Chapter 6

Alternatives

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6.1 Route Alternatives

6.1.1 Introduction

Purpose

This Espoo Report is intended to inform the various national decisions on the Nord Stream Project. Under the terms of the Espoo Convention the developer is required to provide a description of “reasonable alternatives” to the proposed Project, including the alternative of taking no action (referred to in the Convention as the “zero-alternative"). The following chapter of the report fulfils this purpose.

In the context of the Nord Stream Project’s objectives, “reasonable” alternatives are the focus here. Because consent for the Project will be given by the competent authorities based in each country and under their respective national legislation, alternatives are discussed in relation to the waters of each country through which the route passes. Alternatives have hence been addressed individually within the respective national application documents.

Consideration of Alternative Routes and selection of the preferred route

The choice of the proposed pipeline route involved substantial research and has been a complex process stretching over the different project phases, from the feasibility studies between 1997 and 1999 through the conceptual design phase from 2000 to 2005, and the current phase of field investigation, further development and impact assessment. Selection of the preferred route has progressed alongside project design taking into account information and circumstances applying at each stage. Further information is provided in **Chapter 2.2**.

Over this period Nord Stream has dedicated significant resources to identifying an installation corridor that minimises potential environmental and socioeconomic impacts while providing an efficient, reliable, secure and affordable pipeline route. This has included a wide range of surveys and field studies: geophysical reconnaissance surveys during 2005, detailed geophysical, geotechnical and environmental sampling during 2006 and reconnaissance surveys in 2007. During 2008, development of the preferred route has been supported by detailed geophysical investigations, a geotechnical sampling programme and environmental sampling.

In the process of developing the preferred route the conducted surveys and investigations were evaluated against a set of comprehensive route selection criteria to provide a complete appraisal of the advantages and disadvantages of the respective alternatives. These selection criteria evaluate environmental, socioeconomic and technical criteria including pipeline safety – the latter one being the overriding concern:

- Environmental criteria – Route planning aimed to avoid crossing areas designated as “protected” or “environmentally sensitive” – areas hosting ecologically sensitive species of animal or plant life. A further goal was to minimise the extent of seabed intervention works and resulting environmental disturbance

- Socio-economic criteria – Route planning aimed to minimise any restrictions on marine users – those working in shipping, fishing, offshore industry, the military, tourism or recreation and with existing offshore installations, such as cables or wind turbines. Avoiding old munitions dumps and cultural heritage sites also falls within this category

- Technical criteria – Route planning primarily aimed to maximise the safety of pipeline construction activities and long term operations. Further goals were the reduction of construction time to minimise potential disruptions of other actives, minimisation of the technical complexity and potential impacts of the construction of the pipeline, reduction of the overall length reducing construction impacts and resource use required for the operation of the pipeline

In case one alternative shows an advantage over another as a result of the evaluation according to the outlined criteria, the respective route is considered to be the 'preferred' or 'proposed' route alternative.

Five pipeline route alternatives have been considered and evaluated in Russian, Finnish, Swedish, Danish and German waters. These are shown in **Figure 6.1** and are discussed in later sections of this chapter:

- North or south of Gogland, in Russian waters
  The northern route around the island of Gogland is proposed because it is furthest from any protected areas and proposed mineral extraction sites. It requires crossing of one existing cable, but no shipping lane and is shorter by 13 kilometres

- North or south of Kalbådagrund, in Finnish waters
  The southern choice is proposed because it has slight advantages, being technically less complex in requiring less seabed adaptation, and causing less effect on marine organisms

- East or west of Gotland and around Hoburgs Bank, in Swedish waters
  Around the island of Gotland, the eastern route is proposed because it avoids major shipping routes. It is also furthest from military and munitions sites, and is shorter. Around Hoburgs Bank, a route between the Natura 2000 area and a major shipping lane is

preferred, avoiding impact on any protected sites. An alternative further southeast would traverse the risk area associated with munitions dump sites as well as cod and sprat spawning grounds

- Around Bornholm, in Danish and German waters
  A southern route, the so-called “S-route”, is preferred around the island of Bornholm because it avoids the ship traffic lane north of Bornholm and has less impact on the environment. It also avoids several Natura 2000 areas. While being closer to the Pomeranian Bight, the route requires less seabed intervention and there are only three cable crossings

- Bringing the pipeline ashore at Lübeck, Rostock or Greifswald in Germany
  Of these, the last location is preferred early on. Greifswald is proposed for several reasons. The route passes through fewer Natura 2000 sites and requires much less seabed intervention work. This route is also shorter, requiring less construction time, thus minimising the duration and amount of disruption caused. Finally, the Greifswald coastal stretch has far less tourism and residential use

These route alternatives are shown in **Figure 6.1** and are discussed in detail in later sections of this chapter.

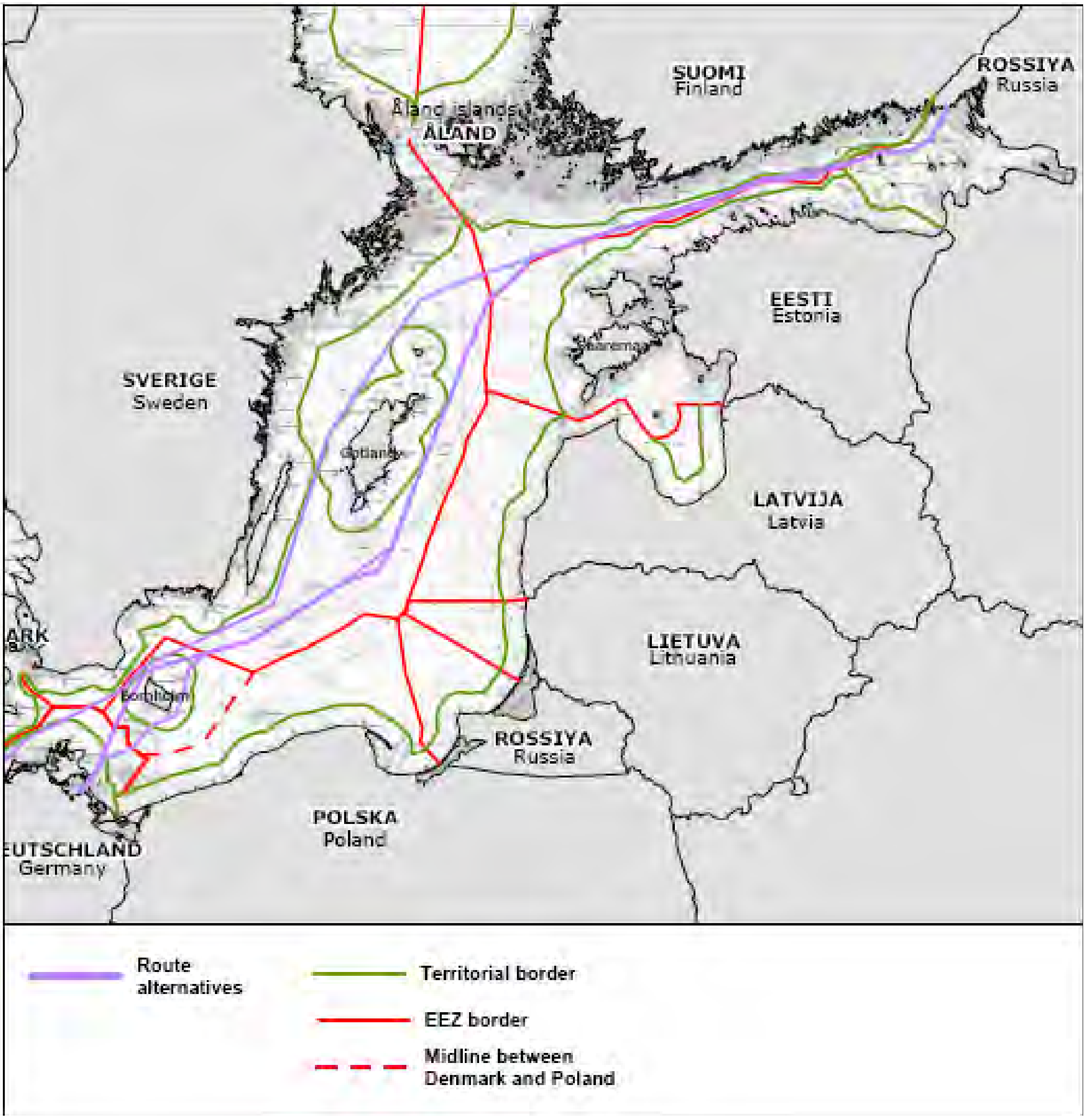


Figure 6.1 Route Alternatives

The purpose of this chapter is to describe the various route alternatives that have been considered in each country's waters, present the results of the appraisal of these alternatives and explain the rationale for selecting the preferred route including environmental reasons.

6.1.2 Route Alternatives Evaluation Methodology

Evaluation Criteria

In order to develop the Nord Stream Route, alternatives have been appraised against a number of objectives. Environmental objectives are key to the choice of preferred route but must be weighed up against other factors such as socio-economic costs and benefits, and technical aspects. The appraisal therefore takes into account environmental, socio-economic and technical objectives, and performance against each of these is measured using corresponding appraisal criteria. The objectives and criteria used for the three groups of factors are described in the following sections.

Environmental Criteria

A key consideration in appraising the various routing alternatives has been the potential environmental impacts that may result from the construction, installation or operation of the Nord Stream Project. A primary objective during the planning phase of the Nord Stream Project has been to minimise, as far as possible, any environmental impacts, through the selection of a route which aims to avoid particularly sensitive environmental baseline features such as protected areas, ecologically sensitive species and sensitive seabed features. The environmental appraisal criteria that have been used to assess and compare the various routing alternatives are summarised in **Table 6.1**.

Table 6.1 Summary of environmental appraisal criteria

Criteria	Description/project objective
Environmental criteria	
Environmentally sensitive areas/protected areas	Avoid crossing of or proximity to environmentally sensitive or protected/designated areas.
Ecologically sensitive species	Avoid crossing of or proximity to ecologically sensitive species of flora and fauna. For example sea grass habitats, marine mammals, feeding or breading areas of seal, or fish spawning/nursery grounds.
Seabed disturbance and sensitive seabed features	Minimise the extent of intrusive seabed works to minimise resulting environmental disturbance and avoid crossing or proximity to potentially sensitive seabed features that may support distinct ecological communities, such as cold water corals, sea mounts, canyons or areas of sensitive seabed substrate (e.g. cobbles or sand waves).

Environmentally sensitive areas

Protected areas in the Baltic Sea cover marine and coastal biotopes designated as:

- Natura 2000[1] sites
- Ramsar sites
- Baltic Sea Protected Areas (BSPA)
- UNESCO sites
- Protected areas in the Russian part of the Baltic Sea

The protection varies from strict legal protection (such as Natura 2000 sites) to recommendations of protection (e.g. Baltic Sea Protected Areas (BSPA)). In particular it should be noted that Natura 2000 sites form the centrepiece of EU nature and biodiversity conservation policy. These sites form an EU wide network of nature protection areas established under the 1992 Habitats Directive. The aim of the network is to assure the long-term survival of Europe's most valuable and threatened species and habitats. It is comprised of Special Areas of Conservation (SACs) designated by Member States under the Habitats Directive, and also incorporates Special Protection Areas (SPAs) which are designated under the 1979 Birds Directive. Any proposed development that may have a significant effect on a designated Natura 2000 site is required to be rigorously assessed to establish whether there will be a possible adverse impact on the site.

Areas within Russian territory are designated as a measure to strengthen the network of LIFE conservation areas.

In order to minimise any potential impacts to designated areas such as those listed above and protected areas under national law, both of which are likely to be more sensitive to environmental disturbance, the routing aims to avoid directly impinging on designated areas or passing in close proximity to such sites.

Ecologically Sensitive Species

The Baltic Sea is known to support certain marine species which in some areas may be considered particularly sensitive to potential impacts associated with the Nord Stream Project. These species include:

(1) Natura 2000 sites include Special Protection Areas (SPAs): areas conserving the birds listed in Annex 1 of the Birds Directive as well as migratory birds and Special Areas of Conservation (SACs): areas conserving the habitat types and animal and plant species listed under the Habitats Directive.

- *Fish species:* The Baltic Sea is home to a number of saltwater, brackish and freshwater species, which inhabit the innermost parts of the Baltic Sea and the coastal areas. The composition of coastal fish communities varies in the different regions of the Baltic Sea in relation to the different habitat characteristics of these regions, with salinity, water temperature, and nutrient availability being among the important factors. Fish in the Baltic Sea are subject to a number of anthropogenic impacts, such as enhanced nutrient loads, contamination by heavy metals, organic toxicants and hormone-like substances, destruction of recruitment habitats, introduction of non-native species, and increased fishing pressures. As a result, it has been recently recommended that 34 species should be considered as high priority for conservation, 70 species as medium priority, and 80 species as low priority on the HELCOM Red List of threatened and declining Baltic fish species(1). Areas of particular sensitivity will be those areas where fish species are known to spawn, migrate or develop as juveniles (nursery grounds). For example spawning and nursery grounds for certain fish species such as cod, herring and sprat have been identified in the Baltic Sea and eels are known to migrate through certain areas of the Baltic Sea

- *Marine mammals:* Compared with the open ocean, the Baltic Sea does not support a large number of marine mammal species. There are no great whales, and the only resident cetacean species is the harbour porpoise. The harbour porpoise is listed as a protected species in the EC Habitats Directive (Annexes II and Annexes IV) and in the Bern Convention (Appendix II). It is furthermore listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Although they are not native to Baltic waters, species such as the minke whale, short-beaked and white-beaked dolphins are known to occur infrequently in the Baltic Sea. There are three resident species of seals: the grey seal, the ringed seal and the harbour seal, all of which are listed as protected species under Appendix II and Appendix V of the EC Habitats Directive as well as Appendix III of the Bern Convention

- *Bird Species:* There are numerous seabird colonies in the Baltic Sea, with more than 30 species breeding along its shores. The seabirds comprise surface feeding species such as gulls and diving birds such as auks, as well as benthic-feeding species, such as dabbling ducks, sea ducks, mergansers and coots. Benthic feeding species comprise at least 75 % of the Baltic Sea winter bird fauna. It is noticeable that relatively few species groups prefer the more open and deeper basins of the Baltic Sea. However, sections of the pipeline which run through Ecological Sub Region (ESR) I (shallow Gulf of Finland) and ESR IV (Greifswalder Bodden) are characterised by shallow water and a high abundance of benthic-feeding seabirds. For details on the concept of ESRs please refer to **Chapter 8**. The distribution of seabirds within the shallower areas is not uniform. In general the lower sub-littoral, the offshore banks and the lagoons are most important to wintering seabirds,

(1) Helsinki Commission. 2007. HELCOM red list of threatened and declining species of lampreys and fishes of the Baltic Sea. Baltic Sea Environmental Proceedings No. 109.

while the biologically impoverished littoral zone is typically of lower importance to birds. Human activities also introduce variations in the distribution of seabirds in the shallower areas due to disturbance from ship traffic in proximity to shipping lanes and harbours

Marine species such as those identified above may be particularly sensitive to impacts associated with the Nord Stream Project; for example marine mammal species can be sensitive to underwater noise. Therefore, as far as is reasonably practical (bearing in mind that many of these species are significantly mobile), the route alternatives have been designed to avoid areas that are known to support sensitive species. These include, for example, fish spawning areas or areas known to be marine mammal feeding grounds.

Seabed disturbance and sensitive seabed features

Seabed substrates in the Baltic are principally fine-grained sands with varying silt content, different types of mud or exposed mineral bed with residual sediments. Where the seabed is uniform and offers a sound base for the pipeline, little intervention is required to lay the pipeline. In other areas special measures such as rock deposit, may be required to span uneven floor conditions, or traverse over or around seabed features. It may also be necessary to bury the pipeline for protection or to lay material such as gravel to create a stable foundation in areas of poor load bearing. These activities are all more likely to lead to adverse impacts, due to pollution and disturbance, than pipe-laying in uniform stable conditions is.

In addition, some specific seabed features are of environmental importance because of their distinct character or the ecological communities they support. These include coral mounds, canyons, rock outcrops or areas of sand waves which could be damaged if the Nord Stream pipelines were to be placed directly over them.

Therefore, as far as is reasonably practical, the route alternatives have been developed to minimise the requirement for seabed works and to avoid any specific seabed features that may be more environmentally sensitive than the surrounding area. This objective aligns with the technical criteria relating to minimising seabed intervention works and ensuring safety of the pipeline, as seabed features, in most cases, represent a potential hazard or complication to pipeline installation. This is due to the fact that the pipe-laying will require rock dumping or other forms of intervention.

Socioeconomic Criteria

A further consideration in appraising the various route alternatives has been the potential adverse socioeconomic impacts that may result from the construction, installation or operation of the Nord Stream Project. The overall objective during the planning phase of the Nord Stream Project has been to minimise, as far as reasonably practical, any significant adverse socioeconomic impacts through selection of a route that aims to avoid areas that are heavily used for other marine activities (e.g. shipping, fishing, tourism etc.) or sites that are particularly sensitive, such as ship wrecks. The socioeconomic appraisal criteria used to assess and compare the various routing alternatives are summarised in **Table 6.2.**

Table 6.2 Summary of socioeconomic appraisal criteria

Criteria	Description/project objective
Socioeconomic criteria	
Shipping traffic activity	Minimise interaction with zones/areas of known shipping activity, e.g. shipping lanes and anchorages.
Existing cable/pipeline routes	Minimise requirement to cross or work in close proximity to existing underwater cables or pipeline, e.g. telecom and power cables.
Marine user activities	Avoid crossing of or close proximity to areas of active marine use (e.g. fishing, dredging, military activity, marine renewables and tourism).
Munitions risks	Avoid crossing or close proximity to areas of known munitions risk.
Cultural heritage sites/areas	Avoid crossing of or close proximity to areas or sites of cultural heritage, such as wrecks/marine archaeology

Shipping traffic activity

The Baltic Sea is one of the busiest seas in the world and provides the only connection to ship traffic for the vast majority of the countries surrounding the Baltic. The Nord Stream pipelines run through the Baltic Sea and therefore both cross and run adjacent to many of the main ship traffic routes. Fourteen primary shipping routes have been identified in the vicinity of the Nord Stream Routing alternatives. The routes identified have traffic levels that range between approximately 800 and 65,000 movements per year.

Pipelines can cause disruption to commercial shipping during installation (e.g. if ships have to divert to avoid the pipe laying works) and may increase the risk of vessel collisions. In addition, if the pipeline were to be situated in an area used as an anchorage, there may be an increased risk that the pipelines (once laid) could be damaged by vessel anchors with potential for adverse consequences for pipeline and ship operations and for the environment.

Therefore, a key consideration in developing the route alternatives has been the avoidance of known shipping lanes and anchorages so as to minimise the potential for any disruption to shipping or increased risk of accidental vessel collisions or pipeline damage.

Cables/pipeline

A number of telecommunications and power cables are laid on the bottom of the Baltic Sea, and several of them will be crossed by the route. While it is technically feasible to safely cross existing cables or pipeline it is desirable to avoid having to do so in order to reduce complexity during installation, associated impacts on schedule and potential environmental impact.

Marine user activities

In addition to the specific uses of the marine environment in the Baltic Sea such as shipping and pipeline, there is a range of marine activities which will take place in specific areas of the Baltic that have influenced the route alternatives. These include the following.

Fishing: Cod, herring and sprat are the most commercially important species, comprising around 90-95% of the total weight of commercial catches in the Baltic Sea. Outside coastal areas, trawls are the main gear type used in the Baltic Sea. Mid-water trawls are used to capture herring and sprat, and bottom trawls are used for cod and flounder. Large-scale beam trawling for benthic fish, mainly flatfish, is not thought to be widely practised in the Baltic Sea, although it is not legally prohibited. The absence of beam trawlers is a result of the fish community structure in the Baltic Sea, which is dominated by pelagic species. Specifically in relation to both bottom and mid-water trawling, certain areas of importance have been identified along the Nord Stream Route alternatives - these are mainly located in the southern Baltic Sea. It should be noted that the Nord Stream Project will be constructed in such a way that allows trawling activity over the pipeline, although there will be some areas with structures (e.g. rock-piles) that prohibit trawling.

Military use: The Baltic Sea has been of significant strategic naval importance and continues to be so today. Hence, there are several designated areas in the Baltic Sea where military exercises frequently take place. The pipe laying work will be coordinated with national defence forces to ensure that the construction of the Nord Stream Project does not interfere with any planned military exercises, but avoidance of these areas would be preferred.

Marine renewables: There are no existing offshore wind parks in operation near the Nord Stream Route alternatives, but various countries have given permission for the construction of offshore wind parks in the vicinity of the Nord Stream Route alternatives or have designated areas of interest for wind parks. The pipelines could interact adversely with development of marine renewables and avoidance of these areas is therefore preferred.

Dredging: The seabed of the Baltic marine area is extremely varied with regard to both topography and sediment distribution. Marine sediments can represent valuable raw-material resources, especially for construction purposes. Several countries around the Baltic Sea have interest in extracting marine sediments. Most exploration of sediments occurs in shallow water depths of less than 20 m because the cost of suitable dredging equipment increases with increasing water depth and the cost of transportation increases with the distance from the coast.

Marine dredging for aggregates is not therefore expected to be widespread in the area of the Nord Stream Route alternatives but there may be interaction with areas that are designated for dredging in the future or are known to contain aggregates that could be a target for dredging. If this were the case then the presence of the Nord Stream Project could disrupt future dredging activities and avoidance of these areas is therefore preferred.

Tourism: Tourism is an important economic activity along the Baltic coast, even though there are no mass tourism sites in the region. Most visitors are domestic or from neighbouring countries, though international cruise ship visits are increasing. The main areas of tourist activity are the islands in the Baltic Sea and coastal zones. Tourism in the coastal areas is highly seasonal due to the weather conditions, with high season during the summer holidays. The main attractions and activities are leisure boating, bathing and summer cottages along the coastal areas. In the summer, the islands and archipelagos attract many sailboats.

The route alternatives have been required to take account of all the above activities, as most could be disrupted by either the installation works or the long term presence of the Nord Stream Project. This could potentially have a secondary socioeconomic impact. The disruption to fishing could for example impact the livelihood of fishermen. In addition some of these activities have the potential to cause damage to the Nord Stream Project should they occur in the same area, for example aggregate dredging would represent a clear safety risk to the Nord Stream Project. Therefore, as far as reasonably practical, the route alternatives have aimed to minimise the potential for conflict of uses in the marine environment.

Munitions

The dumping of munitions at sea has historically been a convenient way of destroying munitions that no longer have any military value. The Baltic Sea has been used as a dumping ground for conventional and chemical munitions during and subsequent to both World War I (WWI) and World War II (WWII). In particular, the Baltic Sea was used as dumping ground for chemical munitions left over from WWII. The Baltic Marine Environment Protection Commission (Helsinki Commission) addressed the issue of chemical weapons in the Baltic Sea at the 16th Meeting of the Helsinki Commission in 1994. The report concluded that approximately 40,000 tonnes of chemical munitions, containing approximately 13,000 tonnes of chemical warfare agents had been dumped in the Baltic Sea. It was estimated that 11,000 tonnes of chemical warfare agents were dumped at a dumping site east of Bornholm and 1,000 tonnes were dumped south-east of Gotland. Different munitions risk zones have been established:

- Zone 1 is the actual dumping site. Fishing activity is prohibited in this area
- Zone 2 is an extension of the dumping site, defined because the circular dumping area was not fully respected during disposal of the munitions. Fishing is prohibited in this area

- Zone 3 is a wider area defined because munitions can be found here. Fishing vessels in this area are required to be equipped with gas and first aid equipment

One major objective has therefore been to avoid areas that are known to contain munitions and to minimise the crossing of lower risk zones. In areas, where munitions zones could not be avoided, the Nord Stream Project has carried out detailed survey works in order to identify specific risks from munitions.

Cultural heritage

Cultural heritage can largely be defined as the record of past and present human activity. It must be recognised that cultural-heritage resources are finite and non-renewable; each site may contain information that is both unique and previously unknown.

The maritime cultural heritage in the Baltic Sea primarily consists of two broad categories of underwater sites: shipwrecks and submerged settlements/landscapes.

Shipwrecks: Shipwreck sites reflect a diverse group of vessels that vary in age, size and type. Some shipwrecks are of no cultural interest, whereas others are of importance for one reason or another such as war graves or historic ships. The integrity of shipwreck sites depends on a number of factors, in particular the manner in which the vessel was wrecked, the conditions on the seabed and later disturbances.

Landscapes: Changing sea levels caused some former land areas to be submerged (particularly in the southern part of the Baltic Sea), thus also submerging human settlements, monuments and the landscapes around them. The preservation of submerged settlements is in many cases far better than that of sites on dry land. Organic materials in particular may be preserved in a fine state. Submerged settlements therefore represent a unique opportunity to gain knowledge of former ways of living. The submerged landscapes are also important for investigating the development of the Baltic Sea and the living conditions of people in the area.

