Scope of Work

Research survey aimed at exploration of seafloor massive sulphides in the area of the Mid-Atlantic Ridge covered by the Contract between the Republic of Poland and the International Seabed Authority.

Polish Geological Institute – National Research Institute

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ABBREVIATIONS:

AUV	Autonomous underwater vehicle
C-O	Computed minus observed
CRP	Common Reference Point
CTD	Conductivity/Temperature/Density
CUBE	Combined Uncertainty and Bathymetry Estimator
DGPS	Differential Global Positioning System
DPR	Daily Progress Report
DPS	Dynamic Positioning System
DRS	Document Release Schedule
DTM	Digital terrain models
EGNOSS	European Geostationary Navigation Overlay Service
ERP	Emergency Response Plan
FTU	Formazine Turbidity Units
GLONASS	Globalnaja Nawigacionnaja Sputnikowaja Sistiema
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
HDOP	Horizontal dilution of precision
HSSE	Health, Safety, Security & Environment
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer
ISA	International Seabed Authority
KP	Kilometer Point
LAT	Lowest astronomical tide
MAR	Mid-Atlantic Ridge
MAPR	Minimal Autonomous Plume Recorder
MARPOL	International Convention for the Prevention of Pollution from Ships
MBES	Multibeam echosounder
MRU	Motion reference units
MSL	mean sea level
MSVP	Moving sound velocity profiler
nT	nano Tesla (magnetic field units)
NTU	Nephelometric Turbidity Units
ORP	Oxidation-reduction potential

QA/QC	Quality Assurance/Quality Control
PGI-NRI	Polish Geological Institute – National Research Institute
PP areas	Potential prospective areas
PPP	Precise Point Positioning
RAIM	Receiver autonomous integrity monitoring
ROV	remotely operated vehicle
SBP	Sub-bottom Profiler
SMS	Seafloor massive sulphides
SOLAS	International Convention for the Safety of Life at Sea
SoW	Scope of Work
SVS	Sound velocity sensor
SVP	Sound velocity profile(r)
Tow-yo	Towed see-sawing transects
TPU	Total propagated uncertainty
TVG	Time varying gain
UNCLOS	United Nations Convention on the Law of the Sea
USBL	Ultra-short baseline acoustic positioning system
UTM	Universal Transverse Mercator
WAAS	Wide Area Augmentation System
WCD	Water column data
WGS	World Geodetic System
WOA13	World Ocean Atlas 2013
XBT	Expendable bathythermograph

DEFNITIONS:

Whenever the term "Ordering Party" is used in this SoW it shall mean the Polish Geological Institute – National Research Institute.

Whenever the term "Ordering Party's Delegates" is used in this SoW it shall mean both the Ordering Party's Authorised Person and the Chief Geoscientist.

Whenever the term "Ordering Party's Cruise Participants" is used in this SoW it shall mean eight (8) persons nominated by the Ordering Party to be present on board the veseel provided by the Contractor and to take part in the research survey covered by this SoW, including two (2) trainees from developing states selected by the ISA as well as the Ordering Party's Delegates.

1. INTRODUCTION

1.1. Context

The Polish Geological Institute - National Research Institute (PGI-NRI) for over 100 years has been carrying out tasks in geology for the benefit of the Polish State. The Institute fulfils the polish geological survey's functions and ensures monitoring of the geological environment, provides early warning of natural hazards and secures national security in mineral resources management.

Given the above, the Chief National Geologist (Ministry of Climate and Environment of the Republic of Poland) entrusted PGI-NRI with the implementation of preparatory works and organisation of a comprehensive research survey in the Atlantic Ocean, under the provisions and scope of the first five-year term of the Contract with ISA.

The overall goal of the entire exploration program is collecting data on the location and characterisation of seafloor massive sulphides (SMS) deposits along the Mid-Atlantic Ridge, covered by the Contract between the Minister of the Environment of the Republic of Poland and the International Seabed Authority (ISA), on 12 February 2018 in London (M.P. of 2018, item 481).

1.2. Exploration area

The research area is located within the northern part of the Mid-Atlantic Ridge between the area covered by the Portuguese application on the extension of the continental shelf, and the French (IFREMER) contracted research area. The area consists of 100 exploration blocks (each 10x10 km in size) divided into five clusters (A-E) with a total area of 10,000 km^2 (Fig. 1). The coordinates of the exploration blocks can be found at the end of this document.

The months of June – July – August are requested as the best working time in the area.

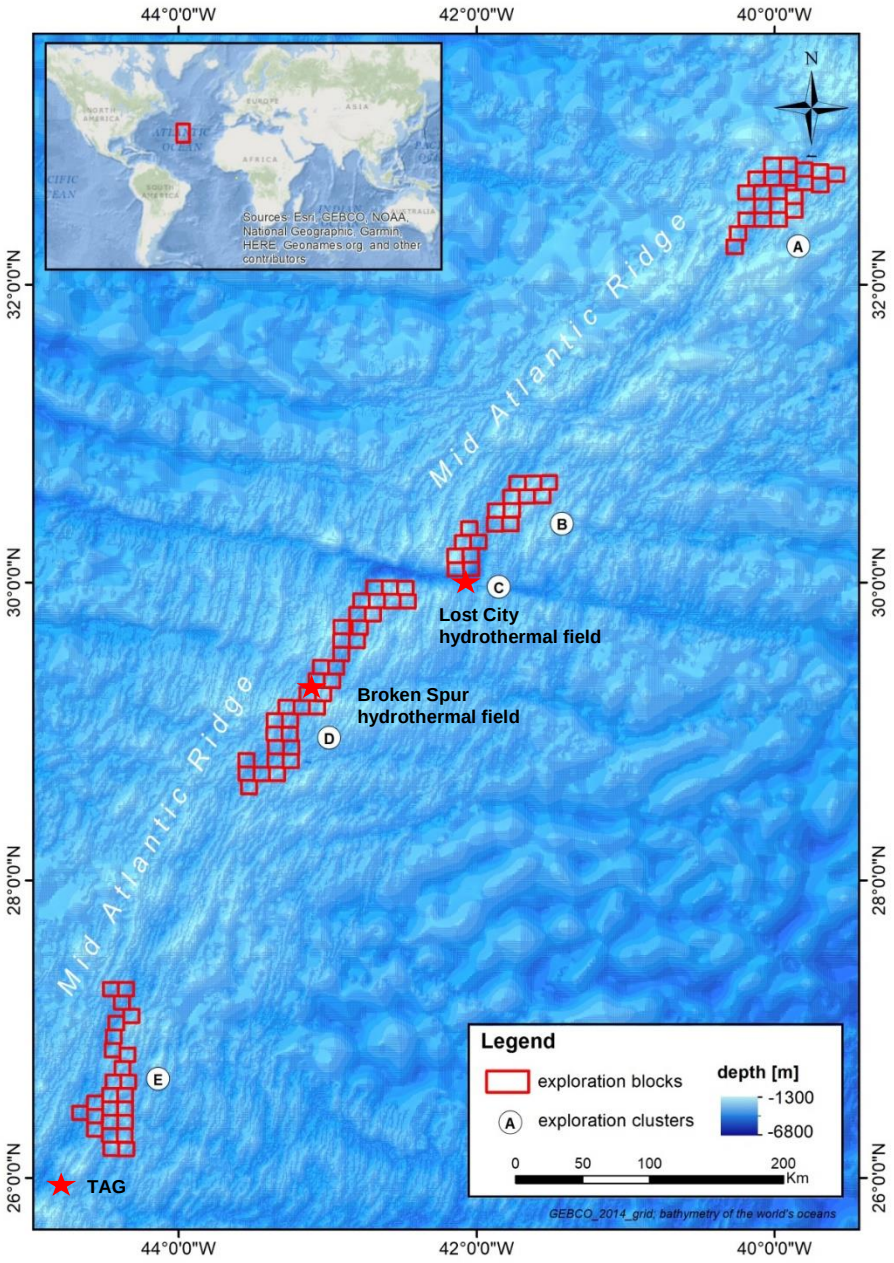

Fig. 1. Location and distribution of the exploration blocks.

Ocean depths in the study area range from 800 to 4700 m. 68% of the study area is in depths of 2500 to 4700 m. More details of the depth ranges are shown in Figure 2.

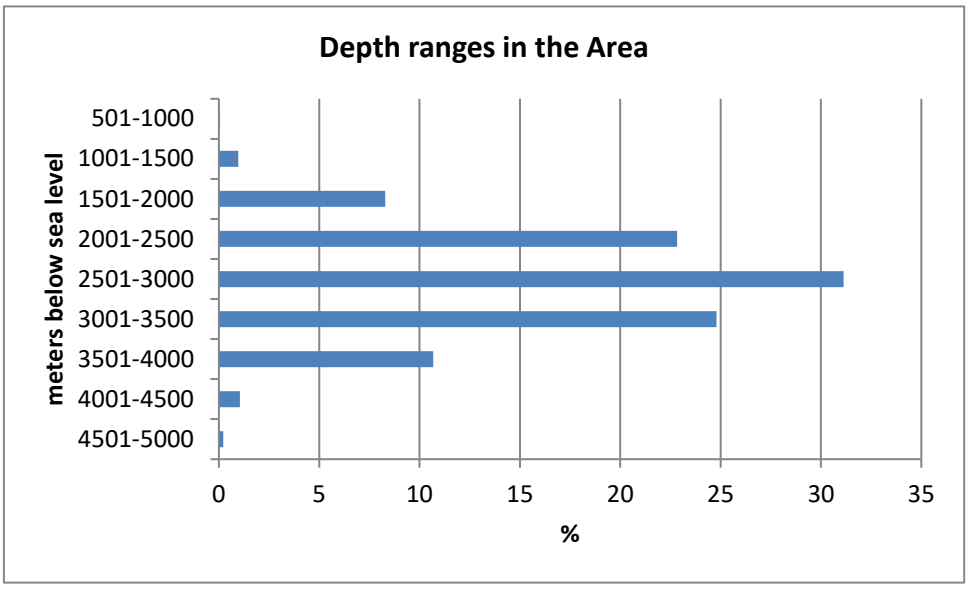

Fig. 2. Depth ranges within the exploration blocks.

