- Top Glacial

NOTES:

NAVIGATIONAL SYSTEMS
Primary System : AD Navigation dc-201 (Long range RTK-GPS)
Motion Sensor : TSS DMS2-05
Secondary System : SAGITTA (DGPS)
Gyro/HPR Sensor : Seatex MRUS

ACOUSTIC SYSTEMS
Echosounder : Multi beam Kongsberg EM3002D
: Single beam Reson Navisound 200
Side Scan Sonar : Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp : Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker : GEO-Spark 200
Magnetometer : Geometrics G-882

SOUND VELOCITY
Sound Velocity : SVP-SMART

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LAESOE CABLE CORRIDOR
ROUTE SURVEY
APRIL - MAY 2010

Rev.	Description	Drawn	Chkd.	Appr.	Date
0	For Clients Approval & Distribution	KXM	NNP	KAE	17-03-11
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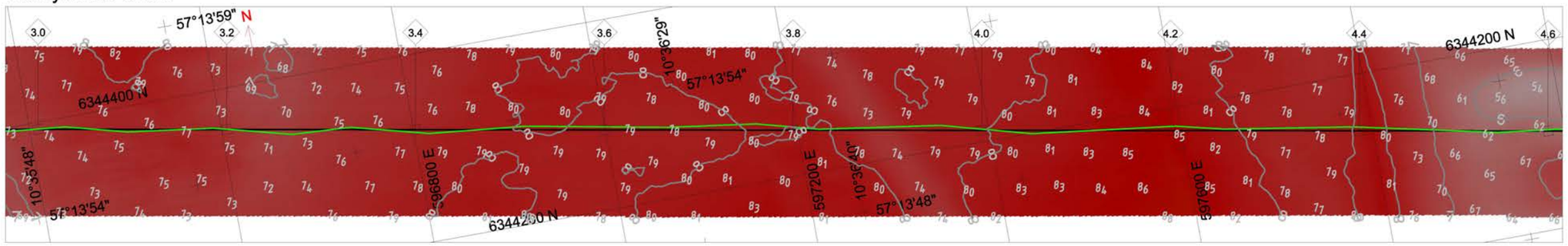
B	For Internal QC	KXM	ADEA	TEB	02-03-11
A	Empty Chart	KXM	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation Chart, Profile Chart, CPT/VC Chart and As Laid - Chart 02 of 14.
Scale (A3 paper) 1:5000

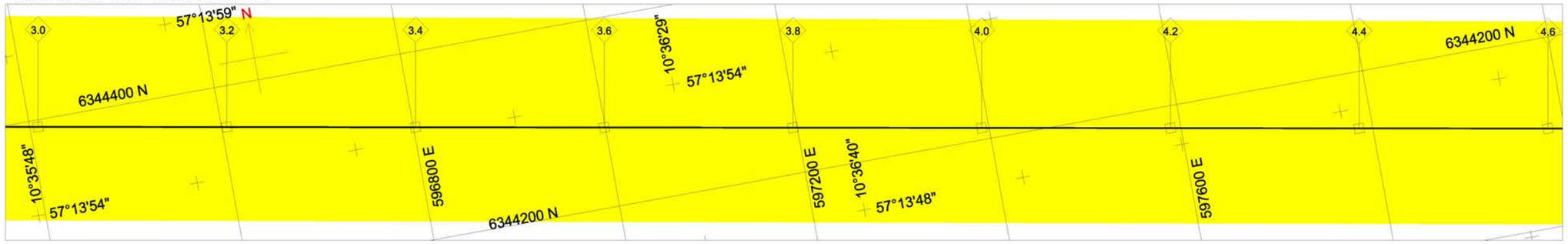
Drawn KXM	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Laesoe Corridor Cable

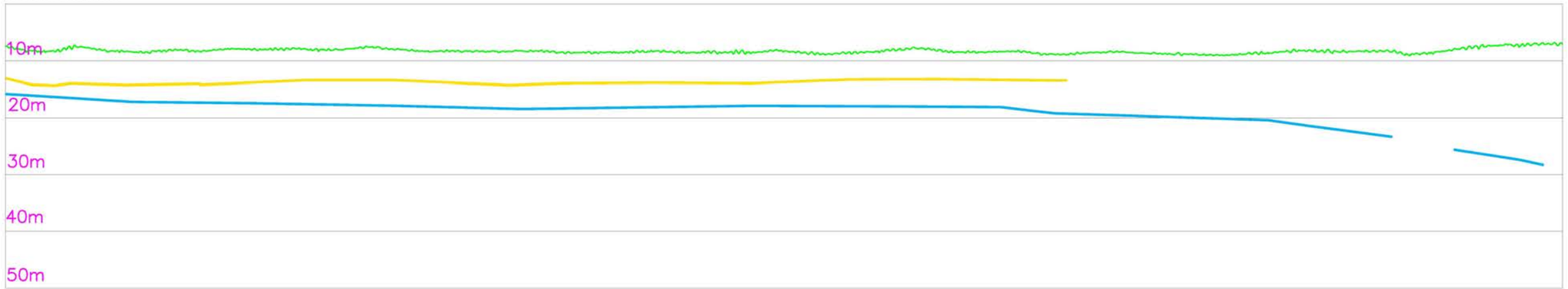
Bathymetric Chart



Side Scan Observation Chart



Profile Chart



CPT / Vibrocore Profile

As laid / Service Chart

KEYMAP 1:500000

COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth Curves (5m to 23m)
- Track of depicted Profile
- (x.x) Indicates Cable Length (x.x) in km from start

COLOUR CODES (Seabed level (m))

-23.8 -20.0 -16.2 -12.4 -8.6 -4.8

SIDE SCAN CHART:
- Featureless Sand
- Silty Mud
- Stones/Large Objects
- Mega-ripples
- Sand Ridges
- Boulders>1m, ID
- Vibrocores, ID
- CABLE w. KP VALUES
- (x.x) Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Late Glacial
- Top Glacial

NOTES:

NAVIGATIONAL SYSTEMS

Primary System	: AD Navigation dc-201 (Long range RTK-GPS)
Motion Sensor	: TSS DMS2-05
Secondary System	: SAGITTA (DGPS)
Gyro/HPR Sensor	: Seatex MRUS

ACOUSTIC SYSTEMS

Echosounder	: Multi beam Kongsberg EM3002D
	: Single beam Reson Navisound 200
Side Scan Sonar	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker	: GEO-Spark 200
Magnetometer	: Geometrics G-882

SOUND VELOCITY

Sound Velocity	: SVP-SMART

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LAESOE CABLE CORRIDOR
ROUTE SURVEY
APRIL - MAY 2010

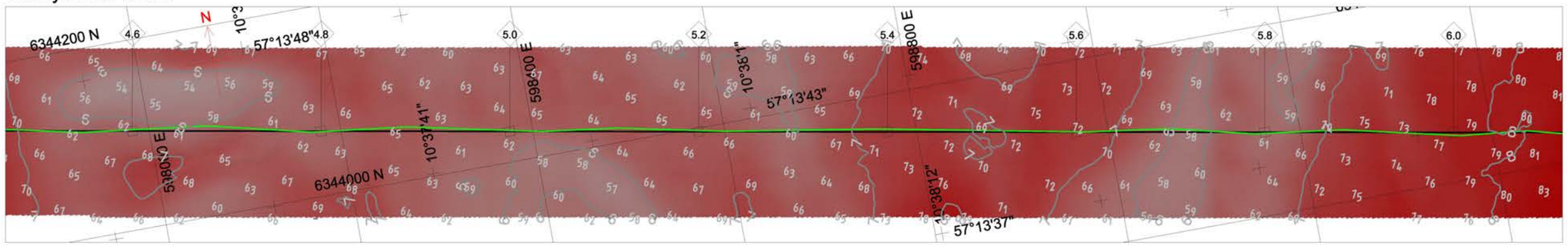
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	For Clients Approval & Distribution	KXM	NNP	KAE	17-03-11
C	For Clients Comment	KXM	NNP	KAE	04-03-11
B	For Internal QC	KXM	ADEA	TEB	02-03-11
A	Empty Chart	KXM	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation Chart, Profile Chart, CPT/VC Chart and As Laid - Chart 03 of 14.
Scale (A3 paper) 1:5000