There are a number of wreck sites and areas of possible presence of submerged Stone Age settlements in the study area. The largest number of wreck sites is encountered within Finnish and Danish waters. The possible presence of submerged settlements is connected to relatively shallow waters in the southern part of the Baltic Sea. Sites on or in very close proximity to the route risk being damaged by the pipeline itself or by seabed intervention works during the installation process. Proper care during installation of the Nord Stream Project can avoid impacts on sites nearby including placing anchors away from sites within the anchoring corridor, but sites in the immediate path of the preferred route will be exposed to potential damage.

Technical Criteria

A further element in appraising the route alternatives has been the technical considerations that must be taken into account in developing the preferred route. Alongside protection of the environment, the other primary objective of the Nord Stream Project has been to ensure the integrity of the pipeline. Other technical factors which also need to be considered are the feasibility of building and operating the pipeline and the overall time required for the construction and installation, the extent of seabed intervention works and the length of the pipeline. The technical appraisal criteria that have been used to assess and compare the route alternatives are summarised in **Table 6.3.**

Table 6.3 Summary of technical appraisal criteria

Criteria	Description/project objectives
Technical Criteria	
Risk and Safety	Maximise the safety of pipeline construction activities and long term operations.
Construction time	Minimise the period required for the construction activities (during which there will be increased potential for other impacts to occur e.g. disruption to fishing).
Technical feasibility and seabed intervention works	Minimise the technical complexity and potential impacts of the construction of the pipeline, as well as level of activity and resource use required (e.g. requirement for pipeline trenching, rock dumping etc.)
Overall length	Minimise potential construction impact and complexity and resource use require for the operation of the pipeline.

Risk and safety

A key factor in developing the route alternatives has been safety considerations. This includes factors such as avoidance of areas which have a high shipping traffic activity, areas with munitions-related risks and areas where trawling or dredging may occur (see socioeconomic criteria above).

Any areas that are deemed to represent a significant safety risk to the Nord Stream Project (during either installation or operation) have been avoided in the pipeline routing. It should be noted that safety is a key criteria for the Nord Stream Project and carries a significant weighting among the factors considered.

Construction time

There is an advantage to the Nord Stream Project in minimising the time required to install the pipeline as it is likely to reduce overall environmental impacts. Environmental impacts of a shorter construction time are related to minimising the time required for installation of the pipeline, which is likely to reduce impacts such as vessel emissions and discharges. Therefore a consideration in the development of route alternatives has been the likely timescale required for construction. It should be noted that construction time is largely a reflection of overall pipeline length and technical complexity, i.e. the shorter and simpler the route, the quicker it will be to install.

Technical feasibility and seabed intervention works

A further consideration in developing the route alternatives has been the technical feasibility of designing, installing and operating the Nord Stream Project. The objective has been to develop a route that minimises technical complexity. This principally means the avoidance of seabed intervention works. Intervention works are necessary at points where the pipelines require additional stability or support to ensure technical integrity, as opposed to simply installing the pipeline directly onto the seabed. For example, in areas where the pipeline is subject to ‘spans’ there will be a requirement to deposit rock as support on the seabed to minimise the unsupported span of the pipeline. In areas where the pipeline may be at risk of impacts from activities such as fishing or vessel anchors it may be necessary to bury the pipeline below the seabed using trenching or ploughing techniques.

Therefore a consideration in the development of route alternatives has been the likely requirement for seabed intervention works, the objective being, as far as reasonably practical, to reduce the number and extent of locations at which seabed intervention works will be necessary.

Overall length

An additional technical consideration in the development of route alternatives has been the overall length of the pipeline. While it is desirable for the pipeline to avoid certain areas of the Baltic Sea that may be unsafe, environmentally sensitive, or used heavily for other marine activities, it is also an objective to keep the overall length of the pipeline to a minimum. Keeping the route shorter, keeping in mind the above mentioned factors, usually yields environmental benefits. It should be noted that the overall length of the pipeline has only been considered as a relevant appraisal criterion where there are no clear differentiating environmental and socioeconomic criteria.

Sources of Information

Application of the criteria described above in an informed manner depends on the availability of "'baseline" information that identifies the relevant environmental, socioeconomic or physical features that could be affected by the various route alternatives. The information used has been collected from literature research, engagement with organisations in the different countries concerned including government authorities, academic institutions and research establishments and with experts from the Baltic Sea states, and studies conducted in the different project phases, in particular, the results from the geophysical and environmental surveys carried out in 2005 – 2008. For more information regarding surveys please refer to **Chapter 8**.

Geophysical surveys: Geophysical surveys have been undertaken to map the bathymetry (water depth and morphology), seabed conditions and the geological layering under the seabed surface. In principle, the best route would be the shortest possible connection between Vyborg in Russia and Greifswalder Bodden in Germany, however, the seafloor is not a flat featureless plain, but has a varying morphology with rocky outcrops, cliffs, trenches etc. Because the pipeline is relatively inflexible and cannot twist and turn to avoid such obstacles, careful mapping of the seafloor is needed to identify feasible routes for the Nord Stream Project and to reduce seabed intervention works to a minimum. A series of geophysical surveys have been undertaken in the period 2005 – 2008 and where results have indicated the need for more detailed surveys, these have been undertaken.

Geotechnical surveys: A series of geotechnical surveys have been undertaken to determine seafloor stability along potential routes for the pipeline. During 2006, detailed geotechnical testing and sampling took place along the all the route alternatives identified at that stage of the project. All geotechnical investigations have been performed according to the same scope of work.

Munitions Surveys: To rule out risks associated with unintentional encounters with munitions lying on the seafloor, extensive surveys have been performed, to determine where the pipeline or the environment could be compromised by the presence of chemical or conventional munitions. In spring 2007, Nord Stream commissioned the development of a new instrument that could screen pipeline corridors for metallic objects. The gradiometer is attached to a ROV that is operated from the survey vessel. The munitions surveys were undertaken during 2007/2008 along the all the route alternatives identified at that stage of the project. The munitions surveys were carried out simultaneously with the geophysical investigations.

Cultural heritage surveys: Surveys have been undertaken along the Nord Stream Route alternatives to look for archaeological artefacts. The identification of cultural heritage resources has been based on interpretation of side scan sonar and sub bottom profile data collected for the geophysical surveys. The resolution of the side scan sonar data from the 2007/2008 surveys has been significantly higher than the earlier surveys and therefore a better identification of wrecks has been possible during the later survey operations. Alternative routes were also investigated. In case information is missing this is indicated in the relevant route appraisal chapters.

Environmental field investigations: A range of environmental field investigations have been carried out in the period 2005 – 2008 to collect physical, chemical and biological data on the marine environment including sampling of water, seabed sediments, plankton (phyto- and zooplankton), macrozoobenthos (fauna living on the seabed), fish and marine mammals and birds. The environmental field investigations were primarily concentrated within a 2000 m wide corridor along the all the route alternatives identified at that stage of the project.

Appraisal of Route Alternatives

The environmental, socio-economic and technical performance of each route alternative has been consistently appraised against the criteria described above and the results have been used to inform selection of the preferred route. The appraisal has been carried out using a qualitative rather than quantitative methodology (i.e. not using numerical scoring or weighting). This has involved applying the expert professional judgment of the Project team to appraising performance against individual environmental, socio-economic and technical criteria and then determining which route is likely to perform best on balance across all the criteria.

For each route alternative within a section, the potential for adverse impact has been recorded using a simple grading and colour coding system (minor to major) in relation to each environmental and socio-economic criterion. This is illustrated in **Table 6.4** with reference to potential impact on seal breeding areas as an example illustrating the methodology used.

Table 6.4 Example of appraisal levels

Potential impact	Matrix shading
Minor	*For example:* The pipeline route is not located in proximity to any seal breeding areas.
Moderate	*For example:* The pipeline route passes near but not through a seal breeding area.
Major	*For example:* The pipeline route passes through a seal breeding area.

In order to allow comparison between route alternatives, the results are presented in a comparative appraisal matrix as illustrated in **Table 6.5**. The grading provides an easy visual representation of the relative merits of route alternatives within the particular section of the route. It must however be emphasised that the grading system is not designed to be used in a quantitative manner, for example by allocating scores and summing them to appraise the overall performance of a route.

Careful inspection of the example matrix presented in **Table 6.5** would lead to the conclusion that route alternative A is preferred because of its avoidance of designated sites, sensitive species, and shipping and cable routes, and its lesser need for seabed intervention. It is slightly longer and passes close to a munitions area but these factors are not considered to outweigh its other advantages.

Table 6.5 Example of completed appraisal matrix

Criteria	Route Alternative (A)	Route Alternative (B)
Environmentally sensitive / protected areas	The pipeline route is not located in proximity to any designated sites	The pipeline route passes within 5 km of a Natura 2000 site.
Ecologically sensitive species	Route passes near but not through seal breeding area.	Route passes through seal breeding area.
Seabed disturbance and sensitive seabed features	No sensitive features	No sensitive features. Slightly more seabed disturbance required
Shipping traffic activity	Route does not pass through any shipping routes.	Route passes through one shipping lane with low traffic activity.
Existing cable / pipeline routes	Requires one cable crossing	Requires 3 cable crossings
Marine user activities	No sensitive marine uses	No sensitive marine uses
Munitions risks	Passes close to munitions risk area	Avoids munitions risks
Cultural heritage sites / areas (e.g. wrecks, marine archaeology)	Several known wrecks near the route	No known wrecks but identified as an area of significant potential
Risk and safety	Greater risk from munitions	Greater risk from shipping
Construction time	No significant difference expected	No significant difference expected
Technical feasibility and seabed intervention works	Lesser requirement for intervention	Small requirement for seabed intervention
Overall length	5km longer	5 km shorter

6.1.3 The Zero-Alternative

Introduction

Appendix II (b) of the Espoo Convention requires a description of the “no-action alternative” (Zero-Alternative) to be provided “where appropriate”. The "Zero Alternative" means not realising the project – this has to be distinguished from potential "Other projects" which are described in **Chapter 2.3.5** "Consequences in case of non-implementation of the project".

It is obvious that the environment in the area of a proposed project would be less affected if a proposed project was not realised, as the environmental impairment due to the occupation of the site, the construction and operation process, the necessary transport movements, emissions, noise, visual impairment etc. would not occur. On the other hand, a project will usually have positive economic, social or societal impact by creating employment, bringing benefits in the form of economic development, profits, taxes, supply chain activities, facilitating communications or, as in the case of a gas or oil pipeline, supplying energy. Sometimes a project may have also a positive contribution to the overall environment, e.g. by contributing to reducing emissions. The consideration of a zero alternative cannot, therefore, limit itself to balancing the environmental aspects of realising a project or not realising it but must consider the overall balance of advantages and disadvantages.

Due to the general objective and structure of the environmental impact legislation, an examination of the zero alternatives serves to prepare the administrative decision on the proposed project. The description of the zero alternative serves the purpose of informing the authorising authorities of the consequences of a refusal to authorise the project. The Espoo Report must therefore discuss all the consequences of such a refusal, including economic, social and societal consequences.

Consequences of a Refusal of any one Permit

Nord Stream will apply for various national permits for constructing and operating the gas pipelines. The rejection of any of these permit applications will result in the fact that the pipeline may not being constructed. This will have various consequences, which need to be considered.

Environmental consequences

As already indicated above, the environment in the area of the proposed project, in general, will be less affected when a project is not realised, as the environmental impairment would not occur. In fact, none of the environmental effects as set out in detail within the various application documents would occur.

The environment will, however, not remain unchanged and the following paragraphs discuss two areas where environmental conditions of the Baltic Sea area are likely to change in the future: water quality and climate change. Water quality has a significant influence on the chemical and biological nature of the sea and can have dramatic effects on biodiversity within such a water body. Changes to the climate have also been seen to affect environmental conditions throughout the world in a significant and potentially irreversible way. Nord Stream's environmental impact has to be considered in the context of these trends caused by other activities taking place in the region.

Water quality: There are two important aspects of water quality that may change the Baltic Sea in the long term: nutrient levels and pollution levels.

The input of nutrients into the Baltic Sea has doubled over the last decade making the Baltic Sea more eutrophic. Sources of nutrients include: direct atmospheric deposition on the Baltic Sea water surface; riverine inputs of nutrients to the sea, diffuse sources mainly originating from agriculture; and natural background sources such as erosion. Increased nutrient levels encourage phytoplankton and cyanobacteria blooms which decrease water transparency and create lower oxygen levels. Over the last 100 years, summertime water transparency has decreased in all Baltic Sea sub-regions although this decreasing trend has levelled out over the past 10-15 years.

Pollutants introduced into the Baltic Sea can be divided into organic or inorganic pollutants. Inorganic pollutants include heavy metals. Concentrations of heavy metals have decreased since the 1980s as their use in many products such as anti-fouling paints have been banned. Organic pollutants include biodegradable organic matter from sewage discharges, oils and materials such as pesticides. There have been substantial inputs of organic pollutants into the Baltic Sea for the past 50 years but several organic pollutants, notably certain organochlorine pesticides, such as DDT and technical-grade hexachlorocyclohexanes (HCH isomers), have been completely banned since the 1980s causing a substantial decrease in their concentrations in the Baltic Sea.

The trends outlined above will cause large scale changes to water quality in the Baltic Sea which in turn will cause changes to the composition and abundance of flora and fauna in the Baltic Sea. The Nord Stream Project will implement a Waste Management Plan to minimise nutrients and other pollutants from entering the Baltic Sea as a result of the Project.

Climate change effects on water temperature and rainfall: As a result of climate change, the Earth’s average surface temperature has risen by 0.76°C since 1850 and is expected to rise by a further 1.8-4.0°C by the end of this century. Nord Stream commissioned a report by the Swedish Meteorological and Hydrological Institute (SHMI) which analysed the impact of the expected climate change on the Baltic Sea during the 21st century. Average sea surface temperatures in the Baltic Sea may rise by 2-4°C by the end of the 21st century resulting in a 50-80 percent decrease in ice cover.

Annual precipitation is expected to increase in the northern parts of the Baltic Sea with alterations to geographic and seasonal precipitation patterns. The southern areas of the Baltic

Sea are expected to become much drier than northern areas, particularly during the summer. These changes will affect runoff from the surrounding land into the Baltic Sea: annual river flow in the north will potentially increase, whereas in the south it is expected to decrease. Overall annual precipitation is expected to be higher for the Baltic Sea. Increased runoff and increased mean wind speeds may also cause a lowering of salinity within the Baltic Sea with knock-on effects on the marine ecosystem.

Climate change is occurring on a global scale as a result of emissions to the atmosphere since the industrial revolution. The Nord Stream Project will add to these emissions but the zero-alternative would not offer a significant benefit since other alternative means of transporting gas would be required that would be likely to cause similar or greater emissions.

In conclusion, significant changes are occurring to the environment which will have long term effects on the Baltic Sea. These changes will have much greater consequences for the environment than impacts from the Nord Stream Project and are currently being addressed by the EU and individual member states.

Economic consequences

The most important economic activities in the Baltic Sea are fishing, shipping and tourism. These activities are constantly changing in response to political, industrial and social pressures. The current levels of these activities, as well as factors that might cause future changes in these activities are discussed below with reference to the zero-alternative.

Fishing: Commercial fisheries are an important economic and cultural activity for many countries which have access to the Baltic Sea. Fishing is not only an important source of food but is often seen as part of the national identity of the countries that border the Baltic Sea. Commercial fisheries are valued at €262 million each year for the entire Baltic Sea. The fishing industry is strongly affected by changes to the fish stock and legislative control of the fishing fleets. Recruitment to fish stocks is affected by factors such as water temperature, plankton levels, predation and pollution. These factors are likely to have a larger impact on fisheries compared to the Nord Stream Project.

Shipping: The Baltic Sea is a heavily trafficked area with 14 major shipping routes with a current level of 800 to 65,000 movements a year. Between 2006 and 2016, the number of tanker movements is expected to increase by 20 percent whereas all other ship movements are expected to stay at the same level.

The level of shipping activity in the Baltic Sea is heavily dependent on the economic activity of the Baltic States. The Baltic Sea is already busy with shipping activity which is strictly regulated to prevent interactions between vessels. Although the Nord Stream Project requires the crossing of shipping lanes at several sections of the pipeline route during the construction phase, the route attempts to avoid heavily trafficked areas. Nord Stream will implement appropriate procedures to prevent interference during the construction phase and the Nord Stream Project will not have long term impacts on shipping.

Therefore, if the Nord Stream Project is not realised, the relative benefit would not be significant, since the reduction in shipping traffic would only be minor.

Tourism and recreational activities: Tourism is an important economic activity for all the Baltic States and accounts for over 2 percent of the national GDP for Estonia, Finland, Sweden and Denmark. In Russia and Germany, tourism is expected to grow in the future Tourism also plays an important role in all other states around the Baltic Sea, such as Poland, Latvia and Lithuania. In many of the Baltic States, tourism is constrained by a lack of development of tourism infrastructure, although a higher level of investment and cooperation between different states is quickly changing this situation. For example, Finland registered a 6 percent growth in the number of foreign tourists from 2005 to 2006. Similar growth is observed across many of the Baltic States. The changes occurring in tourism and recreational activities across the Baltic Sea are large scale, whereas the Nord Stream Project is expected to have short term, minor impacts on tourism in the Baltic Sea.

Socioeconomic consequences

The Nord Stream Project will require a large workforce to be employed in the manufacture, construction and operation of the pipeline and the associated infrastructure. The offshore construction works will require considerable provision of supplies through vessels from onshore supply bases.

The Nord Stream Project will support subcontractors in the creation of jobs in:

- Russia and Germany to manufacture the pipes
- Finland, Sweden and Germany for weight coating plants and interim stockyards
- The zero-alternative will prevent these employment and investment benefits

Summary of environmental, economic and socioeconomic consequences

The Nord Stream Project has been designed to minimise adverse environmental and socioeconomic impacts. Potential environmental and socioeconomic impacts can be expected during the construction phase along the Nord Stream Route but these minor or moderate and are generally limited to the pipeline corridor. The zero-alternative will avoid these adverse impacts. However, if the Nord Stream Project is implemented, positive impacts could occur. The Zero-Alternative will not avoid large scale environmental and socioeconomic impacts as there are none associated with Nord Stream Project. But positive socioeconomic consequences, e.g. increase of employment, will not occur, if the project is not realised.

Substitutes to the Project

There are several possible substitutes to development of an offshore pipeline to transport gas including onshore development and Liquefied Natural Gas (LNG) transport. Arguably it would also be possible to avoid the need for gas transport by developing alternative sources of energy or reducing demand by increased energy efficiency. None of these are reasonable alternatives that fall within the mandate of the project proponent and they are not therefore considered further here. Even if they were reasonable alternatives, apart from the option of using more renewable energy, none of the proposed alternatives leads to substantive environmental gains compared to the Nord Stream Project. The option of using more renewable energy can not, however, generate enough energy to fulfil the demand met by the project. Offshore gas transport has lower carbon dioxide emissions than on-shore pipelines and LNG is the most carbon-intensive way to transport natural gas.

Conclusion

Transferring gas in a submarine pipeline is one of the most efficient and safe ways to transport energy and its impacts on marine flora and fauna must be considered in the context of the environmental impacts of development and use of other fossil fuels in comparison with natural gas. The construction of an off-shore pipeline through the Baltic Sea is considered to be the environmentally most favourable way of increasing the natural gas transportation capacity into the EU, and considering that not increasing import capacity into the EU is not an option, it can be concluded that any other alternative would result in more harmful effects on the environment.

6.1.4 Description of the Nord Stream Route

The Nord Stream pipeline will run for approximately 1,220 km from Vyborg in Russia to a landfall in Germany. The alternatives considered run through the territorial waters and/or Exclusive Economic Zones (EEZ) of Russia, Finland, Sweden, Denmark and Germany. During the course of development of the route, several options have been considered and these are introduced in the following sections which describe and explain route selection through each of these countries' waters. The main alternatives are illustrated in **Figure 6.1** and comprise:

- Options to the north and south of Gogland in Russian waters
- Options to the north and south at Kalbådagrund in Finnish waters
- Options to the east and west of Gotland and around Hoburgs Bank in Swedish waters
- Options around Bornholm in Danish and German waters
- Options for the preferred section of the route and the landfall point in Germany

These options are discussed below in six sections relating to the countries crossed by the potential routes:

- Gulf of Finland (Russia)
- Gulf of Finland (Finland)
- Sweden - Gotland
- Sweden – Hoburgs Bank
- Denmark
- Germany

6.1.5 Route Alternatives in the Gulf of Finland (Russian Section)

Introduction

The Nord Stream Route runs for about 130 km through Russian waters. Two principal alternatives have been considered in this section to the north and south of the island of Gogland, as shown in **Figure 6.2**.

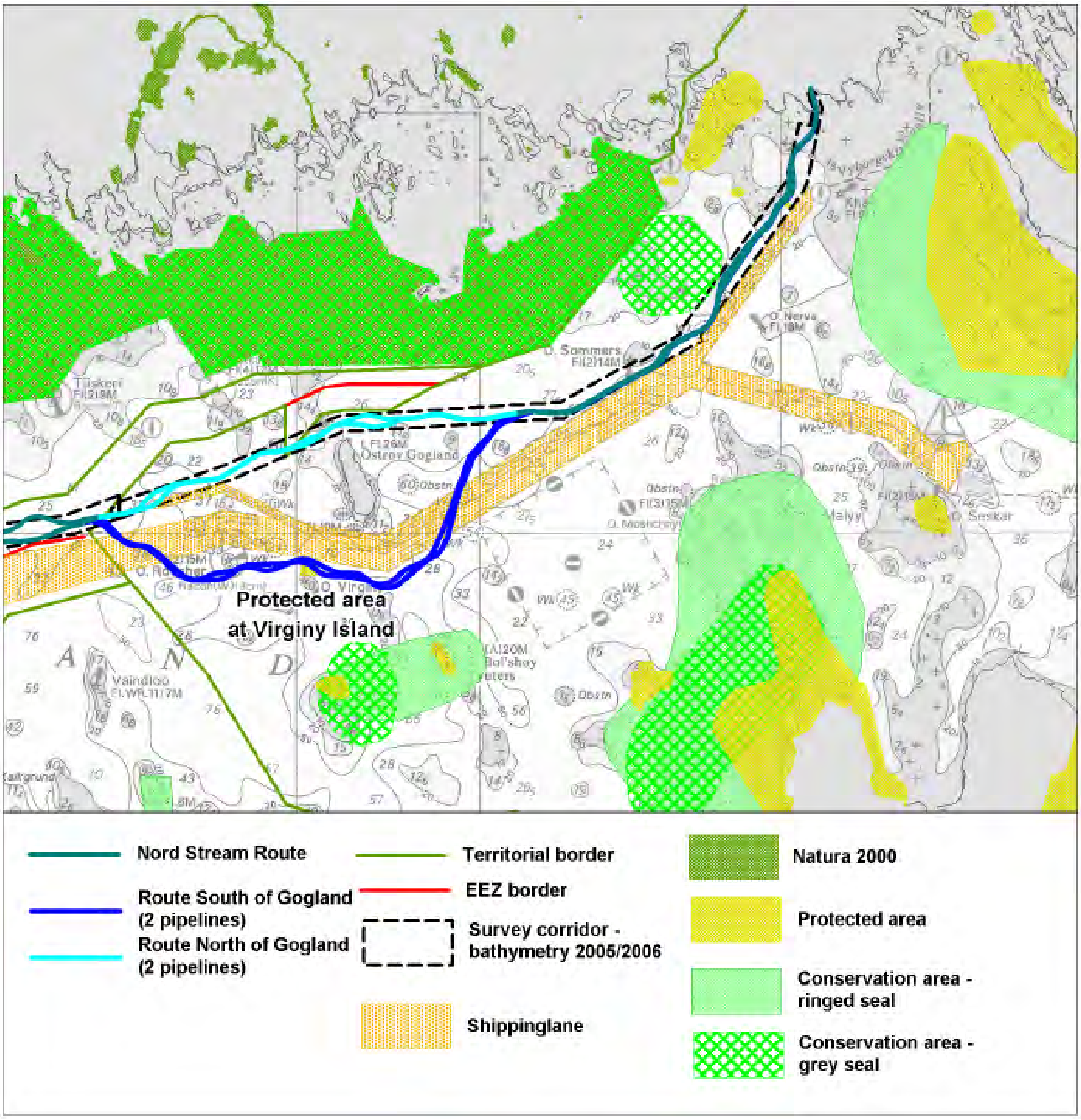


Figure 6.2 Route Alternatives around Gogland

The Nord Stream Project initially developed the route to the north of Gogland but the southern route has been investigated at the request of external stakeholders including Finnish authorities concerned about possible environmental impacts on Natura 2000 areas within Finnish jurisdiction.

The appraisal of the two alternatives against the criteria presented in **Section 6.1.2** is described below.