1.3. Objectives & general research plan

The planned survey results from implementing the Contract research programme approved by the ISA, subdivided into three subsequent five-year periods. Three separate research cruises to the research area are scheduled for the first five-year exploration period:

- regional exploration of the contracted area (reconnaissance; Leg 1):
- detailed exploration of prospective areas (Leg 2);
- environmental (baseline) studies, including but not limited to the sites with hydrothermal activity and/or SMS deposits (Leg 3).

Current proceedings and Scope of Work (SoW) relate exclusively to the execution of the regional exploration (Leg 1).

The main objective of the planned research survey (Leg 1) is regional recognition of the research area by acquiring the seabed and water column data. The obtained information can indicate areas favourable for hydrothermal activity and associated SMS deposits (hydrothermally active and inactive) based on which potential prospective (PP) areas will be selected. These PP areas shall be considered for further detailed exploration to confirm the presence and characterise hydrothermal systems and SMS deposits, including oceanographical, geological and biological sampling (Leg 2 & Leg 3).

The Leg 1 survey is expected to be divided into two phases (depending on the final approach):

- Phase I: dedicated to ship-borne and/or towed-based acquisition of geophysical data from the entire research area and onboard processing to identify and characterise different morphological features as potential favourable areas for hydrothermal activity and SMS occurrence. In addition, constant profiling of the water column intensity (acoustic reverberation) to identify hydrothermal plumes.

- Phase II: dedicated to continuous real-time profiling of physico-chemical parameters (markers) of the water column to identify/confirm hydrothermal fluxes along the Mid Atlantic Ridge (MAR) and sites preselected during Phase I. Survey shall be complemented by additional high-resolution MBES profiling's and allow conclusions about the distribution of PP areas.

PP areas identified within Leg 1, followed by detailed onshore interpretations, will be verified and characterised during Leg 2 by detailed geophysical surveying with advances of autonomous underwater vehicle (AUV) as well as geological observations and sampling by remotely operated vehicle (ROV). Confirmed sites of hydrothermal activity and/or SMS occurrence will be subjected to detailed oceanographic and biological studies during Leg 3. These studies should be supplemented by monitoring stations with a 50x50 km grid.

The data and research material collected during the research survey will be used for the quantitative and qualitative assessment of SMS deposits, preliminary evaluation of the (discovered) deposits economic potential, and assessment of the environmental impact of further activities.

2. GENERAL CONTRACTOR OBLIGATIONS

Research exploration concluded from comprehensive research service at the MAR must be designed and executed in accordance with the provisions of the Contract with ISA (available on: https://www.isa.org.jm/exploration-contracts/government-republic-poland and the guidelines, standards and regulations for area exploration and prospecting established by ISA, resulting from the provisions of United Nations Convention on the Law of the Sea (UNCLOS). The Contractor has to provide a project of the execution plan to be discussed and approved by the Ordering Party prior to mobilisation. The Project Execution Plan should

include but is not limited to reviewing the available knowledge about the study area, methodological approach, and work methodology that allow for identifying PP areas. The Project Execution Plan, subject to possible modifications during the survey, must be consulted with and approved by the Ordering Party. Planned surveys should be designed (and carried out) using the best available technology and knowledge, with care and attention to the reliability and quality of the data. Research activities in the area must be carried out with due regard for the crew's safety, equipment, and maximum environmental protection.

Additionally, the Contractor is obliged to:

- perform the Services in accordance with the applicable standards and law;
- support the permitting process, if required;
- fulfils obligations under the Contract and performs the SoW with reasonable care and diligence as well as with the skills expected from a professional Contractor specialised in the type of work involved;
- comply with all applicable laws, rules and regulations of any governmental or regulatory body having jurisdiction over the Scope of Work and the research area;
- ensure that all work methods required for the execution of the below activities shall be as cost-effective and practical as possible, optimising the performance (time and quality vs cost) of the Services;
- provide the Ordering Party's Cruise Participants with the required training and certificates necessary for participation in the research survey;
- shall clearly state port of mobilisation and demobilisation;
- be responsible for, including but not limited Health, Safety, Security and Environment (HSSE) and Quality Assurance/Quality Control (QA/QC) activities;
- include all costs for consumables (e.g. fuel, etc.) and all costs for personnel (e.g. travel expenses, lodging, etc.).

The provided vessel must have sufficient endurance, hold and maintain a valid class assssigned by a classification society which is a member of the International Association of Classification Societies (“IACS”) and be seaworthy in all respects, suitably equipped with all the necessary facilities/utilities for a cruise to and operations in Mid-Atlantic waters. The vessel should be provided with a Dynamic Positioning System (DPS) for deep ocean survey operations and systems for safe launch & recovery, towing, and data acquisitions. Condition and ship equipment must comply with all relevant IMO regulations, including the International

Convention for the Prevention of Pollution from Ships (MARPOL) and International Convention for the Safety of Life at Sea (SOLAS) conventions as well as in compliance with all the flag state requirements.

The provided vessel must be operated in accordance with a safety management system certified to comply with the International Safety Management Code ("ISM Code") for the Safe Operation of Ships and for Pollution Prevention.

At the date of mobilization of the provided vessel and throughout the service of the provided vessel for the purpouse of this Scope of Work:

(i) she shall have a full and efficient complement of master, officers and crew for a vessel of her tonnage, who shall in any event be not less than the number required by the laws of the flag state and who shall be trained to operate the vessel and her equipment competently and safely;

(ii) all shipboard personnel shall hold valid certificates of competence in accordance with the requirements of the law of the flag state;

(iii) all shipboard personnel shall be trained in accordance with the relevant provisions of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1995 or any additions, modifications or subsequent versions thereof;

(iv) there shall be on board sufficient personnel with a good working knowledge of the English language to enable the Scope of Work to be carried out efficiently and safely and to enable communications between the crew and the Ordering Party's Cruise Participants;

(v) the terms of employment of the vessel's staff and crew will always remain acceptable to The International Transport Worker's Federation and the vessel will at all times carry a Blue Card.

Throughout the service of the provided vessel for the purpouse of this Scope of Work the Contractor shall, whenever the passage of time, wear and tear or any event requires steps to be taken to maintain or restore the conditions stipulated above in this paragraph 2, exercise due diligence so to maintain or restore the provided vessel.

3. SURVEY EQUIPMENT

The Contractor is responsible for supplying the work site in due time with all the equipment and material required to execute the SoW detailed in the Contract. The Contractor mobilises all equipment (and necessary experienced personnel) to perform the SoW in accordance with the present specifications, the actual standards (i.e. ISA) and the state-of-the-art industry practice. The Contractor is entirely and only responsible for all means, methods, techniques, sequences and procedures and for coordinating all operations of the work under the Contract in coordination with the Ordering Party's Delegates present on board during the survey (i.e. client representative; chief scientific). Ordering Party's Authorised Person and the Chief Geoscientist). The Contractor may offer to the Ordering Party modification to the described scope and methods of data acquisition, providing higher accuracy, collection of additional data, adequate to meet the target at the proposed offered for the survey.

Necessary equipment should be the top-class solution of proven relevance to the planned research, all depth-rated at least 4000 m. All the material and equipment must be in ideal technical condition and well adapted to the tasks to be executed, including the following measurements and observations:

- Multibeam echosounder (MBES): bathymetry, acoustic backscatter, acoustic water column data (WCD);
- (chirp) Sub-bottom Profiler (SBP): characteristics of sediments and sub-surface layers;
- Magnetometer: magnetic anomalies;
- Plume detection (tow-yo): Conductivity/Temperature/Density (CTD-) / Minimal Autonomous Plume Recorder (MAPR-) based: profiling of physico-chemical parameters of the water column, i.e., conductivity (salinity), temperature, pressure, depth, pH, oxygen (O_2), methane (CH_4), hydrogen (H_2), turbidity, oxidation/reduction potential (ORP).

The choice of equipment remains the Contractor's responsibility. The Ordering Party's Delegates must approve the equipment before beginning the mobilisation (Project Execution Plan). The Contractor is also responsible for any delay caused by the unsuitability or the deficiency of machinery required to execute the work specified in the Contract. During the execution of the SoW, the Ordering Party can reject equipment that has been or is becoming unsuitable for the SoW.

4. PERSONNEL

The Contractor has to prove his dedicated personnel specialises in large, deep-water MBES projects, with onboard interpretation by experienced geo- or marine scientists in seafloor mapping, characterisation of seabed, morphologic and morphometric anasis as well as water column data interpretation and reporting, fluent in English. A complete list of dedicated personnel shall be provided with the tender and Project Execution Plan. The Contractor proves to have a robust workflow to handle the large quantity of data. Additionally, the Contractor must provide at least ten (10) places in single or double berth cabins for the Ordering Party's Cruise Participants (including two (2) trainees from developing states selected by the ISA as well as the Ordering Party's Delegates) and provide all with the necessary training, certificates and courses if required. The Contractor should inform the Ordering Party in advance of the requirements needed to enable unrestricted participation in the cruise and communicate the responsibilities of the Ordering Party's Cruise Participants. Ordering Party's Cruise Participants should be involved in the research work carried out onboard the vessel as part of the acquisition and processing (without interfering and influencing with the work carried out by the Contractor) and on the onshore party for detailed data interpretation. Ordering Party's Delegates should be involved in onboard decision making and planning for the next day's survey based on comprehensive interpretation of MBES, SBP, (magnetic) and oceanographic data.

