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NORD STREAM 2
ENVIRONMENTAL & SOCIAL MONITORING PROGRAMME - SWEDEN

CONTENTS

ABBREVIATIONS AND DEFINITIONS

ADCP	Acoustic Doppler Current Profiler
AIS	Automatic Identification System
AUV	Autonomous Underwater Vehicle
CHO	Cultural Heritage Object
CTD	Conductivity, Temperature and Depth
EEZ	Exclusive Economic Zone
EPA	Swedish Environmental Protection Agency
ES	Environmental Study
ESMP	Environmental and Social Management Plan
HELCOM	Baltic Marine Environment Protection Commission - Helsinki Commission
HSES MS	Environment and Social Management System
ICES	International Council for the Exploration of the Sea
IMR	Inspection, maintenance and repair
MBES	Multibeam echo sounder
NTU	Nephelometric Turbidity Unit
NSP	Nord Stream project
NSP2	Nord Stream 2 project
OBS	Optical Backscatter Sensor
ROV	Remotely Operated Vehicle
SGU	Geological Survey of Sweden
SHB	Swedish National Heritage Board
SMA	Swedish Maritime Administration
SMHI	Swedish Meteorological and Hydrological Institute
SMM	Swedish National Maritime Museums
SoW	Scope of Work
SSC	Suspended sediment concentration
SwAM	Swedish Agency for Marine and Water Management
UXO	Unexploded Ordnance
VMS	Vessel Monitoring System
ROV	Remotely Operated Vehicle

1. INTRODUCTION

Nord Stream 2 AG plans to construct two parallel offshore natural gas pipelines from Russia to Germany through the Baltic Sea. The length of the entire two-pipeline system will be approximately 1,230 km. The pipelines will pass through the territorial waters and/or Exclusive Economic Zones (EEZ) of Russia, Finland, Sweden, Denmark and Germany. In the Swedish EEZ the planned route more or less follows the existing Nord Stream (NSP) pipeline route, mainly to its eastern side. The length of the route in the Swedish sector is approximately 510 km. The pipelines are scheduled to be laid during 2018 and 2019. Hence the operation phase would commence in 2020.

Nord Stream 2 AG is responsible for environmental monitoring and reporting during the construction and operation of the pipelines. Specifications for the contents of monitoring are presented in the appropriate sections of this programme.

2. ENVIRONMENTAL MONITORING DURING CONSTRUCTION AND OPERATION

2.1 Establishment of the monitoring program

This document has been established in consultation with relevant authorities. Meetings were held in Sweden at the following dates and locations;

2017-09-20, Gothenburg: meeting between Nord Stream 2, Ramboll, Swedish Agency for Marine and Water Management (SwAM), Swedish Meteorological and Hydrological Institute (SMHI), Swedish Environmental Protection Agency (EPA) and Geological Survey of Sweden (SGU). A summary of the outcome from this meeting is presented in Table 1.

2017-12-19, Stockholm: follow up meeting between Nord Stream 2, Ramboll, SwAM, SMHI, EPA and SGU

2.2 General approach

Nord Stream 2's overall project environmental monitoring varies in spatial range, temporal frequency, duration and monitored parameters from area to area in accordance with the potential adverse impacts predicted and in relation to potential receptors. The monitoring activities also address requested reporting requirements at national levels.

The programme outlined in this document presents the monitoring activities that will be carried out in the Swedish EEZ during pipeline construction and operation. The programme has been developed with the following objectives:

- To document the state of the environment during construction
- To monitor that no major adverse environmental impacts will be caused during construction
- To verify the findings of the Environmental Study (ES) and the modelling results used to predict environmental impacts

Environmental and social monitoring together with a specific Environmental and Social Management Plan (ESMP) during the construction and operation phase is an integral part of the overall Nord Stream 2 Health, Safety, Environment and Social Management System (HSES MS) consistent with ISO 14001 and OHSAS 18001.

In order to measure the effectiveness of mitigation measures and potential project-related impact the receptors/indicators identified within the monitoring programme should have/be:

- Low natural variability
- Measurable
- Supported by a sound historic data series
- Appropriate to the scale of impact, the impact mechanism, and temporal and spatial dynamics.

The key principles, which have guided the development and implementation of the national environmental monitoring programmes for the Nord Stream 2 Project have already been implemented in the Nord Stream Project and are briefly described here:

Consistency: To the extent practicable, a harmonised approach in terms of sampling and analysis protocols along the route will be adopted. This ensures data that is more readily comparable and allows for improved environmental management and performance. Monitoring is, where possible, congruent with HELCOM guidelines. Thus NSP2 will, for the specific SoW for each monitoring activity, align with the latest Manual for Marine Monitoring prepared by HELCOM (HELCOM, 2017).

Synergy: In addition to the environmental surveys the Project undertakes engineering inspection and maintenance led surveys. These include seabed investigations to understand seabed conditions, shallow geology, presence of obstacles and cultural heritage, and the condition of pipelines and their support structures. The results of the surveys will be compiled in integrated survey reports.

Reporting and Data Sharing: It is important for the Project to have access to on-going data acquisition programmes by third parties and government institutions. The Project is also committed to share its data with relevant stakeholders. At a Project-wide level, Nord Stream 2 is committed to make its monitoring programme reports available to the public on a regular basis. At a national level, results will be shared with national authorities at a frequency agreed with the relevant national authority.

Seasonal and Inter-Annual Variability: It is important to consider the inherent natural variability that is typical of many of the parameters used in marine monitoring programmes to avoid incorrect conclusions about its presumed impacts. Similarly, reference sites are used to account for the spatial variability that may occur in the marine environment. Where possible the co-use of third parties' (HELCOM etc.) long-term monitoring stations has been considered.

Review and Close Out: Monitoring is not an open-ended process. It is important to regularly review monitoring results, not just from the perspective of corrective action if required, for specific impacts. Overall it is important that the programme remains fit-for-purpose and delivers the main monitoring objectives throughout the Project's lifetime. Expert review will therefore be conducted on a regular basis to ensure these objectives still hold true.

2.3 Scope and schedule

The programme outlined in the following chapters presents the monitoring activities that will be carried out in the Swedish EEZ during construction and operation of the pipelines. The approach is based upon experience from monitoring during the construction of the Nord Stream pipelines between 2010 and 2012[1] and concentrates on potential impacts according to the proposal set out

[1] NSP Environmental Monitoring Programme Sweden 2012, G-PE-PER-MON-100-082016EN-A

in the Swedish ES[2] which concentrates on a limited number of receptors. Conclusions from the NSP-monitoring and the assessments made in the ES are that potential impacts are expected to be limited.

However, since the ES was finalized in September 2016 the project's engineers have further optimised the project design. As a result, the impact is assessed to be even less than what was originally estimated in the ES, where a conservative approach was applied. But even with a conservative approach the impact from the project activities is assessed as insignificant, including the proposed new large Natura 2000 area

The project updates have e.g. meant that the construction activities in the Swedish EEZ, including the Natura 2000 area Hoburgs bank and Midsjöbankarna, have been reduced in both time and space, and that the pre-commissioning concept has been settled for the dry concept which means that no pressure test water will be released in the Swedish EEZ.

Monitoring will be most intensive during the construction phase. However, regular monitoring will be carried out during operation as well, and will continue until it can be assured that there are no unexpected impacts to the selected monitoring targets. In addition, technical pipeline inspections will be carried out throughout the entire operational lifetime of the pipelines as described in Chapter 3.

A meeting with SwAM, SMHI, EPA and SGU was held on 20 September 2017, in order to discuss the monitoring during construction and operation. A summary of the main conclusions are presented in Table 1 below:

Table 1 Summary of the main conclusions from the meeting held on 20 September 2017 with Swedish authorities on environmental monitoring[3].

Commercial fishing Cultural heritage Ship traffic	Agreement to prepare scope of works as described in the ES.
Turbidity in Natura 2000 area	Agreement to prepare scope of works for vessel-based monitoring where trenching is needed in the Natura 2000 area (as described in the ES).
Threshold value for turbidity	NSP2/Ramböll to discuss what levels of turbidity would be suitable to monitor to verify the modelling of sediment spread (and suggest where such measurement could be done). Thresholds shall consider natural background levels (as for NSP).
Sediment transport	NSP2 to prepare trend analysis of sediment transport based on maintenance survey results.
Benthic fauna - reef effect	NSP2 to monitor reef effects based on maintenance survey results.
Ecotoxicological effects	Ramböll to prepare scope of work - in line with and based on lessons learnt from NSP, unless an improved concept can be presented. EPA will provide NSP2/Ramböll with information on which substances they suggest to be included.
Acoustic surveillance /Harbour porpoises in	Currently no planned monitoring.

[2] NSP2 Miljöredovisning Sverige 2016, W-PE-EIA-PSE-REP-805-020100SW

[3] Minutes from meeting 2017-09-20, 800-965-PE-EIA-PSE-MOM-170920SE

Natura 2000 area	
Birds in Natura 2000 area	Indirectly covered (reference to ecotoxicological effects). No monitoring currently planned.

An updated draft of the monitoring program was sent to the authorities in December 2017. SwAM then indicated that they would like to have surveys of underwater noise during the construction work within the Natura 2000 area Hoburgs bank and Midsjöbankarna included in the program, which also were accepted by NSP2.

Table 2 presents the preliminary schedule of the planned environmental monitoring during the coming years. Monitoring of turbidity, commercial fishery, cultural heritage and maritime traffic were all presented in the ES. Following the dialogue with the authorities, monitoring of sediment transport, benthic fauna (reef effect), ecotoxicological effects in mussels and underwater noise are now also planned to be conducted.

Table 2 Preliminary schedule for monitoring activities in the Swedish EEZ during 2018–2024.

Monitoring target	2018	2019	2020	2021	2022	2023	2024
Sediment transport (after construction) **		*					*
Turbidity in Natura 2000 area (during construction)	*	*					
Ecotoxicological effects (prior, during and after construction)	*	*[4]					
Benthic fauna** - reef effect (after construction)					*		*
Commercial fishery ** (prior and after construction)	*				*		
Cultural heritage (prior and after construction)	*	*					
Ship traffic (during construction)	*	*					
Underwater noise (prior and during construction)	*	*					

** Might also be performed after 2024

Table 3 presents the preliminary schedule of the planned environmental reporting during the coming years.