Environmental Appraisal

Environmentally sensitive areas

Designated sites in the vicinity of Gogland are shown on **Figure 6.2.**

The proposed Ingermanlandsky Strict Nature Reserve extends to the south of Gogland Island. This national park will include a number of specially protected areas. The suggested strict nature reserve encompasses nine islands in the Russian EEZ: Dolgiy Kamen, Kopytin, Bolshoy Fiskar, Rock Hally, Virginy, Maly Tuyters, Bolshoy Tyuters, Rock Vigand and Ceskar. The four southernmost islands are part of a reef structure stretching from Estonia to Gogland. The proposed reserve extends to an area of 13,433 hectares, including 12,520 hectares of the marine environment. It is understood that Ingermanlandsky Nature Reserve is intended to protect the landscape of the islands, nesting and migrating birds, and seal populations. At this point in time the Leningrad Oblast has approved the designation, but a final decision from the federal government and funding are pending.

Within the future Ingermanlandsky protection area there will be some areas (Virginy, Maly Tuyters, Bolshoy Tyuters, Rock Vigand) where the potential impact from the pipelines will be greater if the pipeline route south of Gogland is chosen. This route alternative is located in close proximity (approximately 0.2 km) to Virginy Island. Concerns are raised regarding the potential impacts of this route alternative on the features for which the reserve is designated, including disturbance of birds and seals from the physical presence and noise associated with vessels during the pipeline installation works.

At the closest point the northern route alternative is located approximately 5 km from the Eastern Gulf of Finland Archipelago and Waters Natura 2000 site and National Park in the Eastern Gulf of Finland (shown on **Figure 6.2**).

Hydrodynamic modelling studies were carried out by Nord Stream Project and predicted that any significant impacts due to disturbance of sediment associated with rock placement would be limited to an area of approximately 200 - 300 meters around the works. The extent of sediment distribution expected from the pipeline works is illustrated in **Figure 6.3**. This impact would only be temporary, lasting no more than 9 - 10 hours. This shows that sediment disturbance impacts would not extend far enough to affect the nature conservation value of Natura 2000 sites (in the Eastern Gulf of Finland).

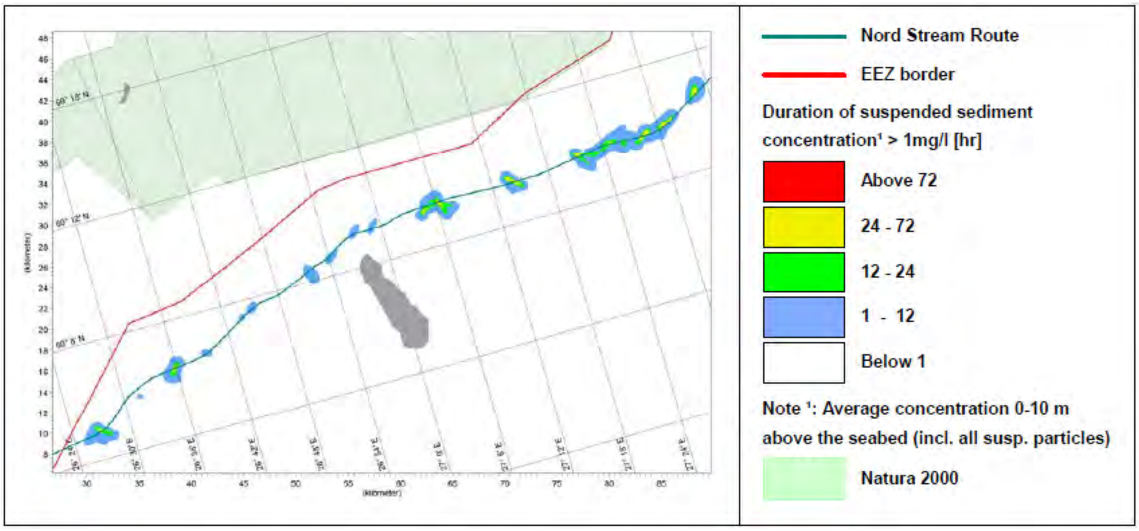


Figure 6.3 Results of sediment distribution modelling for the route north of Gogland

On this basis it is considered that the northern route is likely to have a lower impact on environmentally sensitive sites, as it is located further away from any designated sites when compared to the southern alternative (which will pass at its closest point at 0.2 km from the Ingermanlandsky Strict Nature Reserve). The northern route is therefore deemed to be the preferred option.

Ecologically sensitive species

Although there are no protected bird areas (national or international) on Gogland Island and in the adjacent waters, it is known that significant numbers of birds (over 50 species) inhabit the region and may be observed during migration periods. Gogland plays a significant role as a resting and feeding area for birds migrating from south (Estonia) to the north coast of the Gulf of Finland. Bird populations during these migrating periods are especially dense in the southern part of the island, and the adjacent sea areas to the south are used as a feeding ground. Therefore, it is likely that the southern route around Gogland would have a more significant impact on migrating bird populations than the northern route which is located further away from the most sensitive bird roosting and feeding areas.

The southern route alternative around Gogland would also take the pipelines closer to known seal migration and conservation areas that could be affected during the pipeline installation works (e.g. from the physical presence of vessels and noise). The main areas inhabited by the ringed seal are located in the south-eastern part of the Gulf of Finland and around islands such as northern and southern Virginy Island. The ringed seal is a protected species and the population in the Russian section of the Gulf of Finland is thought to be about 150 - 200 individuals (conservation areas shown in **Figure 6.2**).

Thus, if the pipeline is routed to the south of Gogland, the impact on bird migration, and ringed seal migration and conservation sites will be higher when compared with the northern route.

Seabed disturbance and sensitive seabed features

The seabed morphology along the northern route around Gogland is characterised by an alternation of flat areas and uneven hard soil outcrops (rock/glacial till). The seabed is known to be relatively uneven and the pipeline route to the north would require free spans requiring sea bed intervention work at numerous points along the route.

The seabed along the southern route is generally deeper and initial studies show that less seabed intervention works would be required. The southern route will therefore have a less impact from seabed disturbance. On this basis the southern option is the preferred route on this criterion.

Socioeconomic Appraisal

Shipping traffic activity

A Vessel Traffic Separation (VTS) scheme associated with the main Baltic shipping lane is located to the south of Gogland and to the north of Virginy Island and Vikalla Shoal. This can be seen on **Figure 6.2**. All the traffic to St. Petersburg, Vyborg and Primorsk runs along this route and it is estimated that approximately 35,000 vessel crossings occur in this area annually. The southern route alternative would cross this busy shipping lane twice and therefore would entail an increased risk of disruption to shipping during installation.

The route to the north of Gogland does not cross any significant shipping lanes (only approximately 3,000 vessel crossings annually) and therefore is considered the preferred route on this criterion.

Cables /pipeline

At least two cables cross the area in the vicinity of Gogland (shown in **Figure 6.4)**. The northern alternative is understood to involve the crossing of one single cable, while the southern alternative would require two cable crossing points. The northern alternative route is therefore preferred on the basis that it will have less potential impact on existing cable routes.

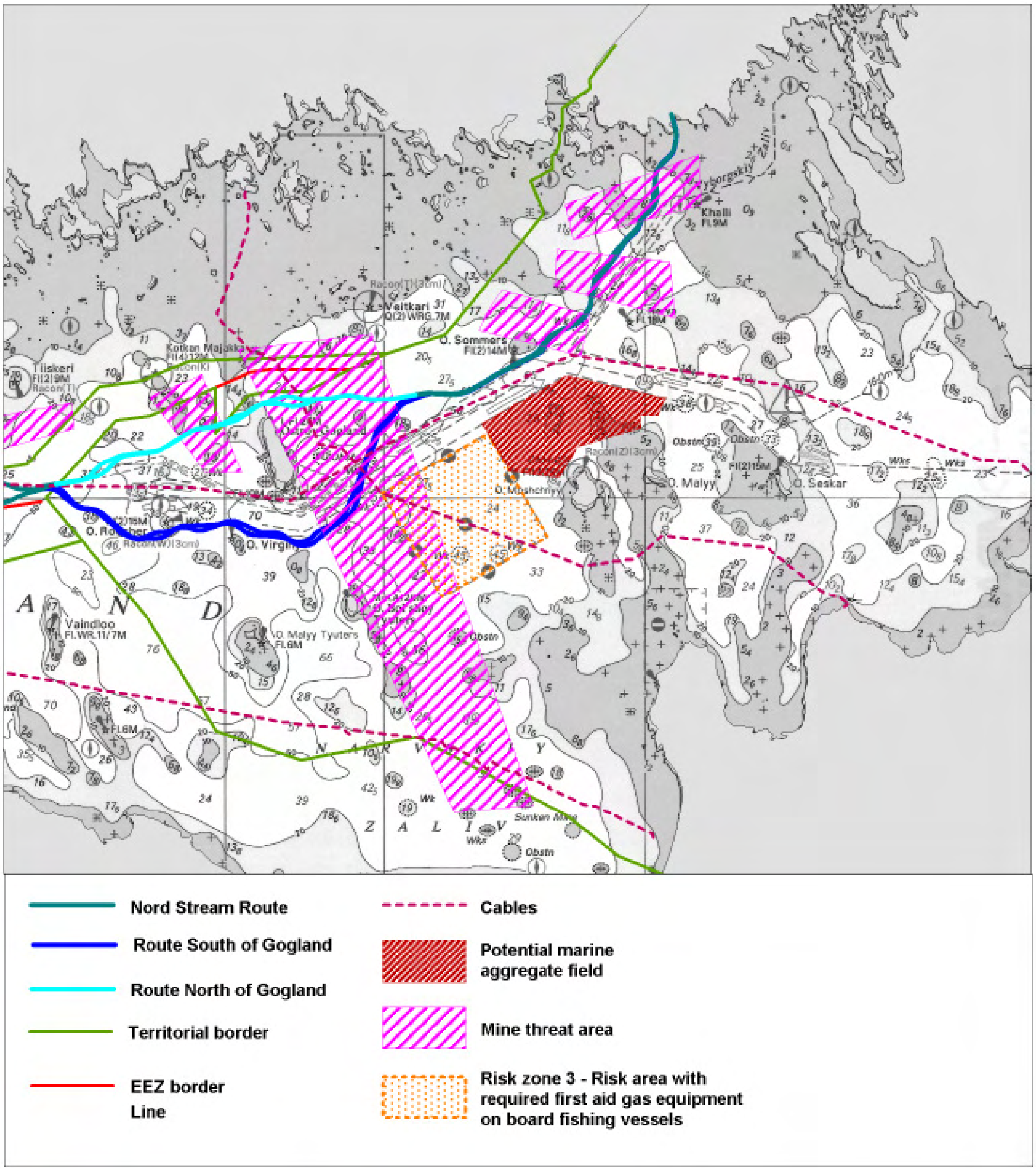


Figure 6.4 Marine user and munitions constraints in the Gogland area

Marine user activities

In the area around Gogland it is understood that there is no extensive use of the marine environment by other activities. The area is not thought to be especially valuable for fishing, military use or marine renewables. This is likely to be due to the intensively used shipping lanes that exist to the south of Gogland and which would preclude many other activities (e.g. fishing) from taking place in the area.

However, it is important to note that certain areas to the south and east of Gogland have been designated as potential offshore dredging areas. In early 2007, three offshore areas were awarded for the mining of ferromanganese nodules as shown in **Figure 6.4**. In terms of the pipeline route alternatives, the most important proposed dredging area is the Kurgalskoe field which is located south of the main shipping lane, adjacent to Moshchnyy Island. It is not known that dredging is taking place currently in these areas, but clearly the potential exists for this to happen in the future.

While the southern route would not directly cross these dredging areas it is likely that it would run much closer than the northern route. Therefore, it is considered that the northern alternative is the preferred route as it carries a lower risk of disruption to future dredging activities.

Munitions

As explained in **Section 6.2**, after WWII, the allied forces dumped chemical munitions found in Germany in the Baltic Marine Area. Mine and munitions risk areas applicable to the pipeline routing alternatives around Gogland Island are shown in **Figure 6.4**.

Both route alternatives will pass through areas of potential risk with regard to munitions. It should be noted that although the Nord Stream Project has undertaken specific munitions studies during the route planning process, and plans to perform clearance works prior to construction so that munitions do not represent a significant safety risk to the Nord Stream Route, avoidance of munitions risk areas is still the preferred option. In the case of the route alternatives around Gogland there are no significant differences between the routes with regard to munitions risks and the required survey and clearance works expected.

Cultural heritage sites

As a result of the survey performed by Nord Stream Project, a number of wrecks have been identified to the nort of Gogland Island.

Four known wrecks are located within the area south of Gogland just to the north of Virginy Island and Vikalla Shoal.

Both route alternatives would avoid any direct impacts to these wrecks and measures will be taken to ensure that any other wrecks of cultural heritage importance are protected. The two alternatives around Gogland are therefore equally rated according to this criterion.

Technical Appraisal

Risk and safety

There are several factors which could influence the safety of the pipeline. In the vicinity of Gogland the principal factors are exposure to impacts from shipping and dredging. For both factors the southern route alternative is potentially exposed to higher risks during construction and operation, due to the proximity of the route to busy shipping lanes (vessel traffic separation scheme) and designated future dredging areas.

On this evidence, the northern route is preferred.

Construction time

The overall length of the southern route is higher, which would suggest a longer installation period. However, the northern route requires more seabed intervention activity which could also contribute to a longer installation period. Therefore it is considered that this will not be a significant criterion affecting the choice of preferred route.

Technical feasibility and seabed intervention works

The northern route alternative is located in an area of more uneven seabed requiring a significant level of seabed intervention in order to ensure the safe installation of the pipeline, and therefore making the pipe installation process more complex. Intervention works are likely to include rock placement or installation of special supports. The southern route alternative passes through a more even seabed environment and will therefore require less intervention works. It does involve a larger number of cable crossings but on balance the southern route is the preferred option regarding technical feasibility and seabed intervention works.

Overall length

The overall length of the section to the north of Gogland is around 60 km; the comparable section to the south of Gogland is around 73 km long. The southern route is therefore 13 km longer and there is an advantage for the northern route.

Summary and Conclusion

A summary of the findings of the Nord Stream Route appraisal is presented in **Table 6.6**. Based on the assessment of the two route alternatives against the defined criteria the northern route alternative has on balance been identified as the preferred option.

The main reasons are as follows:

- The proximity of the southern route to protected areas, areas of importance for species of nature conservation importance, and future dredging areas
- The requirement to cross a busy shipping route and for two cable crossings on the southern route
- The greater risk of damage to the pipeline on the southern route
- The greater length of the southern route

Table 6.6 Comparison of impacts between the route alternatives in the Gulf of Finland

Criteria	**Route alternatives**	
	North of Gogland	**South of Gogland**
Environmentally sensitive / protected areas	The northern route is located at approximately 5 km (at its closest point) from the designated Natura 2000 site and National Park in the eastern Gulf of Finland.	The southern route is located in close proximity (at approximately 0.2 km) to Virginy Island within the future Ingermanlandsky protection area.
Ecologically sensitive species	No particular sensitivities associated with the northern route.	Bird populations on Gogland are especially high in the southern part of the island. The southern route is closer to known seal migration and conservation areas.
Seabed disturbance and sensitive seabed features	The seabed to the north of Gogland is known to be relatively uneven and it is established that more sea bed intervention work will be required.	The seabed along the southern route is generally deeper and the bathymetry is more uniform. Less seabed intervention is required.
Shipping traffic activity	The northern route does not cross any significant shipping lanes.	The southern route crosses a busy shipping lane twice.
Existing cable / pipeline routes	The northern route involves the crossing of one cable.	The southern route requires two cable crossings.
Marine user activities	The northern route is located further away from future dredging areas.	The southern route would be located in closer proximity to proposed dredging areas.
Munitions risks	Unlikely that there will be significant differences between the routes with regard to munitions risks.	Unlikely that there will be significant differences between the routes with regard to munitions risks.

Criteria	Route alternatives	
	North of Gogland	South of Gogland
Cultural heritage sites / areas	Both routes are likely to encounter wrecks therefore there does not appear to be a preferred route alternative according to this criterion.	Both routes are likely to encounter wrecks therefore there does not appear to be a preferred route alternative according to this criterion.
Risk and safety	The northern route is the preferred option as it is less exposed to other marine activities.	The southern route alternative is potentially exposed to higher risks due to the proximity of the route to busy shipping lanes and designated future dredging areas.
	Route technically feasible, no significant difference to other route alternative.	Route technically feasible, no significant difference to other route alternative.
Construction time	No significant difference.	No significant difference.
Technical feasibility and seabed intervention works	The northern route is located in a more uneven seabed environment requiring more seabed intervention.	The southern alternative requires less seabed intervention works.
Overall length	The northern route (60 km) is shorter compared to the southern route alternative.	The southern route (73 km) is longer by 13 km compared to the northern route alternative.

6.1.6 Route Alternatives in the Gulf of Finland (Finnish Section)

Introduction

The total Nord Stream Route length through this section is about 370 km. In this area two main sets of alternatives have been considered, the first relating to routes through either Finnish or Estonian waters and the second to more detailed alternatives within Finnish waters in the area of Kalbådagrund.

The option of routing through Estonian waters had to be discounted at an early stage because of difficulties obtaining consents for the necessary survey work. In 1998 NTG, a predecessor of Nord Stream, applied for permission to survey in the Estonian EEZ to support development of a route for the North European Gas Pipeline. Permission was not granted and the option of crossing Estonian waters was abandoned. In spring 2007 Nord Stream filed a further application to obtain permission to survey a corridor in the Estonian EEZ. A survey corridor identified in

Figure 6.5 (Survey Corridor in Estonian Waters) was submitted to the Estonian authorities as part of the survey application. This application was rejected by the Estonian Ministry of Foreign Affairs in September 2007. Further development of a route alternative in Estonia was therefore abandoned and this is no longer considered as a reasonable option for the project.

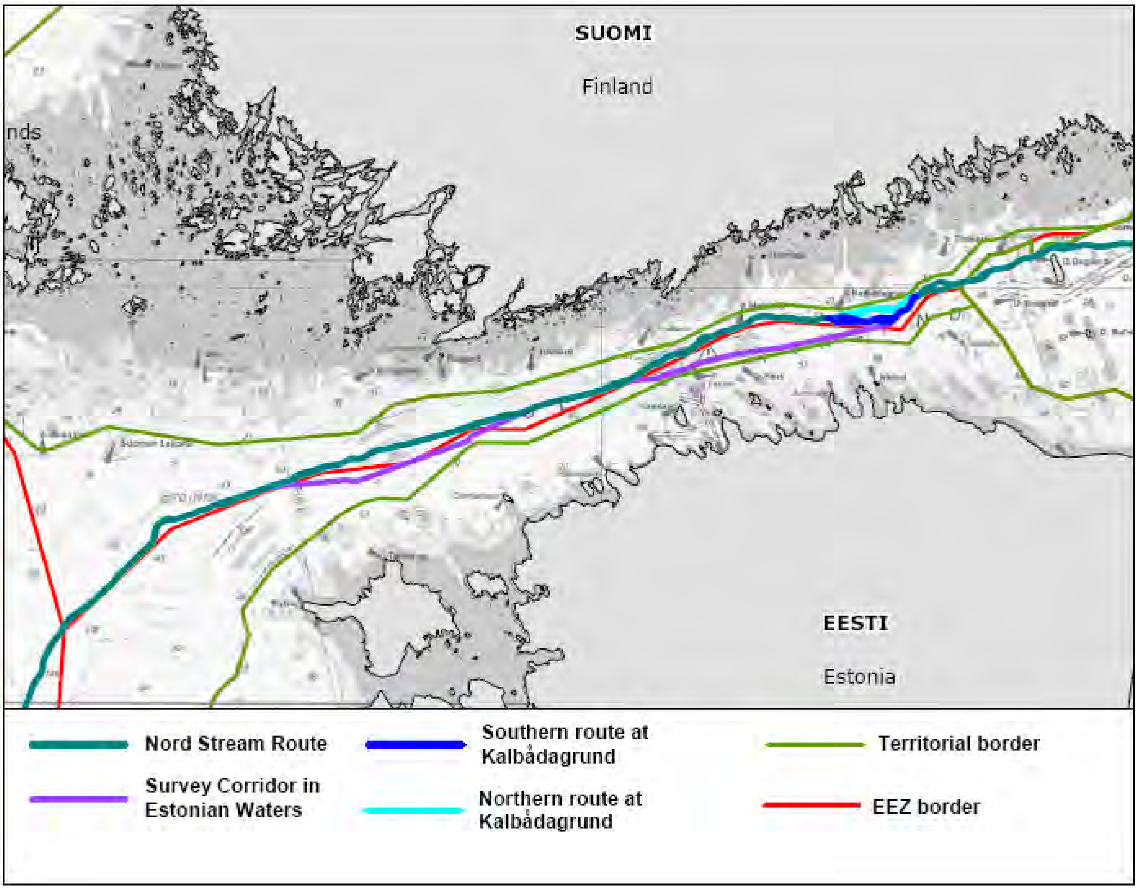


Figure 6.5 **Potential route corridor in the Estonian EEZ**

Following abandonment of the Estonian option two options for part of the Nord Stream Route in Finnish waters, a northern and a southern route, have been examined at Kalbådagrund. These are illustrated in **Figure 6.6**, and their appraisal is described below. Both routes run within the Finnish EEZ but outside Finland's territorial waters.

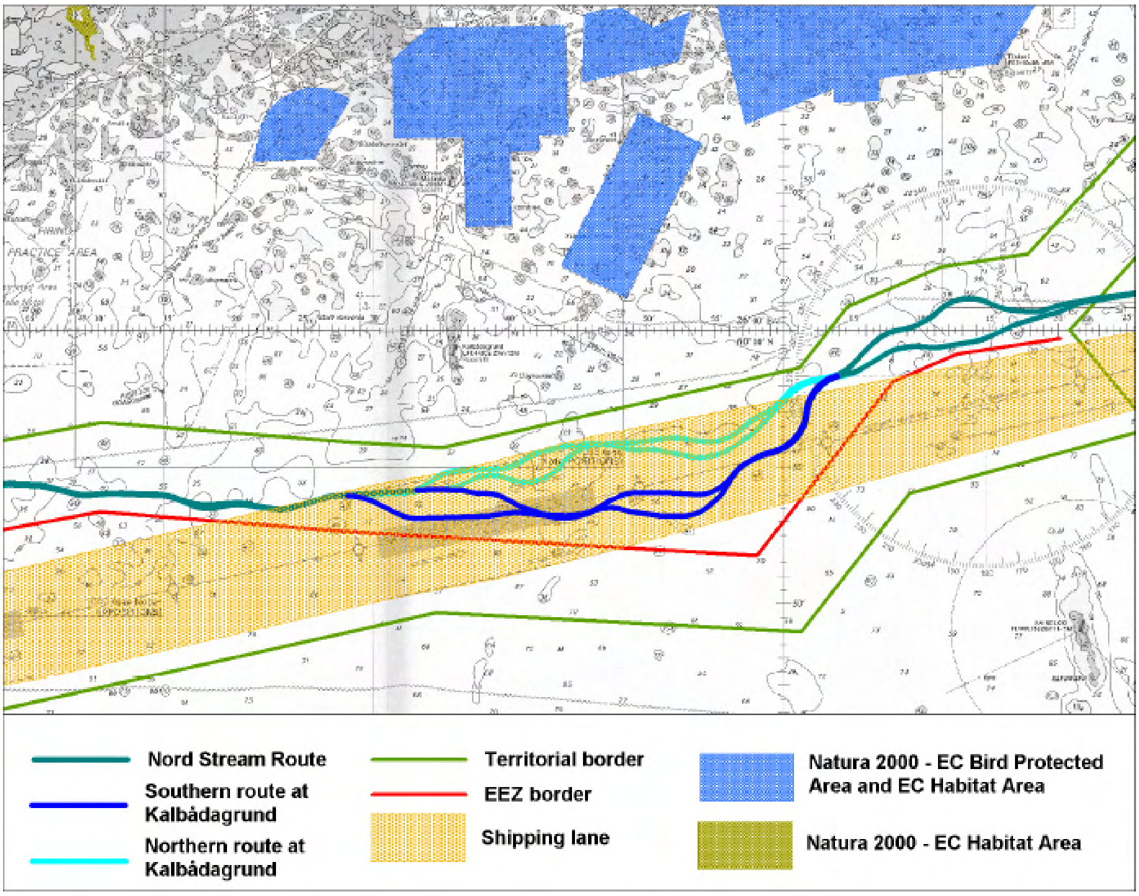


Figure 6.6 Route alternatives at Kalbådagrund

The southern option was suggested by Finnish authorities who asked Nord Stream to explore an alternative to the south of Kalbådagrund, where conditions tend to become more favourable for pipeline activities (e.g. more even seabed conditions). Nord Stream has performed geophysical and geotechnical surveys and environmental sampling to support the route comparison.

Environmental Appraisal

Environmentally sensitive areas

Regarding the proximity of the two alternative pipeline routes to designated environmentally sensitive areas, it can be observed in **Figure 6.6** that neither route is located in close proximity to any designated Natura 2000 sites.

Ecologically sensitive species

The northern route is located in slightly shallower waters (45 - 75 m) than the southern Kalbådagrund alternative (65 - 85 m). The surveys that have been undertaken show that there is little benthic fauna supported at a depth of 75m, a poor fauna community with two species dominant at a depth of 65 m and, depending on the location, a well established fauna community supporting up to seven species at a depth of 55 m. This suggests that the benthic habitat in the area is of higher ecological value in shallower waters. This is likely to be due to less harsh environmental conditions (e.g. higher dissolved oxygen levels).