4.1. Ordering Party's Delegates

The PGI-NRI reserve a right to appoint an external Ordering Party's Authorised Person for the offshore survey, including mobilisation and onboard activities for quality control and daily reporting to the PGI-NRI. The Ordering Party's Authorised Person will accept the certificates and approve the mobilisation reports. In addition, the Ordering Party's Authorised Person will be in charge of controlling the acquisition process and compliance of procedures, including quality control of the data collected and the data flow and archiving. In addition the PGI-NRI will designate the Chief Geoscientist for the offshore party. The Chief Geoscientist will be directly contacted and reported by the Contractor's project leader and the Ordering Party's Authorised Person on reports, certificates, the acquisition process, data quality, and overall work progress, etc. Evaluation and interpretation of the data shall results in adaptaion and modification of the research survey plan and necessary activities, if resoanable. Final decisions regarding survey plan and its modification rest with the Contractor's project leader.

5. CALIBRATION AND CERTIFICATION (MOBILISATION)

The Contractor should ensure valid certifications before starting offshore works for all equipment and sensors that are of significant importance for safety and data quality. Calibration of all survey equipment shall occur during the mobilisation phase to assess the accuracy of the survey systems. The Contractor shall present and submit the calibration results as reports of all survey equipment that detail all mobilisation and calibration activities. Provided data will be subjected to verification during mobilisation by a Ordering Party's Delegates, allowing proposed solutions based on the data obtained. It will include as a minimum:

- Dates, times and locations of verifications;
- Equipment used, including serial numbers where applicable;
- Relevant weather conditions;
- Statistical analysis of results;
- Offset diagrams;
- Resultant computed minus observed (C-Os) corrections and details of where they are applied.

To ensure the highest standard of data acquisition and interpretation over ISA contract areas for SMS deposits using dedicated equipment. The following information should be reported:

- The spatial relationship between all of the sensors in an MBES system with the vessel's frame of reference is paramount to obtain high resolution and accurate data;
- All installation offsets are required to be recorded and detailed within the survey report and processing log of the supplied raw data files;
- Horizontal and vertical offsets between the Differential Global Navigation Satellite System (DGNSS) antenna and transducer(s) shall be observed and applied with a precision better than 0.01 m.
- The onboard system setup shall include but not be limited to vessel drawing (layout) of all sensors (DGNSS antennas, motion reference units - MRU, MBES, ultra-short baseline acoustic positioning system – USBL, gyrocompass system, MBES Depth Sensor, Sound Velocity Sensor (SVS), magnetometer, CTD/MAPR sensors) top view and side view;
- 3D axis sign convention for heading, pitch, roll and heave;
- XYZ offset table for all sensors relative Common Reference Point (CRP), method, and estimated offsets accuracy.

The results of sensors misalignment calibrations before survey commence for the following sensors:

- Gyrocompass calibration (C-O value);
- MRU calibration C-O value for pitch and roll;
- DGNSS verification primary vs secondary;
- MBES patch test calibration (C-O for Yaw, Pitch, Roll and Latency);
- SBP calibration;
- Magnetometer calibration;
- USBL system calibration;
- Sensors for the analysis of physico-chemical parameters of the water column.

6. REQUIREMENTS FOR DATA ACQUISITION

In consultation with the Ordering Party, the Contractor is responsible for specific planning, acquisition, processing, and reporting considerations required for the exploration of SMS. Exploratory data shall be collected in a 'single pass operation' (phase I). Constant and real-time acquisition of the physico-chemical parameters of the water column (phase II), should be limited to the water column up to 500 m above the bottom. Phase II shall be supplemented by additional high-resolution MBES data. Method statements shall be included in the tender. Calibration certificates of the systems must be submitted for Ordering Party approval prior to completion of mobilisation.

6.1. Surface positioning, geodetic reference and datum

GNSS positioning by means of the Precise Point Positioning (PPP) standard will be the primary positioning system currently used for the hydrographic survey. The Global Positioning System (GPS) and Globalnaja Nawigacionnaja Sputnikowaja Sistiema (GLONASS) system should be utilised as a minimum. PPP corrections may be obtained using correction satellites for North Atlantic. In case the PPP corrections are not available, the Ordering Party may consider utilising the Wide Area Augmentation System/European Geostationary Navigation Overlay Service (WAAS/EGNOSS) corrections if available. Every time it should be accepted by the Ordering Party's Delegates . For position computations, the GNSS receiver(s) aboard the vessel will not consider satellites below eight (8) degrees above the horizon. The age of PPP corrections used in position computation must not exceed 60 seconds.

The horizontal datum will be World Geodetic System 84 (WGS84) and projection Universal Transverse Mercator (UTM). The datum parameters entered into the acquisition software will use the GNSS datum WGS84. Any datum shifts (if needed) shall be applied at the post-processing stage. The use of GNSS with Real-Time PPP as a positioning system is required for all acoustic data collection as we aim to resolve an absolute positional accuracy: horizontal accuracy < 10cm 95%, vertical <15cm 95%). All positioning data should be provided as track plots (in x, y, z format) to enable interpretation of the vessel transits. The quality control of the horizontal position will be performed all the time. Satellite geometry alone is not a sufficient statistic for determining horizontal positioning accuracy. Other variables, including semi-minor, semi-major ellipse axis, F-test value, receiver autonomous integrity monitoring (RAIM) age of corrections, must be used in conjunction with Horizontal dilution of precision (HDOP) to estimate horizontal positioning accuracy. A minimum of 8 satellites must be used to compute all positions. The position of both the survey vessel and equipment must be continuously monitored during the execution of the Scope of Work. The Contractor is responsible for the calibration of the positioning systems. Two independent positioning systems are to be provided, maintained and operated to determine the location of survey vessels and survey equipment. The secondary system shall be available both as a backup for the primary system and online quality assurance. The system shall provide updated corrections at better than 10-second intervals. The independent secondary system shall be operated in parallel with the primary system to provide full real-time redundancy. A continuous comparison between the position solutions derived from the primary and secondary systems shall be made throughout the survey.

Gyrocompass and MRU must provide full vessel heading, heave, pitch and roll corrections as input to vessel-mounted geophysical sensor offset positions. The gyrocompass and MRU shall be aligned to the vessel axes and calibrated to demonstrate proper sensing, alignment and application during mobilisation. All references to water depth shall be relative to mean sea level (MSL). The underwater positioning systems (USBL) shall be used for towed survey equipment.

6.2. MBES survey (bathymetry, acoustic backscatter and acoustic water column data)

The purpose of a hull-mounted deep-water MBES system(s) and topside electronics aboard the survey vessel is to acquire bathymetry, acoustic backscatter, and water column acoustic) anomalies data of the entire 100 exploration blocks of the research area. The bathymetry shall be used for general geological and identification and interpretation of morphological units and morphometric analysis, particularly on more hydrothermally prone regions. In addition, the

bathymetry is needed for a digital terrain model (DTM) to optimise the morphological analysis of key areas and to plan any near-seabed ROV or AUV work.
Backscatter data should provide information that geologists can interpret for relative changes in hardness and rugosity, both of which may be affected by hydrothermal activity and SMS deposition. These data shall be used to define the seabed classification map.
The water column intensity data (WCD) will be used to create imagery of objects in the water column, such as hydrothermal fluxes and seeps. They should allow interpretation of significant changes (anomalies) in acoustic reverberation in the water column, related to expected gas phases (bubble plumes) and/or potentially particle-rich hydrothermal plumes.
The Contractor shall suggest the most efficient line spacing and towing depth to ensure proper coverage and successful data acquisition. The setup of MBES survey lines shall cover the entire exploration area, i.e. line turns shall not be within the survey area. The Contractor shall divide the exploration area in reasonable multiple sub-areas and start processing collected data to visualise 3D models of the MBES bathymetry data in real-time during survey work to identify favourable areas (phase I) that can be investigated by the identification of physico-chemical anomalies of the water-related to hydrothermal plumes (CTD/MAPR) (phase II).

The bathymetric system shall be a long-range vessel-mounted MBES system capable of mapping the deepest points in the research area. This system shall include full quality control and data processing facilities capable of providing data binning statistics, final sounding density, geo-referenced XYZ data in digital format, contour maps and profiles. Soundings shall be corrected and compensated for variations in sound velocity, tide, ray bending and other environmental/atmospheric effects and referenced to the vertical survey datum. The sounding system should display real-time bathymetry and water column data to confirm data acquisition and preliminary bottom features. The speed is to be restricted such that the quality of the data gathered is not affected. The Contractor shall state the operating speeds of the vessel for all aspects of the operation and the subsequent resolution of the instruments at those maximum speeds. All the data coming from the heave compensator, gyrocompass and navigation (GNSS) should be time-flagged and interfaced with a navigation computer and MBES computer. The data quality across the entire swath must be sufficiently high to identify the geomorphological structures of interest with the exact high resolution.

