Appendix 16.7: Marine Geophysical, Environmental and Archaeological Survey Methods

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Marine Geophysical, Environmental and Archaeological Survey Methods

The equipment used for geophysical and environmental surveys related to the Russian offshore sector of the Project encompassed a broad spectrum of scientific and engineering applications. They can be classified into acoustic and magnetic instrumentation. More detailed information on employed survey methods can be found in the original integrated survey report (Ref. 16.134). For information on third-party survey contractors and survey dates, refer to Tables 16.3 and 16.4.

The acoustic instrumentation and methods included side-scan sonar, a seismic array, sub-bottom profilers, and multi-beam echo sounders. These instruments and their specifications are summarised below.

Side-scan sonar data was collected along the proposed pipeline route to identify objects and features protruding up from the seafloor. Two primary side-scan sonar devices (SSSD) were used: a Benthos SIS 1624 multi-beam side-scan that operated in two frequency spreads of 110 to 130 kHz and 370 to 390 kHz; and a L3 Klein 3000 with dynamically steered beams operating at a chirped frequency spread of 100 to 500 kHz.

Sub-seafloor investigations were conducted along the proposed pipeline route to locate geological features, such as faults, scarps, turbidites, and other geomorphic features commonly associated with geohazards for pipeline construction. For deep sediment penetration, a BOLT 2800LLX 2D seismic array using 193 channel streamers and 300 joule air guns producing an average frequency of 20 to 500 Hz was used. Higher resolution sub-bottom profiling data was collected by two additional systems, including an Innomar SES2000 system with the primary frequency of 100 kHz and a secondary frequency of either 6 or 12 kH; and an Applied Acoustic AA200 boomer operating at 300 joule sound source (electric plate) and a central frequency spread of 360 to 550 Hz.

Multi-beam echo sounders were employed to further record seafloor features along the proposed pipeline route. The two systems consisted of a Reson Seabat 8160 with 126 beams operating at 50 kH with a 130 degree beam angle; and a Simrad EM300 D with 512 beams operating at 293 to 307 kHz and a 200 degree beam angle.

Magnetic data was collected to locate ferrous anomalies along the proposed pipeline route in the nearshore and offshore shallow continental shelf areas only. Instrumentation consisted of a high-resolution marine magnetometer from IXSEA Magis. The Magis system samples the earth's magnetic field at 10 Hz, is sensitive down to 0.5 nT, with a maximum operational depth of 300 m. However, the magnetometer failed, so no magnetic data was collected.

Vessel navigation was maintained and recorded through the use of satellite based global positioning system (GPS) using differential corrections from shore stations and satellite data (OmniStar DGPS). Using a combination of fixed differential GPS receivers on the vessel and inertial guidance systems, vessel position was calculated and verified, maintaining sub meter accuracy for ship positions. This system enabled assigning all incoming data with highly accurate real time positioning. In addition to the Trimble navigation systems, a Raven Invicta 210 DGPS system was used in conjunction with a backup system that consisted of a Seapath 20

DGPS beacon receiver with integrated gyrocompass. Navigation validation and integration was assessed with Ashtech Evaluate software during the survey.

During the archaeological investigation carried out in 2012, remotely operated vehicles (ROV) were used to conduct visual inspections of potential archaeological targets. The ROV surveys were completed using a TAUZ ROV model Sub Fighter 7500 deployed off the RV *Borey*. This ROV used both sector scanning sonar and acoustic range and azimuth (USB) to navigate along the seafloor. The ROV used the USB navigation to move to the general position of the anomalies and the operator then used the sector scanning sonar to identify the specific target to be examined.

Marine Data Interpretation Methods

Data collected from the geophysical and environmental surveys were initially processed by the third party survey contractors. This included formatting raw, numerical data into more useable, interpretable data sets. More in-depth information on employed data processing methods can be found in the original integrated survey report (Ref. 16.134).

Post-processed marine data was reviewed and interpreted by cultural heritage experts to assess the potential for cultural heritage and archaeological material to exist within the vicinity of the proposed pipeline route. Side-scan sonar imagery was primarily reviewed for this analysis and assessment, and all acoustic targets were entered into GIS along with proposed pipeline routing information (Pipeline Route #300512, dated 30 May 2012). Objects that met certain criteria were flagged as potential cultural heritage objects (CHOs). These criteria included overall size (greater than 5 m in length), shape, height off the bottom, and acoustic reflectivity of the objects in the sonar images. Objects that were flagged as potential CHOs and that could potentially be impacted by Project activities selected for visual inspection and identification via ROV.

The other acoustic data sets were reviewed for marine cultural heritage and archaeological potential of submerged prehistoric sites in the nearshore section. These data were assessed to identify submerged ancient landforms, incised drainages and waterways, and other areas that have increased potential for prehistoric human activity and occupation.

The magnetic data was not released by the sub-contractor due to equipment failure, and subsequently magnetic data has not been reviewed.

Geographic Information System Analysis Methods

In accordance with legislation and international agreements, and aligned with standards and guidelines for financing, avoidance is the preferred method of mitigation for CHO. To ensure the protection of marine CHOs during all phases of the Project, an initial 150 m avoidance buffer was placed around all objects within the vicinity of the Project Area. This avoidance buffer distance was chosen after careful consideration of engineering and design constraints and after a review of commonly-used avoidance buffer intervals for similar marine construction projects.

Generation of the 150 m avoidance buffer was completed using GIS mapping and analysis. Marine CHO distances were calculated using the four individual pipeline route centrelines. A 150 m radius buffer was placed around each pipeline centreline, and if that buffer intersected the GPS coordinate of a CHO, then the CHO was flagged as 'within the pipeline corridor.' Marine CHOs located at a distance greater than 150 m from the nearest pipeline are at little to no risk of being adversely impacted by pipeline laydown activities, while marine CHOs located within 150 m of the nearest pipeline (i.e., within the pipeline corridor) are at a greater risk of being affected by these activities. The size of marine CHOs varies and ranges from 5 m long to 65 m long. Given that a single GPS coordinate was recorded for each marine CHO and the size of marine CHOs can considerably vary, the chosen distance should provide adequate coverage and protection of archaeological sites and objects.

In addition to the 150 m radius buffer placed around each of the four pipelines, all marine CHOs and potential CHOs within 1 km radius of the proposed pipeline centreline route received individual 150 m radius avoidance buffers for protection from Project vessel anchoring and other ancillary activities. The distance of 150 m is meant to be an initial protective measure and can be refined and reduced on an *ad hoc* basis in consultation with the government regulatory agencies for each country, and based on the collection of additional high-resolution remote sensing survey data.