These findings suggest that the southern route will affect an area with slightly less biological variety and therefore with slightly less ecological value than the northern route alternative. Neither route will have any significant impact on any particularly sensitive species. It is therefore considered that the southern route is the preferred option from the perspective of impacts on ecological communities.

Seabed disturbance and sensitive seabed features

The seabed morphology is generally characterised by an alternation of flat clayey areas and uneven hard outcrops (rock/glacial till). When comparing the northern corridor with the southern Kalbådagrund route, the extent of hard outcrops increases to the north and the southern route traverses less of the structural feature associated with Kalbådagrund. Therefore it is concluded that the southern Kalbådagrund alternative is the preferred option from the perspective of seabed disturbance.

Socioeconomic Appraisal

Shipping traffic activity

With regard to the potential interaction with shipping traffic during operation, both alternatives are partially located in the main shipping lane of the Gulf of Finland (see **Figure 6.6**). While the northern route alternative is located in the northern part of the west bound shipping lane, the southern route alternative runs through both east and west bound shipping lanes. The number of annual ship crossings on the southern corridor is comparable to the northern corridor. As both alternatives interfere to some extent with the ship traffic, no clear preference on this criterion can be derived.

Cables /pipeline

There are a number of cables that pass through the Kalbådagrund area. The northern route alternative involves a single cable crossing, whereas the southern alternative will involve three crossings. The northern route is therefore preferred.

Marine user activities

There is no evidence to suggest that the area crossed by the two route alternatives is widely used by any other marine activities that could influence the pipeline works. This may be a reflection of the extensive shipping activity and the ship reporting scheme in the region which is likely to preclude other activities such as fishing or dredging taking place. There is therefore considered to be no significant difference between the alternative routes.

Munitions

Detailed surveys have been performed for the northern and southern routes to identify potential munitions objects. The assessment of the survey results shows that the number of identified objects is comparable (for crossed munitions areas please see **Figure 6.7**). There is, therefore, no preferred route on this criterion. If necessary, clearance works will be undertaken prior to pipeline installation so that munitions do not represent a significant safety risk to the Nord Stream Route.

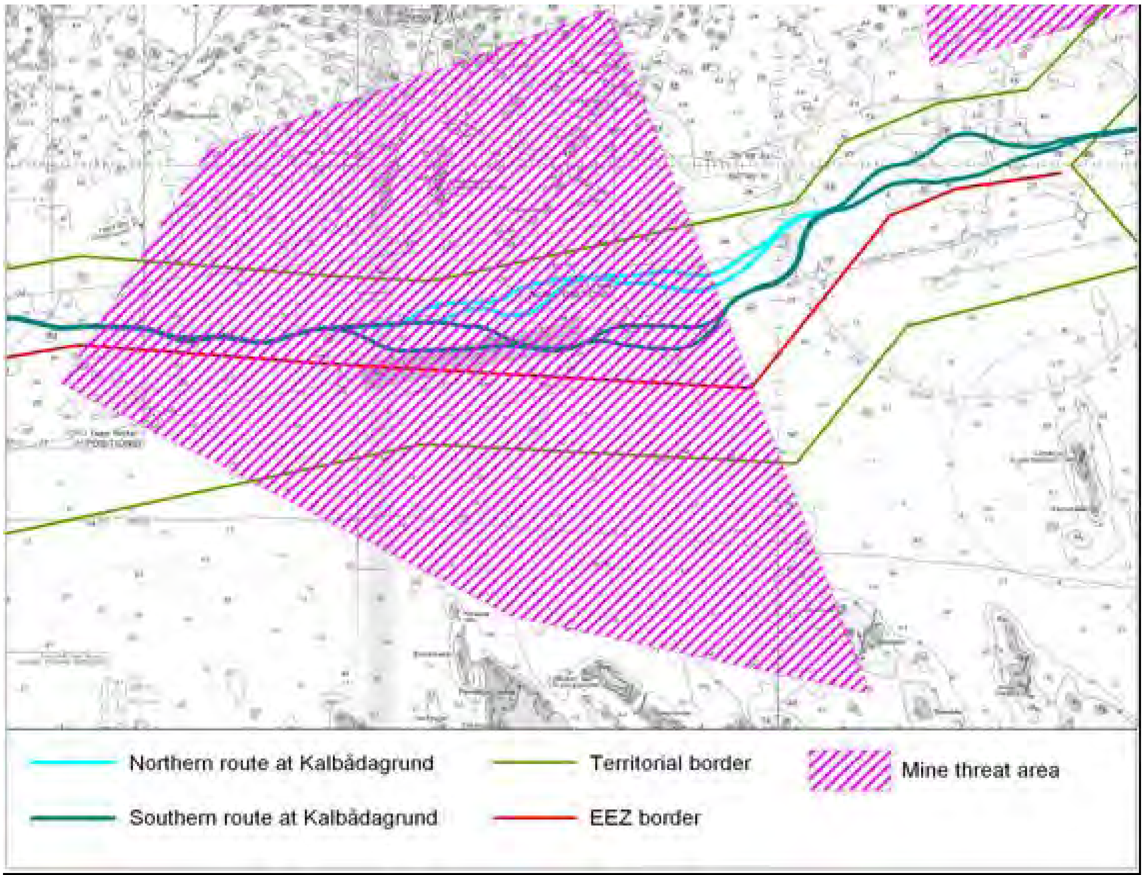


Figure 6.7 Munitions risk areas at Kalbådagrund

Cultural heritage sites

Detailed geophysical surveys have not identified any wrecks in either corridor in the vicinity of Kalbådagrund. On this basis, neither route alternative can be considered as preferable on the basis of this criterion.

Technical Appraisal

Risk and safety

The main risks to the safety of the pipeline alternatives in this section are the chance of encountering munitions and interaction with shipping activities. For both issues the southern and northern route alternatives are considered to have comparable exposure to risk. It can therefore be concluded that there is no preferred route option, in terms of the safety criterion.

Both route alternatives can be safely installed, as appropriate risk mitigation measures will be applied, e.g. shipping re-routing during construction and munitions clearance works prior to installation.

Construction time

There is no significant difference between the two alternatives with regard to construction timescale. The southern route alternative is likely to be less complicated and quicker to construct, as fewer seabed works will be required. However, it is also a slightly longer route (by 2 km for each pipeline). Therefore, there is only a small difference between the two alternatives and this is not considered to be an important criterion by which to compare the routes.

Technical feasibility and seabed intervention works

While both route alternatives are technically feasible, the seabed bathymetry along the southern route is more even and consequently there will be fewer requirements for seabed intervention works as part of the pipeline installation activities. The investigation of intervention works for the southern route predicts a reduction of total intervention works (146 for the northern route to 133 for the southern alternative), but has slightly higher gravel requirements required for on-bottom stability and free span correction. On balance, the southern route is considered to be slightly preferred in terms of this criterion.

Overall length

The northern route alternative at Kalbådagrund is approximately 39 km in length and the southern route alternative is slightly longer at 41 km. In terms of overall pipeline length, the difference of approximately 2 km is of little significance.

Summary and Conclusion

A summary of the findings of the route appraisal is presented in **Table 6.7**.

Some slight advantages of the southern route exist based on the outlined assessment but overall the assessment indicates that both routes perform equally and there is no clear preference for either

The main reasons for the preference of the southern route at Kalbådagrund are:

- The lower requirement for seabed intervention works as part of the pipeline installation and the consequent advantage this offers in terms of environmental impact and technical complexity
- The lower potential for impact on protected areas and ecologically sensitive species

Table 6.7 Comparison of impacts between the route alternatives in the Gulf of Finland

Criteria	Route alternatives	
	North at Kalbådagrund	**South at Kalbådagrund**
Environmentally sensitive / protected areas	No impact on Natura 2000 sites. The northern route alternative traverses the structural feature associated with Kalbådagrund.	No impact on Natura 2000 sites. The southern route traverses less of the structural feature associated with Kalbådagrund.
Ecologically sensitive species	The northern route is located in slightly shallower waters which suggest that the benthic habitat in the area is of higher ecological value.	The southern route will affect an area of slightly less ecological value than the northern route alternative.
Seabed disturbance and sensitive seabed features	More crossings of uneven hard outcrops.	Less crossing of uneven hard outcrops.
Shipping traffic activity	The northern route alternative is partially located in the Gulf of Finland shipping lane, no significant difference to southern route in shipping activity.	The southern route runs through the shipping lane of the Gulf of Finland, no significant difference to northern route in shipping activity.
Existing cable / pipeline routes	The northern route involves a single cable crossing.	The southern route will involve three cable crossings.

Criteria	Route alternatives	
	North at Kalbådagrund	**South at Kalbådagrund**
Marine user activities	There is no evidence to suggest that the Kalbådagrund area is widely used by any other marine activities that could influence the pipeline works.	There is no evidence to suggest that the Kalbådagrund area is widely used by any other marine activities that could influence the pipeline works.
Munitions risks	Few potential munitions objects identified.	Few potential munitions objects identified.
Cultural heritage sites / areas (e.g. wrecks, marine archaeology)	No wrecks identified in the vicinity of Kalbådagrund.	No wrecks identified in the vicinity of Kalbådagrund.
Risk and safety	Both routes are comparable in regard to safety (see shipping and munitions).	Both routes are comparable in regard to safety (see shipping and munitions).
Construction time	No significant difference in the two alternatives.	No significant difference in the two alternatives.
Technical feasibility and seabed intervention works	Route is technically feasible. The northern route will require more seabed intervention works but slightly less gravel.	Route is technically feasible. The southern route will require less seabed intervention works but slightly more gravel. On balance the southern route is preferred.
Overall length	There is only 2 km difference between the two route alternatives in terms of overall pipeline length.	There is only 2 km difference between the two route alternatives in terms of overall pipeline length.

6.1.7 Route Alternatives in Sweden – Gotland & Hoburgs Bank

Introduction to Route Alternatives in Sweden

The Nord Stream pipeline will run for about 500 km through Swedish waters, past the island of Gotland and shallow banks at Hoburgs Bank and Norra Midsjöbanken. Alternatives have been investigated in two main sections of the Nord Stream Route: the first around Gotland and the second past Hoburgs Bank and Norra Midsjöbanken.

The different phases in the history of the project influenced the routing options of the pipelines in the Swedish section. A comprehensive historic overview is given in the project history, in **Chapter 2.2.**

Route Alternatives for Gotland

North Transgas Oy (NTG) conducted a feasibility study in 1997–1999 that considered route alternatives to the east and west of Gotland (see **Figure 6.8** below):

- The western route alternative was originally proposed by NTG and runs west of Gotland between the island and the Swedish mainland, skirting Sweden's territorial waters around Gotland then bordering Sweden's mainland territorial waters before entering the Danish EEZ heading towards Bornholm and an ultimate landfall as far west as possible on the German Baltic coast near Lübeck or Rostock

- The eastern alternative runs east of Gotland within the Swedish EEZ but outside of territorial waters. It borders territorial waters around Gotland at the most easterly point heading for a landfall location on the eastern German Baltic Sea coast

Both pipeline corridors have been surveyed, including geophysical and geotechnical investigations and mapping of the constraints to the Nord Stream Route in order to assess the corridors.

It should be noted that the landfall at Greifswald (see **Section 6.1.9**) meant that the route alternative to the west of Gotland was longer in overall length and also had other disadvantages including munitions and maritime traffic.

The route alternative to the east of Gotland runs within the Swedish EEZ, but outside territorial waters. It borders territorial waters around Gotland at the most easterly point. The proposed route avoids crossing the Natura 2000 sites of Hoburgs Bank and Norra Midsjöbanken. The route alternative east of Gotland has been carefully considered taking into account environmental and socioeconomic restrictions to the north of Gotland and along the eastern side of Gotland.

To the north the eastern route alternative around Gotland is naturally restricted by the Natura 2000 area of Gotska Sandön, which could be impacted by a large-scale north-western rerouting of the pipelines. A small scale rerouting to the north-west would encounter similar seabed conditions as the proposed route.

Rerouting the eastern route alternative further to the east on a large scale would potentially impact the shipping lane and bring the pipeline into the cod and sprat spawning area as well as putting the pipelines outside the Swedish EEZ. As discussed below, a route further to the east would also bring the route closer to the risk zone 2 of the munitions dumping area south-east of Gotland. Additionally, shallower waters around Klints Bank would have to be passed; possibly resulting in increased seabed intervention works and associated sediment spreading, which in turn could impact the marine fauna in this area.

Along the eastern side of Gotland, a routing of the eastern route alternative closer to the island would require additional seabed intervention works in the shallower waters. The benthic fauna, as well as areas of national importance to the Swedish fishery and the abundance of different bird species feeding in this area may potentially be impacted.

The preferred route alternative and the western route around the island of Gotland are shown in **Figure 6.8**.

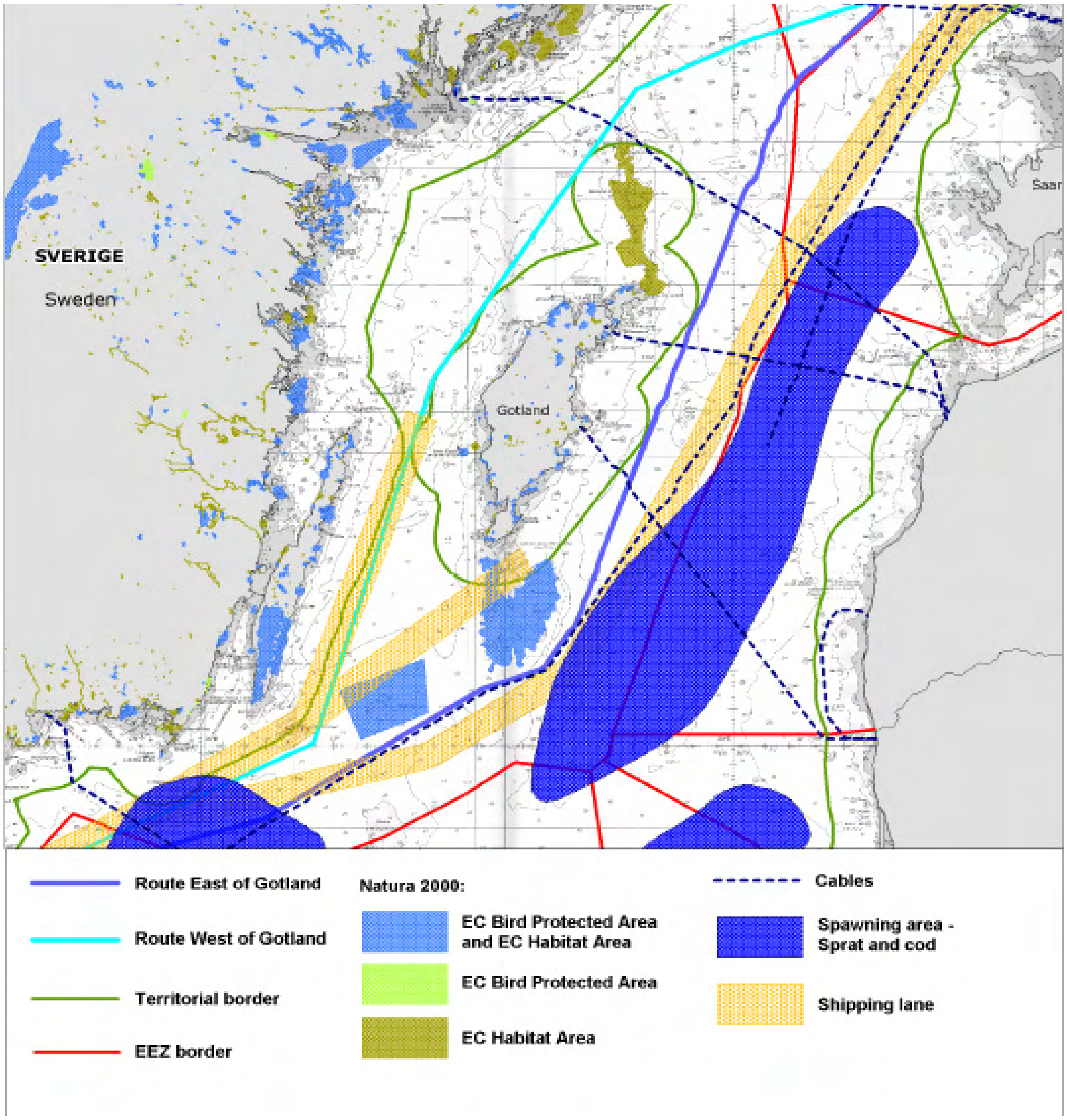


Figure 6.8 Route alternatives west and east of Gotland

Route Alternatives for Hoburgs Bank

During the conceptual design a route alternative south of Gotland was initially developed around the southern edge of Hoburgs Bank. It became evident that this bordered the Natura 2000 area and it was therefore moved to the southeast in order to increase the distance to the Natura 2000 site to avoid any potential adverse impact. The original conceptual design route and the optimised route are shown in **Figure 6.9**.

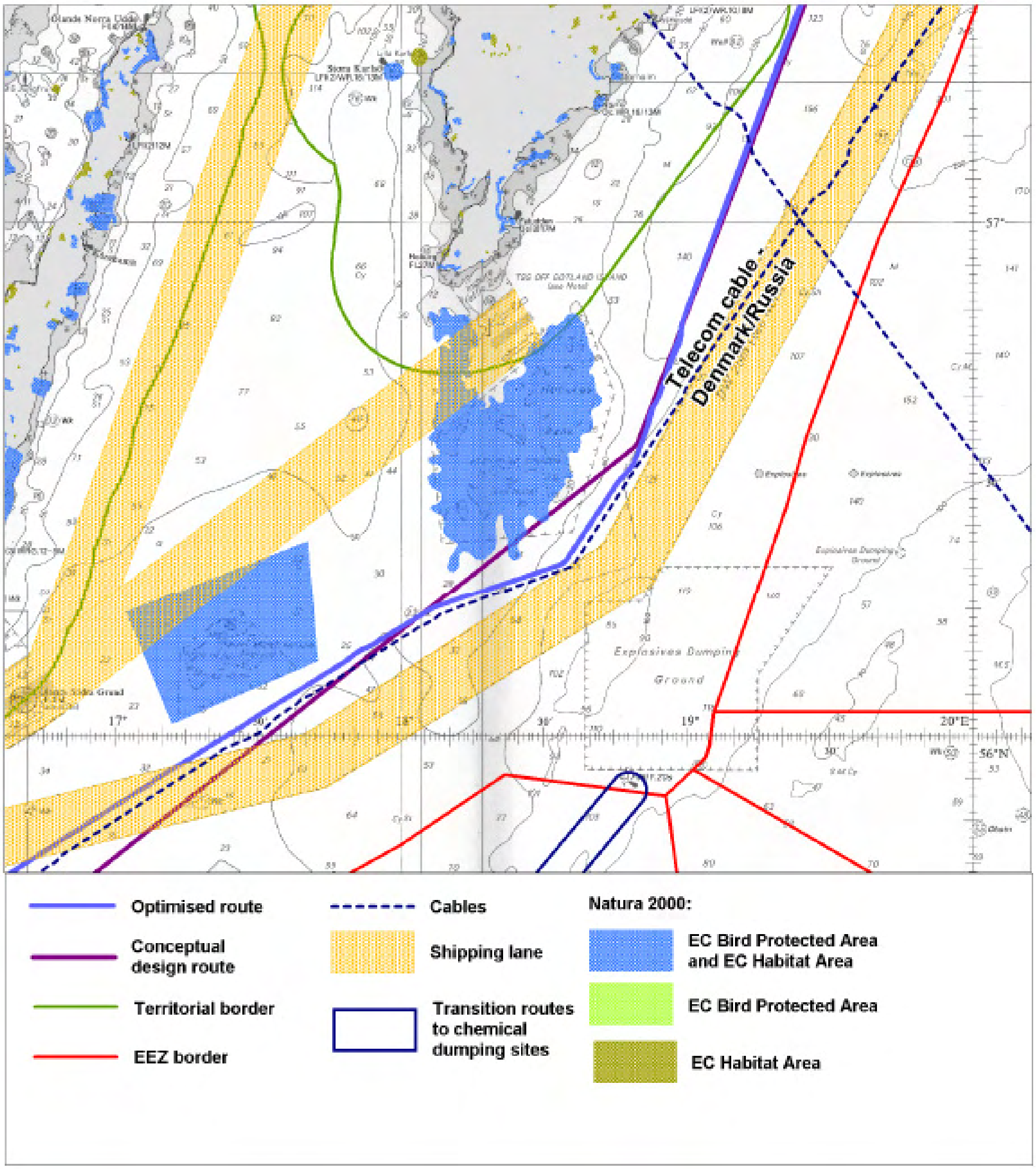


Figure 6.9 **Conceptual design and optimised (proposed) route alternatives at Hoburgs Bank**

As shown in **Figure 6.9**, the optimised route runs in parallel with the Denmark-Russia telecom cable and avoids the main shipping lane east of Gotland. The route passes between the Natura 2000 area Norra Midsjöbanken (at a distance of approximately 3.2 km) and Södra Midsjöbanken (located at the very bottom of the figure, directly south of Norra Midsjöbanken), which is an area of national interest for a potential offshore wind park (at a distance of approximately 21.1 km). It also avoids the Natura 2000 area Hoburgs Bank (at a distance of 4 km).

The differences between the original conceptual design route for the eastern alternative around the Natura 2000 area of Hoburgs Bank and the optimised route are not assessed further as proximity to the Natura 2000 site Hoburgs Bank was the primary reason for the re-routing in the conceptual design phase. Thus in the following only the optimised route is appraised as a full route alternative.

Route further south east of Hoburgs Bank

Upon request during the consultations with the authorities before filing the Swedish application, a study area was investigated to the south east of the optimised route around Hoburgs Bank to further increase the distance to the Natura 2000 area. As a result, a desk study of a corridor to the southeast was conducted to determine whether a further amendment to the route would be beneficial. The study corridor to the southeast of the revised route is also shown in **Figure 6.10**.

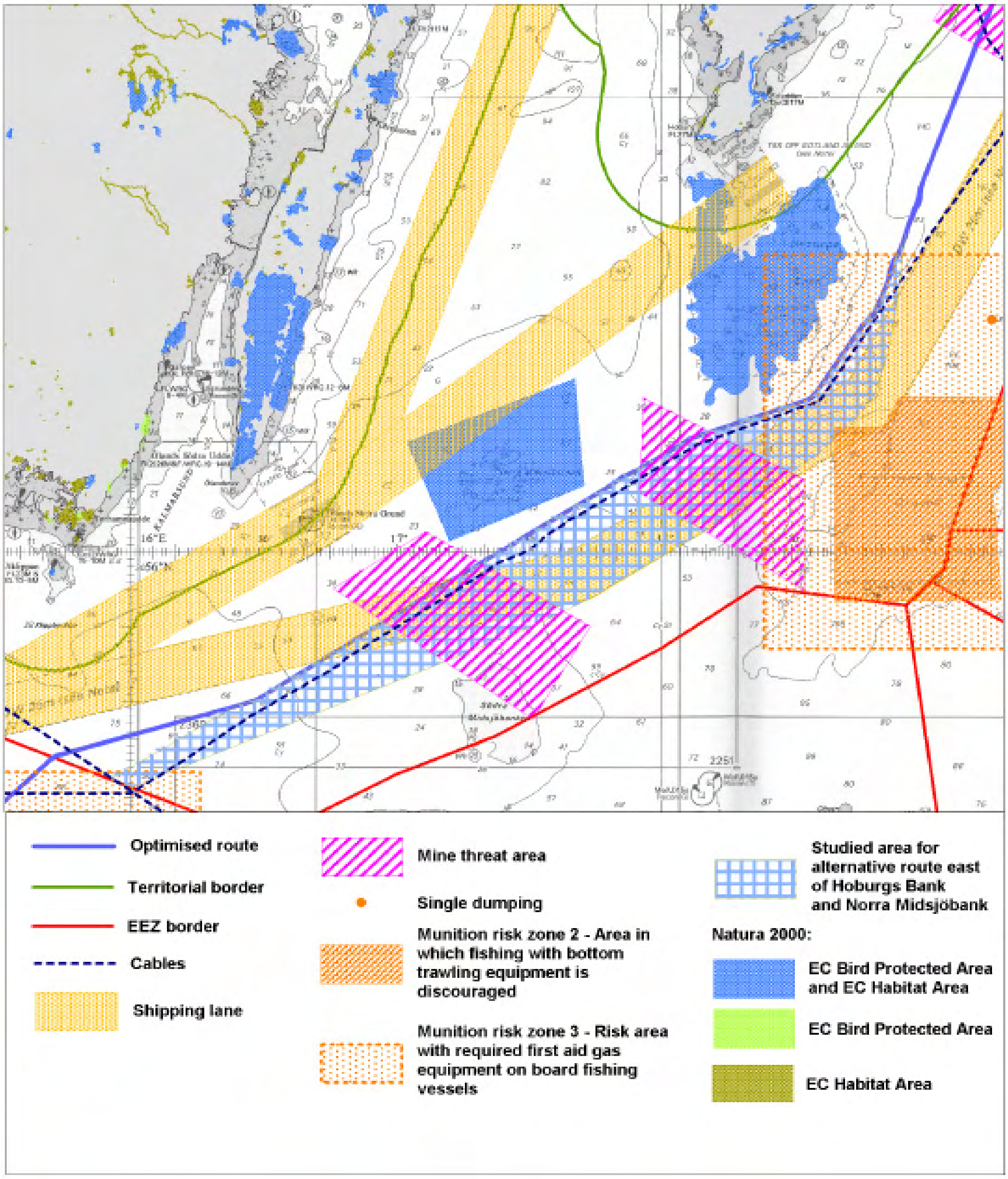


Figure 6.10 Alternative corridor at Hoburgs Bank

The options running west and east of Gotland, the optimised route at Hoburgs Bank and the corridor to the south east of Hoburgs Bank have been appraised and the findings are discussed below.