Table 3 Preliminary schedule for NSP2 environmental reporting.

Monitoring target	2018	2019	2020	2021	2022	2023	2024

[4] Depending on the results in the laboratory testing monitoring might be required for a longer period.

Sediment transport (after construction) **			*				*
Turbidity in Natura 2000 area (during construction)	*	*	*				
Ecotoxicological effects (prior, during and after construction)	*	*[4]					
Benthic fauna** - reef effect (after construction)					*		*
Commercial fishery ** (prior and after construction)					*		
Cultural heritage (prior and after construction)		*					
Ship traffic (during construction)	*	*					
Underwater noise (prior and during construction)		*					

2.4 Sediment transport

Monitoring of the sediments adjacent to the pipelines will be done in order to verify that the pipelines will not impact the topographical environment along the route, and that the pipelines (including rock placement) will not significantly hinder natural sediment movements.

2.4.1 Experience and lessons learnt from NSP

Nord Stream 2's Supplement to its Application filed in Feb. 2017 and the results from Nord Stream's surveys, investigations and previous monitoring programmes, have shown that the impacts are expected to be limited (both in space and time). However, NSP2 will include this in the monitoring programme in order to verify these conclusions.

2.4.2 Scope of the NSP2-monitoring

NSP2 will prepare a trend analysis of sediment transport as part of the inspection and maintenance surveys similar to the ones carried out for NSP. Survey are planned to be performed on a yearly basis during the first years after construction and then less frequently in the following years in consultation with the authorities. Due to the expected small incremental changes in topography and patters of sediment transport and deposition per year, the monitoring reports are suggested to be performed five and 10 years after that the pipelines have been laid.

2.4.3 Monitoring areas

The sediment height will be measured using a multibeam echo sounder (MBES) at nine positions along the pipeline as shown on Figure 1 on the following page: one on the top of the pipe line (at central seabed level), two adjacent to each side of the pipeline (at the right and left seabed level), two at one meters, two at three meters and two at five meters from each side of the pipe line.

Figure 1 Longitudinal profile - cross section data. The sediment height will be measured using a multibeam echo sounder at nine positions (vertical lines in figure) along the pipeline.

2.4.4 Methods for NSP2-monitoring

The survey will use multibeam echo sounder (MBES) equipment to determine seabed cross profiles and allow the derivation of 9-point listings. A “9-point-file” will be generated to measure the sediment height at nine locations across the pipe (see Figure 1).

The collected data from the maintenance surveys will be compared to the data captured in the “as build survey” (which will be performed after the construction activities have been completed) to detect any possible changes in the surrounding seabed up to 5 m from the installed pipeline.

Relative accuracy of MBES mounted on a ROV flying close to a pipeline during inspection is considered to be better than 5 cm (of difference of the sediment level compared to previous measurements). Since the installed pipeline can move slightly vertically (or in some instances horizontally) during its lifetime, it is common practice to determine mean undisturbed seabed (5 m to 10 m) distance from the pipeline. This means that the seabed level then becomes the reference to which the pipeline and surrounding seabed can be compared in cross profiles. Any height/depth changes in pipeline or local seabed areas can then be compared “year on year” or “inspection on inspection.” This way the changes in sediment build/depletion can be quantified. Such comparison can be made using the 9-point data files or MBES difference plots from each successive survey. Areas of build-up, areas of seabed scour or pipeline spanning can be determined easily by this survey process. A typical MBES data display during pipeline inspection is shown in Figure 2 on the following page.

Figure 2 Typical multibeam echo sounder data display during pipeline inspection.

2.5 Water quality

The construction phase of the proposed Nord Stream 2 pipeline system will generate sediment dispersion that can potentially have an environmental impact on the marine life. Within the Swedish EEZ, the NSP2-route goes through the proposed extended Natura 2000-area Hoburgs bank and Norra Midsjöbankarna (which is suggested toinclude the Natura 2000 areas: Hoburgs bank and Norra Midsjöbanken). The scientific rationale behind the extended Natura 2000 area draws primarily from the results of the SAMBAH project, which indicated the area to be of importance for harbour porpoises. Harbour porpoises are however not evaluated to be particularly sensitive to increased turbidity. The focus of the monitoring is therefore directed toward the environmental values on the shallow banks of Hoburgs bank and Norra Midsjöbanken, which holds important habitats for mussels, fish and birds, where precaution is taken to avoid any high levels of suspension during an extended period of time.

Based on the planned seabed interventions works and experience from e.g. NSP regarding sediment spill rates, numerical modelling of the sediment dispersion has been carried out for NSP2. The modelling has shown that increased sediment concentrations as a result of seabed interventions work in Swedish waters will be limited to the close vicinity of the construction sites.

The purpose of the programme for monitoring of dispersion of released sediments is to verify that the above assessment is correct. In particular, the purpose is to verify that the order of magnitude of sediment spill is correct, and hence to confirm that the overall impact can be expected to be none or negligible at Hoburgs bank and Norra Midsjöbanken.

2.5.1 Experience and lessons learnt from NSP

The monitoring programme in Sweden during NSP included measurements of sediment fluxes in the sediment plumes from post-lay trenching. The purpose of these was both to be able to calculate the sediment spill rate (in kg/s) and to establish typical suspended sediment concentrations (SSC) at various distances from the spill source.

Prior to the construction works for NSP, no documentation of the spill rate from ploughing in an environment like the Baltic Sea, with a stratified water column and a non-depositional seabed consisting of lag sediments, was found in the literature. But due to the fact that results of actual measurements from post-lay trenching for NSP now are available, it is not expected that the sediment spill rate will be significantly different from what is assumed in the modelling. At least not higher, due to the conservative approach that was used.

In Sweden, monitoring of suspended sediments was measured by four fixed stations at the borders of Hoburgs bank and Norra Midsjöbanken during NSP as well as vessel-based monitoring near the trenching areas.

No systematic changes in turbidity levels before, during or after the trenching were observed at the four fixed long termed (LT)-stations at the border of the banks. The largest turbidity peaks occurred during rough weather and before trenching was initiated. The highest value (115 mg/l) was measured when no intervention works were taking place in the vicinity of the stations. The deviation was therefore considered to be the result of natural variations (e.g. storms, currents) or other activities in the Baltic Sea (e.g. bottom trawling). Due to the conclusive results, and in agreement with the Swedish authorities, it was decided not to continue with the LT stations measurements for the second NSP pipeline (Line 2). The vessel-based monitoring however remained in order to verify that the results from work on Line 2 did not differ significantly from that for Line 1 and to document permit compliance (Nord Stream AG, 2012).

The vessel based monitoring took place in close vicinity of the trenching. The highest suspended sediment concentration (SSC) measured by water samples was 7.3 mg/l. The calibrated turbidity readings showed a few peaks of slightly higher values but no peaks of excess concentrations above 15 mg/l were observed within Swedish waters even close (200 m) to the plough. Apart from these peak values measured just behind the plough, the SSCs were generally below 5 mg/l in all transects (Nord Stream AG, 2012).

For NSP, the permit included a threshold value of 15 mg/l at the boundaries of the banks. This value was included in the permit after a commitment regarding this was given by NSP, in order to provide a guidance value under which no impacts could be foreseen[5]. This is assessed to be a very conservative threshold value since it has been shown that natural turbidity can reach such levels during rough weather. Such concentration levels must furthermore be maintained for a long time to have any potential impact on the environment. Mussels have for instance shown to be generally tolerant to suspended particles, with laboratory testing indicating a tolerance to sediment concentrations of up to 50 mg/l (Hammar, Magnusson, Rosenberg, & Gambo, 2009).

2.5.2 Scope of the NSP2-monitoring

Even though the results from NSP monitoring shows that the risk of significant levels of sediment spreading to the banks are very low (not the least because NSP2 is situated east of the Nord Stream pipeline i.e. further away from the important shallow bank areas), some monitoring is

[5] The value of 15 mg/l was e.g. based on “Øresund Link. Dredging & reclamation conference. Øresund konsortiet. 26 – 28 May 1999. Copenhagen, Denmark”. The <15 mg/l is related to birds (eiders/swans).

considered to be appropriate due to the sensitivity of these areas, and to meet some of the statements received through the consultation process.

The purpose of the suggested vessel-based monitoring programme is to measure turbidity during trenching along defined sections in the vicinity of the important banks, in order to verify that the assumptions for the Environmental Study (ES) with respect to the sediment spill rate and sediment dispersion modelling are valid. Although the conservative value of 15 mg/l is not a value in which any environmental impact can be foreseen, unless possibly if maintained for a significant period of time, it is useful as an indicator for the amounts of sediment dispersion.

Monitoring is proposed to be performed during trenching operations for both lines. Sediment dispersion from other construction activities within the proposed extended Natura 2000 area (e.g. pipelay, rock placement and cable crossings) is not assessed to give rise to any significant turbidity or sediment spread. The monitoring is suggested to take place for a few days/weeks after the lay of each pipeline for two out of three trenching sections within the proposed extended Natura 2000 area; one at the planned trenching site south of Hoburgs bank, and one at the planned trenching site south-east of Norra Midsjöbanken. The third planned trenching sections is located far from the banks (south of Norra Midsjöbanken) and in the deep water shipping lane. Due to the very low risk of any environmental impacts from the sediment spreading in this area, monitoring is suggested to be performed only within the two previously mentioned trenching sections.

2.5.3 Monitoring areas

The vessel-based monitoring will take place in sections close to the important banks. The sediment measurements are suggested to take place as close to the plough as considered safe from the perspective of both the trenching activities and the monitoring vessel. The distance currently expected to be acceptable is 200 m behind the plough and 200 m to the sides of the trenching vessel. These distances were evaluated to provide an acceptable safety zone during the likewise monitoring for NSP. No activities are allowed in front of the trenching vessel. To give priority to the safety for all involved parties, a video link communication system will be installed on all vessels. In Figure 3 on the following page, a schematic layout of the principle used for vessel-based monitoring is showed.