The MBES system shall collect full-coverage bathymetry and backscatter and be optimised to work in depths between 600 and 6000 meters. The MBES package shall include minimum setup:

- GNSS with RT-PPP corrections navigation system;
- vessel motion sensing system (gyrocompass and MRU);
- capability to collect and process data needed for sound speed and refraction corrections of acoustic signals;
- sound velocity sensor (SVS) by the MBES head for proper beamforming;
- digiquartz depth sensor located at MBES head to log dynamic vessel draft changes;
- time synchronisation and integration of all the systems;
- the ability to process data onboard and produce plots suitable for real-time quality control and interpretation (daily progress reports).

During MBES survey operations, the following items will be logged by the online navigation system:

- Date/Time;
- Vessel position logs – GGA string, heading;
- Depth sensor;
- Kilometer Point (KP) along the survey runline (profile);
- Attitude (Pitch, Roll, Heave);
- Name of survey line and KP along the survey runline (profile);
- MBES data (including water column and backscatter), SBP data, Magnetic data.

Mapping coverage and measurement resolution

The MBES should be preferably set to equidistant mode (where the system allows) and changes in settings during surveys limited to optimise acoustic backscatter data but keeping them as stable as possible to obtain homogenous mosaic after. Seafloor mapping coverage must be performed with sufficient overlap (min. 20 %), of the individual profile lines to ensure 100 % seafloor coverage and data quality at the swath boundaries, in particular, grazing angles and spreading losses to compensate for the large variation in individual backscattering intensities at the outer beam edges. To preserve data quality in outer beams, a swath opening of a maximum of 60° shall be used. It is possible to increase swath opening in shallower areas upon agreement with the Ordering Party's Delegates. During phase II (tow-yos), narrower beam widths (30° - 45°) shall be applied. The vessel's speed will directly impact the density of soundings reaching the seafloor, the quality of the data (in the return signal), and to some degree, determine the resolution of the final raster datasets. The survey speed should be adjusted accordingly to capture the required resolution for further interpretations, but not higher than 8kn. It should be

noted that aeration problems (bubble sweep) that reduce the signal or the quality of the signal at the transducer head is a function of sea state but also of the heading with respect to the wave direction and the vessel speed. It is strongly advised that the aeration problems versus sea state with heading and vessel speed are recorded in the field logbook.

Resolution is understood as the density of soundings along the track and across-track should be at least 80 m (at least one (1) real-sounding within every square 80x80 m at a depth of 3000 m. An increased density of survey points at the seafloor surface is expected at shallower depths. Where the depths may change rapidly, a comprehensive plan of survey lines may not be useful, has to be modified as the bathymetry data is collected. The seafloor topography and the slope (gradient of the slope) is an important consideration for planning the survey lines. If survey lines must run up and down the slope, a reduction of vessel speed or reduction in swath width may be required to allow for the echo sounder to track the bottom continuously. Planned lines must be activated in this instance to ensure that gaps are not created. For surveys where MBES/backscatter information is essential for confirmation and characterisation of research targets (key areas), the measurement density should be increased during phase II while profiling the physical and chemical water column along with the preselected sites.

All data should be attributed with uncertainty estimates at the 95% confidence level for position and relevant depth, with vertical error <1% of depths in phase I mapping. The Contractor shall document the methods used to minimise the errors associated with determining depth (corrections to echo soundings) in the technical filed report.

6.3. Sound velocity profiling

To correct the MBES measurements, the SVPs shall be performed consisting of synthetic profiles derived from the CTD or Sound Velocity Profiler data and expendable bathythermograph (XBT) probes compared with the profiles from the WOA13 sound speed database. The measurements taken shall include salinity, temperature and conductivity or direct acoustic velocity measurement considering the entire water column. The Contractor shall provide the procedure of sound velocity profiling. Sound Velocity Profiles should be taken min. 1 per day and monitored for changes with respect to Sound Velocity Probe by the MBES head. The continuously working moving sound velocity profiler (MSVP) is preferred. SVP log files and processed profiles should be recorded for post-processing. If the sound speed at the transducer varies by >2m/s compared to the collected SV profile, another SVP should be collected. Valid calibration certificates for all SVP equipment must be provided.

6.4. Depth reduction

All sounding data must be corrected for tides related to the lowest astronomical tide (LAT) or MSL. The survey Contractor will supply corrections prior to the commencement of the survey. To ensure that the depth charted is the true depth and not depth under the keel, the vessel draft must be taken into consideration during data acquisition to account for changes in the draft (due to, for example, fuel usage). However, this will depend on the model of the vessel used for the survey. The vessel draft should be measured at the start and at the end of the surveys, and the dynamic draft should be taken into consideration with measurements of the waterline conducted regularly. The vessel draft should be recorded during a survey in the vessel log and/or entered into the acquisition system, and all changes during the survey should be monitored and explained. An elevation reduction model over the ellipsoid that reduces the data to MSL, or LAT, should be described with all compensations in place.

6.5. SBP survey

Sub-bottom profiler will be used as a complementary source of data in the regional study to help identify hydrothermal structures such as discontinuities in the bottom layers, areas with thin sediment cover or faults. It allows to detect and map sedimentary layers if present. The analysis should reveal the detailed structure of the uppermost sedimentary unit in the Atlantic Ocean Ridge and understand the processes that form it. The chirp sub-bottom profiles will be integrated/overlaid with MBES/acoustic backscatter/water column intensity data to enhance the interpretation of features indicating hydrothermal vent sites SMS occurrence. The SBP data will also be correlated with future geological samples collected from the seabed (Leg 2). Both an integrated MBES solution or standalone parametric SBP are acceptable, although standalone parametric will be preferred.

6.6. Magnetic anomalies

Magnetometer shall be towed system. This system shall include full quality control and data processing facilities to provide data binning statistics and graphics (maps). Magnetic data should have all proper corrections before conducting measurements: reduction to pole magnetisation (measured at the research site), ship's magnetisation effect, magnetic diurnal variations, tide and any other environmental/atmospheric/equipment effects and referenced to the vertical survey datum. The sounding system should have a real-time magnetisation display to confirm data acquisition. The magnetic data will be integrated/overlaid with MBES/backscatter/water column intensity data and physico-chemical data of the water column to provide complexity for assessing PP areas location.

6.7. Physico-chemical water column data – plume detection (CTD/MAPR).

A combination of anomalies from different sensors is expected to measure to identify hydrothermal activity and venting sites. The CTD/MAPR based sensors shall allow identification of physical and chemical markers in the water column such as turbidity (Formazine Turbidity Units - FTU/ Nephelometric Turbidity Units - NTU anomaly), oxidation-reduction potential (ORP) Eh (mV), as well as pH, temperature, salinity (specific conductivity (mS/cm), dissolved (mg/l) O_2, CH_4, H_2, measured to determine CTD/MARP profiling (with a typical ship speed of < 1 kn) yielding in higher resolution datasets should be conducted constantly along the ridge, e.g. from the southern tip of the research area towards the most northern exploration block, following preselected sites, where either the geologic setting from the ships MBES looks favourable for hydrothermal venting (e.g. axial volcanic heights), or WCD recorded an anomaly (plume signal). Extended analysis of the physico-chemical parameters of the water column shall also be performed during CTD-based calibration of MBES (phase I). Hydroacustic identification o the hydrothermal plumes can be obtained by sigle beam, multibeam (WCD) and sub-bottom profiler operating at high-frequency mode (PHF).

7. DATA PROCESSING

Most of the data processing work should be performed onboard during the offshore survey to provide live data interpretation. This approach shall allow identification of anomalies and morphological features (during phase I of Leg 1) to preliminary delineate the favourable areas for hydrothermal activity and/or SMS occurrence for phase II of the survey (plume detection), as well as purposes Leg 2 (detailed exploration of the prospective areas).

Processed data products must be created as separated files for each exploratory block (10x10 km). The spatial resolution of the gridded data deliverables should not be less than 50 m for the entire research area (applies to DTMs and acoustic backscatter data mosaics of the entire area). At least 95% of grid points should be based on at least one physical measurement.

Resolution for the magnetic anomalies data mosaics should be not less than 1500 m.

It is essential that any smoothing of the surfaces or contour lines be kept to a minimum.

The final processing and interpretation of the data obtained will be completed within three months after the demobilisation.

During and after the offshore survey, the scope and methods of data processing have to be discussed and agreed upon with the Ordering Party.

7.1. Processing of the MBES bathymetry data

Uncertainty related to the bathymetry (depth) measurements can be quantified and incorporated into a statistical model to derive the total propagated uncertainty (TPU) of the resulting bathymetry surfaces, involving, i.e., draft setting of the transducer, incorrect sound velocity profiles, spatial variation in the sound velocity, temporal variation in the sound velocity, instrumental uncertainty (internal precision of the MBES unit) and motion (heave, pitch and roll corrections), settlement and squat of the vessel in the water and incorrect tidal corrections. Where possible, the Combined Uncertainty and Bathymetry Estimator (CUBE) should be used to calculate the TPU for the bathymetry surface as a measure of uncertainty in the survey.

7.2. Processing of the MBES acoustic backscatter data

A 3σ filter or equivalent must be applied to the backscatter data to emphasise the difference between higher and lower backscattering areas that provide MBES time-series mosaic. First pass processing of some artefacts must be conducted on board, and some small areas may require further editing onshore. Backscatter data should be corrected for angular and spatial distortions to create a homogeneous mosaic reflecting seabed physical properties.

7.3. Processing of the MBES water column acoustic reverberation data

Each beam echo with water column data shall be translated onto 3D scatter points corrected for slant range by incorporating information on beam angles, ship motion and position, sensors offsets, and sound velocity profiles for correct ray tracing. Intensity values should be referred to the volume sample that they represent. The sequence of water column intensity values from survey results in a detailed three-dimensional acoustic image of water volume along the ship track should be generated. Significant interferences, artefacts, and distortions shall be identified and extracted.