Environmental Appraisal

Environmentally sensitive / protected areas

Designated areas are shown in **Figure 6.8.**

None of the route alternatives will have a significant impact on any of the Natura 2000 sites in the vicinity of the pipelines: Hoburgs Bank, Gotska Sandön and Norra Midsjöbanken.

The Natura 2000 site *Hoburgs Bank* is a shallow sea area with large areas of approximately 35 m water depth. The bank consists partly of bedrock, but in large areas there are sublittoral sandbanks and reefs. The unique substrate of the bank is very rare and affects the flora and fauna communities found there. Long-tailed ducks are found in this area and are protected by the Birds Directive which also protects the common eider duck (*Somateria mollissima*) and black guillemot (*Cepphus grylle)*.

Gotska Sandön is a national park located on an island that has an area of 36 km^2 with a length of 9 km. Together with Kopparstenarna and Salvorev, it forms a Natura 2000 area north of Fårö Island. Two species are found here that are protected by the Habitats Directive: grey seal (*Halichoerus grypus*) and the beetle *(Boros schneideri)*. More than 120 Red List species have been found on the island.

The *Norra Midsjöbanken* Natura 2000 site is a large bank consisting of a moraine ridge on bedrock. It is a breeding area for turbot (*Psetta maxima*) and herring (*Clupea harengus*) and is of global importance for black guillemot (*C. grylle*) and an important wintering area for long-tailed duck (*C. hyemalis*).

The route alternative to the *west of Gotland* passes more closely to Gotska Sandön (approximately 23.1 km) than the eastern route alternative (approximately 40.3 km), however the route alternative to the *east of Gotland* passes Hoburgs Bank more closely (approximately 4. km) than the route alternative to the west of Gotland (approximately 46.1 km from Hoburgs Bank). Both route alternatives pass reasonably close to Norra Midsjöbanken: the east Gotland route alternative at a distance of 3.2 km and the west Gotland route alternative at a distance of 4 km.

The closest distance of the optimised route around Hoburgs Bank to any Natura 2000 sites in Sweden is 3.2 km to Norra Midsjöbanken. Models of sediment spread at Hoburgs Bank and Norra Midsjöbanken show that an increased sediment concentration east of Norra Midsjöbanken and Hoburgs Bank will only occur close to the pipelines and only for a limited duration (see **Figure 9.10** and **Figure 9.11** in **Chapter 9**). This will not result in an impact on either Natura 2000 site. Modelling was also conducted for the route alternative east of Gotland around Gotska Sandön and predicted no resulting impacts.

Ecologically sensitive species

Neither the route alternative east of Gotland nor west of Gotland would cross or pass near any areas with ecologically sensitive species. For the optimised route around Hoburgs Bank no adverse impacts are expected either. The route alternative further south east of Hoburgs Bank could potentially impact fish as it will be placed closer or within spawning areas of sprat and cod (the Gotlandsdjupet and the Slupsk Furrow), see below.

There is a cod and sprat spawning ground east of Gotland. It is approximately 36 km from the route alternative east of Gotland. In the south, the optimised route is 3.5 km from that spawning area (see **Figure 6.8**) and will not have an impact on the area. A route alternative further south east of Hoburgs Bank would bring the pipeline closer to the spawning area. Seabed topography in this area suggests that rather extensive seabed intervention works are required that may have an impact on the cod-spawning. All alternatives cross the cod spawning area in the south western area of the Swedish Section (see **Figure 6.8**), but at this area, no seabed intervention works are required. The optimized route is, thus, preferable as regards to impact on ecologically sensitive species. A route alternative further south east of Hoburgs Bank would also bring the pipeline closer to Södra Midsjöbanken which is of great importance to wintering sea birds, especially the black guillemot. This area would potentially be crossed by the pipeline if the pipeline were relocated farther to the south-east. This may have a temporary impact on bird life during the installation phase, depending on season.

Seabed disturbance and sensitive seabed features

In principle, there is no significant difference in seabed features between the route alternatives in Swedish waters. A seabed geology interpretation based on different surveys indicates that the seabed passing around the west of Gotland and to the east of Gotland, as well as at the Hoburgs Bank and Norra Midsjöbanken areas is generally fairly smooth and consists of clay and sand with some glacial till outcrops. However, as stated above, a route further east of Gotland and south-east of Hoburgs Bank etc. would probably require increased seabed intervention works due to the seabed topography.

Socioeconomic Appraisal

Shipping traffic activity

There are two main shipping routes through the Swedish section that could be impacted by the pipeline route alternatives (see **Figure 6.8, Figure 6.9** and **Figure 6.10**). The pipeline route alternative to the west of Gotland is located within the area of a shipping route. The northern section of the optimised route to the east of Gotland is not within any shipping lanes and runs close to but does not cross the IMO-recommended shipping lane in the area of Hoburgs Bank. The route alternative further south east of Hoburgs Bank brings the pipeline to the southern side of the shipping lane and crosses the shipping lane at its bend (see **Figure 6.10**) which may further hamper shipping traffic and increase the risks connected with installation and maintenance/monitoring during pipeline operation. The option with the least interference with shipping traffic is therefore the route east of Gotland with the optimisation around Hoburgs Bank.

Existing cable/pipeline routes

Routes are shown on **Figure 6.8**, **Figure 6.9** and **Figure 6.10**.

The pipeline route to the west of Gotland crosses several existing cables. The optimised route alternative to the east of Gotland crosses two cables that lead to Gotland itself and one to the north of Gotland. The optimised route alternative to the east of Gotland and around Hoburgs Bank closely follows the Denmark-Russia telecom cable but does not cross it. The route further south east of Hoburgs Bank, however, would cross the cable twice.

It can therefore be concluded that the route to the east of Gotland is the preferred route considering cable crossings. Looking at the route around Hoburgs Bank the optimised route also offers advantages in this regard.

Marine user activities

There are differences between the route alternatives for military activity areas and proposed future infrastructure, but no differences for tourism or any other marine activities.

There is a firing danger area approximately 2 km from the route east of Gotland near Gotska Sandön and the northern part of Gotland (see **Figure 6.11**) but there should be no impact during construction and operation. The route to the west of Gotland passes through a military exercise area in the south eastern part of Sweden. The route to the east of Gotland is therefore preferred.

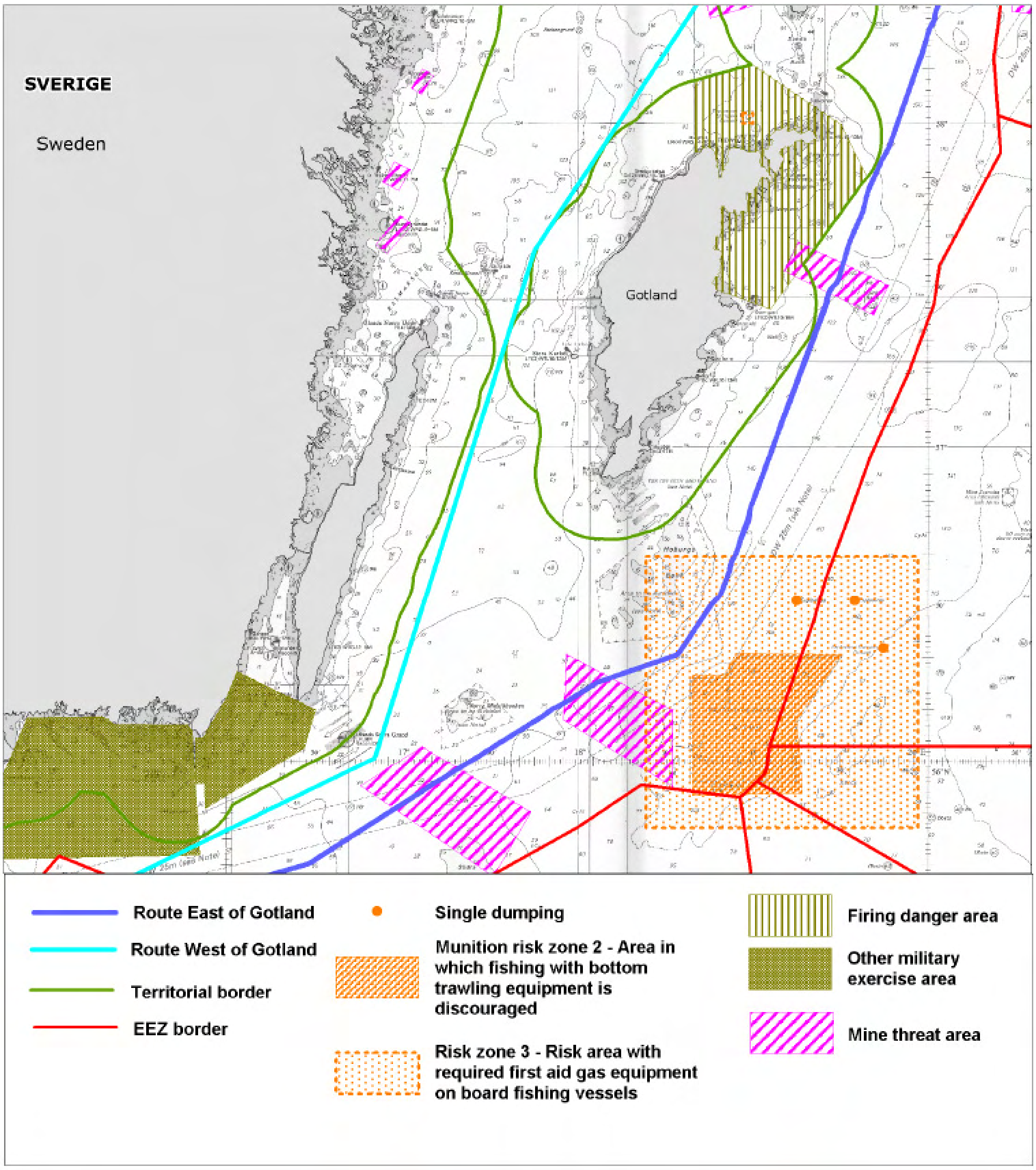


Figure 6.11 Munitions risk and military areas near Gotland and Hoburgs Bank

The route further south east of Hoburgs Bank will bring the pipeline slightly closer to Södra Midsjöbanken, where an area is proposed for an offshore wind farm development, but due to the distance from this site, neither of the route options will impact the area.

In the area farther to the south-east of the Hoburgs Bank, the company OPAB has sought a concession for oil prospecting. The most relevant parts of this area are those in the southern section, nearest the Polish exclusive economic zone. A pipeline route farther to the south-east would bring the pipeline closer to this area, which may be used for oil and gas extraction, and the risk of conflicts between the various interests is judged to increase.

Munitions

There are several areas within the Swedish EEZ where it is possible that munitions may be encountered (see **Figure 6.11**).

As the pipeline route to the west of Gotland leaves the Finnish EEZ to pass to the west of Gotland it passes within approximately 5.6 km of a mine threat area near the Öland Peninsula. There are a number of munitions close to the pipeline route to the north west of the Natura 2000 site Gotska Sandön and abandoned minefields between Gotland and the mainland of Sweden. As the route heads towards Bornholm it passes through other areas of munitions.

The route to the east of Gotland passes through three mine threat areas and a Risk Zone 3 which surrounds a chemical munitions dumping area (see **Figure 6.11**). The route also comes within approximately 9.1 km of a Risk Zone 2 where bottom trawling is discouraged and passes dumping sites approximately 26.3 km away. In the waters off north east Gotland there is unexploded ordnance but this will be cleared prior to construction.

As mentioned above, the optimised route around Hoburgs Bank passes through a Risk Zone 3 and through two mine threat sites. The route further south east of Hoburgs Bank would pass through the centre of the two mine threat sites and further into the Risk Zone 3 so that it actually passes through a dumping area for chemical munitions at Gotland Deep, which entails a slightly higher risk of encountering munitions along the route (see **Figure 6.10**).

Culture heritage sites/areas

Surveys were conducted in 2005–2008 using side scan sonar and video from a ROV (Remotely Operated Vehicle) No sites of cultural heritage were found on the Swedish continental shelf within the pipeline corridor to the East of Gotland. There are no known wrecks along the route to the west of Gotland, but detailed surveys have not been conducted during the feasibility study for this area.

Technical Appraisal

Risk and safety

There are several potential factors which could influence the safety of the pipeline. In the case of the route alternatives around Gotland and Hoburgs Bank, one important factor influencing safety is possible exposure to impacts from shipping.

The western route around Gotland is potentially exposed to higher risks due to its location in the shipping lane for a much longer distance than the eastern route. When comparing the optimised route to the option further south east of Hoburgs Bank, the route further south east brings the pipeline to the southern side of the shipping lane and crosses the shipping lane in the bend which may further hamper shipping traffic and increase the risks connected with installation and maintenance/monitoring during pipeline operation. The optimised route is therefore preferred.

Construction time

The route to the east of Gotland is the shortest route and will therefore take the least time to construct. A detailed comparison between the optimised route around Hoburgs Bank and the route further south east of Hoburgs Bank cannot be conducted as a specific pipeline routing has not been considered.

Technical feasibility and seabed intervention works

Sections of the optimised route south of Hoburgs Bank will require pipeline stabilisation in the form of a total length of some 50 km of rock-placement and/or trenching. Trenching is also planned for the section of the pipeline between Norra Midsjöbanken and Södra Midsjöbanken. The route corridor further south east of Hoburgs Bank will come very close to the shallow water at Södra Midsjöbanken, and additional trenching for the pipelines may be needed in order to protect them from waves and currents. Further, as stated above, a more southern routing from Hoburgs Bank could conflict with the cod spawning area of the Slupsk Furrow, where increased seabed intervention works are expected.

No detailed engineering assessment has been conducted for the route to the west of Gotland in regard to the required amount of seabed intervention works.

Overall length

The route to the east of Gotland is the shortest route at approximately 506 km around Gotland. The route to the west of Gotland is approximately 517 km long.

A specific pipeline route has not been considered for the option further south east of Hoburgs Bank as a general study area was used instead. As such, no detailed comparison of route length can be provided.

Summary and Conclusion

An appraisal summary for the route alternatives west and east of Gotland and the alternative routes at Hoburgs Bank is presented in **Table 6.8**.

The route to the east of Gotland was chosen at an early stage of the project for the following key reasons:

- The route avoids major shipping routes
- There are fewer crossings of military and munitions areas
- Considering a landfall at Greifswald, the route in the Swedish sector is shorter

At Hoburgs Bank, the assessment of the alternatives against the defined criteria concludes that the optimised route around Hoburgs Bank is to be preferred. Moving the route further to the southeast would not be beneficial. The main reasons are as follows.

- The investigation of an alternative study corridor was initiated because of concerns about impacts of construction on Natura 2000 sites. Detailed modelling studies have demonstrated that sediment dispersion from the works will not have any adverse impact at the distances involved, and that moving the route would therefore not yield significant benefit
- The route further southeast is closer to the cod and sprat spawning grounds with a potential for increased seabed intervention works; and moving the route would bring it into potential conflict with a main shipping lane and require additional cable crossings

Table 6.8 Comparison of impacts between the route alternatives in Sweden

Criteria	Route alternatives			
	Gotland		Hoburgs Bank	
	West	East	Optimised route	Route further southeast
Environmentally sensitive / protected areas	Route passes Natura 2000 sites > 4km: Gotska Sandön/ Norra Midsjöbanken. No difference in impact expected.	Route is >3 km from Hoburgs Bank/ Norra Midsjöbanken. No difference in impact expected.	Route is > 3 km from Hoburgs Bank. No difference in impact expected.	Route is further away from Hoburgs Bank. No difference in impact expected.
Ecologically sensitive species	There are no known ecologically sensitive species in this area.	There is a cod and sprat spawning ground to the east of Gotland.	There is a cod and sprat spawning ground to the east of Hoburgs Bank.	This route is closer to the cod and sprat spawning grounds as well as wintering areas for sea birds at Södra Midsjöbanken
Seabed disturbance and sensitive seabed features	None at Norra Midsjöbanken, no other known.	None at Hoburgs Bank/ Norra Midsjö, no others known.	None at Hoburgs Bank, no other known.	Increased seabed intervention works expected near cod-spawning area.
Shipping traffic activity	Route located in main fairway.	Route parallel to main fairway.	Route close to main fairway.	Route crosses shipping lane in bend.
Existing cable / pipeline routes	Route crosses several existing cables.	Route crosses three cables/pipeline.	Route parallel to existing telecom cable.	Route crosses telecom cable twice.
Marine user activities	This route passes through a military exercise area.	There is a firing danger area approximately 2 km from this route.	No significant conflicts with marine user activities.	No significant conflicts with marine user activities.
Munitions	Two areas of munitions charges/	One area of munitions/ three	Two mine threat areas, no	Two mine threat areas/ One

Criteria	Route alternatives			
	Gotland		Hoburgs Bank	
	West	East	Optimised route	Route further southeast
	one abandoned minefields area/ one mine threat area.	mine threat areas.	munitions findings.	chemical munitions dumping area, no detailed munitions surveys.
Cultural heritage sites / areas (e.g. wrecks, marine archaeology)	It is unknown whether there are any wrecks along this route.	No cultural heritage sites found.	No cultural heritage sites found.	No known wrecks/cultural heritage sites in the area.
Risk and safety	Route located in main fairway.	Route parallel to main fairway.	Route close to main fairway.	Route crosses shipping lane in bend.
Construction time	This route is longer and should require more construction time.	This route is shorter and should require less construction time.	No comparison possible as no specific route further southeast has been considered.	No comparison possible as no specific route further southeast has been considered.
Technical feasibility and seabed intervention works	Route technically feasible, but no detailed evaluation conducted.	Some seabed intervention works required.	Some seabed intervention works required.	Possible additional trenching in shallow water areas near Södra Midsjöbanken.
Overall length	Approximately 517 km.	Approximately 506 km.	No comparison possible as no specific route further southeast has been considered.	No comparison possible as no specific route further southeast has been considered.

Request for investigations of a possible alternative east of the recommended shipping lane

Within the Swedish application process the Swedish Maritime Administration and the Swedish Environmental Protection Agency have in bilateral discussions and in comments to the Nord Stream documentation brought up the need to analyse the possibility of an alternative alignment in the area southeast of Gotland, see Figure 6.8a [1].

The Swedish Environmental Protection Agency takes a favourable view of the fact that Nord Stream AG describes in part why the primary option was selected in preference to an alignment further south east of Hoburgs Bank. Despite Nord Stream’s account, the Swedish Environmental Protection Agency however considers that an alternative route for the gas pipelines in the “Hoburgs Bank” and “Norra Midsjöbanken” Natura 2000 areas, further south-east than the current proposal, should be investigated and described. This due to the fact that the Agency is not fully convinced by the arguments put forward by Nord Stream that the optimal route has been found.

From the navigational point of view the Swedish Maritime Administration can see several alternative alignments to the east and the south of the “deep water” channel through the Baltic Sea that they consider to be more suitable. The Maritime Administration considers the areas around Hoburgs Bank and Norra Midsjöbanken to be critical to navigation if the gas pipelines are to entail restrictions on the possibility of anchoring in an emergency with the aim of avoiding the conservation areas of the banks. The Swedish Maritime Administration also considers that the gas pipelines should run at right angles to the direction of the deep water channel where the two cross.

Nord Stream's evaluation of alternatives has been done against a number of criteria as described in detail above in **Chapter 6.1.7** and as summarised in **Table 6.8**.

As far as environmental aspects are concerned, it is evaluated that neither the installation nor the operation of the pipelines will have any significant impact on the Natura 2000 areas of the Hoburg Bank and the Norra Midsjöbanken.

Moreover, a route further to the south-east entails a higher complexity for the route selection, and will include more potential conflicts among the following issues; see also **Figure 6.8b**:

- Conflicts with other nature interests

- Conflicts with deep-water Baltic shipping lanes

(1) The information in figure 6.8a is based on a map handed over at the Espoo work group meeting in Copenhagen on February 13, 2009

- Conflicts with area for dumped chemical munitions
- Changed scale of work on sea bed
- Conflicts with natural resources, planned wind power farms and cables

A route further to the east and south-east, south of the Södra Midsjöbanken, would mean that the pipelines will be taken directly through central parts of an area containing dumped chemical ammunition, through the most interesting area for possible future extraction of oil/gas and through potential breeding grounds for cod in the Gotland Deeps and the Stolpe Furrow. The route would also mean probable sea bed work at e.g. the Södra Midsjöbanken, with potential impacts on habitat, bird life and a cod spawning area.

Therefore the benefit to nature and environment of taking the pipelines further to the south-east from the Hoburg Bank and Norra Midsjöbanken is not fully clear.

Nord Stream does however understand the need for detailed assessments into a potential minimisation of possible effects on the maritime traffic; including an assessment of a route on the eastern side of the recommended shipping lane as requested by the Swedish Maritime Authority, see **Figure 6.8a**, and is in the process of preparing the necessary documentation. The results will be discussed with the relevant authorities during the international consultation period and on a bilateral basis with the authorities.

The above mentioned additional assessments and the remaining topics raised by the Swedish authorities will naturally also be addressed in the national environmental report.