Figure 3 Schematic layout of the principle used for vessel-based monitoring for NSP and also suggested for NSP2 (not to scale).

2.5.4 Method for NSP2-monitoring

The environmental impacts caused by dispersion of sediment spill as a result of seabed interventions are assessed in the Swedish ES for NSP2. Based on experience from other projects, the sediment spill rate has conservatively been assumed to be the following (the same as was used for NSP):

Post-lay trenching:	2% of the handled mass of seabed materials during trenching ~ 4-16 kg/s, depending on seabed sediment type.
Rock placement:	0.5% of rock mass ~ 0.29-0.34 kg/s.

As the assumed sediment spill rate from trenching is 1-2 orders of magnitude larger than the assumed sediment spill rate from rock placement, the sediment spill monitoring will only measure spill from trenching.

The sediment spill rate is also called the source strength, as it defines the flux of sediments away from a given source at a given time. The sediment spill rate is measured as the discharge of water through a given cross-sectional area (q_w, $[m^3/(s \cdot m^2)]$) times the concentration of suspended sediments in the water (SSC, $[kg/m^3]$), summed up to cover the area through which the spilled sediments are transported across the sediment plume (from sea surface to seabed, and horizontally across the sediment plume).

Turbidity is a well-recognized parameter for monitoring of suspended matter in water and therefore it is recommended using for sediment tracking. Turbidity sensors measure turbidity in NTU-/FTU-units and these units can be transformed to solid substance concentrations (mg/l) in water by using local conversion factors based on laboratory analysis. Similar methods are commonly used on dredging and dumping operations. Based on turbidity measurements, an estimate of the amount of re-suspended matter can be calculated.

The vessel-based monitoring of sediment spread follows the same methodology as for NSP where increased turbidity near the working area and between the working area and the two banks was measured during the period of trenching (Nord Stream AG, 2012).

Monitoring equipment

Turbidity is measured by an OBS (optical backscatter sensor) mounted on a cable. On the same cable there will be a C/T sensor for measuring water temperature, oxygen and conductivity / salinity. The turbidity obtained from the OBS-instrument is measured in NTU, but both NTU and mg/l values will be presented in the monitoring reports. The conversion from NTU to SSC (mg/l) during the survey will be done using a standard conversion factor of 1.8 (SSC = 1.8×NTU). This standard conversion factor was established by NSP during the surveys when trenching was taking place outside Hoburgs bank and Norra Midsjöbanken[6]. It should be noted that the conversion factor from NTU to mg/l always needs to be confirmed after the survey, based on laboratory results from analyses of water samples extracted during the actual survey. This is because the conversion factor depends on a number of parameters including sediment grain size distribution, sediment colour and organic content.

6 Nord Stream AG (2012) Monitoring of Water Quality, Sweden 2010-2011, G-PE-PER-MON-100-04060000

To make it possible to convert the results of the turbidity measurements to concentrations of suspended sediments, water samples are taken frequently at the same levels as, where the turbidity sensors are measuring. The OBS measurements are typically done 1-3 m above seabed where the highest SSCs are expected.

An Acoustic Doppler Current Profiler (ADCP) that will measure the underwater current field (current speed and direction) vertically throughout the whole water column is used from the vessel. By using the backscatter signal from the ADCP measurements, the distribution of the suspended sediments in the water column (in case a sediment plume exists beneath the vessel) is visualised, making it possible to optimise the quantitative turbidity measurements and water sampling.

Water sample analysis for calibration of turbidity measurements

A number of water samples are taken from the same levels in the water column as where the turbidity meters are situated. The number of water samples from each level depends on the variability of the sediment concentrations, the degree of heterogeneity of the suspended sediment grain size distribution, etc. The water samples are analysed for mass concentration of suspended solids. This will be done by filtering the water samples through pre-rinsed and pre-weighted 0.45 µm Millipore membrane filters or similar and weighing the dried filters afterwards. In that way the mass of suspended solids in the sample per volume unit of the water-sediment suspension can be established.

Conversion from turbidity measurements to mass concentration of suspended sediments is done using regressions between these parameters established from the above turbidity measurements and water samples from the same time and level in the water column.

Calibration and maintenance of measuring equipment

Calibration and maintenance is decided together with the contractor. The frequency depends on the exact type of instruments to be used and is planned with due consideration to vessel logistics.

Monitoring set-up

In order to be able to relate measurements of SSC close to the spill source (transect measurements from vessel) to the expected SSC at the border of the banks, modelling of the sediment concentrations at various distances from the spill source was carried out for a selection of pre-defined velocity speeds during NSP. The sediment spread was evaluated using the general numerical particle analysis model MIKE 3 PA, developed by the Danish water environment consultancy DHI. The model is forced by hydrodynamic data including currents, salinity and temperature for representative hydrographical periods.

The modelling is based on the following assumptions:

- Settling velocities of different sediment types and sediment type distribution are as shown in the Swedish sediment NSP-modelling report[7]. Sediments are initially suspended evenly in the lowermost 10 m of the water column.
- A transversal dispersion coefficient of D_T = 1 m^2/s is used in the modelling (this coefficient determines the sediment dispersion perpendicular to the current direction in the modelling).

[7] Nord Stream AG, Offshore pipeline through the Baltic Sea, Memo 4.3A-5. Spreading of sediment and contaminants during works in the seabed, Sep 2008 Doc no: GE-PE-PER-EIA-100-43A50000

- Sediment concentrations are proportional to the sediment spill rate.

The modelling can be described as a "reverse" calculation where the spill rate is scale in order to reach a SSC of 15 mg/l at the border of the banks. E.g. for currents of 10 cm/s an unrealistic spill rate of 6,200 kg/s is required. A spill rate of 40 kg/s is the lowest possible that has the potential to reach the banks under a persistent unfavourable combination of current speed and direction. Previously, spill rates of 7-19 kg/s have been applied for NSP-modelling.

Results during NSP showed that an excess SSC of 1 mg/l never was reached at the border of the two Natura 2000 areas of Hoburgs bank and Norra Midsjöbanken (suggested to be joined and extended to a larger Natura 2000 area). Based on experience from the 2010/11 campaign, monitoring will be carried out as near the spill source as possible and within 1 km from the trenching site.

Figure 4 Sediment concentrations in the lowermost 10 m of the water column, at various distances from the sediment spill source, and at various current velocities. The horizontal red line corresponds to 15 mg/l.

In Figure 4, the result of the NSP-modelling is shown. The curves show the SSC as a function of the distance from the trenching site under the assumption that the concentration is 15 mg/l at the border of the shallow banks (marked with green area). From the same Figure 4 it is seen that the monitored SSC must be higher than 35 mg/l (1,000 m from the spill source) for the SSC to have the potential to reach 15 mg/l at the border of the banks within a distance of 4.2 km. The closest distance between the trenching areas and the banks was 4.2 km for NSP. NSP2 construction sites are, however, more distant to the banks and the closest distance between the trenching areas and the banks is 5.4 km. Since it is known from the results in Figure 4 that the concentration is decreasing with distance it is obvious that the limits for NSP2 could be lowered compared to NSP. For precautionary reasons the finding from NSP is adopted for the NSP2 project as guidance values. In Table 3, the different values for vessel-based sediment monitoring are shown. Also the above considerations require that the current is flowing toward the banks. If

the current direction is away from the banks (which it normally is) it is trivial that no impact is possible. For all velocities lower than 10 cm/s there are in principle no constraints.

Table 3 Guidance values for monitoring related to the threshold at the border of the shallow banks in the proposed Natura 2000 area. The concentrations are given for a minimum distance of 4,200 m between ploughing site and the border of the nearest bank area.

Current conditions	SSC guidance values*
current > 20 cm/s	35 mg/l
10 cm/s < current ≤ 20 cm/s	65 mg/l
current ≤ 10 cm/s	Unlimited

** SSC to be fulfilled within a 1,000 m corridor around the pipeline.*

As already mentioned above, the values presented are very conservative based on the calculation from NSP. This since the NSP2 pipelines will be further away than the NSP pipelines, meaning that less impact can be expected. More so, the 15 mg/l-threshold at the banks is assessed to be a very conservative threshold in itself since it has been shown that natural turbidity e.g. can be higher than this during rough weather. Such concentrations must furthermore be maintained for a long time to have any potential impact. The conservative value will nevertheless be used as an indicator also for NSP2 trenching activities.

In case the limits in the table above are exceeded, depending on current velocities and direction, control transects are immediately to be performed between the pipeline and the nearest bank. The initial control transects will be carried out in a distance of 900-1,000 m away from the pipeline in the direction of the nearest bank. If concentrations in two consecutive control transects exceeds the guidance values, a signal will go from the monitoring vessel to the trenching vessels for awareness. The SSC and the currents will be continuously measured at various distances from the sediment plume, and the measurements will be compared with the forecasts shown in Figure 4. Impacts from dissolved sediment/contaminants from trenching will be short term of only hours – up to approx. one day for a specific location. If the thresholds are exceeded in several transects in the direction of the banks, suitable mitigation measures will be initiated (this could e.g. be: slowing down the trenching speed, delaying start of next trenching section, pausing work awaiting lower turbidity levels or shifting the order of sections to be trenched).

The measurements will to a large degree be co-incident with the measurements carried out for establishing the sediment spill rate. In case unexpectedly large SSC values of 15 mg/l or more are measured at the border of the Natura 2000 areas, NSP2 will inform the Swedish authorities (and both the construction works and the further monitoring programme might be adjusted) in agreement with the authorities.

2.6 Ecotoxicological effects

In natural accumulation areas for fine-grained sediments in the Baltic Sea, the levels of contaminants in the surface sediments are in some areas relatively high. This is due to the fact that hydrophobic substances, such as heavy metals and organic contaminants, readily adsorbs to the surfaces of fine-grained sediments and particulate organic matter.

The two banks are important areas for macroalgae and benthic fauna, as well as for fish and birds. The aim of the monitoring is to measure potential ecotoxicological effects on biota caused by release of sediment and associated contaminants from the Nord Stream 2 construction work by measuring growth and accumulation of contaminants in the Common mussel (*Mytilus edulis*).

