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NORD STREAM 2
MODELLING OF SEDIMENT SPILL IN FINLAND

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Ramboll

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ABBREVIATIONS LIST

ADCP	Acoustic Doppler Current Profiler
DHI	Danish Hydraulic Institute
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
Espoo EIA	EIA on transboundary impacts in the entire project area, according to the Espoo Convention
GTK	Geologian Tutkimuskeskus (Geological Survey of Finland)
NSP	Nord Stream pipeline system
NSP2	Nord Stream 2 pipeline system
MIKE 3	three-dimensional modelling suite
MIKE 3 HD	hydrodynamic module of MIKE 3
MIKE 3 PT	particle tracking module of MIKE 3

1. INTRODUCTION

The environmental impact assessment (EIA) for the Nord Stream 2 pipeline (NSP2) requires forecasting of the sediment and contaminant spread expected during seabed intervention works in order to evaluate the corresponding impacts on the marine environment. This report documents the model input and the results of the simulations that have been selected as representative scenarios.

The purpose of this report is to disseminate model results among contributors to the Finnish and Espoo EIAs. Consequently, it focuses on the presentation of results. Background information on the hydrographic basis and the fundamental assumptions and common methodology for Finland, Sweden and Denmark are only briefly summarised in this report. An in-depth description can be found in /1/.

This report contains a brief description of the seabed intervention works that form the basis for the scenarios. The works include both rock placements and munitions clearance. Rock placement works are related to the pipeline crossings, pre- and post-lay, in-service buckling mitigation and tie-in. Modelling is carried out for one pipeline, and it is assumed that the impact from seabed intervention works for the other pipeline is similar to the pipeline modelled. Seabed interventions for line A is used for the modelling. A full description all the scenarios carried out in connection with NSP2 can be found in /2/.

The interrelationship between this report and the related background documents is illustrated in Figure 1-1.

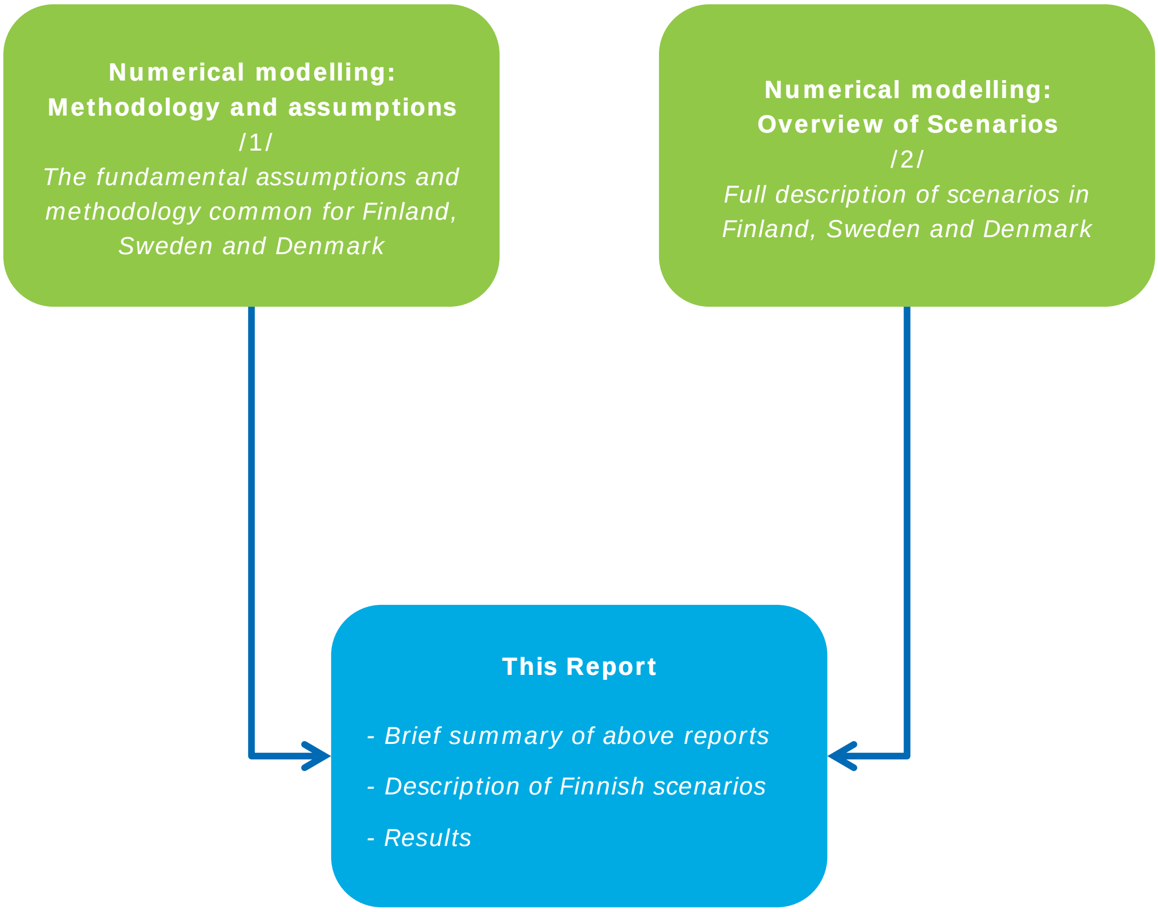


Figure 1-1 Interrelationship between this report and background documents.

2. HYDRODYNAMIC BASIS FOR MODELLING

Hydrodynamic modelling of sediment spill is based on the flexible mesh version of the MIKE 3 model suitable for three-dimensional modelling of currents, water levels and the transport of suspended sediment, contaminants and spilled oil.

The hydrodynamic model basis is delivered by DHI in a MIKE 3 hydrodynamic (HD) set-up that is dedicated to the NSP2 project. The model covers the entire Baltic Sea.

The model set-up includes a fine mesh along the pipeline corridor and in the Gulf of Finland. A full year of hindcast data covering 2010 has been produced by the hydrodynamic model for application as the basis for the environmental modelling used for the environmental assessments of NSP2. Descriptions of the model and the calibration of the model are found in /1/.

For the transport modelling of suspended sediment and contaminants the MIKE 3 PT (Particle Tracking) module is used, which is a Lagrangian particle transport type of model. The Lagrangian-type approach, involves no other spatial discretisations than those associated with the description of the bathymetry, current and water level fields. Some of the advantages of a Lagrangian-type model are:

- No numerical diffusion
- No accumulation of sub-grid effects
- Effective in resolving narrow plumes

The main reasons for choosing the MIKE3 PT model over other transport models are the ones mentioned above and that the transport modelling can be executed in a finer mesh than the hydrodynamic modelling, which is necessary to resolve the plumes resulting from the spill.

When using the MIKE3 PT model the concentration levels are calculated on basis of the instantaneous particle positions in each time step. Each particle is assigned a mass based on the spill rate and the concentration in each box of the mesh is calculated by the MIKE3 PT model on basis of the total mass contained in the box. The mesh where the concentrations are calculated is independent of the calculation mesh used for the hydrodynamic (HD) setup. Therefore it is possible to represent the concentrations in an even more detailed grid than the grid used in the HD calculations without compromising the calculation time of the models.

To give a good representation of the concentration levels an initial sensitivity study is made on the number of particles to ensure independency of the results to the used number of particles. On this basis 2000 particles per time step is used to represent the sediment spill.

2.1 Hydrographic scenarios

The modelling is carried out using actual hind-casted hydrographic scenarios. Meaning that the modelling is carried out for a real design period as opposed to an artificial situation the representative design period should within a short period of time (approximately one month) reflect conditions that are typically seen and that characterise long-term data.

The scenario periods are chosen to represent different current conditions (for transport modelling) and different stratification conditions.

On the basis of current, salinity and temperature time series from the hydrodynamic model, scenario periods are selected to represent:

- Summer, typical (calm conditions / weak currents and high stratification)
- Normal conditions (average currents and stratification for an entire year)
- Winter, typical (rough conditions / strong currents and low stratification)

The terms "summer", "normal" and "winter" reflect the fact that relatively calm summer conditions result in reduced particle spreading over a small area close to the point where a substance is released, whereas relatively rough winter conditions cause transport further away from the point of release under larger dilution.

When a particle (or a quantity of dissolved substance) is released, it is transported by the ambient water. The net transport (linear distance between the start and the end of the trajectory) is in the following chosen to be the measure for characterising the above-mentioned hydrographic scenario periods in relation to transport and spreading.

A time series of monitoring data and model data for the locations shown in Figure 3-1 has been analysed for a three-year period, starting in autumn 2009. Measured current velocities are acquired from Acoustic Doppler Current Profiler (ADCP) measurements at locations P5 and P6, obtained from the Nord Stream monitoring program. Time series of modelled currents are extracted from the hydrodynamic model positions (P1 to P4) shown in Figure 2-1. Temperature and salinity data are extracted from positions P1 to P6.

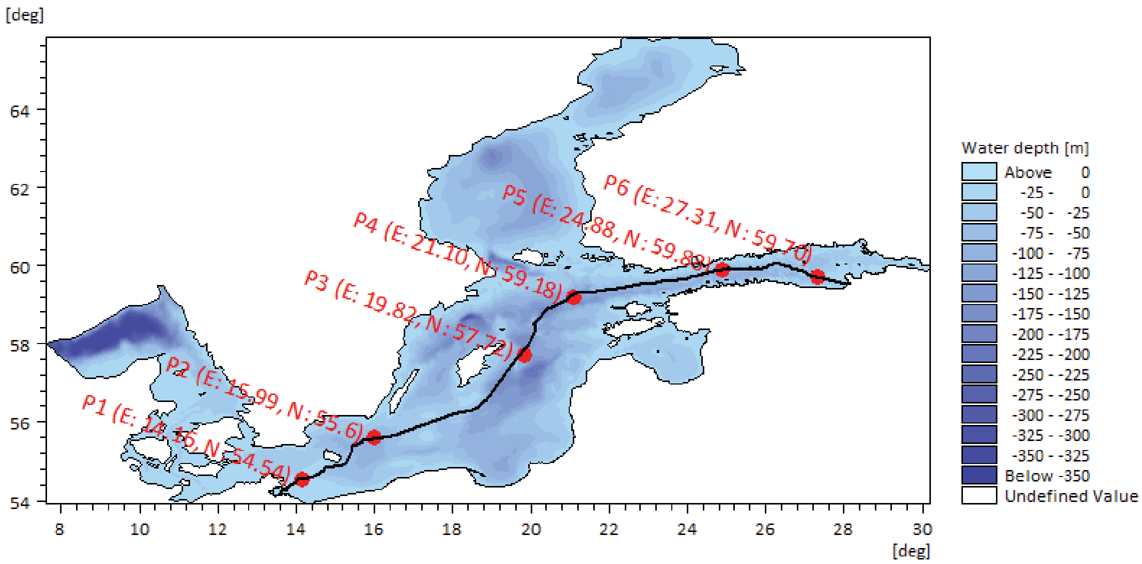


Figure 2-1 Positions of time series data from the MIKE 3 hydrodynamic model and ADCP measurements. The black line represents the position of NSP2.

On the basis of time series from the six positions shown on Figure 2-1, the three mentioned scenario periods are chosen with respect to particle transport and temperature/salinity stratification.

On the basis of evaluations of accumulated frequency diagrams for particle transport distances and evaluations of isopleth plots for salinity and temperature stratifications, the following scenario periods are chosen:

Normal conditions

April 2010: Represents average current conditions with average particle transport capacity and average temperature and salinity stratification.

Calm conditions (summer)

June 2010: Represents calm current conditions with little particle transport capacity and relatively strong temperature and salinity stratification.

Rough conditions (winter)
November 2010: Represents relatively strong current conditions with high particle transport capacity and relatively low temperature and salinity stratification (but without ice coverage).

Further details about the choice of periods can be found in the modelling basis report, /1/.

The hydrographic forcing (current fields) is simulated by a calibrated MIKE 3 hydrodynamic (HD) model. For detailed information on the set-up and calibration of the hydrodynamic model, see /3/.

3. SEABED INTERVENTION SCENARIOS

Construction activities in the Finnish EEZ cover both rock placement and munition clearance – and for both the rock placement and munitions clearance activities both dispersion of sediment spill and spill of chemical compounds contained in the sediment is modelled.

3.1 Rock placement

The rock placement scenarios are based on EIA1 data for Finland, /6/. EIA1 is an early stage set of project assumption that is defined and supplied by NPS2. EIA1 is characterised as moderately conservative. The seabed intervention scenarios based on the EIA1 data covering rock placement operations is divided into two scenarios:

- Rock placement for line A
- Rock placement for line A, alternative route (including both Z35 Alt1_01 and Z34 Alt2_01)

In both scenarios the modelling has been carried out for line A. Line B is expected to give similar impacts to the impacts calculated for line A. The rock placement volumes are shown in Table 3-1.

Table 3-1: Rock placement volumes used in the model scenarios

Type	Rock volume – line A (m^3)	Rock volume – line A, Alternative route (m^3)
Pre-lay	163,600	221,500
Post-lay	629,600	670,800
Pipeline crossings	18,700	18,700
Tie-in	80,000	80,000
In-service buckling mitigation	210,500	220,500
Total	**1,102,500**	**1,211,500**

The rock placement scenario for line A has been modelled for the normal, summer and winter conditions. The alternative route has only been modelled using winter conditions. The winter conditions are chosen, because it is assumed to give an impact in the largest area of the three hydrographic scenarios. The alternative route is described further in the next section.

Rock placement is anticipated to be carried out with a speed of 20.000 t/day. In simulations no time for relocation of the equipment is included. This is a conservative assumption, but necessary in order to limit the simulation period to the design period. For line A, based on these assumptions, the rock placement operations will cover a period of 93 days if all intervention works are done by one vessel. In the modelling, three rock placement vessels have been assumed as working simultaneously from different locations along the pipeline, to keep the total work time close to the design hydrographic periods of 30 days. That will be conservative compared to a working period of 93 days.

The rock volumes are split into the three vessels the following way. One vessel carries out the pre-lay intervention works, the pipeline crossings and the spot gravel dumping (33 days of work), the second vessel is assumed doing the main part of the postlay intervention works (30 days of work) and the third vessel finishes the postlay intervention works and the construction of the hyperbaric tie-in (30 days of work).

For line A - Alternative route the working period is increased due to an increase in rock volumes to handle. In total, there is an increase in working period of 9 days, divided between the three vessels it gives an increase of three days.

The spill rates are calculated on the basis of guidelines in /5/, assuming that

- 30% of the rock volume contributes to the spilling
- a velocity of the falling rock inside a tube of 1.44 m/s
- 10% of the total energy will cause a resuspension of sediments

The total calculated spill from rock placement operations for line A and line A Alternative route is 2592 T and 2850 T respectively. The rock volumes for all construction works and corresponding spill rates divided on the individual rock berms and sediment fractions are shown in Appendix 3.

3.1.1 Rock placement locations

The rock placement operation works used for the model scenario for line A in Finland are shown in Figure 3-1, Figure 3-2 and Figure 3-3. The planned seabed intervention works for pre-lay, post-lay and pipeline crossing is also shown in appendix 4 in a larger scale. As seen in the figures some sections are split into two and mark the alternative pipeline route. As it has not yet been decided which of the two routes shall be used both are modelled. The Southern route includes Line A Alternative route 01 – Z35 and Line A Alternative route 02 – Z34 as specified in /6/. In this report the alternative pipeline route including the lines Z35 and Z 34 will be referred to as “Line A Alternative route”.

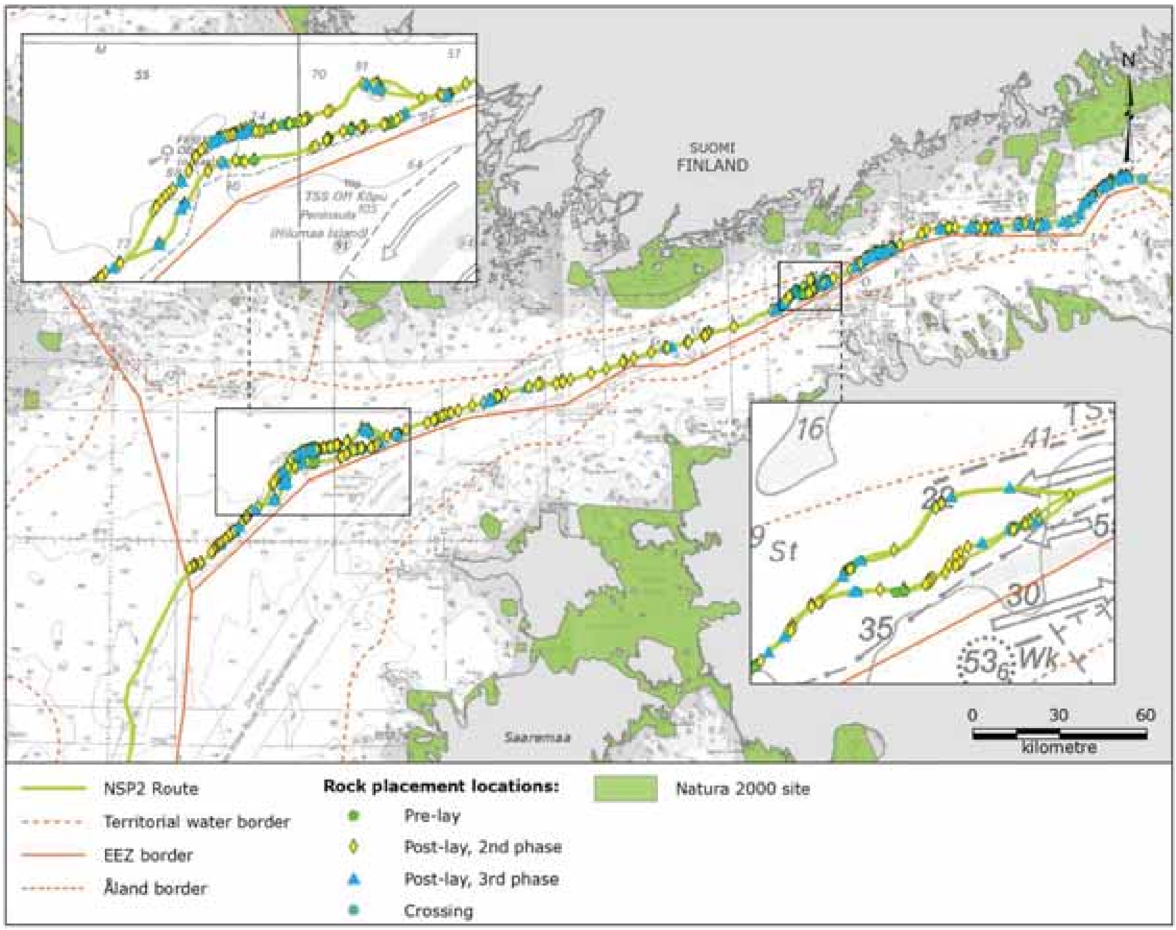


Figure 3-1 **Map of Finnish EEZ with planned seabed intervention works (pre-lay, post-lay and pipeline crossing)**

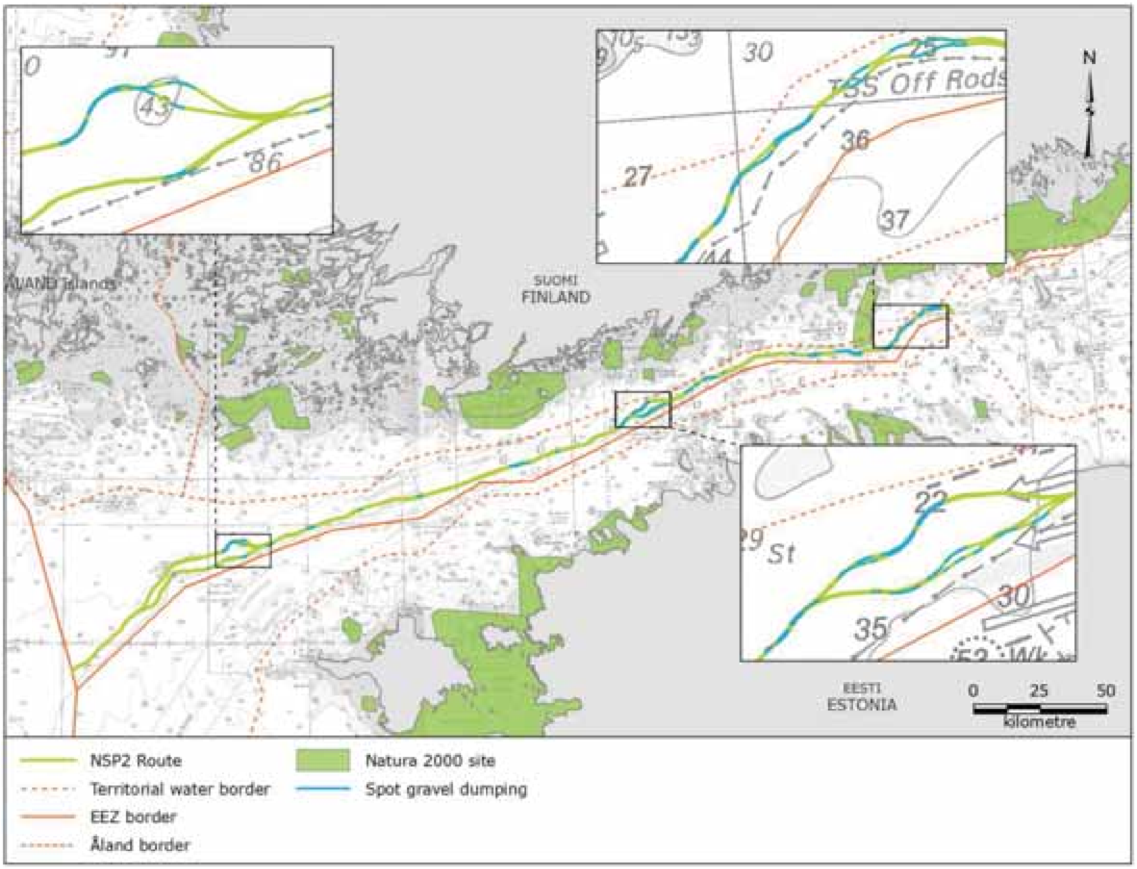


Figure 3-2 Map of Finnish EEZ with planned seabed intervention works (in-service buckling mitigation)

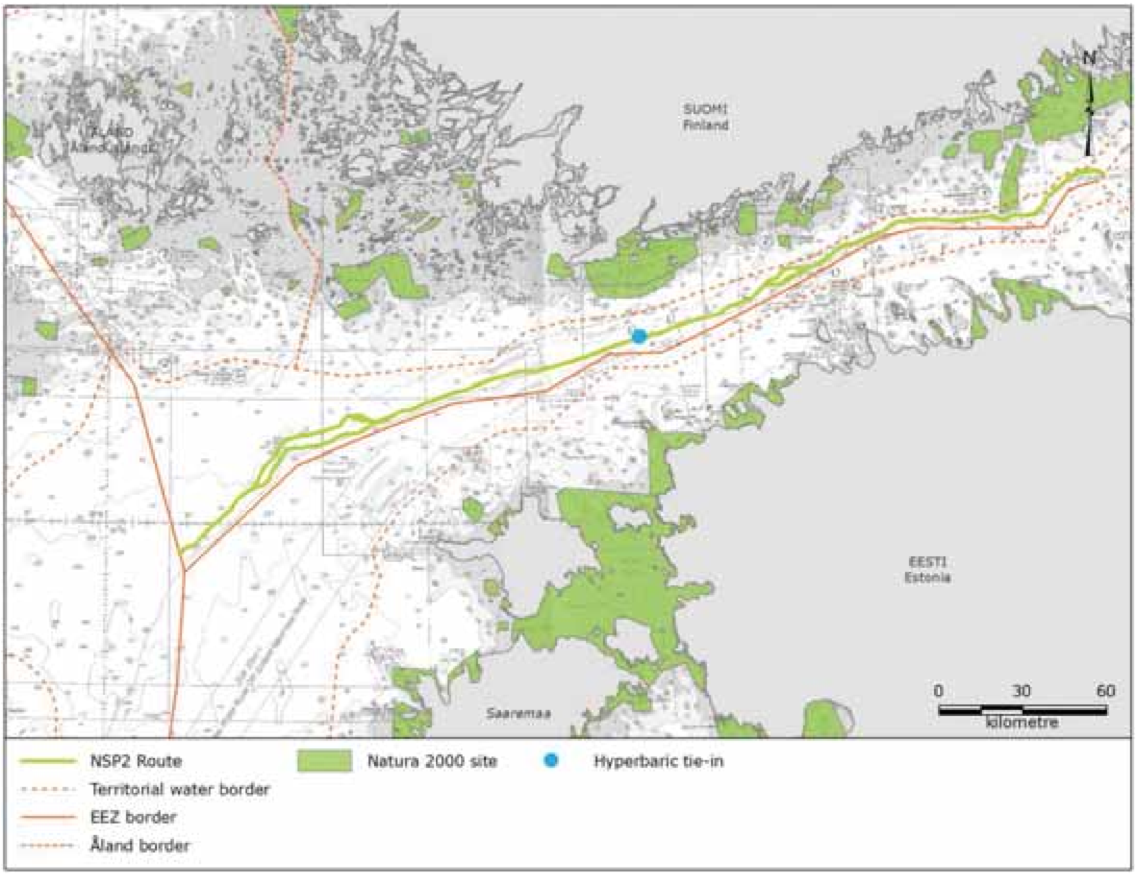


Figure 3-3 Map of Finnish EEZ with planned seabed intervention works (Hyperbaric tie-in)

3.2 Munitions clearance

Sediment dispersion due to munition clearance is modelled using a generic scenario. Four locations in the Gulf of Finland are chosen and the locations are selected either in areas with a high density of monitions (locations SED2-SED4) or in the vicinity of protected areas (location SED1) (as shown in Figure 3-4). The locations SED1-SED4 refer to Figure 3-4. The generic scenario is based on clearance of typical midsize charge (30-64 kg) and clearance of typical large-size charge (100-350 kg). The charge sizes and crater volumes have been found from analysis of the munitions clearance monitoring during NSP. Documentation is found in /1/.

At each location six munitions with a distance of 1 km are assumed to be cleared one at a time with 24 hours between each clearance. The six munitions cleared at each location are shifting between medium and large size munitions with a crater volume of 20 m^3 and 42 m^3 respectively. See /1/ for definition of medium and large size craters and estimation of crater volumes.

The crater volumes and number of munitions are shown in Table 3-2 below.

Table 3-2 Munitions clearance (generic scenario).

ID number[1]	Charge sizes	Number of munitions	Crater volume [m^3]
SED1	Large	3	42
	Medium	3	20
SED2	Large	3	42
	Medium	3	20
SED3	Large	3	42
	Medium	3	20
SED4	Large	3	42
	Medium	3	20

[1] ID refers to numbering in Figure 3-4

All the scenarios cover a clearance of 24 munitions half of which are medium sized and half of which is large sized. The total sediment volume released during the munitions clearance is 744 m^3. The duration of the scenario is 24 days.

The spill of sediment is anticipated to be the total content of fines (grain-sizes below 0.2 mm) within in the crater. This content is estimated on basis of the density of the specific sediment type [kg/m^3], the dry matter content in the specific sediment type and the percentage of fines in the specific sediment type. The sediment characteristics are described in chapter 4. The total sediment spill is calculated to be 1030 tonnes.

The sediments are anticipated to be released momentarily – during one time step (half an hour) - in the model simulations.

3.2.1 Munitions clearance locations

The munitions clearance locations used for the modelling are shown in Figure 3-4. The base map shows the munitions density in the Gulf of Finland.

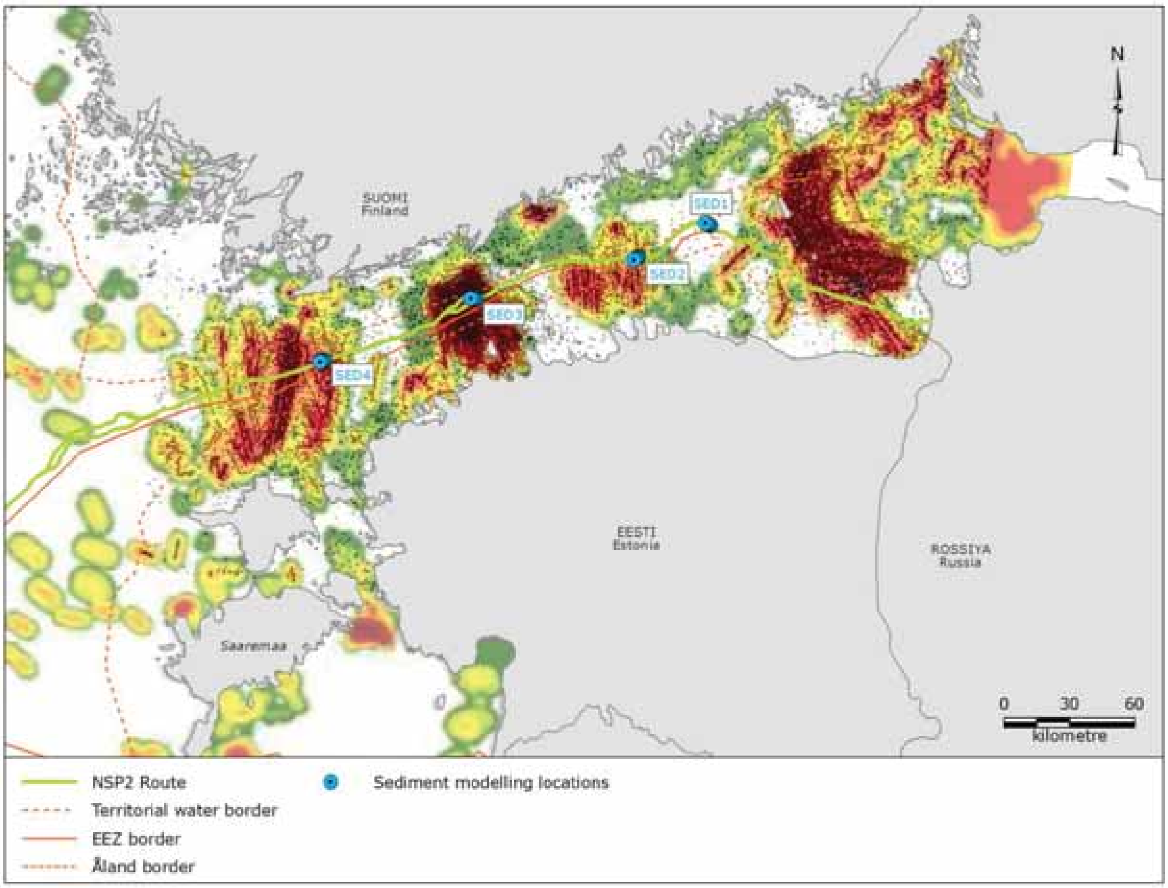


Figure 3-4 Map of Finnish EEZ with indication of munitions clearance sites for generic scenario. Each of the sites SED1 – SED4 consists of six charges. The underlying base map shows known locations of munitions (dot), while the contour shows the relative density of munitions (not absolute scale), /7/.

3.3 Release of contaminants

Chemical compounds with the potential to cause ecotoxicological effects on the Baltic ecosystems and/or bioaccumulate have been deposited over centuries on the seabed of the Baltic Sea or the compounds are naturally present in the area. During the establishment of the gas pipeline, sediments can be re-suspended, thus mobilising some of these chemical compounds, with the potential to cause possible effects on organisms inhabiting the Baltic Sea.

The content of contaminates in the sediment has been estimated based on samples from the Gulf of Finland collected during the Nord Stream project. The results are presented as the 95% percentile of the series of samples and are shown in table 3-3.

In order to cause toxicological effects, a chemical compound has to be bioavailable, i.e. dissolved and in a chemical form that can be taken up by organisms and/or interact with receptors. Desorption and bioactivity factors are specific for specific contaminates. The values are discussed in /1/. The factors are summarised in Table 3-3.

The dispersion of contaminants is modelled similar to the dispersion modelling for sediment. Only the dissolved and bioactive fraction is modelled. Consequently, the contaminants are not settling and for precautionary reasons, no decay is assumed. The model results are given as concentration of dissolved/bioactive contaminants and are denoted as predicted environmental concentration (PEC). This is the estimated exposure concentration in the water body based on spill and spreading.

The predicted no-effect concentration (PNEC) has been compiled, see /1/. The PNEC estimates lower limit of the concentration range in the water body known to cause effects. Relevant PNEC values are presented in Table 3-3.

The relative toxicity is estimated. The relative toxicity is quantified as the ratio between the predicted no-effect concentration (PNEC) and the predicted environmental concentration (PEC). The relative toxicity is given in Table 3-3. It is seen that the relatively most toxic substances are assumed to be Benzo(a)pyrene (PAH), WHO (2005) PCDD/F TEQ upper (Dioxin/Furans) and Zinc in descending order.

Table 3-3 Observed concentration of contaminants based sediment samples from Gulf of Finland collected during NSP1. The results are presented as the 95% percentile of the samples. Relative toxicity expressed as the volume of water required to dilute the contaminant due to release of one kilogram of dry matter (DW). Red indicates the most critical compound, yellow the second most critical and green the third most critical compound.

Chemical compound	Desorption	Bioactivity	Concentration in sediment	Concentration of desorbed /bioactive	PNEC (in excess to background)	Relative toxicity
			mg/kg DW	mg/kg DW	mg/m³	m³/kg DW
Metal						
Arsenic, As	50%	25%	35.8	4.48	0.6	7.5
Cadmium, Cd	50%	25%	1.80	0.225	2	-
Mercury, Hg	50%	25%	0.070	0.00875	0.05	-
Zinc, Zn	50%	25%	224	28.0	3.4	8.2
Lead, Pb	50%	25%	42.7	5.34	0.83	6.4
Copper, Cu	50%	25%	49.4	6.18	0.9	6.9
Nickel, Ni	50%	25%	55.1	6.89	8.6	-
Organotin						
Tributyltin, TBT	10%	100%	0.0767	0.00767	0.0015	5.1
PAH						
Benzo(a)pyrene	10%	100%	0.170	0.017	0.00017	100
Dioxin/Furans						
WHO (2005) PCDD/F TEQ upper	10%	100%	20.3E-06	2.03E-06	1.00E-07	20.3

3.4 Summary

An overview of the input to the model simulations are given in Table 3-3.

Table 3-3 Summary of input to model simulations

Scenario FI-01	Rock placement		Rock placement – Alternative route		Munitions Clearance
Locations	Gulf of Finland		Gulf of Finland		Gulf of Finland
Route	NSP2 line A		NSP2 line A – inclusive alternative route Z35 and Z34		NSP2 line A
Activity	Rock placement		Rock placement		Munitions clearance
Method	Fall-pipe		Fall-pipe		Blasting
Speed	20,000 T/day		20,000 T/day		One blasting per 24 h
Scope	248 locations (+46 spot gravel sections)		248 locations (+51 spot gravel sections)		Four locations with 6 six munitions each place
Volume	1,102,500 m^3		1,211,500 m^3		744 m^3
Duration	35 days		38 days		24 days
Spill	<0.5% (2592 T)	0.08-0.36 kg/s	<0.5% (2850 T)	0.08-0.36 kg/s	100% of fines (1030 T)
Parameters	Sediment, Contaminants		Sediment		Sediment, Contaminants
Weather	Normal, winter, summer		Winter		Normal, winter, summer
Comment	Based on EIA1 data, /6/		Based on EIA 1data, /6/		Generic scenario

4. SEDIMENT CHARACTERISTICS

4.1 General description of sediments

This section presents an analysis of the sediment samples and the model input for the seabed intervention works planned in Finnish EEZ.

The characterisation of the sediment to be re-suspended in Finland is based on sediment classification maps from Geologian Tutkimuskeskus (Geological Survey of Finland) (GTK), /3/. The classes applied in this context are:

1. Bedrock
2. Hard bottom complex
3. Hard clay
4. Mud
5. Sand

According to GTK there are in general four classes of sediments (2, 3, 4 and 5) represented in the area of seabed intervention works in Finnish EEZ, see Figure 4-4.

Each sediment class is characterised on the basis of sediment distribution analyses of samples within each of the classified areas. For example, all grain size distributions within areas classified as "hard clay" are grouped into one class and a characteristic grain size distribution is estimated. The characteristic grain size distributions are shown on Figure 4-1. For full details on the methodology and the detailed estimation, see /1/.

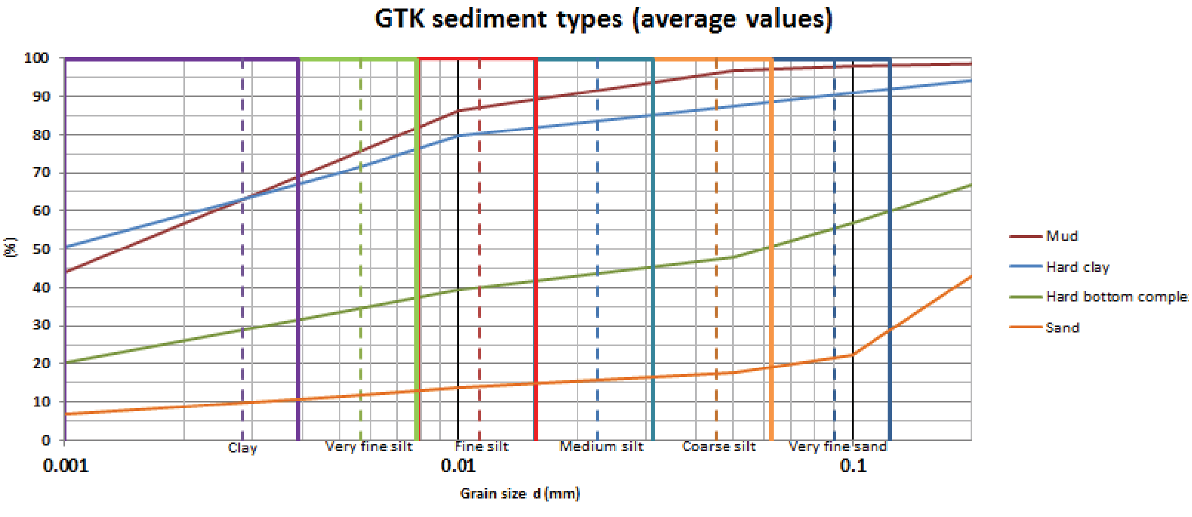


Figure 4-1 **Average values for GTK sediment types. Vertical dashed-lines are the mean values represented Table 4-1.**

The grain size distributions are divided into six different particle fractions, which will be used in the modelling: very fine sand (0.06-0.125 mm), coarse silt (0.03-0.06 mm), medium silt (0.015-0.03 mm), fine silt (0.008-0.015 mm), very fine silt (0.004-0.008 mm) and clay (<0.004 mm). For each of the GTK sediment types the amount (percentage) of sediment within each fraction is determined on the basis of the curves shown in Figure 4-1. The sediment types are characterised by these percentages as e.g. type 4 (mud) contains 63% within the clay fraction and 2% within the fine sand fraction, while type 5 (sand) contains 10% within the clay fraction and 10% within the fine sand fraction. The full description of the percentage of the particle fractions for each sediment type can be found in /1/.

The coarser sediment fractions (coarser than 0.125 mm) are not taken into consideration in this context because they will settle in the proximity of the seabed intervention works and therefore will not influence the environment outside the immediate work area.

Table 4-1 shows the grain size ranges for each of the fractions used in the modelling. The representative logarithmic mean grain sizes are also shown in the table.

Settling velocities are estimated for each fraction in /1/ on the basis of average water properties for the Gulf of Finland. Settling velocities are also given in Table 4-1.

Table 4-1 Grain size range and corresponding settling velocity.

Sediment spill class	Lower grain size limit (mm)	Upper grain size limit (mm)	Mean (ln) grain size within range (mm)	Settling velocity (m/s)
Very fine sand	0.0625	0.1250	0.0902	0.0032
Coarse silt	0.0310	0.0625	0.0338	0.00089
Medium silt	0.0156	0.0310	0.0225	0.0004
Fine silt	0.0078	0.0156	0.0169	0.00025
Very fine silt	0.0039	0.0078	0.0056	0.00013
Clay	-	0.0039	0.0028	0.000069

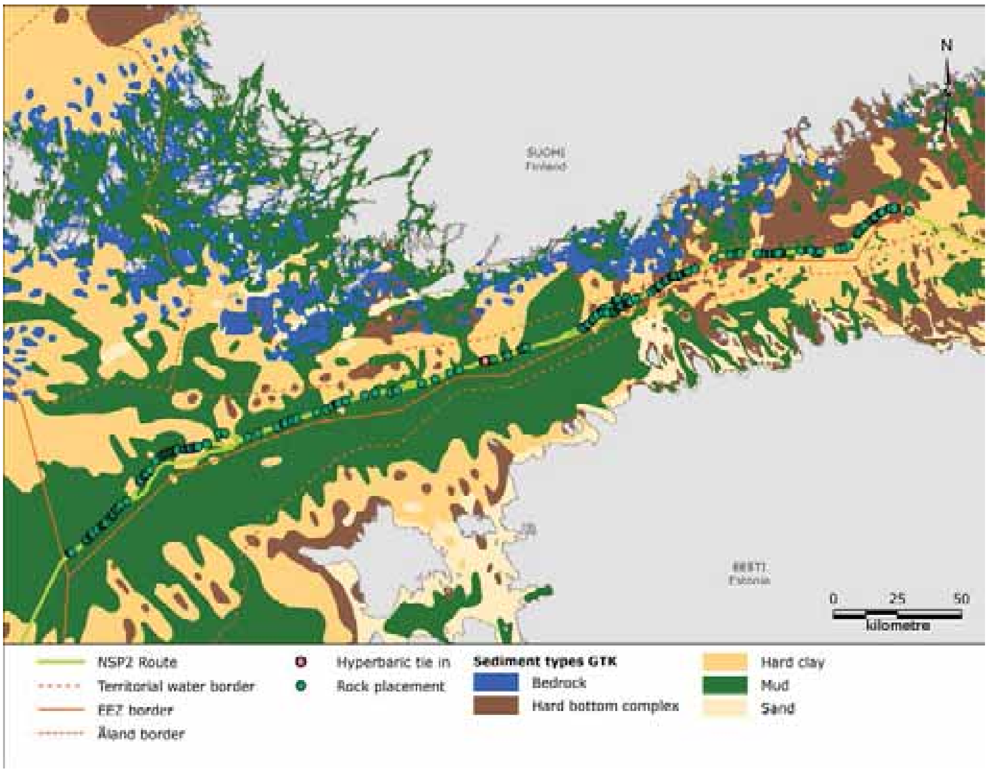
The water content and the content of dry matter are estimated in /1/ but water content and dry weight used in the modelling are given in Table 4-2. For full details, see /1/.

Table 4-2 Estimated average water/dry content matter given as weight percentage of total wet weight – Finland.

Sediment type	Dry weight (%)	Water content (%)
Mud	50	50
Hard clay	80	20
Hard bottom complex	80	20
Sand	75	25
There is a discrepancy between the given water contents which we refers in /1/ and the description of the samples. The water content seems unrealistic high. Applying those questionable water contents would lead to low sediment releases. As a precautionary measure we applied lower water content based on our best professional knowledge.		

4.2 Sediment types at rock placement and munitions locations

Figure 4-2 depicts the rock placement locations and the corresponding sediment types and Figure 4-3 shows the in-service buckling mitigation sections and corresponding sediment types. For the in-service buckling mitigation sections it is assumed that rock berms are placed minimum 50 m apart.



igure 4-2 Locations of rock placement and sediment classification, GTK, /4/.

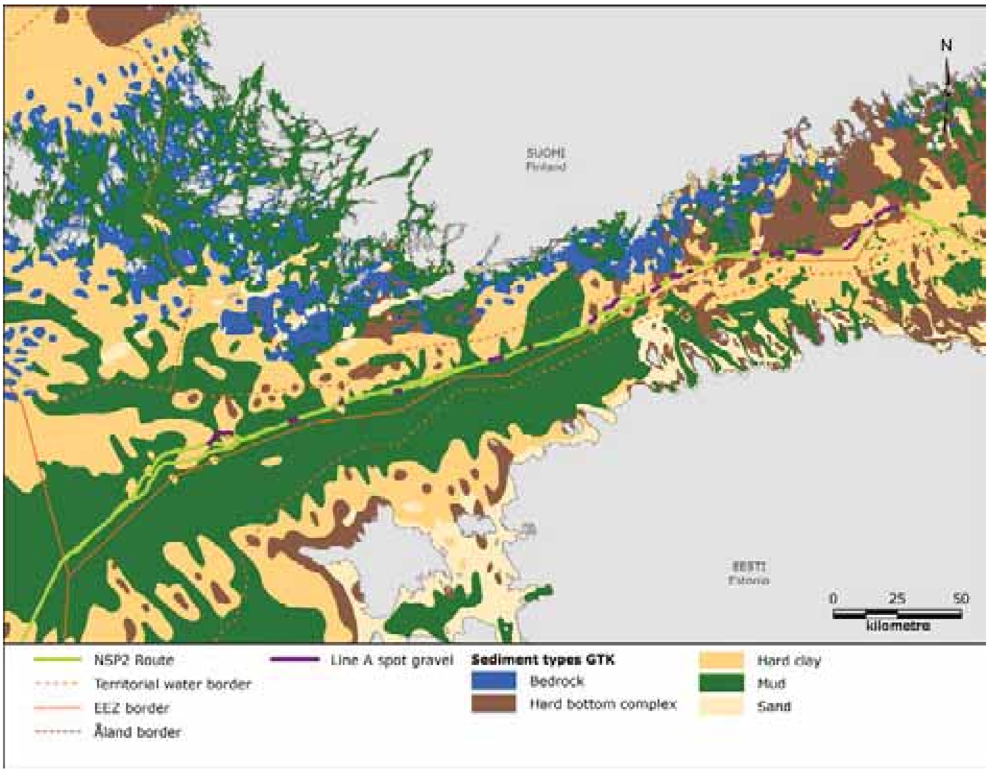


Figure 4-3 Locations of in-service buckling mitigation and sediment classification , GTK, /4/. Rock berms are placed per 50 m on sections where rock placement is planned.

Figure 4-4 depicts the four munitions clearance locations and the corresponding sediment types.