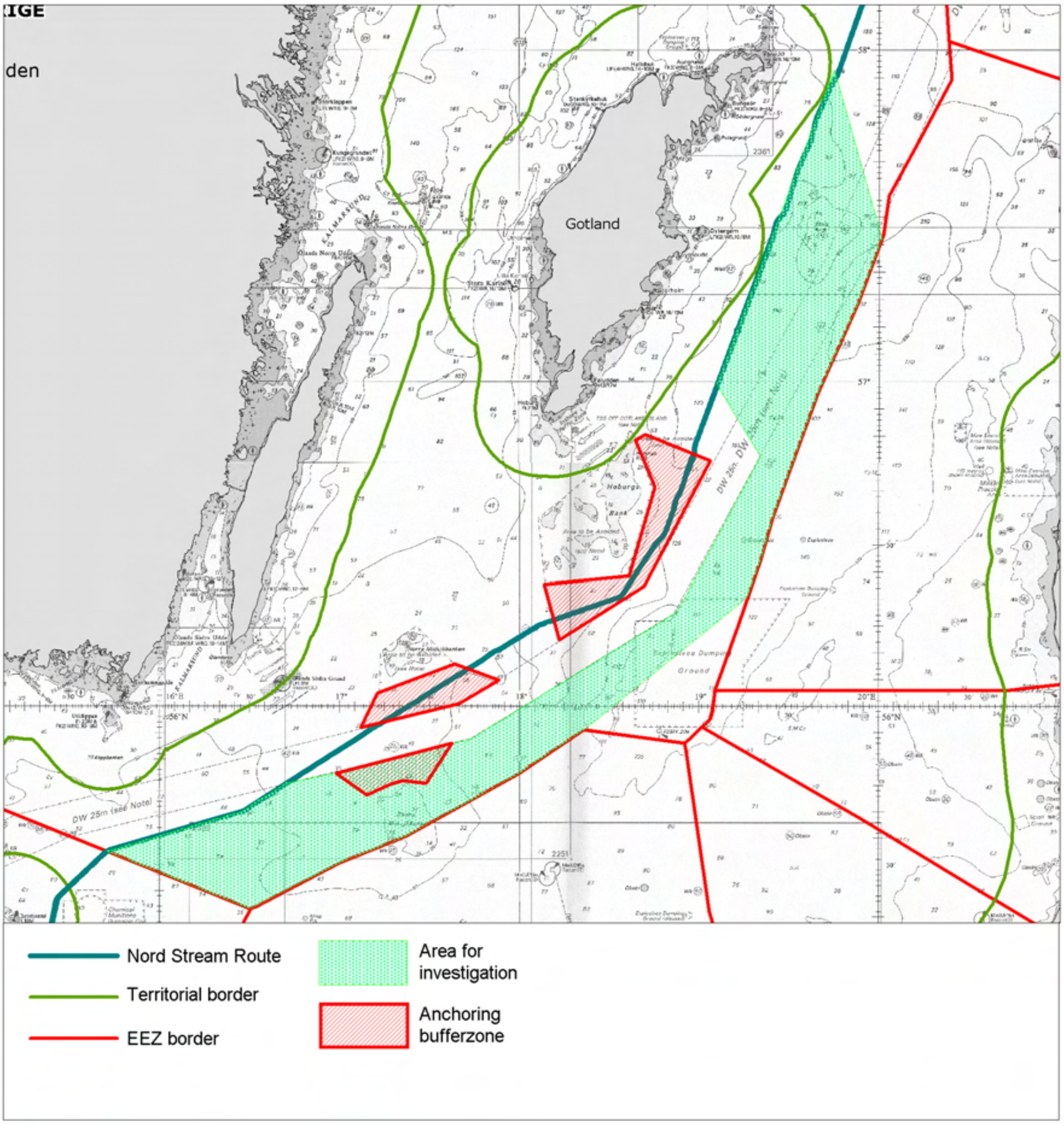


Figure 6.8a Investigation area requested by the Swedish EPA (Naturvårdsverket) and the Swedish Maritime Authorities (Sjöfartsverket). Handed over to Nord Stream AG at the Espoo Work Group meeting on February 13, 2009

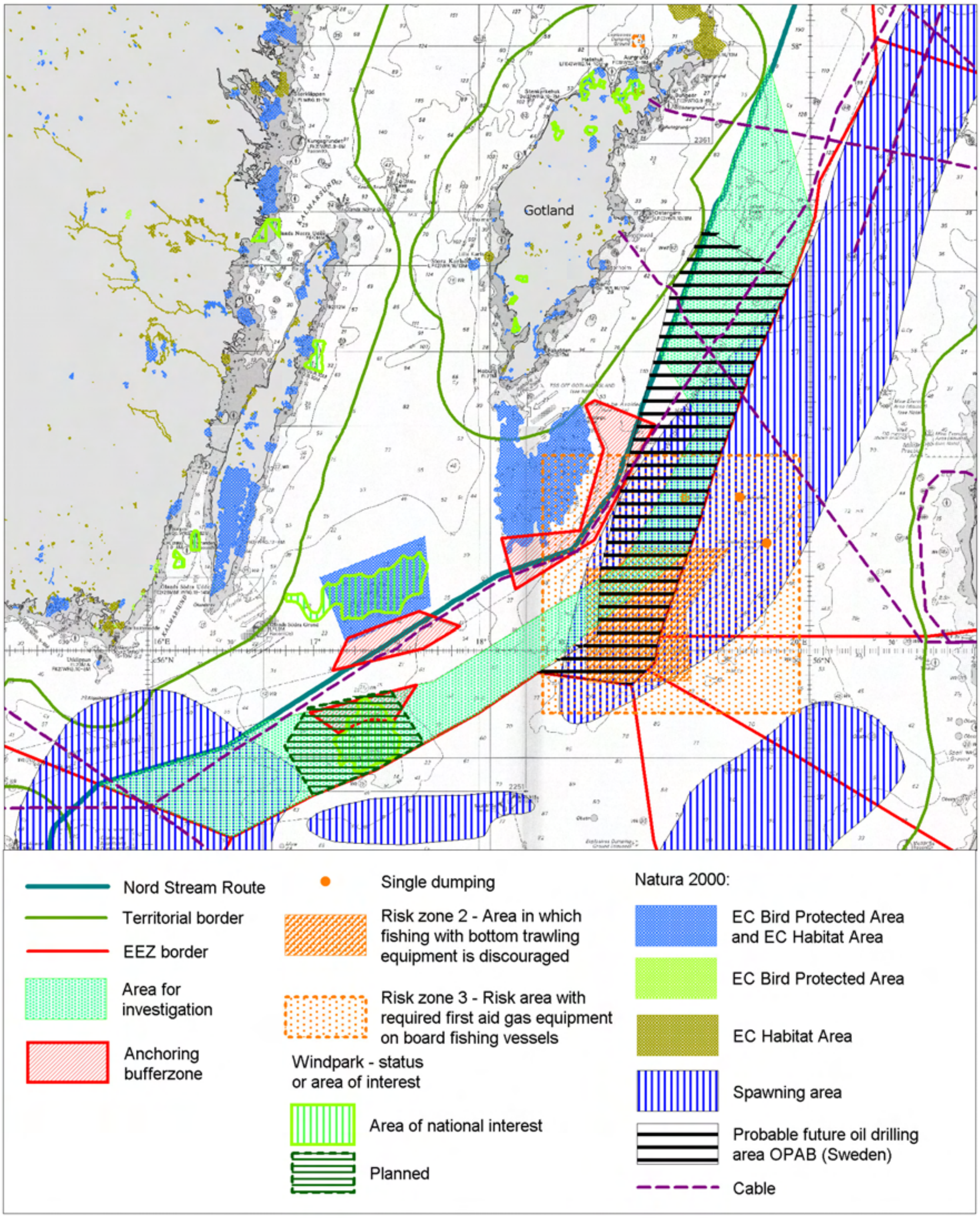


Figure 6.8b Different interests in the requested investigation area

6.1.8 Route Alternatives in Denmark – Bornholm

Introduction to Route Alternatives in Denmark

The Nord Stream Route runs for about 140 km through Danish waters. During route development Nord Stream has identified and studied a total of five alternatives taking different routes around the island of Bornholm. In close collaboration with the authorities, two alternatives, a northern route around Bornholm and an alternative S-route to the south of Bornholm were subject to detailed consideration. These are shown on **Figure 6.12.**

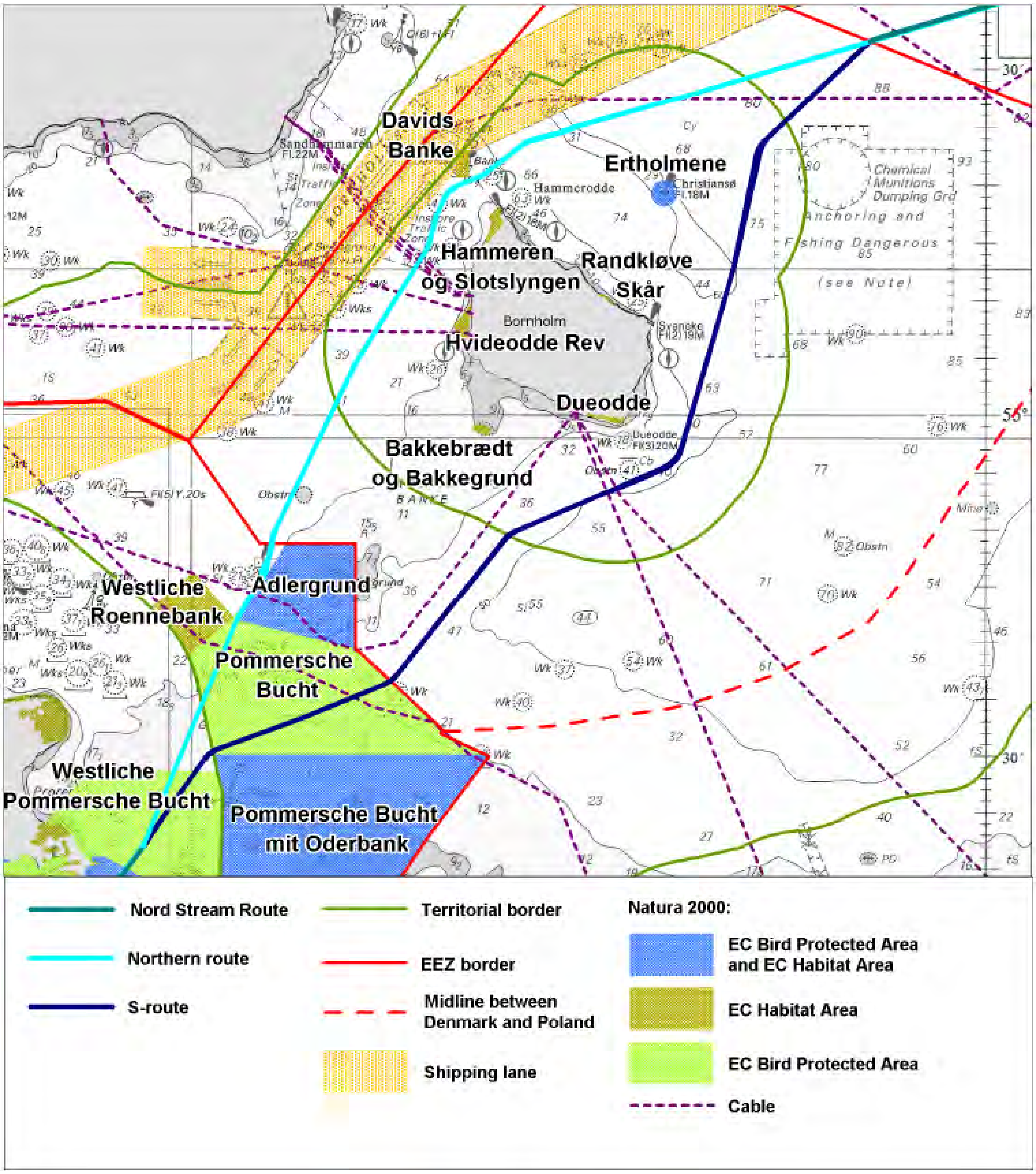


Figure 6.12 Route alternatives at Bornholm

The northern route around Bornholm

The northern route alternative passes through Danish territorial waters, to the north of Bornholm, but south of the main shipping traffic lane in this region (see **Figure 6.12**). The route is to the south east of the David's Bank Natura 2000 site, and away from the majority of large vessels travelling in and out of the Baltic Sea. The corridor was surveyed in mid-2007. The identification of the northern route as one option was done by considering the technical advantages such as layability, environmental impact and influence of sensitive environmental areas as well as potential munitions risks.

S-route in the south of Bornholm

In January 2008 the Danish Energy Authority recommended that an alternative route south of Bornholm should be considered as an alternative to the northern route due to the shipping risks north of Bornholm. This was reiterated in meetings in March and June 2008. The S-route was developed to avoid traversing a munitions Risk Zone 2 and the main shipping lane. The S-route deviates from the northern route at the EEZ boundary between Denmark and Sweden, passing west of the chemical munitions Risk Zone 2 and joining the northern route in the German EEZ (see **Figure 6.13**).

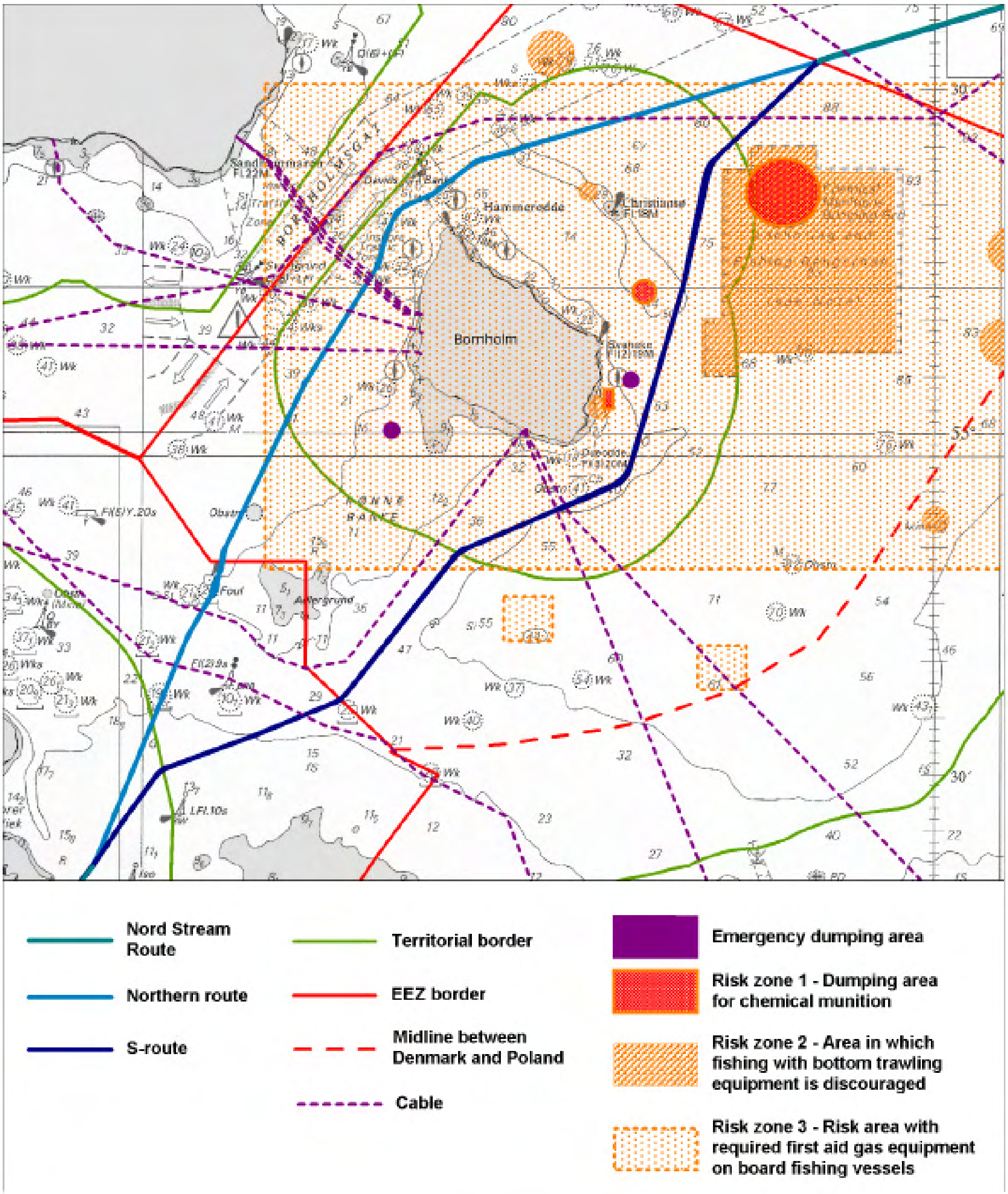


Figure 6.13 Munitions risks around Bornholm

Since both options extend into the German EEZ the appraisal takes into account their impact in both Denmark and Germany.

Environmental Appraisal

Environmentally sensitive / protected areas

In Denmark there are a number of Natura 2000 sites and other protected areas (SAC, SPA and Ramsar sites) as shown in **Figure 6.12**. The northern route passes approximately 0.5 km south of the David's Bank SAC. It also passes 11.9 km from the Ertholmene SAC, SPA and Ramsar site. The S-route does not pass through any Natura 2000 areas in Danish waters. It passes the Ertholmene SAC, SPA and Ramsar site at a distance of 11.1 km, at a similar distance to the northern route. Therefore, it is considered that in Danish waters the northern route alternative has a higher potential risk of impacts on environmentally sensitive sites, as this route passes significantly closer (within 0.5 km) to a protected site than the southern route.

Both the northern route and S-route will pass through the Pomeranian Bay Natura 2000 site in German waters. The S-route will pass through 51 km of the site but at present no seabed intervention works are expected to be required within this area. The northern route crosses a shorter distance through the Pomeranian Bay (43 km) but the seabed intervention works will be more extensive. Additionally, the northern route will pass close to the Adlergrund Natura 2000 site.

Overall, it is concluded that the S-route to the south of Bornholm is the preferred alternative as it has less potential risk of impacts on Natura 2000 sites in both Danish and German waters.

Ecologically sensitive species

Surveys have been carried out for both routes and extensive secondary data was taken into account in order to assess the route alternatives.

In total four species of marine mammals (porpoises and seals) are found in the Baltic Sea. However, colonies and populations near the proposed pipeline route are mainly found to the eastern and western ends of the pipeline, and are not commonly sighted in the Danish area. No significant difference can be expected regarding the impact on fish species between the northern route and S-route since seabed intervention is limited for both of these routes.

Benthos may be temporarily affected by construction of the northern route, due to the higher species richness, abundance and biomass of benthos to the north of Bornholm. Such impacts will be temporary in duration but likely to be marginally greater than for the S-route. Both the S-route and northern route pass near to the Ertholmene protected bird area, however no impacts on birds at this site are expected from either route, as the pipeline will be constructed at a sufficient distance from the site. The northern route and S-route also pass through the Pomeranian Bay protected bird area in the German sector. Although the length of the S-route through the SPA is slightly longer, greater seabed intervention works are required on the northern route and any impact on birds during construction is likely to be of similar scale.

Overall, it is considered that no difference in impacts on sensitive species is to be expected from the alternative routes.

Seabed disturbance and sensitive seabed features

There is little significant difference in seabed features between the northern and southern route alternatives. An interpretation of the seabed geology, based on different surveys, indicated that the seabed in the Bornholm area is generally quite flat and does not support specific seabed features that would be sensitive to impacts from the pipeline. This is supported by the fact that very limited seabed intervention works (either pre-lay or post-lay) are expected to be required for either the northern or the southern route alternatives around Bornholm.

In German waters the northern route alternative will require more significant seabed intervention works than the S-route, however the magnitude of intervention works required is overall quite low for both options.

In conclusion, it is considered that there is no significant difference between the two route alternatives with regard to potential impacts on sensitive seabed features.

Socioeconomic Appraisal

Shipping Traffic Activity

Both routes were designed to avoid impacts on shipping activities. In general only minor impact can be expected during the construction phase. During the operational phase of the pipeline no shipping traffic limitations are to be expected.

Along the northern route a Vessel Traffic Separation (VTS) scheme has been established. The pipeline route is at a distance of 1.4 km from the shipping lane as shown in **Figure 6.12** and any impact will be minor. Ship traffic along the S-route is smaller than in the area of the northern route and as a result there will be a smaller impact on shipping.

Consequently, the S-route is preferred in terms of the impact on shipping traffic activity.

Existing cable / pipeline routes

Routes are shown on **Figure 6.12**. There will be no crossings of existing pipelines along the northern route or S-route in either the Danish or the German EEZ. Six existing cables will be crossed by the northern route within the Danish EEZ and one additional cable in the German EEZ. This compares to three cable crossings required on the S-route, which makes the S-route preferable from this perspective.

Marine user activities

Fishing intensity to the north, south and east of Bornholm (except in the chemical munitions risk zone to the east of Bornholm) is very high with a high trawling fishing effort. Catch statistics from trawling data show that the quantity of fish caught north and south of Bornholm is similar, although slightly greater to the north than to the south. due to the shallower waters south of Bornholm. Disruption caused by the northern route is therefore expected to be slightly higher and this will be reinforced by the greater level of seabed intervention works. All pipeline routes will have a small impact on fisheries and fishermen will obtain compensation which will be subject to agreement. It is important to note that no significant impacts on fish species/fish stocks are to be expected through either of the two routes.

Neither the northern route nor the S-route interfere with dredging or interests related to natural resources in the seabed

Along the northern route, the pipeline will pass through 42 km of firing danger area, mainly within the German sector. A military practice area will be crossed for 113 km on the S-route. In summary, the northern route will have slightly less potential impact on than the S-route, in terms of interference with military practice areas.

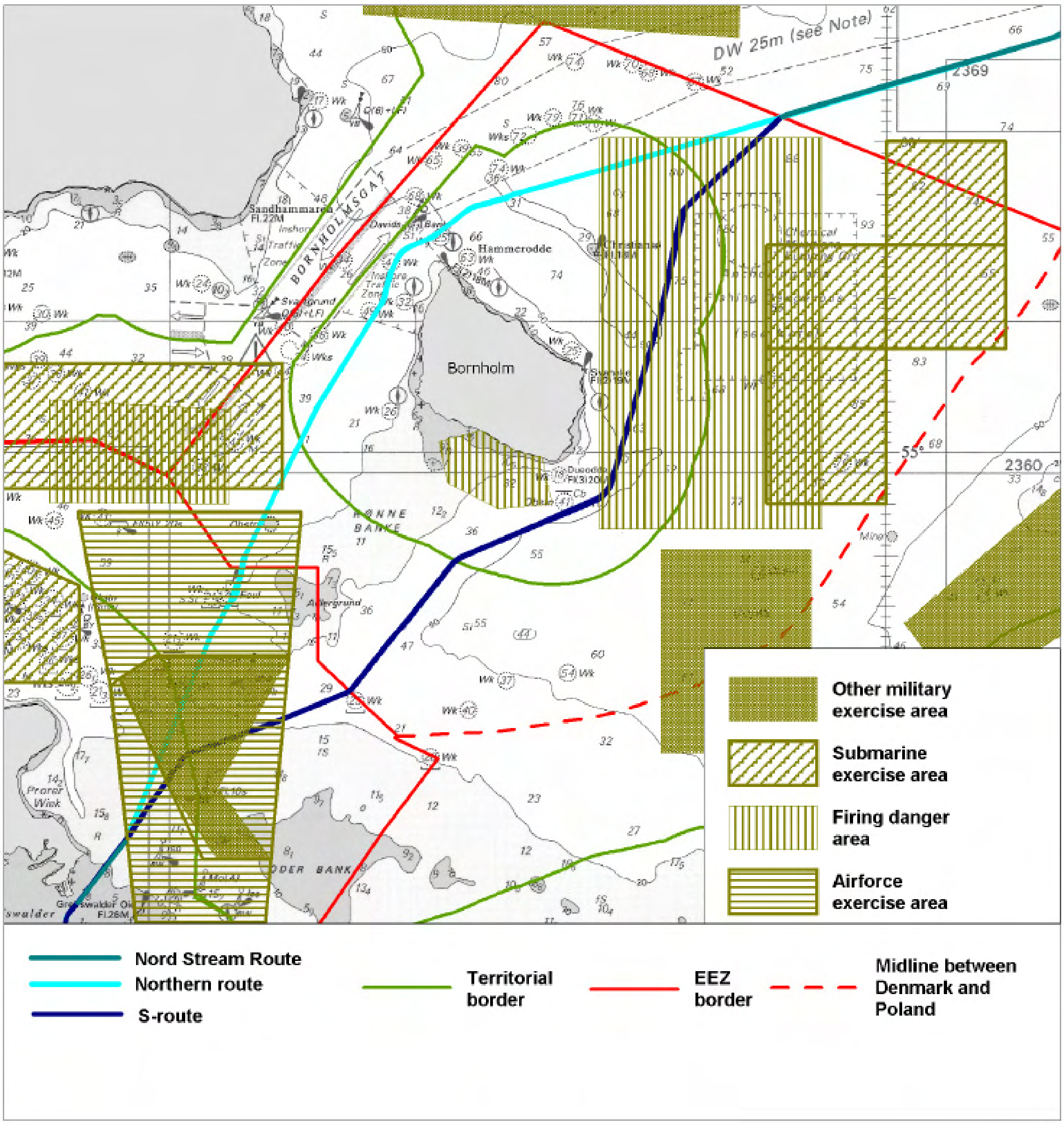


Figure 6.14 Military areas around Bornholm

Tourism is important to Bornholm's economy, with over two-thirds of visitors to Bornholm being tourists. Attractions include beaches in the north and south, Hammer Odde on Bornholm's northern tip, the Ertholmene archipelago, and leisure boating around the island. The northern route passes more beaches at Sandvig, Næs, Sandkaas, Hasle Lystskov, Antionette and Nørrekås but the smaller number passed by the S-route (Dueodde and Balka) are more popular. Leisure boating is particularly common around the north of Bornholm, to the Ertholmene archipelago and there are 10 main marinas located on the west, north and east coasts of the island. Tourism resources are therefore located at similar distances from both routes; impacts are likely to very limited but similar.

Munitions

There is an area of discarded chemical munitions and waste to the east of Bornholm. The area around Bornholm is divided into the three chemical munitions risk zones explained in **Section 6.1.2**, Environmental Criteria, as shown in **Figure 6.14**.

Both the northern route and S-route avoid passing through chemical munitions risk zones 1 and 2. The S-route is closer to risk zone 2. Nevertheless, survey results report no findings but chemical testing results give an indication of a diffuse low level of background contamination below all thresholds. These results were expected given the history of the area, but indicate that pipelay in this area will be unproblematic. Along the northern route surveys were carried out and no munitions were found. As a result neither route option is preferred on this basis.

Cultural heritage sites /areas

Surveys located ten wrecks along the northern route, and seven along the S-route. These wrecks are not of major concern for the routing, as they are far enough from the pipeline to avoid the need to lift wrecks or initiate marine archaeological excavation or documentation on either route.

Technical Appraisal

Risk and safety

A risk assessment for the operational phase for both routes has been carried out to assess issues pertaining to the safety of the pipelines.

The risk assessment for the northern route highlights that the ferry boat line operation along the northern route would lead to higher ship traffic intensity over the pipelines (in terms of number of ship crossings) than on the S-route and thus slightly greater risk to the pipeline. The risk is well below internationally accepted standards and is therefore acceptable for both routes.

Construction time

There is no significant difference between the northern route and the S-route with regard to construction timescale.

Technical feasibility and seabed intervention works

The geological setting of routes does not differ greatly and there is no evidence to suggest that there is any difference in tectonic and seismic activity between the northern route and S-route.

On the northern route approximately 40 km of post-trenching intervention works will be required for the pipelines in Germany and off the northern tip of Bornholm, where harder ground forms a sub sea ridge to David's Bank and waters are shallower. Screening has been carried out to assess the feasibility of the intervention works planned. The results of the analysis do not highlight any problems regarding these works.

Along the S-route, approximately 7 km of post-trenching intervention works will be required for on-bottom stability for the pipelines. These works are expected to be required mainly near Dueodde, as well as where the route traverses the Christiansö Horst, extending south-east from Ertholmene.