Lessons learned from the previous monitoring programme have been considered to improve the monitoring and will possibly be adjusted, in agreement with the authorities.

2.6.1 Experience and lessons learnt from NSP

Nord Stream developed a monitoring programme which included monitoring of ecotoxicological effects in Common mussel (*Mytilus edulis*) within Hoburgs bank and Norra Midsjöbanken (Nord Stream AG, 2011). The aim of this survey was to monitor ecotoxicological effects on biota caused by release of sediment and associated contaminants during the Nord Stream construction work. By comparing growth and the concentrations of chemicals in mussels from impact stations with mussels from reference stations not exposed to the potential source of contaminants, it would be possible to measure the exposure of the mussels for particle-associated contaminants caused by the Project.

Growths were measured by analysing physical parameters including; length, total weight, wet and dry weight of soft tissue, shell weight and gonadal status of the mussels. Accumulation of contaminants was investigated by means of chemical analysis by an accredited chemical laboratory. Analyses included metals (Hg, Cd, Cu, As, Zn, Ni, Pb, Cr, Sn) and organotins (MBT, DBT, TBT, TeBT, MOT, DOT, TCHT, MPhT, DPhT, TPhT).

The monitoring set-up included monitoring before, during and after post-lay trenching of Line 1. The programme included a total of 12 stations: six stations at Hoburgs bank and Norra Midsjöbanken respectively, with three impact stations at the southern border of each bank located relatively close to the Nord Stream Pipeline, and three reference stations on each bank located north or northwest of the impact stations inside the banks. Four of these stations (two at each bank) were establish as an extra security if some of the stations should be lost during the monitoring.

All mussels used at the different stations and different periods were collected from Faludden near Gotland before the monitoring started. This was considered to be a relatively clean area according to the Gotland County Board at that time. Mussels were placed in mussel frames at each station for a period of approximately six weeks, after which they were collected and sent for physical and chemical analyses. Analyses were also carried out for mussels collected at the Faludden collection site. This procedure where mussels were exchanged and analyzed took place three times in the monitoring period between December 2010 and May 2011, i.e. before, during and after post-lay trenching.

Both descriptive statistics, such as average and standard deviation, and statistical analysis such as analysis of variance (ANOVA) and multiple comparison tests was conducted for the four field surveys of contaminants in Common mussels during the monitoring programme. The results of the physical growth related parameters (length, weight, gonadal status) of the mussels at Norra Midsjöbanken and Hoburgs bank showed in general no unequivocal differences between the impact and the reference stations. The chemical analyses included analysis of 11 metals and 10 organic tin compounds. All metals were detected in concentrations above detection limit, while only four organic tin compounds (tributyltin (TBT), dibutyltin (DBT), monobutyltin (MBT) and monooctyltin (MOT)) could be detected in the analysis of mussel tissue. The analysis showed elevated levels of DBT and MBT in the whole monitoring period at the impact and reference stations at Norra Midsjöbanken, Hoburgs bank, and in mussels from the collection site at Faludden.

For NSP, no impacts related to the construction works could be observed during the surveys conducted in 2011 but it was difficult to interpret the results. Due to external factors (such as natural weather, currents and toxins) that are included in an in-situ experiment it was difficult to

evaluate the independent variable and causality between a possible effect on mussels and the trenching activity. The different results of physical, chemical parameters (metal and organic tin content) measured and analysed in the Common mussel, at the impact and reference areas at Hoburgs bank and Norra Midsjöbanken, at the different surveys (monitoring periods) can basically be ascribed to the following conditions:

- Natural variations in physical, chemical and biological parameters geographically and seasonal.
- That the highest concentration of metals and organic tin compounds was measured in mussels from Faludden.
- That the four surveys from December 2010 – May 2011 were performed during winter and spring. During this period temperature is very low and food supply reduced, all conditions that affect the metabolic rate, filtering and respiration activity in the mussels, and thereby uptake and accumulation of contaminants.

Another monitoring set-up for measuring potential eco-toxicological impacts is therefore suggested where tests are done in a more controlled experimental environment as described below.

2.6.2 Scope of the NSP2-monitoring

The monitoring programme for the Common mussel has been designed with the objective to:

- Describe and evaluate potential effects on the Common mussel inside Hoburgs bank and Norra Midsjöbanken from contaminants brought in suspension during post-lay trenching activities along the pipeline route.
- Evaluate the results and conclusions described in the Swedish ES and the concerns raised by the Swedish authorities and other stakeholders, regarding environmental effects from a potential increased concentration of contaminants.

The source of impacts from trenching activities on the water quality and on the marine fauna (including mussels) at the border of Norra Midsjöbanken and Hoburgs Bank, may be related to dispersion of sediment with/without content of associated contaminants.

For setting up a meaningful monitoring programme for assessment of the environmental impacts on mussels at the border of the two banks, it is important to know the type of impact that can be foreseen, this in respect to:

- Type and concentration of contaminants potentially dissolved in the water environment from trenching.
- The concentration of dissolved contaminants at the border of the two banks. The duration of the impacts (the time that mussels will be exposed to increased concentrations of contaminants), and the period of the year where impact may occur.

Based on the results from the environmental survey carried out in 2015 (DHI, 2015) increased concentrations of contaminants are not expected.

Trenching activities are furthermore likely to be carried out outside of the summer months, hence during periods where the metabolic rate in marine fauna is low or very low.

In order to establish a relevant mussel monitoring programme, it must therefore be taken into account that a possible impact, if any, will be short term, and during suitable periods as to the potential for environmental impacts.

2.6.3 Monitoring areas

There are three trenching sections planned within the Swedish EEZ (see Figure 5). One of those sections is located far from the banks (south of Norra Midsjöbanken) and in the deep water shipping lane. Due to the very low risk for any environmental impacts that sediment spreading in this area would have, monitoring is suggested to be performed only within the two other planned trenching sections in the vicinity of Norra Midsjöbanken and Hoburgs bank .

Table 4 shows the expected length of the two trenching sections for Line A and line B, together with the distance from where trenching is planned to be carried out and to the border of the banks in the former two Natura 2000 areas, and finally, the duration of the trenching activities, - and so the approximate duration where mussels may be exposed to changes in the water quality caused by trenching.

Table 4 Length of the two planned NSP2 trenching sections, distance to the border of the banks and the duration of the trenching activities.

Parameter	NSP2 Trenching sections (Line A and B)	
	South of Norra Midsjöbanken	South of Hoburgs bank
Line A		
Length	7.0 km	4.3 km
Distance to border of Natura 2000 area	≥5.5 km	≥6.7 km
Duration of trenching (400 m/hr)	Approx. 18 hours	Approx. 11 hours
Line B		
Length	7.9 km	8.3 km
Distance to border of Natura 2000 area	≥5.4 km	≥6.8 km
Duration of trenching (400 m/hr)	Approx. 20 hours	Approx. 21 hours

Figure 5. Planned trenching sections of Line A and B in the vicinity of Norra Midsjöbanken and Hoburgs bank.

2.6.4 Methods for NSP2-monitoring

This proposed monitoring programme for monitoring of impacts on water quality/mussels is divided in three chronological steps. Whether the monitoring programme continues to the next step will depend on the results of the previous step.

Step 1

It is proposed to carry out sediment sampling at six stations, with three stations at the planned trenching south of Hoburgs bank, and three stations at the trenching section at Norra Midsjöbanken. The locations of the sediment sampling stations are shown in Figure 6.

Figure 6 Sediment monitoring stations 1 – 6 at the two trenching sections.

Sediment samples shall be vibrocore samples to a depth down to 1.5 m below the seabed surface in order to represent the sediment that could be brought in suspension by trenching. Sediment samples for chemical analyses for content of contaminants (metals and organic substances) shall be taken from following depths: 0 -0.02 m, 0 -0.5 m, 0.5 -1.0 m, and 1.0 –1.5 m. Furthermore, analyses of dry matter (DM), total organic carbon (TOC), and loss of ignition (LOI) will be carried out on all samples.

If results from chemical analyses for substances is in line with the results from 2015, and results from substances not analysed in 2015 are below detection limit or in accordance with guideline values (Naturvårdsverket, 1999) (SGU, 2017), no additional steps are deemed necessary.

If results show increased content of contaminants of any significance, then monitoring has to continue, see step 2.

Step 2

It is proposed to carry out leaching tests on the vibrocore sediment samples by using natural seawater at a temperature according to the temperature when trenching is planned to be carried out. As a most conservative approach, the leaching test should be undertaken for a period comparable to the duration of the trenching activities inclusive the period from where sediment is brought in suspension and until it would reach the border of the Natura 2000 areas.

Leaching water has to be analysed for the specific contaminants that in Step 1 were found with increased concentrations.

If results from the leaching test show concentrations of contaminants below detection limit or in accordance with guideline values for substances according to (Naturvårdsverket, 1999) and

(HaVS, 2013), as well as the EU Directive 2013/39/EU, then it is proposed to finalize monitoring, as there will be no risk of impacts.

If the result shows increased concentrations of contaminants in the leaching water then monitoring has to continue, see step 3.

Step 3
It is proposed to carry out laboratory accumulation tests using mussels from the region where trenching is planned to be carried out, and using sediment from location and/or leaching water.

The time for mussels to be exposed to sea water with increased content of contaminants is preliminary assessed to be between two – five days.

Mussel tissue and water samples from the mussel tests will be analysed for content of contaminants both before and after the mussel accumulation test have been carried out.

The numbers of tests/analyses to be carried out have to be agreed upon so that the results will be statistically solid.

During the trenching operation
During trenching, measurement of the current direction and measurement of sediment dispersion at the trenching site will be carried out (as explained in section 2.5.4, monitoring equipment). Based on the results from these measurements and the results from the in-situ mussel monitoring it will be possible to make a final detailed assessment of the actual environmental impacts on the mussels.

Based on previous experience (see sections 2.6.1 and 2.6.2), it is Ramböll's view that the steps presented above represent a better approach compared to the monitoring set-up for NSP. This since a long-term test with mussel frames in the Natura 2000 area might provide ambiguous data, in which it will be difficult to distinguish and make any conclusions about the contribution from the NSP2 project compared to other activities (including bottom trawling) and natural occurrences. However, with the results from the above presented method steps and the mussel accumulation tests it will be possible to make a detailed assessment of the actual environmental impacts on the marine fauna/mussels and whether further investigations are needed or not.