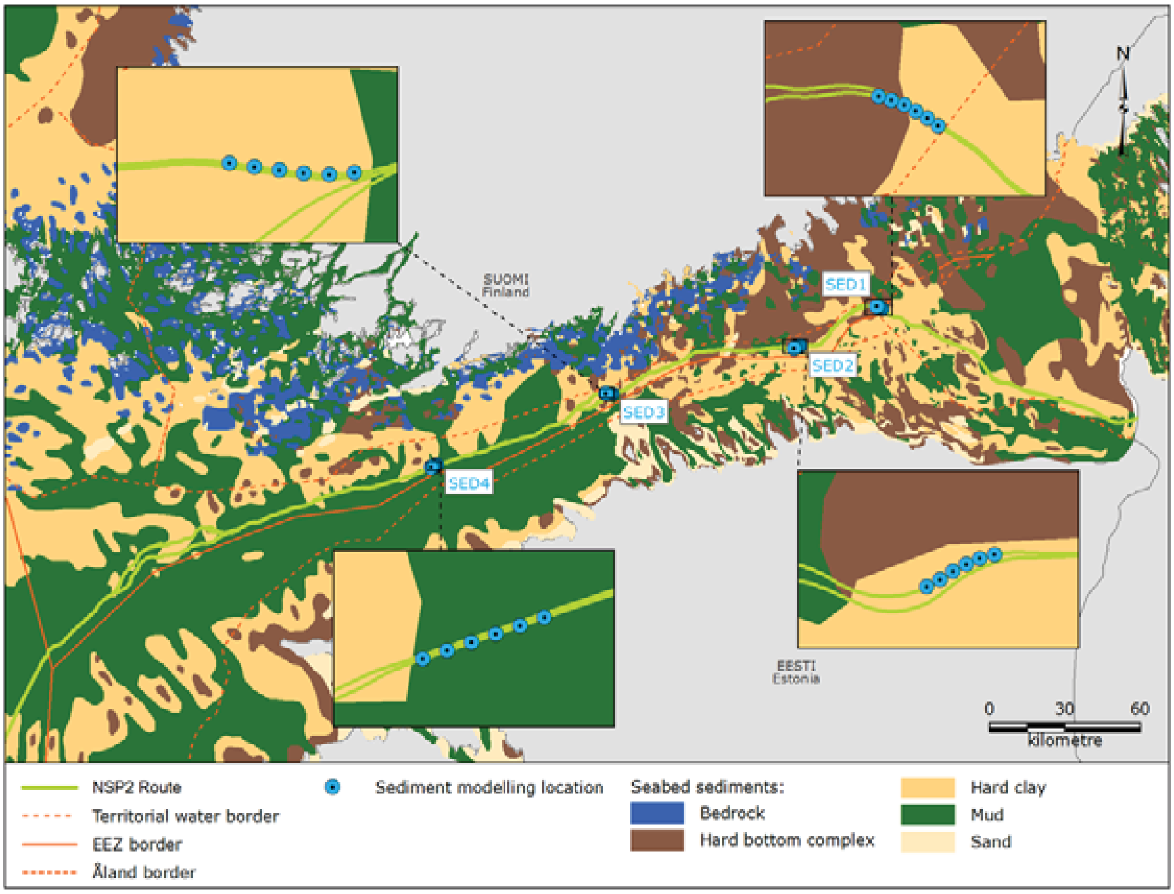


Figure 4-4 Locations for munition clearance (six spots in each location) and sediment classification map, GTK, /4/.

5. MODEL RESULTS - SEDIMENT

This chapter presents the results of the modelling of the seabed intervention works. The results are presented as two-dimensional maps of the depth integrated concentrations.

Sediment is released close to the seabed, for rock placement modelling 2 m above the seabed and for munitions clearance 15 m above the seabed. This is evaluated on basis of the type of intervention works and experience from NSP as described in, /1/ .Due to the location of the release and because sediment is settling through the water column, the highest sediment concentrations are found near the seabed. Therefore all results related to suspended sediment from rock placement are based on an average of the lower 10 m of the water column. For munitions clearance additional plots representing maximum sediment concentrations over the interval 10-20 m above the seabed are shown – due to the release 15 m above sea bed. The concentrations from the interval 10-20 m above the seabed for munitions clearance are shown to document if the higher concentrations are seen in the layers above the lowest 10 m in this scenario.

The maps show the following parameters:

- The maximum concentration of suspended sediment occurring under the entire simulation period.
- Duration of exceedance of 2 mg/l (in excess to background concentration in the Baltic Sea). This is the accumulated period of time in hours during which the concentration of suspended material exceeds 2 mg/l during rock placement. Other thresholds of 10mg/l and 15mg/l are also depicted for the munitions clearance scenarios. For the rock placement scenarios, these thresholds are not shown because of the very limited duration of these thresholds, which would be invisible on the maps.
- Sedimentation, which is expressed as g/m^2. The corresponding thickness depends on the density, which again is dependent on the consolidation of the material. Considering fluffy sediment with a dry matter content of 100 kg/m^3 means that a 1 mm thickness corresponds to a sedimentation of 100 g/m^2. A higher degree of consolidation (consequently higher density) corresponds to a thinner layer thickness for the same sedimentation e.g. 100 g/m^2.

The results for rock placement are presented in the following sections. The figures presenting the results are summarised in Table 5-1.

Table 5-1 Overview of modelling results.

	Seabed intervention work	Annual / normal	Summer	Winter
Rock placement (Line A)	Maximum concentration of suspended sediment	Figure 5-1, Figure 5-2	Figure 5-3, Figure 5-4	Figure 5-5, Figure 5-6
	Duration of exceeding threshold concentration 2mg/l	Figure 5-7, Figure 5-8	Figure 5-9, Figure 5-10	Figure 5-11, Figure 5-12
	Sedimentation	Figure 5-13, Figure 5-14	Figure 5-15, Figure 5-16	Figure 5-17, Figure 5-18
Rock placement (Line A Alternative route)	Maximum concentration of suspended sediment			Figure 5-19, Figure 5-20
	Duration of exceeding threshold concentration 2mg/l			Figure 5-21, Figure 5-22
	Sedimentation			Figure 5-23, Figure 5-24
Munitions clearance	Maximum concentration of suspended sediment	Figure 5-25, Figure 5-26	Figure 5-27, Figure 5-28	Figure 5-29, Figure 5-30
	Duration of exceeding threshold concentration 2mg/l	Figure 5-31, Figure 5-32	Figure 5-33, Figure 5-34	Figure 5-35, Figure 5-36
	Duration of exceeding threshold concentration 10mg/l	Figure 5-37, Figure 5-38	Figure 5-39, Figure 5-40	Figure 5-41, Figure 5-42
	Duration of exceeding threshold concentration 15mg/l	Figure 5-43, Figure 5-44	Figure 5-45, Figure 5-46	Figure 5-47, Figure 5-48
	Sedimentation	Figure 5-49	Figure 5-50	Figure 5-51

5.1 Rock placement

Figure 5-1 and Figure 5-2 show the highest concentration observed under normal conditions.

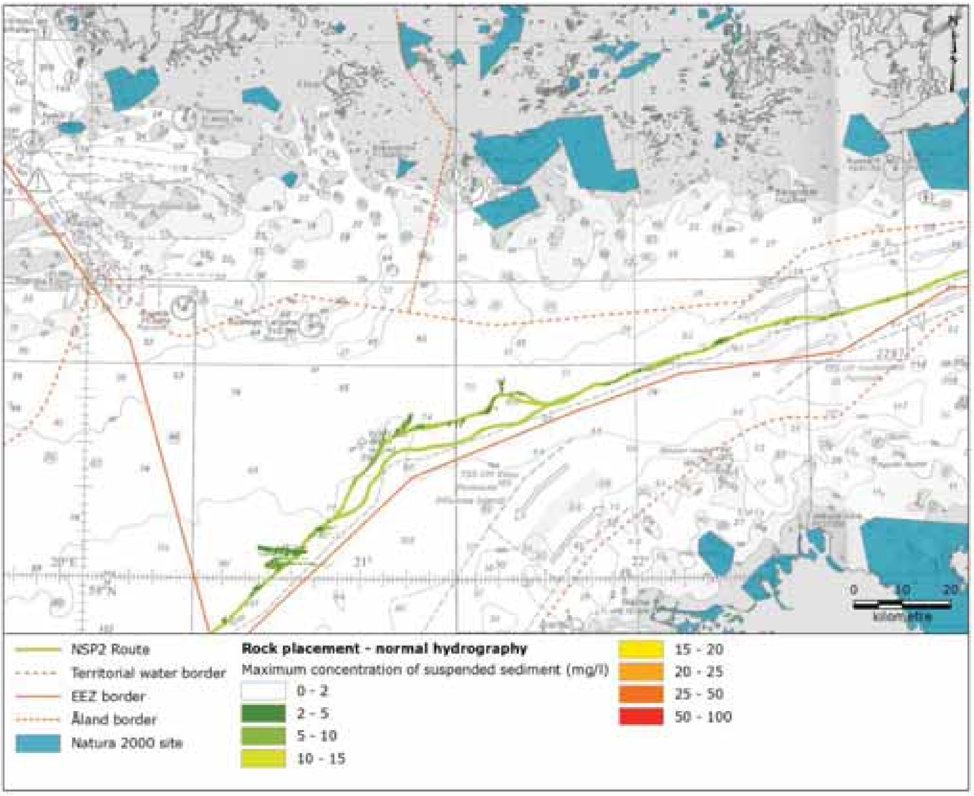


Figure 5-1 Maximum concentration of suspended sediment for rock placement under annual / normal hydrographic conditions. Western part of the Gulf of Finland.

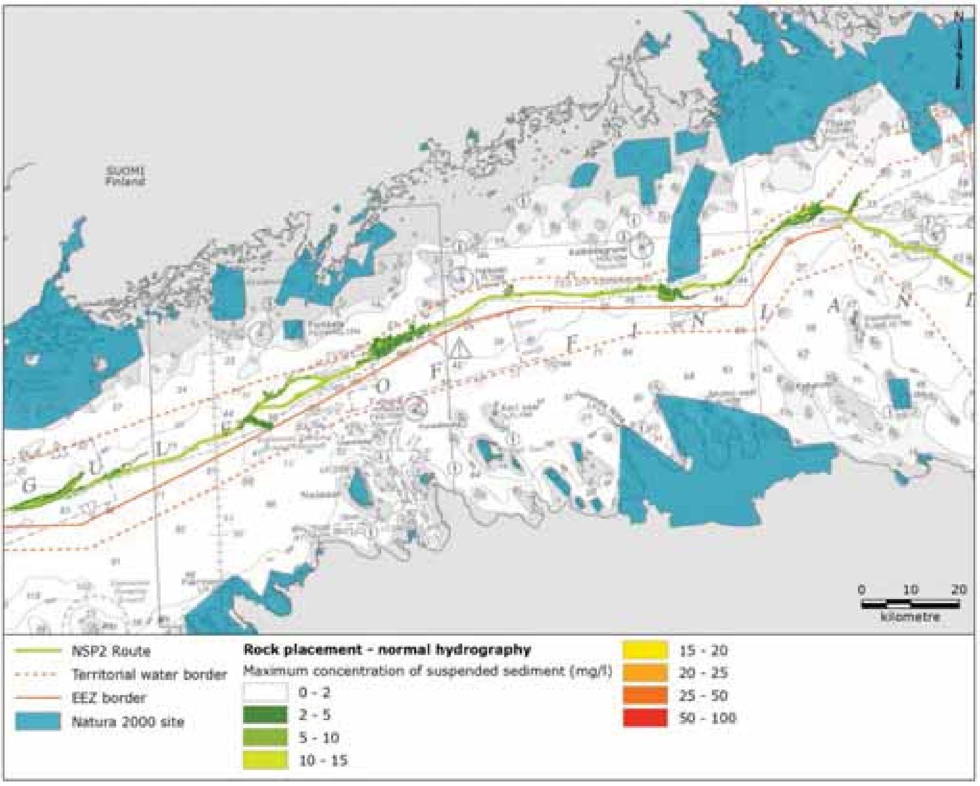


Figure 5-2 Maximum concentration of suspended sediment for rock placement under annual / normal hydrographic conditions. Eastern part of the Gulf of Finland.

Figure 5-3 and Figure 5-4 show the highest concentration observed under typical summer conditions.

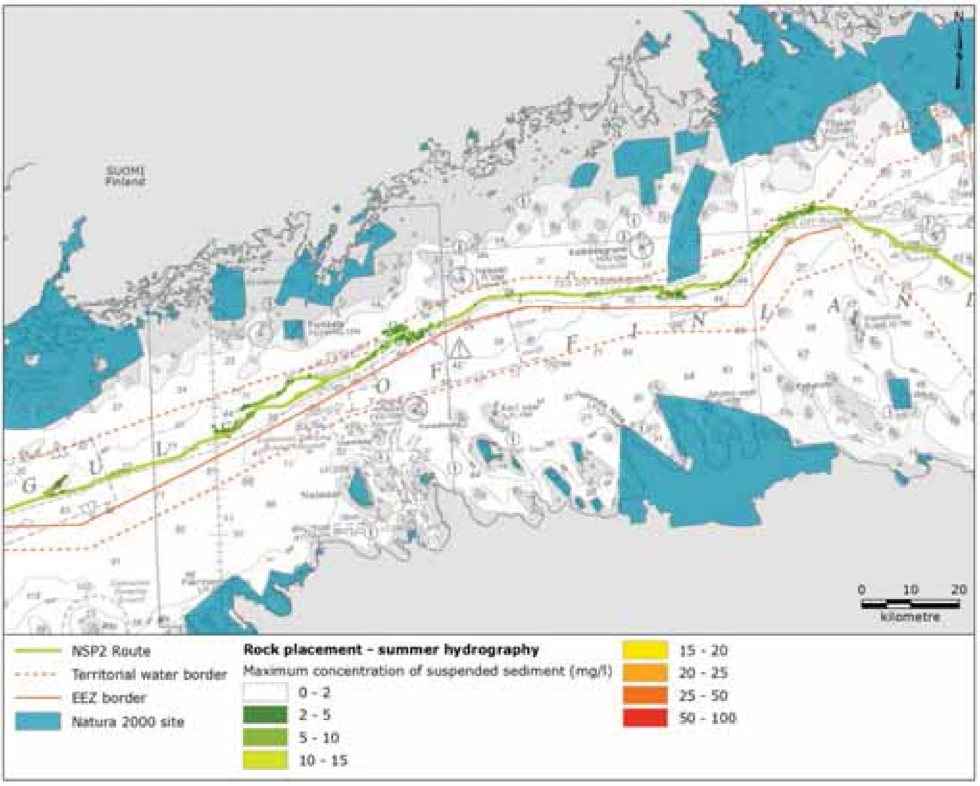


Figure 5-3 **Maximum concentration of suspended sediment for rock placement under typical summer conditions. Eastern part of the Gulf of Finland.**

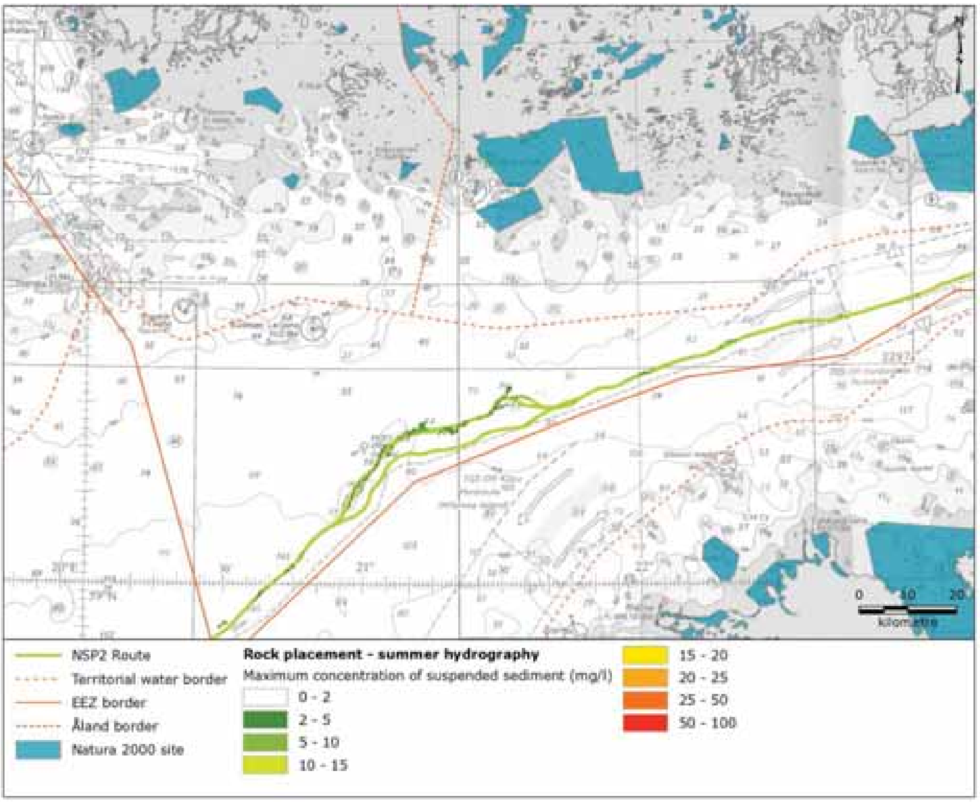


Figure 5-4 **Maximum concentration of suspended sediment for rock placement under typical summer conditions. Western part of the Gulf of Finland.**

Figure 5-5 and Figure 5-6 show the highest concentration observed under typical winter conditions.

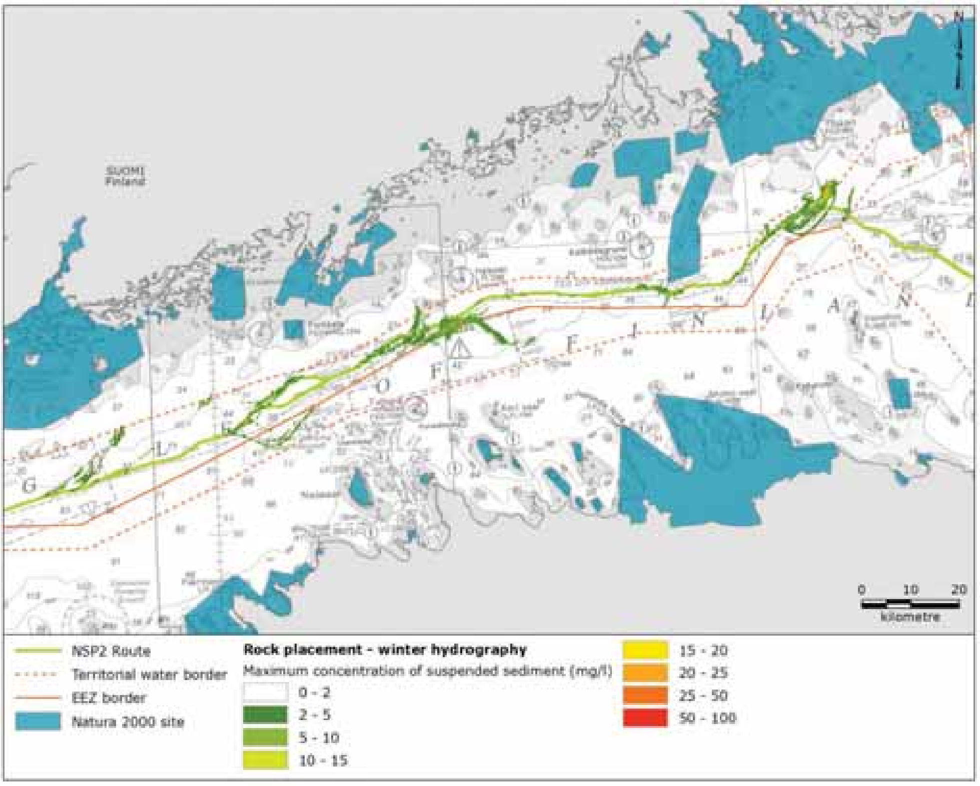


Figure 5-5 Maximum concentration of suspended sediment for rock placement under typical winter conditions. Eastern part of the Gulf of Finland.

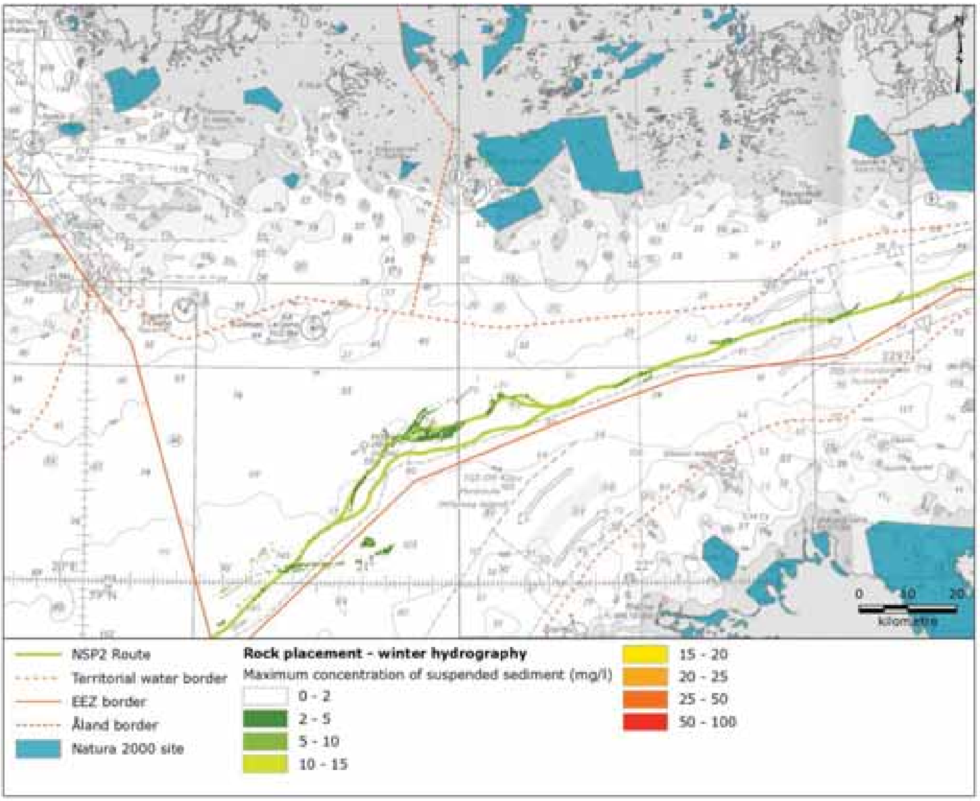


Figure 5-6 Maximum concentration of suspended sediment for rock placement under typical winter conditions. Western part of the Gulf of Finland.

Figure 5-7 and Figure 5-8 show the duration for which the concentration threshold of 2 mg/l is exceeded during the rock placement section under normal conditions. The largest value observed is 43 hours.

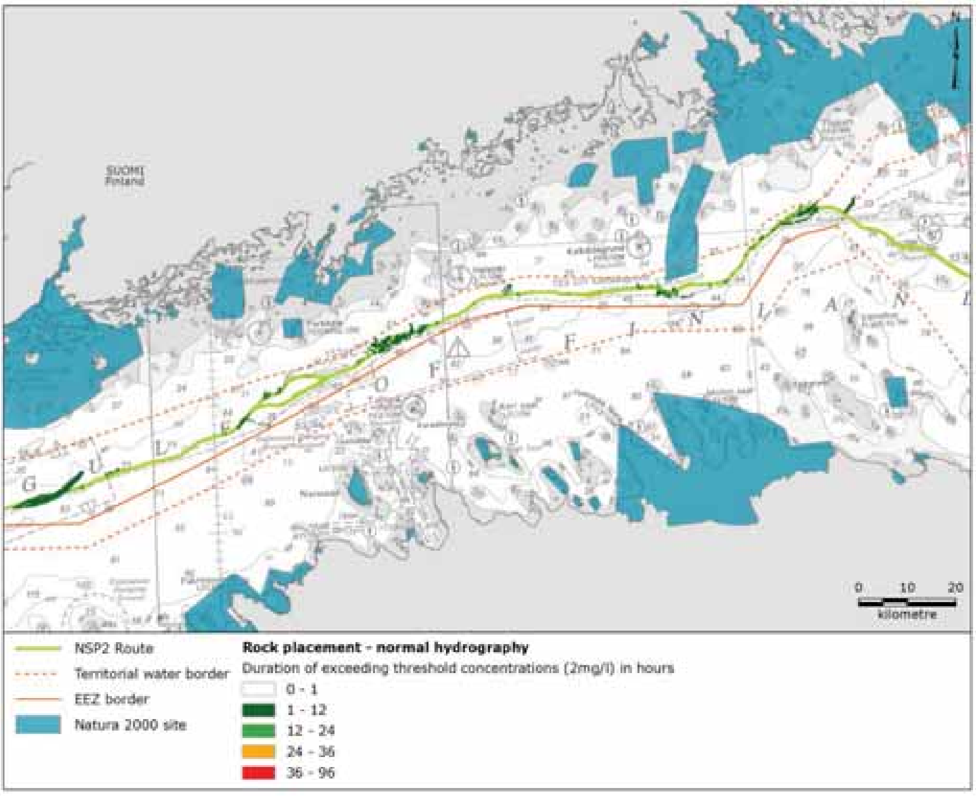


Figure 5-7 **Duration of exceeding 2 mg/l for rock placement under annual/normal hydrographic conditions. Eastern part of the Gulf of Finland.**

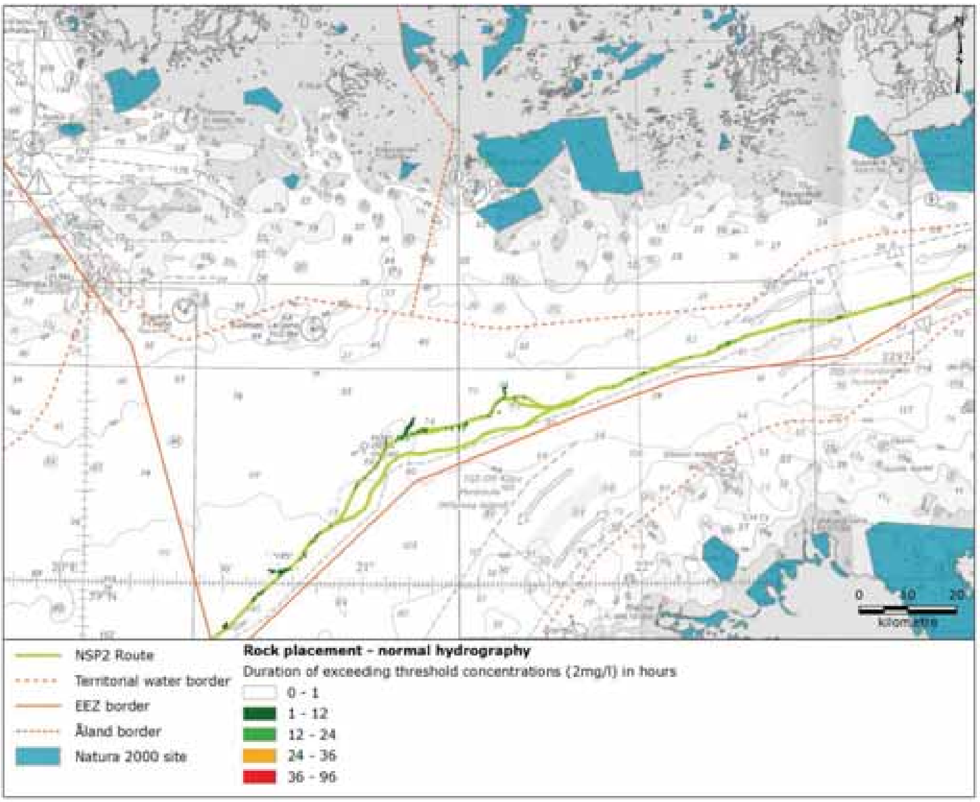


Figure 5-8 **Duration of exceeding 2 mg/l for rock placement under annual / normal hydrographic conditions. Western part of the Gulf of Finland.**

Figure 5-9 and Figure 5-10 show the duration for which the concentration threshold of 2 mg/l is exceeded during the rock placement section under typical summer conditions. The largest value observed is 165 hours caused by extremely calm local current conditions during the summer period and a long period of sediment release at one single spot.

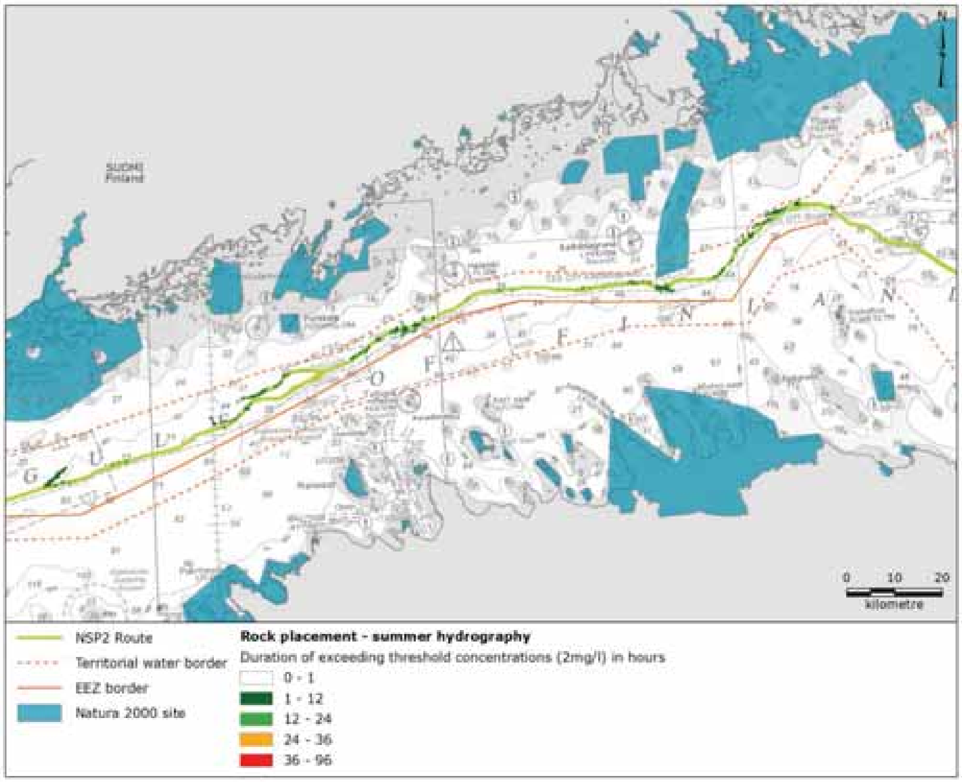


Figure 5-9 Duration of exceeding 2 mg/l for rock placement under typical summer conditions. Eastern part of the Gulf of Finland.

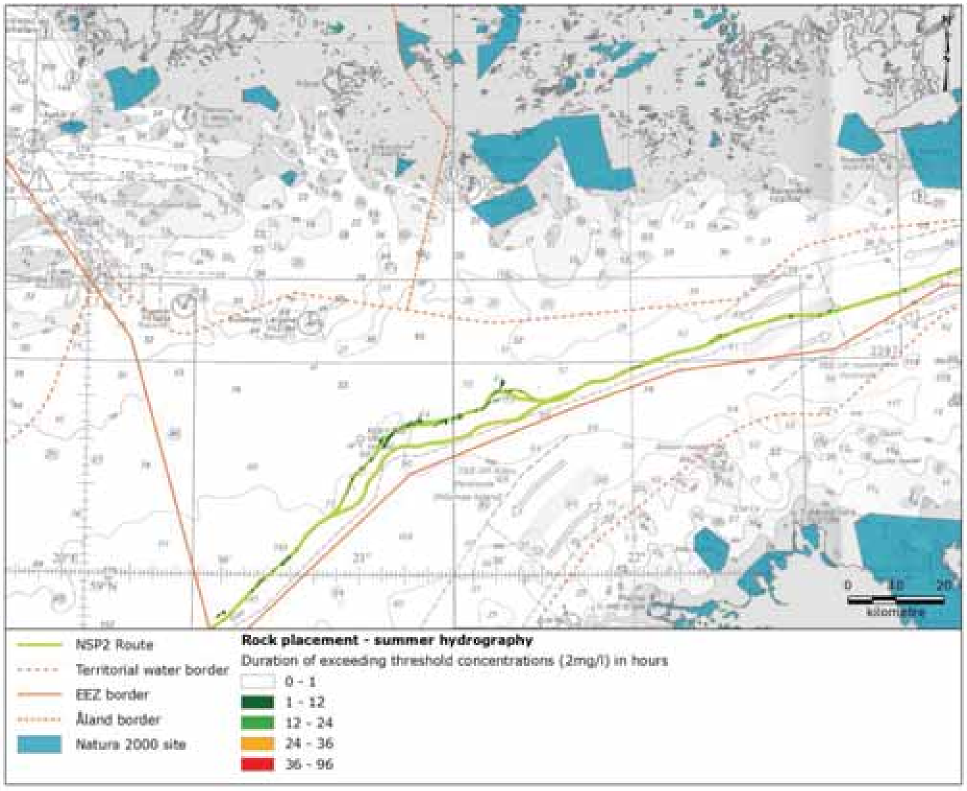


Figure 5-10 Duration of exceeding 2 mg/l for rock placement under typical summer conditions. Western part of the Gulf of Finland.

Figure 5-11 and Figure 5-12 show the duration for which the concentration threshold of 2 mg/l is exceeded during the rock placement section under typical winter conditions. The largest value observed is 24 hours.

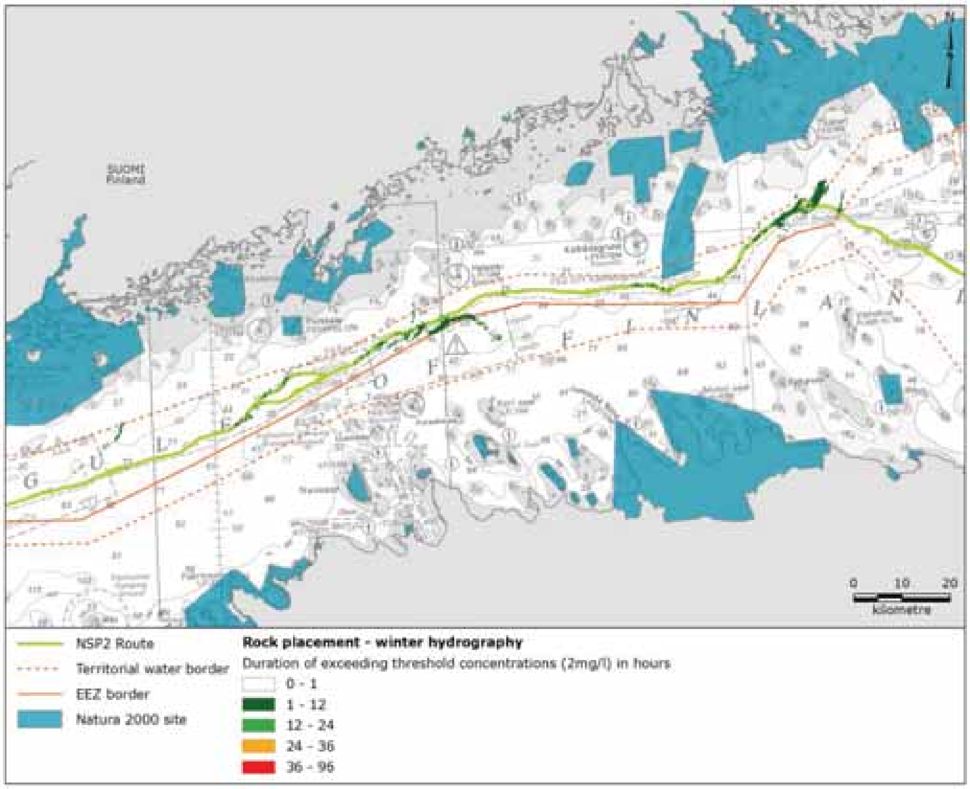


Figure 5-11 Duration of exceeding 2 mg/l for rock placement under typical winter conditions. Eastern part of the Gulf of Finland.

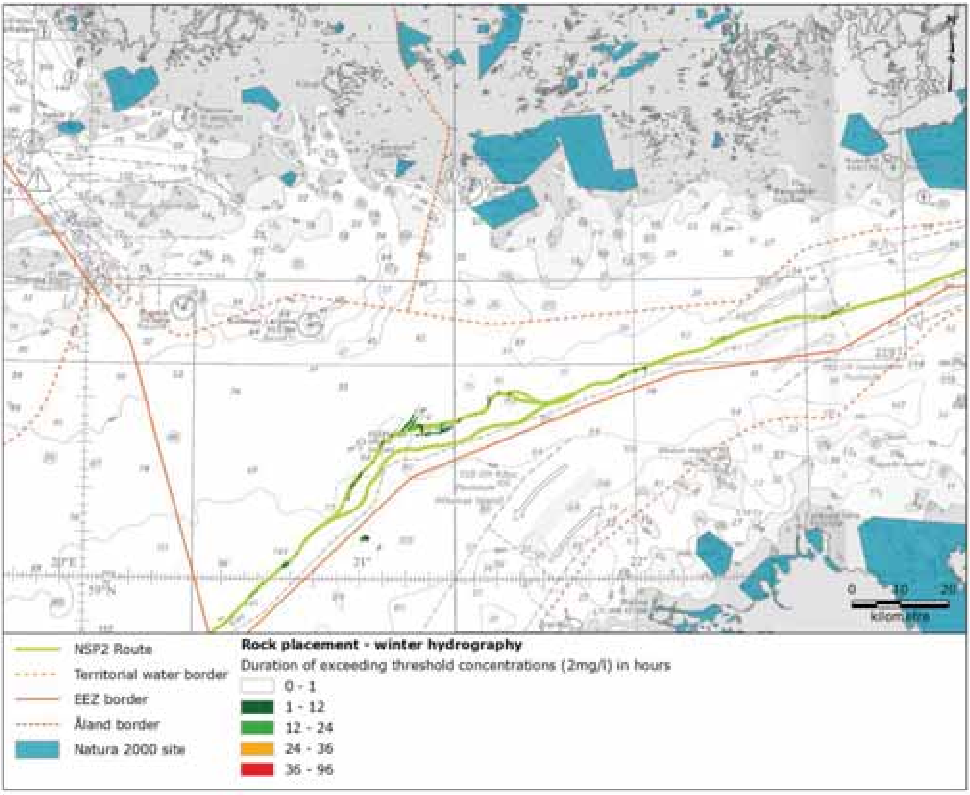


Figure 5-12 Duration of exceeding 2 mg/l for rock placement under typical winter conditions. Western part of the Gulf of Finland.

Figure 5-13 and Figure 5-14 show the sedimentation at the last time step of the simulation under normal conditions.

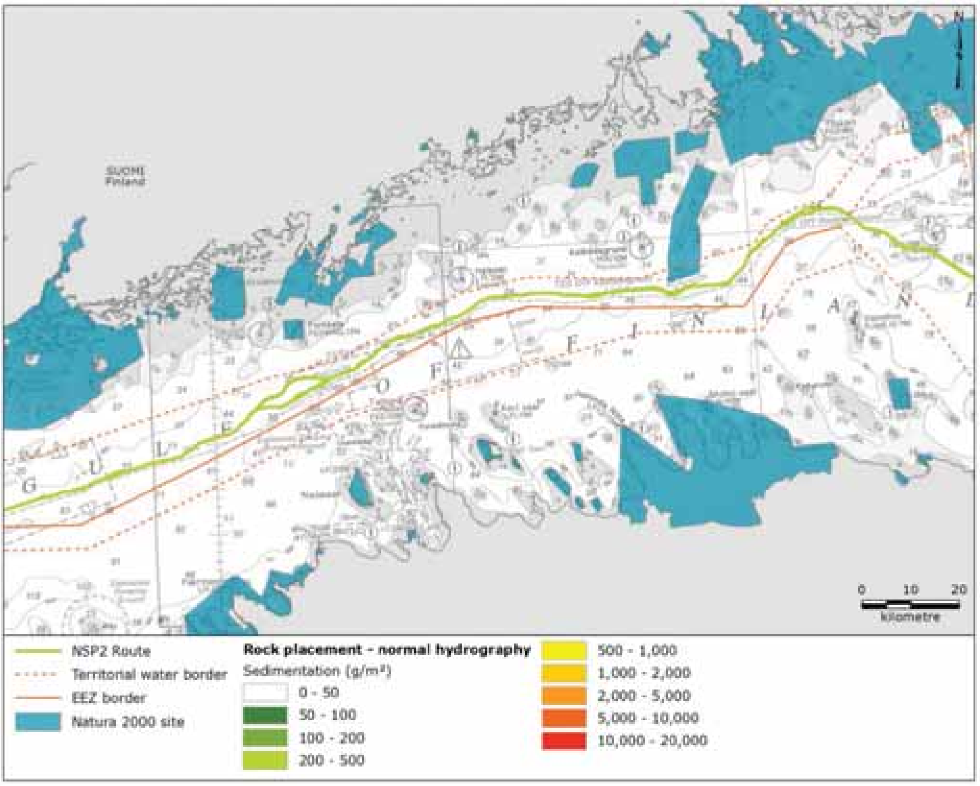


Figure 5-13 Sedimentation of released material due to rock placement under annual / normal hydrographic conditions. Eastern part of the Gulf of Finland.

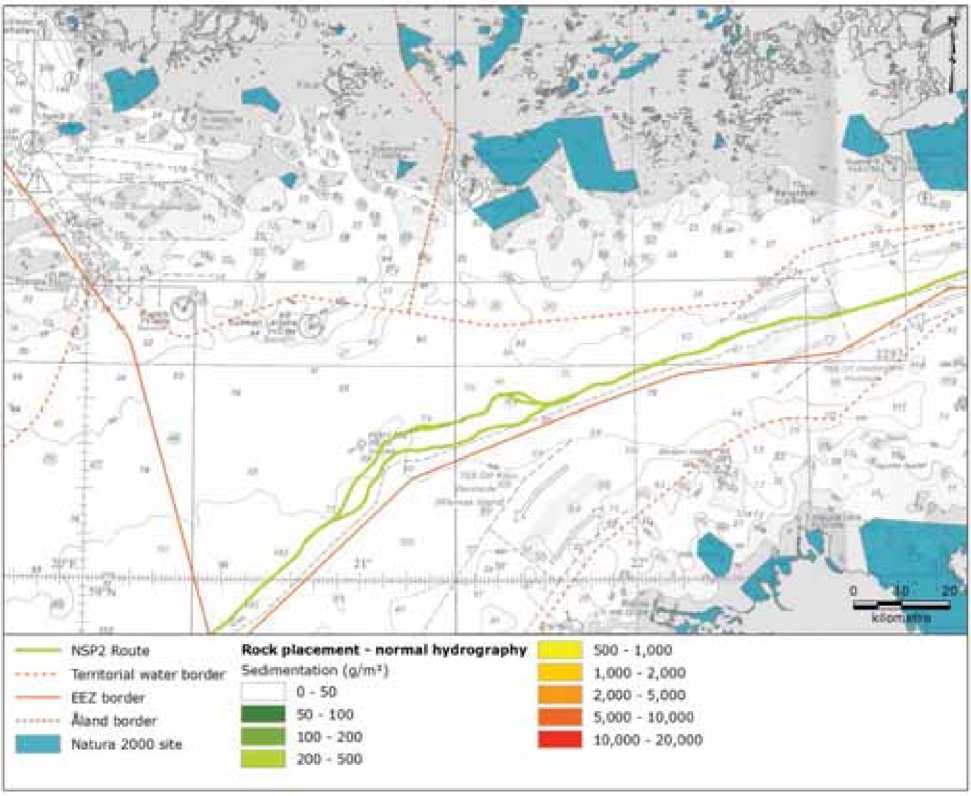


Figure 5-14 Sedimentation of released material due to rock placement under annual / normal hydrographic conditions. Western part of the Gulf of Finland.

Figure 5-15 and Figure 5-16 show the sedimentation at the last time step of the simulation under typical summer conditions.

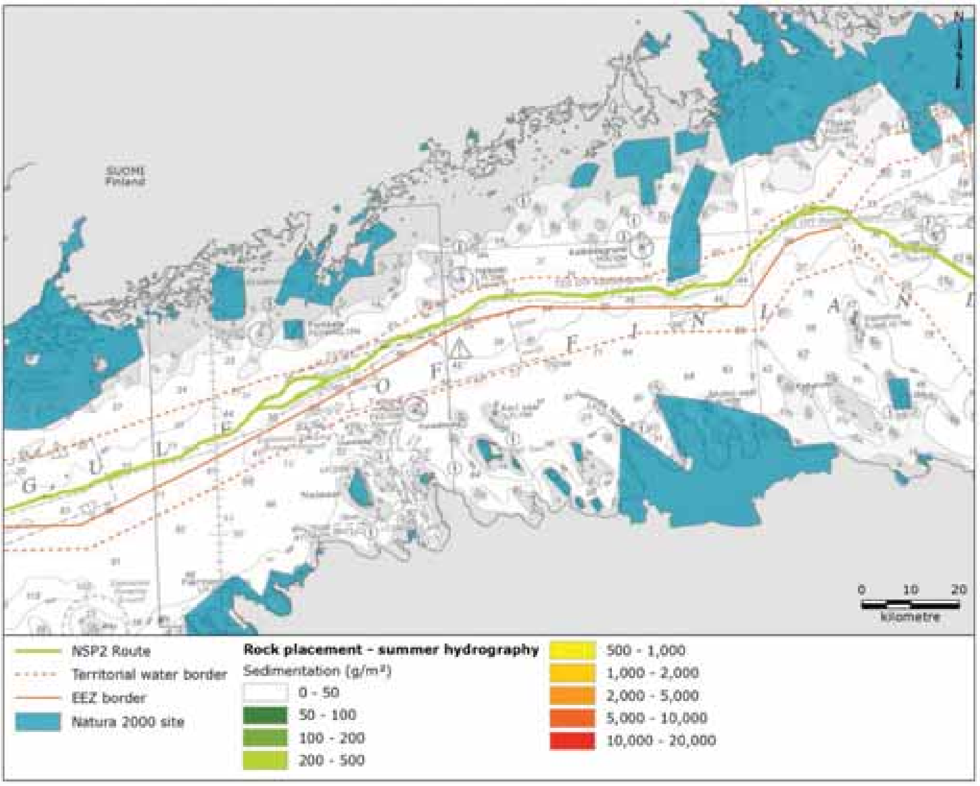


Figure 5-15 Sedimentation of released material due to rock placement under typical summer conditions. Eastern part of the Gulf of Finland.

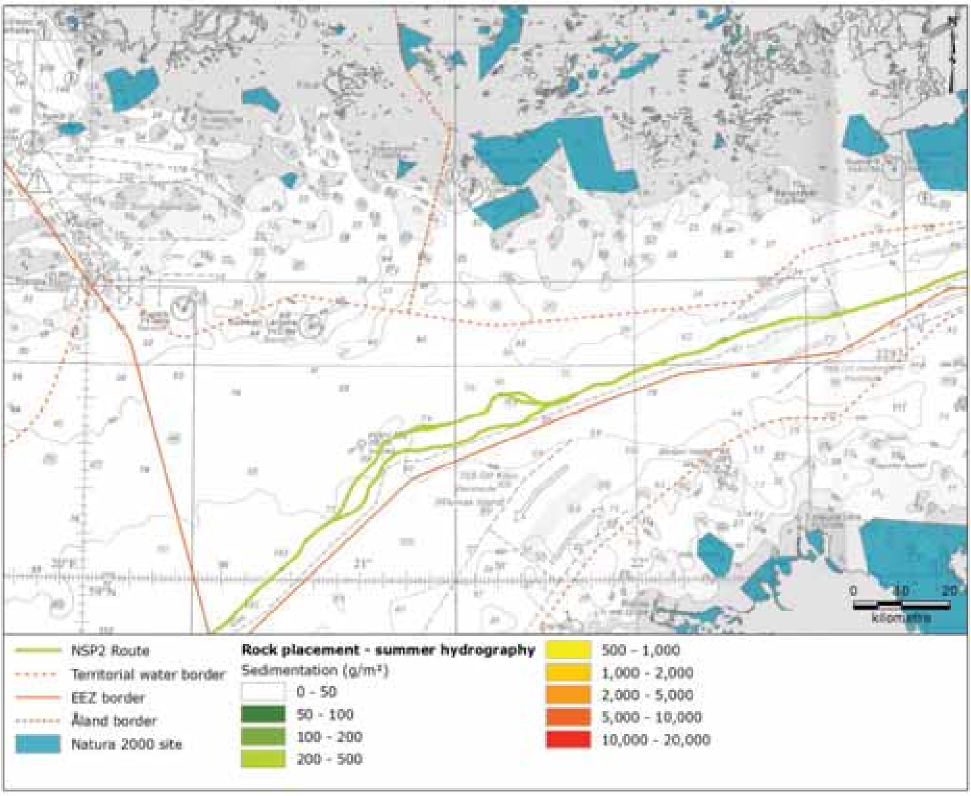


Figure 5-16 Sedimentation of released material due to rock placement under typical summer conditions. Western part of the Gulf of Finland.