No free-span corrections via rock placement or installation of special support structures are expected to be required on either route and overall the S-route is preferable from this perspective.

Overall length

The northern route runs approximately 140 km around Bornholm (48 km in the Danish EEZ and 92 km in the Danish territorial waters), and the S-route runs approximately 136 km (49 km within the Danish EEZ and 87 km within Danish territorial waters). Thus there is no reason to favour either alternative on the basis of pipeline length.

Summary and Conclusion

Two route alternatives have been assessed in detail within the Danish section, and the findings are summarised in **Table 6.9**.

Based on the assessment against the defined criteria the S-route has been identified as the preferred route. The main reasons for this are:

- The northern route passes closer to Natura 2000 sites in Danish waters and requires more seabed intervention in the Pomeranian Bay Natura 2000 site
- The northern route requires more seabed intervention works in the Danish and the German section
- The northern route runs near the busy shipping lane north of Bornholm and although the risk from shipping is not significant along either route, it is slightly higher on the northern route
- The northern route involves seven rather than three cable crossings
- The northern route will involve a greater level of seabed intervention works

Table 6.9 Comparison of impacts between the route alternatives in Denmark

Criteria	Route alternatives	
	Northern route	**S-route**
Environmentally sensitive / protected areas	Route passes close to Natura 2000 sites in Danish and German waters and through a Natura 2000 site (SPA Pomeranian Bay) in the German EEZ. The route requires more significant seabed intervention work in the SPA.	Route does not pass close to Natura 2000 sites in Danish waters, but through a Natura 2000 site (SPA Pomeranian Bay) in the German EEZ.
Ecologically sensitive species	No significant difference to the S-Route.	No significant difference to the Northern Route.
Seabed disturbance and sensitive seabed features	No significant difference to the S-Route.	No significant difference to the Northern Route.
Shipping traffic activity	The northern Route runs close to a shipping lane north of Bornholm	S-Route avoids running close to a shipping lane north of Bornholm avoiding potential minor impact during construction phase.
Existing cable / pipeline routes	Route crosses seven cables in total.	Route crosses three cables in total.
Marine user activities	Minor impacts on fishing and tourism expected during construction phase.	Minor impacts on fishing and tourism expected during construction phase.
Munitions risks	No significant munitions risk, but crossing of risk zone 3.	No significant munitions risk, but crossing of risk zone 3 and closer to risk zone 1 and 2.
Cultural heritage sites / areas (e.g. wrecks, marine archaeology)	No cultural heritage found in proximity to the route.	No cultural heritage found in proximity to the route.
Risk and safety	Risk higher compared to S-route, but below the internationally accepted standards.	Risk below the internationally accepted standards; slightly lower compared to Northern Route, as proximity to shipping lane is avoided.

Criteria	Route alternatives	
	Northern route	S-route
Construction time	No significant difference in construction time predicted between this route and S-Route.	No significant difference in construction time predicted between this route and northern Route.
Technical feasibility and seabed intervention works	Route technically feasible. Seabed intervention works required along 40 km of the route.	Route technically feasible. Seabed intervention works required along 7 km of the route.
Overall length	140 km.	136 km.

6.1.9 Route Alternatives in Germany

Introduction

The German section of the Nord Stream Project will run through the German EEZ and territorial waters to terminate on the German coast. A review of the feasibility of different locations for the landfall of the Nord Stream pipeline in Germany during early stages of project development identified three alternative areas: Greifswald, Rostock and Lübeck, shown in **Figure 6.15**, and the appraisal of these is discussed here.

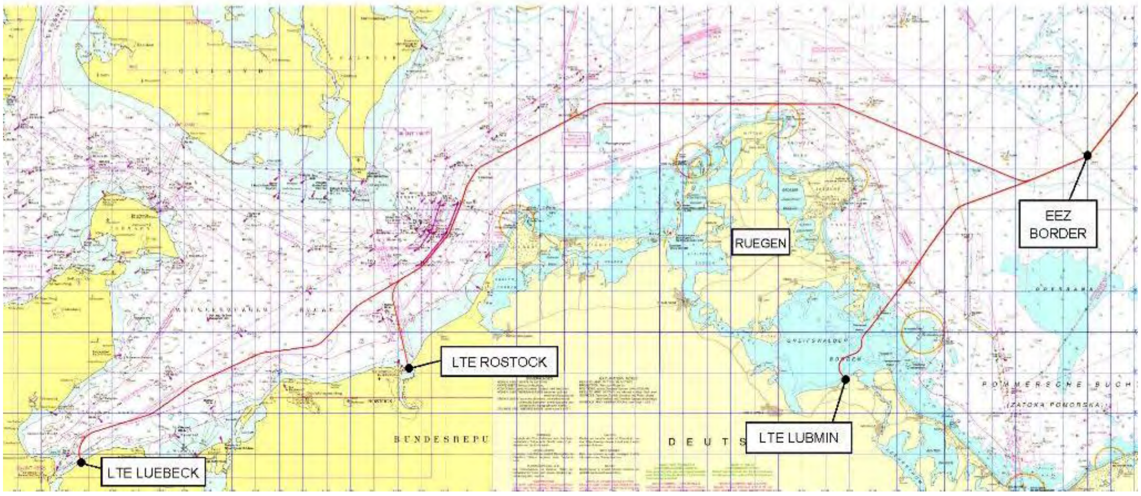


Figure 6.15 Routes to alternative landfall points: Greifswald, Rostock and Lübeck

Greifswald Route

The Greifswald route is shown in **Figure 6.16** It runs in a westerly direction after entering the German EEZ south of the Adlergrund. East of Rügen the route turns to the southwest and from Landtief Tonne B, it enters a regional planning corridor designated as a preferred route for pipeline development through the Greifswalder Bodden(1). It follows this corridor with minor deviations to the landfall point. Within this corridor, defined in the state spatial development programme (LREP) of the State of Mecklenburg-West Pomerania, no regional planning procedure is needed for pipeline development, as it runs primarily through the pre-defined preference corridor in the Greifswalder Bodden. In the Greifswalder Bodden in the area of Boddenrandschwelle, the route curves south before turning in a west-south-westerly direction, east of the Schumachergrund.

(1) Ministerium fuer Arbeit, Bau und Landesentwicklung Mecklenburg-Vorpommern. 2005. Landesraumentwicklungsprogramm Mecklenburg-Vorpommern.

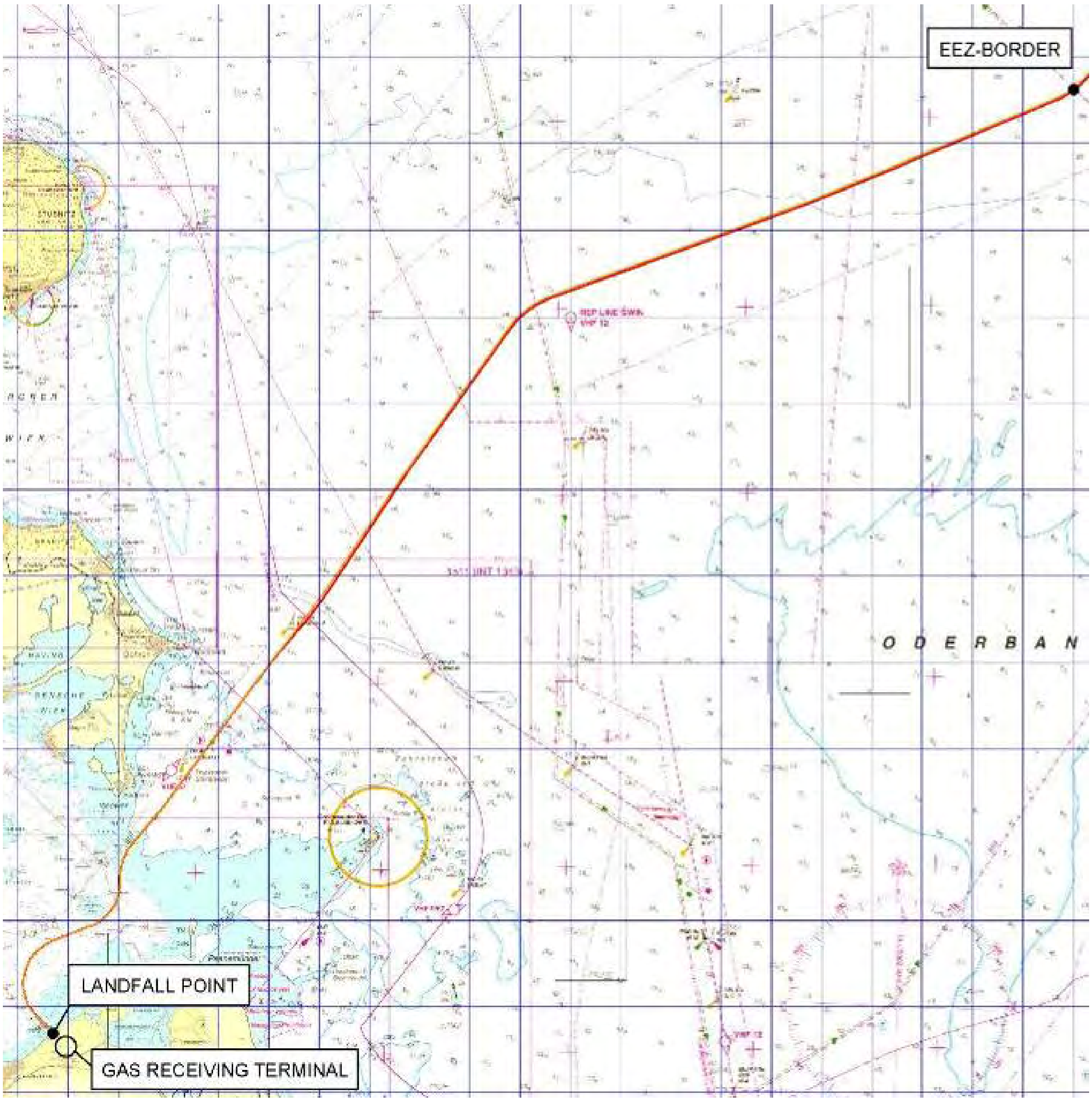


Figure 6.16 The Greifswald route

Rostock route

Like the Greifswald route, the route alternative to the Rostock area (shown in **Figure 6.17**) crosses the boundary to the German EEZ south of the Adlergrund. After about 15 km it bends west-north-west and continues for 25 km in this direction. After another 53 km, the route turns south-west, parallel to the Kadet Channel shipping lane, and continues in this direction for approximately 32 km. The direction changes to south-south-west, parallel to the Kadet Channel. After some 31 km, the route reaches the approach to Rostock Harbour and turns to a south-south-easterly direction, reaching the landfall site after approximately 22 km. The route and its 2 km-wide construction corridor was chosen to minimise contact with protected areas and shipping lanes. The spatial planning situation for the Rostock landfall point is based on the state development programme for Mecklenburg-West Pomerania. A landfall near Rostock would require a special regional planning procedure for the landward connection lines, while the offshore part does not require such a procedure.

Figure 6.17 The Rostock route

Lübeck route

The route alternative to the Lübeck area, shown in **Figure 6.18**, follows the route alternative to the Rostock area as far as the entrance to Rostock Harbour. From there, it continues to Lübeck over a distance of 89 km, parallel to the coastline, in a west-south-westerly direction. The route passes the Bay of Mecklenburg and Bay of Lübeck south of the Lübeck-Gedser shipping lane and then turns south, reaching the landfall point east of Lübeck. As there are no definitions in any existing state or regional planning or development programme, comparable to the state development programme for Mecklenburg-West Pomerania, planning procedures would be required for both the coastal waters and the landward connection lines.

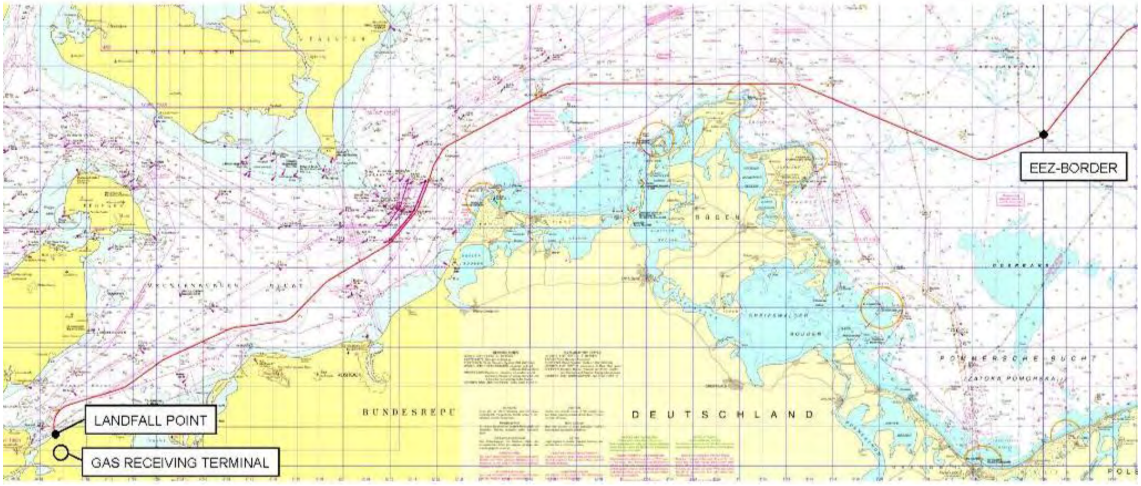


Figure 6.18 The Lübeck route

Environmental Appraisal

Environmentally sensitive/protected areas

Environmentally protected areas in the German section of the pipeline route are shown in **Figure 6.19**.

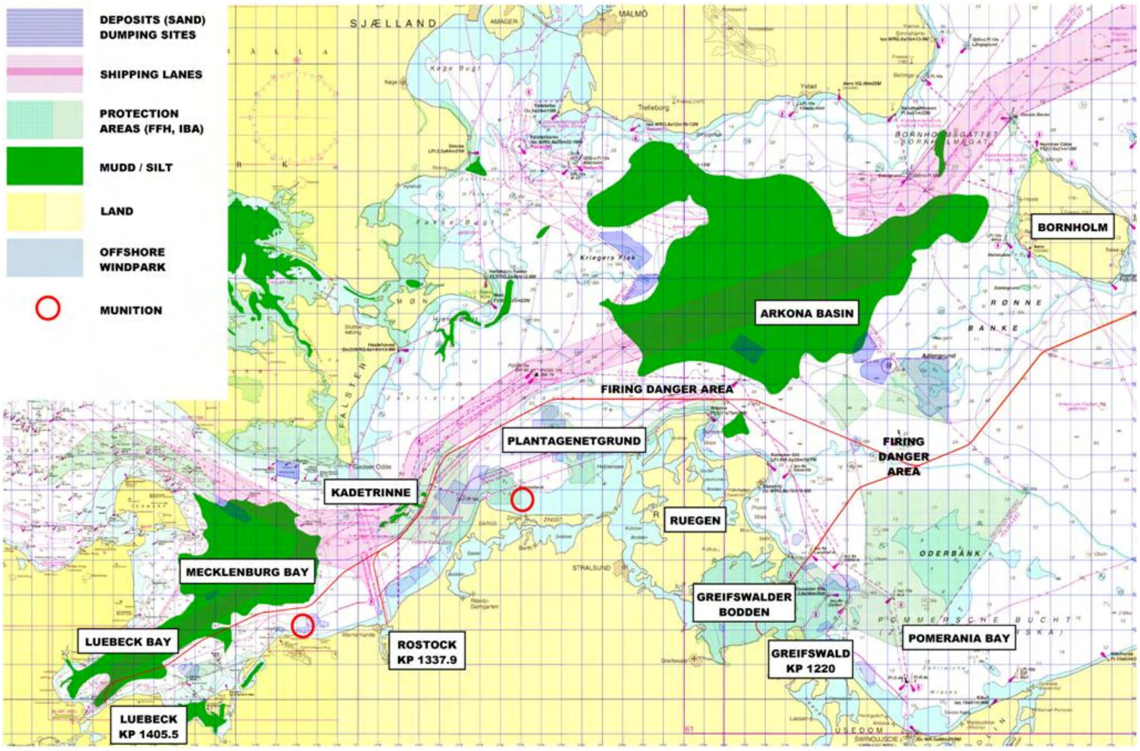


Figure 6.19 Features of the German route alternatives

The Greifswald route passes through a number of protected environmental areas. Seaward of the Greifswald area, the route runs within the Western Bay of Pomerania Natura 2000 site, designated for its bird populations. Within the Greifswalder Bodden, the Greifswald route runs through a Natura 2000 site, the Greifswalder Boddenrandschwelle and parts of four other Natura 2000 sites. In doing so, the Greifswald route passes through reef habitats for approximately 4.7 km on the Boddenrandschwelle and adjacent north-easterly waters as well as for approximately 1 km within the bay. Temporary structural changes to the reef habitats will be caused by laying the pipeline, but these areas will regenerate in the medium term once the stone covering is restored.

At the Greifswalder Bodden landfall the pipeline can be connected to existing energy infrastructure limiting the disturbance caused.

The section of the route alternative to the Rostock area which runs parallel to the shipping lane in the Kadet Channel would require burial of the pipelines. This could result in significant impacts on the "Darßer Barrier" Natura 2000 area, in particular reef habitat, through which approximately 12 km of pipeline are expected to run.

There are no protected areas identified for the section from the Kadet Channel to the landfall east of Rostock. The sea area to the north-east of Rostock contains a large area of stone and rubble deposits (residual sediments of till) at a distance of 5 to 15 km which is sometimes classified as reef habitat. This is not part of a Natura 2000 area, but is protected under the State Nature Conservation Act of the federal state of Mecklenburg-Vorpommern (LNatG M-V). As a consequence of the planned intervention works involved in laying the pipeline, and taking the restoration of the stone covering into account, a short to medium-term impact on these habitats could occur. The landfall area to the east of Rostock contains beaches, coastal protection dunes, and adjacent polders (reclaimed land), and the Wälder und Moore der Rostocker Heide Natura 2000 site lies in the vicinity. The landfall could require land use in wood and forest habitats.

The only section of the route alternative to the Lübeck area to have potential impacts on a Natura 2000 area is located at the landfall area in the Bay of Lübeck. The route would pass through the Coast Klützer Winkel and Shore of Dassower See and Trave Natura 2000 area. The cutoff trench within the route alternative to the Lübeck area is likely to result in a medium-term impact on the benthos, if existing stone and rubble cover were restored following construction. Due to the need to bury the pipelines for a total length of approximately 221 km, the temperature decrease might cause an effect on water and seabed ecology.

The landward coastal fringe is also designated as a nature protection area. The inshore habitats in the landfall corridor would be used temporarily for the construction phase, however after the pipelines have been laid, the original condition of the habitats will largely be restored and regeneration should occur in the short to medium term. More significant impacts would occur on land, which is covered by a nearly contiguous wooded stretch of over 100 m width. Since the route alternative to the Lübeck area would cross this stretch, permanent changes would occur due to the clearing of major trees. The landfall terminal associated with the route alternative to the Lübeck area could probably be constructed on agricultural land, minimising the impact on the terrestrial environment.

Ecologically sensitive species

Along the Greifswald route, fish spawning areas are present within the habitats that could be affected and impacts on these will be mitigated by ensuring that no construction measures are carried out during the spawning season. Visual stimuli, noise, increased opacity and other disturbances could have a temporary impact on susceptible species during the construction phase.

The Rostock route has greater potential for impacts on sensitive species as long-lived mussel species such as *Astarte borealis*, *Astarte elliptica* and *Arctica islandica*, present in the section alongside the Kadet Channel. Some of these mussel species live well over ten years and regeneration times for communities of benthic organisms following dredging for the Rostock route could be significant. The Kadet Channel is also classified as an important habitat for porpoises and other sensitive marine mammals and fish species which could be affected by the significant seabed intervention works required for this alternative.

The Lübeck route is likely to have the same impacts as the Rostock route alongside the Kadet Channel, but in addition dredging through the muddy areas of Lübeck bay is likely to cause strong resuspension and deposition of sediments with a negative impact on benthic species. These are extremely diverse in this area and may include long-lived mussel species. Contaminants and organic components in the mud could also be released into the sea water increasing the adverse impact. An impact on porpoises in the area of the route to the Bay of Lübeck is also possible, as occurrences of these marine mammals increases towards the west, approaching the Fehmarn Belt.

Seabed disturbance and sensitive seabed features

The Greifswald route will pass reef habitats at the Boddenrandschwelle and adjacent north-easterly waters for about 5 km, and in the bay for approximately 1 km. Any temporary structural damage will regenerate in the medium term once the stone covering is restored.

The Rostock alternative could result in significant impacts on the reef within the 'Darßer Barrier' Natura 2000 area over about 12 km and on the State protected reef area north east of Rostock comprised of stone and rubble deposits. The affected areas, however, are subject to many other marine user activities, which represent existing pressures on this area. The length of burial and isolation of the pipeline could also cause an effect on water and seabed.

The Lübeck alternative would additionally pass through the Coast Klützer Winkel and Shore of Dassower See and Trave Natura 2000 area. The cut-off trench within the route alternative to the Lübeck area is likely to result in a medium-term impact on the benthos, provided that existing stone and rubble cover are restored following construction. The inshore habitats in the landfall corridor would be used temporarily for the construction phase, however after the pipelines have been laid, the original condition of the habitats will largely be restored.

Socioeconomic Appraisal

Shipping traffic activity

The Greifswald route would require the crossing of three shipping channels in German territory. However, the main shipping lane in this area is far enough away that no risk to the pipeline is expected from shipping traffic. No significant disturbance of ship traffic is expected.

The Rostock route would cross a total of three shipping channels within the German Sector (see also **Figure 6.19**). Highly frequented shipping lanes are located in parallel and in close proximity to this route alternative, including the Kadet Channel, passed by some 65,000 large ships each year. Shipping traffic will be disturbed to a more significant extent.

The Lübeck route would cross a total of five shipping lanes within the German sector (see also **Figure 6.19**). Highly frequented shipping lanes are located in parallel and in close proximity to this route alternative, including the Kadet Channel. Therefore, as for the route alternative to the Rostock area, the risk of disturbance to shipping traffic is higher than for the Greifswald route.

Existing cable/pipeline routes

The Greifswald route would require the crossing of three existing cables in the German section, compared to 12 cables for the route alternative to the Rostock area and 14 for the route alternative to the Lübeck area. Thus the Greifswald route is preferable in terms of minimising the number of cable crossings.

Marine user activities

The appraisal of alternatives in this section of the pipeline includes impacts on coastal as well as marine users, given the potential impacts of the pipeline landfall and associated infrastructure.

There are no sensitive land or marine uses near the Greifswald route. The coastal area is not regularly used by visitors, and there is no residential area in the close vicinity of the pipeline.

The Rostock route presents greater risk of adverse impacts on recreational interests as the outer coast of Rostock is used extensively by beach tourists and coastal towns and beach access points are highly frequented by visitors. Built-up areas and the Hohe Düne military facilities lie to the east of the harbour entrance to Rostock and the coastal hinterland is dominated by woodland and protected near-coastal moorland such as Hüttelmoor with Heiligensee and the Great Ribnitzer Moor, a narrow dune-forest complex and the Neuhaus colony which extends parallel to the shore between the Great Ribnitzer Moor and Dierhagen.

The outer coast in the Lübeck area is also used extensively by beach tourists and coastal towns, beach access points (such as at Barendorf, Rosenhagen and Pötenitz) and the road parallel to the coast (formerly Kolonnenweg) are highly frequented by visitors. The coastal hinterland is dominated by agricultural land and rural tourism. The Lübeck route is therefore likely to have greater impact on recreational interests than the Greifswald alternative.

Several deposits of sand and gravel are located along the coastline of the southern Baltic Sea and in the area of Adlergrund, southwest of Bornholm. More than 25 offshore fields within the German sector are planned or approved for sediment extraction although only a few are in use at present. Most of these areas are close to the coast. A large dredged spoil dumping ground is in use within the Bay of Lübeck and there are smaller dumping grounds along the coast. Crossing sand deposits and dumping grounds could cause impact on these sites and therefore greater constraints are to be found on the Rostock and Lübeck routes compared to the Greifswald route.

Several different types of military practice zone cover widespread areas within the Arkona Basin north of Rügen and the Pomeranian Bay as well as the Bay of Lübeck. Avoidance of these areas is not feasible for any of the routes.

The Greifswald route runs through firing exercise areas between the border of the German EEZ and the seaward edge of the Boddenrandschwelle, whilst the Rostock and Lübeck routes leave these areas at a point northeast of Rügen. Both the Rostock and Lübeck routes cross the Submarine Exercise Area north of Rügen.

About 10 wind parks are currently in planning, approved or in use in the western Baltic Sea but most of these are located in the Arkona Basin (see **Figure 6.19**) and are not affected by the route alternatives.

Munitions

There are two areas related to munitions, one is located east of the Kadet Channel on the route alternative to the Rostock and Lübeck areas, while the other area is located in the range of the Bay of Lübeck. However risks associated with crossing or proximity to munitions for all route alternatives are evaluated to be comparable for all three alternatives since dangerous areas can be avoided.