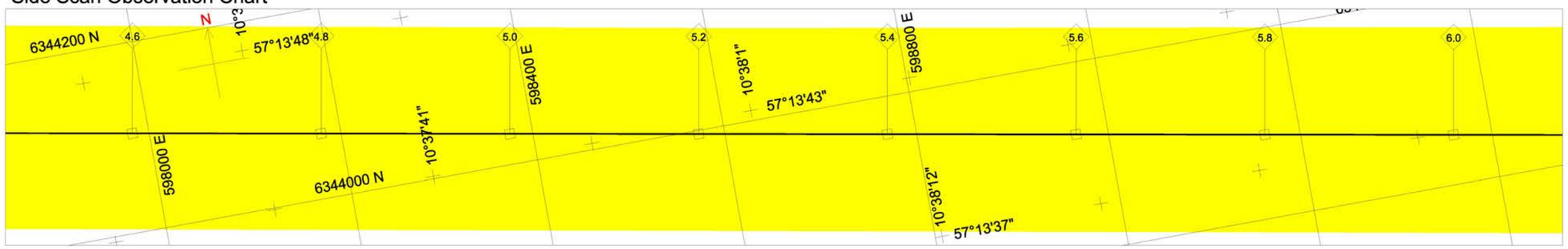
Drawn KXM	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Laesoe Corridor Cable

Bathymetric Chart



Side Scan Observation Chart



Profile Chart

CPT / Vibrocore Profile

As laid / Service Chart

KEYMAP 1:500000

COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth Curves (5m to 23m)
- Track of depicted Profile
- (x.x) Indicates Cable Length (x.x) in km from start

COLOUR CODES (Seabed level (m))

-23.8 -20.0 -16.2 -12.4 -8.6 -4.8

SIDE SCAN CHART:
- Featureless Sand
- Silty Mud
- Stones/Large Objects
- Mega-ripples
- Sand Ridges
- Boulders>1m, ID
- Vibrocores, ID
- CABLE w. KP VALUES
- (x.x) Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Late Glacial
- Top Glacial

NOTES:

NAVIGATIONAL SYSTEMS

Primary System : AD Navigation dc-201 (Long range RTK-GPS)
Motion Sensor : TSS DMS2-05
Secondary System : SAGITTA (DGPS)
Gyro/HPR Sensor : Seatex MRUS

ACOUSTIC SYSTEMS

Echosounder : Multi beam Kongsberg EM3002D
: Single beam Reson Navisound 200
Side Scan Sonar : Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp : Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker : GEO-Spark 200
Magnetometer : Geometrics G-882

SOUND VELOCITY

Sound Velocity : SVP-SMART

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LAESOE CABLE CORRIDOR
ROUTE SURVEY
APRIL - MAY 2010

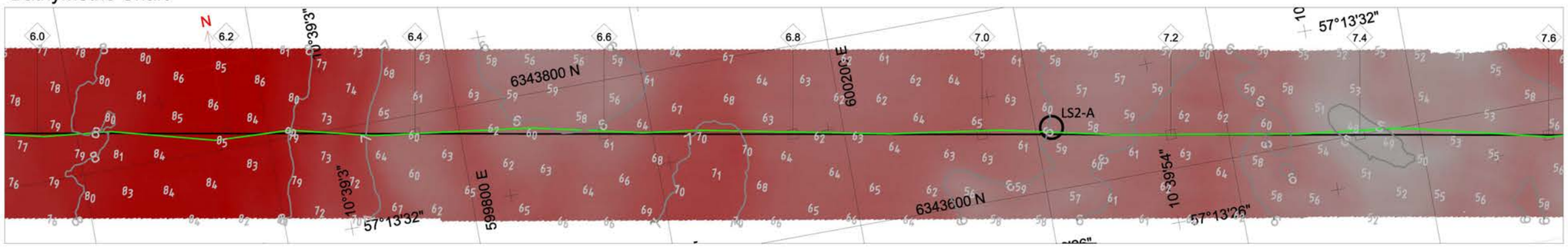
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	For Clients Approval & Distribution	KXM	NNP	KAE	17-03-11
C	For Clients Comment	KXM	NNP	KAE	04-03-11
B	For Internal QC	KXM	ADEA	TEB	02-03-11
A	Empty Chart	KXM	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation Chart, Profile Chart, CPT/VC Chart and As Laid - Chart 04 of 14.
Scale (A3 paper) 1:5000

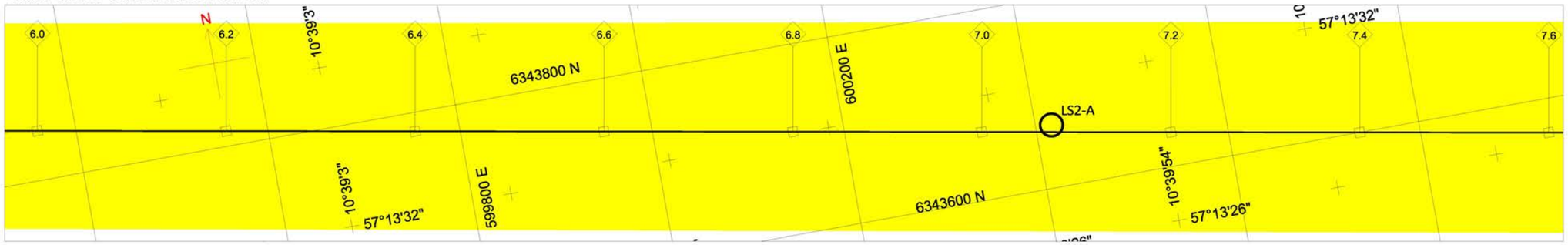
Drawn KXM	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Laesoe Corridor Cable

Bathymetric Chart

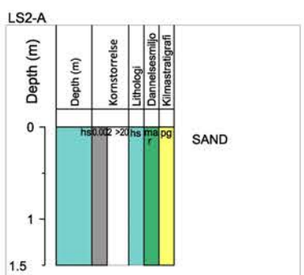


Side Scan Observation Chart



Profile Chart

CPT / Vibrocore Profile



As laid / Service Chart

KEYMAP 1:500000

COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth Curves (5m to 23m)
- Track of depicted Profile
- (x.x) Indicates Cable Length (x.x) in km from start

COLOUR CODES (Seabed level (m))

-23.8 -20.0 -16.2 -12.4 -8.6 -4.8

SIDE SCAN CHART:
- Featureless Sand
- Silty Mud
- Stones/Large Objects
- Mega-ripples
- Sand Ridges
- Boulders>1m, ID
- Vibrocores, ID
- CABLE w. KP VALUES
- (x.x) Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Late Glacial
- Top Glacial

NOTES:

NAVIGATIONAL SYSTEMS

Primary System	: AD Navigation dc-201 (Long range RTK-GPS)
Motion Sensor	: TSS DMS2-05
Secondary System	: SAGITTA (DGPS)
Gyro/HPR Sensor	: Seatex MRUS

ACOUSTIC SYSTEMS

Echosounder	: Multi beam Kongsberg EM3002D
	: Single beam Reson Navisound 200
Side Scan Sonar	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker	: GEO-Spark 200
Magnetometer	: Geometrics G-882

SOUND VELOCITY

Sound Velocity	: SVP-SMART

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LAESOE CABLE CORRIDOR ROUTE SURVEY APRIL - MAY 2010

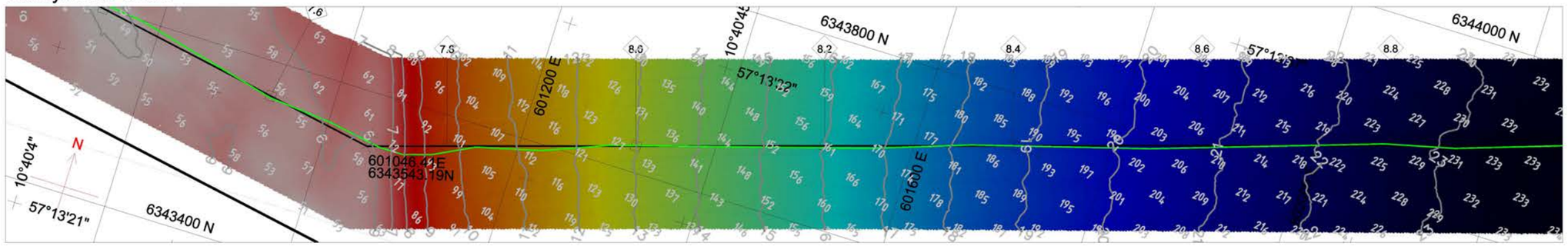
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	For Clients Approval & Distribution	KXM	NNP	KAE	17-03-11
C	For Clients Comment	KXM	NNP	KAE	04-03-11
B	For Internal QC	KXM	ADEA	TEB	02-03-11
A	Empty Chart	KXM	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation Chart, Profile Chart, CPT/VC Chart and As Laid - Chart 05 of 14.
Scale (A3 paper) 1:5000