Figure 5-17 and Figure 5-18 show the sedimentation at the last time step of the simulation under typical winter conditions.

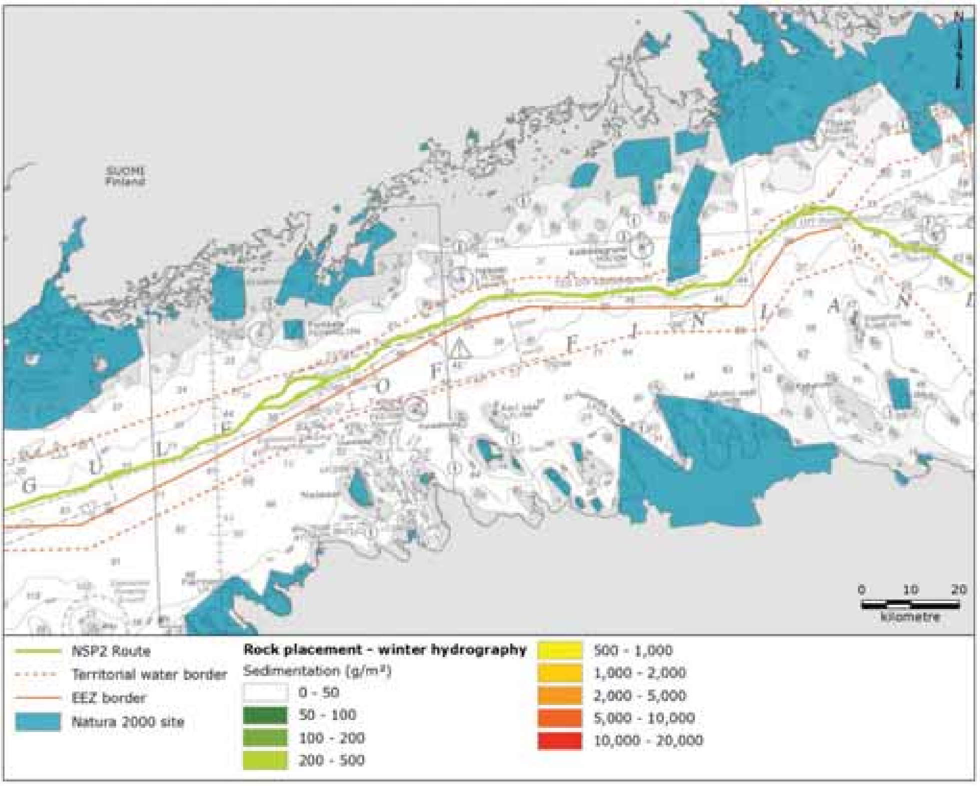


Figure 5-17 Sedimentation of released material due to rock placement under typical winter conditions. Eastern part of the Gulf of Finland.

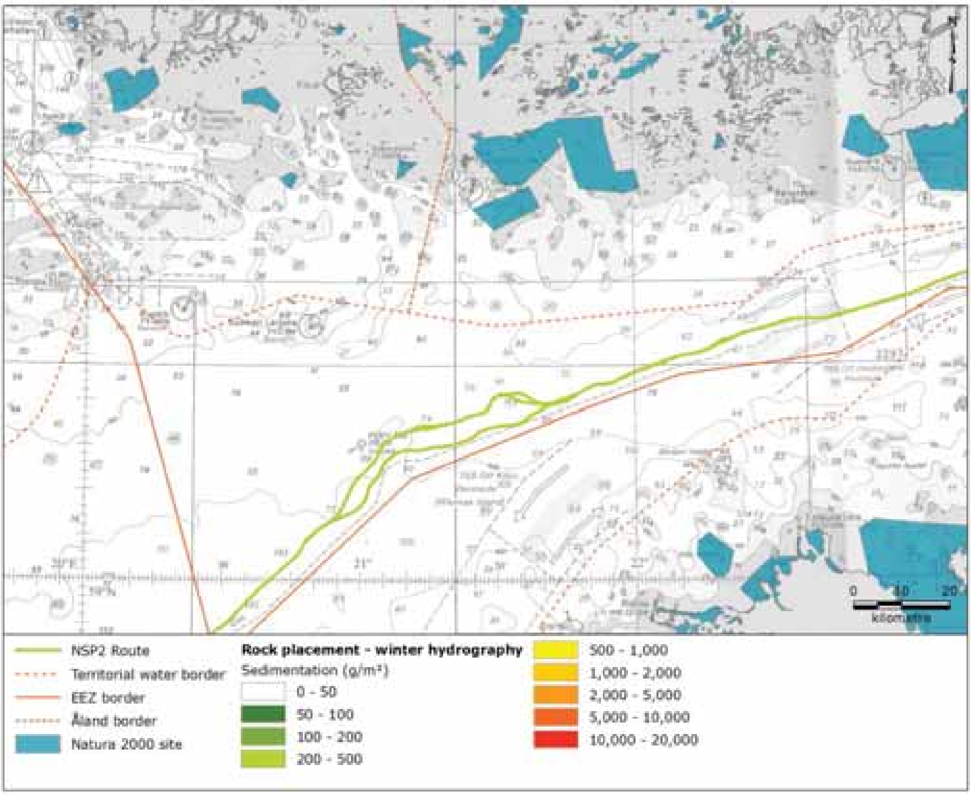


Figure 5-18 Sedimentation of released material due to rock placement under typical winter conditions. Western part of the Gulf of Finland.

5.1.1 Line A Alternative route

For Line A Alternative route, the results for the winter scenario are given in Figure 5-19 to Figure 5-24 – only the winter scenario is modelled. Figure 5-19 and Figure 5-20 show the highest concentration observed under typical winter conditions for Line A Alternative route.

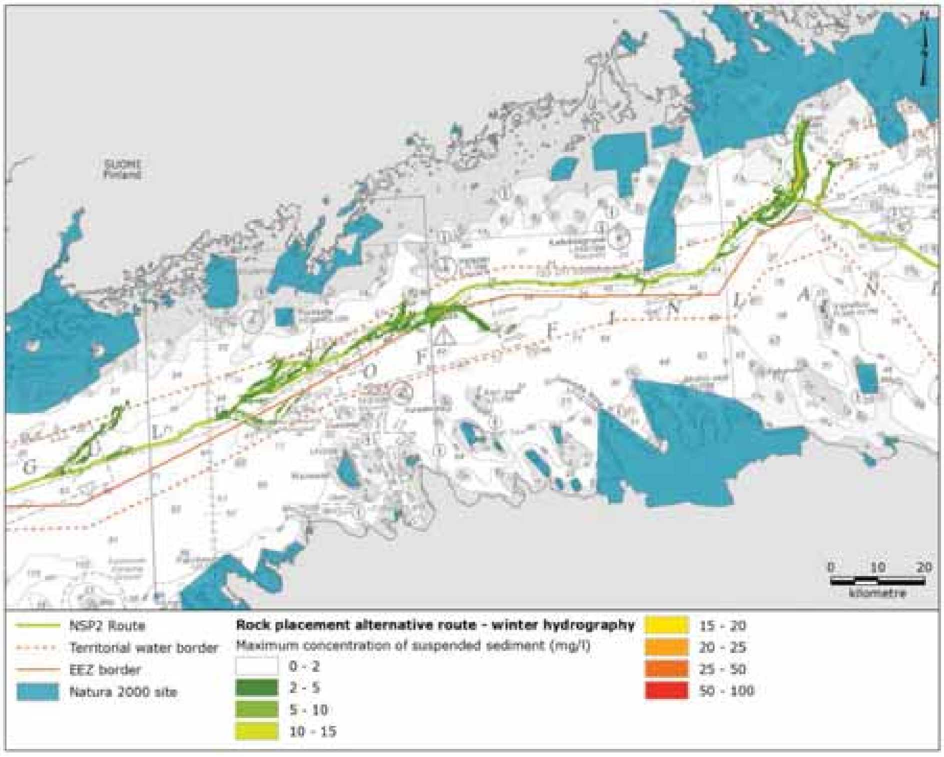


Figure 5-19 **Maximum concentration of suspended sediment for rock placement under typical winter conditions. Line A Alternative route. Eastern part of the Gulf of Finland.**

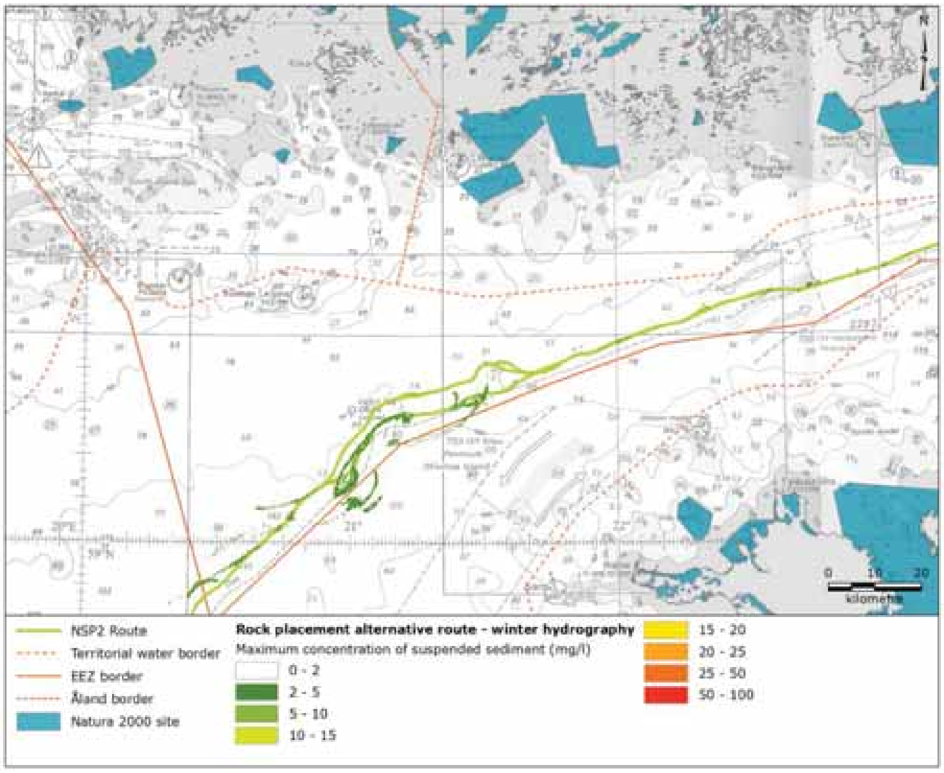


Figure 5-20 **Maximum concentration of suspended sediment for rock placement under typical winter conditions. Line A Alternative route. Western part of the Gulf of Finland.**

Figure 5-21 and Figure 5-22 show the duration for which the concentration threshold of 2 mg/l is exceeded during the rock placement section under typical winter conditions for the alternative route. The largest duration observed is 32 hours.

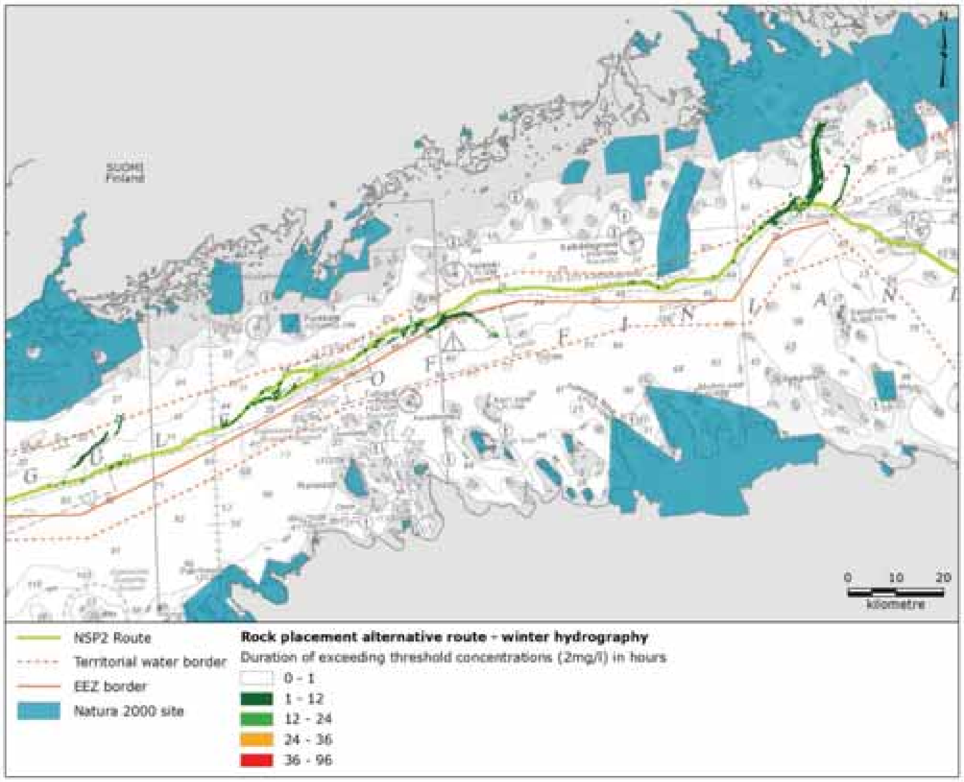


Figure 5-21 Duration of exceeding 2 mg/l for rock placement under typical winter conditions. Line A Alternative route. Eastern part of the Gulf of Finland.

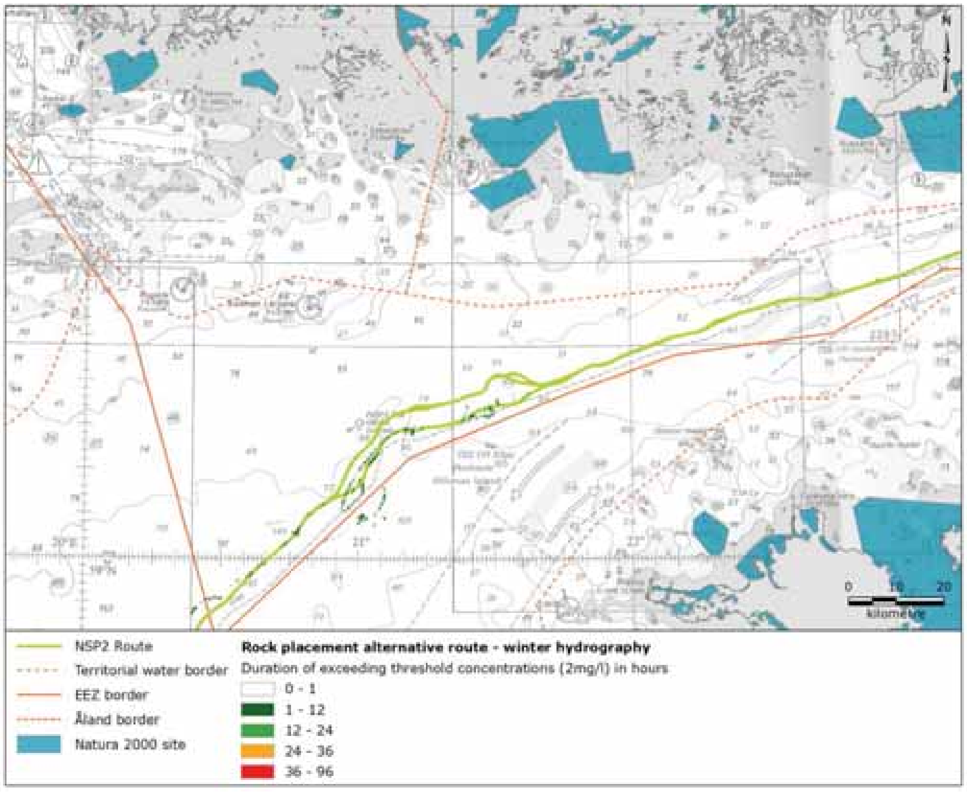


Figure 5-22 Duration of exceeding 2 mg/l for rock placement under typical winter conditions. Line A Alternative route. Western part of the Gulf of Finland.

Figure 5-23 and Figure 5-24 show the sedimentation at the last time step of the simulation under typical winter conditions for Line A Alternative route.

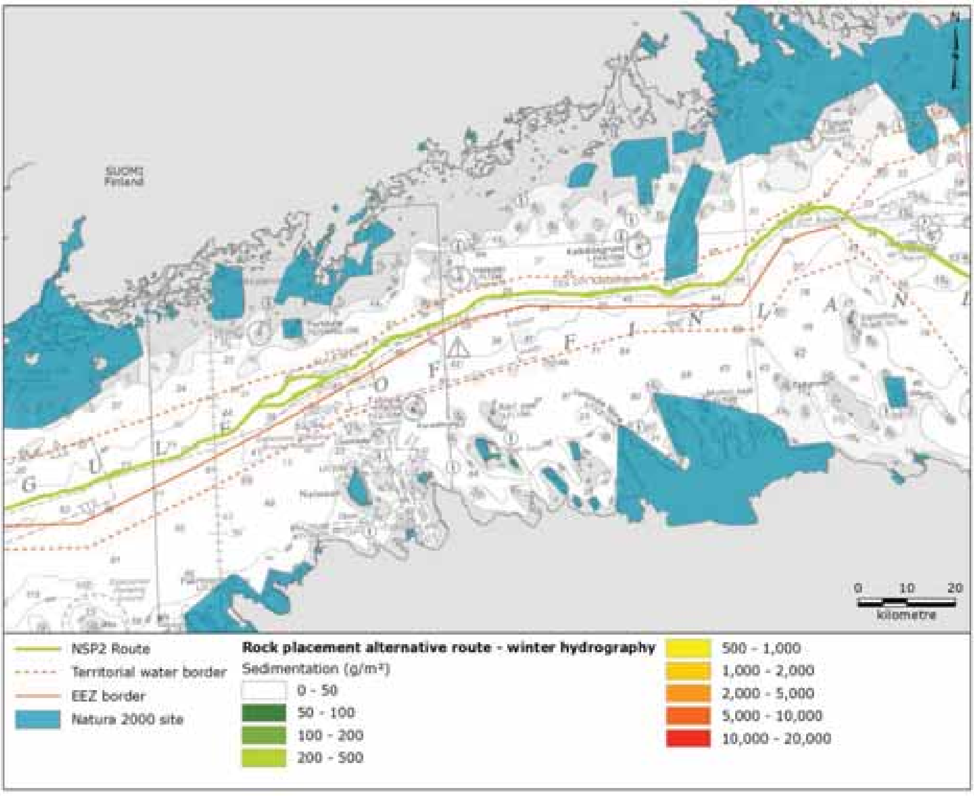


Figure 5-23 **Sedimentation of released material due to rock placement under typical winter conditions. Line A Alternative route. Eastern part of the Gulf of Finland.**

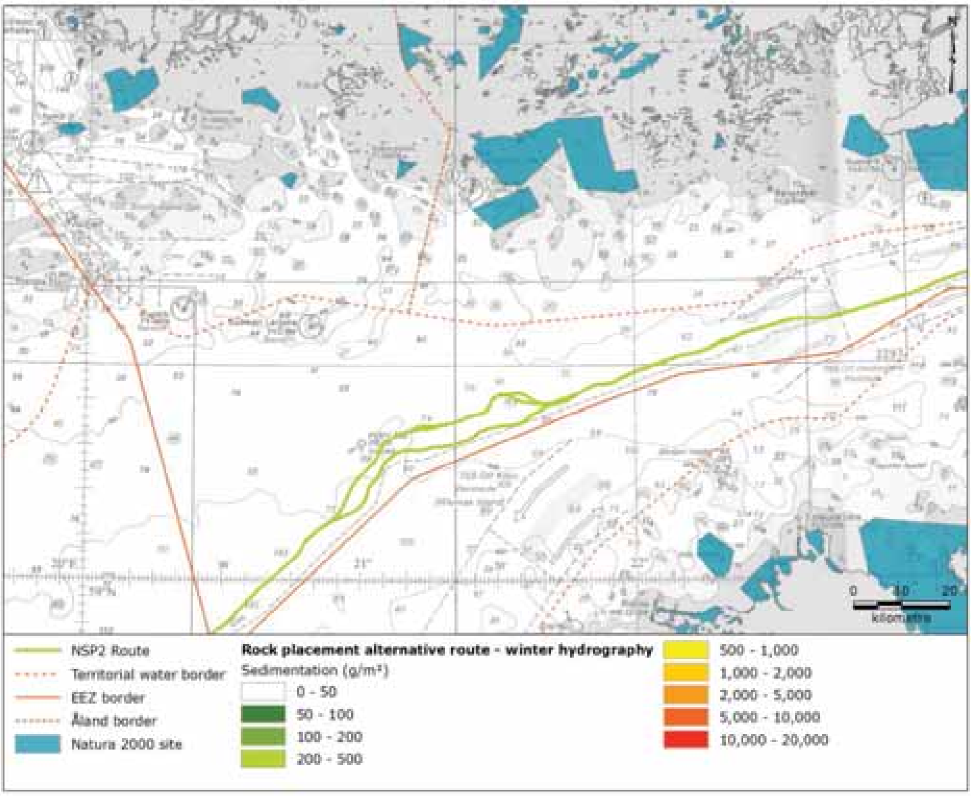


Figure 5-24 **Sedimentation of released material due to rock placement under typical winter conditions. Line A Alternative route. Western part of the Gulf of Finland.**

5.2 Munitions clearance

Figure 5-25 shows the highest concentrations observed during munition clearance operations under normal conditions in the lower 10m of the water column. Figure 5-26 shows the highest concentrations observed during munition clearance operations under normal conditions between 10m and 20m above seabed.

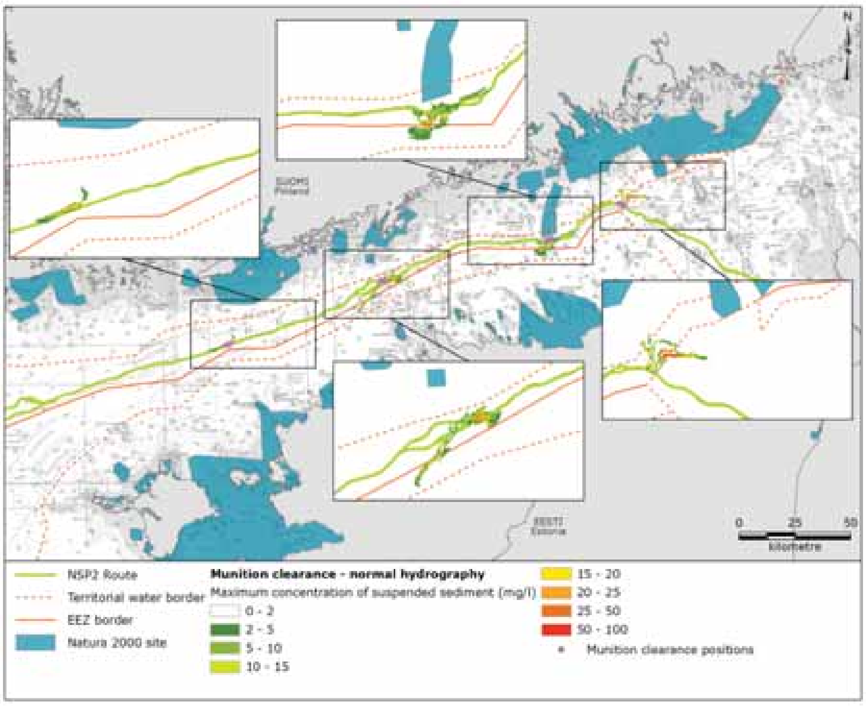


Figure 5-25 Maximum concentration of suspended sediment for munitions clearance under annual/normal hydrographic conditions. 0-10m above the seabed.

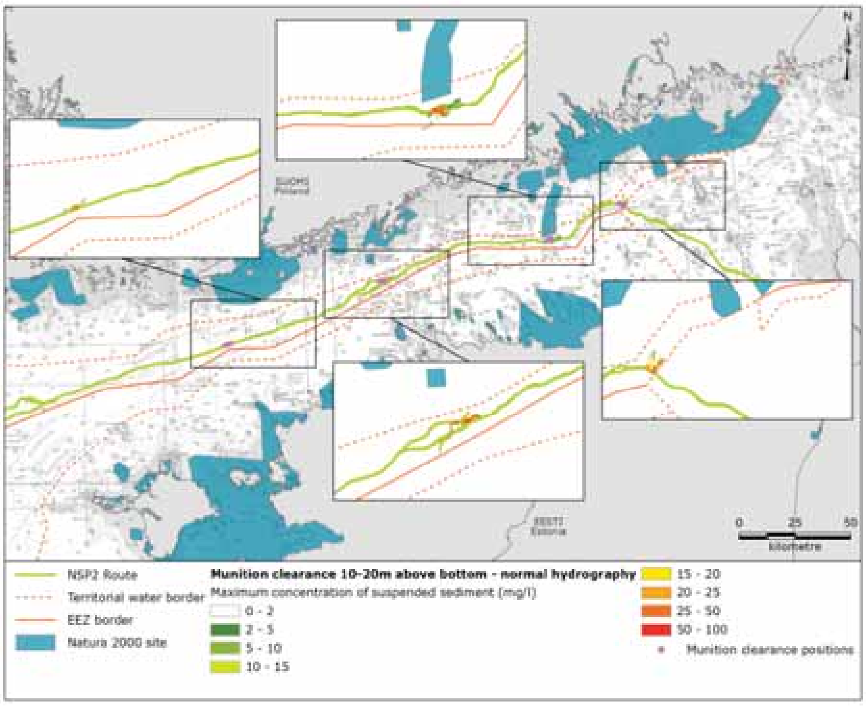


Figure 5-26 Maximum concentration of suspended sediment for munitions clearance under annual/normal hydrographic conditions. 10m-20m above the seabed.

Figure 5-27 shows the highest concentrations observed during munitions clearance operations under typical summer conditions in the lower 10m of the water column. Figure 5-28 shows the highest concentrations observed during munitions clearance operations under summer conditions between 10m and 20m above the seabed.

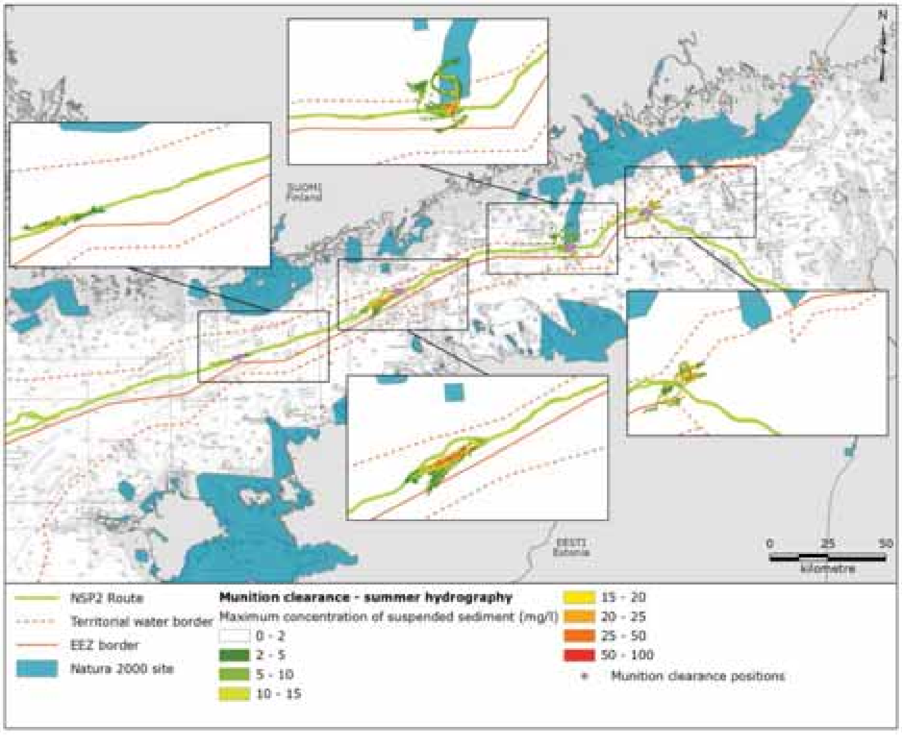


Figure 5-27 Maximum concentration of suspended sediment for munitions clearance under typical summer conditions. 0m-10m above the seabed.

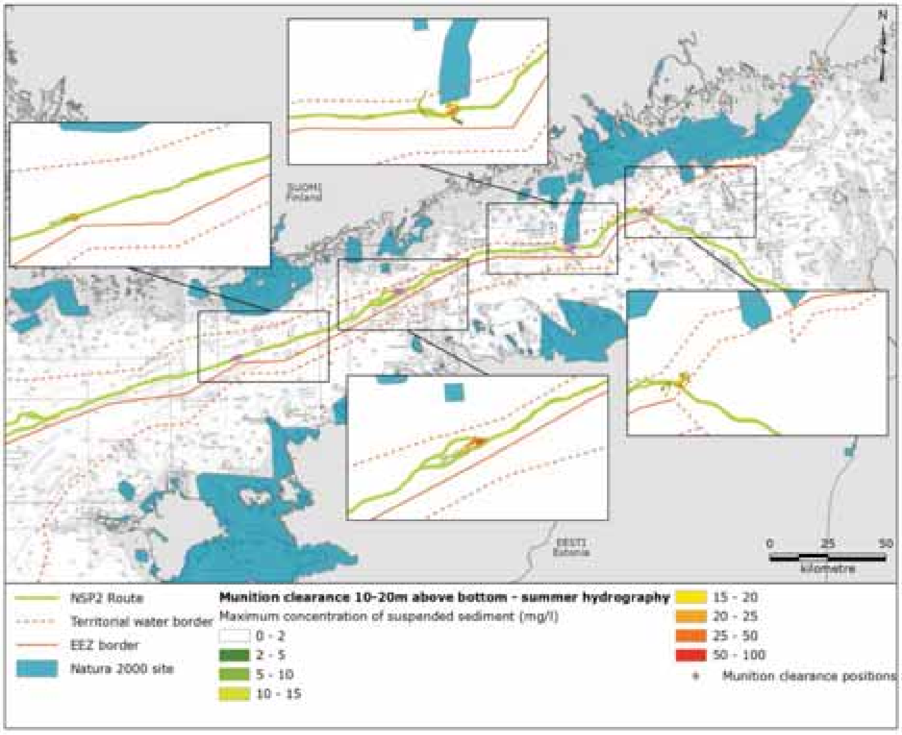


Figure 5-28 Maximum concentration of suspended sediment for munitions clearance under typical summer conditions. 10m-20m above the seabed.

Figure 5-29 shows the highest concentrations observed during munitions clearance operations under typical winter conditions in the lower 10m of the water column. Figure 5-30 shows the highest concentrations observed during munitions clearance operations under winter conditions between 10m and 20m above the seabed.

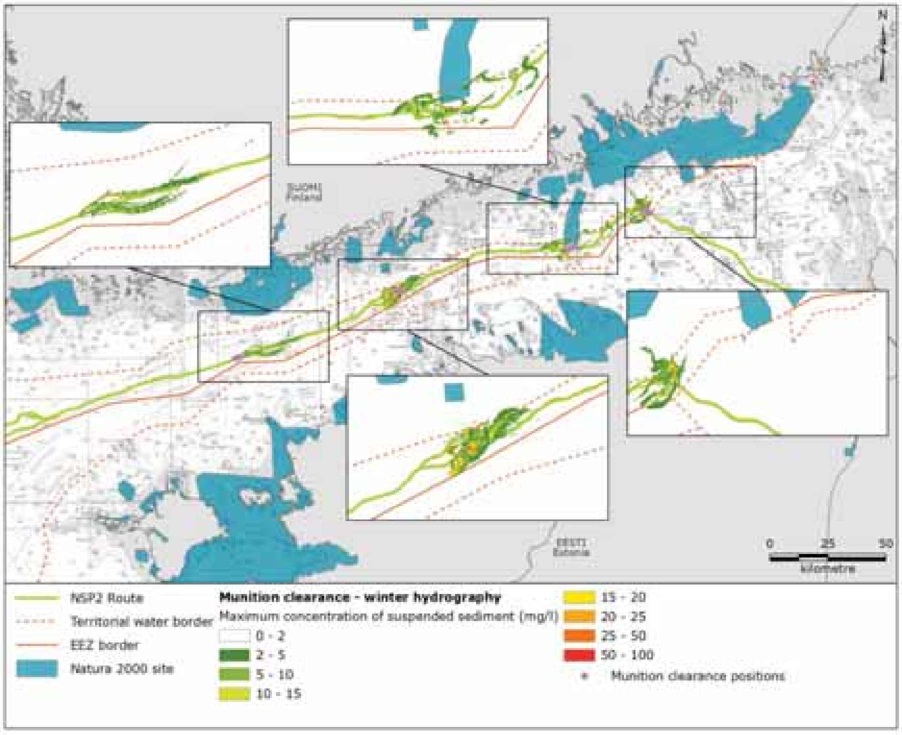


Figure 5-29 **Maximum concentration of suspended sediment for munitions clearance under typical winter conditions. 0m-10m above the seabed.**

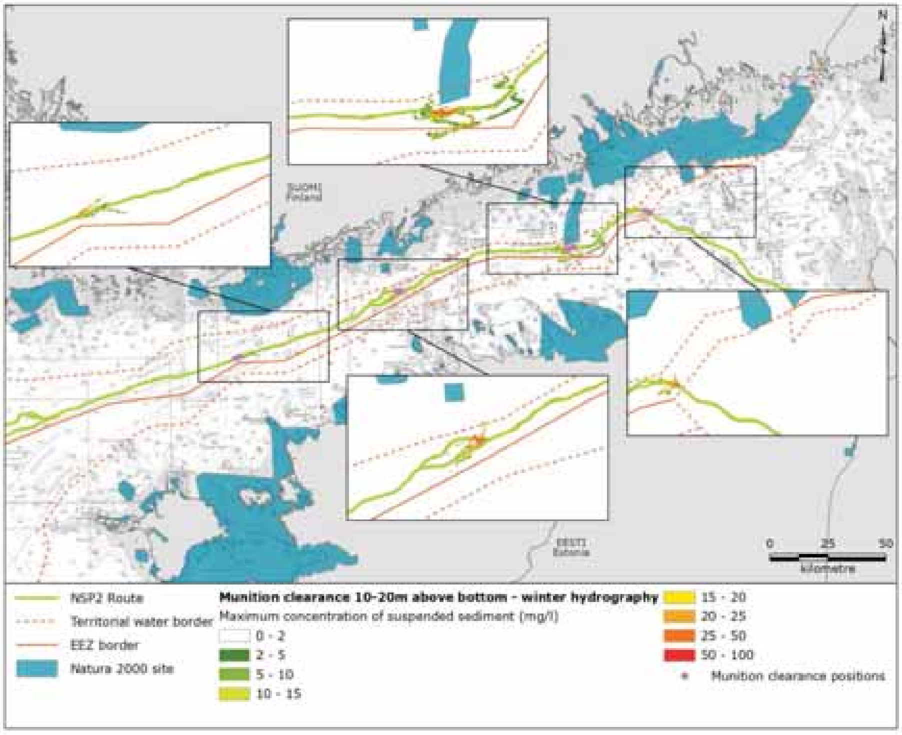


Figure 5-30 **Maximum concentration of suspended sediment for munitions clearance under typical winter conditions. 10m-20m above sea bed.**

Figure 5-31 shows the duration for which the concentration threshold of 2 mg/l is exceeded during the munitions clearance operations under normal conditions in the lower 10m of the water column. The largest value observed is 24 hours. Figure 5-32 shows the exceedance of 2mg/l observed during munitions clearance operations under normal conditions between 10m and 20m above the seabed. The largest value observed is 21 hours.

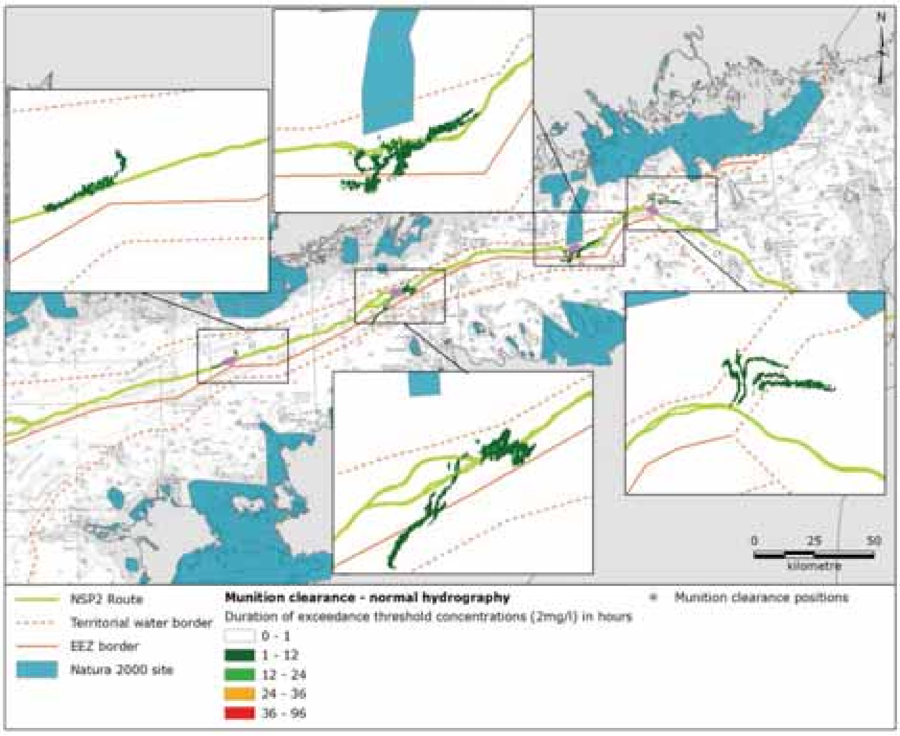


Figure 5-31 Duration of exceeding 2 mg/l for munitions clearance under annual / normal hydrographic conditions. 0m-10m above the seabed.

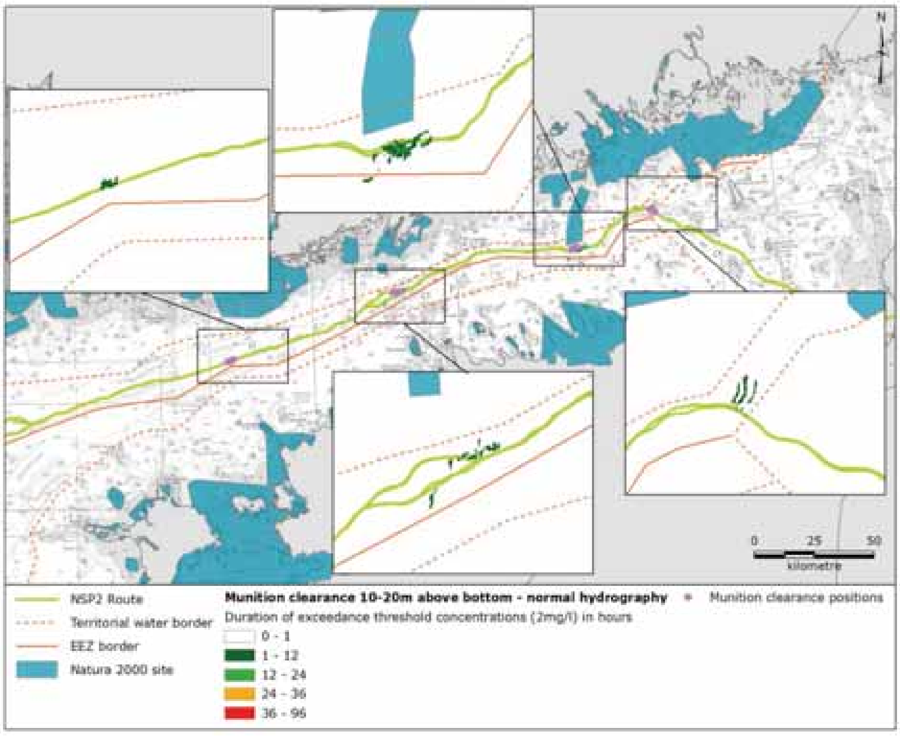


Figure 5-32 Duration of exceeding 2 mg/l for munitions clearance under annual / normal hydrographic conditions. 10m-20m above the seabed.

Figure 5-33 shows the duration for which the concentration threshold of 2 mg/l is exceeded during the munitions clearance operations under typical summer conditions in the lower 10m of the water column. The largest value observed is 23 hours. Figure 5-34 shows the highest exceedance of 2mg/l observed during munitions clearance operations under summer conditions between 10m and 20m above the seabed. The largest value observed is 15 hours

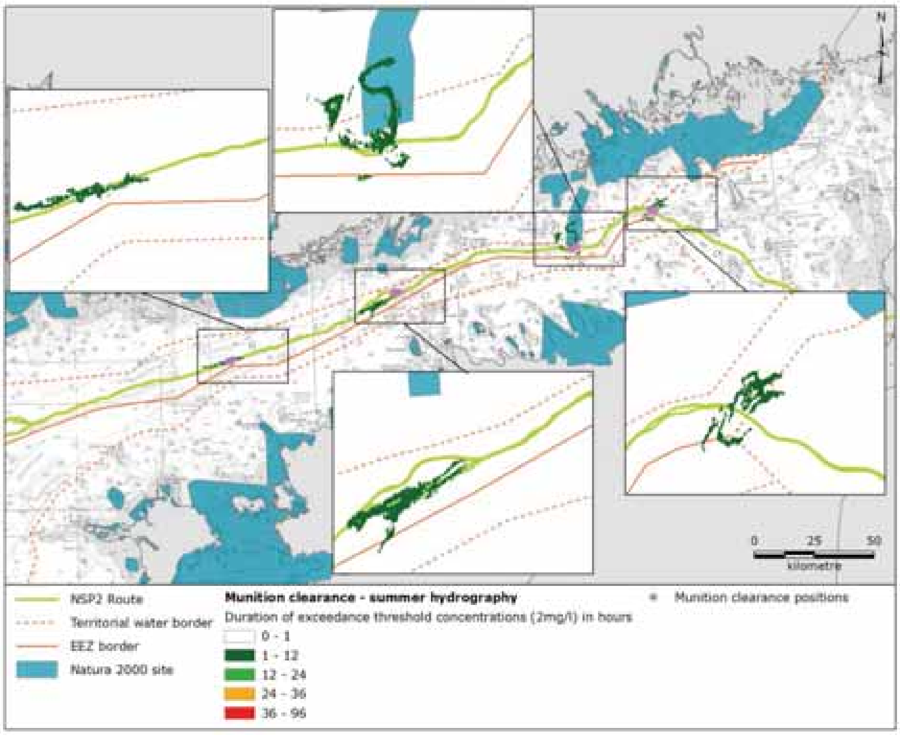


Figure 5-33 Duration of exceeding 2 mg/l for munitions clearance under typical summer conditions. 0m-10m above the seabed.

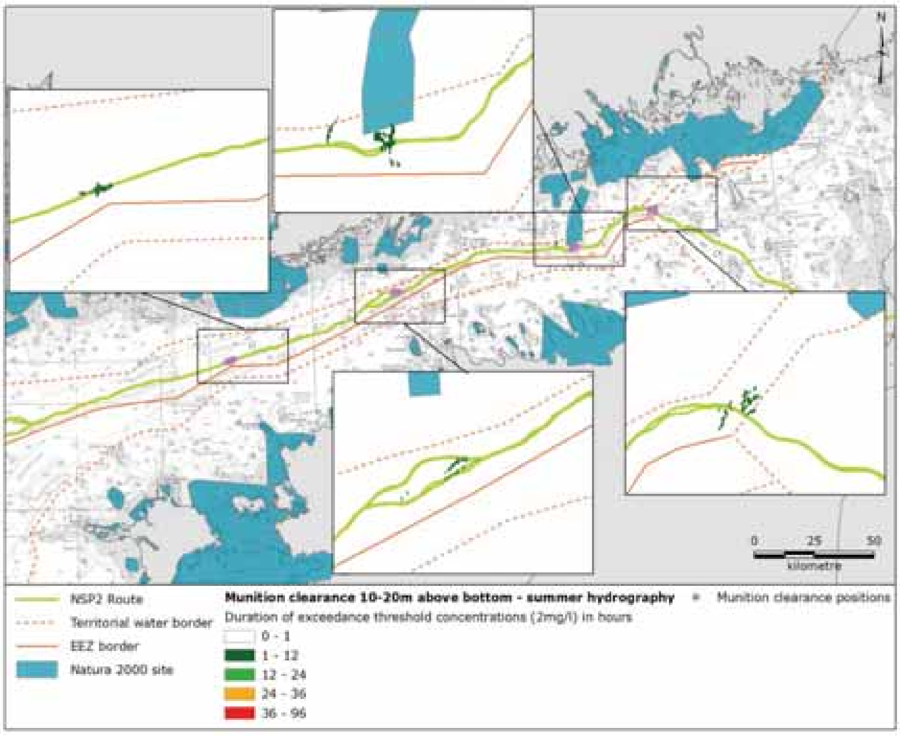


Figure 5-34 Duration of exceeding 2 mg/l for munitions clearance under typical summer conditions. 10m-20m above the seabed.

Figure 5-35 shows the duration for which the concentration threshold of 2 mg/l is exceeded during the munitions clearance operations under typical winter conditions in the lower 10m of the water column. The largest value observed is 20 hours. Figure 5-36 shows the highest exceedance of 2mg/l observed during munitions clearance operations under winter conditions between 10m and 20m above the seabed. The largest value observed is 12 hours.