7.4. Processing of the magnetic anomalies data

To compensate for the natural temporal variations of the Earth's magnetic field during the survey, the magnetic data shall go through diurnal correction and heading effects, if any. The broader anomalies or regional gradients due to Earth's field or very deep or distant sources shall be removed from data to examine anomalies better. Corrected magnetic data shall be gridded to generate the total field magnetic map. Filtering to the signals shall be applied to enhance anomalous features with a specific wavelength.

7.5. Processing of the SBP data

Tidal corrections should be applied to sub-bottom data, sound velocity corrections for sound variations in the water column, and layback corrections for towfish. Usually, one or more measurements of the speed of sound shall be performed daily in the project area. To digitise the chirp sub-bottom layers and best estimate the seabed surface in the seismic software, the following adjustments should be applied: TVG (time-varying gain controls), frequency filters, swell filter, noise filter and sediment sound speed correction. The result of the interpretation is a database containing digitised data of geological layers obtained from SBP profiles.

7.6. Processing of the water column physico-chemical data (CTD/MAPR and SVP/CTD).

The CTD/MAPR data should be processed following the standard procedures of the particular measurement or equipment used. Processing of the MAPR data (turbidity and Eh) should be completed in the unique Excel spreadsheet provided by the NOAA-PMEL where measurement needs to be corrected for the latitude and NTU calculated from raw data according to the formula: $Delta\ NTU = (V_r - V_b)/a_n$, where V_r is the raw voltage, V_b is the background voltage of ambient seawater, not affected by hydrothermal plumes and a_n is a factor unique for each backscatter sensor, which the NOAA labs have determined.

Processing of the CTD data should be performed accordingly with the software dedicated to the type of CTD used for the measurement. Collected raw data (e.g. files .hex or .dat) should be converted to .cnv (for all data) which allows them to be plotted, e.g. in Sea Plot software. In addition, all data should be exported to ASCII files (.asc) for processing by various types of software. All processing applies to both regular cats and tow-yo. A compilation of all produced CTD and MAPR measurements should be possible to be plotted as a function of latitude and/or longitude to present spatial distribution of physico-chemical parameters in the water column. This should be done using Sea Plot or Ocean Data View software. CTD/Eh/turbidity etc., data should be processed according to the type of devices used and checked for proper navigation. The MB Systems (or similar software) should be used for navigation corrections. The final product should present the results as 2D plots of the spatial distribution of measured parameters. The appropriate data format is indicated in section 10.4.

8. DATA INTERPRETATION

The Contractor must provide a comprehensive interpretation of the data obtained during the survey and present it as a separate document described in point 10.3. Data synthesis and interpretation of anomalies and morphological features shall result in the assessment of the location of the favourable areas with hydrothermal activity and/or SMS hosting systems. To achieve this goal, the Contractor will provide appropriate technical and research staff during the offshore survey and during the final processing and interpretation stage of the data onshore. The scope and method of data interpretation, both during and after the offshore survey, must always be agreed upon with the Ordering Party. The Contractor may propose the Ordering Party changes to the described scope and method of data interpretation, if more convenient to achieve the project target/aim of the research survey.

The selection of PP areas shall be substantively motivated and described thoroughly the data obtained during the survey and, as a result of processing, indicating their presence. The analysis of bathymetry data aims to characterise and classify the seafloor to help understand seabed morphology and topography. The combination of morphology, topography (bathymetry), textural surfaces (backscatter), a cross-section of subsurface sediments, and magnetic anomalies shall be interpreted to define the extent of particular geological forms and the location of favourable areas. Daily-based interpretation of all the data acquired during phase I to be verified within phase II dedicated to constant profiling of the physico-chemical parameters of the water column along the ridge and (favourable areas) (plume detection). It is expected that the Contractor will use all the scientific research potential and available knowledge to carry out an in-depth analysis of all acquired research material and to develop its final interpretation. The Contractor should select PP areas based on his experience, state-of-the-art industry practice and generally accepted, standard methods described in the literature by referring to sources. Additionally, the results should be compared to the regional settings of the area. The Contractor should provide the final product of data interpretation within the three (3) months after demobilisation.

9. DATA DELIVERY AND FINAL PRODUCTS

The Contractor shall deliver all raw (9.1) and finally processed (9.2) data as well as a comprehensive product of data interpretation (9.3.) (study containing text, maps and graphics). All data shall be delivered together with the relevant reports, including technical field report of data acquisition (separate report for each service), onboard QC (Quality Control report), calibration report and data processing report (separate report for each processed data type) (9.4.). Ordering Party requests agreement on the outlines of the report's content (during the project phase). All reports, plans, data sets and other deliverables shall be submitted to the Ordering Party for approval.

9.1. Raw data

All raw data obtained during the offshore survey shall be provided in native format as created directly from the used acquisition system. The following data is expected to be received:

- MBES bathymetry data;
- MBES acoustics backscatter data;
- MBES acoustic water column data;
- Magnetic anomalies data;
- SBP data;
- Data of physico-chemical parameters of the water column (CTD/MAPR);
- Data of physical parameters of the water column (SVP/CTD).

9.2. Processed data

In the best way, final processing products should reflect the morphostructural units associated with hydrothermal activity and the locations of SMS and topography of the seabed. The following processed data is expected to be received in the form of:

- DTMs;
- Bathymetric contour maps (at a scale of not less than 1:50,000);
- Slope angle maps to design ROV tracks (PP areas);
- Mosaics based on the MBES acoustic backscatter data, including compensated (normalised) version;
- 3D acoustic image of water volume based on the MBES water column data;
- Mosaics based on the magnetic anomalies data;

- Contour maps of magnetic anomalies data;
- SBP geophysical profiles (ready for interpretation);
- Processed data of physico-chemical parameters of the water column (CTD/MAPR);
- Processed data of physical and chemical parameters of the water column (SVP/CTD);
- Coordinates of all stations: CTD/MAPR regular casts and start/finish position of tow-yo transects (profiles), in the form of Shapefiles and .csv;
- 2D plots of measured physico-chemical parameters according to their character (i.e. regular or tow-yo);
- Maps of the spatial distribution of measured physico-chemical parameters.

9.3. Data interpretation

Data interpretation will be carried out onboard and reported daily based to the Ordering Party's Delegates (preliminary interpretation report) and after the survey completion (final data interpretation report).

The Contractor will provide the final data interpretation report (within three months after the demobilisation): Assessment of potential prospective areas for detailed exploration of SMS within the Polish contracted area in the Mid-Atlantic Ridge.

The report shall include the following information as a minimum:

Text:

- Description of the research objective;
- Summary and a brief description of the measurement and research methods used and data processing methods;
- Description of the data interpretation methods;
- Presentation and discussion of the results.

Maps and graphics:

- Map of seabed classification (acoustic backscatter data interpreted to substrate type).
- Spatial identification and classification of the particular morphological/geological forms based on the MBES bathymetry data;
- Classification and graphical presentation of the water column properties and anomalies indicating the presence of hydrothermal activity (e.g. maps, cross-sections, models);
- Map of the PP areas for exploration of SMS (hydrothermal activities, SMS occurrence).

9.4. Technical reports

The Contractor shall submit the following documents:

During the project phase:

- A Project Execution Plan (i.e. with personnel, equipment and contingency plan);
- All relevant method statements (incl. equipment and vessel specification);
- A Document Release Schedule (DRS), i.e. a list of documents which will be provided to the Ordering Party during the different stages of Services;
- An HSSE plan with risk and hazard assessments;
- An Emergency Response Plan (ERP);

During the mobilisation:

- QA/QC reports;
- Certifications
- Calibration reports

During and after the offshore survey/research survey:

- QA/QC reports;
- Daily Progress Report (DPR);
- Survey logbook;
- Technical field reports of data acquisition (separate report shall be provided for each of the services);
- Data processing reports (separate report shall be provided for each processed data type);

Any other report is necessary to complete the task in accordance with best practices.

10. DATA FORMAT

Raw, processed and interpreted data will be delivered by the Contractor in the appropriate industry recognisable file formats. The expected formats that Ordering Party uses are described further in the document.

Other data delivery formats may also be accepted as long as the tools used by the Ordering Party allow their unlimited use. However, this requires prior agreement with the Ordering Party.

The Contractor shall determine a clear, logical and easy to manage file naming system in terms of date, time, location to be discussed and confirmed by the Ordering Party prior to the mobilisation.

The acquired and generated data should be recorded and stored by the Contractor securely and continuously on two memory data carriers simultaneously. All survey data should be provided to the Ordering Party immediately after the research survey is completed (during the demobilisation). After demobilisation, all other results should be submitted within three (3) months. The data transfer must be confirmed by an approval protocol, whereby the Ordering Party confirms the transfer after the data have been successfully located and secured on its servers. The storage period of all obtained data may not be shorter than six (6) months after signing the data transfer protocol. After finally delivering and accepting all data by Ordering Party, the Contractor shall delete all the data from the Contractor's and any third-party databases.