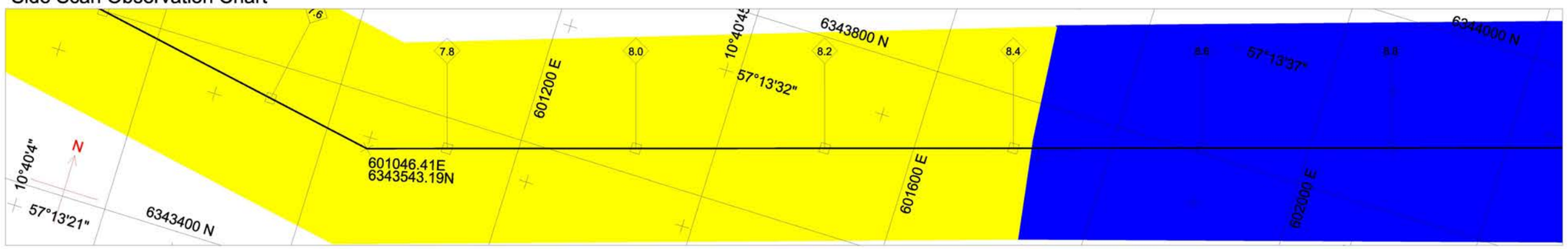
Drawn KXM	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Laesoe Corridor Cable

Bathymetric Chart



Side Scan Observation Chart

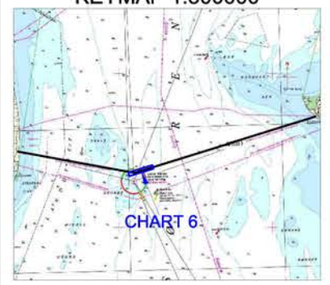


Profile Chart

CPT / Vibrocore Profile

As laid / Service Chart

KEYMAP 1:500000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth Curves (5m to 23m)
- Track of depicted Profile
- (x.x) Indicates Cable Length (x.x) in km from start

COLOUR CODES (Seabed level (m))

-23.8 -20.0 -16.2 -12.4 -8.6 -4.8

SIDE SCAN CHART:
- Featureless Sand
- Silty Mud
- Stones/Large Objects
- Mega-ripples
- Sand Ridges
- Boulders>1m, ID
- Vibrocores, ID
- CABLE w. KP VALUES
- (x.x) Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Late Glacial
- Top Glacial

NOTES:

NAVIGATIONAL SYSTEMS
Primary System : AD Navigation dc-201 (Long range RTK-GPS)
Motion Sensor : TSS DMS2-05
Secondary System : SAGITTA (DGPS)
Gyro/HPR Sensor : Seatex MRUS

ACOUSTIC SYSTEMS
Echosounder : Multi beam Kongsberg EM3002D
: Single beam Reson Navisound 200
Side Scan Sonar : Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp : Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker : GEO-Spark 200
Magnetometer : Geometrics G-882

SOUND VELOCITY
Sound Velocity : SVP-SMART

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LAESOE CABLE CORRIDOR
ROUTE SURVEY
APRIL - MAY 2010

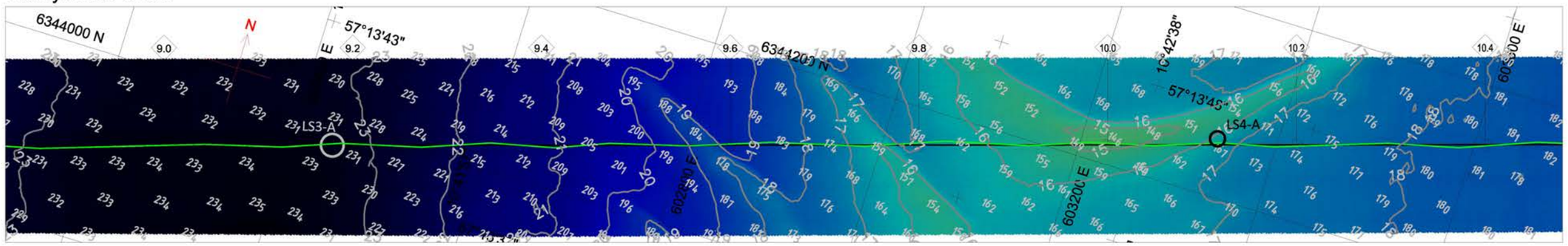
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	For Clients Approval & Distribution	KXM	NNP	KAE	17-03-11
C	For Clients Comment	KXM	NNP	KAE	04-03-11
B	For Internal QC	KXM	ADEA	TEB	02-03-11
A	Empty Chart	KXM	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation Chart, Profile Chart, CPT/VC Chart and As Laid - Chart 06 of 14.
Scale (A3 paper) 1:5000

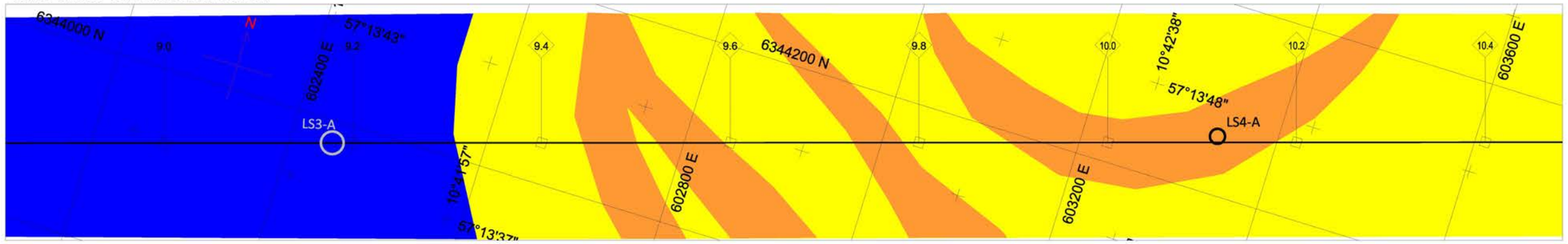
Drawn KXM	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Geo Job No. XXXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Laesoe Corridor Cable

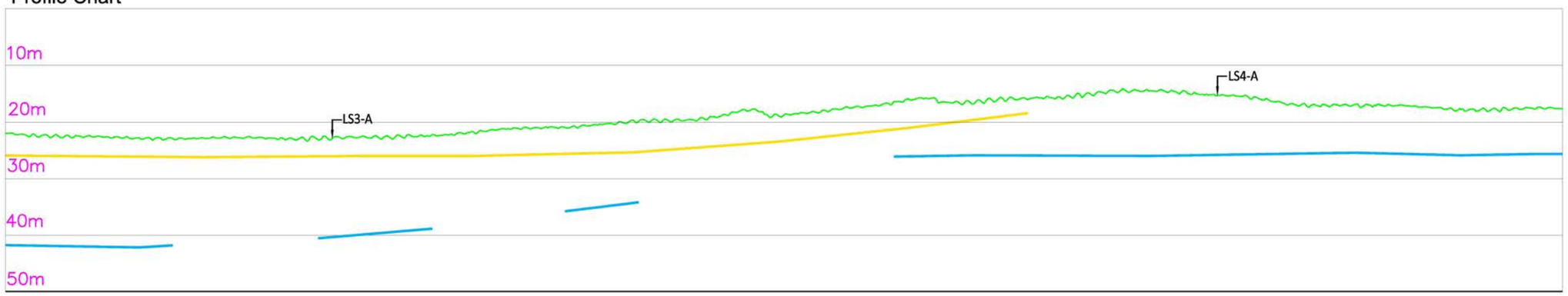
Bathymetric Chart



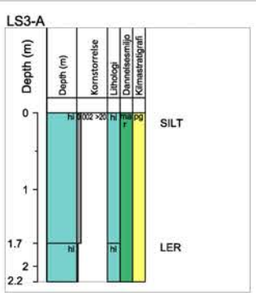
Side Scan Observation Chart

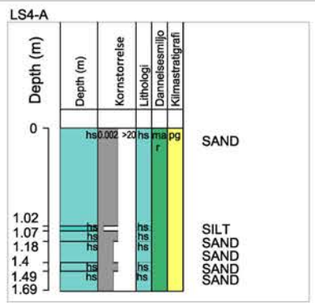


Profile Chart



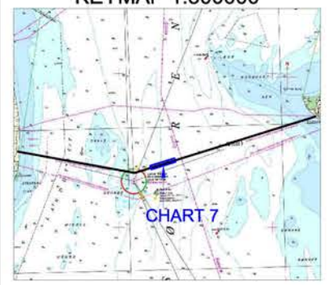
CPT / Vibrocore Profile





As laid / Service Chart

KEYMAP 1:500000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth Curves (5m to 23m)
- Track of depicted Profile
- xx Indicates Cable Length (x.x) in km from start