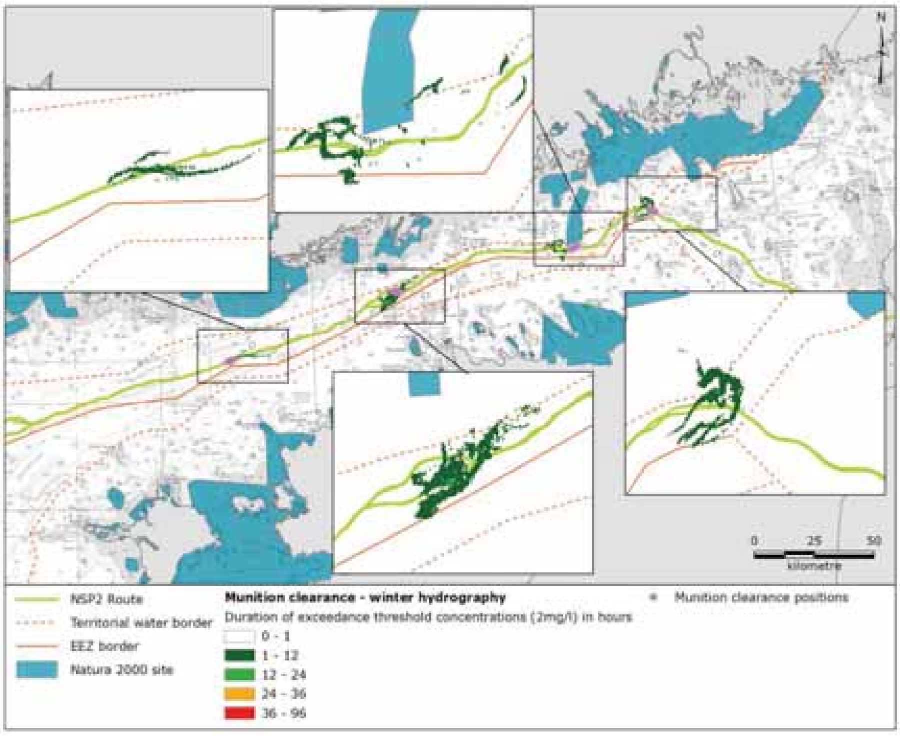


Figure 5-35 Duration of exceeding 2 mg/l for munitions clearance under typical winter conditions. 0m-10m above the seabed.

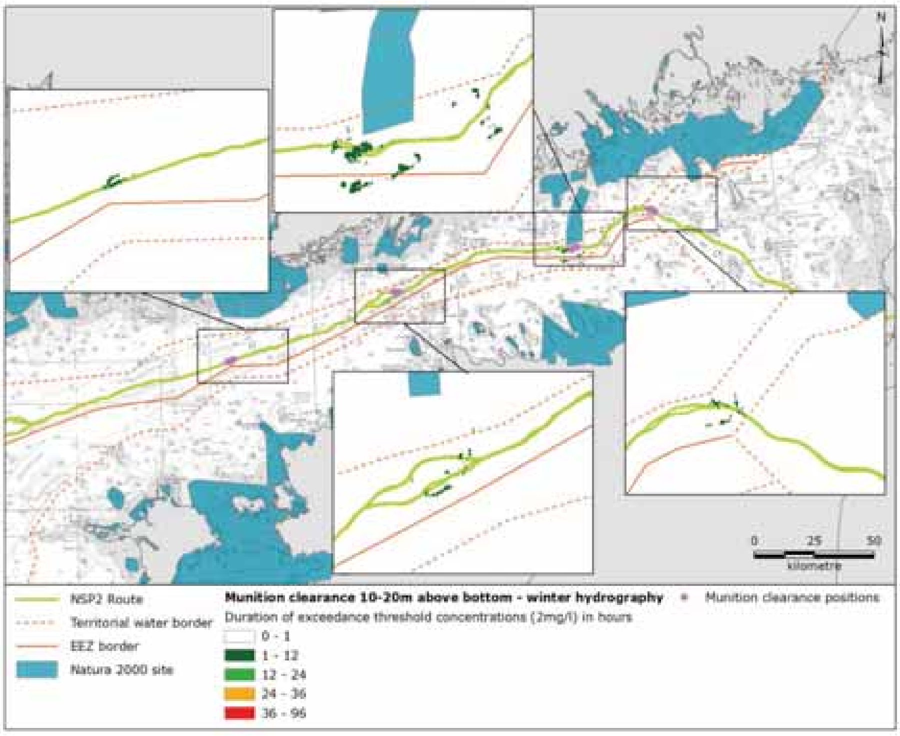


Figure 5-36 Duration of exceeding 2 mg/l for munitions clearance under typical winter conditions. 10m-20m above the seabed.

Figure 5-37shows the duration for which the concentration threshold of 10 mg/l is exceeded during the munitions clearance operations under normal conditions in the lower 10m of the water column. The largest value observed is 13 hours. Figure 5-38 shows the highest exceedance of 10mg/l observed during munitions clearance operations under normal conditions between 10m and 20m above the seabed. The largest value observed is 12 hours.

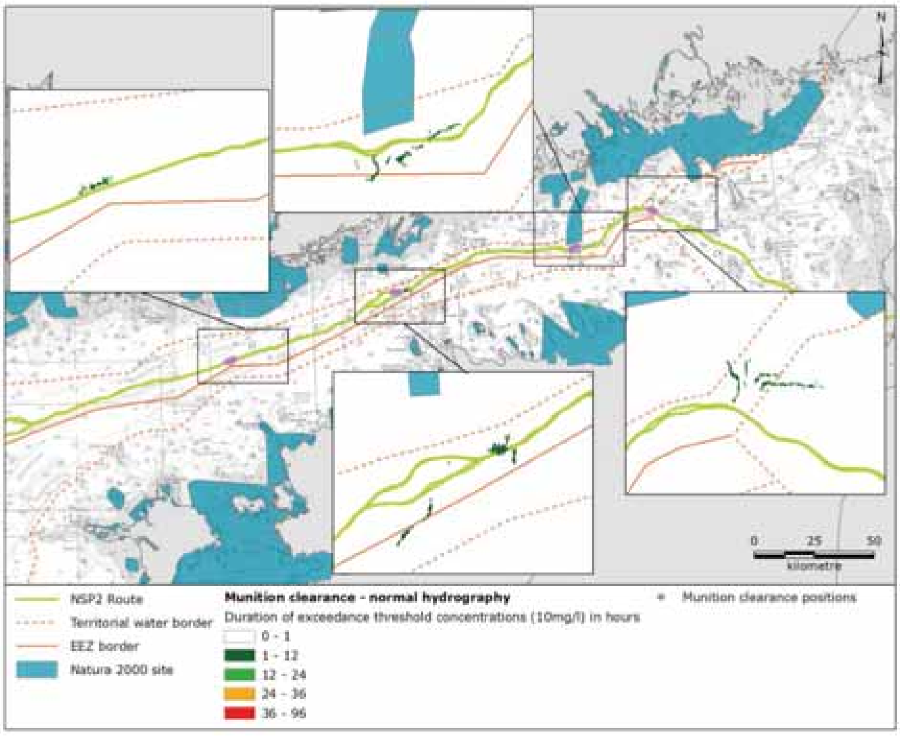


Figure 5-37 Duration of exceeding 10 mg/l for munitions clearance under annual / normal hydrographic conditions. 0m-10m above the seabed.

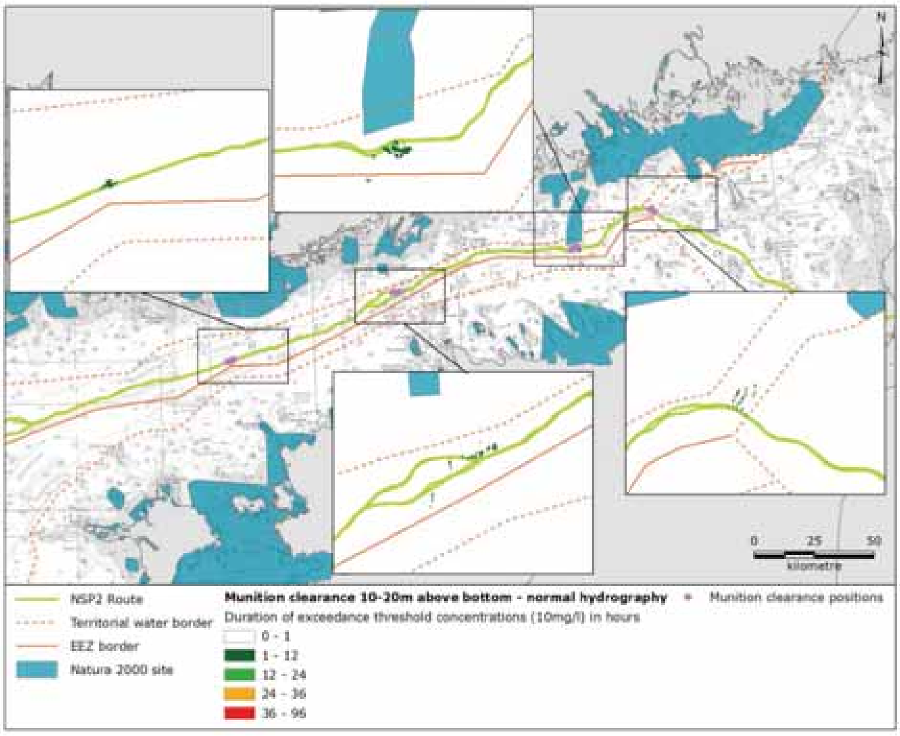


Figure 5-38 Duration of exceeding 10 mg/l for munitions clearance under annual / normal hydrographic conditions. 10m-20m above the seabed.

Figure 5-39 shows the duration for which the concentration threshold of 10 mg/l is exceeded during the munitions clearance operations under typical summer conditions in the lower 10m of the water column. The largest value observed is nine hours. Figure 5-40 shows the highest exceedance of 10mg/l observed during munitions clearance operations under summer conditions between 10m and 20m above the seabed. The largest value observed is six hours.

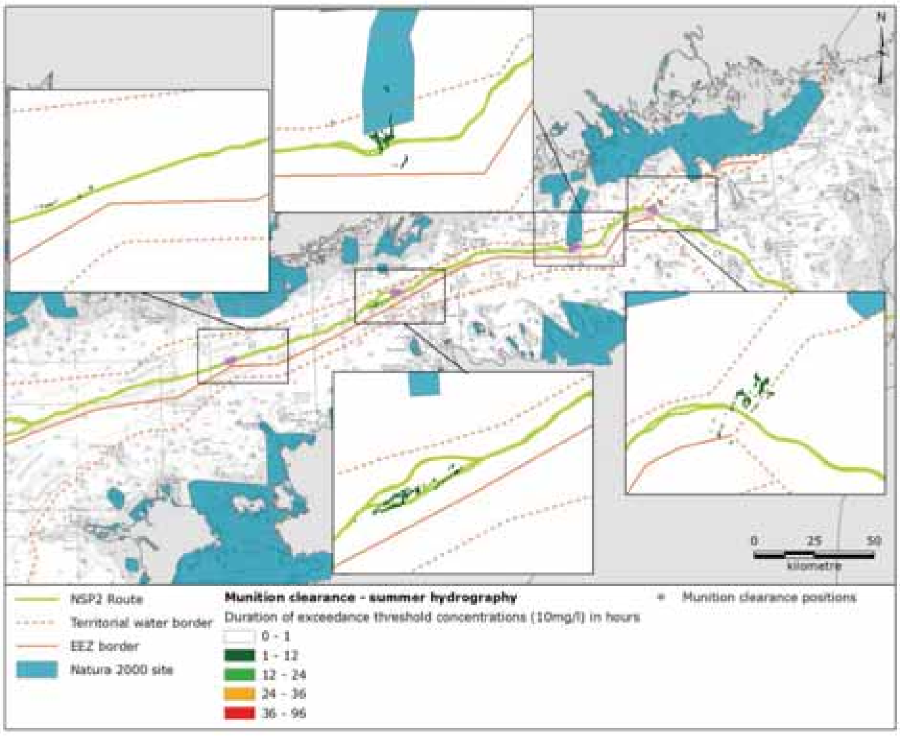


Figure 5-39 Duration of exceeding 10 mg/l for munitions clearance under typical summer conditions. 0m-10m above the seabed.

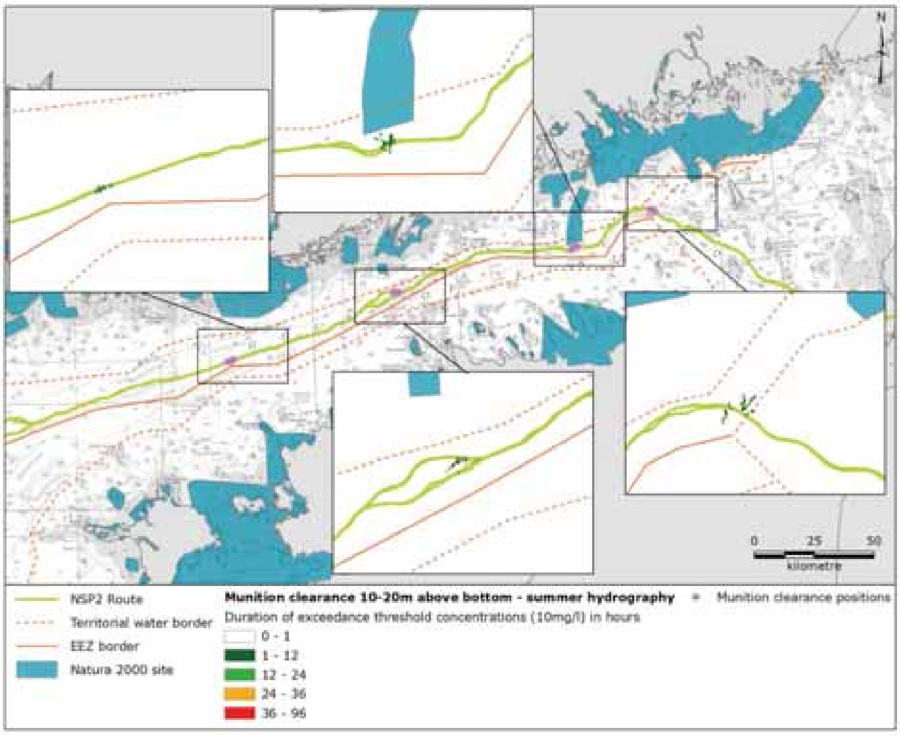


Figure 5-40 Duration of exceeding 10 mg/l for munitions clearance under typical summer conditions. 10m-20m above the seabed.

Figure 5-41 shows the duration for which the concentration threshold of 10 mg/l is exceeded during the munitions clearance operations under typical winter conditions in the lower 10m of the water column. The largest value observed is seven hours. Figure 5-42 shows the highest exceedance of 10mg/l observed during munitions clearance operations under winter conditions between 10m and 20m above the seabed. The largest value observed is nine hours

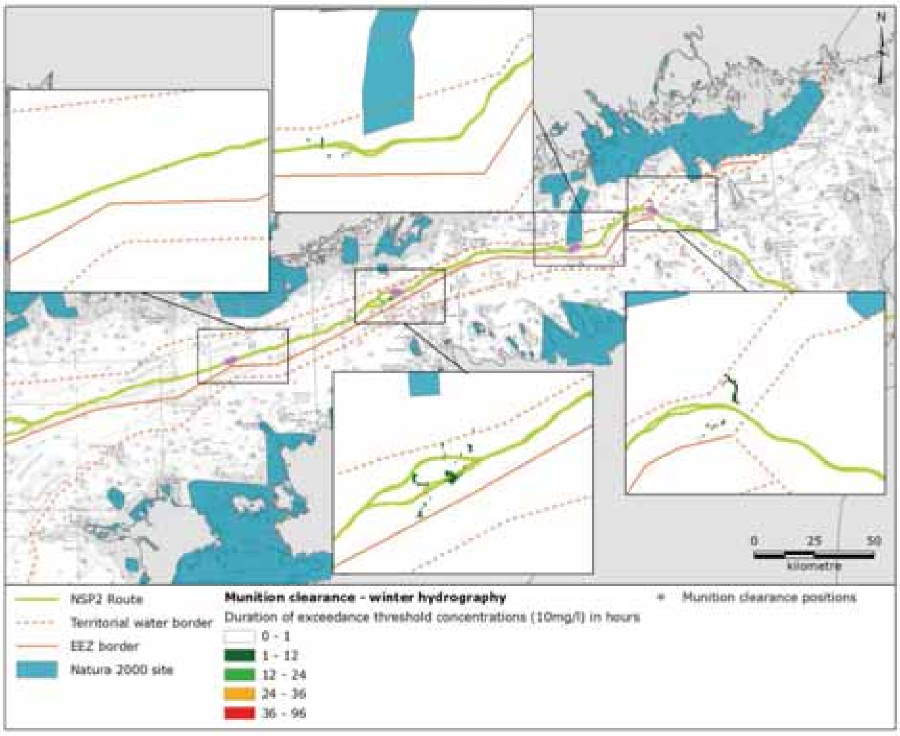


Figure 5-41 **Duration of exceeding 10 mg/l for munitions clearance under typical winter conditions. 0m-10m above the seabed.**

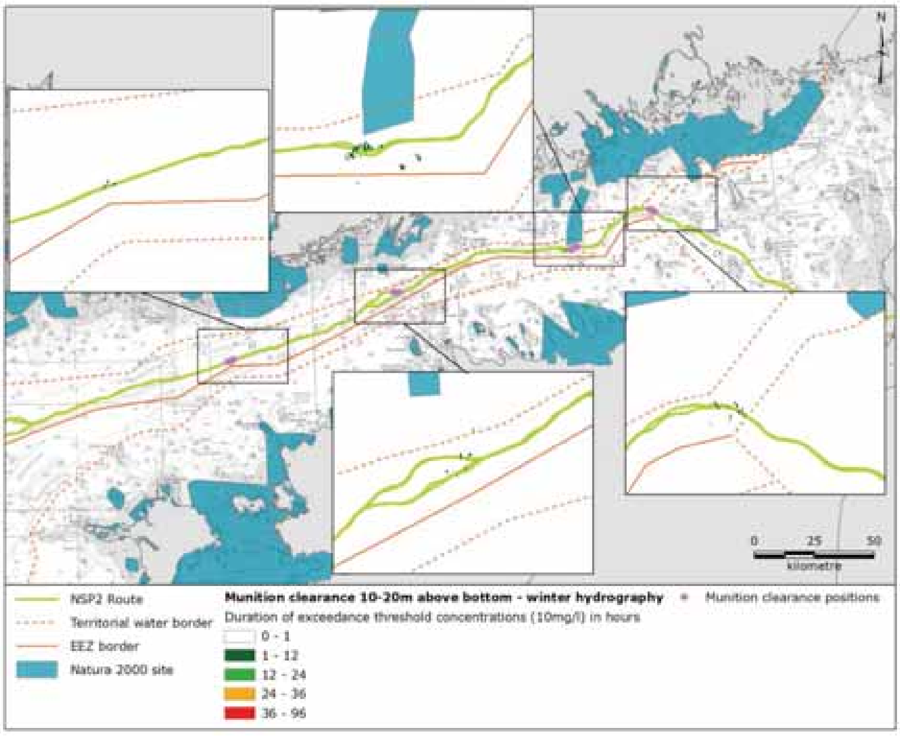


Figure 5-42 **Duration of exceeding 10 mg/l for munitions clearance under typical winter conditions. 10m-20m above the seabed.**

Figure 5-43 shows the duration for which the concentration threshold of15 mg/l is exceeded during the munitions clearance operations under normal conditions in the lower 10m of the water column. The largest value observed is 10 hours. Figure 5-44 shows the highest exceedance of 15mg/l observed during munitions clearance operations under normal conditions between 10m and 20m above the seabed. The largest value observed is 11 hours.

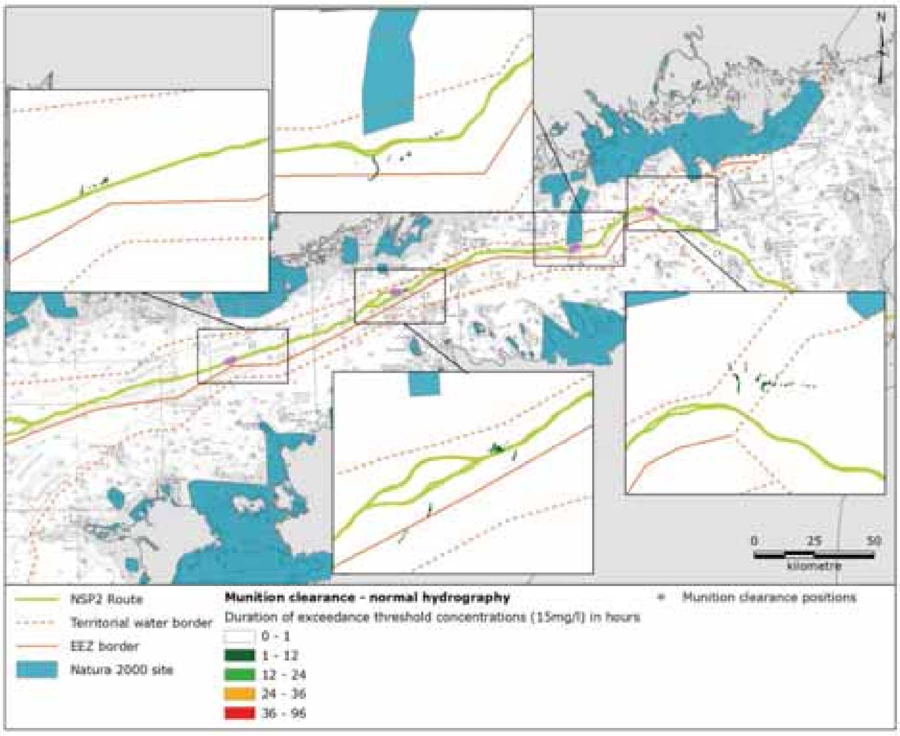


Figure 5-43 Duration of exceeding 15 mg/l for munitions clearance under annual/normal hydrographic conditions. 0m-10m above the seabed.

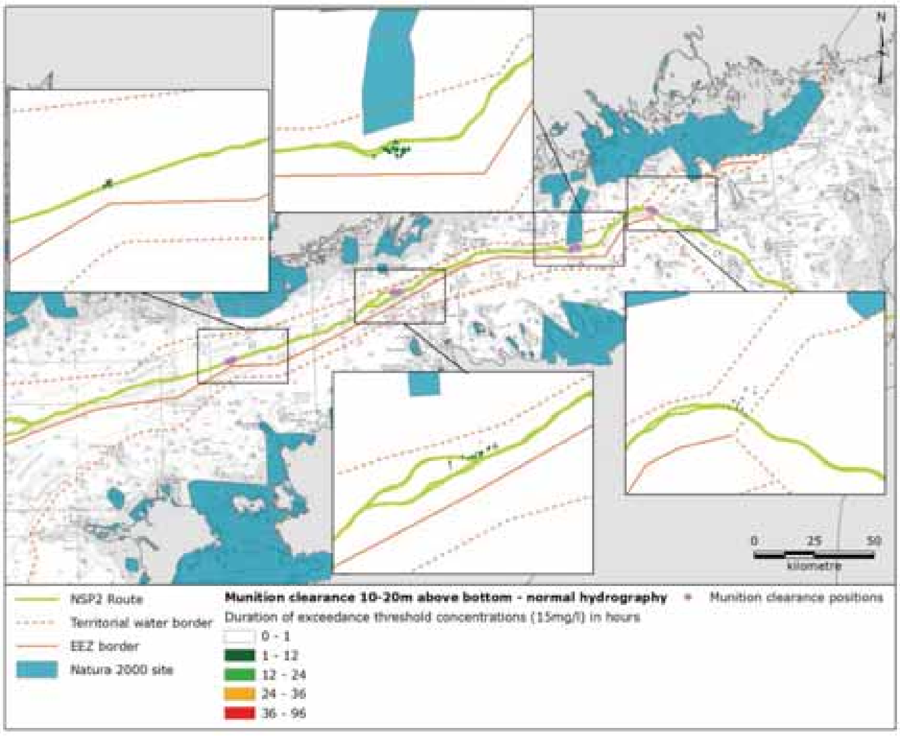


Figure 5-44 Duration of exceeding 15 mg/l for munitions clearance under annual/normal hydrographic conditions. 10m-20m above the seabed.

Figure 5-45 shows the duration for which the concentration threshold of 15 mg/l is exceeded during the munitions clearance operations under typical summer conditions in the lower 10m of the water column. The largest value observed is eight hours. Figure 5-46 shows the highest exceedance of 15mg/l observed during munitions clearance operations under summer conditions between 10m and 20m above the seabed. The largest value observed is six hours.

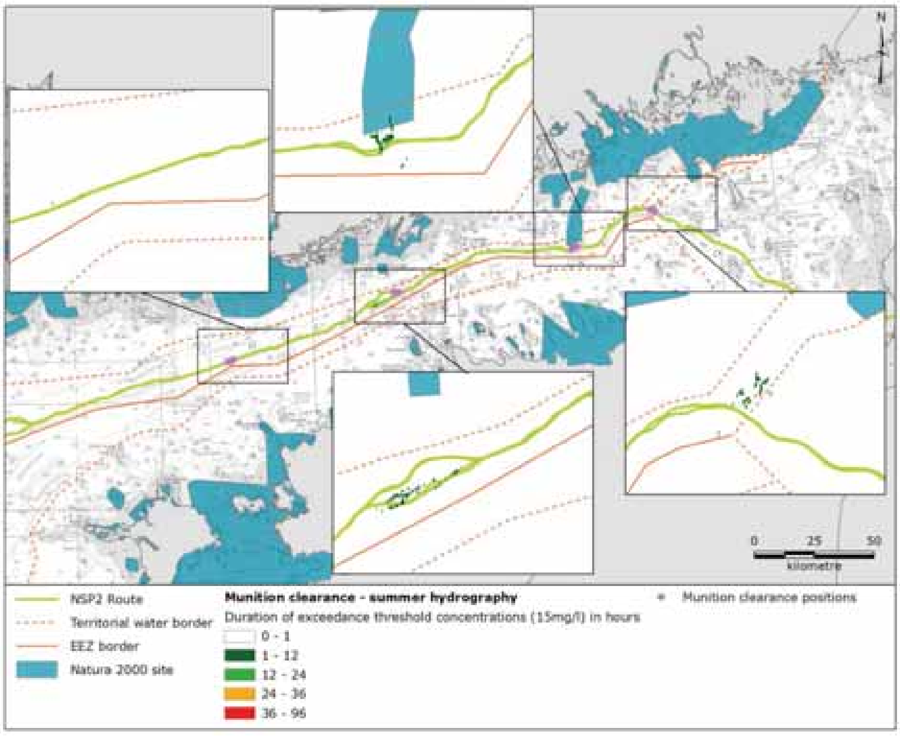


Figure 5-45 Duration of exceeding 15 mg/l for munitions clearance under typical summer conditions. 0m-10m above the seabed.

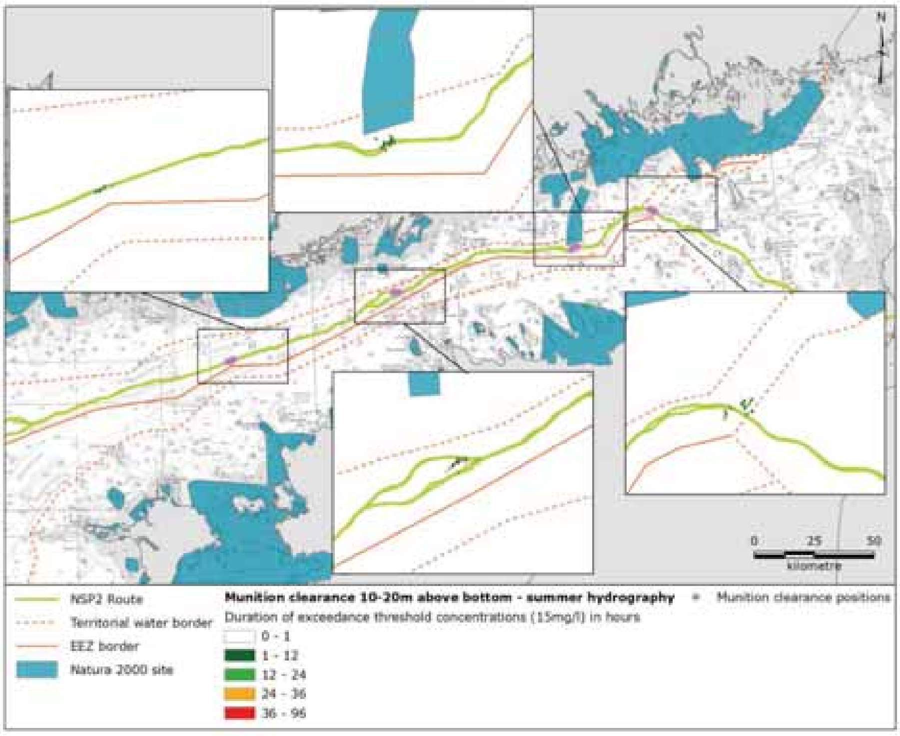


Figure 5-46 Duration of exceeding 15 mg/l for munitions clearance under typical summer conditions. 10m-20m above the seabed.

Figure 5-47 shows the duration for which the concentration threshold of 15 mg/l is exceeded during the munitions clearance operations under typical winter conditions in the lower 10m of the water column. The largest value observed is 5 hours. Figure 5-48 shows the highest exceedance of 15mg/l observed during munitions clearance operations under winter conditions between 10m and 20m above the seabed. The largest value observed is five hours.

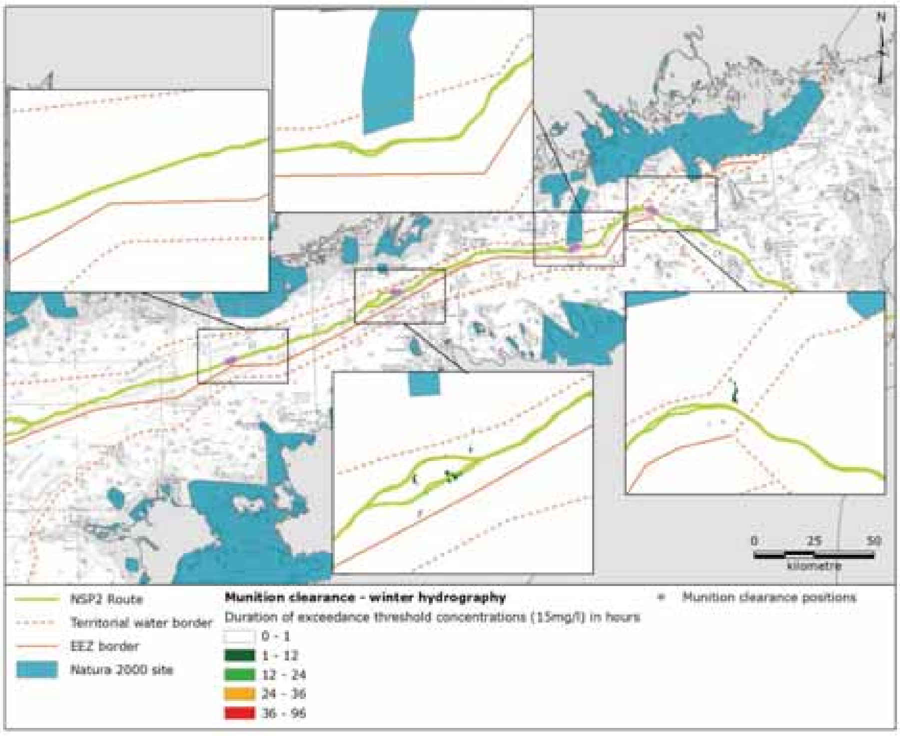


Figure 5-47 **Duration of exceeding 15 mg/l for munitions clearance under typical winter conditions. 0m-10m above the seabed.**

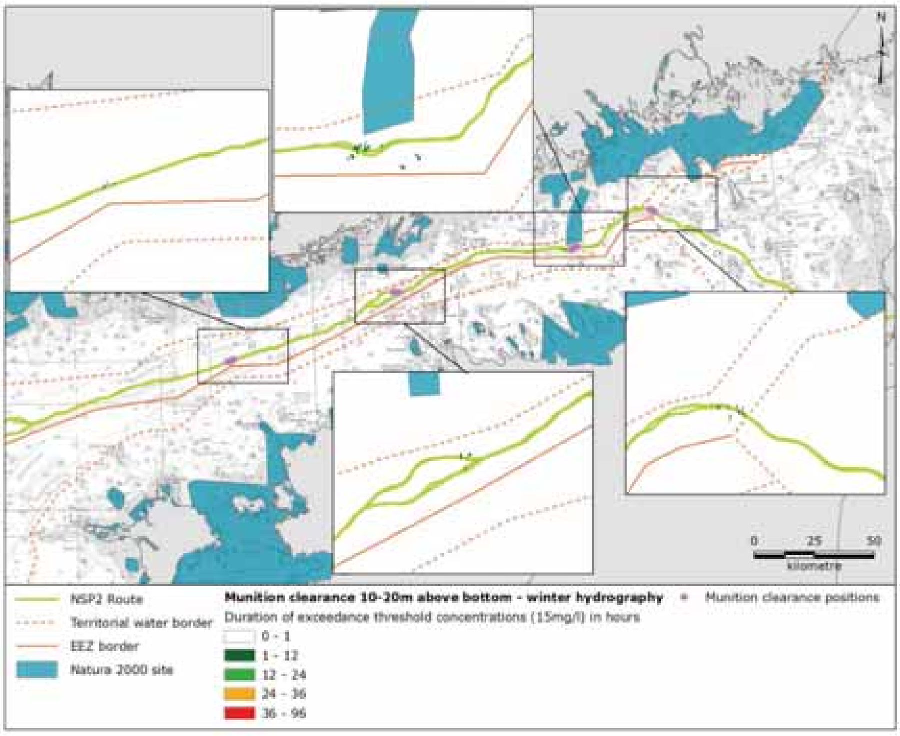


Figure 5-48 **Duration of exceeding 15 mg/l for munitions clearance under typical winter conditions. 10m-20m above the seabed.**

Figure 5-50 shows the sedimentation at the last time step of the simulation under typical summer conditions.

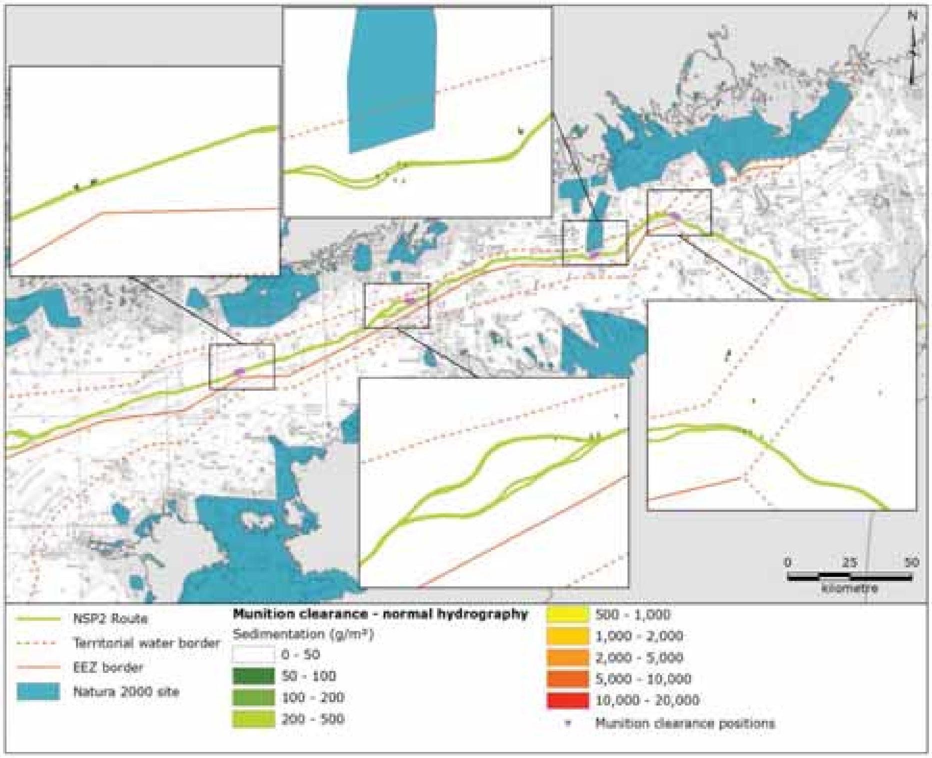


Figure 5-49 Sedimentation of released material due to munitions clearance under annual/normal hydrographic conditions.

Figure 5-49 shows the sedimentation at the last time step of the simulation under normal conditions.

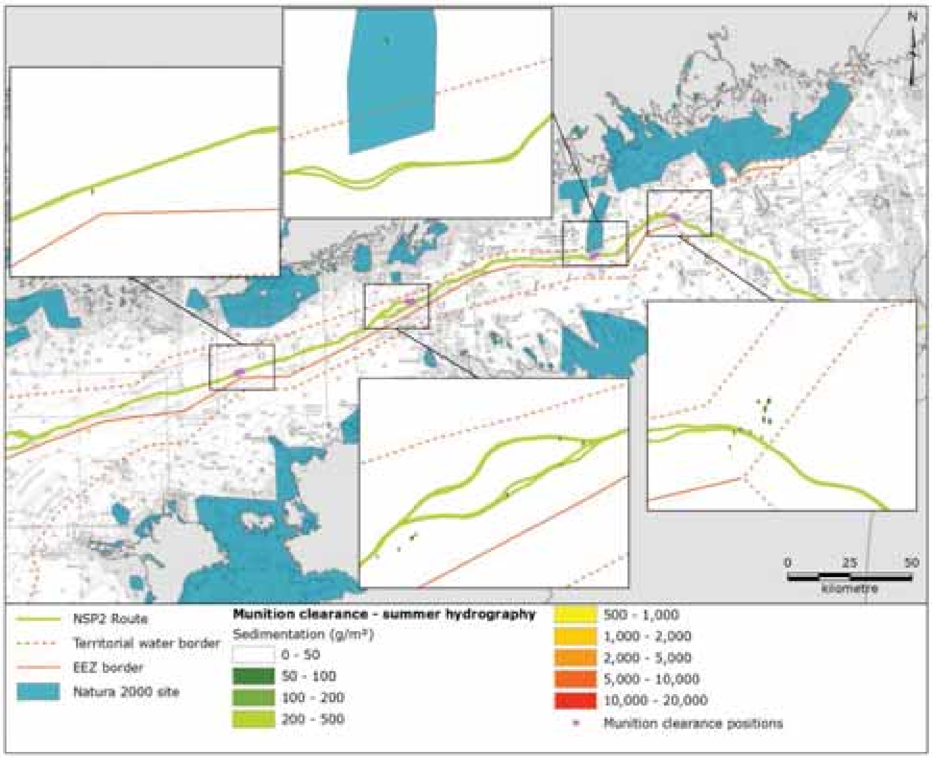


Figure 5-50 Sedimentation of released material due to munitions clearance under typical summer conditions.

Figure 5-51 shows the sedimentation at the last time step of the simulation under typical winter conditions.

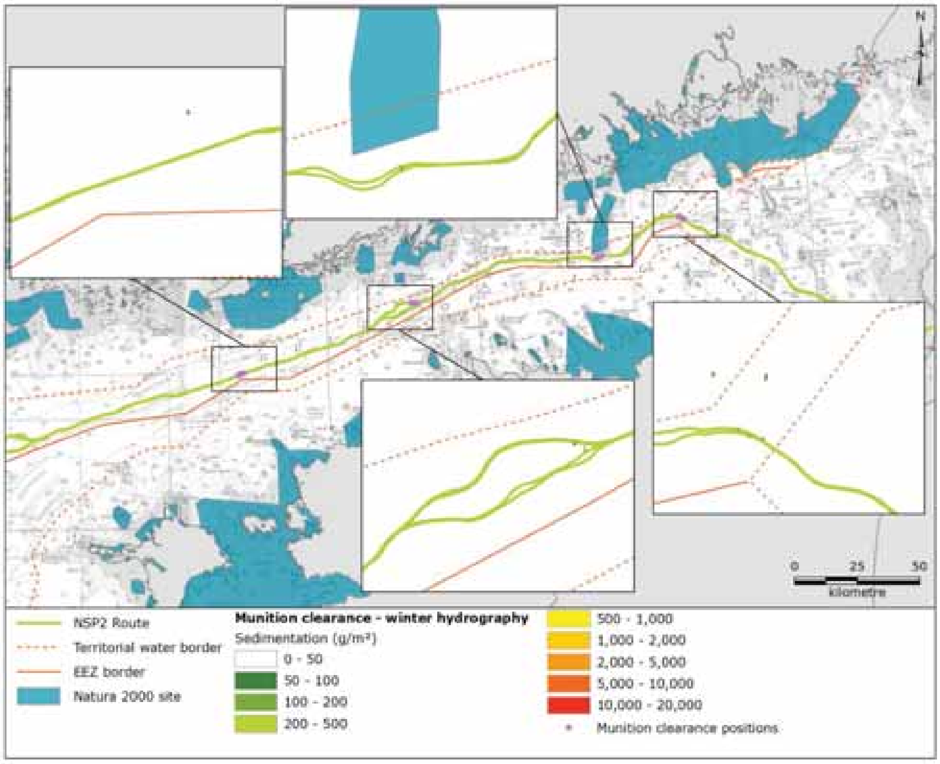


Figure 5-51 Sedimentation of released material due to munitions clearance under typical winter conditions.

5.3 Summary of results

This section presents a summary of the modelling results for rock placement and munitions clearance simulations. The summary contains:

- Areas where concentrations of 2 mg/l, 10 mg/l and 15 mg/l are exceeded
- Maximum duration of exceedance of 2 mg/l (plus 10 mg/l and 15 mg/l for munitions clearance)
- Areas where sedimentation of 10, 50, 100, 150, 200 g/m^2 are exceeded
- Maximum concentration (mg/l) at specific distances from the pipelines.
- Maximum sedimentation (g/m^2) at specific distances from the pipelines

The values presented are overall maximum values covering all three hydrographic scenarios – normal, summer and winter. This means that for each item the largest value of the three scenarios has been used. The corresponding tables for the individual hydrographic scenarios are presented in Appendix 1.

Table 5-2 Maximum areas where threshold concentrations are exceeded.

Seabed intervention works – maximum of hydrographic scenarios	Suspended sediment	Area with concentration		
		> 2 mg/l	> 10 mg/l	> 15 mg/l
	tonnes	km^2	km^2	km^2
Rock placement – Line A	2593	267	6.00	1.67
Rock placement – Line A Alternative route[1]	2848	353	9.46	3.01
Munitions clearance (0-10m)	1030	258	46.1	27.8
Munitions clearance (10-20m)	1030	77.8	31.3	21.9

[1]: Line A Alternative route has only been run for the winter scenario, while the others have been run for normal, winter and summer. See individual scenarios in Appendix 1.

The smallest grid size (modelling setup) has an area of 0.0195 km^2

Table 5-3 Highest maximum duration of exceeding threshold concentrations.

Seabed intervention works – maximum of hydrographic scenarios	Suspended sediment	Max duration with concentration		
		> 2 mg/l	> 10 mg/l	> 15 mg/l
	tonnes	hours	hours	hours
Rock placement – Line A	2593	163	18	7.5
Rock placement – Line A Alternative route[1]	2848	32	7.0	1.5
Munitions clearance (0-10m)	1030	24	13	10
Munitions clearance (10-20m)	1030	21	12	11

[1]: Line A Alternative route has only been run for the winter scenario, while the others have been run for normal, winter and summer. See individual scenarios in Appendix 1.

The smallest grid size (modelling setup) has an area of 0.0195 km^2

Table 5-4 Maximum areas where sedimentation values are exceeded.

Seabed intervention works – maximum of hydrographic scenarios	Suspended sediment	Area with sedimentation				
		> 10 g/m²	> 50 g/m²	> 100 g/m²	> 150 g/m²	> 200 g/m²
	tonnes	km²	km²	km²	km²	km²
Rock placement – Line A	2593	63.9	3.92	0.61	0.17	0.05
Rock placement – Line A Alternative route[1]	2848	25.3	0.98	0.09	0.05	~0
Munitions clearance	1030	27.9	1.48	0.14	0.09	~0

[1]: Line A Alternative route has only been run for the winter scenario, while the others have been run for normal, winter and summer. See individual scenarios in Appendix 1.

The smallest grid size (modelling setup) has an area of 0.0195 km²

Table 5-5 Maximum concentration in highest specific distances from pipelines.

Seabed intervention works – maximum of hydrographic scenarios	Suspended sediment	Max concentration at specific distances from pipelines		
		200 m	500 m	1000 m
	tonnes	mg/l	mg/l	mg/l
Rock placement – Line A	2593	21	20	17
Rock placement – Line A Alternative route[1]	2848	14	10	10
Munitions clearance (0-10m)	1030	106	100	100
Munitions clearance (10-20m)		108	108	68

[1]: Line A Alternative route has only been run for the winter scenario, while the others have been run for normal, winter and summer. See individual scenarios in Appendix 1.

The smallest grid size (modelling setup) has an area of 0.0195 km²

6. MODEL RESULTS - CONTAMINANTS

This chapter presents the results of the modelling of released contaminants due to the seabed intervention works.

Contaminants are released to the environment when sediment is handled due to seabed intervention works. Contaminants have to be dissolved in order to pose a risk to receptors in the environment as described in /1/. Dissolved contaminants will over time be adsorbed to particles. enter the food chain or settle on the seabed and thereby leave the water column again.
The modelling study describes the acute effects and, also for precautionary reasons, the settling of contaminants is disregarded.

Contaminants are released respectively 2 m and 15 m above seabed for respectively rock placement and munitions clearance. The contaminants will disperse over the water column and as mentioned above contaminants are neither decaying nor settling in the model. Contaminants could therefore be distributed over the entire water column, a part of the water column or it will be embedded at a certain level depending on the stratification. As a conservative assumption the model results are interpreted as the mass of contaminants over the entire water column, concentrated in a 10 m layer.

The results are presented as two-dimensional maps. The maps show the following parameters:

- The maximum concentration of contaminants occurring under the entire simulation period.
- Duration of exceedance of PNEC for PAH, Dioxin and Zinc. This is the accumulated period of time in hours during which the concentration of contaminants exceeds PNEC during rock placement or munitions clearance.

The results for release of contaminants are presented in the following sections. The figures presenting the results are summarised in Table 6-1.

Table 6-1 Overview of modelling results for release of contaminants.