2.7 Benthic fauna – reef effect

The purpose of monitoring benthic fauna along the pipeline route is to evaluate and document the establishment and growth of epifauna on and in the near vicinity of the pipelines and rock berms following completion of all construction activities in order to identify the establishment of communities on the new habitats (artificial reefs).

2.7.1 Experience and lessons learnt from NSP

Monitoring of epifauna was carried out at four locations along Line 1 in Swedish waters. At each of these locations, a 250 m section of the pipeline was recorded using three video cameras mounted on an ROV covering the top and sides of the pipeline. The monitoring was carried out annually from July to September, between 2011 and 2014.

In 2014, the video recordings from the four analysed areas in Swedish waters documented an increase in the colonisation of sessile epifauna (blue mussels) in comparison with the previous survey and showed a more pronounced establishment within the shallow area (sampling location: ~26 m) compared with the deeper areas (sampling locations at ~58 m, ~41m and ~46m). One mobile species of epifauna, the crustacean Saduria

entomon, was found to be present on and next to the pipeline. In addition, three species of fish, cod, short-spined sea scorpion (Cottus scorpius) and gobies, particularly black goby (Gobius niger), were observed on and in the immediate vicinity of the pipeline. The colonisation of sessile epifauna gradually increased between the years and showed a more pronounced establishment in the shallow area compared with deeper areas (Nord Stream 2 AG, 2016).

In accordance with the expected effects of the new hard-bottom substrate (the pipeline), a general increase in epifauna has been observed since 2011, when the first epifauna survey took place. In 2013, the first establishment of blue mussels was confirmed, and the population of the mobile crustacean Saduria entomon on and next to the pipeline had increased compared with the surveys in 2011 and 2012. The most recent report presents the results from the survey carried out in 2014 (Nordstream AG, 2015).

Lessons learnt from NSP are that poor quality of images makes it rather difficult to distinguish the innate structure of the surface of the pipeline from a sporadic and scattered presence of mussels or other epifauna. Therefore the footage quality has to be good.

2.7.2 Scope of the NSP2-monitoring

The monitoring programme for epifauna is directed at rock placement and pipelay construction activities and in the Natura 2000 conservation area Hoburgs bank and Norra Midsjöbanken in the Swedish EEZ.

The survey will be done with the intention of evaluating the potential qualitative and quantitative changes in epifauna communities such as new habitats (artificial reefs). Fouling communities are documented by means of visual inspection during the external technical inspection (artificial reefs effect).

2.7.3 Monitoring areas

Epifauna inspections will take place in four sections along the route; two sections on the pipeline within the Natura 2000 area and in two sections where rock placement is planned (see Figure 7).

At each of the suggested locations, a 250 m section of the pipeline will be recorded using three video cameras mounted on an ROV covering the top and sides of the pipeline.

Figure 7 Monitoring stations - Reef effect.

2.7.4 Methods for NSP2-monitoring

Visual inspection/video recording of the pipeline and any rock berms will be conducted using ROV. Measurement of conductivity/salinity, temperature, depth and oxygen throughout the entire water column will also be performed to support the analyses. Since the epifauna growth is rather slow the monitoring is suggested to be carried out three and five years after construction.

One camera on the front of the ROV will film the pipeline from above. Two other cameras mounted on port and starboard ROV boom arms will film the pipeline from each side (see Figure 8 on the following page).

Figure 8 Remotely Operated Vehicle (ROV)

The speed of the ROV can be adjusted to move a bit slower for more detailed inspections in areas of interest. However, the quality of recording will also allow playback at slower speeds when evaluating the video data in such areas of interest.

Post lay rock berms (in shallow areas) that will cover the pipeline will also be inspected to see if any epifauna growth can be observed. A pipe tracker mounted on the ROV will ensure the ROV tracks the pipeline beneath the rock berms. The data will be compared to the base line study in the same area. To cover a larger survey width or corridor of interest, the ROV will be used to perform a “high pass” run, at approximately 10 m altitude above the rock berm and will therefore be able to cover a much wider footprint of seabed if required.

2.8 Commercial fishery

From a technical point of view, the NSP2-pipeline is designed to allow fishing over the pipelines without damage to the pipelines, i.e. to withstand hits from all types of trawling equipment used in the Baltic Sea. However, some fishery communities have raised concern about the conditions for trawling over and in the vicinity of the NSP2 (as well as the Nord Stream Pipelines). Thus, a monitoring programme for fishery, similar to what was done for NSP, has also been elaborated for NSP2.

In the Baltic Sea, trawls are the main gear type used outside coastal areas. Mid-water trawls are used primarily to catch herring and sprat. Bottom trawls are used mainly for cod. Pelagic trawlers catching a mixture of herring and sprat dominate the fishing activities in the Baltic. The proportion of the two species in the catches varies according to area and season. Mid-water trawls are used throughout the Baltic Sea, whereas bottom trawls mainly are used in the south-western Baltic, and in the Baltic Proper. High-opening trawls are used in the Bornholm Basin (ICES, 2005).

The objective of the fishery monitoring programme is to investigate whether the commercial fishery patterns in areas close to the NSP2 have changed after the installation of the pipelines.

2.8.1 Experience and lessons learnt from NSP

In connection with NSP the environmental monitoring programme for fishery in the Swedish EEZ was prepared by Nord Stream AG in consultation with the Swedish authorities. The fishery patterns were evaluated on the basis of VMS data, which monitors the position and speed of fishing vessels for each hour of sailing. VMS data on bottom trawling and bottom net fishery by Swedish fishing vessels was supplied by SwAM for the period 2010-2014.

The general bottom trawling patterns and net fishery patterns in 2010-2014 were the same as those observed during the baseline survey in 2004-2009, so no changes to the fishery patterns were observed as a result of the presence of the pipeline system.

Bottom trawling close to the pipelines in the period 2010-2014 was limited and generally located west of the pipelines and south of Öland. During that time most of the bottom trawling activity was performed outside the Swedish EEZ, toward Poland. However, the activity varied slightly over time and in terms of geographical location. The majority of the bottom trawling activity close to the pipeline system was performed almost perpendicular to the pipeline route.

The catch pattern has been evaluated on the basis of logbook data. The estimated catches by bottom trawling and bottom net fishery in 2010-2014 after installation of the pipeline system generally showed annual variations in landings of both quota and non-quota fish species. Ramboll assesses that none of the changes in annual fish landings can be attributed to the presence of the NSP pipeline.

2.8.2 Scope of the NSP2-monitoring

The objective of the fishery monitoring programme is to investigate whether the commercial fishery patterns in areas close to the NSP2 are changed after the installation of the pipelines. Changes in pelagic fishing, bottom trawling, gill net locations and changes in fish species and catch sizes will be evaluated as part of the monitoring.

2.8.3 Monitoring areas

The area to be monitored is the areas surrounding the pipeline route within the Swedish EEZ.

2.8.4 Methods used for NSP2-monitoring

The same methodology as for NSP will be applied for the monitoring of NSP28. In Swedish waters there will only be an addition since there have been statements suggesting that there is an impact on pelagic fishery, in spite expert opinions on the contrary as evident in the ES, monitoring will also include an analysis of pelagic fishing patterns.

The analyses will be based on fisheries data collected by SwAM as part of the statutory reporting of fishery patterns and fish catches by the Swedish fishing fleet. The collected data will be compared and evaluated against the baseline conditions.

2.8.4.1 Fishery pattern

[8] Monitoring of fishery, Sweden 2014, C-OP-PER-MON-100-040315EN

The fishing vessels' movements in the pipeline area and possible changes in fishing patterns in the Swedish EEZ will be monitored through the VMS system in combination with AIS data. For this purpose the tracking data obtained prior to the construction will be compared with the tracking data that will be gathered approx. three years after construction of the pipeline system. If required, data could also be assessed after some additional years of the pipelines being in operation.

VMS data will be used to map density of fishing to show where the fishermen fish. AIS data can be used to map how the pipeline is crossed e.g. to identify if the fishing vessels and gear cross the pipeline in a particular angle.

Table 5 Schedule for monitoring activities during 2017–2022 in the Swedish EEZ.

Parameters, methods and timing of monitoring				
Target group	**Parameter**	**Method**	**Data coverage**	**Reporting**
Swedish pelagic (mid-water) trawl fishery	Density/ location	Analysing of vessel Monitoring System (VMS) satellite tracking data. Analysis of vessels with AIS data	Impact monitoring: Before and under construction: 2015 – 2018 After construction: 2020 – 2022 (or even longer if deemed needed)	Two-three years after the construction phase in 2022
Swedish bottom trawl fishery	Density /location	Analysing of vessel Monitoring System (VMS) satellite tracking data. Analysis of vessels with AIS data	Impact monitoring: Before and under construction: 2015 – 2018 After construction: 2020 – 2022 (or even longer if deemed needed)	Two-three years after the construction phase in 2022
Swedish gill net (standing gear) fishery	Density/ location	Analysing of vessel Monitoring System (VMS) satellite tracking data.	Impact monitoring: Before and under construction: 2015 – 2018 After construction: 2020 – 2022 (or even longer if deemed needed)	Two-three years after the construction phase in 2022

The VMS/ AIS survey may also be accompanied with interviews with representatives from the fishery organisations in order to circumference other factors connected to the pipelines that may affect the fishing patterns.

2.8.4.2 Fish catch pattern

The fisheries in the Baltic Sea are divided by international fishery statistical areas (so called ICES rectangles), where national and international fishery regulations, requirements and quotas apply and the majority of the catch data is separated. All Swedish fishing vessels ≥10 m are required to register their catches within these ICES statistical rectangles (approx. 30 x 30 nautical miles, see Figure 9). This data gives a good overview of the spatial distribution of where the various species are caught and the amount (weight) of the catches. Fishing vessels <10 m are only required to note their catches in coastal water declarations where the location of the catch is given in much larger areas (ICES subdivisions).