COLOUR CODES (Seabed level (m))

-23.8 -20.0 -16.2 -12.4 -8.6 -4.8

SIDE SCAN CHART:
- Featureless Sand
- Silty Mud
- Stones/Large Objects
- Mega-ripples
- Sand Ridges
- xx Boulders>1m, ID
- LSxx Vibrocores, ID
- CABLE w. KP VALUES
- xx

PROFILE CHART
- Seabed
- Top Late Glacial
- Top Glacial

NOTES:

NAVIGATIONAL SYSTEMS

Primary System	: AD Navigation dc-201 (Long range RTK-GPS)
Motion Sensor	: TSS DMS2-05
Secondary System	: SAGITTA (DGPS)
Gyro/HPR Sensor	: Seatex MRUS

ACOUSTIC SYSTEMS

Echosounder	: Multi beam Kongsberg EM3002D
	: Single beam Reson Navisound 200
Side Scan Sonar	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker	: GEO-Spark 200
Magnetometer	: Geometrics G-882

SOUND VELOCITY

Sound Velocity	: SVP-SMART

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LAESOE CABLE CORRIDOR
ROUTE SURVEY
APRIL - MAY 2010

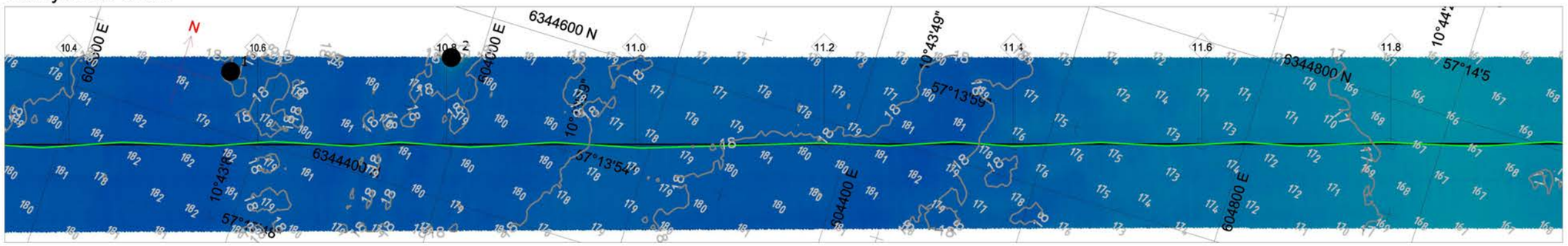
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	For Clients Approval & Distribution	KXM	NNP	KAE	17-03-11
C	For Clients Comment	KXM	NNP	KAE	04-03-11
B	For Internal QC	KXM	ADEA	TEB	02-03-11
A	Empty Chart	KXM	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation Chart, Profile Chart, CPT/VC Chart and As Laid - Chart 07 of 14.
Scale (A3 paper) 1:5000

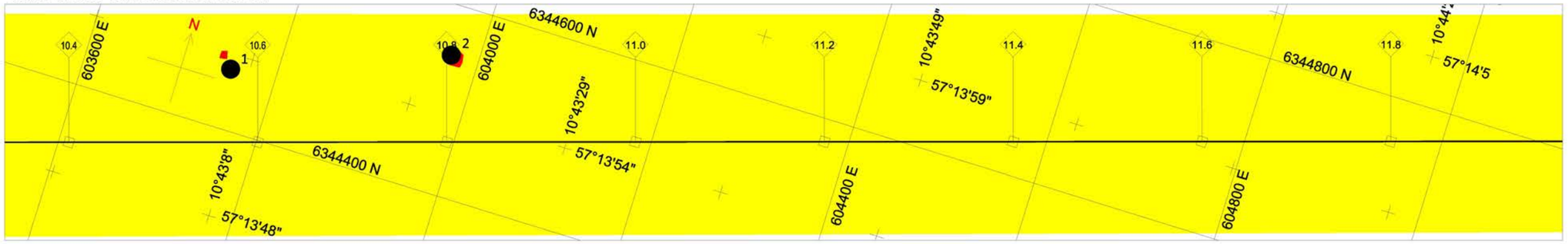
Drawn	Date		
KXM	2011-03-17		
Interp.	Date		
NNP	2011-01-20		
Checked	Date		
NNP	XXXX-XX-XX		
Approved	Date	Geo Job No.	
KAE	XXXX-XX-XX	XXXXXXX	
Client		Encl. No.	
ENERGINET.DK		XXXX	

Laesoe Corridor Cable

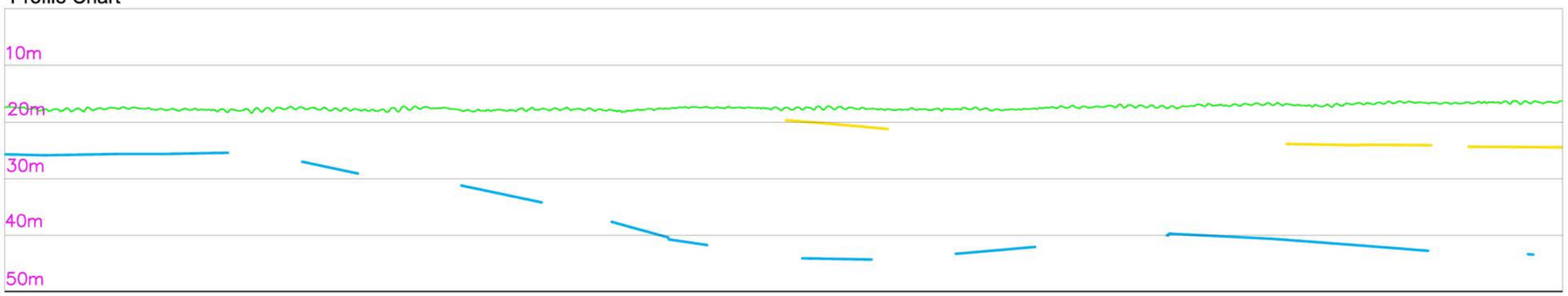
Bathymetric Chart



Side Scan Observation Chart



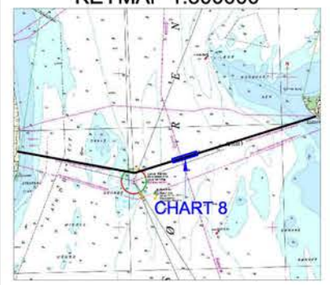
Profile Chart



CPT / Vibrocore Profile

As laid / Service Chart

KEYMAP 1:500000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth Curves (5m to 23m)
- Track of depicted Profile
- (x.x) Indicates Cable Length (x.x) in km from start

COLOUR CODES (Seabed level (m))

-23.8 -20.0 -16.2 -12.4 -8.6 -4.8

SIDE SCAN CHART:
- Featureless Sand
- Silty Mud
- Stones/Large Objects
- Mega-ripples
- Sand Ridges
- (xx) (usx) Boulders>1m, ID
- Vibrocores, ID
- CABLE w. KP VALUES
- (x.x) Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Late Glacial
- Top Glacial

NOTES:

NAVIGATIONAL SYSTEMS

Primary System	: AD Navigation dc-201 (Long range RTK-GPS)
Motion Sensor	: TSS DMS2-05
Secondary System	: SAGITTA (DGPS)
Gyro/HPR Sensor	: Seatex MRUS

ACOUSTIC SYSTEMS

Echosounder	: Multi beam Kongsberg EM3002D
	: Single beam Reson Navisound 200
Side Scan Sonar	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker	: GEO-Spark 200
Magnetometer	: Geometrics G-882

SOUND VELOCITY

Sound Velocity	: SVP-SMART

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LAESOE CABLE CORRIDOR
ROUTE SURVEY
APRIL - MAY 2010

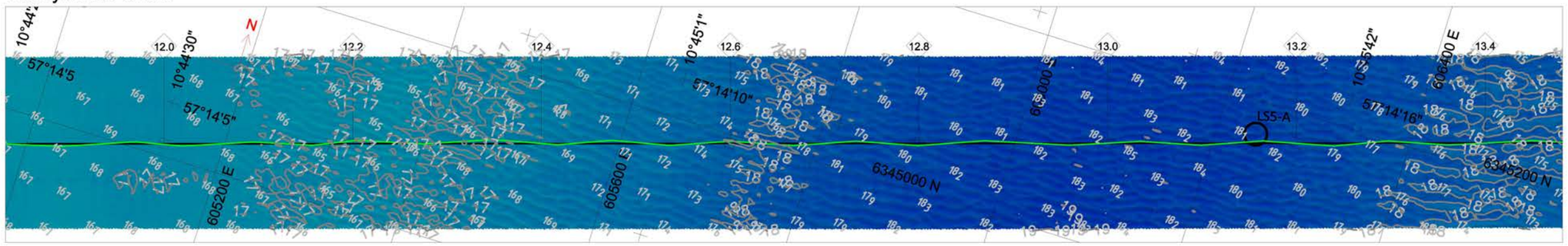
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	For Clients Approval & Distribution	KXM	NNP	KAE	17-03-11
C	For Clients Comment	KXM	NNP	KAE	04-03-11
B	For Internal QC	KXM	ADEA	TEB	02-03-11
A	Empty Chart	KXM	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation Chart, Profile Chart, CPT/VC Chart and As Laid - Chart 08 of 14.
Scale (A3 paper) 1:5000

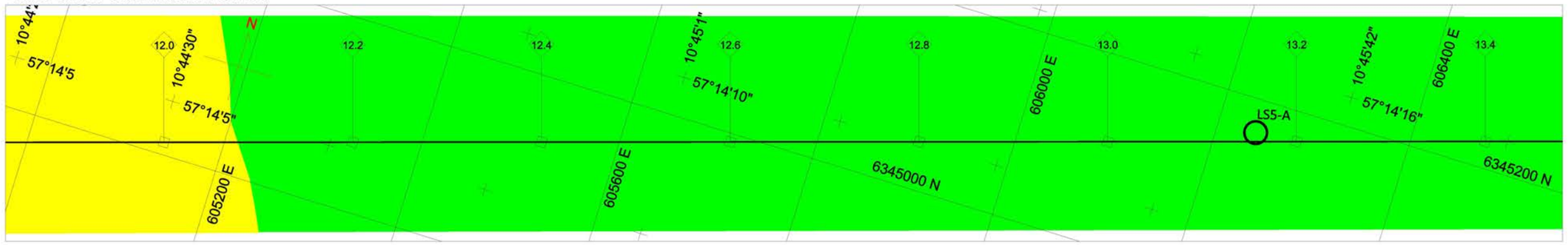
Drawn KXM	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Laesoe Corridor Cable

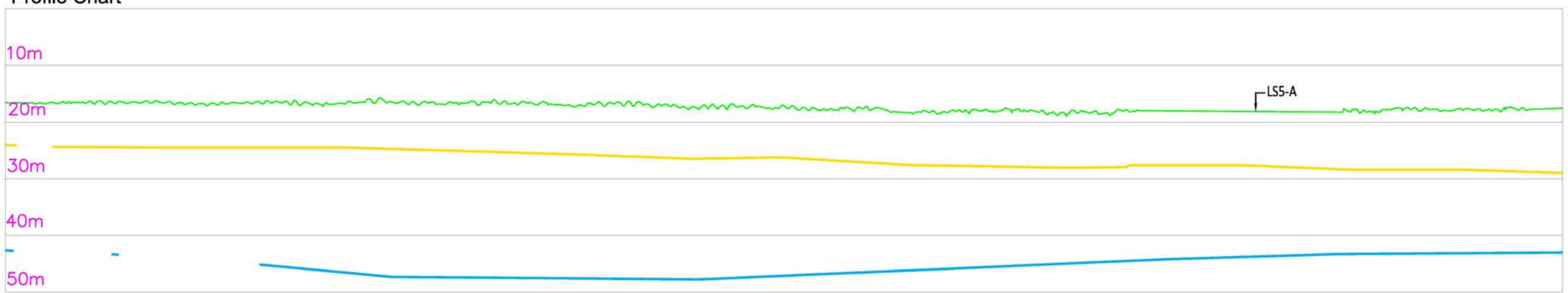
Bathymetric Chart



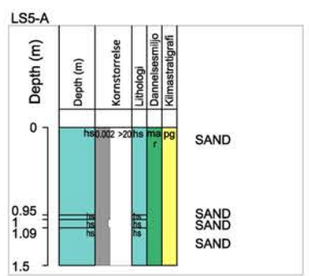
Side Scan Observation Chart



Profile Chart



CPT / Vibrocore Profile



As laid / Service Chart

KEYMAP 1:500000

COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth Curves (5m to 23m)
- Track of depicted Profile
- (x.x) Indicates Cable Length (x.x) in km from start

COLOUR CODES (Seabed level (m))

-23.8 -20.0 -16.2 -12.4 -8.6 -4.8

SIDE SCAN CHART:
- Featureless Sand
- Silty Mud
- Stones/Large Objects
- Mega-ripples
- Sand Ridges
- Boulders>1m, ID
- Vibrocores, ID
- CABLE w. KP VALUES
- (x.x) Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Late Glacial
- Top Glacial

NOTES:

NAVIGATIONAL SYSTEMS

Primary System	: AD Navigation dc-201 (Long range RTK-GPS)
Motion Sensor	: TSS DMS2-05
Secondary System	: SAGITTA (DGPS)
Gyro/HPR Sensor	: Seatex MRUS

ACOUSTIC SYSTEMS

Echosounder	: Multi beam Kongsberg EM3002D
	: Single beam Reson Navisound 200
Side Scan Sonar	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker	: GEO-Spark 200
Magnetometer	: Geometrics G-882

SOUND VELOCITY

Sound Velocity	: SVP-SMART

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LAESOE CABLE CORRIDOR ROUTE SURVEY APRIL - MAY 2010

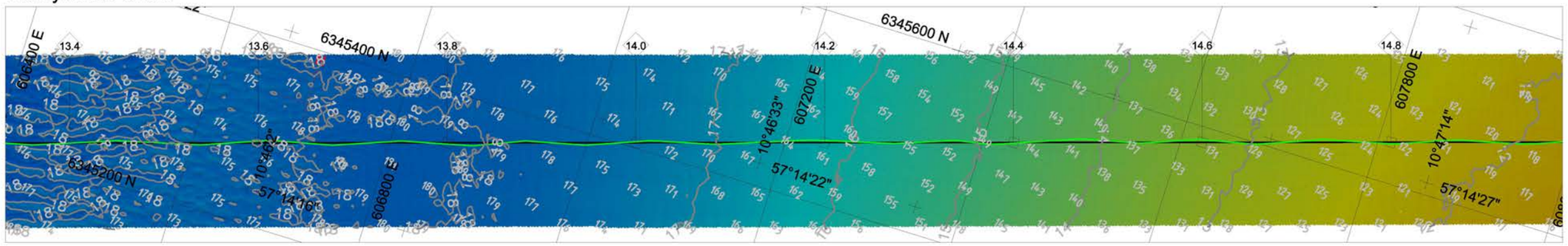
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	For Clients Approval & Distribution	KXM	NNP	KAE	17-03-11
C	For Clients Comment	KXM	NNP	KAE	04-03-11
B	For Internal QC	KXM	ADEA	TEB	02-03-11
A	Empty Chart	KXM	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation Chart, Profile Chart, CPT/VC Chart and As Laid - Chart 09 of 14.
Scale (A3 paper) 1:5000