	Seabed intervention work Contaminants	Annual / normal	Summer	Winter
Rock placement (Line A)	Maximum concentration of Benzo(a)pyrene (PAH)	Figure 6-9 Figure 6-10	Figure 6-5 Figure 6-6	Figure 6-1 Figure 6-2
	Duration of exceeding PNEC for Benzo(a)pyrene (PAH)	Figure 6-11 Figure 6-12	Figure 6-7 Figure 6-8	Figure 6-3 Figure 6-4
	Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans)	Figure 6-17 Figure 6-18	Figure 6-15 Figure 6-16	Figure 6-13 Figure 6-14
	Duration of exceeding PNEC for WHO (2005) PCDD/F TEQ upper (Dioxin/Furans)	No concentrations above PNEC anywhere in the domain	No concentrations above PNEC anywhere in the domain	No concentrations above PNEC anywhere in the domain
	Maximum concentration of Zinc	Figure 6-23 Figure 6-24	Figure 6-21 Figure 6-22	Figure 6-19 Figure 6-20
	Duration of exceeding PNEC for Zinc	No concentrations above PNEC anywhere in the domain	No concentrations above PNEC anywhere in the domain	No concentrations above PNEC anywhere in the domain
Munitions clearance	Maximum concentration of Benzo(a)pyrene (PAH)	Figure 6-31 Figure 6-32	Figure 6-28 Figure 6-29	Figure 6-25 Figure 6-26
	Duration of exceeding PNEC for Benzo(a)pyrene (PAH)	Figure 6-33	Figure 6-30	Figure 6-27
	Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans)	Figure 6-38 Figure 6-39	Figure 6-36 Figure 6-37	Figure 6-34 Figure 6-35
	Duration of exceeding PNEC for WHO (2005) PCDD/F TEQ upper (Dioxin/Furans)	PNEC is only exceeded in a very small area	PNEC is only exceeded in a very small area	PNEC is only exceeded in a very small area
	Maximum concentration of Zinc	Figure 6-44 Figure 6-45	Figure 6-42 Figure 6-43	Figure 6-40 Figure 6-41
	Duration of exceeding PNEC for Zinc	PNEC is only exceeded in a very small area	PNEC is only exceeded in a very small area	PNEC is only exceeded in a very small area

6.1 Rock placement

6.1.1 PAH

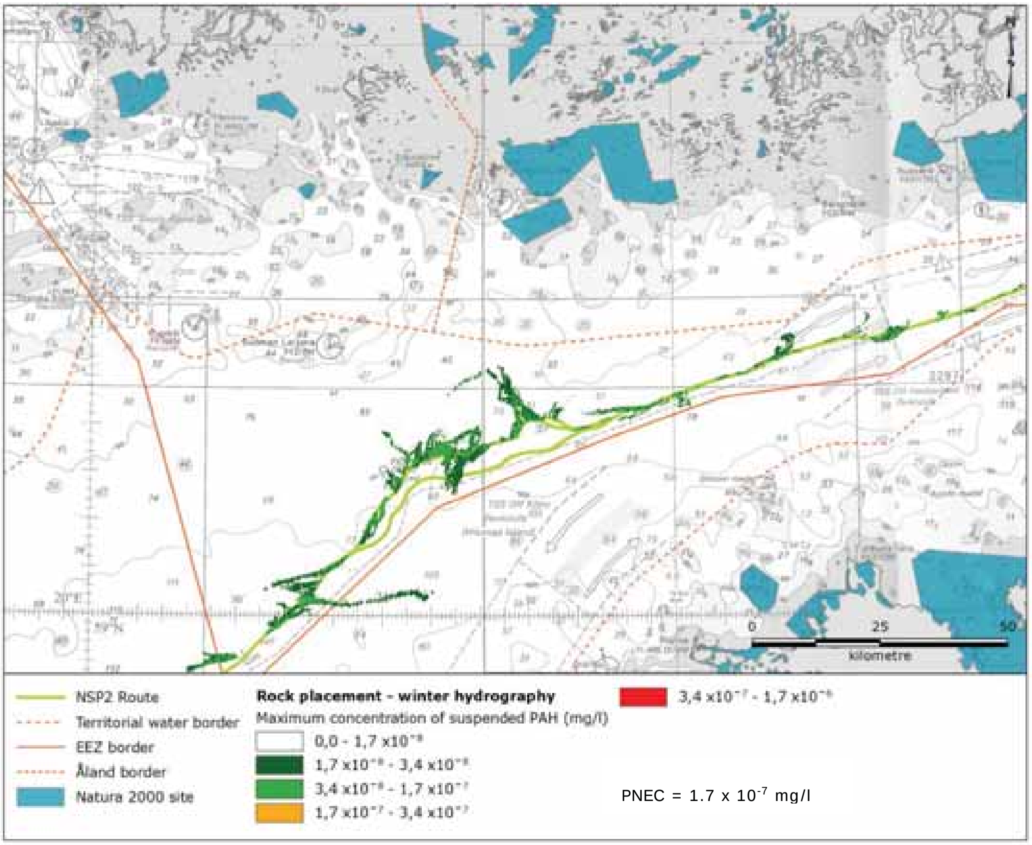


Figure 6-1 **Maximum concentration of Benzo(a)pyrene (PAH) during rock placement under typical winter conditions. Western part of the Gulf of Finland.**

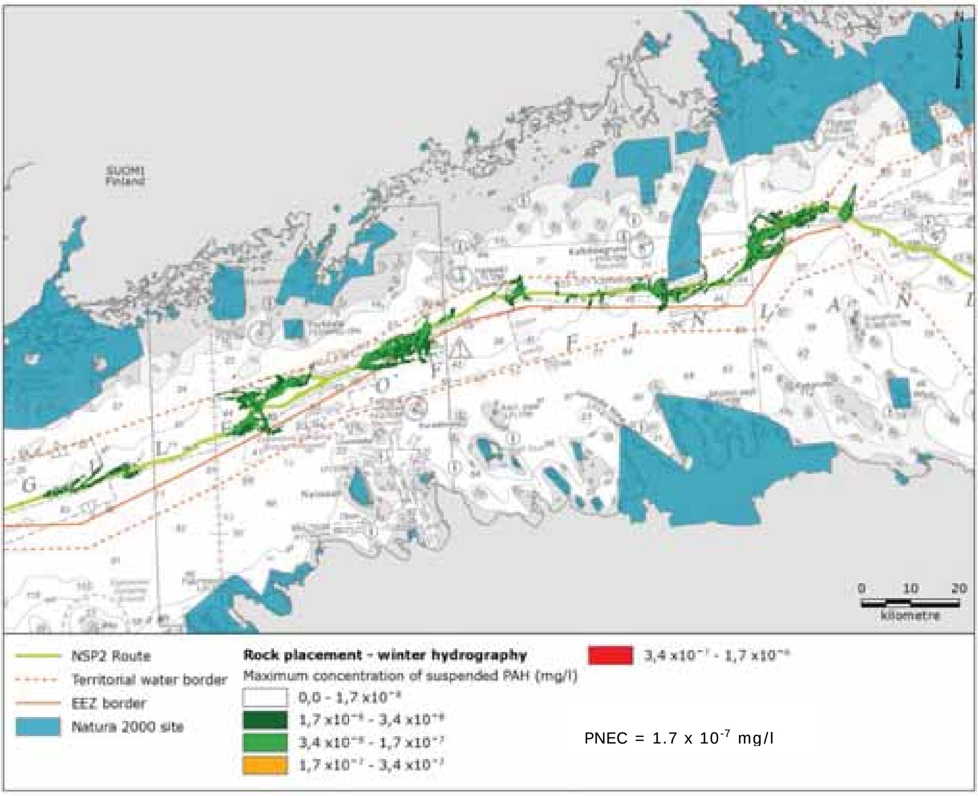


Figure 6-2 **Maximum concentration of Benzo(a)pyrene (PAH) during rock placement under typical winter conditions. Eastern part of the Gulf of Finland.**

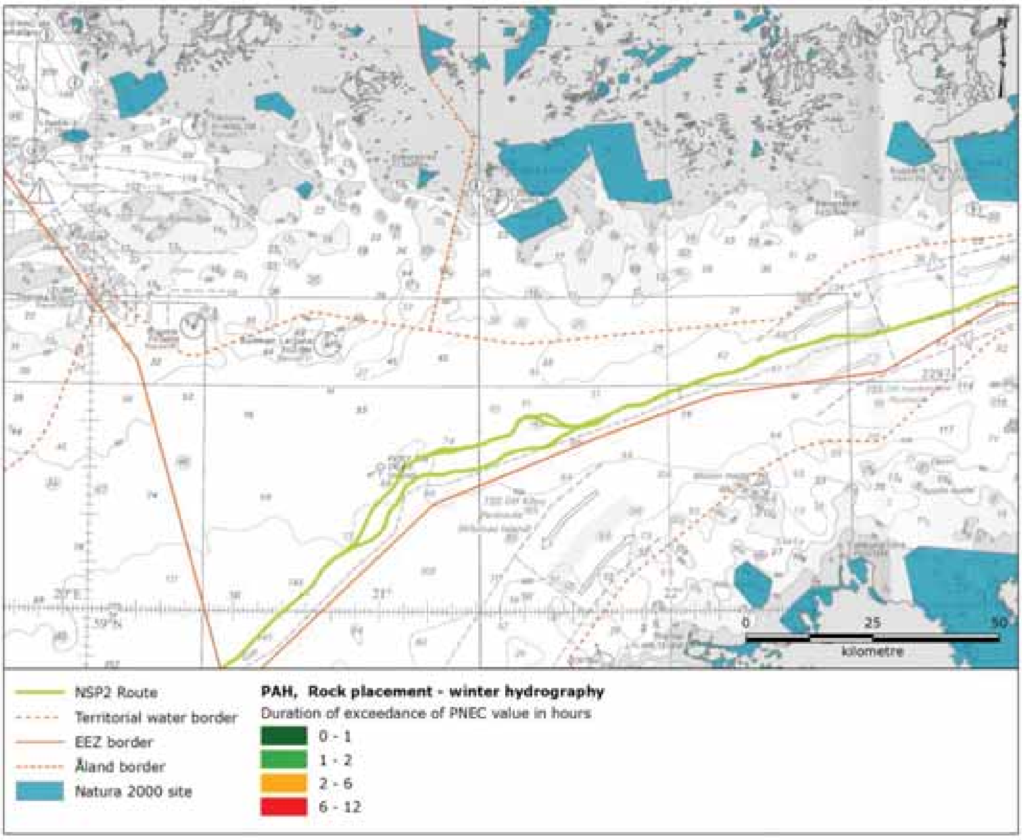


Figure 6-3 **Duration of exceeding of PNEC for Benzo(a)pyrene during rock placement under typical winter conditions. Western part of the Gulf of Finland.**

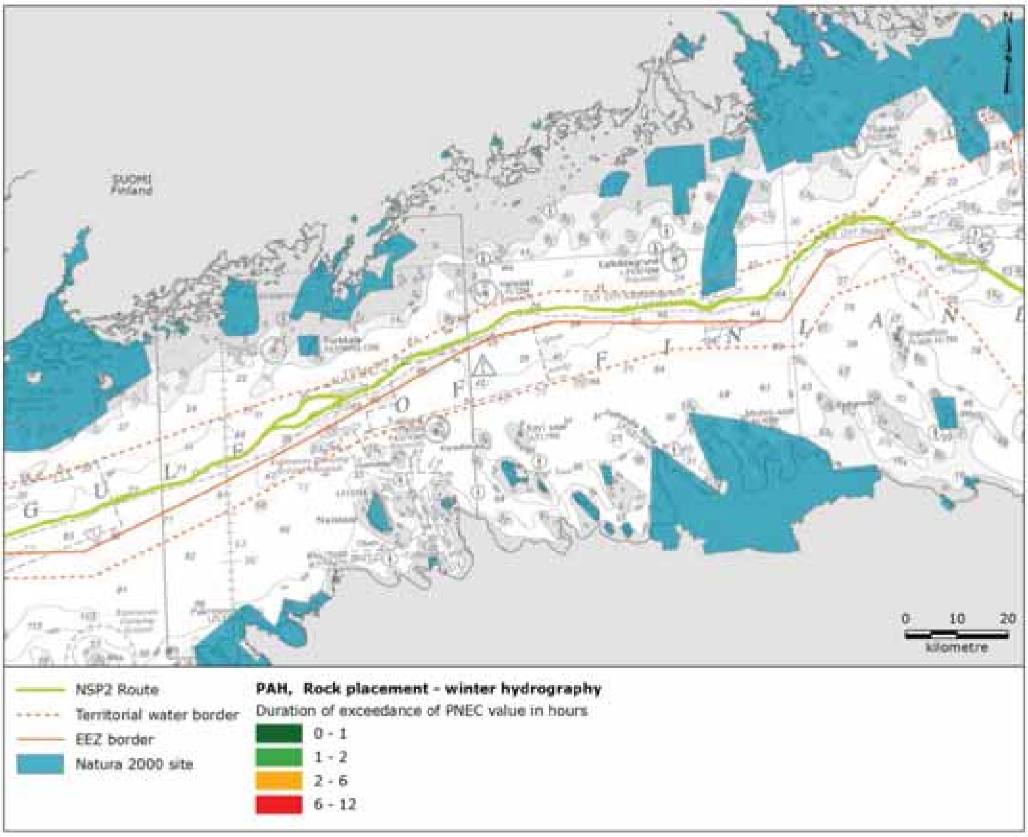


Figure 6-4 **Duration of exceeding of PNEC for Benzo(a)pyrene during rock placement under typical winter conditions. Eastern part of the Gulf of Finland.**

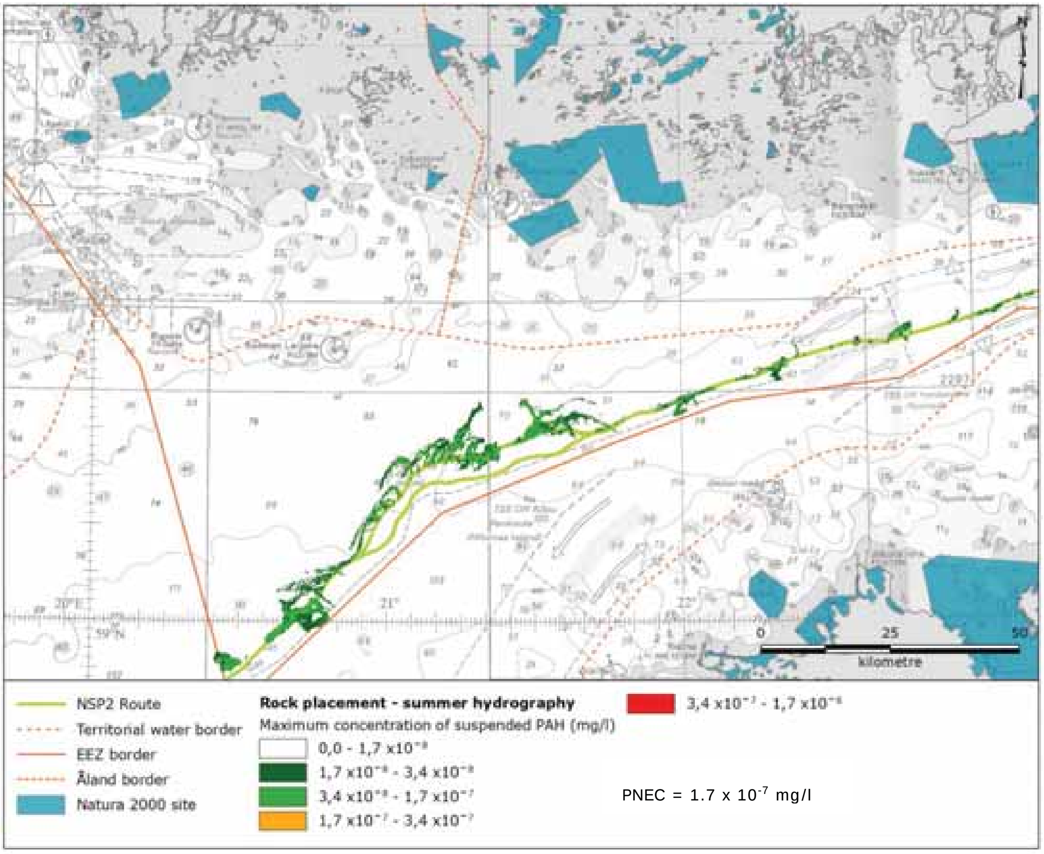


Figure 6-5 Maximum concentration of Benzo(a)pyrene (PAH) during rock placement under typical summer conditions. Western part of the Gulf of Finland.

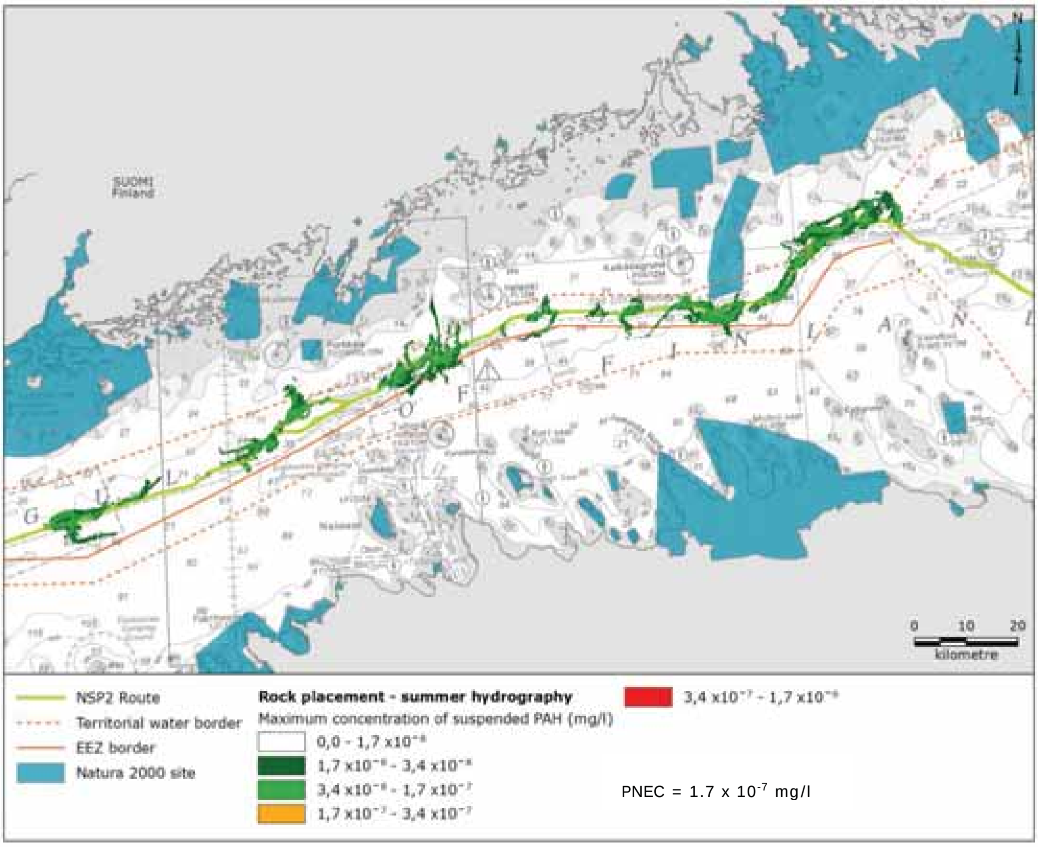


Figure 6-6 Maximum concentration of Benzo(a)pyrene (PAH) during rock placement under typical summer conditions. Eastern part of the Gulf of Finland.

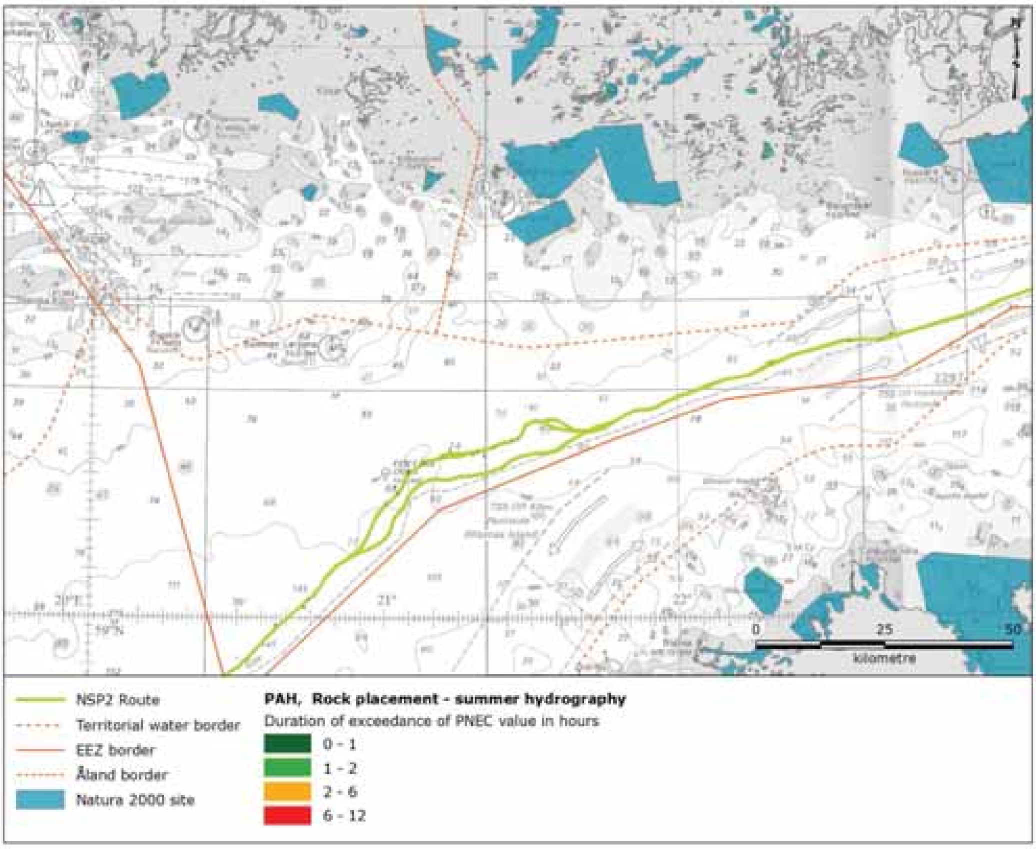


Figure 6-7 Duration of exceeding of PNEC for Benzo(a)pyrene during rock placement under typical summer conditions. Western part of the Gulf of Finland.

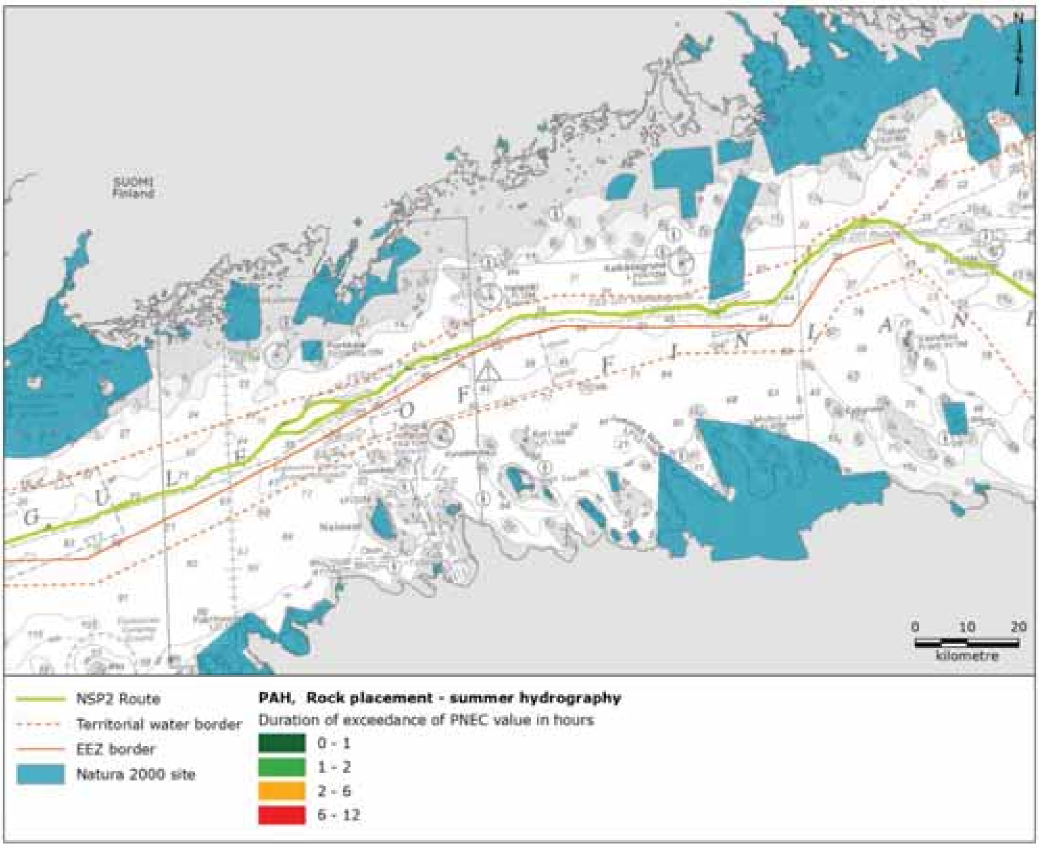


Figure 6-8 Duration of exceeding of PNEC for Benzo(a)pyrene during rock placement under typical summer conditions. Eastern part of the Gulf of Finland.

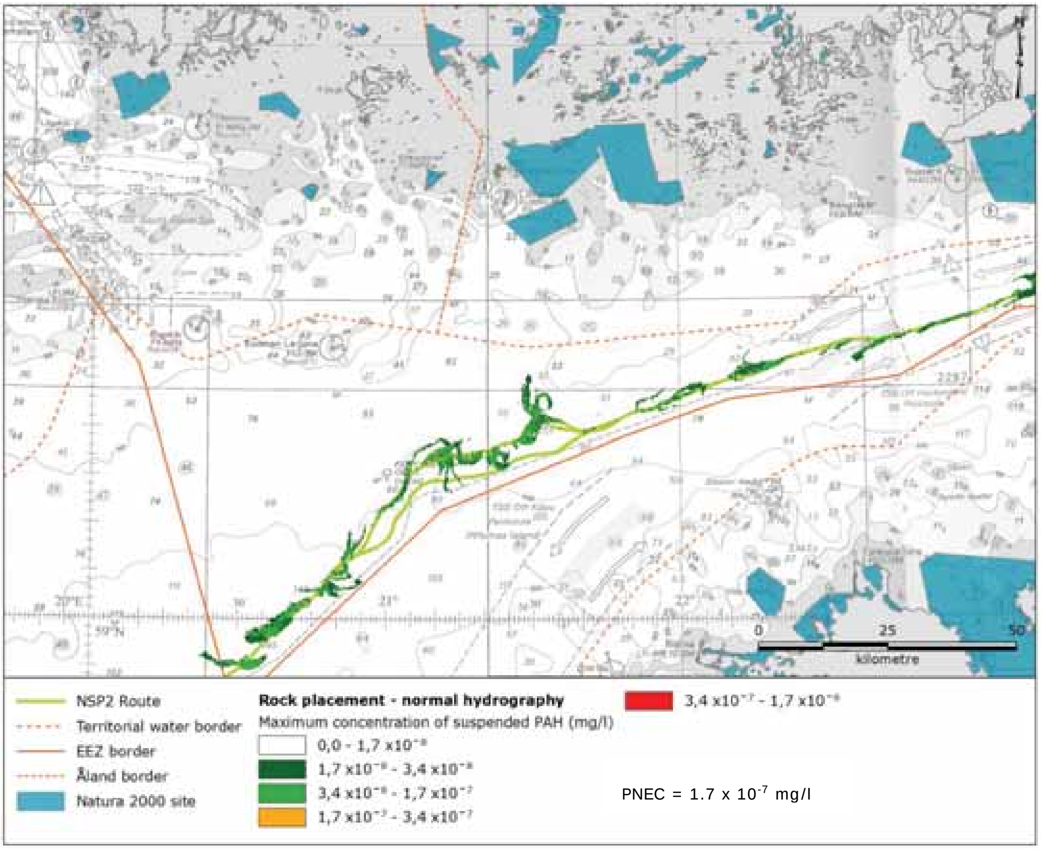


Figure 6-9 **Maximum concentration of Benzo(a)pyrene (PAH) during rock placement under normal conditions. Western part of the Gulf of Finland.**

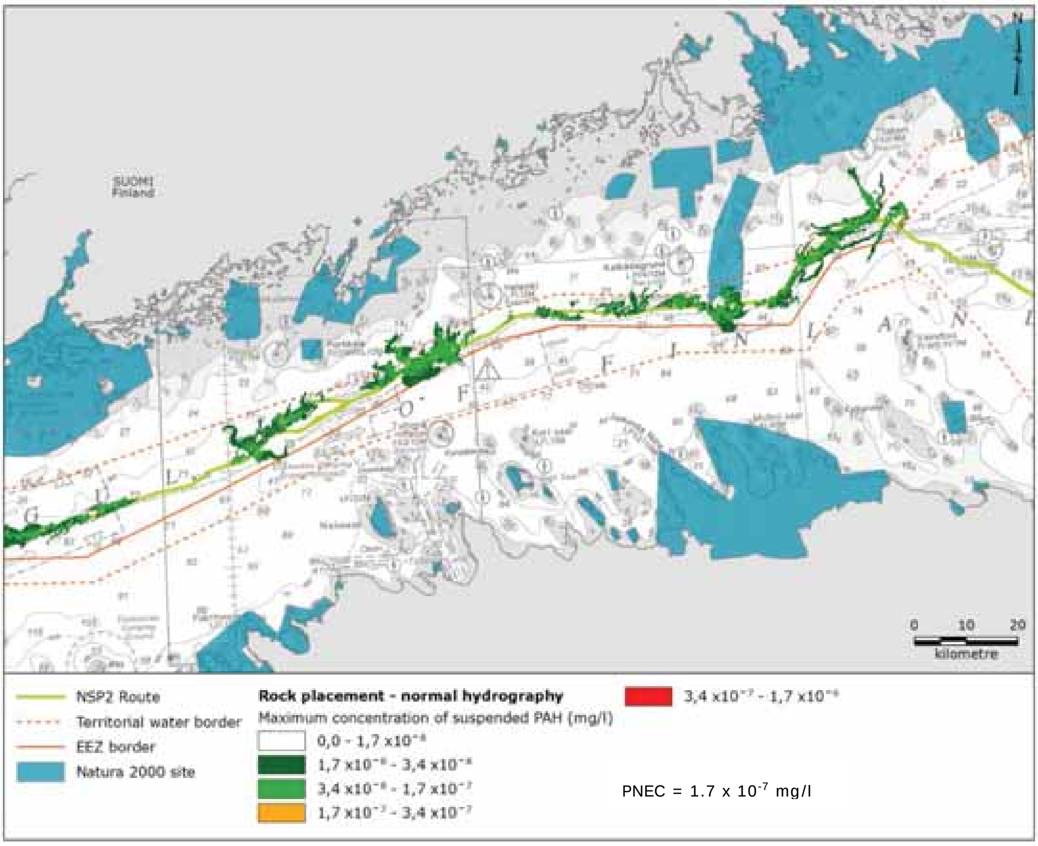


Figure 6-10 **Maximum concentration of Benzo(a)pyrene (PAH) during rock placement under normal conditions. Eastern part of the Gulf of Finland.**

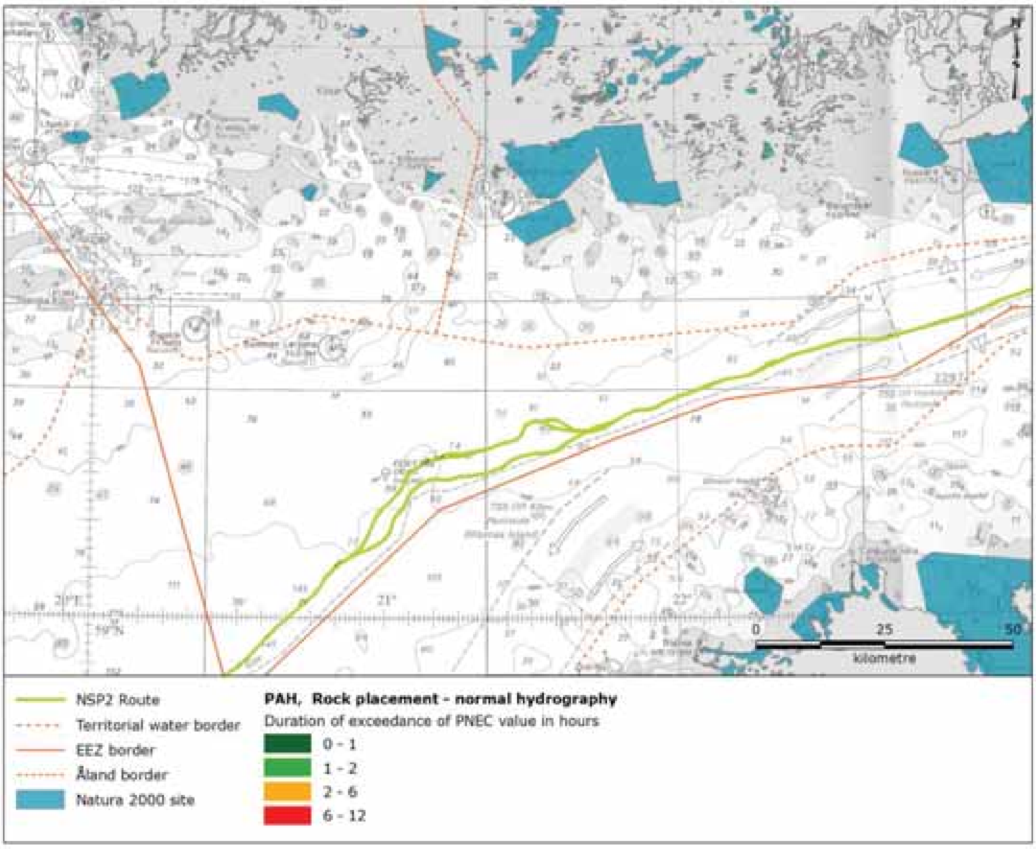


Figure 6-11 **Duration of exceeding of PNEC for Benzo(a)pyrene during rock placement under normal conditions. Western part of the Gulf of Finland.**

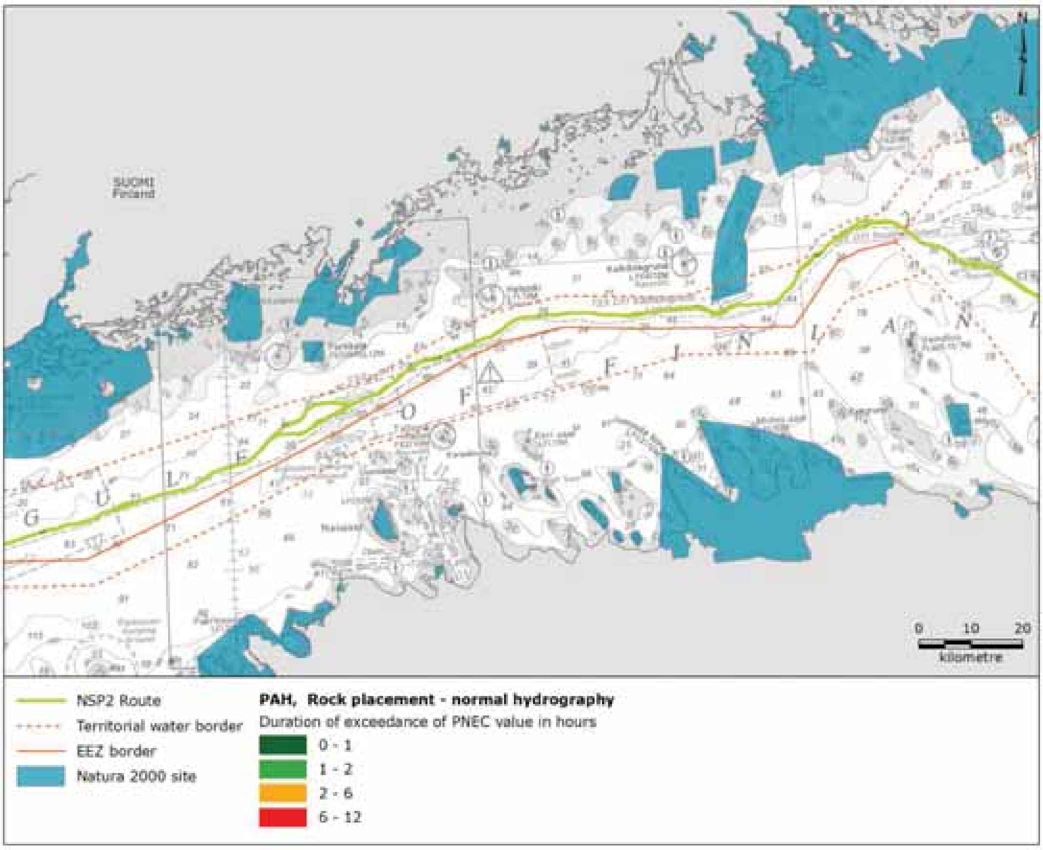


Figure 6-12 **Duration of exceeding of PNEC for Benzo(a)pyrene during rock placement under normal conditions. Eastern part of the Gulf of Finland.**

6.1.2 Dioxin

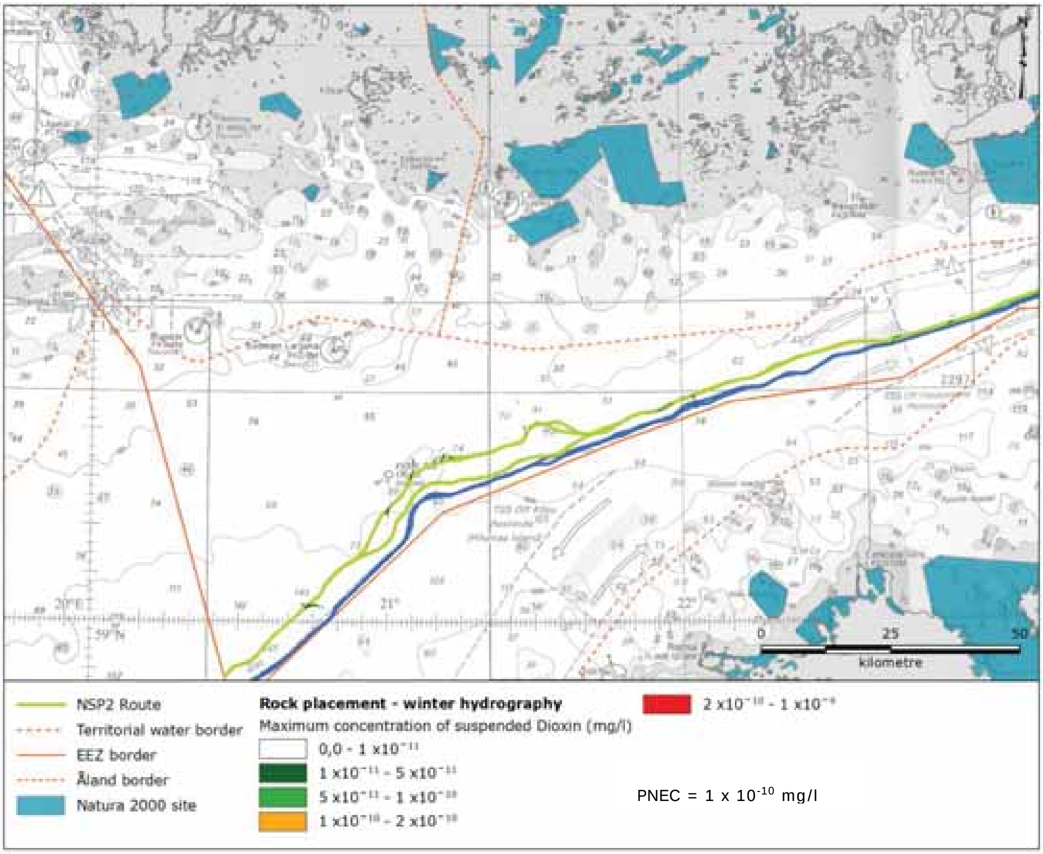


Figure 6-13 Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans) during rock placement under typical winter conditions. Western part of the Gulf of Finland.

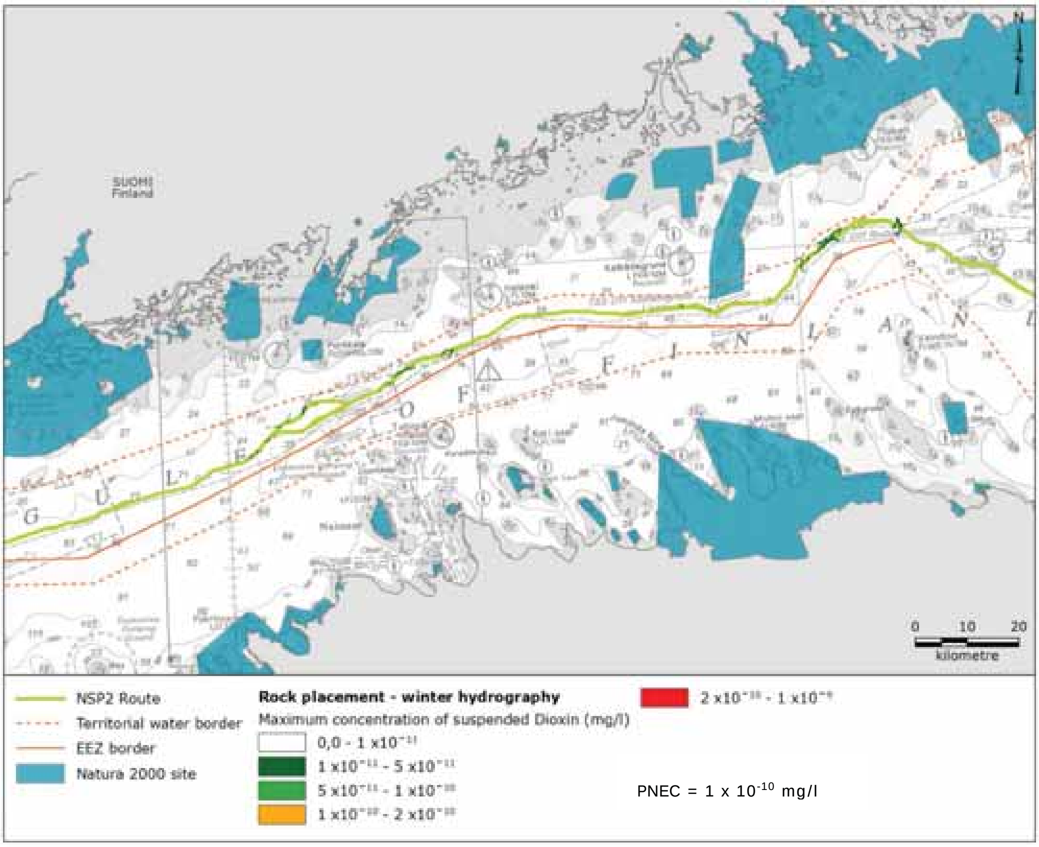


Figure 6-14 Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans) during rock placement under typical winter conditions. Eastern part of the Gulf of Finland.

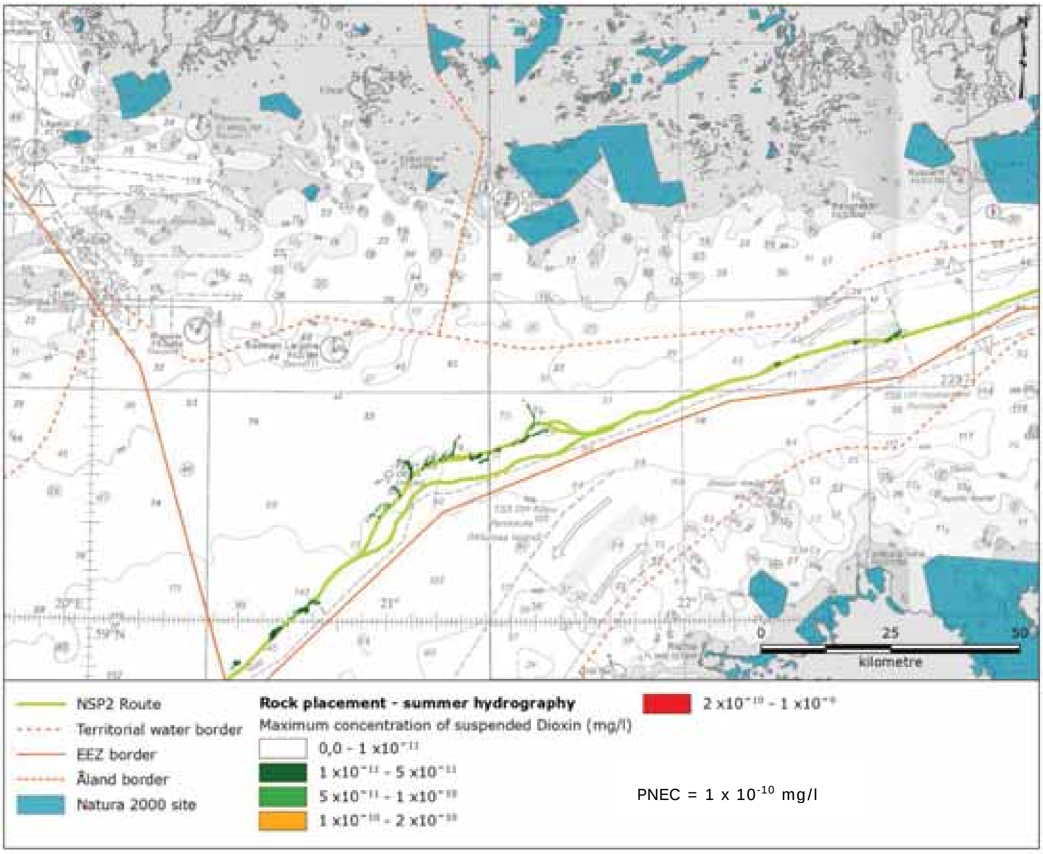


Figure 6-15 Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans) during rock placement under typical summer conditions. Western part of the Gulf of Finland.

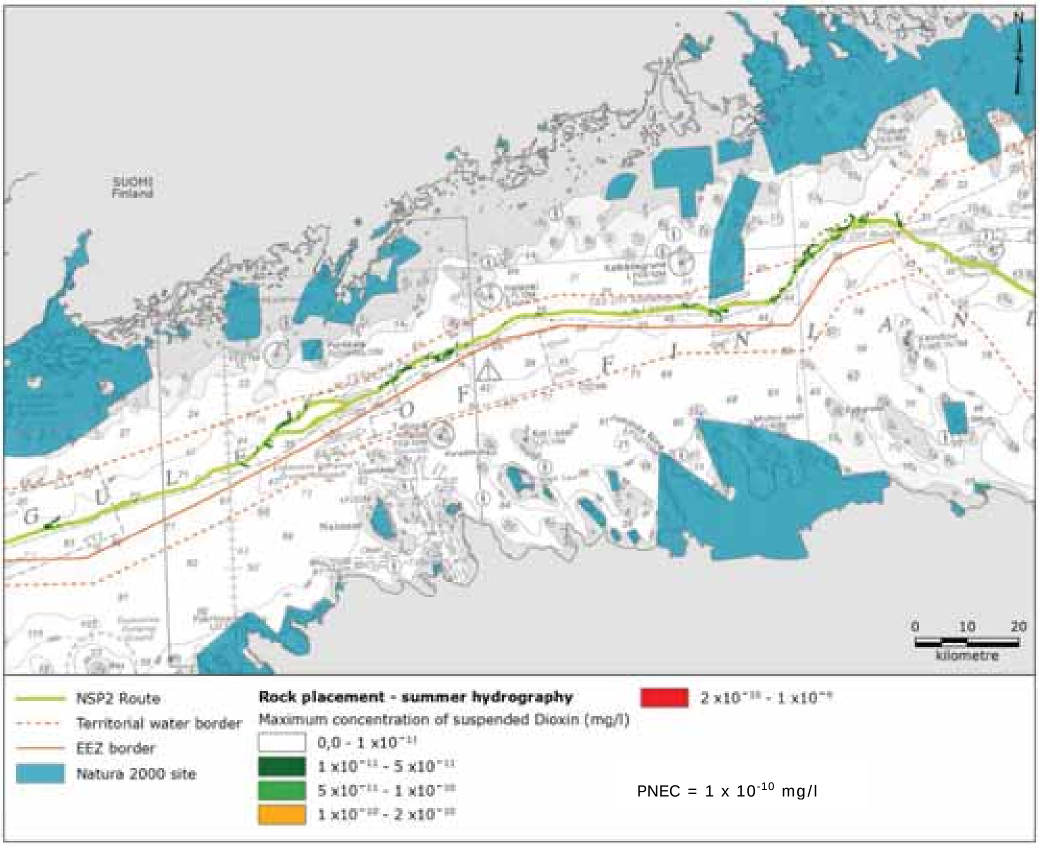


Figure 6-16 Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans) during rock placement under typical summer conditions. Eastern part of the Gulf of Finland.