Figure 9 The ICES rectangles along and adjacent to the NSP2 route. In Swedish waters the pipeline route crosses the following ICES statistical rectangles: 46H0, 45H0, 44G9, 43G9, 42G9, 42G8,41 G8, 41G7, 40G7, 40G6, 40G5.

The data from the registered catches will be compared to a base line situation before the construction and operation of the NSP2 pipelines.

2.9 Cultural heritage

Due to the physical conditions in the deeper parts of the Baltic Sea (low salt content, relatively low temperatures, low oxygen content, etc.) and the absence of shipworm (Teridinidae), the decomposition of wood and other organic materials progresses slowly. Consequently, the preservation of organic materials is exceptional. The preservation value and scientific potential of underwater cultural remains in the Baltic Sea are therefore high. In the Swedish EEZ, the cultural heritage values comprise of shipwrecks.

Historically and archeologically significant cultural heritage object (CHO) sites have been taken into consideration when planning the routing of the pipelines in the Swedish EEZ. Sonar surveys as well as some visual inspections have been carried out to identify possible CHO sites on the seabed along the route alignment. All potential cultural heritage sites that are located nearby the pipeline route (±250 m) have been evaluated carefully.

2.9.1 Experience and lessons learnt from NSP

Inspections were performed before and after the construction of the pipelines in the NSP project. The pre- and post-construction inspection results were assessed by the Swedish Maritime Museums. After pipelaying activities it was concluded that one CHO was impacted by an anchor

chain during construction of NSP. Since the anchored-based lay vessels have been exchanged for dynamically-positioned vessels in the NSP2 project, the risk of such an event re-occurring has been removed.

2.9.2 Scope of the NSP2 monitoring

The purpose of the cultural heritage monitoring is to document the condition of a number of selected wrecks before construction and to verify the condition of those wrecks after construction.

On the Swedish continental shelf, the planned pipeline route passes close to 23 identified wreck sites according to the survey data. Six wrecks are located within 250 m from either of the pipelines (the pipeline corridor applied for + 50 m as security area) but none is closer than 50 m. Those wrecks within 250 m from a pipeline are suggested to be monitored. In addition, one object (S-R30-0997, approximately 700 m from the pipeline corridor) is of special interest for the Swedish cultural heritage authorities and might therefore also be included in the monitoring during the construction of the NSP2 pipelines.

2.9.3 Monitoring areas

In Figure 10, the positions of wrecks close to the NSP2-pipelines are shown.

Figure 10 Positions of identified wrecks (close to the NSP2 pipeline route) found during the geophysical reconnaissance survey.

2.9.4 Methods for NSP2-monitoring

The methodology will follow the approach used during NSP. The condition and location of each of the selected cultural heritage sites will be surveyed prior to start of pipelay activities. In order to verify that the cultural heritage object sites have not be affected by the pipelay, a post-construction survey will also be performed. This will consist of a visual inspection by ROV and a MBES (Multibeam) survey. Possible impacts of the construction activities to the CHO site will be detected by having marine-archeological expertise comparing the baseline survey and the post-lay survey results..

Table 6 Monitoring of impacts on cultural heritage.

Parameters, methods and timing of monitoring				
Target group	**Parameter**	**Method**	**Location**	**Timing / frequency**
S-R17-4285 **S-R19-1026** **S-R24-5317** **S-R27-0640** **S-R27-5051** **R-29-93462** **(S-R30-0997)**	Location (coordinates) and Condition (intact/impacted)	ROV visual inspection MBES survey	Location of CHO sites	Prior to pipelay activities. After pipelay activities have been finalised.

2.10 Ship traffic

The purpose of the control and monitoring related to marine traffic is to minimize the risk of collisions or other accidents involving commercial shipping traffic and/or vessels carrying out construction activities for the project. The monitoring activities proposed for NSP2 will focus on demonstrating that information has been provided to the authorities as agreed, that the construction vessels behave as intended, and that safe passage for third party vessels, and the NSP2 construction vessels, is possible.

Three monitoring activities of offshore work during the construction phase are given in the following with the purpose of documenting safe navigation for commercial ships passing the construction works during the constructions phase.

2.10.1 Experience and lessons learnt from NSP

During NSP, monitoring of ship traffic was performed using AIS data and reported to authorities to verify/adjust risk reducing measures ensuring safety for the commercial ship traffic during the construction phase.

Yearly analysis of ship tracks along the pipeline was reported to identify if there had been any incidents were ships have either
- Drifted and performed emergency anchoring close to/on top of pipeline.
- Indication of unintentional dragged anchors impacting the pipeline.

During the construction in the Swedish EEZ, it was also verified that Nord Stream and its construction vessels followed the communication and reporting procedures that were agreed with Swedish authorities and organizations. Nord Stream provided the relevant authorities with notifications (generally four weeks prior to the commencement of a new construction activity), monthly forecasts as well as daily updates from the construction vessels. Regular information to

the fishing community was provided from the time when the construction activities started and continued throughout the construction phase.

Precautionary safety measures were successfully implemented and the construction activities were all performed without any accidents or significant incidents with third party vessels. On some occasions however, mainly during the initial weeks of construction, other vessels entered into the requested safety zones around the construction vessels. The monitoring and communication procedures onboard the construction vessels were then followed successfully and none of these safety zone intrusions resulted in any risk-related situations or incidents.

2.10.2 Scope of the NSP2 monitoring

The monitoring activities for maritime traffic described in the Swedish ES (see section 12.5.4) focus on the information provided from NSP2 to the authorities, up-front as well on a day to day basis in relation to notification of work plans and monitoring of third party vessels passing the construction activities. These activities are similar to the activities performed during the construction of NSP, as described above (see section 2.10.1).

The monitoring activities proposed for NSP2 will focus on demonstrating that information has been provided to the authorities as agreed (activity 1), that the construction vessels behave as intended (activity 2) and that safe passage for third party vessels, and the NSP2 construction vessels, is possible (activity 3).

The following tasks will be performed in relation to monitoring maritime traffic and construction activities in the Swedish Territorial Waters:

- Activity 1:
    - Information provided to the authorities as agreed

- Activity 2:
    - Pipe-laying (incl. guard vessels as required)
    - Rock placement (pre-lay and post-lay)
    - Post-lay trenching
    - Cable crossings
    - Survey vessels during construction (including pre-commissioning)
    - Pipe carriers
    - Supply vessels

- Activity 3:

Third party vessels around the lay-barge (and other construction vessels) acknowledging the safety zones during construction works'

2.10.3 Monitoring areas

Activity 1
"Notifications to Authorities as agreed."

The purpose of this activity is to document that NSP2 has provided information to the authorities and other stakeholders as proposed in the Swedish ES (see section 12.5.4) and as agreed in later consultations.

In the Swedish ES it is stated that:

> "The monitoring will follow the construction vessels. During construction works in the Swedish EEZ, a daily report on all construction activities will be transmitted from the vessels. These reports will include the name, call sign, current position and plan of the vessel for the next 24 h. Before and during construction, the locations of the construction vessels will be announced in Notices to Mariners by the SMA in order to increase awareness of project-generated vessel traffic."

The details as to the information to be provided, the timing and frequency of when it is delivered etc. will be further detailed during meetings with the relevant authorities, as well as the fishing organisations and possibly other stakeholders, before construction works are initiated.

By analysing correspondence between NSP2 and authorities and other stakeholders it will be verified that information has been provided as agreed.

Activity 2
"Monitor construction ship traffic in AIS data to document proper and safe behaviour of construction vessels to the authorities." This reporting can be done several times during the construction phase based on NSP2's continuous monitoring of the construction vessels.

The purpose of this monitoring activity is to document to the authorities that the construction vessels are following their intended routes, perform their activities within the planned timelines, areas of work etc. as previously presented in project documentation.

AIS data for the construction vessels will be gathered and analysed to illustrate observed ship tracks from the construction vessels. The observed ship tracks from the construction vessels will be compared to the intended behaviour of the construction vessels as described in the plans for the construction activities and the restrictions given by the safety zones. The comparison is done to show how the observed behaviour of the construction vessels matches the plans.

The results will be presented in maps showing the behaviour of the construction vessels. If incidents of special interest occurs then movies presenting vessel movements in space and over time can be produced to illustrate the situation. If this monitoring is done continuously throughout the construction period, then it will enable NSP2 to either confirm or adjust the behaviour of the contractor performing the construction activities.

Locations where work has taken place and details of the work performed will be reported and compared to the previously presented project plans in order to verify that the project is performed in-line with what has been presented in project documentation.

Activity 3
"Monitor the commercial ship traffic, passing the slow moving construction vessels (e.g. the lay-barge), using AIS data. This is done to document to the authorities that the commercial ship traffic has safe and free navigation when passing the construction vessels."

Any unexpected vessels entering a 'closest point of approach' radius are contacted and monitored closely. If necessary and available, support vessels of the spread are used to alert them. In order to notify smaller vessels, fishing organizations and maritime organizations are informed prior to the commencement of construction works and updated during the performance of the construction works.

AIS data for the commercial ships will be gathered and analysed to construct observed ship tracks from the commercial vessels when passing the safety zones around the slow moving lay barge.

The observed ship tracks from the commercial ships will show if the commercial ships are able to recognise the construction vessels and their safety zone in due time to safely plan their journey around the slow moving construction vessels.

Furthermore, when the slow moving construction vessels are working close to a Traffic Separation Scheme (TSS), south of Gotland, east of Hoburgs bank, then the observed ship tracks from the passing commercial ships will show, if the commercial vessels are able to pass the safety zones of the construction vessels and stay inside the TSS, maintaining safe and free navigation.

If incidents of special interest occurs then movies presenting vessel movements in space and over time can be produced to illustrate the situation. This monitoring will be done continuously throughout the construction period and will enable NSP2 to either confirm or adjust (in

consultation with the relevant authorities) the safety measures adopted to enable safe and free passage of commercial ships passing the construction activities.