10.1. MBES data

The following scope and rules apply as a minimum:

- Raw MBES bathymetry, acoustic backscatter, and water column acoustic reverberation data shall be provided in native format as created directly from the used MBES acquisition system, preferably recording bathymetry data separately from water column if applicable (e.g. *.all or *.kall for Kongsberg EM series, *.s7k for a newer version of Reson SeaBat). For all other MBES systems, it is required that raw data include SV profile, attitude, navigation, heading, raw bathymetry, raw backscatter per beam and, if available raw backscatter as seabed image or snippets style.
- Processed MBES bathymetry, acoustic backscatter and water column acoustic reverberation data:

  Preferred format: Teledyne Caris (e.g. HIPS & SIPS), EIVA, QPS (e.g. Fledermaus FMM).

- Un-gridded processed MBES bathymetry and acoustic backscatter data for each track:
  ASCII XYZ file format, comma-delimited, Z in the negative metre at 2 decimal places (bathymetry data) or in dB at 2 decimal places (acoustic backscatter data);
- Gridded processed MBES bathymetry and acoustic backscatter data:

ASCII XYZ file format, comma-delimited, Z in the negative metre at 2 decimal places (bathymetry data) or in dB at 2 decimal places (acoustic backscatter data), Esri ASCII grid (*.asc) or GeoTIFF format;

- Processed MBES water column acoustic reverberation data (location of features detected in the water column):
  ASCII XYZ file format, comma-delimited, Z in the negative metre at 2 decimal places

MBES supplementary data

- The spatial extent of research sub-areas (if separated): ESRI .shp file format
- Target list from seabed objects (morphological/geological features): ESRI .shp file format;
- Vessel transect log map to show the position of the vessel survey lines within the region (ESRI .shp file format);
- Quality control data (navigation, attitude): data format to be agreed
- Correction for sound velocity: data format to be agreed;
- Tide reduction: data format to be agreed;

10.2. Magnetic anomalies data

The following scope and rules apply as a minimum:

- Raw magnetic anomalies data shall be provided in native format as created directly from the used acquisition system;
- Processed magnetic anomalies data;
- Un-gridded processed magnetic anomalies data for each track:
  ASCII XYZ file format, comma-delimited, Z in nano Tesla ('nT') units
- Gridded processed magnetic anomalies data (mosaic):
- ASCII XYZ file format, comma-delimited, Z in 'nT', Esri ASCII grid (format *.asc) or GeoTIFF format.

Magnetic anomalies supplementary data

- The spatial extent of research sub-areas (if separated): ESRI .shp file format;
- Map of magnetic signatures/anomalies in combination with bathymetric map;
- Vessel track lines: ESRI .shp file format;
- Quality control data (navigation, attitude): data format to be agreed;

10.3. SBP data

SBP data should be industry-standard and provided in SEG-Y format.

The following scope and rules apply as a minimum:

- Raw SBP data shall be provided in native format as created directly from the used acquisition system (e.g. Hypack – SEG-Y, RAW, LOG; Qinsy - *.db);
- Processed SBP data (ready for interpretation): SEG-Y file format
- Interpreted SBP data: Bottom track of seabed surface and digitised SBP reflector layers – XYZ format.

SBP supplementary data

- Sound velocity corrections: data format to be agreed;
- Tide correction: data format to be agreed;
- Speed of sound propagation in different types of sediments: data format to be agreed;

10.4. Physico-chemical water column data (CTD/MAPR and SVP/CTD)

The following scope and rules apply as a minimum:

- Raw data of physico-chemical parameters of the water column shall be provided in native format as created directly from the used acquisition system with UTC date, time, position and depth (ex. Valeport, AML, ASCII *.csv),
- Processed data of physico-chemical parameters of the water column: data format to be agreed.

10.5. Tide

Tide data used for tide correction (date, time and depth(m.mm)/pressure (dBar).
Data format: Caris tide *.tid and ASCII *.csv

10.6. True Heave

Delayed, processed heave saved independently from raw sonar file, logged in 600-720 minutes period. Data format: Applanix ATH or equivalent (Caris compatible).

10.7. TPU/ CUBE related information

- XYZ of MRU to Transducers;
- XYZ of NAV to Transducers;
- Transducers mounting angles (if not horizontal);
- Type of Navigation system;
- Type of MRU system;
- Sign conventions used to calculate XYZ (Down positive, etc.).

Data format: ASCII text.

It is essential that all developed maps, both at the design stage and those resulting from the processing and interpretation of the obtained and processed data, shall be provided in the original format used by the Contractor and in a format compliant with ESRI ArcGIS (if different).

List of coordinates describing each of the exploration block (n=100)

Cluster	Block no.	Corner	Longitude	Latitude
A	1	1	39° 57.760' W	32° 45.378' N
A	1	2	40° 4.164' W	32° 45.326' N
A	1	3	40° 4.230' W	32° 50.785' N
A	1	4	39° 57.819' W	32° 50.837' N
A	2	1	39° 51.338' W	32° 45.434' N
A	2	2	39° 57.742' W	32° 45.388' N
A	2	3	39° 57.801' W	32° 50.846' N
A	2	4	39° 51.390' W	32° 50.893' N
A	3	1	39° 44.923' W	32° 43.561' N
A	3	2	39° 51.325' W	32° 43.520' N
A	3	3	39° 51.377' W	32° 48.979' N
A	3	4	39° 44.968' W	32° 49.020' N
A	4	1	39° 38.504' W	32° 42.809' N
A	4	2	39° 44.906' W	32° 42.774' N
A	4	3	39° 44.952' W	32° 48.2334' N
A	4	4	39° 38.543' W	32° 48.2648' N
A	5	1	39° 32.100' W	32° 41.481' N
A	5	2	39° 38.501' W	32° 41.451' N
A	5	3	39° 38.540' W	32° 46.910' N
A	5	4	39° 32.133' W	32° 46.940' N
A	6	1	40° 4.092' W	32° 39.868' N
A	6	2	40° 10.489' W	32° 39.810' N
A	6	3	40° 10.561' W	32° 45.268' N
A	6	4	40° 4.157' W	32° 45.326' N
A	7	1	39° 57.673' W	32° 39.909' N
A	7	2	40° 4.071' W	32° 39.857' N
A	7	3	40° 4.136' W	32° 45.316' N
A	7	4	39° 57.732' W	32° 45.368' N
A	8	1	39° 51.277' W	32° 39.963' N
A	8	2	39° 57.675' W	32° 39.917' N
A	8	3	39° 57.734' W	32° 45.375' N
A	8	4	39° 51.329' W	32° 45.422' N
A	9	1	39° 44.888' W	32° 38.125' N
A	9	2	39° 51.284' W	32° 38.085' N
A	9	3	39° 51.336' W	32° 43.543' N
A	9	4	39° 44.934' W	32° 43.584' N

Cluster	Block no.	Corner	Longitude	Latitude
A	10	1	39° 38.470' W	32° 37.347' N
A	10	2	39° 44.865' W	32° 37.312' N
A	10	3	39° 44.910' W	32° 42.771' N
A	10	4	39° 38.509' W	32° 42.806' N
A	11	1	40° 8.177' W	32° 34.370' N
A	11	2	40° 14.567' W	32° 34.310' N
A	11	3	40° 14.643' W	32° 39.768' N
A	11	4	40° 8.246' W	32° 39.828' N
A	12	1	40° 1.788' W	32° 34.422' N
A	12	2	40° 8.179' W	32° 34.367' N
A	12	3	40° 8.248' W	32° 39.826' N
A	12	4	40° 1.850' W	32° 39.881' N
A	13	1	39° 55.391' W	32° 34.468' N
A	13	2	40° 1.782' W	32° 34.418' N
A	13	3	40° 1.845' W	32° 39.876' N
A	13	4	39° 55.447' W	32° 39.926' N
A	14	1	39° 48.987' W	32° 32.629' N
A	14	2	39° 55.377' W	32° 32.585' N
A	14	3	39° 55.433' W	32° 38.044' N
A	14	4	39° 49.037' W	32° 38.088' N
A	15	1	40° 1.721' W	32° 28.967' N
A	15	2	40° 8.106' W	32° 28.912' N
A	15	3	40° 8.175' W	32° 34.371' N
A	15	4	40° 1.784' W	32° 34.426' N
A	16	1	39° 55.335' W	32° 29.006' N
A	16	2	40° 1.720' W	32° 28.956' N
A	16	3	40° 1.783' W	32° 34.415' N
A	16	4	39° 55.391' W	32° 34.465' N
A	17	1	39° 48.935' W	32° 27.158' N
A	17	2	39° 55.318' W	32° 27.114' N
A	17	3	39° 55.373' W	32° 32.573' N
A	17	4	39° 48.984' W	32° 32.617' N
A	18	1	40° 8.037' W	32° 23.459' N
A	18	2	40° 14.415' W	32° 23.399' N
A	18	3	40° 14.490' W	32° 28.857' N
A	18	4	40° 8.105' W	32° 28.917' N
A	19	1	40° 1.661' W	32° 23.507' N
A	19	2	40° 8.039' W	32° 23.452' N
A	19	3	40° 8.107' W	32° 28.911' N
A	19	4	40° 1.723' W	32° 28.966' N