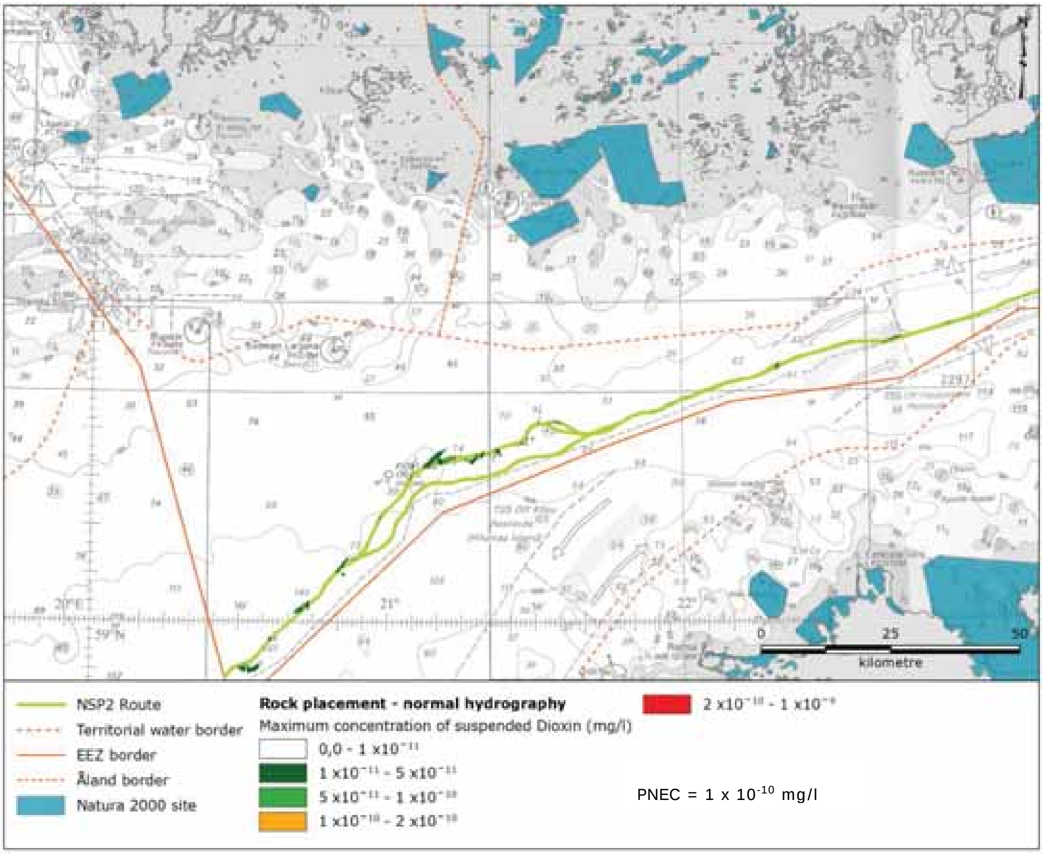


Figure 6-17 **Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans) during rock placement under normal conditions. Western part of the Gulf of Finland.**

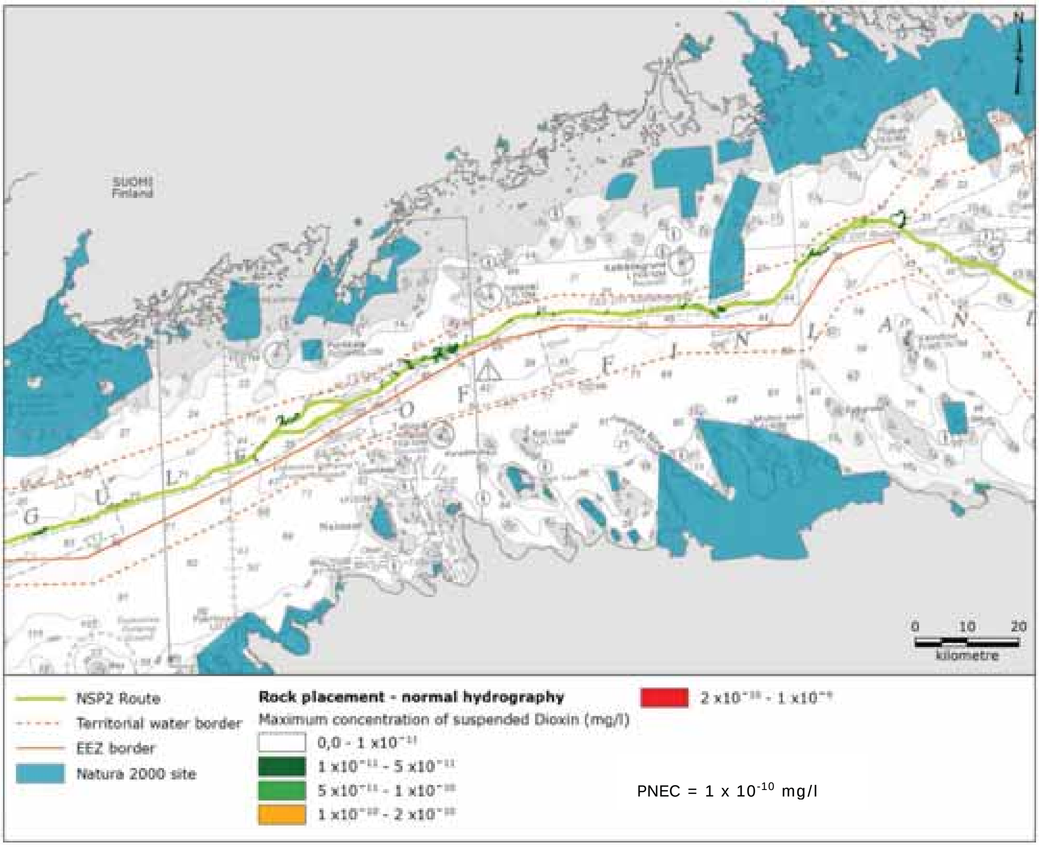


Figure 6-18 **Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans) during rock placement under normal conditions. Eastern part of the Gulf of Finland.**

6.1.3 Zinc

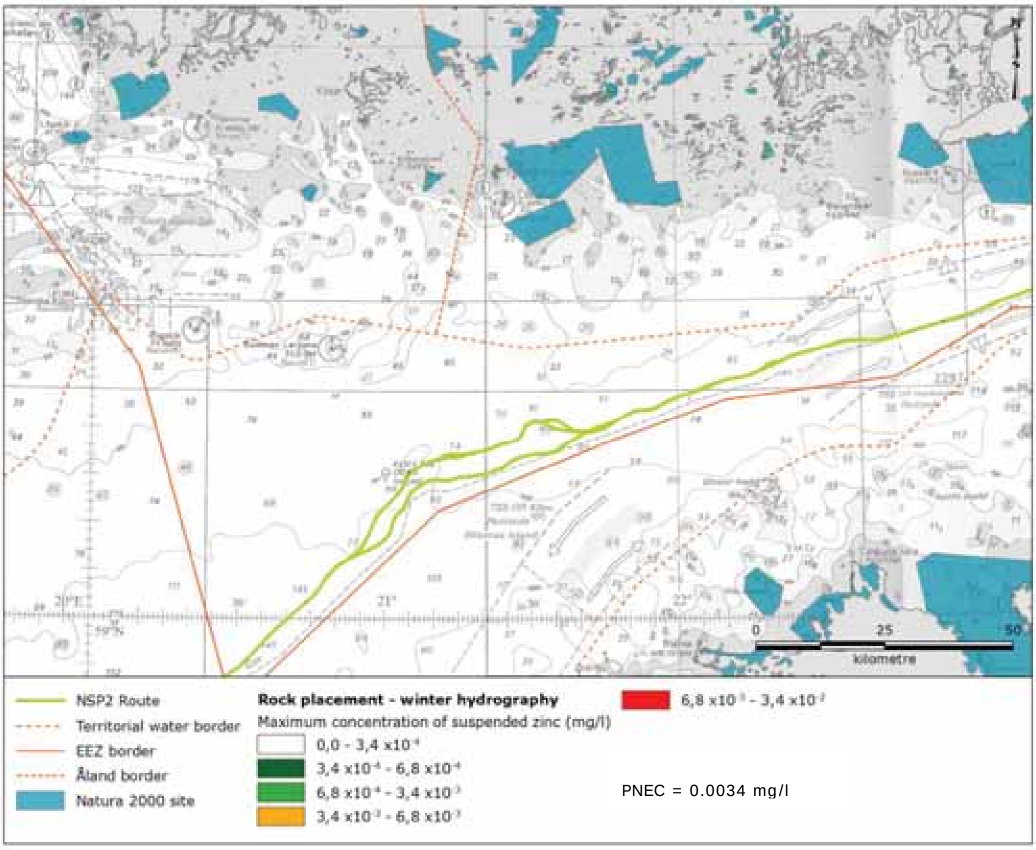


Figure 6-19 Maximum concentration of Zinc during rock placement under typical winter conditions. Western part of the Gulf of Finland.

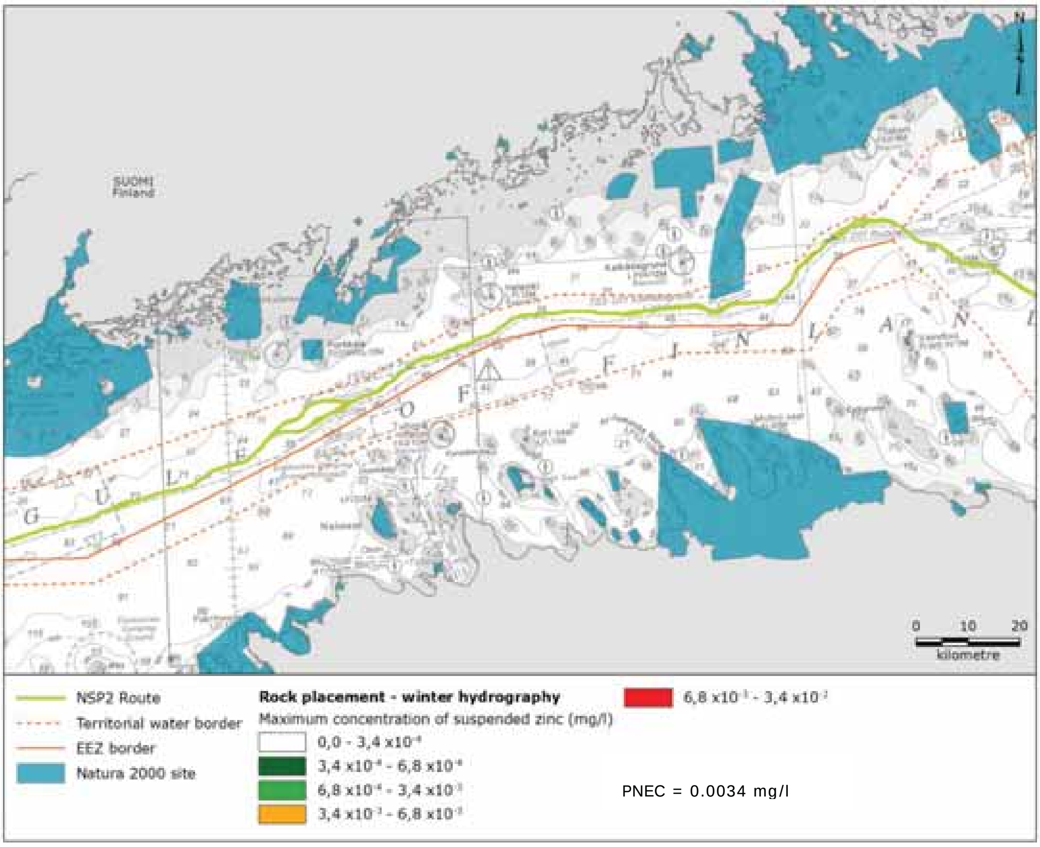


Figure 6-20 Maximum concentration of Zinc during rock placement under typical winter conditions. Eastern part of the Gulf of Finland.

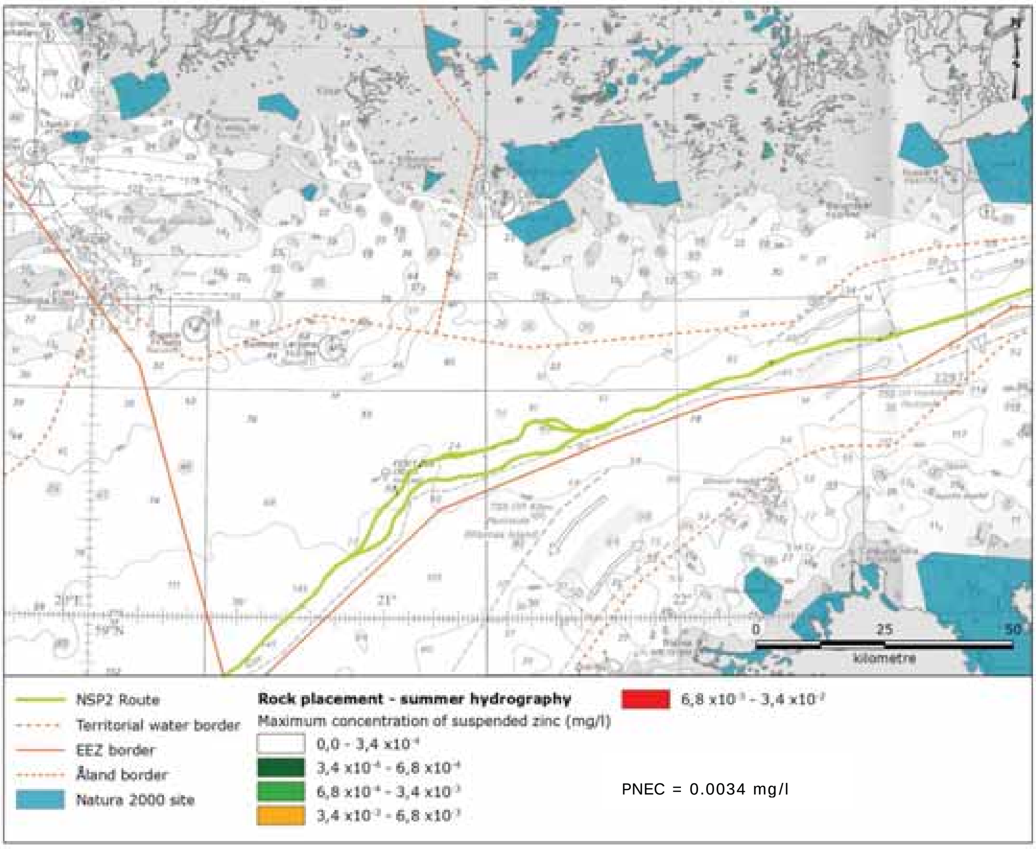


Figure 6-21 **Maximum concentration of Zinc during rock placement under typical summer conditions. Western part of the Gulf of Finland.**

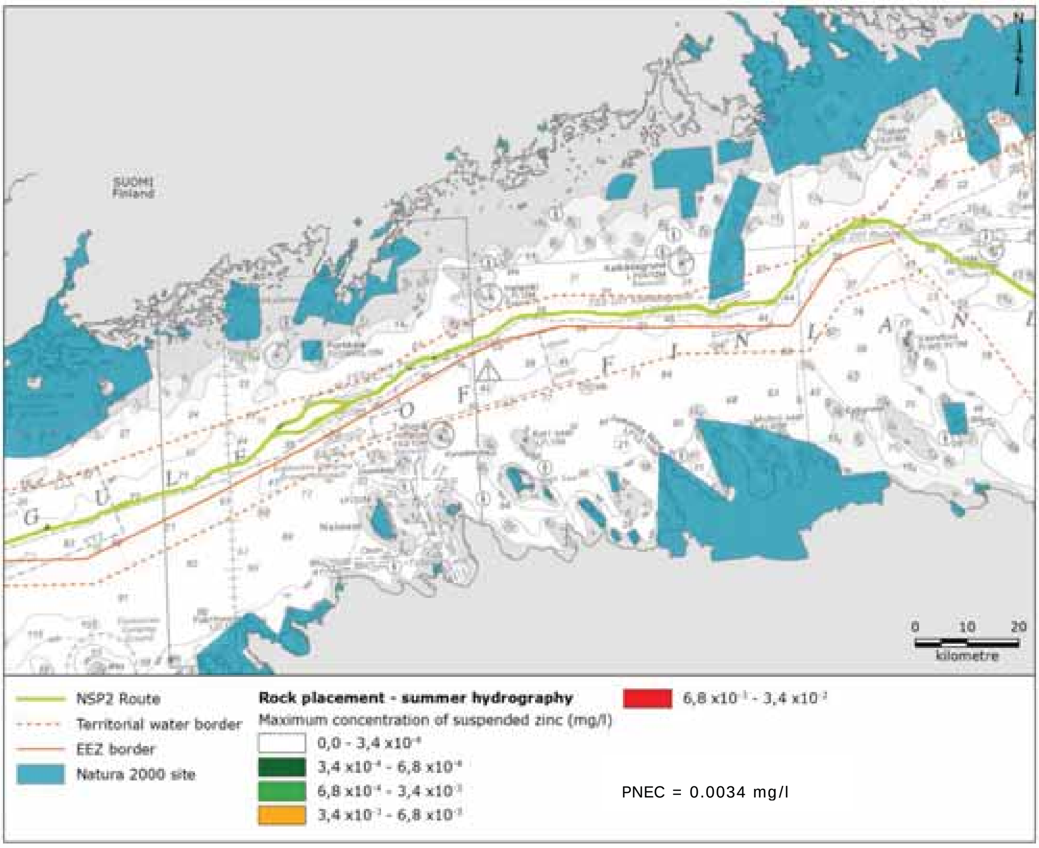


Figure 6-22 **Maximum concentration of Zinc during rock placement under typical summer conditions. Eastern part of the Gulf of Finland.**

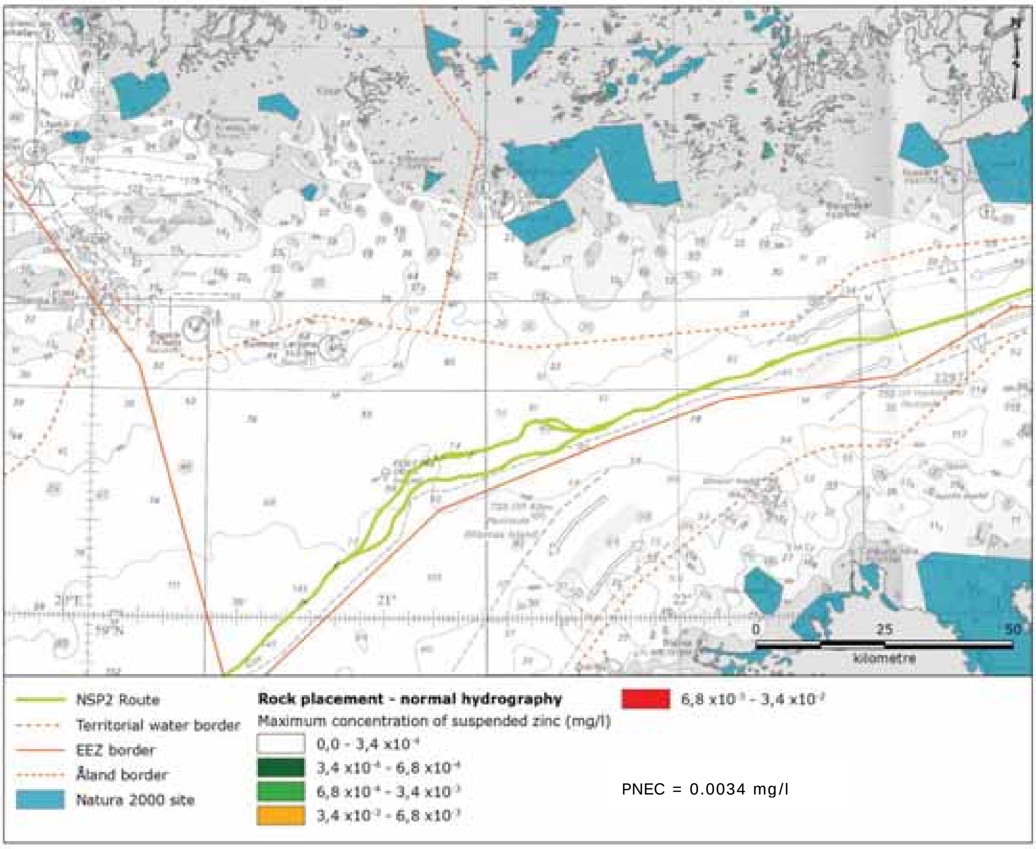


Figure 6-23 **Maximum concentration of Zinc during rock placement under normal conditions. Western part of the Gulf of Finland.**

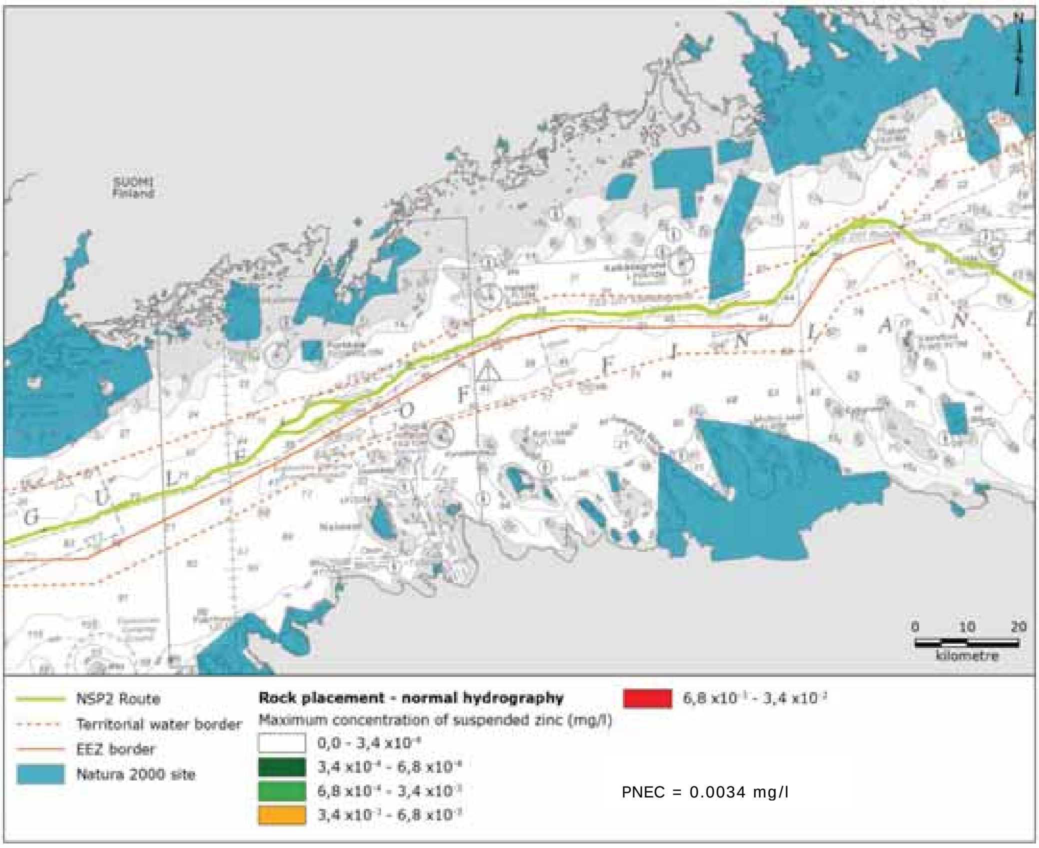


Figure 6-24 **Maximum concentration of Zinc during rock placement under normal conditions. Eastern part of the Gulf of Finland.**

6.2 Munitions clearance

6.2.1 PAH

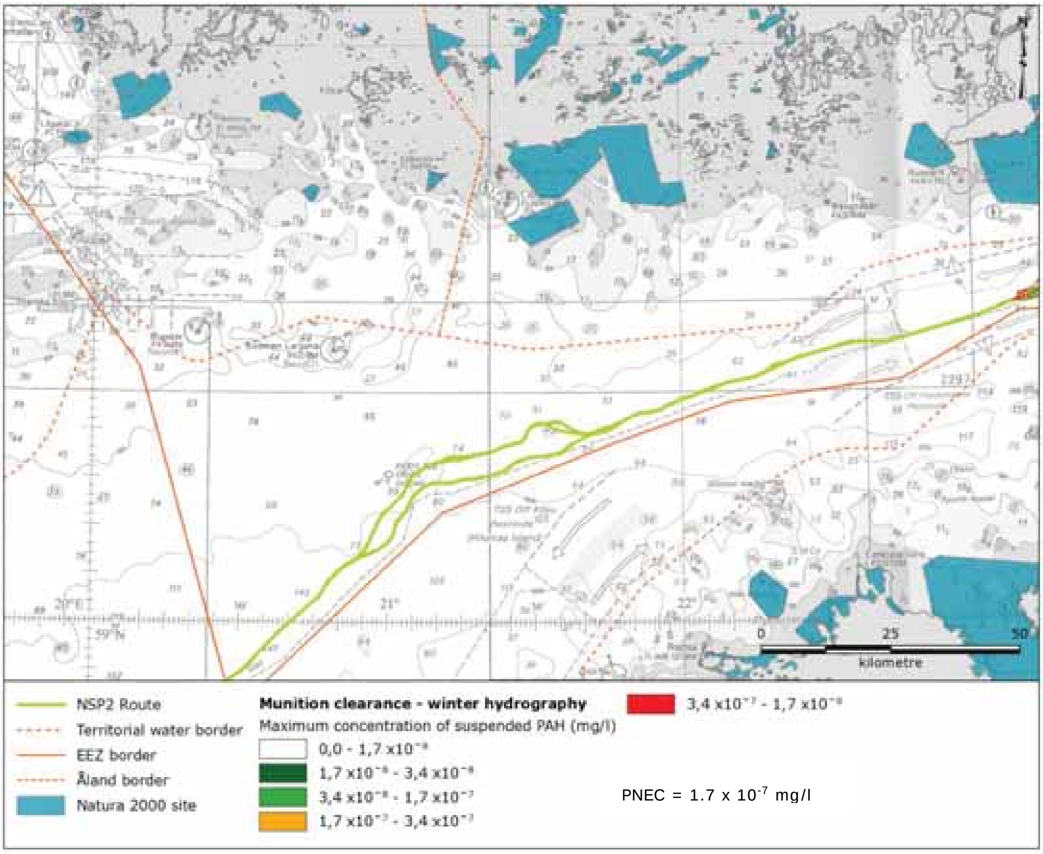


Figure 6-25 **Maximum concentration of Benzo(a)pyrene (PAH) during munitions clearance under typical winter conditions. Western part of the Gulf of Finland.**

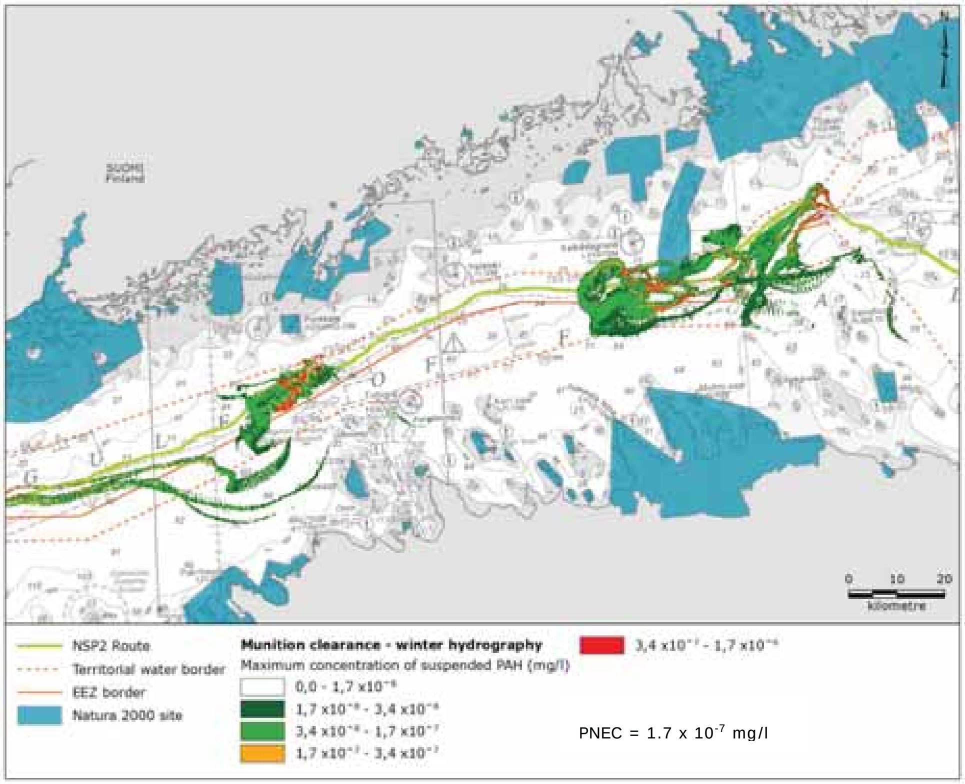


Figure 6-26 **Maximum concentration of Benzo(a)pyrene (PAH) during munitions clearance under typical winter conditions. Eastern part of the Gulf of Finland.**

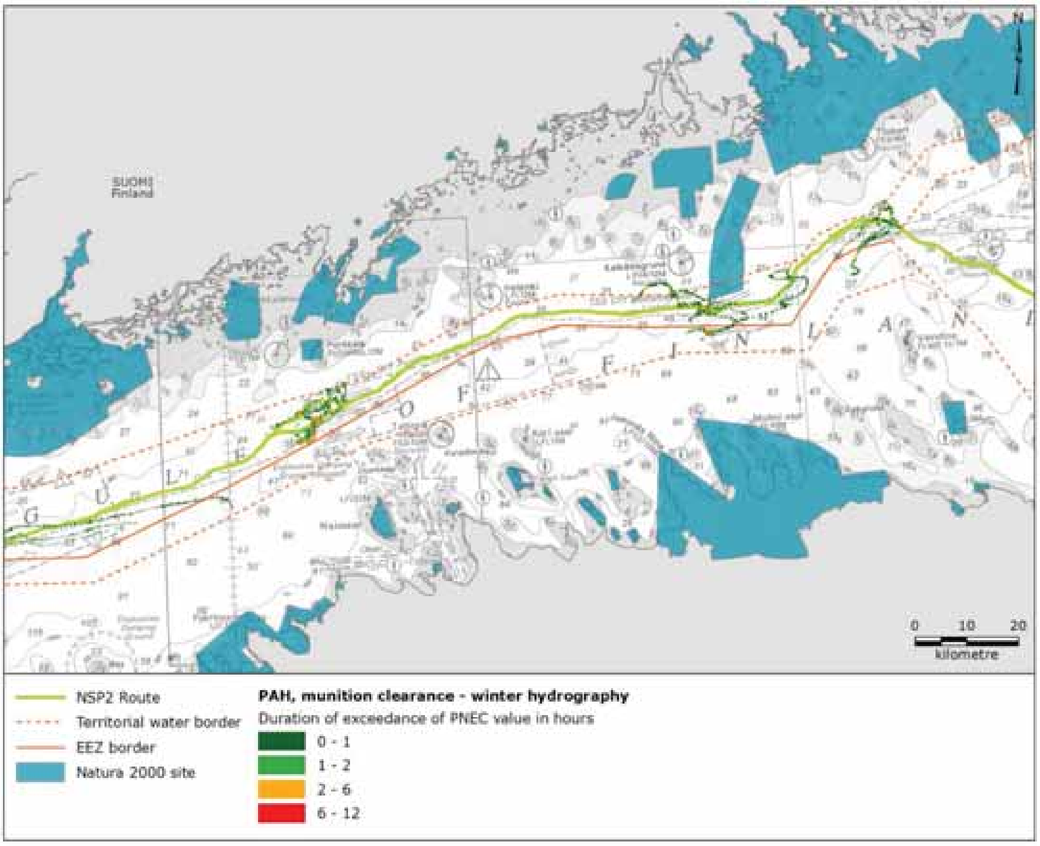


Figure 6-27 **Duration of exceeding of PNEC for Benzo(a)pyrene during munitions clearance under typical winter conditions. Eastern part of the Gulf of Finland.**

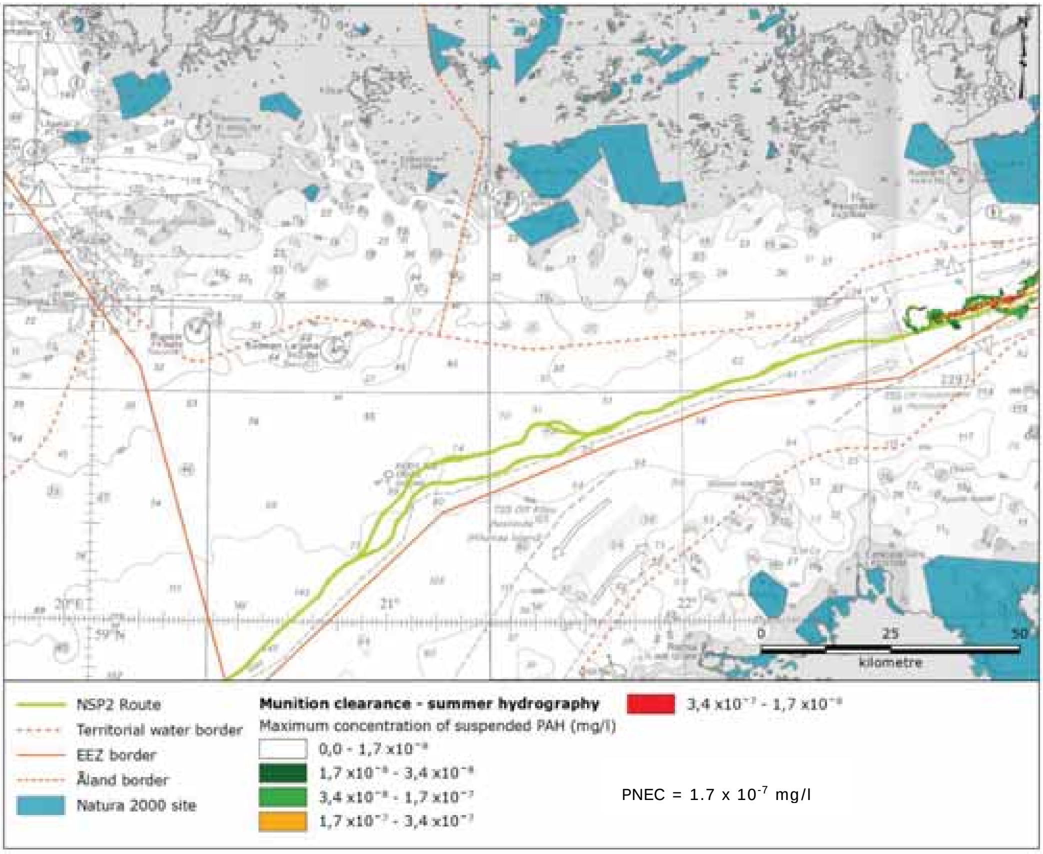


Figure 6-28 **Maximum concentration of Benzo(a)pyrene (PAH) during munitions clearance under typical summer conditions. Western part of the Gulf of Finland.**

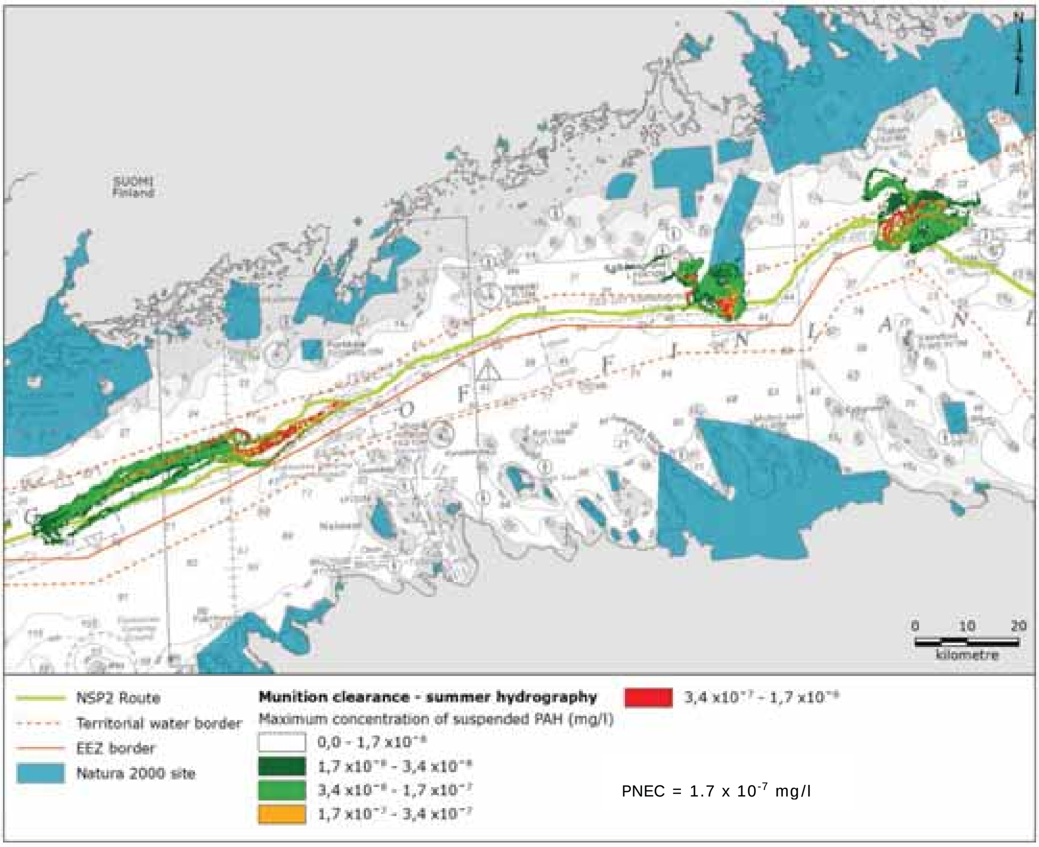


Figure 6-29 **Maximum concentration of Benzo(a)pyrene (PAH) during munitions clearance under typical summer conditions. Eastern part of the Gulf of Finland.**

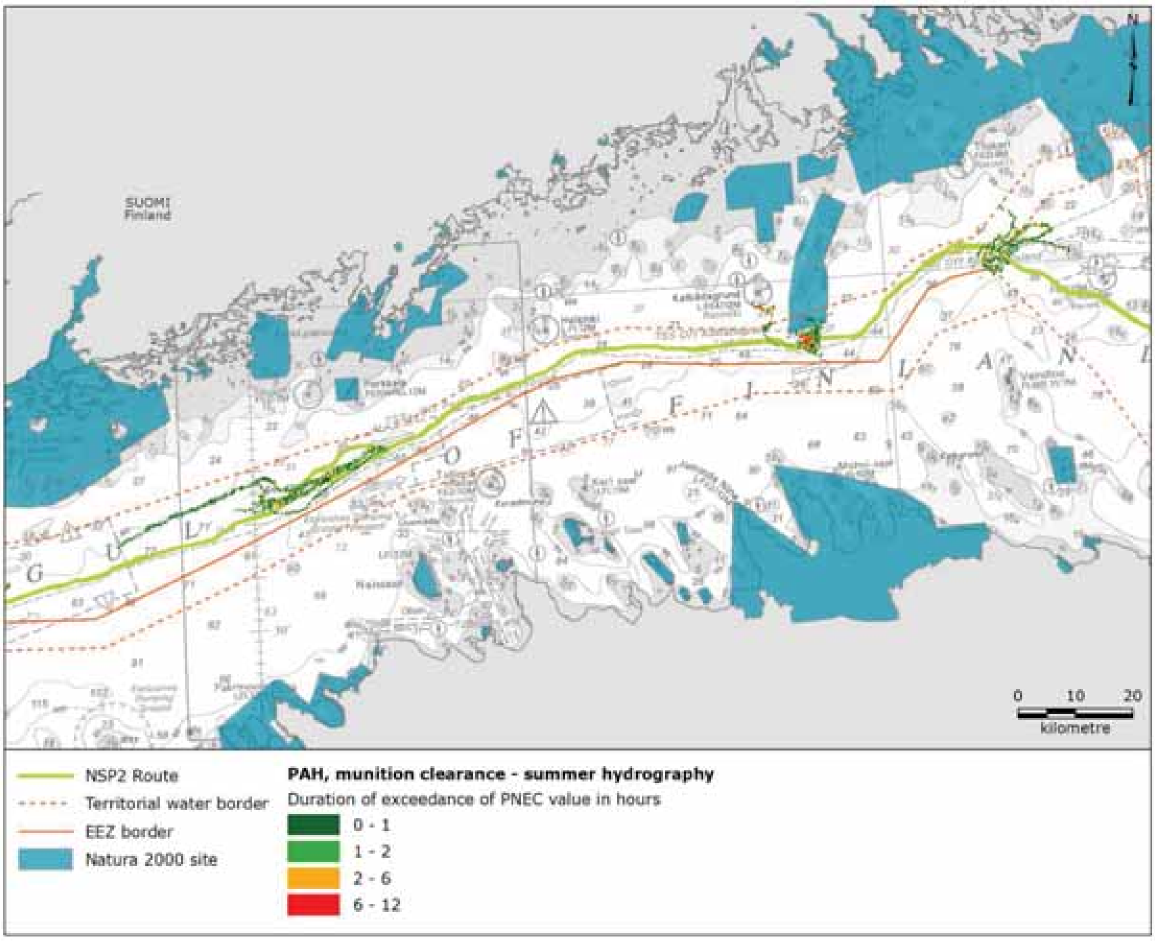


Figure 6-30 Duration of exceeding of PNEC for Benzo(a)pyrene during munitions clearance under typical summer conditions. Eastern part of the Gulf of Finland.

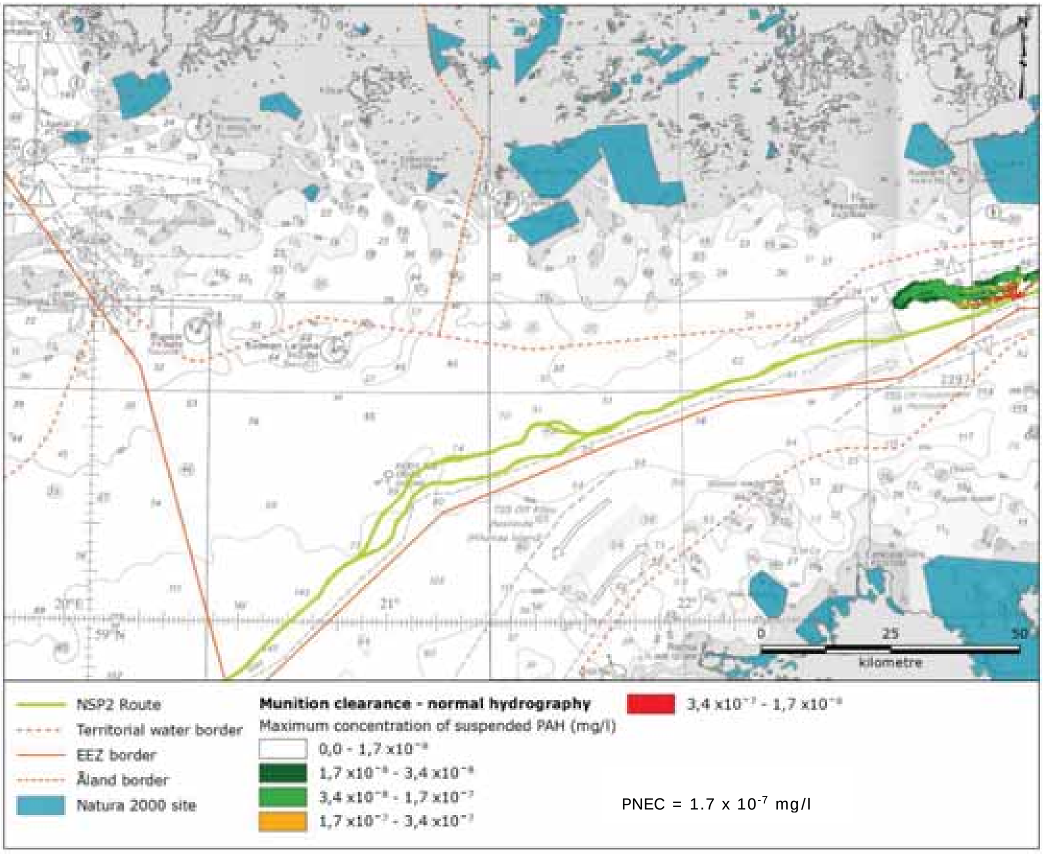


Figure 6-31 **Maximum concentration of Benzo(a)pyrene (PAH) during munitions clearance under normal conditions. Western part of the Gulf of Finland.**

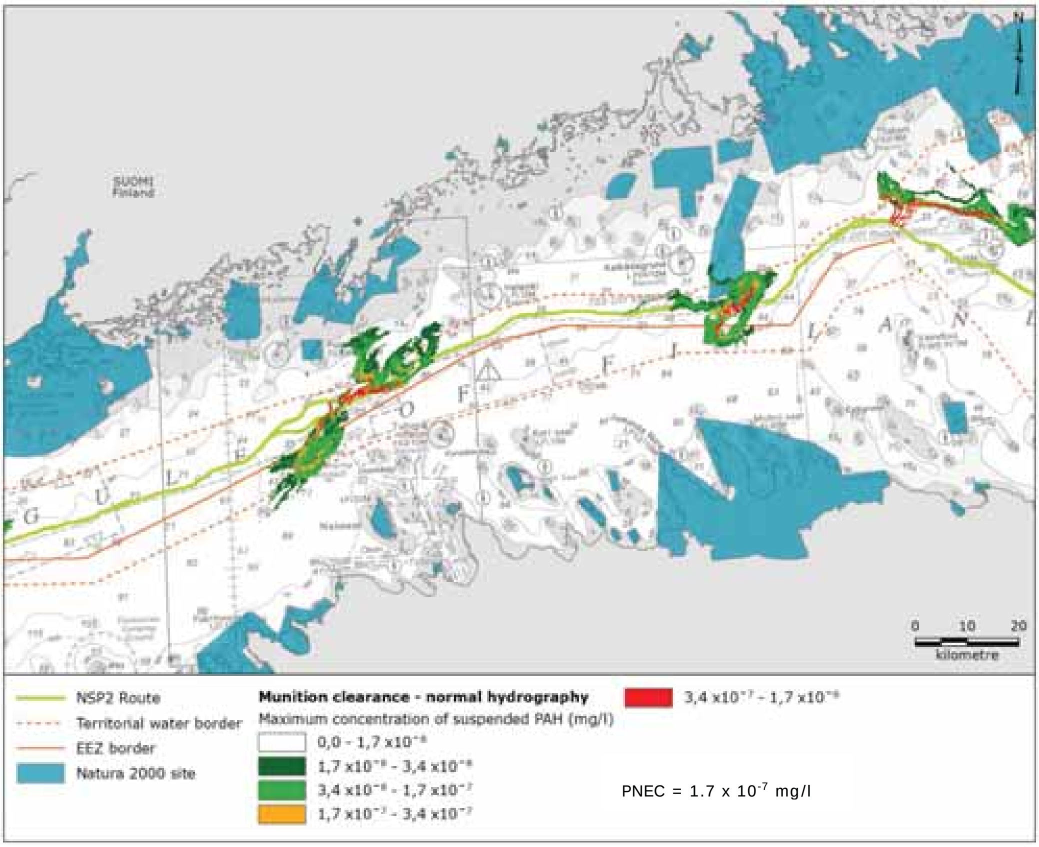


Figure 6-32 **Maximum concentration of Benzo(a)pyrene (PAH) during munitions clearance under normal conditions. Eastern part of the Gulf of Finland.**

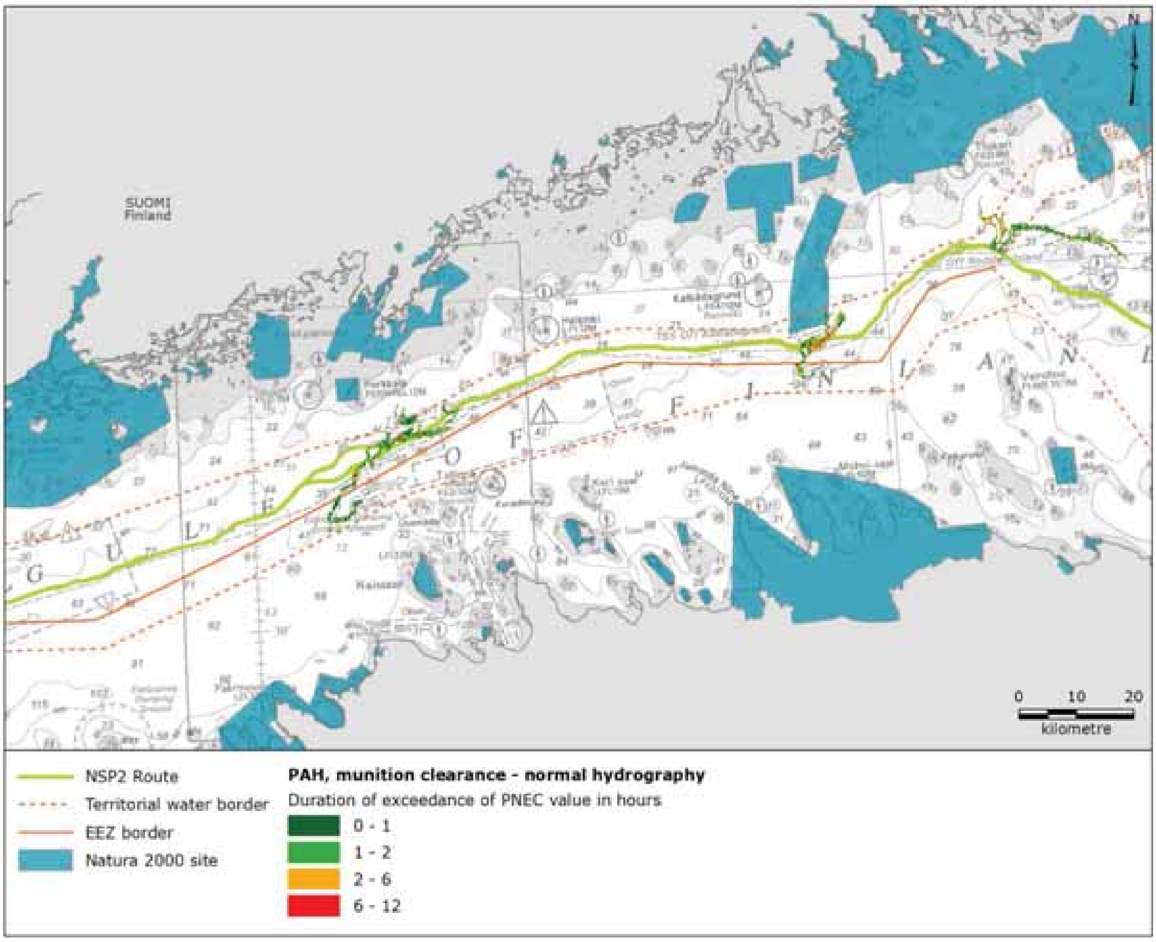


Figure 6-33 Duration of exceeding of PNEC for Benzo(a)pyrene during munitions clearance under normal conditions. Eastern part of the Gulf of Finland.