2.11 Underwater noise

An expansion of the Natura 2000 area between Hoburgs bank, Norra Midsjöbanken and Södra Midsjöbanken, was proposed to the European Commission in December 2016 and established for the purpose to protect the Baltic population of harbour porpoise. The harbour porpoises in the Natura 2000 area are estimated to be approximately 500 individuals. During summer, the harbour porpoises concentrate around the shallow banks south of Gotland and Öland. During winter, the porpoises are more widespread to the north and along the coasts of Lithuania and Poland.

Monitoring of underwater noise is conducted in order to further verify the conclusions in the environmental report and replies during the public referral regarding potential impact from NSP2 construction activities on harbour porpoise in the Natura 2000 area.

2.11.1 Experience and lessons learnt from NSP

Underwater noise was monitored during the construction phase for NSP. Focus at that time was to measure and quantify noise from the construction work as well as ambient noise to compare NSP contribution to the soundscape in the area and also verify conclusions regarding the risks of temporary or permanent hearing damage on marine mammals. The bandwidth of the recordings was limited to 3 kHz since that was sufficient for the monitoring objective,

Authorities have now raised concerns around the construction of the NSP2 pipelines with arguments that the underwater noise may cause disturbance of behaviour and masking effects on harbour porpoise.

According to Ramböll and other experts on underwater noise, there is greater attenuation leading to propagation loss at higher frequencies[9]. Hence frequencies >100 kHz are not expected to be measurable in distances >500 m from the vessels.

2.11.2 Scope of the NSP2 monitoring

Harbour porpoises produce short ultrasonic clicks (130 kHz peak frequency, 50-100 µs duration). To measure if construction activities (including noise from construction vessels) produce high energy frequencies with potential to mask harbour porpoise echolocation, monitoring of underwater noise during construction of the NSP2 pipelines will cover frequencies up to 150 kHz. A baseline study will be performed also this time in order to compare NSP2 contribution to the background noise in the area.

2.11.3 Monitoring areas

As deployed for the underwater noise survey performed by Totalförsvarets forskningsinstitut (FOI) during construction of NSP, the ambient, shipping and construction noise shall be measured in three pairs of hydrophone rigs (six in total) which are placed approximately at the locations indicated in Figure 11. The distance between the two rigs in each pair should be about 1 km.

[9] Computational Ocean Acoustics, Authors: Jensen, F.B., Kuperman, W.A., Porter, M.B., Schmidt, H., 2011

Figure 111 Proposed positions for monitoring of underwater noise'.

The A1, A2 positions are placed at coordinates equal to the survey during the construction of the NSP pipelines. The rationale of this is to be able to compare results from the former study. B1 and B2 will monitor the sound from the pipelay close to Norra Midsjöbanken. Positioning should be as close as possible to the pipeline corridor but obeying safety regulations. C1, C2 are added to this monitoring programme in order to verify the conclusions regarding rock-placement in the Environmental Study. The C stations are to be considered as a separate part of the monitoring, not fully comparable with the results from the other stations (A and B), since they deviate in depth and bottom characteristics from the other stations.

2.11.4 Methods for NSP2-monitoring

In order to align with the work performed by FOI in 2012 and benefit from those efforts in the analyses of the results, the set-up should follow this alignment where possible and deemed appropriate. But since the focus is somewhat different to what was requested by the authorities at that time, the set-up might deviate to some extent.

The measurements shall include:
Field survey to cover background levels (base line)
Field survey to cover post-lay rock intervention work (IW)
Field survey during pipelay
Field survey during trenching[10]

[10] This is considered as optional since such measurements already are considered sufficiently covered by the underwater noise measurements for NSP.

- Monitoring of the existing underwater noise levels (baseline) should be performed before the construction vessel reaches the selected area and then monitor the underwater noise as the construction vessels passes by the monitoring positions. Knowing the exact time and distance between the monitoring positions and the construction vessel then comparing the measured levels to the existing background levels and levels from selected passing ships.
- Provide recorded sampled data for later analysis with sampling rate higher than 300 kHz for usable recording bandwidth at least 150 kHz.
- Measurement/calculation of sound speed profiles for all stations when they are deployed and recovered. This could be measured with sound speed probe or computed from CTD-measurements

3. TECHNICAL INSPECTIONS DURING OPERATION

In addition to the monitoring scope presented above, regular inspection surveys of the pipeline system will be carried out as part of the inspection, maintenance and repair (IMR) programme throughout the operation phase. The main goal of inspection surveys is to ensure the safe and reliable operation of the pipeline system throughout its lifetime.

Before the start of operation of the pipeline system an Inspection and Monitoring Strategy will have been developed. It describes the main types of inspections, their requirements and frequency. All the inspection requirements identified during the design phase as affecting the overall pipeline integrity (safety and reliability) during operation are covered in the Inspection and Monitoring Strategy.

Four types of inspections are planned for the entire route of the pipelines from Russia to Germany:

- External offshore inspection for the main marine section of the system (deeper than approximately 15 m),
- Internal inspection over the full pipeline length (pig-trap Russia to pig-trap Germany)
- Shallow water and onshore inspections surveys using geophysical surveys of the buried sections (Russia and Germany) – not performed in Sweden
- External inspections of the exposed onshore section (Russia and Germany) – not performed in Sweden

External Offshore Inspection will evaluate the pipeline / seabed configuration and the external condition of the pipelines. This inspection survey will be executed from a survey vessel equipped with ROVs or AUVs having visual, acoustic and electro-magnetic survey tools. During offshore external inspections the following information is determined:

- Damages to the pipelines e.g. to concrete coating and field joints
- Damage to pipeline support structures e.g. rock berms and cable crossing support mattresses
- Damage or depletion of anodes and deficiencies of cathodic protection
- Significant movement of pipelines, in particular if movement is outside of the installation corridor or outside the defined lateral movement acceptance criteria
- Locations where rock placement has to be carried out as a remedial action to support the pipeline, based on the survey inspection information
- Possible new objects (UXO, CHO or other) and targets within the pipeline installation corridor
- The location and condition of wrecks and barrages in the vicinity of the pipelines
- The location of the munitions in the vicinity of the pipelines

All collected data are compared with previous surveys and annual inspection surveys to allow comparison to the design and as-built condition. Historical trending is used to assess the development of such items as free spans, seabed scour, areas prone to damage, and consumption and physical loss of anodes (prediction of anode wastage).

Internal inspection is executed with internal pipeline guides.
In pipeline internal inspections potential local anomalies in the pipeline geometry are detected with pipeline inspection gauges (PIGS):

1. Pipe internal or external metal losses (wall thickness anomaly) e.g. due to corrosion
2. Individual wrinkles (internal diameter anomaly)
3. Out-of-roundness (ovality) dents
4. Change in curvature of the pipelines (bending)

The location and extent of the anomalies as for aforementioned parameters are proposed to be reported, if

1. Pipe wall thickness anomaly is greater than 10% of wall thickness
2. Pipe internal diameter anomaly is greater than 2.5 mm
3. Pipe ovality is greater than 1% of internal diameter
4. Pipeline bending is greater than 0.125% of bending strain (pipeline radius/bend radius)

The frequency and the starting date of each following inspection will depend on the results of the previous inspection surveys.

The Inspection and Monitoring Strategy will also provide for special inspections in case of any unexpected events which may impair the safety and reliability of the system. If the pipeline parameters are discovered to deviate critically from the design limits in any of the inspections, an appropriate maintenance or repair programme will be implemented.

4. REPORTING

4.1 General

The monitoring results and conclusions of the environmental impacts during construction and operation of the pipelines will be presented in annual reports. The structure will follow the alignment presented in section 2. Reports will be prepared in English but will also include a section with a summary in Swedish. The report will be submitted to the relevant authorities for each calendar year in May the following year.

The annual report summarises the monitoring results from all monitored activities for each monitored parameter. In the annual report, the significance of environmental impacts are assessed and discussed based on monitoring results of each monitoring target. The results will be compared with the monitoring results received during a similar gas pipeline project (NSP) in the same sea area in the Swedish EEZ.

Unexpected events and chance finds will be reported immediately.

4.2 Sediment transport

Surveys are planned to be performed on a yearly basis during the first years after construction and then less frequently in the following years in consultation with the authorities. Due to the

expected limited developments per year, the monitoring reports are suggested to be prepared five and 10 years after that the pipelines have been laid.

4.3 Water quality

Reporting will be done after each monitoring period has ended. Calibrated and quality controlled water quality and currents readings are published together with time and location information. The reports should in addition to the assessed results also include information about used instruments, installation method, water depths and other auxiliary data. Data will be analyzed separately against modelled results.

A short summary report will be delivered right after trenching of each pipeline. A report on water quality, covering the work that has been done in 2018, will be provided as part of the yearly monitoring report in 2019. A complete report, including the results from water quality monitoring for both pipelines, will be presented as part of the yearly monitoring report produced in 2020.

4.4 Ecotoxicological effects

Tests will be done in several stages and for every step it will be concluded if it is needed to proceed with the next step as described below.

1. Sediment sampling down to 1.5 m depth (vibrocore sampling) and chemical analysis for content of selected metals and organic pollutants.
2. Based on results from 1 – Leaching tests on sediment samples are performed. Leaching water samples for chemical analysis for concentration of dissolved metals and organic pollutants.
3. Based on results from 2 – leaching water from leaching tests used in accumulation tests on Common mussel (*Mytilus edulis*). Chemical analysis of Common mussel tissue for content of metals and organic pollutants.

A summary report on potential ecotoxicological effects will be provided after all tests have been done. Smaller reports (providing the basis for the decision regarding if the monitoring should proceed or not) are suggested to be provided for each step.

4.5 Benthic fauna- reef effect

Epifauna inspections will take place in four sections along the route; two sections on the pipeline within the Natura 2000 area and in two sections where rock placement is planned. At each of these locations, a 250 m section of the pipeline will be recorded using three video cameras mounted on an ROV covering the top and sides of the pipeline. The monitoring will be carried out three and five years after construction with reports produced and provided to the authorities.

4.6 Commercial fishery

Based on the monitoring activities, impacts of the construction works on fishing behaviour and fishing patterns in the project area in Swedish waters will be reported as preliminary scheduled in Table 2. The results will be compared with the data from the previous monitoring activity among the Swedish offshore trawl fishermen operating in the Swedish EEZ.