Cluster	Block no.	Corner	Longitude	Latitude
A	20	1	39° 55.282' W	32° 23.551' N
A	20	2	40° 1.661' W	32° 23.501' N
A	20	3	40° 1.723' W	32° 28.960' N
A	20	4	39° 55.338' W	32° 29.009' N
A	21	1	40° 11.558' W	32° 17.967' N
A	21	2	40° 17.930' W	32° 17.904' N
A	21	3	40° 18.008' W	32° 23.362' N
A	21	4	40° 11.630' W	32° 23.425' N
A	22	1	40° 12.848' W	32° 12.495' N
A	22	2	40° 19.213' W	32° 12.432' N
A	22	3	40° 19.292' W	32° 17.890' N
A	22	4	40° 12.921' W	32° 17.954' N
B	23	1	41° 40.339' W	30° 37.319' N
B	23	2	41° 46.592' W	30° 37.188' N
B	23	3	41° 46.749' W	30° 42.642' N
B	23	4	41° 40.489' W	30° 42.774' N
B	24	1	41° 34.080' W	30° 37.442' N
B	24	2	41° 40.334' W	30° 37.316' N
B	24	3	41° 40.484' W	30° 42.771' N
B	24	4	41° 34.225' W	30° 42.898' N
B	25	1	41° 27.835' W	30° 37.564' N
B	25	2	41° 34.089' W	30° 37.443' N
B	25	3	41° 34.234' W	30° 42.898' N
B	25	4	41° 27.973' W	30° 43.020' N
B	26	1	41° 42.893' W	30° 31.804' N
B	26	2	41° 49.140' W	30° 31.671' N
B	26	3	41° 49.298' W	30° 37.125' N
B	26	4	41° 43.045' W	30° 37.259' N
B	27	1	41° 36.646' W	30° 31.930' N
B	27	2	41° 42.893' W	30° 31.803' N
B	27	3	41° 43.045' W	30° 37.258' N
B	27	4	41° 36.792' W	30° 37.386' N
B	28	1	41° 30.401' W	30° 32.051' N
B	28	2	41° 36.650' W	30° 31.928' N
B	28	3	41° 36.796' W	30° 37.383' N
B	28	4	41° 30.542' W	30° 37.507' N
B	29	1	41° 48.979' W	30° 26.224' N
B	29	2	41° 55.219' W	30° 26.087' N
B	29	3	41° 55.382' W	30° 31.541' N
B	29	4	41° 49.136' W	30° 31.678' N

Cluster	Block no.	Corner	Longitude	Latitude
B	30	1	41° 42.743' W	30° 26.348' N
B	30	2	41° 48.984' W	30° 26.216' N
B	30	3	41° 49.141' W	30° 31.670' N
B	30	4	41° 42.894' W	30° 31.803' N
C	31	1	41° 59.811' W	30° 19.081' N
C	31	2	42° 6.043' W	30° 18.936' N
C	31	3	42° 6.216' W	30° 24.389' N
C	31	4	41° 59.978' W	30° 24.535' N
C	32	1	41° 49.509' W	30° 20.750' N
C	32	2	41° 55.744' W	30° 20.613' N
C	32	3	41° 55.907' W	30° 26.067' N
C	32	4	41° 49.666' W	30° 26.205' N
B	33	1	41° 43.272' W	30° 20.884' N
B	33	2	41° 49.507' W	30° 20.752' N
B	33	3	41° 49.664' W	30° 26.206' N
B	33	4	41° 43.423' W	30° 26.339' N
C	34	1	42° 2.376' W	30° 13.568' N
C	34	2	42° 8.602' W	30° 13.421' N
C	34	3	42° 8.776' W	30° 18.874' N
C	34	4	42° 2.544' W	30° 19.021' N
C	35	1	41° 56.138' W	30° 13.710' N
C	35	2	42° 2.364' W	30° 13.568' N
C	35	3	42° 2.533' W	30° 19.022' N
C	35	4	41° 56.300' W	30° 19.165' N
C	36	1	42° 5.414' W	30° 8.039' N
C	36	2	42° 11.634' W	30° 7.890' N
C	36	3	42° 11.810' W	30° 13.343' N
C	36	4	42° 5.584' W	30° 13.493' N
C	37	1	41° 59.194' W	30° 8.178' N
C	37	2	42° 5.414' W	30° 8.034' N
C	37	3	42° 5.585' W	30° 13.487' N
C	37	4	41° 59.358' W	30° 13.632' N
C	38	1	42° 5.248' W	30° 2.586' N
C	38	2	42° 11.462' W	30° 2.437' N
C	38	3	42° 11.638' W	30° 7.890' N
C	38	4	42° 5.418' W	30° 8.039' N
C	39	1	41° 59.022' W	30° 2.726' N
C	39	2	42° 5.237' W	30° 2.583' N
C	39	3	42° 5.407' W	30° 8.036' N
C	39	4	41° 59.186' W	30° 8.180' N

Cluster	Block no.	Corner	Longitude	Latitude
D	40	1	42° 38.076' W	29° 55.214' N
D	40	2	42° 44.287' W	29° 55.323' N
D	40	3	42° 44.165' W	30° 0.734' N
D	40	4	42° 37.948' W	30° 0.624' N
D	41	1	42° 31.866' W	29° 55.100' N
D	41	2	42° 38.076' W	29° 55.214' N
D	41	3	42° 37.948' W	30° 0.624' N
D	41	4	42° 31.732' W	30° 0.510' N
D	42	1	42° 25.656' W	29° 54.982' N
D	42	2	42° 31.866' W	29° 55.100' N
D	42	3	42° 31.732' W	30° 0.510' N
D	42	4	42° 25.517' W	30° 0.391' N
D	43	1	42° 43.358' W	29° 49.899' N
D	43	2	42° 49.564' W	29° 50.004' N
D	43	3	42° 49.446' W	29° 55.415' N
D	43	4	42° 43.235' W	29° 55.310' N
D	44	1	42° 37.153' W	29° 49.790' N
D	44	2	42° 43.358' W	29° 49.899' N
D	44	3	42° 43.235' W	29° 55.310' N
D	44	4	42° 37.024' W	29° 55.200' N
D	45	1	42° 30.948' W	29° 49.675' N
D	45	2	42° 37.153' W	29° 49.790' N
D	45	3	42° 37.024' W	29° 55.200' N
D	45	4	42° 30.814' W	29° 55.085' N
D	46	1	42° 24.744' W	29° 49.556' N
D	46	2	42° 30.948' W	29° 49.675' N
D	46	3	42° 30.814' W	29° 55.085' N
D	46	4	42° 24.604' W	29° 54.965' N
D	47	1	42° 44.959' W	29° 44.524' N
D	47	2	42° 51.159' W	29° 44.627' N
D	47	3	42° 51.043' W	29° 50.038' N
D	47	4	42° 44.837' W	29° 49.935' N
D	48	1	42° 38.759' W	29° 44.411' N
D	48	2	42° 44.959' W	29° 44.519' N
D	48	3	42° 44.838' W	29° 49.930' N
D	48	4	42° 38.632' W	29° 49.822' N
D	49	1	42° 51.274' W	29° 39.209' N
D	49	2	42° 57.470' W	29° 39.307' N
D	49	3	42° 57.360' W	29° 44.719' N
D	49	4	42° 51.159' W	29° 44.620' N

Cluster	Block no.	Corner	Longitude	Latitude
D	50	1	42° 44.014' W	29° 39.091' N
D	50	2	42° 50.209' W	29° 39.194' N
D	50	3	42° 50.093' W	29° 44.606' N
D	50	4	42° 43.892' W	29° 44.502' N
D	51	1	42° 51.389' W	29° 33.798' N
D	51	2	42° 57.579' W	29° 33.895' N
D	51	3	42° 57.470' W	29° 39.307' N
D	51	4	42° 51.275' W	29° 39.209' N
D	52	1	42° 45.200' W	29° 33.698' N
D	52	2	42° 51.389' W	29° 33.800' N
D	52	3	42° 51.274' W	29° 39.211' N
D	52	4	42° 45.080' W	29° 39.109' N
D	53	1	42° 51.503' W	29° 28.386' N
D	53	2	42° 57.688' W	29° 28.484' N
D	53	3	42° 57.579' W	29° 33.895' N
D	53	4	42° 51.389' W	29° 33.798' N
D	54	1	42° 59.667' W	29° 23.104' N
D	54	2	43° 5.847' W	29° 23.195' N
D	54	3	43° 5.746' W	29° 28.607' N
D	54	4	42° 59.561' W	29° 28.516' N
D	55	1	42° 53.488' W	29° 23.009' N
D	55	2	42° 59.667' W	29° 23.104' N
D	55	3	42° 59.561' W	29° 28.516' N
D	55	4	42° 53.376' W	29° 28.420' N
D	56	1	43° 1.378' W	29° 17.716' N
D	56	2	43° 7.553' W	29° 17.805' N
D	56	3	43° 7.454' W	29° 23.218' N
D	56	4	43° 1.274' W	29° 23.128' N
D	57	1	42° 55.204' W	29° 17.622' N
D	57	2	43° 1.378' W	29° 17.716' N
D	57	3	43° 1.274' W	29° 23.128' N
D	57	4	42° 55.095' W	29° 23.034' N
D	58	1	43° 4.982' W	29° 12.354' N
D	58	2	43° 11.151' W	29° 12.440' N
D	58	3	43° 11.056' W	29° 17.852' N
D	58	4	43° 4.881' W	29° 17.766' N
D	59	1	42° 58.813' W	29° 12.263' N
D	59	2	43° 4.982' W	29° 12.354' N
D	59	3	43° 4.881' W	29° 17.766' N
D	59	4	42° 58.707' W	29° 17.675' N