6.2.2 Dioxin

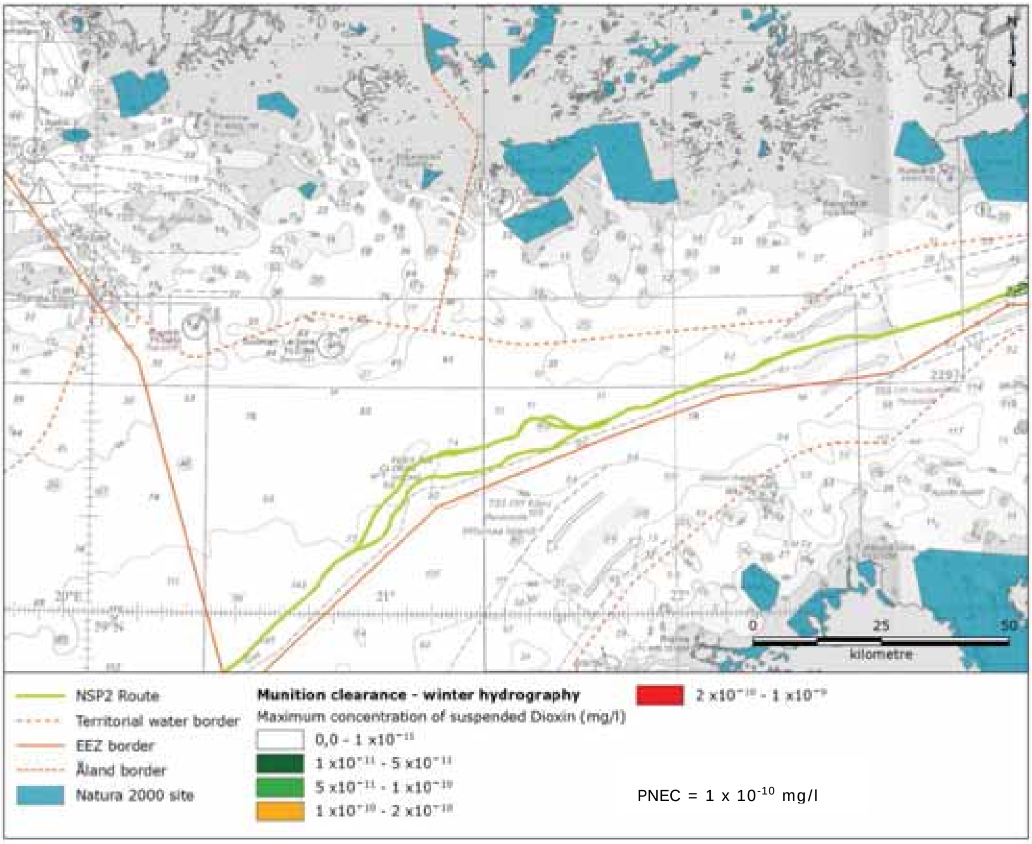


Figure 6-34 Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans) during munitions clearance under typical winter conditions. Western part of the Gulf of Finland.

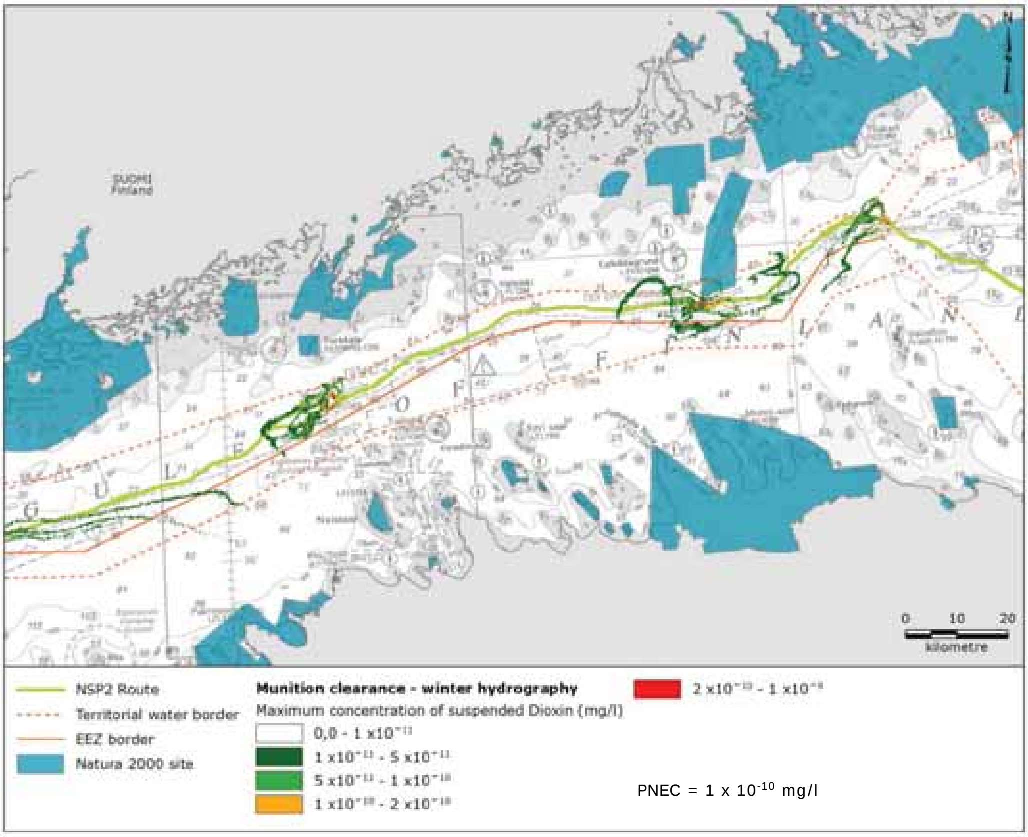


Figure 6-35 Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans) during munitions clearance under typical winter conditions. Eastern part of the Gulf of Finland.

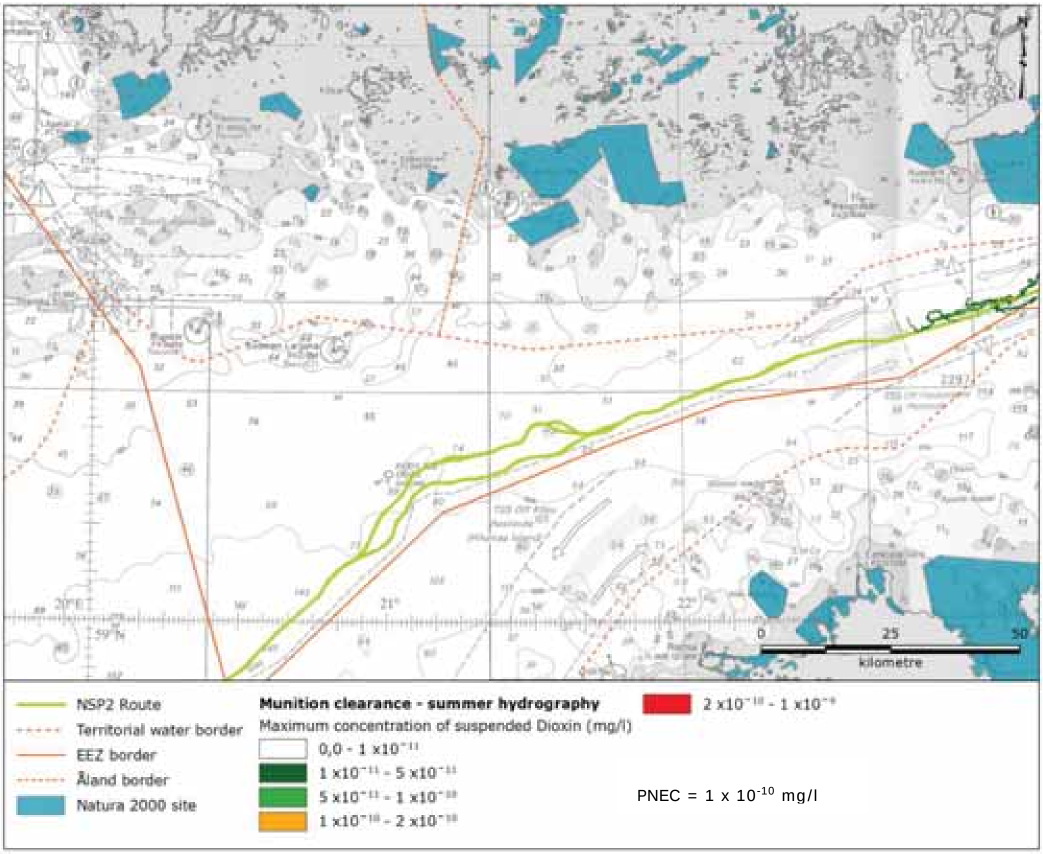


Figure 6-36 **Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans) during munitions clearance under typical summer conditions. Western part of the GoF.**

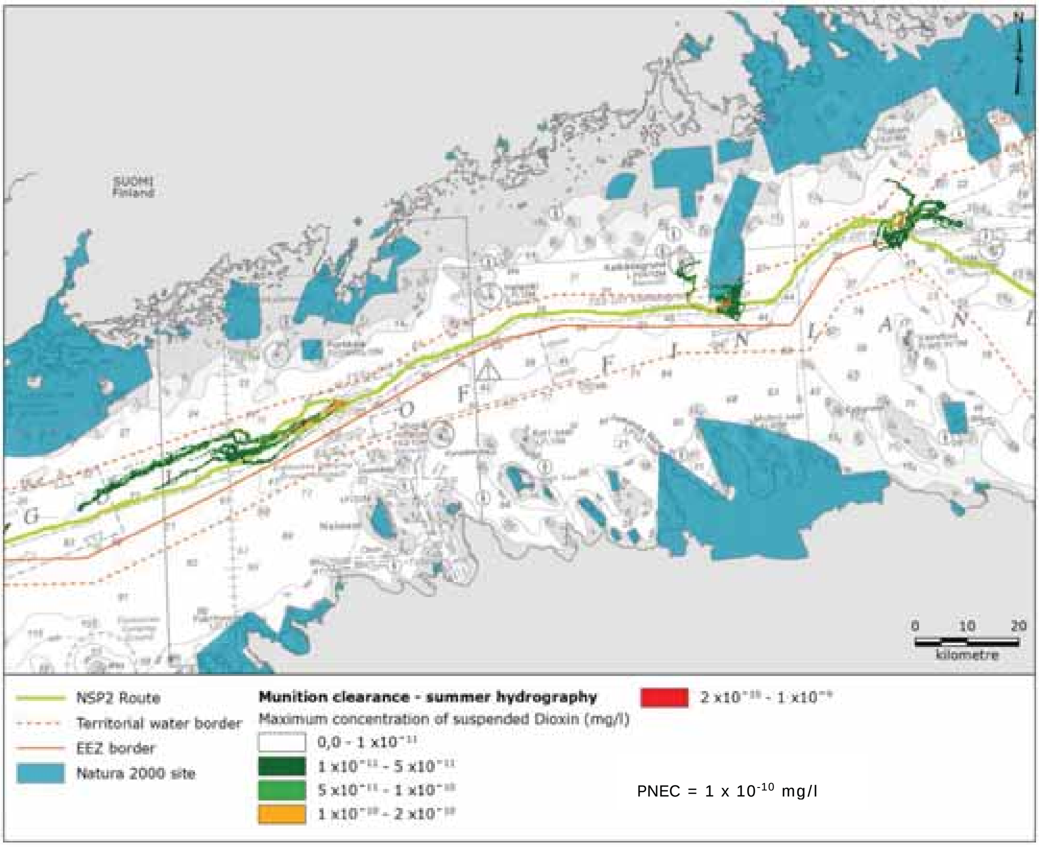


Figure 6-37 **Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans) during munitions clearance under typical summer conditions. Eastern part of the Gulf of Finland.**

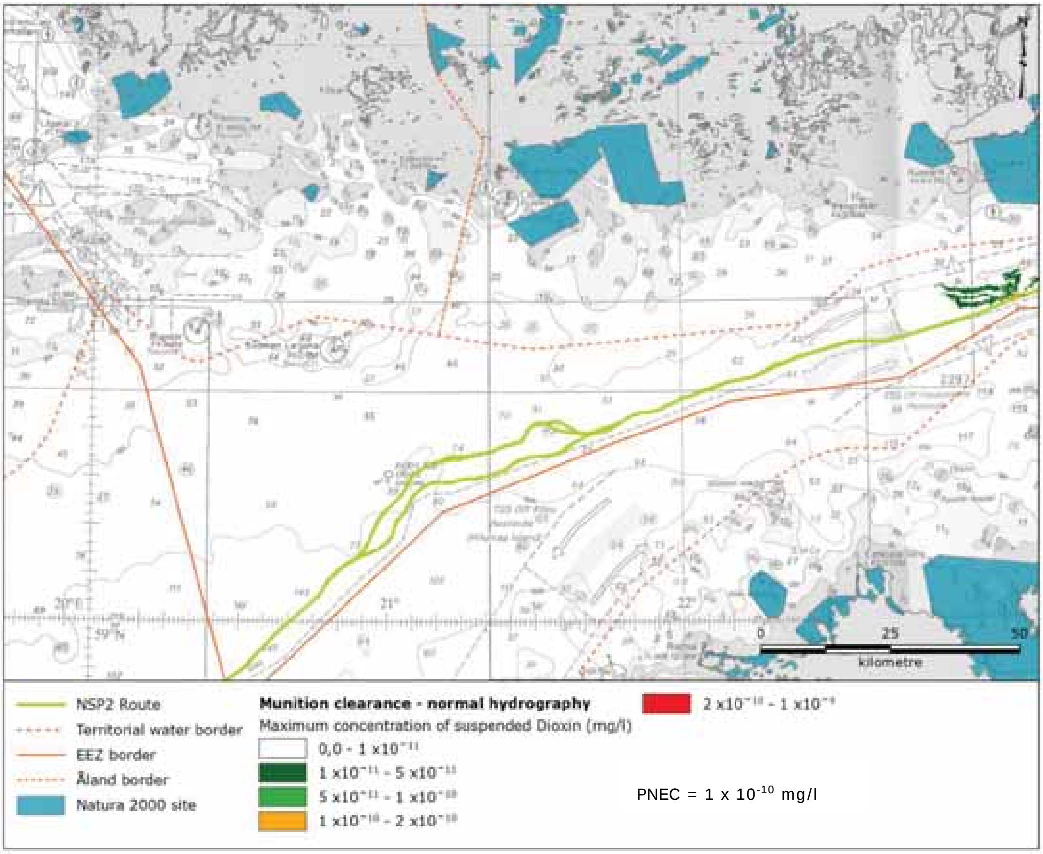


Figure 6-38 **Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans) during munitions clearance under normal conditions. Western part of the Gulf of Finland.**

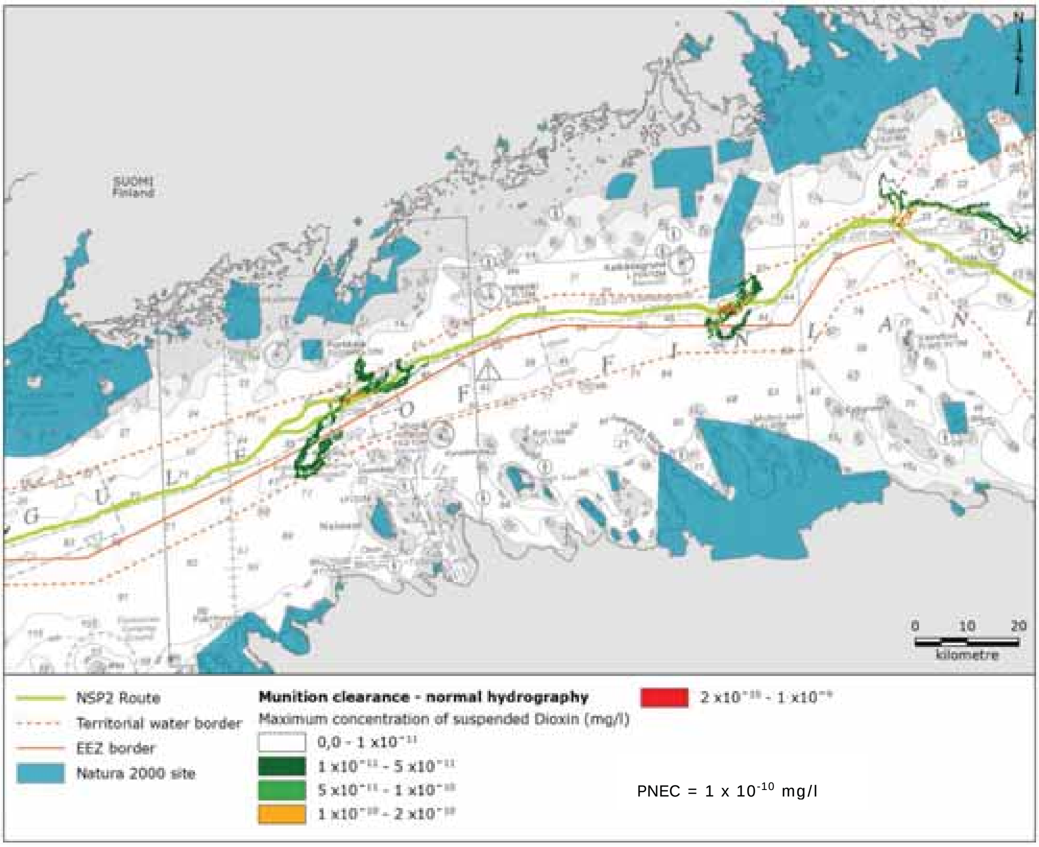


Figure 6-39 **Maximum concentration of WHO (2005) PCDD/F TEQ upper (Dioxin/Furans) during munitions clearance under normal conditions. Eastern part of the Gulf of Finland.**

6.2.3 Zinc

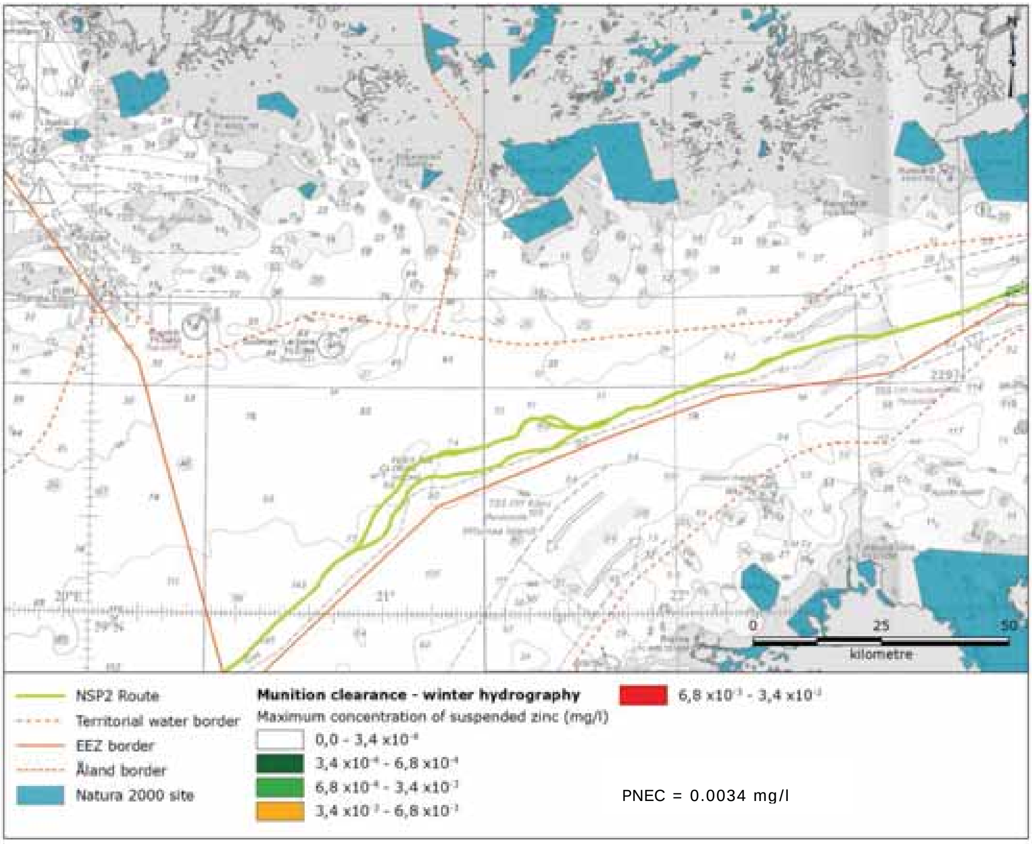


Figure 6-40 Maximum concentration of Zinc during munitions clearance under typical winter conditions. Western part of the Gulf of Finland.

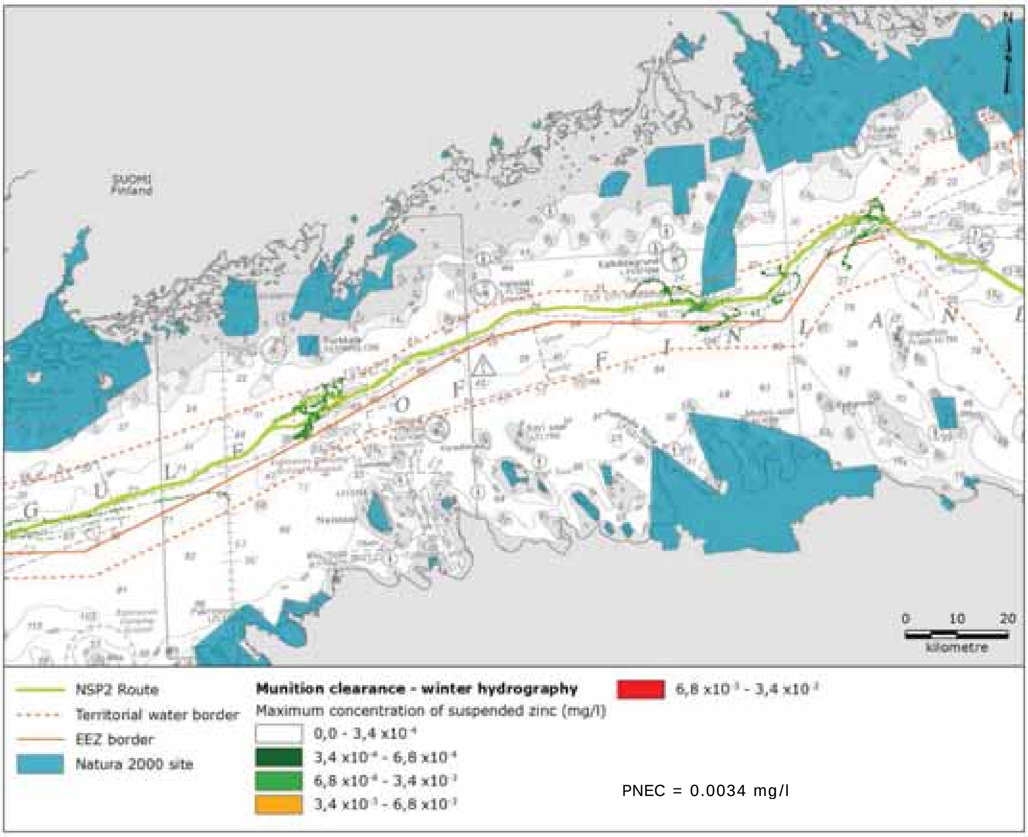


Figure 6-41 Maximum concentration of Zinc during munitions clearance under typical winter conditions. Eastern part of the Gulf of Finland.

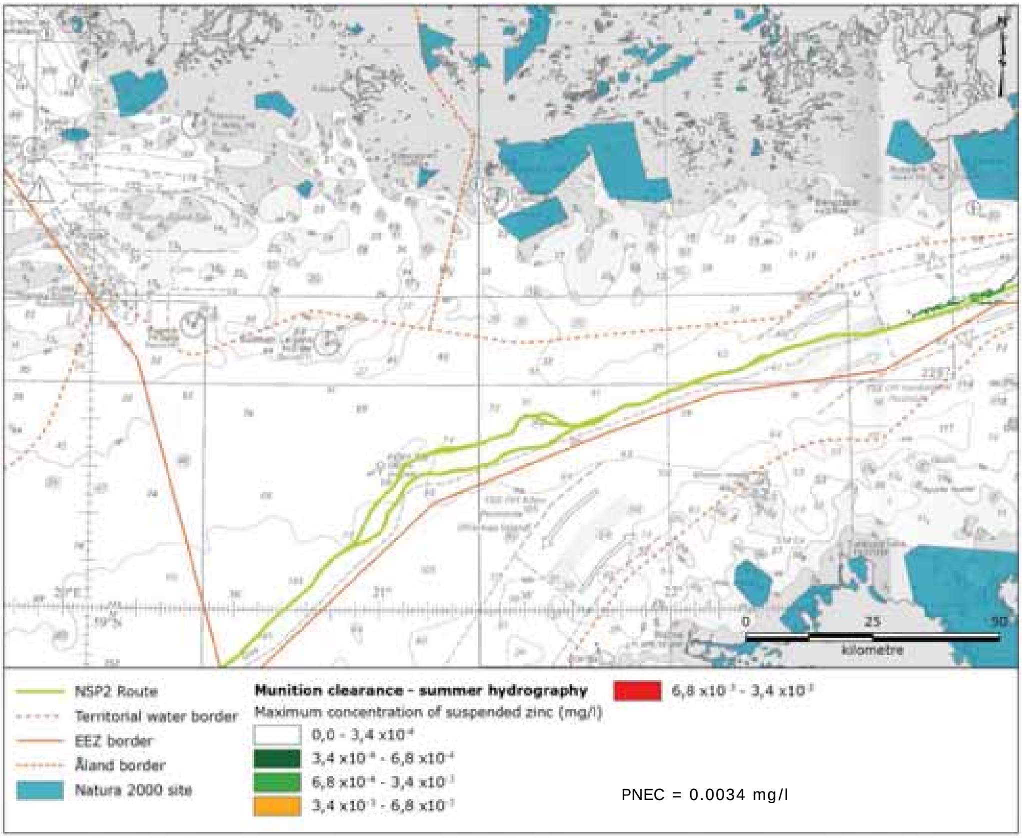


Figure 6-42 Maximum concentration of Zinc during munitions clearance under typical summer conditions. Western part of the Gulf of Finland.

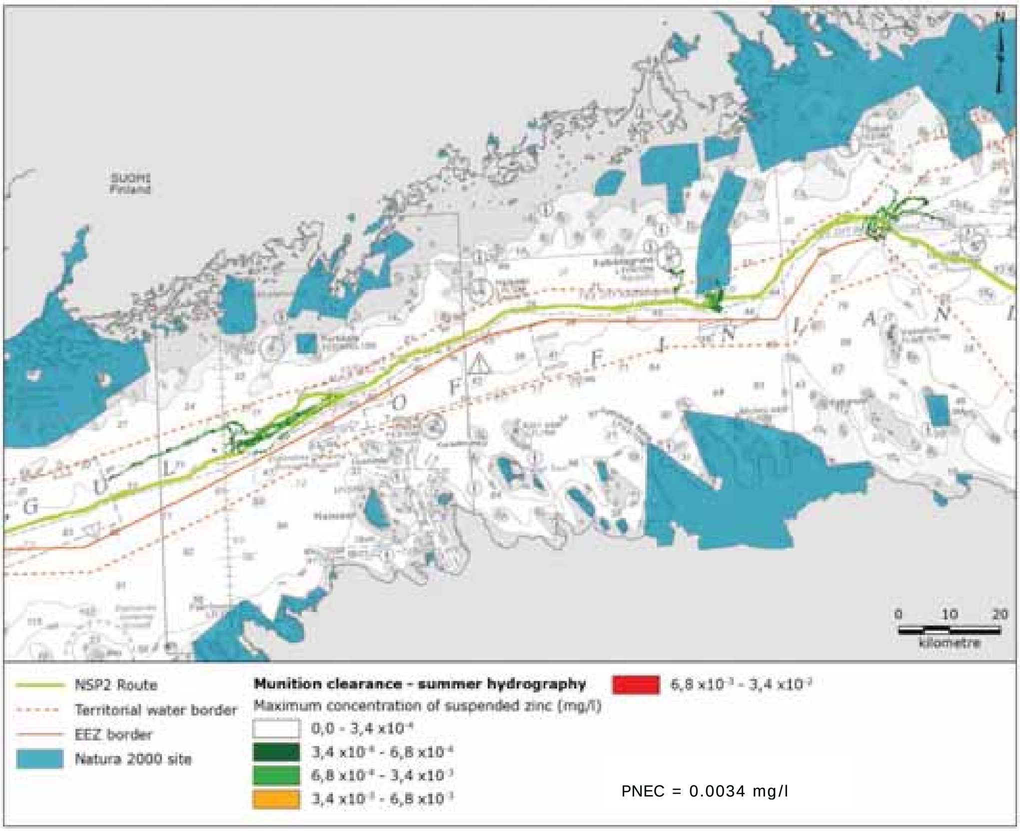


Figure 6-43 Maximum concentration of Zinc during munitions clearance under typical summer conditions. Eastern part of the Gulf of Finland.

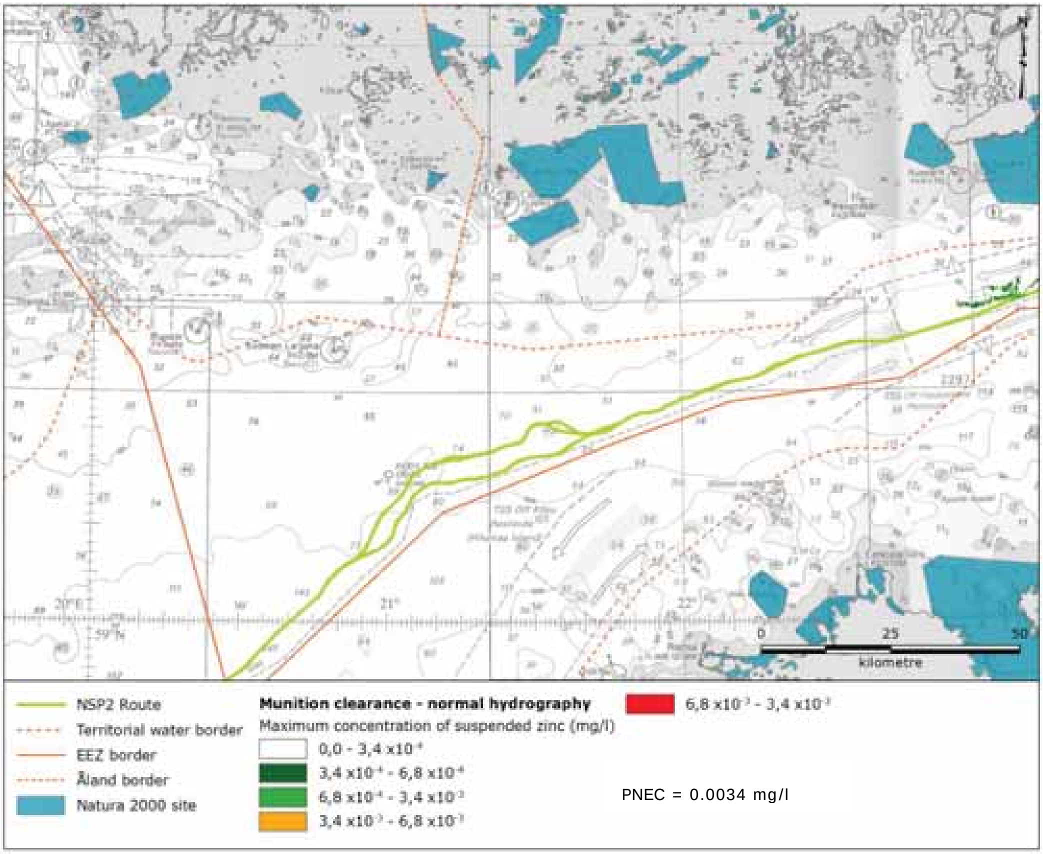


Figure 6-44 Maximum concentration of Zinc during munitions clearance under normal conditions. Western part of the Gulf of Finland.

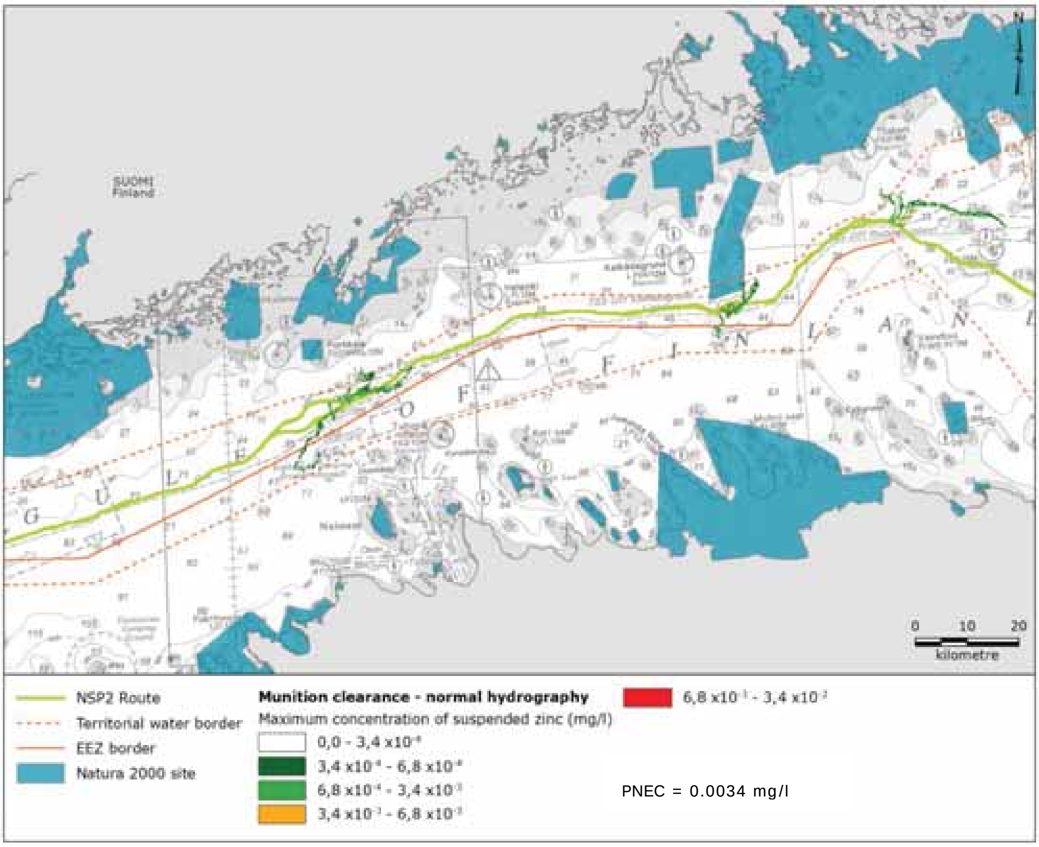


Figure 6-45 Maximum concentration of Zinc during munitions clearance under normal conditions. Eastern part of the Gulf of Finland.

6.3 Summary of results

This section presents a summary of the modelling results for contaminant spreading in rock placement and munitions clearance simulations. The summary contains:

- Areas where concentrations are exceeding PNEC value for PAH, Dioxin and Zinc
- Maximum duration of exceedance of PNEC value for PAH, Dioxin and Zinc
- Graphs showing area vs. duration of concentrations exceeding PNEC value for PAH.

The graphs of areas vs. duration show the size of areas in which the different durations are exceeded. The graphs are only shown for PAH, because areas for Dioxin and Zinc is small compared to PAH.

The values presented are overall maximum values covering all three hydrographic scenarios – normal, summer and winter. The corresponding tables for the individual hydrographic scenarios are presented in Appendix 2.

Table 6-2: Summary of areas

Seabed intervention works – maximum of hydrographic scenarios	Area with concentration exceeding PNEC value		
	PAH	Dioxin	Zinc
	km^2	km^2	km^2
Rock placement (Line A)	9.60	< 0.02	< 0.02
Munitions clearance	118.37	21.14	2.82
Total FI	127.97	21.14	2.82
The smallest grid size (modelling setup) has an area of 0.0195 km2			

Table 6-3: Summary of durations

Seabed intervention works – maximum of hydrographic scenarios	Max duration with concentration exceeding PNEC value		
	PAH	Dioxin	Zinc
	hours	hours	hours
Rock placement (Line A)	22	0	0
Munitions clearance	19	7	3

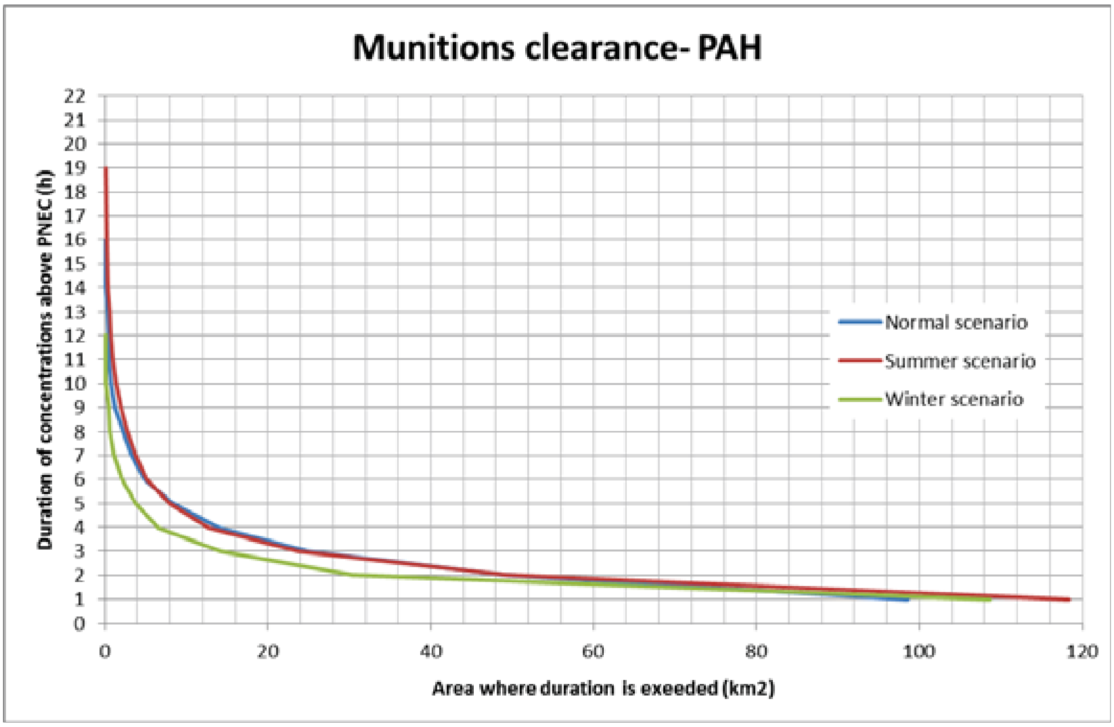


Figure 6-46: Graphs of area vs. duration for PAH from the munitions clearance scenario. The graphs show the size of areas in which the different durations are exceeded.

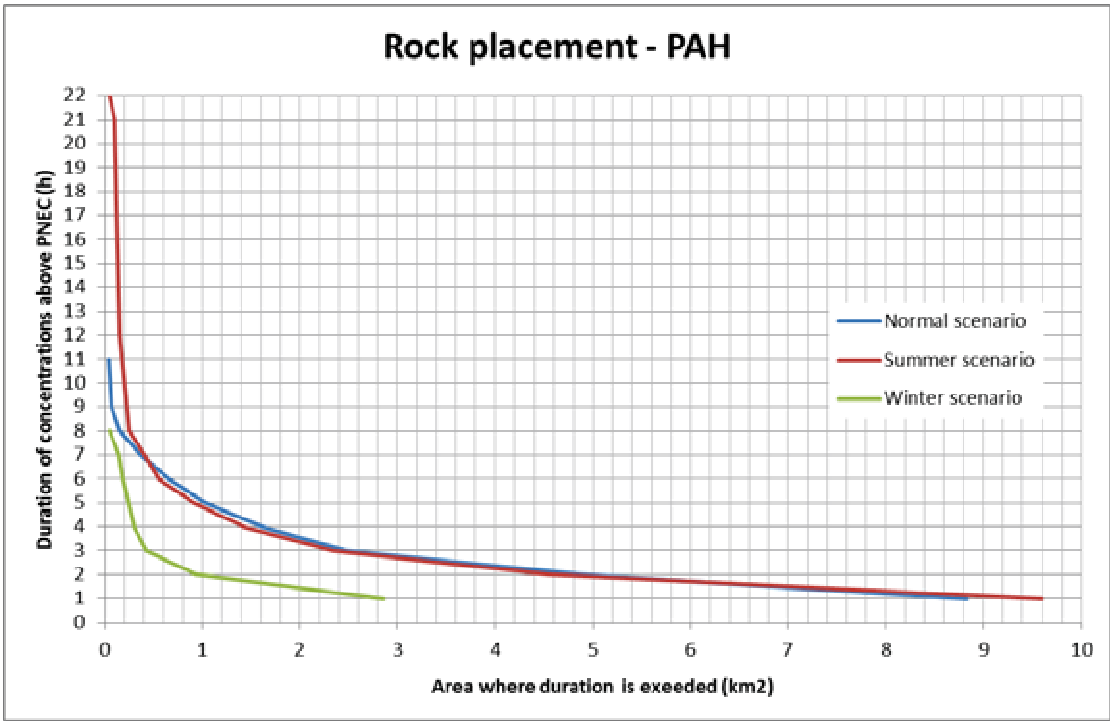


Figure 6-47: Graphs of area vs. duration for PAH from the rock placement scenario. The graphs show the size of areas in which the different durations are exceeded.

7. CONCLUSION

7.1 Sediment spill

7.1.1 Rock placement scenarios

For the rock placement scenarios the maximum concentration of suspended sediment are limited to a few model cells and never exceed 61 mg/l during winter conditions and 22 mg/l during normal and summer conditions. As shown in Figure 5-1 to Figure 5-6 there are no significant concentrations outside the pipeline corridor.

Sedimentation does not exceed 400 g/m^2 at any location after rock placement operations(summer) and 170 g/m^2 (winter and normal conditions). The corresponding thickness depends on the density, which again is dependent on the consolidation of the material. Considering fluffy sediment with a dry matter content of 100 kg/m^3 a 1 mm thickness corresponds to a sedimentation of 100 g/m^2. A higher degree of consolidation (consequently higher density) corresponds to a thinner layer thickness for the same sedimentation, e.g. 100 g/m^2.

For the alternative route there is, in general, a slight increase in both the duration of exceedance and in sedimentation compared to the main route. Results are based on simulations of the winter period.

7.1.2 Munitions clearance

For the munitions clearance scenarios the maximum concentration of suspended sediment are also limited to a few model cells, and the concentration never exceeds 107 mg/l in neither the lowest 10 m of the water column nor over the interval between 10 m and 20 m above the seabed. As also shown in Figure 5-25 to Figure 5-30, the concentrations and durations observed between 10m and 20m above the seabed are smaller than the ones observed for the lowest 10m above the seabed. However, the concentrations are still considered significant and should not be neglected.