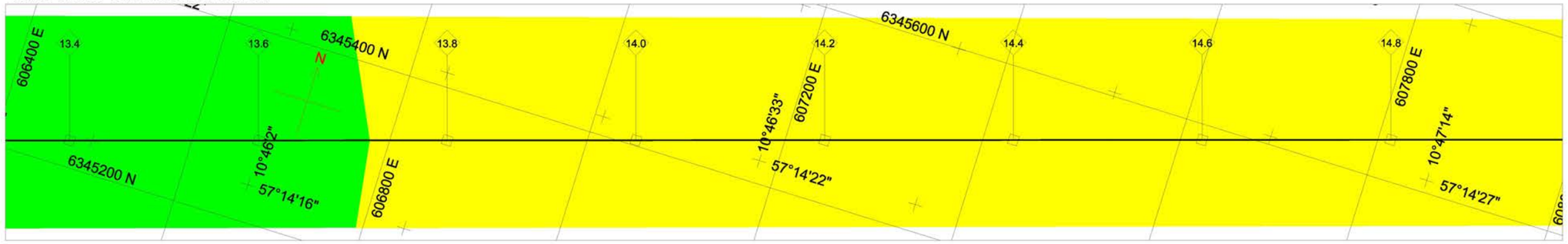
Drawn	KXM	Date	2011-03-17
Interp.	NNP	Date	2011-01-20
Checked	NNP	Date	XXXX-XX-XX
Approved	KAE	Date	XXXX-XX-XX
Geo Job No.	XXXXXXX		
Client	ENERGINET.DK	Encl. No.	XXXX

Laesoe Corridor Cable

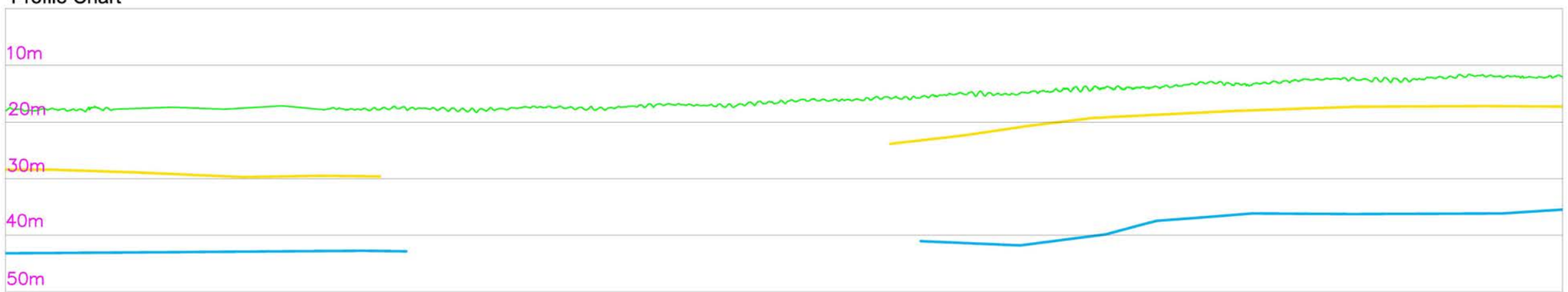
Bathymetric Chart



Side Scan Observation Chart



Profile Chart



CPT / Vibrocore Profile

As laid / Service Chart

KEYMAP 1:500000

COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth Curves (5m to 23m)
- Track of depicted Profile
- (x.x) Indicates Cable Length (x.x) in km from start

COLOUR CODES (Seabed level (m))

-23.8 -20.0 -16.2 -12.4 -8.6 -4.8

SIDE SCAN CHART:
- Featureless Sand
- Silty Mud
- Stones/Large Objects
- Mega-ripples
- Sand Ridges
- (XX) Boulders>1m, ID
- (USX) Vibrocores, ID
- CABLE w. KP VALUES
- (x.x) Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Late Glacial
- Top Glacial

NOTES:

NAVIGATIONAL SYSTEMS

Primary System	: AD Navigation dc-201 (Long range RTK-GPS)
Motion Sensor	: TSS DMS2-05
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ACOUSTIC SYSTEMS

Echosounder	: Multi beam Kongsberg EM3002D
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Chirp	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker	: GEO-Spark 200
Magnetometer	: Geometrics G-882

SOUND VELOCITY

Sound Velocity	: SVP-SMART

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LAESOE CABLE CORRIDOR
ROUTE SURVEY
APRIL - MAY 2010

Rev.	Description	Drawn	Chkd.	Appr.	Date
0	For Clients Approval & Distribution	KXM	NNP	KAE	17-03-11
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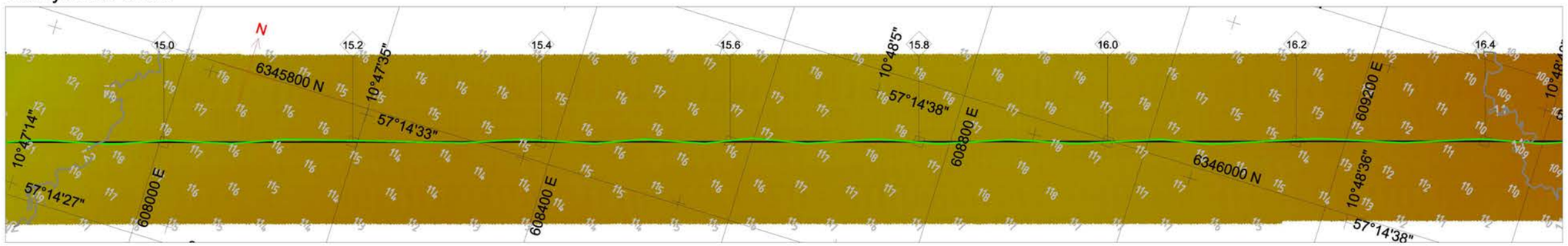
B	For Internal QC	KXM	ADEA	TEB	02-03-11
A	Empty Chart	KXM	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation Chart, Profile Chart, CPT/VC Chart and As Laid - Chart 10 of 14.
Scale (A3 paper) 1:5000

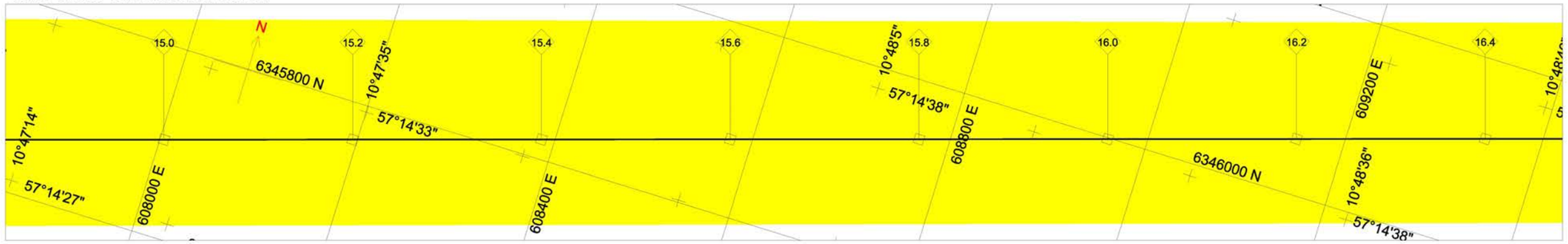
Drawn KXM	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Laesoe Corridor Cable