A report on commercial fishery will be provided three years after the finalisation of the pipeline construction, possibly also followed by another report some years later in consultation with the authority expert group.

4.7 Cultural heritage

Reporting concentrates on the comparison of pre-construction survey results with post-construction survey results of the condition of chosen wrecks. By comparison of the positions and still images of the wreck features observed during different time periods it can be established whether the wrecks have been interfered with or otherwise affected by the pipeline construction works.

Reports of monitoring of wrecks and relevant survey data will be provided to marine-archeological expertise (Swedish Maritime Museums - SMM). SMM will perform an evaluation of the monitoring results and report back to the Swedish National Heritage Board (SHB). This report will in turn represent the background information for the yearly summary report that will be compiled and sent to the authority expert group.

4.8 Ship traffic

AIS data will be analysed together with information available in NSP2 communication with authorities (e.g. daily, monthly reports). The monitoring activities will then be evaluated according to the activities:

1. By analyzing correspondence between NSP2 and the authorities it will be investigated if information has been provided to the authorities as agreed.
2. Evaluate the contractors performing construction activities and if their activities have been in alignment with the authorities demands on proper and safe behavior at sea.
3. Evaluate if safe and free passage of commercial ships passing the construction activities, as well as for the project vessels, have been enabled.

These analyses will be presented in yearly reports during the construction period. Relevant authorities will naturally be informed and consulted immediately in case any results show that safety measures can be improved.

4.9 Underwater noise

Monitoring shall take place before and during the construction of the first pipeline according to the schedule in Table 2. The results of the data collection will be presented in a report shortly after the data collection has ended. This report will be supplemented with an impact evaluation in the yearly monitoring report in 2019.

5. REFERENCES

Nordstream 2 AG. (2016). *Modelling of sediment spill in Sweden. 2016. W-PE-EIA-PSE-REP-805-020200EN.*

DHI. (2015). *Infauna report for Swedish waters in 2015, Doc. No.:WE-PE-EIA-PSE-REP-810-BLINFAEN-04.*

DHI. (2015). *Seabed sediments survey report for Swedish waters in 2015, Doc.No.:W-PE-EIA-PSE-REP-810-BLFISUEN-06.*

Hammar, L., Magnusson, M., Rosenberg, R., & Gambo, Å. (2009). *Miljöeffekter vid muddring och dumpning - en litteratursammanställning.Naturvårdsverket. Report No. 5999. 72 p.* Webbadress: https://www.naturvardsverket.se/Documents/publikationer/978-91-620-5999-6.pdf. Hämtad: 2017-10-20.

HaVS. (2013). *Havs- och vattenmyndighetens författningssamling. HVMFS 2013:19.*

HELCOM. (2017). *Manual for Marine Monitoring in the Combine Programme of HELCOM.* [http://helcom.fi/Documents/Action%20areas/Monitoring%20and%20assessment/Manuals%20and%20Guidelines/Manual%20for%20Marine%20Monitoring%20in%20the%20COMBINE%20Programme%20of%20HELCOM.pdf] Received October 12 in 2017.

ICES. (2005). *Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems. ICES Advice. Vol. 8. 159 p. ISBN:8774820427.* [http://iea.uoregon.edu/indicators/Fish.Salmon.Baltic.Data.SeePage141.pdf]. Recieved 10 October 2017 .

Johansson, A., & M.H, A. (2012). *Ambient Underwater Noise Levels at Norra Midsjöbanken during Construction of the Nord Stream Pipeline.*

Naturvårdsverket. (1999). *Environmental quality criteria. Coasts and seas. Swedish environmental protection agency.(Englih version, 2000. ISBN: 91-620-5052-4).*

Nord Stream 2 AG. (1). *Minimum HSES Standards for Survey and Environmental studies. Doc. Nr: W-HS-HSE-GEN-PRO-800-SURENVEN.*

Nord Stream 2 AG. (10). *Permitting Data Management Requirements for Data Deliverables from Human Observations. Doc. Nr: W-PE-EMS-GEN-SPE-800-DATAOBEN.*

Nord Stream 2 AG. (11). *Geodetic Parameters. Doc. Nr: W-SU-ENG-GEN-TNO-800-GEO001EN.*

Nord Stream 2 AG. (2). *Offshore Safety, Emergency Training and Medical Fitness. Doc. Nr: W-HS-HSE-GEN-PRO-800-OSETMFEN.*

Nord Stream 2 AG. (2016). *Utläggande av två rörledningar på den svenska kontinentalsockeln. Ansökan om tillstånd enligt 15 a § lagen (1966:314) om kontinentalsockeln, September 2016.*

Nord Stream 2 AG. (3). *Permitting Data Management. Doc. Nr: W-PE-EMS-GEN-SPE-800-DATAMGEN-02.*

Nord Stream 2 AG. (4). *Permitting Data Management Requirements for Metadata. Doc. Nr: W-PE-EMS-GEN-SPE-800-METADAEN.*

Nord Stream 2 AG. (5). *Permitting Data Management Requirements for Processing Geographic Data. Doc. Nr: W-PE-EMS-GEN-SPE-800-DATAGEEN.*

Nord Stream 2 AG. (6). *Permitting Data Management Requirements for File Formats, Naming and History. Doc. Nr: W-PE-EMS-GEN-SPE-800-DATAFIEN.*

Nord Stream 2 AG. (7). *Permitting Data Management Requirements for Data types, units and schemas. Doc. Nr : W-PE-EMS-GEN-SPE-800-DATAFOEN.*

Nord Stream 2 AG. (8). *Permitting Data Management Requirements for Data Deliverables from Instrument Measurements. Doc. Nr: W-PE-EMS-GEN-SPE-800-DATAINEN.*

Nord Stream 2 AG. (9). *Permitting Data Management Requirements for Data Deliverables from Sampling. Doc. Nr: W-PE-EMS-GEN-SPE-800-DATASAEN.*

Nord Stream AG. (2011). *Monitoring of ecotoxicological effects in Common mussel, Sweden 2010 – 2011. Doc-nr G-PE-PER-MON-100-04030000.*

Nord Stream AG. (2012). *Monitoring of Water Quality, Sweden 2012. Doc nr:ER-MON-100-04200000.*

Nordstream AG. (2015). *Monitoring of epifauna on the pipeline, Sweden 2014. 2015-05-05.*

SGU. (2017). *Klassning av halter av organiska föroreningar i sedimentet. SGU-rapport 2017:12.*

Tougaard, J., & Sveegaard, S. (2017). *Impact of the NSP2 gas pipeline on Harbour porpoises within the Natura 2000 site "Hoburgs Bank och Midsjöbankarna". DCE-report, 2017-09-01.*

APPENDIX 1

In the table below suggested contaminants to be analysed in sediments are shown. The substances are what already have been analysed by DHI in 2015[11], and some substances suggested from IVL[12] (PFAS, PBDE, Phenols and Phtalates).

Metals and organic contaminants to be analysed	
Cas no:	**Substance**
Metals	
	Arsenic (As)
	Cadmium (Cd)
	Cobalt (Co)
	Chromium (Cr)
	Cupper (Cu)
	Mercury (Hg)
	Nickel (Ni)
	Lead (Pb)
	Vanadium (V)
	Zinc (Zn)
PAH (polyaromatic hydrocarbons)	
91-20-3	Naphthalene
208-96-8	Acenaphthylene
83-32-9	Acenaphthene
86-73-7	Fluorene
85-01-8	Phenanthrene
120–12–7	Anthracene
206–44–0	Fluoranthene
129–00–0	Pyrene
56-55-3	Benz(a)anthracene
218–01–9	Chrysene
205–99–2	Benz(b)fluoranthene
207–08–9	Benz(k)fluoranthene
50–32–8	Benz(a)pyrene
53–07–3	Dibenz(a,h)anthracene
191–24–2	Benzo(ghi)perylene
193–39–5	Indeno(123cd)pyrene
Organotins	
1118-46-3	Monobutyltin (MBT)
1002-53-5	Dibutyltin (DBT)
1461-22-9	Tributyltin (TBT)
892-20-6	Tripropyltin (TPT)

[11] DHI (2015) Seabed Sediments Survey Report for Swedish Waters in 2015. Doc. No.: W-PE-EIA-PSE-REP-810-BLFISUEN-06

[12] IVL (2017) Second Opinion – The Nord Stream 2 project potential effects on Birds and Habitats in the new Natura 2000 area Ramböll. Doc no.: W-PE-EIA-PSE-REP-805-IVL010SW-01

Metals and organic contaminants to be analysed	
Cas no:	**Substance**
94410-05-6	Dioctyltin (DOT)
Chlorinated biphenyls (CB) congeners (previously analysed as PCBs)	
7012-37-5	CB 28
35693-99-3	CB 52
37680-73-2	CB 101
31508-00-6	CB 118
35065-28-2	CB 138
35065-27-1	CB 153
35065-29-3	CB180
Pesticides	
118-74-1	Hexachlorobenzene
5103-74-2	Trans-chlordane
5103-71-9	Cis- chlordane
319-84-6	Alpha-HCH
319-85-7	Beta-HCH
58-89-9	Gamma-HCH
39765-80-5	Trans-nonachlor
DDT compounds:	
789-02-6	o,p-DDT
50-29-3	p,p-DDT
53-19-0	o,p-DDD
72-54-8	p,p-DDD
3424-82-6	o,p-DDE
72-55-9	p,p-DDE
PFAS (perfluorinated and polyfluorinated substances)	
1763-23-1	PFOS
335-67-1	PFOA
PBDE (Polybrominated diphenyl ethers)	
3194-55-6	HBCDD
Phthalates	
84-66-2	Dietylphalat (DEP)
84-69-5	di-iso-buytilphalat (DIBP)
84-74-2	di-n-butylphalat (DBP)
85-68-7	Butylbensylphalat (BBzP)
2 117-81-7	dietylhexylphtalat / di-n-oktylftalat (DEHP, DOP)
28553-12-0	di-isononylphtalat (DINP)
26761-40-0	di-iso-decylphtalat (DIDP)
Phenols	
25154-52-3	Nonylphenol
	Octophenol