Sedimentation does not exceed 179 g/m^2 at any location after munitions clearance – and sedimentation is located in the vicinity of the munitions clearance areas. For munitions clearance the resulting layer thickness also depend on the consolidation of the material.

7.2 Release of contaminants

7.2.1 Rock placement scenarios

For the rock placement scenarios only PAH show concentrations exceeding the PNEC value, while the concentrations of Dioxin and Zinc does not exceed the PNEC values anywhere in the model domain. The PNEC value for PAH is only exceeded in a very small area - less than 10 km^2 distributed along the entire pipeline route within the Finnish EEZ and only for a very short period of time in most of the impacted area. In 90% of the impacted area the PNEC value is exceeded in less than five hours in the normal and summer scenarios and even less in the winter scenario, as can be seen from Figure 6-47.

7.2.2 Munitions clearance

In the munitions clearance scenarios there are areas where the PNEC value is exceeded for all three contaminants. For Dioxin and Zinc the concentrations are exceeding the PNEC value only in very small areas of approximately 20 km^2 and 3 km^2 respectively,while the calculated concentration of PAH is above the PNEC value in an area of a little more than 100 km^2 in total. The duration of the exceedance is seen to be very short. Also for the munitions clearance scenarios the PNEC value is exceeded in less than 4-5 hours in 90% of the impacted area. The maximum duration is calculated to 19 hours, as can be seen from Figure 6-46.

8. REFERENCES

/1/ Nord Stream 2. Numerical Modelling: Methodology and assumptions. Ramboll, May 2016. Doc. no. W-PE-EIA-POF-REP-805-070100EN-01, rev 01

/2/ Nord Stream 2. Numerical Modelling: Overview of Scenarios. Ramboll, March 2016. Doc. no. W-PE-EIA-POF-MEM-805-070200EN-01

/3/ Nord Stream 2 Project in the Baltic, Hydrographic basis for spill assessment, Data from enhanced DHI hydrographic model. Technical Note, DHI, January 2016.

/4/ GTK, Geologian Tutkimuskeskus (geological survey of Finland), Finland

/5/ CIRIA, CUR and CETMEF, 2007, *The Rock Manual - The use of rock in hydraulic engineering*, C683, CIRIA, London

/6/ Nord Stream 2. Input data for EIA 1, Finland. Saipem, 13-05-2016, Rev. 3.

/7/ HELCOM, The explosive legacy from the Wars Baltic Ordnance Safty bord, Szczecin 2014-10-29.

/8/ Luode Consulting, Water quality, sediment and benthos monitoring during Nord Stream operations in the Gulf of Finland, ammunition clearance operations, 2011-01-16, rev B. G-PE-EMS-MON-175-LUODEQ2A-B

APPENDIX 1
RESULT TABLES FOR NORMAL, SUMMER AND WINTER HYDROGRAPHY

Normal hydrography

This section presents a summary of the modelling results for normal hydrography.

Seabed intervention works – normal conditions	Suspended sediment	Area with concentration		
		> 2 mg/l	> 10 mg/l	> 15 mg/l
	tonnes	km²	km²	km²
Rock placement	2592.5	190.68	6.00	0.59
Rock placement – alternative routes	2848.3	x	x	x
Munitions clearance (0-10m)	1030.2	128.91	35.18	18.82
Munitions clearance (10-20m)		33.11	20.33	16.94
Total FI	3622.7	319.59	41.18	19.41
The smallest grid size (modelling setup) has an area of 0.0195 km2				

Seabed intervention works – normal conditions	Suspended sediment	Max duration with concentration		
		> 2 mg/l	> 10 mg/l	> 15 mg/l
	tonnes	hours	hours	hours
Rock placement	2592.5	42.98	7.00	1.50
Rock placement – alternative routes	2848.3	x	x	x
Munitions clearance (0-10m)	1030.2	23.98	12.99	9.99
Munitions clearance (10-20m)		20.99	11.49	10.49
The smallest grid size (modelling setup) has an area of 0.0195 km2				

For the threshold 10mg/l and 15mg/l it has been decided not to show any maps due to the very limited duration, which would be invisible in the maps.

Seabed intervention works – normal conditions	Suspended sediment	Area with sedimentation				
		> 10 g/m²	> 50 g/m²	> 100 g/m²	> 150 g/m²	> 200 g/m²
	tonnes	km²	km²	km²	km²	km²
Rock placement	2592.5	59.00	3.63	0.61	0.06	0.00
Rock placement – alternative routes	2848.3	x	x	x	x	x
Munitions clearance (0-10m)	1030.2	27.91	1.48	0.14	0.04	0.00
Total FI	3622.7	86.91	5.11	0.75	0.10	0.00
The smallest grid size (modelling setup) has an area of 0.0195 km2						

Seabed intervention works – normal conditions	Suspended sediment	Max concentration at specific distances from pipelines		
		200 m	500 m	1000 m
	tonnes	mg/l	mg/l	mg/l
Rock placement	2592.5	20	20	17
Rock placement – alternative routes	2848.3	x	x	x
Munitions clearance (0-10m)	1030.2	69	68	53
Munitions clearance (10-20m)		108	108	68
The smallest grid size (modelling setup) has an area of 0.0195 km2				

Summer hydrography

This section presents a summary of the modelling results for summer hydrography.

Seabed intervention works – summer conditions	Suspended sediment	Area with concentration		
		> 2 mg/l	> 10 mg/l	> 15 mg/l
	tonnes	km^2	km^2	km^2
Rock placement	2592.5	120.78	4.02	1.20
Rock placement – alternative routes	2848.3	x	x	x
Munitions clearance (0-10m)	1030.2	155.21	46.06	27.84
Munitions clearance (10-20m)		35.39	19.82	15.60
Total FI	3622.7	275.99	50.08	29.04
The smallest grid size (modelling setup) has an area of 0.0195 km2				

Seabed intervention works – summer conditions	Suspended sediment	Max duration with concentration		
		> 2 mg/l	> 10 mg/l	> 15 mg/l
	tonnes	hours	hours	hours
Rock placement	2592.5	164.92	18.49	7.50
Rock placement – alternative routes	2848.3	x	x	x
Munitions clearance (0-10m)	1030.2	22.48	8.49	8.00
Munitions clearance (10-20m)		14.49	6.00	5.50
The smallest grid size (modelling setup) has an area of 0.0195 km2				

For the threshold 10mg/l and 15mg/l it has been decided not to show any maps due to the very limited duration, which would be invisible in the maps.

Seabed intervention works – summer conditions	Suspended sediment	Area with sedimentation				
		> 10 g/m^2	> 50 g/m^2	> 100 g/m^2	> 150 g/m^2	> 200 g/m^2
	tonnes	km^2	km^2	km^2	km^2	km^2
Rock placement	2592.5	63.90	3.92	0.59	0.17	0.05
Rock placement – alternative routes	2848.3	x	x	x	x	x
Munitions clearance (0-10m)	1030.2	22.29	1.25	0.12	0.00	0.00
Total FI	3622.7	86.19	5.17	0.71	0.17	0.05
The smallest grid size (modelling setup) has an area of 0.0195 km2						

Seabed intervention works – summer conditions	Suspended sediment	Max concentration a specific distances from pipelines		
		200 m	500 m	1000 m
	tonnes	mg/l	mg/l	mg/l
Rock placement	2592.5	21	20	17
Rock placement – alternative routes	2848.3	x	x	x
Munitions clearance (0-10m)	1030.2	106	100	100
Munitions clearance (10-20m)		90	83	75
The smallest grid size (modelling setup) has an area of 0.0195 km2				

Winter hydrography

This section presents a summary of the modelling results for winter hydrography.

Seabed intervention works – winter conditions	Suspended sediment	Area with concentration		
		> 2 mg/l	> 10 mg/l	> 15 mg/l
	tonnes	km^2	km^2	km^2
Rock placement	2592.5	267.31	4.49	1.67
Rock placement – alternative routes	2848.3	353.09	9.46	3.01
Munitions clearance (0-10m)	1030.2	258.19	32.75	15.87
Munitions clearance (10-20m)		77.81	31.29	21.92
Total FI	3622.7	525.50	37.24	17.54
Total FI - alternative	3878.5	611.28	42.21	18.88
The smallest grid size (modelling setup) has an area of 0.0195 km2				

Seabed intervention works – winter conditions	Suspended sediment	Max duration with concentration		
		> 2 mg/l	> 10 mg/l	> 15 mg/l
	tonnes	hours	hours	hours
Rock placement	2592.5	23.99	7.00	2.50
Rock placement – alternative routes	2848.3	31.98	7.00	1.50
Munitions clearance (0-10m)	1030.2	19.99	7.00	4.50
Munitions clearance (10-20m)		11.99	8.99	4.50
The smallest grid size (modelling setup) has an area of 0.0195 km2				

For the threshold 10mg/l and 15mg/l it has been decided not to show any maps due to the very limited duration, which would be invisible in the maps.

Seabed intervention works – winter conditions	Suspended sediment	Area with sedimentation				
		> 10 g/m^2	> 50 g/m^2	> 100 g/m^2	> 150 g/m^2	> 200 g/m^2
	tonnes	km^2	km^2	km^2	km^2	km^2
Rock placement	2592.5	21.65	0.50	0.04	0.00	0.00
Rock placement – alternative routes	2848.3	25.26	0.98	0.09	0.05	0.00
Munitions clearance (0-10m)	1030.2	12.94	0.48	0.10	0.09	0.00
Total FI	3622.7	34.59	0.98	0.14	0.09	0.00
Total FI - alternative	3878.5	38.20	1.46	0.19	0.14	0.00
The smallest grid size (modelling setup) has an area of 0.0195 km2						

Seabed intervention works – winter conditions	Suspended sediment	Max concentration a specific distances from pipelines		
		200 m	500 m	1000 m
	tonnes	mg/l	mg/l	mg/l
Rock placement	2592.5	14	10	10
Rock placement – alternative routes	2848.3	14	10	10
Munitions clearance (0-10m)	1030.2	96	82	82
Munitions clearance (10-20m)		90	85	54
The smallest grid size (modelling setup) has an area of 0.0195 km2				

APPENDIX 2
CONTAMINANT RESULT TABLES FOR NORMAL, SUMMER AND WINTER HYDROGRAPHY

Normal hydrography

This section presents a summary of the modelling results for normal hydrography.

Seabed intervention works – normal conditions	Area with concentration exeeding PNEC value		
	PAH	Dioxin	Zinc
	km^2	km^2	km^2
Rock placement	8.83	< 0.02	< 0.02
Munitions clearance	98.52	18.89	2.53
Total FI	107.35	18.89	2.53
The smallest grid size (modelling setup) has an area of 0.0195 km2			

Seabed intervention works – normal conditions	Max duration with concentration exceeding PNEC value		
	PAH	Dioxin	Zinc
	hours	hours	hours
Rock placement	11	0	0
Munitions clearance	16	7	3

Summer hydrography

This section presents a summary of the modelling results for summer hydrography.

Seabed intervention works – normal conditions	Area with concentration exeeding PNEC value		
	PAH	Dioxin	Zinc
	km^2	km^2	km^2
Rock placement	9.60	< 0.02	< 0.02
Munitions clearance	118.37	21.14	2.82
Total FI	127.97	21.14	2.82
The smallest grid size (modelling setup) has an area of 0.0195 km2			

Seabed intervention works – normal conditions	Max duration with concentration exceeding PNEC value		
	PAH	Dioxin	Zinc
	hours	hours	hours
Rock placement	22	0	0
Munitions clearance	19	6	3

Winter hydrography

This section presents a summary of the modelling results for winter hydrography.

Seabed intervention works – normal conditions	Area with concentration exeeding PNEC value		
	PAH	Dioxin	Zinc
	km^2	km^2	km^2
Rock placement	2.86	< 0.02	< 0.02
Munitions clearance	108.62	18.75	2.16
Total FI	111.48	18.75	2.16
The smallest grid size (modelling setup) has an area of 0.0195 km2			

Seabed intervention works – normal conditions	Max duration with concentration exceeding PNEC value		
	PAH	Dioxin	Zinc
	hours	hours	hours
Rock placement	8	0	0
Munitions clearance	12	5	3

APPENDIX 3
INPUT SPILL RATES PER LOCATION

Table 8-1: Rock placement for seabed intervention works – calculated spill rates in kg/s and rock berm volumes in m^3, /6/.

Seabed intervention type		Very fine sand (kg/s)	Coarse silt (kg/s)	Medium silt (kg/s)	Fine silt (kg/s)	Very fine silt (kg/s)	Clay (kg/s)	Rock berm (m^3)
Prelay	A1001	0.033	0.007	0.015	0.022	0.018	0.107	2970
	A1002	0.015	0.007	0.015	0.029	0.033	0.232	10673
	A1003	0.015	0.007	0.015	0.029	0.033	0.232	2970
	A1004	0.015	0.007	0.015	0.029	0.033	0.232	909
	A1005	0.033	0.007	0.015	0.022	0.018	0.107	13235
	A1006	0.015	0.007	0.015	0.029	0.033	0.232	2794
	A1007	0.015	0.007	0.015	0.029	0.033	0.232	10673
	A1008	0.033	0.007	0.015	0.022	0.018	0.107	6135
	A1009	0.033	0.007	0.015	0.022	0.018	0.107	2645
	A1010	0.033	0.007	0.015	0.022	0.018	0.107	2645
	A1011	0.033	0.007	0.015	0.022	0.018	0.107	10673
	A1012	0.015	0.007	0.015	0.029	0.033	0.232	1882
	A1013	0.015	0.007	0.015	0.029	0.033	0.232	6135
	A1014	0.015	0.007	0.015	0.029	0.033	0.232	2970
	A1015	0.015	0.007	0.015	0.029	0.033	0.232	2970
	A1016	0.015	0.007	0.015	0.029	0.033	0.232	2645
	A1017	0.015	0.007	0.015	0.029	0.033	0.232	10673
	A1018	0.015	0.007	0.015	0.029	0.033	0.232	6135
	A1019	0.015	0.007	0.015	0.029	0.033	0.232	2794
	A1020	0.015	0.007	0.015	0.029	0.033	0.232	2890
	A1021	0.015	0.007	0.015	0.029	0.033	0.232	10673
	A1022	0.015	0.007	0.015	0.029	0.033	0.232	6135
	A1023	0.015	0.007	0.015	0.029	0.033	0.232	6135
	A1024	0.015	0.007	0.015	0.029	0.033	0.232	10673
	A1025	0.007	0.011	0.022	0.040	0.044	0.232	2491
	A1026	0.007	0.011	0.022	0.040	0.044	0.232	2882
	A1027	0.015	0.007	0.015	0.029	0.033	0.232	6135
	A1028	0.015	0.007	0.015	0.029	0.033	0.232	753
	A1029	0.015	0.007	0.015	0.029	0.033	0.232	6135
	A1030	0.015	0.007	0.015	0.029	0.033	0.232	6135
Postlay 2nd phase	A1201	0.033	0.007	0.015	0.022	0.018	0.107	648
	A1202	0.033	0.007	0.015	0.022	0.018	0.107	3717
	A1203	0.033	0.007	0.015	0.022	0.018	0.107	5006
	A1204	0.033	0.007	0.015	0.022	0.018	0.107	7099
	A1205	0.033	0.007	0.015	0.022	0.018	0.107	7099
	A1206	0.033	0.007	0.015	0.022	0.018	0.107	285
	A1207	0.015	0.007	0.015	0.029	0.033	0.232	7099
	A1208	0.015	0.007	0.015	0.029	0.033	0.232	7099
	A1209	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1210	0.015	0.007	0.015	0.029	0.033	0.232	7099
	A1211	0.015	0.007	0.015	0.029	0.033	0.232	4229
	A1212	0.015	0.007	0.015	0.029	0.033	0.232	3717

	A1213	0.015	0.007	0.015	0.029	0.033	0.232	5006
	A1214	0.015	0.007	0.015	0.029	0.033	0.232	10673
	A1215	0.015	0.007	0.015	0.029	0.033	0.232	285
	A1216	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1217	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1218	0.015	0.007	0.015	0.029	0.033	0.232	10673
	A1219	0.033	0.007	0.015	0.022	0.018	0.107	10673
	A1220	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1221	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1222	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1223	0.015	0.007	0.015	0.029	0.033	0.232	4229
	A1224	0.015	0.007	0.015	0.029	0.033	0.232	10673
	A1225	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1226	0.007	0.011	0.022	0.040	0.044	0.232	4229
	A1227	0.007	0.011	0.022	0.040	0.044	0.232	648
	A1228	0.033	0.007	0.015	0.022	0.018	0.107	2948
	A1229	0.033	0.007	0.015	0.022	0.018	0.107	285
	A1230	0.033	0.007	0.015	0.022	0.018	0.107	648
	A1231	0.033	0.007	0.015	0.022	0.018	0.107	841
	A1232	0.033	0.007	0.015	0.022	0.018	0.107	2948
	A1233	0.033	0.007	0.015	0.022	0.018	0.107	2948
	A1234	0.033	0.007	0.015	0.022	0.018	0.107	285
	A1235	0.033	0.007	0.015	0.022	0.018	0.107	285
	A1236	0.011	0.007	0.007	0.007	0.007	0.037	3717
	A1237	0.033	0.007	0.015	0.022	0.018	0.107	7099
	A1238	0.033	0.007	0.015	0.022	0.018	0.107	2948
	A1239	0.033	0.007	0.015	0.022	0.018	0.107	5006
	A1240	0.015	0.007	0.015	0.029	0.033	0.232	3717
	A1241	0.015	0.007	0.015	0.029	0.033	0.232	648
	A1242	0.015	0.007	0.015	0.029	0.033	0.232	181
	A1243	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1244	0.015	0.007	0.015	0.029	0.033	0.232	10673
	A1245	0.015	0.007	0.015	0.029	0.033	0.232	10673
	A1246	0.015	0.007	0.015	0.029	0.033	0.232	3717
	A1247	0.015	0.007	0.015	0.029	0.033	0.232	648
	A1248	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1249	0.015	0.007	0.015	0.029	0.033	0.232	3717
	A1250	0.015	0.007	0.015	0.029	0.033	0.232	4229
	A1251	0.015	0.007	0.015	0.029	0.033	0.232	4229
	A1252	0.015	0.007	0.015	0.029	0.033	0.232	841
	A1253	0.015	0.007	0.015	0.029	0.033	0.232	1200
	A1254	0.015	0.007	0.015	0.029	0.033	0.232	648
	A1255	0.015	0.007	0.015	0.029	0.033	0.232	5006
	A1256	0.015	0.007	0.015	0.029	0.033	0.232	5006
	A1257	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1258	0.015	0.007	0.015	0.029	0.033	0.232	2948

	A1259	0.015	0.007	0.015	0.029	0.033	0.232	2645
	A1260	0.015	0.007	0.015	0.029	0.033	0.232	648
	A1261	0.015	0.007	0.015	0.029	0.033	0.232	285
	A1262	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1263	0.015	0.007	0.015	0.029	0.033	0.232	10673
	A1264	0.015	0.007	0.015	0.029	0.033	0.232	7099
	A1265	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1266	0.015	0.007	0.015	0.029	0.033	0.232	648
	A1267	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1268	0.015	0.007	0.015	0.029	0.033	0.232	1366
	A1269	0.015	0.007	0.015	0.029	0.033	0.232	3717
	A1270	0.015	0.007	0.015	0.029	0.033	0.232	285
	A1271	0.015	0.007	0.015	0.029	0.033	0.232	648
	A1272	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1273	0.015	0.007	0.015	0.029	0.033	0.232	2948
	A1274	0.015	0.007	0.015	0.029	0.033	0.232	3717
	A1275	0.015	0.007	0.015	0.029	0.033	0.232	5006
	A1276	0.015	0.007	0.015	0.029	0.033	0.232	3717
	A1277	0.015	0.007	0.015	0.029	0.033	0.232	285
	A1278	0.015	0.007	0.015	0.029	0.033	0.232	648
	A1279	0.015	0.007	0.015	0.029	0.033	0.232	648
	A1280	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1281	0.007	0.011	0.022	0.040	0.044	0.232	1366
	A1282	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1283	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1284	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1285	0.007	0.011	0.022	0.040	0.044	0.232	5006
	A1286	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1287	0.007	0.011	0.022	0.040	0.044	0.232	5006
	A1288	0.015	0.007	0.015	0.029	0.033	0.232	1121
	A1289	0.007	0.011	0.022	0.040	0.044	0.232	1366
	A1290	0.015	0.007	0.015	0.029	0.033	0.232	1004
	A1291	0.015	0.007	0.015	0.029	0.033	0.232	3717
	A1292	0.015	0.007	0.015	0.029	0.033	0.232	3058
	A1293	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1294	0.007	0.011	0.022	0.040	0.044	0.232	7099
	A1295	0.007	0.011	0.022	0.040	0.044	0.232	4229
	A1296	0.007	0.011	0.022	0.040	0.044	0.232	1004
	A1297	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1298	0.007	0.011	0.022	0.040	0.044	0.232	1121
	A1299	0.015	0.007	0.015	0.029	0.033	0.232	841
	A1300	0.015	0.007	0.015	0.029	0.033	0.232	7099
	A1301	0.015	0.007	0.015	0.029	0.033	0.232	9006
	A1302	0.015	0.007	0.015	0.029	0.033	0.232	1121
	A1303	0.015	0.007	0.015	0.029	0.033	0.232	1121
	A1304	0.007	0.011	0.022	0.040	0.044	0.232	1121

	A1305	0.007	0.011	0.022	0.040	0.044	0.232	1121
	A1306	0.007	0.011	0.022	0.040	0.044	0.232	1121
	A1307	0.007	0.011	0.022	0.040	0.044	0.232	1004
	A1308	0.007	0.011	0.022	0.040	0.044	0.232	1121
	A1309	0.007	0.011	0.022	0.040	0.044	0.232	1366
	A1310	0.007	0.011	0.022	0.040	0.044	0.232	648
	A1311	0.007	0.011	0.022	0.040	0.044	0.232	1121
	A1312	0.015	0.007	0.015	0.029	0.033	0.232	7099
	A1313	0.015	0.007	0.015	0.029	0.033	0.232	1366
	A1314	0.015	0.007	0.015	0.029	0.033	0.232	1366
	A1315	0.007	0.011	0.022	0.040	0.044	0.232	7099
	A1316	0.015	0.007	0.015	0.029	0.033	0.232	3717
	A1317	0.015	0.007	0.015	0.029	0.033	0.232	5006
	A1318	0.015	0.007	0.015	0.029	0.033	0.232	3717
	A1319	0.015	0.007	0.015	0.029	0.033	0.232	1366
	A1320	0.015	0.007	0.015	0.029	0.033	0.232	4229
	A1321	0.015	0.007	0.015	0.029	0.033	0.232	7099
	A1322	0.015	0.007	0.015	0.029	0.033	0.232	4229
	A1323	0.015	0.007	0.015	0.029	0.033	0.232	285
	A1324	0.015	0.007	0.015	0.029	0.033	0.232	285
	A1325	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1326	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1327	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1328	0.007	0.011	0.022	0.040	0.044	0.232	1366
	A1329	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1330	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1331	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1332	0.007	0.011	0.022	0.040	0.044	0.232	5006
	A1333	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1334	0.007	0.011	0.022	0.040	0.044	0.232	5006
	A1335	0.007	0.011	0.022	0.040	0.044	0.232	7099
	A1336	0.007	0.011	0.022	0.040	0.044	0.232	7099
	A1337	0.007	0.011	0.022	0.040	0.044	0.232	7099
	A1338	0.015	0.007	0.015	0.029	0.033	0.232	4229
	A1339	0.015	0.007	0.015	0.029	0.033	0.232	1366
	A1340	0.015	0.007	0.015	0.029	0.033	0.232	3717
	A1341	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1342	0.007	0.011	0.022	0.040	0.044	0.232	1366
	A1343	0.007	0.011	0.022	0.040	0.044	0.232	1366
	A1344	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1345	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1346	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1347	0.007	0.011	0.022	0.040	0.044	0.232	5006
	A1348	0.007	0.011	0.022	0.040	0.044	0.232	4229
	A1349	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1350	0.007	0.011	0.022	0.040	0.044	0.232	3717

	A1351	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1352	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1353	0.007	0.011	0.022	0.040	0.044	0.232	7099
	A1354	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1355	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1356	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1357	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1358	0.007	0.011	0.022	0.040	0.044	0.232	7099
	A1359	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1360	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1361	0.007	0.011	0.022	0.040	0.044	0.232	2948
	A1362	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1363	0.007	0.011	0.022	0.040	0.044	0.232	7099
	A1364	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1365	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1366	0.007	0.011	0.022	0.040	0.044	0.232	5006
	A1367	0.007	0.011	0.022	0.040	0.044	0.232	7099
	A1368	0.007	0.011	0.022	0.040	0.044	0.232	1366
Postlay 3rd phase	**A1601**	0.033	0.007	0.015	0.022	0.018	0.107	715
	A1602	0.033	0.007	0.015	0.022	0.018	0.107	417
	A1603	0.015	0.007	0.015	0.029	0.033	0.232	501
	A1604	0.033	0.007	0.015	0.022	0.018	0.107	715
	A1605	0.015	0.007	0.015	0.029	0.033	0.232	501
	A1606	0.015	0.007	0.015	0.029	0.033	0.232	1346
	A1607	0.015	0.007	0.015	0.029	0.033	0.232	715
	A1608	0.007	0.011	0.022	0.040	0.044	0.232	715
	A1609	0.033	0.007	0.015	0.022	0.018	0.107	1346
	A1610	0.033	0.007	0.015	0.022	0.018	0.107	417
	A1611	0.033	0.007	0.015	0.022	0.018	0.107	501
	A1612	0.033	0.007	0.015	0.022	0.018	0.107	417
	A1613	0.033	0.007	0.015	0.022	0.018	0.107	1200
	A1614	0.033	0.007	0.015	0.022	0.018	0.107	501
	A1615	0.033	0.007	0.015	0.022	0.018	0.107	501
	A1616	0.033	0.007	0.015	0.022	0.018	0.107	417
	A1617	0.007	0.011	0.022	0.040	0.044	0.232	1346
	A1618	0.015	0.007	0.015	0.029	0.033	0.232	1200
	A1619	0.015	0.007	0.015	0.029	0.033	0.232	417
	A1620	0.015	0.007	0.015	0.029	0.033	0.232	417
	A1621	0.015	0.007	0.015	0.029	0.033	0.232	1200
	A1622	0.015	0.007	0.015	0.029	0.033	0.232	1346
	A1623	0.015	0.007	0.015	0.029	0.033	0.232	2645
	A1624	0.015	0.007	0.015	0.029	0.033	0.232	442
	A1625	0.015	0.007	0.015	0.029	0.033	0.232	715
	A1626	0.015	0.007	0.015	0.029	0.033	0.232	1346
	A1627	0.015	0.007	0.015	0.029	0.033	0.232	1346
	A1628	0.015	0.007	0.015	0.029	0.033	0.232	1906

	A1629	0.015	0.007	0.015	0.029	0.033	0.232	501
	A1630	0.015	0.007	0.015	0.029	0.033	0.232	1906
	A1631	0.015	0.007	0.015	0.029	0.033	0.232	417
	A1632	0.015	0.007	0.015	0.029	0.033	0.232	501
	A1633	0.007	0.011	0.022	0.040	0.044	0.232	1121
	A1634	0.015	0.007	0.015	0.029	0.033	0.232	1121
	A1635	0.007	0.011	0.022	0.040	0.044	0.232	1121
	A1636	0.015	0.007	0.015	0.029	0.033	0.232	417
	A1637	0.015	0.007	0.015	0.029	0.033	0.232	1121
	A1638	0.007	0.011	0.022	0.040	0.044	0.232	1121
	A1639	0.015	0.007	0.015	0.029	0.033	0.232	417
	A1640	0.015	0.007	0.015	0.029	0.033	0.232	501
	A1641	0.007	0.011	0.022	0.040	0.044	0.232	1346
	A1642	0.007	0.011	0.022	0.040	0.044	0.232	417
	A1643	0.007	0.011	0.022	0.040	0.044	0.232	1346
	A1644	0.007	0.011	0.022	0.040	0.044	0.232	1346
Pipeline crossing	**A1031**	0.015	0.007	0.015	0.029	0.033	0.232	1700
	A1032	0.015	0.007	0.015	0.029	0.033	0.232	830
	A1033	0.015	0.007	0.015	0.029	0.033	0.232	830
	A1034	0.015	0.007	0.015	0.029	0.033	0.232	1700
	Frozen	0.015	0.007	0.015	0.029	0.033	0.232	13660
Tie-in		0.015	0.007	0.015	0.029	0.033	0.232	80000

The sediment characteristics (fluxes) for the alternative route – related to rock placement works activities are presented in Table 8-2. The major part of the intervention works for the alternative route is the same as for the route described above, but for the sections where there is an alternative in /6/, the intervention works for this is inserted.

Table 8-2: Rock placement for seabed intervention works (alternative routes) – calculated spill rates in kg/s and volumes in m³, /6/.

Seabed intervention type		Very fine sand (kg/s)	Coarse silt (kg/s)	Medium silt (kg/s)	Fine silt (kg/s)	Very fine silt (kg/s)	Clay (kg/s)	Rock berm (m^3)
Prelay	A1001 - A1018	Unchanged						
	ALT1_1001	0.015	0.007	0.015	0.029	0.033	0.232	2970
	ALT1_1002	0.015	0.007	0.015	0.029	0.033	0.232	3386
	ALT1_1003	0.033	0.007	0.015	0.022	0.018	0.107	6135
	ALT1_1004	0.033	0.007	0.015	0.022	0.018	0.107	6135
	ALT1_1005	0.015	0.007	0.015	0.029	0.033	0.232	1882
	ALT1_1006	0.015	0.007	0.015	0.029	0.033	0.232	1882
	ALT1_1007	0.015	0.007	0.015	0.029	0.033	0.232	2097
	A1021 - A1026	Unchanged						
	ALT2_1001	0.015	0.007	0.015	0.029	0.033	0.232	1882
	ALT2_1002	0.007	0.011	0.022	0.040	0.044	0.232	12381
	ALT2_1003	0.007	0.011	0.022	0.040	0.044	0.232	10673
	ALT2_1004	0.007	0.011	0.022	0.040	0.044	0.232	10673
	ALT2_1005	0.007	0.011	0.022	0.040	0.044	0.232	10673
	ALT2_1006	0.007	0.011	0.022	0.040	0.044	0.232	11954
Postlay 2nd phase	A1201 - A1269	Unchanged						
	ALT1_1201	0.015	0.007	0.015	0.029	0.033	0.232	10673
	ALT1_1202	0.015	0.007	0.015	0.029	0.033	0.232	3717
	ALT1_1203	0.015	0.007	0.015	0.029	0.033	0.232	3717
	ALT1_1204	0.015	0.007	0.015	0.029	0.033	0.232	338
	ALT1_1205	0.033	0.007	0.015	0.022	0.018	0.107	648
	ALT1_1206	0.033	0.007	0.015	0.022	0.018	0.107	2948
	ALT1_1207	0.033	0.007	0.015	0.022	0.018	0.107	7099
	ALT1_1208	0.033	0.007	0.015	0.022	0.018	0.107	4229
	ALT1_1209	0.015	0.007	0.015	0.029	0.033	0.232	3717
	ALT1_1210	0.015	0.007	0.015	0.029	0.033	0.232	7099

Seabed intervention type		Very fine sand (kg/s)	Coarse silt (kg/s)	Medium silt (kg/s)	Fine silt (kg/s)	Very fine silt (kg/s)	Clay (kg/s)	Rock berm (m^3)
	ALT1_1211	0.015	0.007	0.015	0.029	0.033	0.232	4229
	ALT1_1212	0.015	0.007	0.015	0.029	0.033	0.232	2948
	ALT1_1213	0.015	0.007	0.015	0.029	0.033	0.232	648
	ALT1_1214	0.015	0.007	0.015	0.029	0.033	0.232	4732
	ALT1_1215	0.007	0.011	0.022	0.040	0.044	0.232	7099
	ALT1_1216	0.007	0.011	0.022	0.040	0.044	0.232	7099
	ALT1_1217	0.007	0.011	0.022	0.040	0.044	0.232	3717
	A1273 - A1311	Unchanged						
	ALT2_1201	0.007	0.011	0.022	0.040	0.044	0.232	2948
	ALT2_1202	0.015	0.007	0.015	0.029	0.033	0.232	285
	ALT2_1203	0.015	0.007	0.015	0.029	0.033	0.232	7099
	ALT2_1204	0.007	0.011	0.022	0.040	0.044	0.232	2948
	ALT2_1205	0.007	0.011	0.022	0.040	0.044	0.232	10673
	ALT2_1206	0.007	0.011	0.022	0.040	0.044	0.232	1121
	ALT2_1207	0.007	0.011	0.022	0.040	0.044	0.232	5006
	ALT2_1208	0.007	0.011	0.022	0.040	0.044	0.232	2948
	ALT2_1209	0.007	0.011	0.022	0.040	0.044	0.232	5006
	ALT2_1210	0.007	0.011	0.022	0.040	0.044	0.232	10673
	ALT2_1211	0.007	0.011	0.022	0.040	0.044	0.232	2948
	ALT2_1212	0.015	0.007	0.015	0.029	0.033	0.232	7099
	ALT2_1213	0.015	0.007	0.015	0.029	0.033	0.232	2948
	ALT2_1214	0.015	0.007	0.015	0.029	0.033	0.232	285
	ALT2_1215	0.007	0.011	0.022	0.040	0.044	0.232	5006
	ALT2_1216	0.007	0.011	0.022	0.040	0.044	0.232	1121
	ALT2_1217	0.007	0.011	0.022	0.040	0.044	0.232	7099

Seabed intervention type		Very fine sand (kg/s)	Coarse silt (kg/s)	Medium silt (kg/s)	Fine silt (kg/s)	Very fine silt (kg/s)	Clay (kg/s)	Rock berm (m^3)
	ALT2_1218	0.007	0.011	0.022	0.040	0.044	0.232	7099
	ALT2_1219	0.007	0.011	0.022	0.040	0.044	0.232	5006
	A1345 – A1368	Unchanged						
Postlay 3rd phase	A1601 - A1627	Unchanged						
	ALT1_1601	0.033	0.007	0.015	0.022	0.018	0.107	19906
	ALT1_1602	0.033	0.007	0.015	0.022	0.018	0.107	501
	ALT1_1603	0.015	0.007	0.015	0.029	0.033	0.232	1346
	ALT1_1604	0.015	0.007	0.015	0.029	0.033	0.232	1200
	A1631 - A1638	Unchanged						
	ALT2_1601	0.007	0.011	0.022	0.040	0.044	0.232	1346
	ALT2_1602	0.015	0.007	0.015	0.029	0.033	0.232	1121
	ALT2_1603	0.015	0.007	0.015	0.029	0.033	0.232	1346
	ALT2_1604	0.007	0.011	0.022	0.040	0.044	0.232	1346
	ALT2_1605	0.007	0.011	0.022	0.040	0.044	0.232	1346
	A1643 - A1644	Unchanged						
Pipeline crossing		Unchanged						
Tie-in		Unchanged						

Table 8-3: Rock placement for in-service buckling mitigation – calculated spill rates in kg/s and volumes in m^3, /6/.

Section number	Very fine sand (kg/s)	Coarse silt (kg/s)	Medium silt (kg/s)	Fine silt (kg/s)	Very fine silt (kg/s)	Clay (kg/s)	Rock berm (m^3)	Number of rock berms
1	0.033	0.007	0.015	0.022	0.018	0.107	171.1	21
2	0.033	0.007	0.015	0.022	0.018	0.107	177.2	25
3	0.015 0.033	0.007 0.007	0.015 0.015	0.029 0.022	0.033 0.018	0.232 0.107	170.3	1 12
4	0.015	0.007	0.015	0.029	0.033	0.232	173.4	30
5	0.015	0.007	0.015	0.029	0.033	0.232	175.8	27
6	0.015	0.007	0.015	0.029	0.033	0.232	165.3	12
7	0.015	0.007	0.015	0.029	0.033	0.232	178.6	34
8	0.015 0.033	0.007 0.007	0.015 0.015	0.029 0.022	0.033 0.018	0.232 0.107	177.1	2 25
9	0.015 0.033	0.007 0.007	0.015 0.015	0.029 0.022	0.033 0.018	0.232 0.107	176.4	3 28
10	0.015	0.007	0.015	0.029	0.033	0.232	174.5	30
11	0.015	0.007	0.015	0.029	0.033	0.232	168.1	18
12	0.015	0.007	0.015	0.029	0.033	0.232	178.2	41
13	0.015	0.007	0.015	0.029	0.033	0.232	175.1	32
14	0.015 0.033	0.007 0.007	0.015 0.015	0.029 0.022	0.033 0.018	0.232 0.107	175.9	25 10
15	0.007	0.011	0.022	0.040	0.044	0.232	176.7	46
16	0.007	0.011	0.022	0.040	0.044	0.232	171.0	21
17	0.007	0.011	0.022	0.040	0.044	0.232	176.6	26
18	0.033	0.007	0.015	0.022	0.018	0.107	160.1	12
19	0.033	0.007	0.015	0.022	0.018	0.107	172.4	18
20	0.033	0.007	0.015	0.022	0.018	0.107	170.4	22
21	0.011	0.007	0.007	0.007	0.007	0.037	175.2	20
22	0.015	0.007	0.015	0.029	0.033	0.232	175.4	19
23	0.015	0.007	0.015	0.029	0.033	0.232	175.7	35
24	0.015	0.007	0.015	0.029	0.033	0.232	178.5	37
25	0.015	0.007	0.015	0.029	0.033	0.232	175.2	26
26	0.015	0.007	0.015	0.029	0.033	0.232	170.7	23
27	0.015	0.007	0.015	0.029	0.033	0.232	177.9	46
28	0.015	0.007	0.015	0.029	0.033	0.232	178.4	54
29	0.015	0.007	0.015	0.029	0.033	0.232	171.9	18
30	0.015	0.007	0.015	0.029	0.033	0.232	172.2	19
31	0.015	0.007	0.015	0.029	0.033	0.232	170.0	22
32	0.015	0.007	0.015	0.029	0.033	0.232	160.7	12
33	0.007	0.011	0.022	0.040	0.044	0.232	173.5	15
34	0.007	0.011	0.022	0.040	0.044	0.232	171.8	25
35	0.015 0.007	0.007 0.011	0.015 0.022	0.029 0.040	0.033 0.044	0.232 0.232	175.1	27 7
36	0.015 0.007	0.007 0.011	0.015 0.022	0.029 0.040	0.033 0.044	0.232 0.232	176.1	17 2
37	0.007	0.011	0.022	0.040	0.044	0.232	151.8	9

38	0.007	0.011	0.022	0.040	0.044	0.232	167.1	12
39	0.015 0.007	0.007 0.011	0.015 0.022	0.029 0.040	0.033 0.044	0.232 0.232	173.4	16 2
40	0.007	0.011	0.022	0.040	0.044	0.232	174.6	25
41	0.007	0.011	0.022	0.040	0.044	0.232	175.3	24
42	0.015 0.033	0.007 0.007	0.015 0.015	0.029 0.022	0.033 0.018	0.232 0.107	177.1	15 25
43	0.015	0.007	0.015	0.029	0.033	0.232	170.2	16
44	0.007 0.015	0.011 0.007	0.022 0.015	0.040 0.029	0.044 0.033	0.232 0.232	177.5	32 10
45	0.015 0.007	0.007 0.011	0.015 0.022	0.029 0.040	0.033 0.044	0.232 0.232	174.6	6 19
46	0.015	0.007	0.015	0.029	0.033	0.232	178	49

The fluxes for the alternative route for the in-service buckling mitigation sections are given in Table 8-4.

Table 8-4: Rock placement for in-service buckling mitigation works (alternative routes) – calculated spill rates in kg/s and volumes in m^3, /6/.

Section number	Very fine sand (kg/s)	Coarse silt (kg/s)	Medium silt (kg/s)	Fine silt (kg/s)	Very fine silt (kg/s)	Clay (kg/s)	Rock berm (m^3)	Number of rock berms
1- 26	Unchanged							
1001	0.015	0.007	0.015	0.029	0.033	0.015	174.7	32
1002	0.015	0.007	0.015	0.029	0.033	0.015	174.7	26
28 - 41	Unchanged							
1005	0.015	0.007	0.015	0.029	0.033	0.232	176.8	29
43 – 46	Unchanged							
1003	0.015	0.007	0.015	0.029	0.033	0.232	173.5	20
1004	0.015	0.007	0.015	0.029	0.033	0.232	176.3	20
1005	0.015	0.007	0.015	0.029	0.033	0.232	176.8	29
1006	0.015	0.007	0.015	0.029	0.033	0.232	168.7	9
1007	0.007	0.011	0.022	0.040	0.044	0.232	153.8	9

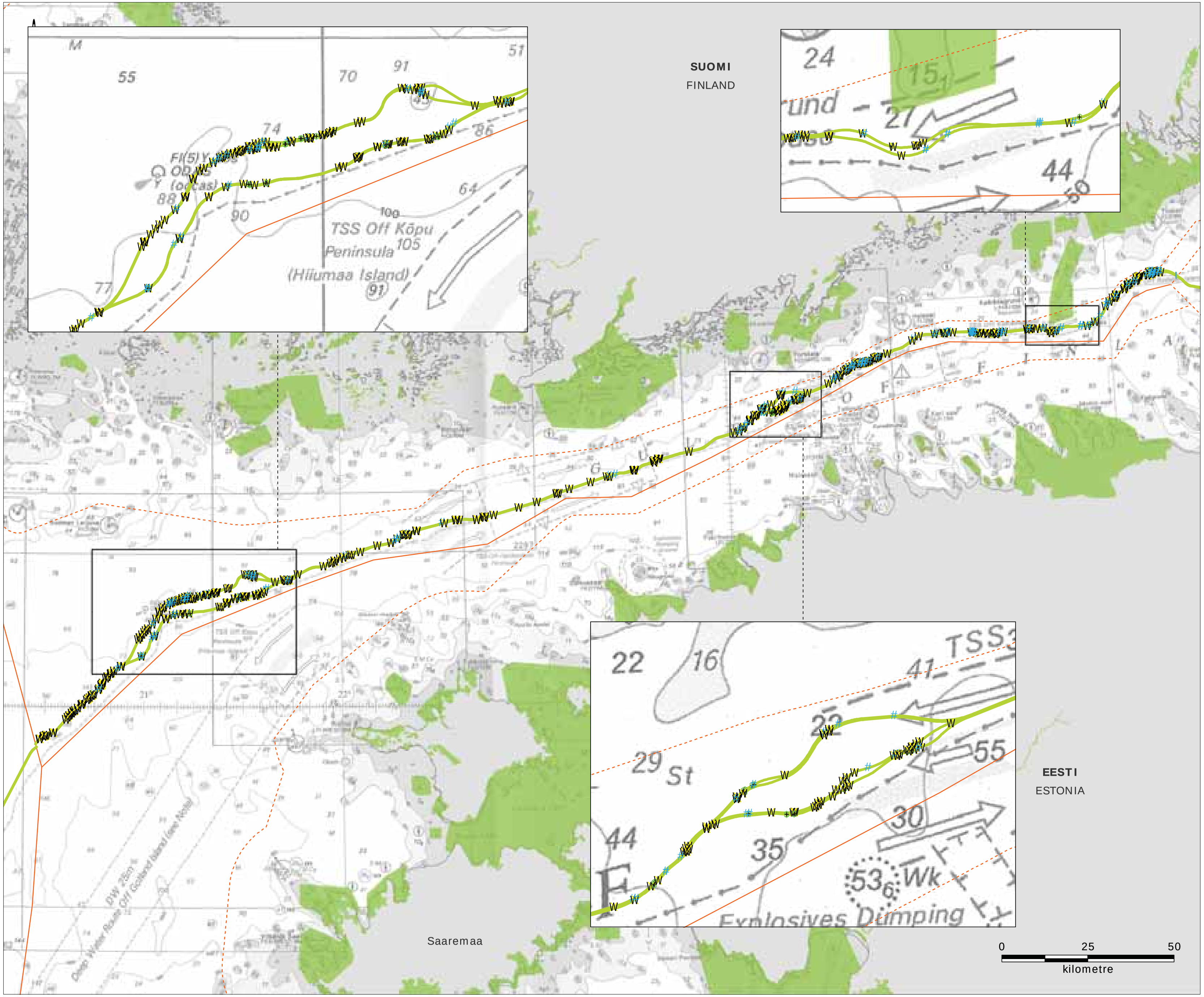
The sediment characteristics for the 24 locations are estimated and presented in Table 8-5.

Table 8-5 Munitions clearance locations and spill rates.

	Crater volume (m^3)	Very fine sand (kg/s)	Coarse silt (kg/s)	Medium silt (kg/s)	Fine silt (kg/s)	Very fine silt (kg/s)	Clay (kg/s)
SED1_1	20	0.826	0.413	0.826	1.651	1.857	13.002
SED1_2	42	1.734	0.867	1.734	3.467	3.901	27.304
SED1_3	20	0.826	0.413	0.826	1.651	1.857	13.002
SED1_4	42	3.901	0.867	1.734	2.600	2.167	12.569
SED1_5	20	1.857	0.413	0.826	1.238	1.032	5.985
SED1_6	42	3.901	0.867	1.734	2.600	2.167	12.569
SED2_1	20	0.826	0.413	0.826	1.651	1.857	13.002
SED2_2	42	1.734	0.867	1.734	3.467	3.901	27.304
SED2_3	20	0.826	0.413	0.826	1.651	1.857	13.002
SED2_4	42	1.734	0.867	1.734	3.467	3.901	27.304

SED2_5	20	0.826	0.413	0.826	1.651	1.857	13.002
SED2_6	42	1.734	0.867	1.734	3.467	3.901	27.304
SED3_1	20	0.826	0.413	0.826	1.651	1.857	13.002
SED3_2	42	1.734	0.867	1.734	3.467	3.901	27.304
SED3_3	20	0.826	0.413	0.826	1.651	1.857	13.002
SED3_4	42	1.734	0.867	1.734	3.467	3.901	27.304
SED3_5	20	0.826	0.413	0.826	1.651	1.857	13.002
SED3_6	42	1.734	0.867	1.734	3.467	3.901	27.304
SED4_1	20	0.203	0.305	0.610	1.118	1.220	6.403
SED4_2	42	0.427	0.640	1.281	2.348	2.561	13.447
SED4_3	20	0.203	0.305	0.610	1.118	1.220	6.403
SED4_4	42	0.427	0.640	1.281	2.348	2.561	13.447
SED4_5	20	0.203	0.305	0.610	1.118	1.220	6.403
SED4_6	42	0.427	0.640	1.281	2.348	2.561	13.447

APPENDIX 4
PLANNED SEABED INTERVENTION WORKS (PRE-LAY, POST-LAY AND PIPELINE CROSSING)



Legend:

- NSP2 Route
- Territorial water border
- EEZ border
- Natura 2000 site

Rock placement locations:

- Pre-lay
- Post-lay, 2nd phase
- Post-lay, 3rd phase
- Crossing

Version: 01
Date: 2016-09-15
Prepared: MSTB
Controlled: JAN

Appendix 4

Planned seabed intervention works (pre-lay, post-lay and pipeline crossing)

RAMBOLL