Cluster	Block no.	Corner	Longitude	Latitude
D	60	1	43° 13.587' W	29° 7.060' N
D	60	2	43° 19.751' W	29° 7.139' N
D	60	3	43° 19.663' W	29° 12.552' N
D	60	4	43° 13.494' W	29° 12.473' N
D	61	1	43° 7.423' W	29° 6.976' N
D	61	2	43° 13.587' W	29° 7.060' N
D	61	3	43° 13.494' W	29° 12.473' N
D	61	4	43° 7.324' W	29° 12.388' N
D	62	1	43° 1.252' W	29° 6.886' N
D	62	2	43° 7.416' W	29° 6.974' N
D	62	3	43° 7.317' W	29° 12.387' N
D	62	4	43° 1.148' W	29° 12.298' N
D	63	1	43° 18.246' W	29° 1.703' N
D	63	2	43° 24.406' W	29° 1.778' N
D	63	3	43° 24.322' W	29° 7.192' N
D	63	4	43° 18.158' W	29° 7.116' N
D	64	1	43° 12.087' W	29° 1.623' N
D	64	2	43° 18.246' W	29° 1.703' N
D	64	3	43° 18.158' W	29° 7.116' N
D	64	4	43° 11.993' W	29° 7.036' N
D	65	1	43° 18.335' W	28° 56.275' N
D	65	2	43° 24.489' W	28° 56.351' N
D	65	3	43° 24.406' W	29° 1.764' N
D	65	4	43° 18.247' W	29° 1.689' N
D	66	1	43° 12.181' W	28° 56.196' N
D	66	2	43° 18.335' W	28° 56.275' N
D	66	3	43° 18.247' W	29° 1.689' N
D	66	4	43° 12.088' W	29° 1.609' N
D	67	1	43° 17.823' W	28° 50.858' N
D	67	2	43° 23.971' W	28° 50.933' N
D	67	3	43° 23.888' W	28° 56.347' N
D	67	4	43° 17.734' W	28° 56.271' N
D	68	1	43° 11.676' W	28° 50.778' N
D	68	2	43° 17.824' W	28° 50.858' N
D	68	3	43° 17.736' W	28° 56.271' N
D	68	4	43° 11.582' W	28° 56.191' N
D	69	1	43° 29.558' W	28° 45.582' N
D	69	2	43° 35.702' W	28° 45.648' N
D	69	3	43° 35.629' W	28° 51.062' N
D	69	4	43° 29.480' W	28° 50.996' N

Cluster	Block no.	Corner	Longitude	Latitude
D	70	1	43° 17.909' W	28° 45.450' N
D	70	2	43° 24.052' W	28° 45.525' N
D	70	3	43° 23.970' W	28° 50.938' N
D	70	4	43° 17.821' W	28° 50.863' N
D	71	1	43° 11.766' W	28° 45.370' N
D	71	2	43° 17.909' W	28° 45.450' N
D	71	3	43° 17.821' W	28° 50.863' N
D	71	4	43° 11.673' W	28° 50.783' N
D	72	1	43° 29.636' W	28° 40.170' N
D	72	2	43° 35.775' W	28° 40.236' N
D	72	3	43° 35.703' W	28° 45.650' N
D	72	4	43° 29.559' W	28° 45.584' N
D	73	1	43° 23.498' W	28° 40.100' N
D	73	2	43° 29.636' W	28° 40.170' N
D	73	3	43° 29.559' W	28° 45.584' N
D	73	4	43° 23.415' W	28° 45.513' N
D	74	1	43° 17.360' W	28° 40.024' N
D	74	2	43° 23.498' W	28° 40.100' N
D	74	3	43° 23.415' W	28° 45.513' N
D	74	4	43° 17.271' W	28° 45.438' N
D	75	1	43° 28.672' W	28° 34.745' N
D	75	2	43° 34.806' W	28° 34.812' N
D	75	3	43° 34.733' W	28° 40.226' N
D	75	4	43° 28.594' W	28° 40.159' N
E	76	1	44° 24.216' W	27° 13.474' N
E	76	2	44° 30.275' W	27° 13.498' N
E	76	3	44° 30.251' W	27° 18.914' N
E	76	4	44° 24.187' W	27° 18.891' N
E	77	1	44° 18.157' W	27° 13.447' N
E	77	2	44° 24.216' W	27° 13.475' N
E	77	3	44° 24.187' W	27° 18.891' N
E	77	4	44° 18.123' W	27° 18.863' N
E	78	1	44° 19.739' W	27° 8.040' N
E	78	2	44° 25.794' W	27° 8.066' N
E	78	3	44° 25.766' W	27° 13.483' N
E	78	4	44° 19.707' W	27° 13.456' N
E	79	1	44° 15.986' W	27° 2.603' N
E	79	2	44° 22.035' W	27° 2.632' N
E	79	3	44° 22.005' W	27° 8.049' N
E	79	4	44° 15.951' W	27° 8.019' N

Cluster	Block no.	Corner	Longitude	Latitude
E	80	1	44° 22.051' W	26° 59.736' N
E	80	2	44° 28.098' W	26° 59.761' N
E	80	3	44° 28.073' W	27° 5.178' N
E	80	4	44° 22.021' W	27° 5.153' N
E	81	1	44° 23.066' W	26° 54.323' N
E	81	2	44° 29.108' W	26° 54.347' N
E	81	3	44° 29.083' W	26° 59.764' N
E	81	4	44° 23.036' W	26° 59.740' N
E	82	1	44° 23.545' W	26° 48.909' N
E	82	2	44° 29.582' W	26° 48.933' N
E	82	3	44° 29.558' W	26° 54.350' N
E	82	4	44° 23.516' W	26° 54.326' N
E	83	1	44° 17.515' W	26° 46.908' N
E	83	2	44° 23.550' W	26° 46.936' N
E	83	3	44° 23.521' W	26° 52.353' N
E	83	4	44° 17.481' W	26° 52.325' N
E	84	1	44° 19.517' W	26° 41.499' N
E	84	2	44° 25.547' W	26° 41.525' N
E	84	3	44° 25.520' W	26° 46.943' N
E	84	4	44° 19.485' W	26° 46.916' N
E	85	1	44° 23.231' W	26° 36.102' N
E	85	2	44° 29.258' W	26° 36.126' N
E	85	3	44° 29.233' W	26° 41.543' N
E	85	4	44° 23.202' W	26° 41.519' N
E	86	1	44° 17.206' W	26° 36.074' N
E	86	2	44° 23.231' W	26° 36.102' N
E	86	3	44° 23.202' W	26° 41.519' N
E	86	4	44° 17.172' W	26° 41.491' N
E	87	1	44° 24.558' W	26° 30.695' N
E	87	2	44° 30.579' W	26° 30.718' N
E	87	3	44° 30.556' W	26° 36.135' N
E	87	4	44° 24.530' W	26° 36.112' N
E	88	1	44° 18.536' W	26° 30.668' N
E	88	2	44° 24.558' W	26° 30.695' N
E	88	3	44° 24.530' W	26° 36.112' N
E	88	4	44° 18.504' W	26° 36.085' N
E	89	1	44° 30.584' W	26° 27.701' N
E	89	2	44° 36.603' W	26° 27.720' N
E	89	3	44° 36.585' W	26° 33.137' N
E	89	4	44° 30.561' W	26° 33.119' N

Cluster	Block no.	Corner	Longitude	Latitude
E	90	1	44° 24.585' W	26° 25.282' N
E	90	2	44° 30.602' W	26° 25.305' N
E	90	3	44° 30.579' W	26° 30.722' N
E	90	4	44° 24.557' W	26° 30.699' N
E	91	1	44° 18.569' W	26° 25.255' N
E	91	2	44° 24.585' W	26° 25.282' N
E	91	3	44° 24.557' W	26° 30.699' N
E	91	4	44° 18.536' W	26° 30.672' N
E	92	1	44° 36.612' W	26° 23.534' N
E	92	2	44° 42.628' W	26° 23.549' N
E	92	3	44° 42.614' W	26° 28.966' N
E	92	4	44° 36.594' W	26° 28.952' N
E	93	1	44° 30.607' W	26° 22.284' N
E	93	2	44° 36.621' W	26° 22.302' N
E	93	3	44° 36.603' W	26° 27.720' N
E	93	4	44° 30.584' W	26° 27.701' N
E	94	1	44° 24.613' W	26° 19.864' N
E	94	2	44° 30.625' W	26° 19.887' N
E	94	3	44° 30.602' W	26° 25.305' N
E	94	4	44° 24.585' W	26° 25.282' N
E	95	1	44° 18.601' W	26° 19.838' N
E	95	2	44° 24.613' W	26° 19.864' N
E	95	3	44° 24.585' W	26° 25.282' N
E	95	4	44° 18.569' W	26° 25.255' N
E	96	1	44° 30.630' W	26° 16.866' N
E	96	2	44° 36.640' W	26° 16.885' N
E	96	3	44° 36.621' W	26° 22.302' N
E	96	4	44° 30.607' W	26° 22.284' N
E	97	1	44° 24.640' W	26° 14.447' N
E	97	2	44° 30.647' W	26° 14.470' N
E	97	3	44° 30.625' W	26° 19.887' N
E	97	4	44° 24.613' W	26° 19.864' N
E	98	1	44° 18.633' W	26° 14.420' N
E	98	2	44° 24.640' W	26° 14.447' N
E	98	3	44° 24.613' W	26° 19.864' N
E	98	4	44° 18.601' W	26° 19.838' N
E	99	1	44° 24.043' W	26° 9.020' N
E	99	2	44° 30.046' W	26° 9.043' N
E	99	3	44° 30.023' W	26° 14.461' N
E	99	4	44° 24.016' W	26° 14.438' N

Cluster	Block no.	Corner	Longitude	Latitude
E	100	1	44° 18.041' W	26° 8.993' N
E	100	2	44° 24.043' W	26° 9.020' N
E	100	3	44° 24.016' W	26° 14.438' N
E	100	4	44° 18.008' W	26° 14.411' N