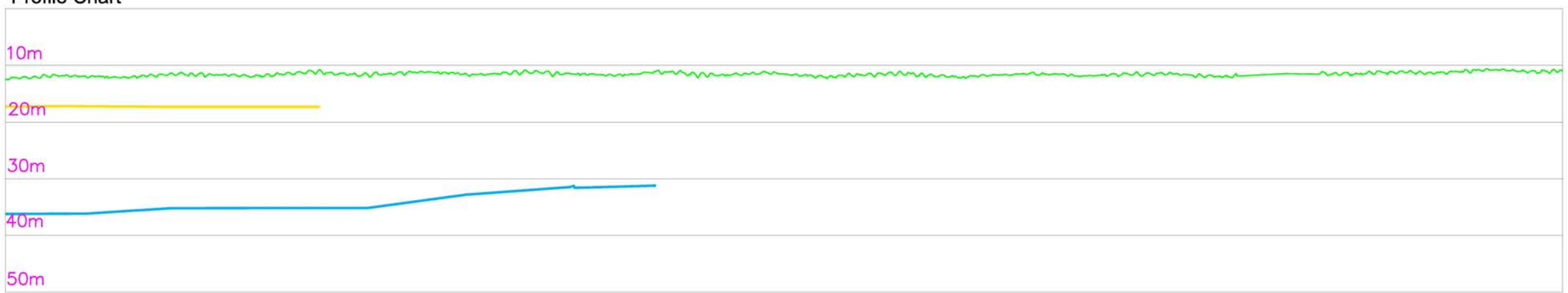
Bathymetric Chart



Side Scan Observation Chart



Profile Chart



CPT / Vibrocore Profile

As laid / Service Chart

KEYMAP 1:500000

COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

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- CABLE w. KP VALUES
- Depth Curves (5m to 23m)
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SIDE SCAN CHART:
- Featureless Sand
- Silty Mud
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- Mega-ripples
- Sand Ridges
- Boulders>1m, ID
- Vibrocores, ID
- CABLE w. KP VALUES
- (x.x) Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Late Glacial
- Top Glacial

NOTES:

NAVIGATIONAL SYSTEMS

Primary System	: AD Navigation dc-201 (Long range RTK-GPS)
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Sparker	: GEO-Spark 200
Magnetometer	: Geometrics G-882

SOUND VELOCITY

Sound Velocity	: SVP-SMART

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LAESOE CABLE CORRIDOR
ROUTE SURVEY
APRIL - MAY 2010

Rev.	Description	Drawn	Chkd.	Appr.	Date
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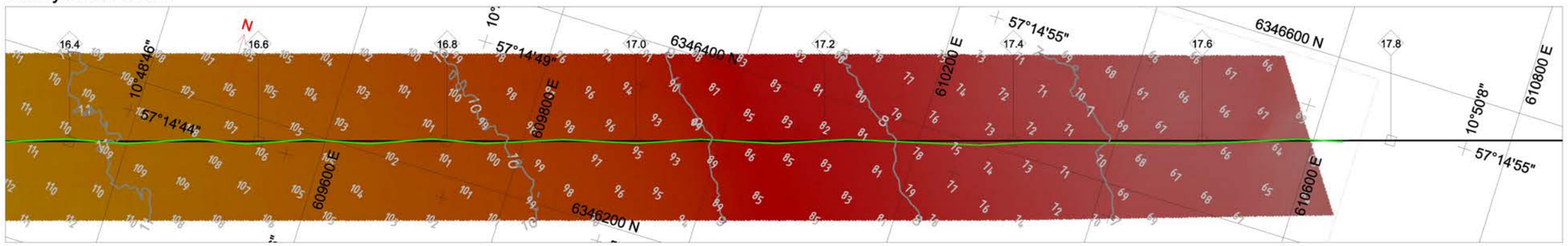
Bathymetric Chart, Side Scan Observation Chart, Profile Chart, CPT/VC Chart and As Laid - Chart 11 of 14.
Scale (A3 paper) 1:5000

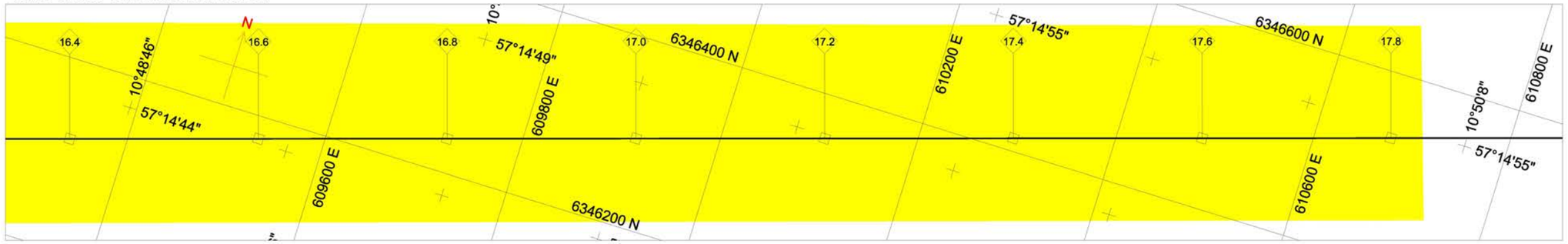
Drawn KXM	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Laesoe Corridor Cable

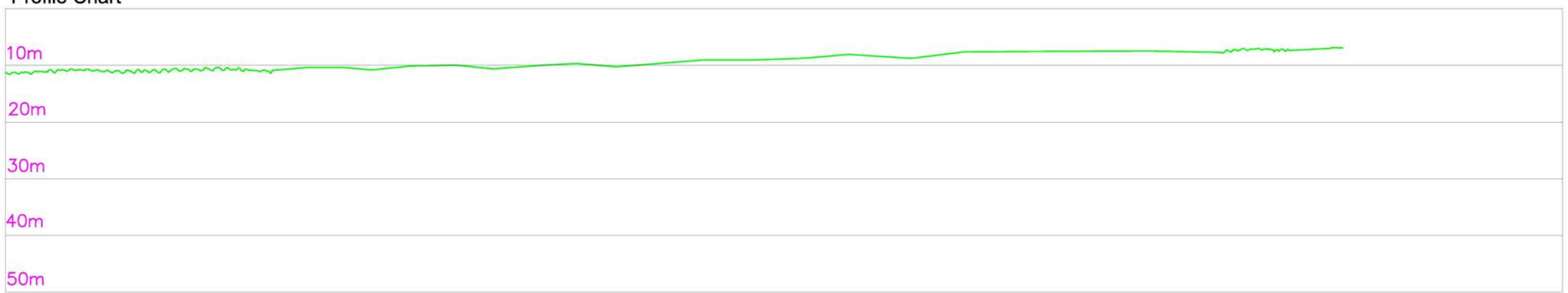
Bathymetric Chart



Side Scan Observation Chart



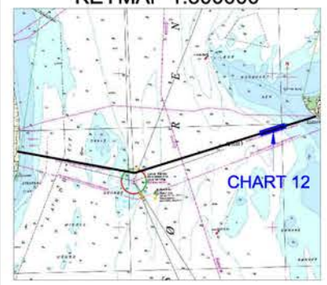
Profile Chart



CPT / Vibrocore Profile

As laid / Service Chart

KEYMAP 1:500000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth Curves (5m to 23m)
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COLOUR CODES (Seabed level (m))

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SIDE SCAN CHART:
- Featureless Sand
- Silty Mud
- Stones/Large Objects
- Mega-ripples
- Sand Ridges
- Boulders>1m, ID
- Vibrocores, ID
- CABLE w. KP VALUES
- (x.x) Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Late Glacial
- Top Glacial

NOTES:

NAVIGATIONAL SYSTEMS

Primary System	: AD Navigation dc-201 (Long range RTK-GPS)
Motion Sensor	: TSS DMS2-05
Secondary System	: SAGITTA (DGPS)
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	: Single beam Reson Navisound 200
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Chirp	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker	: GEO-Spark 200
Magnetometer	: Geometrics G-882

SOUND VELOCITY

Sound Velocity	: SVP-SMART

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LAESOE CABLE CORRIDOR
ROUTE SURVEY
APRIL - MAY 2010

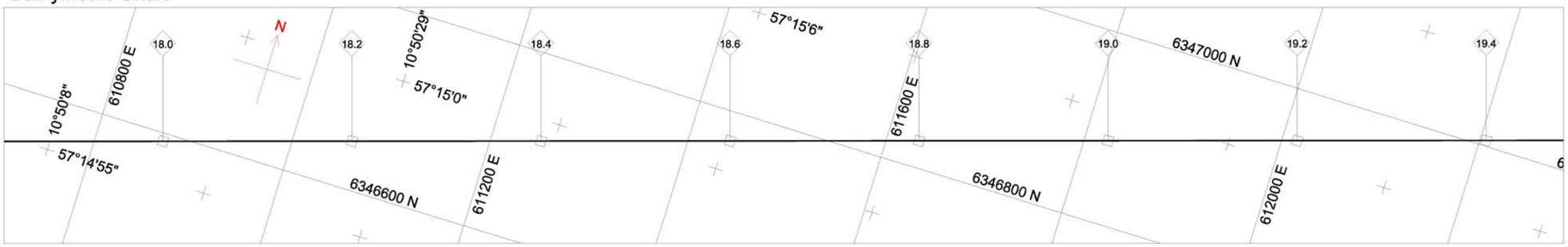
Rev.	Description	Drawn	Chkd.	Appr.	Date
0	For Clients Approval & Distribution	KXM	NNP	KAE	17-03-11
C	For Clients Comment	KXM	NNP	KAE	04-03-11
B	For Internal QC	KXM	ADEA	TEB	02-03-11
A	Empty Chart	KXM	NNP	KAE	22-02-11

Bathymetric Chart, Side Scan Observation Chart, Profile Chart, CPT/VC Chart and As Laid - Chart 12 of 14.
Scale (A3 paper) 1:5000

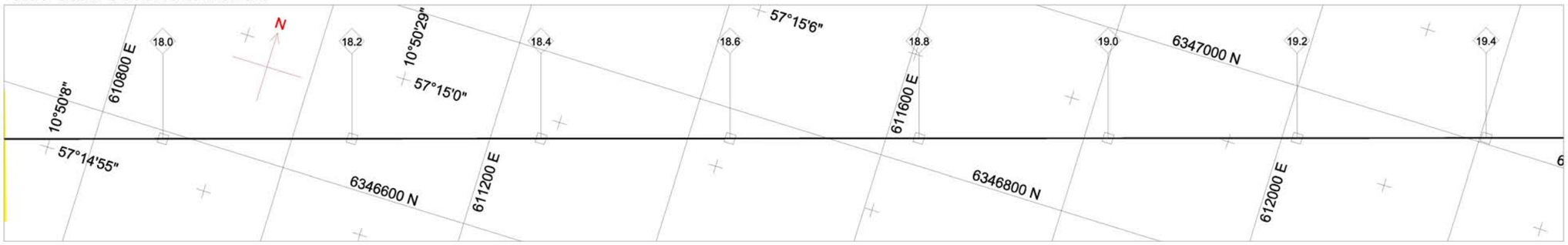
Drawn KXM	Date 2011-03-17		
Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
Approved KAE	Date XXXX-XX-XX	Ceo Job No. XXXXXXX	
Client ENERGINET.DK			Encl. No. XXXX

Laesoe Corridor Cable

Bathymetric Chart



Side Scan Observation Chart



Profile Chart

10m

20m

30m

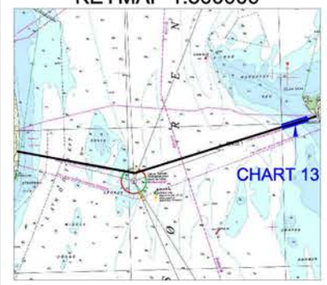
40m

50m

CPT / Vibrocore Profile

As laid / Service Chart

KEYMAP 1:500000



COORDINATE SYSTEM:

DATUM : EUREF 89 (WGS 84)
PROJECTION: UTM Zone 32 North
DEPTHS : In meters reduced to DVR-90

LEGEND:

BATHYMETRIC CHART:
- CABLE w. KP VALUES
- Depth Curves (5m to 23m)
- Track of depicted Profile
- (x.x) Indicates Cable Length (x.x) in km from start

COLOUR CODES (Seabed level (m))

-23.8 -20.0 -16.2 -12.4 -8.6 -4.8

SIDE SCAN CHART:
- Featureless Sand
- Silty Mud
- Stones/Large Objects
- Mega-ripples
- Sand Ridges
- Boulders>1m, ID
- Vibrocores, ID
- CABLE w. KP VALUES
- Indicates Cable Length (x.x) in km from start

PROFILE CHART
- Seabed
- Top Late Glacial
- Top Glacial

NOTES:

NAVIGATIONAL SYSTEMS

Primary System	: AD Navigation dc-201 (Long range RTK-GPS)
Motion Sensor	: TSS DMS2-05
Secondary System	: SAGITTA (DGPS)
Gyro/HPR Sensor	: Seatex MRUS

ACOUSTIC SYSTEMS

Echosounder	: Multi beam Kongsberg EM3002D
	: Single beam Reson Navisound 200
Side Scan Sonar	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Chirp	: Teledyne Benthos SIS-1625/TTV290 Tow fish
Sparker	: GEO-Spark 200
Magnetometer	: Geometrics G-882

SOUND VELOCITY

Sound Velocity	: SVP-SMART

A3 Paper Size Scale 1:5000

50 0 50 100 150 200

GEUS RAMBØLL ENERGINET.DK

LAESOE CABLE CORRIDOR
ROUTE SURVEY
APRIL - MAY 2010

Rev.	Description	Drawn	Chkd.	Appr.	Date
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Bathymetric Chart, Side Scan Observation Chart, Profile Chart, CPT/VC Chart and As Laid - Chart 13 of 14.
Scale (A3 paper) 1:5000

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Interp. NNP	Date 2011-01-20		
Checked NNP	Date XXXX-XX-XX		
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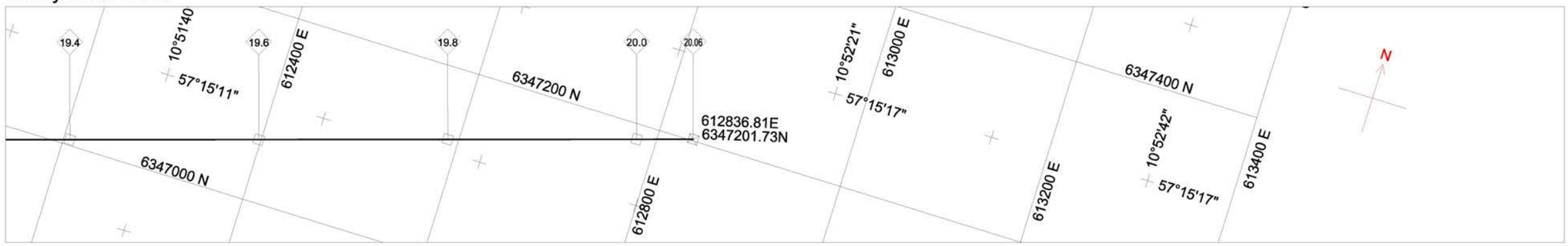
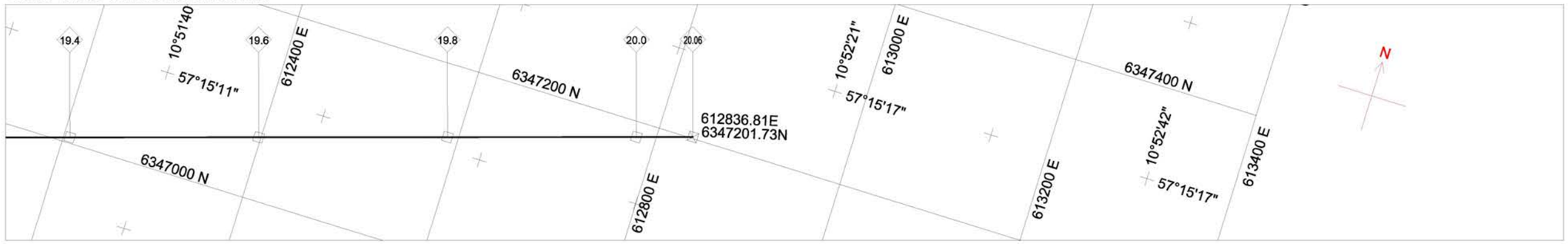
Client ENERGINET.DK			Encl. No. XXXX

Laesoe Corridor Cable

Bathymetric Chart



Side Scan Observation Chart



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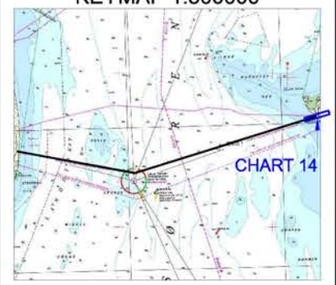

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Approved KAE	Date XXXX-XX-XX	Geo Job No. XXXXXXX	
Client ENERGINET.DK			Encl. No. XXXX