Cultural heritage sites/areas

A number of historical ship wrecks are located along the Greifswald route. There is a line of ships at the 'Boddenrandschwelle' that were scuttled by the Swedish Navy in 1715 to form a barrier to other ships wanting to enter the bay. During the construction process one of the wrecks would be removed to prevent damage. This would be funded by Nord Stream and supervised by the Department for Culture and the Preservation of Ancient Monuments of Mecklenburg Western-Pomerania which will provide an opportunity for Nord Stream and archaeologists to work together to improve knowledge of cultural heritage in this area. Lifting the wreck from the seabed gives archaeologists the opportunity to investigate the ship wreck and the adverse impact of removal will be in some measure offset by this benefit. No specific obstacles due to cultural heritage areas have been recorded for the other route alternatives.

Technical Appraisal

Risk and safety

The Greifswald route is not affected by highly frequented shipping lanes and is therefore the preferred route in this regard. In contrast, both alternatives run along the shipping lane in the

Kadet Channel area. The Kadet Channel is considered to be one of the most dangerous and most difficult bodies of water in the Baltic and is passed by some 65,000 ships each year. As a result, interference to ship traffic is expected during pipeline construction. During operation of the pipelines, risk to the pipelines is higher due to the shipping traffic nearby on the Lübeck and on the Rostock route compared to the Greifswald route. No alternative route planning along this area is feasible due to the narrow width of the Kadet Channel.

Construction time

A direct correlation can be established between the route length and the duration of construction. Another factor, which needs to be taken into account, is the amount of seabed intervention works for each route alternative.

Compared to the Greifswald route, the route alternative to the Rostock area is 103 km longer, and construction time would be about one and a half times that for the Greifswald route.

Compared to the Greifswald route, the route alternative to the Lübeck area is 170 km longer and the construction time would be about two and a half times that for the Greifswald route.

Technical feasibility and seabed intervention works

The Greifswald and Rostock routes run through sandy areas which do not pose any serious problems in terms of technical feasibility. In contrast muddy sediments with low bearing capacity cover the central part of the Bay of Lübeck. These are unsuited to a stable, secure long-term position for the pipeline and could result in undesired subsidence or buoyancy of the pipeline. These cannot be avoided because of other activities in the bay and as a result 7.7 million m^3 of muddy sediments will require replacement with suitable floor material and would have to be deposited on land.

In order to minimise impacts on shipping safety and to ensure on-bottom stability, it will be necessary to carry out seabed intervention works in the form of 27 km of pre-lay trenching and 41 km of post-lay trenching on the Greifswald route. Equivalent figures for the Rostock route are 65 km and 84 km and for the Lübeck route, 82 km and 135 km.

The Lübeck route is considered to be the least favourable option in terms of seabed intervention works.

Overall length

The Greifswald route is the shortest of the three route alternatives in the German section. The pipelines run 81 km through the German EEZ and territorial waters. This choice would result in the shortest overall pipeline length (from Russia to Germany) of approximately 1,220 km.

The total length following the route alternative to the Rostock area is approximately 1,323 km, with 184 km located in the German section. The total length following the route alternative to the Lübeck area is 1,391 km, of which approximately 251 km would be located in the German section.

Summary and Conclusion

A summary of the appraisal of options in this section is presented in **Table 6.10.** Based on assessment against the defined criteria, the route to Greifswald is identified as the preferred route. The main reasons for this are:

- Its much shorter length and lesser requirement for seabed intervention
- Its resulting shorter construction time
- The lower risk of disturbance to shipping and the lower risk to the pipeline from damage caused by shipping
- The lower level of tourism and residential use of the coast
- The avoidance of impacts to water and seabed organisms from temperature differences between the gas and the surrounding environment resulting from the burial of the pipeline over a long distance
- The lesser risk to reef habitats and the avoidance of risks to sensitive species (mussels and marine mammals) in the Kadet Channel and Bay of Lübeck
- The availability of existing landside infrastructure reducing the impacts of new construction

Table 6.10 Comparison of impacts between the route alternatives in Germany

	Route alternative		
Criteria	**Greifswald route**	**Rostock route**	**Lübeck route**
Environmentally sensitive / protected areas	Route passes through Natura 2000 areas within marine and landfall areas. No major temperature impact on habitats due to pipeline burial	Route passes through higher number of Natura 2000 area within marine section; pipeline burial in this section likely to have a significant impact on the Natura 2000 area. Temperature impact expected due to pipeline burial	Route passes through a higher number of Natura 2000 area within marine areas. Temperature impact expected due to pipeline burial
Ecologically sensitive species	Small possible impacts on fish spawning areas.	Potentially significant impacts on long-lived mussel species in the Kadet Channel area following dredging; possible impacts also on porpoises and other sensitive marine mammals and fish species.	Potentially significant impacts from dredging on benthic communities which may include long-lived mussels, exacerbated by any release of organic components from sediments into the sea water. Impacts on porpoises in the Bay of Lübeck also possible.
Seabed disturbance and sensitive seabed features	Small potential impacts on reef habitats.	Potentially significant impacts on reef habitats.	Potentially significant impact on reef habitats and possible medium term impact on inshore coastal habitats
Shipping traffic activity	3 shipping lanes crossed Safe distance from highly frequented shipping lanes.	3 shipping lanes crossed Parallel and in close proximity to highly frequented shipping zones.	5 shipping lanes crossed Parallel and in close proximity to highly frequented shipping zones.
Existing cable / pipeline routes	3 cables crossed.	12 cables crossed.	14 cables crossed.

	Route alternative		
Criteria	**Greifswald route**	**Rostock route**	**Lübeck route**
Marine user activities (e.g. fishing, dredging, military areas, marine renewables, tourism)	Crossing of a firing exercise area.	Tourism is important, with the route passing an intensively used beach. Crossing of several types of military practice areas	Tourism is important, with the route passing an intensively used beach; rural tourism is important in the area of the landfall. Crossing of several types of military practice areas
Munitions risks	No significant risk.	No significant risk	No significant risk.
Cultural heritage sites / areas (e.g. wrecks, marine archaeology)	Impact on historic wrecks although project offers opportunity for beneficial research which is considered to offset the adverse effect.	No significant impact.	No significant impact.
Risk and safety	No significant risk.	No significant risk. Proximity to highly frequented shipping lane.	No significant risk. Proximity to highly frequented shipping lane.
Construction time	Shortest route - base of comparison.	Construction time to be extended by approximately 50% longer construction time	Construction time to be extended by approximately 150% longer construction time

	Route alternative		
Criteria	**Greifswald route**	**Rostock route**	**Lübeck route**
Technical feasibility and seabed intervention works	Sandy soil of marine section suitable for laying pipeline. Bearing capacity sufficient. Low volume of soil replacement required. Approximately 27 km of trenching required.	Sandy soil, suitable for laying pipeline. Bearing capacity sufficient. Amount of soil replacement required not known. Approximately 65 km of trenching required.	Crossing of larger parts of muddy sediments not suitable for laying pipeline, soil replacement needed. Bearing capacity insufficient in muddy areas. Pipeline may rise due to freezing. High volume of soil replacement needed. Approximately 82 km of trenching required.
Overall length	approx. 81 km.	approx. 184 km.	approx. 251 km.

6.2 Technical Alternatives

This section discusses the technical alternative evaluation process that has been applied in the selection of materials and technical methods to be used in the design and installation of the two Nord Stream pipelines. It describes the considerations which underpin the selection of the various "base case" technical options, including elaboration of the related environmental impacts. The following technical alternative aspects are discussed:

- Pipeline system design concepts
- Pipeline materials selection (comprising materials selection for line pipe, internal pipe coating, external anti-corrosion pipe coating, concrete weighting, field joint coating and cathodic protection)
- Logistics
- Construction methods (comprising seabed intervention works, pipe lay methods and landfall construction)
- Pre-commissioning
- Commissioning

The chapter is structured as follows:

- **Section 6.2.1** provides some background to the planning process that has driven the selection of technical alternatives for the Nord Stream Project
- **Section 6.2.2** presents an overview of the general approach that has taken place in assessing and selecting alternative options
- **Section 6.2.3** provides an overview of the respective technical area and the selected base case as well as the discussion of the technical alternative selection process for each technical area

6.2.1 Technical Planning Background

Nord Stream is fully aware of its responsibility for the safe execution of the Project and in the longer term, as operator, for the safe operation of the System. As such, Nord Stream has commissioned a comprehensive suite of surveying activities, design studies and related impact assessments.

Nord Stream has drawn on the know-how and experience of its shareholders in developing and optimising the Nord Stream design. Moreover, Nord Stream has contracted some of the most experienced companies dealing with offshore business, including:

- *Snamprogetti*, an engineering company with longstanding experience in the field of offshore pipeline design: Snamprogetti has developed a number of high diameter offshore pipelines worldwide and has been chosen as the main conceptual and detailed design contractor of the Nord Stream Project

- *Saipem,* one of the largest and most experienced contractors in the offshore gas industry: Saipem has performed various offshore pipeline installations worldwide and has been chosen as the main installation contractor for the Nord Stream pipelines

- *Det Norske Veritas (DNV),* a classification and certification company which has developed widely used standards for the offshore pipeline industry: DNV is responsible for verification of the Nord Stream pipeline system

Nord Stream has thus developed a pipeline design and applies technologies which are well proven in the industry and fully compliant with existing codes and standards. The compliance will be confirmed by independently operating verification companies.

Codes and Standards

The Nord Stream Project has been planned according to the Submarine Pipeline Systems Code DNV-OS-F101, version 2000 (with the amendments of 2003; check against the 2007 code amendments will be performed). This is a renowned international code for offshore works. In addition, national codes are applied at landfalls and other codes and standards have been applied where specific requirements apply and are consequently followed as guidance in these areas.

The assessment of different technical options as part of the design process can therefore be summarised as based on the following Project objectives:

- To execute the Project in a safe manner

- To design and construct the System to allow safe operation

- To execute the Project while minimising any significant impacts to the environment

- To design the System so as to allow for high levels of quality, reliability and maintainability during operation

- To execute all activities within:

- The HSE aspirations and standards
- The relevant quality standards
- The planning schedule
- The budget

6.2.2 Technical alternatives evaluation methodology

For any given aspect of a Project, it is usual that a number of technical options exist which require assessment based on the given Project objectives (as illustrated above). This has been an iterative process involving multiple parties such as design engineering consultants, environmental consultants and installation contractors. The general approach taken to assessing technical alternatives is illustrated graphically in **Figure 6.20** with more detail about each stage elaborated upon below.

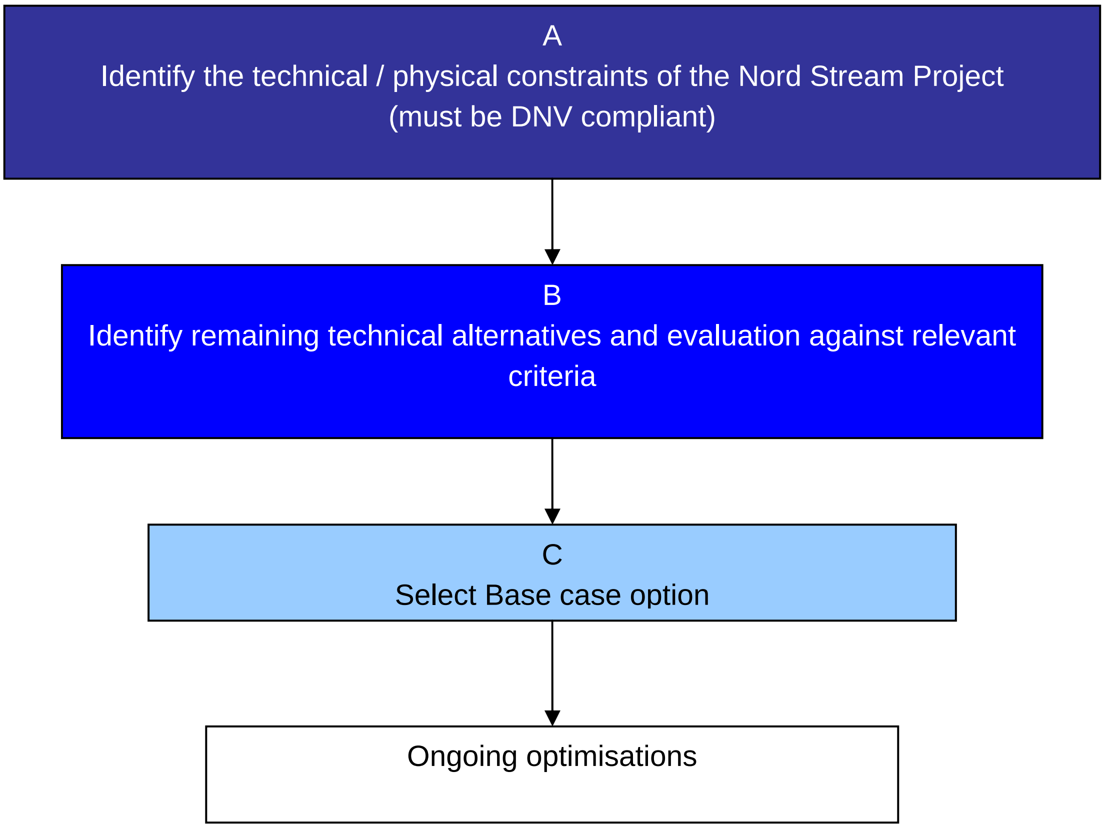


Figure 6.20 Illustrative Generic Framework for Technical Alternatives Selection

A: Identify Technical / Physical Project Constraints

The Nord Stream Project inherently involves certain technical or physical constraints that, at the outset, have limited the range of viable technical options available for further consideration. An example of a *physical* constraint is water depth, which influences the types of vessels that are suitable to use in certain Project locations. An example of a *technical* constraint that also sets this initial agenda on the scope of viable alternatives is the diameter and weight of the pipelines. These factors rule out certain installation methods.

B: Evaluation of Technical Alternatives against Relevant Criteria

After the primary consideration of technical / physical constraints, a number of potential technical alternatives remained, and these alternatives have also been evaluated against various criteria with the input of a range of experts such as engineering and environmental specialists and pipeline installation contractors. The criteria that are relevant for this assessment of certain technical areas vary; however, the process of selecting a particular option as the "base case" has essentially involved consideration of factors such as technical feasibility, environmental factors, logistics (e.g. availability of equipment) and time constraints.

C: Selection of the Base Case

The alternatives selection process has resulted in selection of a "base case" technical option for each aspect of the Project. This "base case" has been taken forward for assessment. Where the base case has subsequently been subject to further optimisations as the Project moves forward further, these iterations have been taken into account.

6.2.3 Technical Alternative Assessment

This section provides an overview of the different technical areas for which alternatives were considered within the Project design:

- Pipeline System Design Concept
- Line Pipe Material
- Internal Pipe Material
- External Anticorrosion Pipe Coating Material
- Concrete Weight Coating
- Field Joint Coating

- Cathodic Protection
- Logistics
- Preparation of Seabed
- Offshore and Shallow Water Pipeline Installation
- Landfall Installation
- Pre-commissioning
- Commissioning

For each technical area, the viable alternatives and the evaluation process (with particular reference to environmental considerations) that has lain behind selection of the "base case" alternative is described. For each technical component evaluated the discussion is presented under the following sub-headings (reflecting the general process outlined in **Figure 6.20**):

- *Overview and Base Case Selection:* A brief overview of the technical aspect of the Project and a summary of the outcome of the technical alternative evaluation process
- *Description and Evaluation of Alternatives:* A brief overview of the potential viable technical options available for that particular aspect of the Project and a discussion on the considerations that have influenced the selection of the final base case alternative (with particular emphasis on environmental factors)

Pipeline System Design Concept – Overview and Base Case Selection

This section examines the technical alternatives considered for the overall design of the pipelines and, in particular, those features of the design that are deemed to have environmental implications, incl.

- Intermediate Service Platform
- Number of Lines and Pipeline Diameter
- Segmented Design

The following design features have been fixed for the Project for technical reasons:

- The length of the pipelines is approximately 1,222 km (after route selection). This parameter was fixed after performing several route optimisations as described in **chapter 6.1** (Route Alternatives) which took into account environmental, technical and safety investigations

- The capacity of natural gas to be transported in the pipelines is 55 bcm p.a. This parameter is fixed by forecasts of supply and demand of natural gas in Russia and the EU respectively
- The receiving pressure at the landfall facilities in Germany must be 102 bar

Intermediate Service Platform

The need for a mid-route platform has been analyzed from the view point of flow rate guarantee, pre-commissioning and commissioning. Following this analysis, the Project has selected the alternative of not using an ISP. This is on the basis that the Project is deemed technically achievable without the requirement for an ISP (for example safe operation and long distance pigging of 1,222 km is considered feasible).

Additionally there are also environmental impacts which can be avoided by not building and operating an ISP. These include reducing environmental impacts on the seabed during construction and reducing risks to shipping.

Number of Lines and Pipeline Diameter

Two pipelines, 48 inch diameter each have been selected as the base case for the Nord Stream pipelines. The reasoning behind that decision was mainly technical as it reduces construction and operations complexity. However, there is also an environmental benefit of that decision as it reduces the amount of materials and the impacts associated with the construction of the pipelines.

Segmented Design

A three pressure segment design has been adopted as part of the pipeline design strategy because of its requirement for fewer resources (e.g. steel) which will reduce the environmental impact of the Project. The steel wall thickness has been defined according to DNV OS-F101, Ref./A1/, in order to satisfy the relevant subsea conditions and has been independently verified by DNV. The segmented design will result in the pipelines having varying wall thicknesses (of between 26.8 mm and 41.0 mm) which results in significant reductions in the amount of steel required for the Project.

Therefore it is considered that the adoption of the two pipeline 48 inch diameter alternative, with segmented design, and without an intermediate service platform is the best option from an environmental perspective compared with the other technically feasible alternatives that were considered by the Project.

Pipeline System Design Concept - Description and Evaluation of Alternatives

The following pipeline design options were examined by the Project:

Intermediate Service Platform (ISP)

For subsea pipelines of the length proposed for the Nord Stream Project (i.e. 1,222 km) it can be useful to install an Intermediate Service Platform (ISP) midway along the pipelines as it can help during pre-commissioning and commissioning, to provide services such as additional compression and reduce risks of long distance pigging during operation. The requirement for an ISP has therefore been considered by Nord Stream as a viable design alternative to the alternative of not constructing an ISP.

The requirement for an ISP has been assessed in terms of technical considerations during the construction, pre-commissioning and operational stage of the Project.

- *Construction:* Pipeline installation and construction activities would be simplified by removing the requirement for an ISP

- *Pre-commissioning:* It is estimated that pipeline testing activities during pre-commissioning can be completed in approximately four months if an ISP is incorporated in Project design, as opposed to approximately six months without an ISP. Not building an ISP would add complexity to the pre-commissioning process and therefore have a scheduling impact on this stage of the Project

- *Operation:* An ISP is not an essential requirement to maintain gas flow in the pipelines (i.e. for compression). In addition, potentially severe weather and sea conditions in the Baltic Sea, i.e. cold, ice bound conditions, would lead to specific requirements to ensure safe operations of the ISP. However, the provision of an ISP would remove the need for long distance pigging which is a potentially more complex operation than pigging over shorter distances with an ISP as part of the design. To overcome this issue Nord Stream has invested in research to demonstrate that long distance pigging is technically feasible for the Project, hence it has been concluded that an ISP is not required solely to support pigging operations

In summary, technical studies carried out for the Nord Stream Project have concluded that an ISP is not necessary for ensuring a constant gas flow rate to Germany (i.e. in terms of providing additional compression) or for supporting the pigging operations. An ISP would add some operational flexibility (for example, by allowing the shut down of a part of a single pipeline while keeping the other part operational). Overall it is considered that, while there are some technical advantages with regard to simplifying the pre-commissioning phase and the operational pigging of the pipelines, it is technically feasible for the Project to be carried out without an ISP.

The environmental effects of not having an ISP mid-stream of the pipelines are assessed as follows:

- *Construction:* Not building the ISP would avoid the environmental impacts due to significantly larger scale seabed intervention works associated with construction of the ISP (compared to those associated with pipelaying), such as pile driving. These activities would have a direct impact on the seabed features in the immediate vicinity of the ISP whilst the mobilisation (disturbance) of seabed sediments would be likely to adversely impact local water quality in a wider area. Noise from the hammering of piles and use of vessels would also result in disturbance of marine mammals and fish within a 10 km radius during the installation activities. Clearly if the Project does not construct an ISP these impacts would be largely avoided and the impacts on the marine environment would be limited to those expected during the installation of the pipelines only

- *Pre-commissioning:* The presence of an ISP enables the water used in the system pressure test to be discharged away from the landfall sites. Discharging this test water into the deeper water in the vicinity of the ISP would have a lesser impact as dilution and dispersion rates would be higher than in coastal areas where water depths are shallower. Not constructing the ISP would take away the option to discharge the water into the deeper water in the vicinity of the ISP

- *Operation:* The presence of an ISP during the long term operation of the pipelines would represent an increased risk in relation to shipping in the area. Although the likelihood of a collision between a ship and the ISP would be very low, the presence of the structure would represent a higher risk than the alternative of not building the ISP. Should a collision occur between the ISP and a ship there is an associated risk of an oil spill which would have an environmental impact on the wider area. Therefore, there are clear environmental benefits of not having an ISP in terms of risk during operations

In summary, there are environmental benefits associated with avoiding the requirement for an ISP in that it will reduce the intrusive construction activities on the seabed and will avoid any additional risks associated with the potential for ship collisions.

Number of Lines and Pipeline Diameter

The capacity of the Nord Stream pipelines has been set to 55 bcm p.a. This represents, together with the receiving pressure at the German landfall of 102 bar, a boundary condition for the system design.

Three high level design alternatives have been assessed during the conceptual stage of the Project, including:

1. Two pipelines, each 48 inch diameter, with a maximum intake pressure in Russia of 220 bar

2. Three pipelines, each 42 inch diameter, with a maximum intake pressure in Russia of 210 bar

3. Two pipelines, each 42 inch diameter, with a maximum intake pressure in Russia of 220 bar plus an additional offshore compressor-station at the halfway point in Swedish waters

Early in the Project design the decision was taken to adopt alternative 1 as listed above (i.e. two pipelines each of 48 inch diameter). This decision was taken predominantly for technical reasons; however, environmental considerations were also taken as part of the decision as summarised below:

- Adopting a two pipeline alternative as opposed to three pipelines (alternative 2) not only reduces construction and installation complexity but also significantly reduces the use of materials (such as steel, etc.). The extent of seabed intervention works is less and the permanent presence of the pipelines on the sea floor will be less intrusive

- An additional offshore compressor station (alternative 3) requires the erection of an ISP. As mentioned above, this would add construction and installation complexity and result in environmental impacts as a result of the construction of the ISP (for example piling on the seabed) and a potential increase in the risk of collision with shipping in the Baltic Sea. The additional compressor station would also be a significant consumer of fuel gas and would accordingly result in the discharge of greenhouse gases to atmosphere

Segmented Design

A pressure segmentation approach has been adopted in the most recent gas trunklines put into operation in the North Sea. This is based on the fact that the downstream portion of a long gas transmission pipeline never experiences pressures as high as at the upstream end and therefore is not required to meet the same design requirements (for example pipeline wall thickness).

Based on this industry experience, a pressure segmentation design concept has been considered for the Nord Stream Project.

The benefit of using a segmented design approach is the potential for a reduction in pipeline steel usage in step with the drop in gas pressure along the length of the pipe and therefore a reduction in the required pipeline wall thickness.

Through the history of the Nord Stream pipeline design process, various alternatives for segmentation have been assessed. At an early stage of the Project, the alternative of having three or four design pressures were considered.

A series of hydraulic analyses, both in steady and transient conditions, were carried out by the Project in order to:

- Verify that the proposed design pressures are in compliance with the resulting pressure profiles both in steady and transient conditions
- Assess the possibility of reducing the number of design pressure values and relevant segments (from four to three)
- Identify the optimum design pressure segments, i.e. the pipeline Kilometric Progressives (KPs) where design pressures can be safely changed

On the basis of the hydraulic analyses results, pipeline sections were identified for design pressure segmentation. The design pressure segmentation that was proposed is outlined in **Table 6.11** below, which compares three and four design pressures.

Table 6.11 Design pressure segmentation

From KP	To KP	Pipeline Length	Four Design Pressures	Three Design Pressures
			Design Pressure	Design Pressure
[km]	[km]	[km]	[barg]	[barg]
0	150	150	220	220
150	300	150	210	220
300	542	242	210	200
542	800	258	200	200
800	1222	422	170	170

The benefits of three design pressures instead of four design pressures are summarised as follows:

- *Technical:* the additional 150 km with a design pressure of 220 barg instead of 210 barg in the northern pipeline section are counterbalanced by the decrease of the design pressure in the remaining 242 km of northern pipeline section from 210 barg down to 200 barg
- *Materials Use:* lower steel thickness may be used
- *Installation:* one hyperbaric tie-in per pipeline may be avoided; lower complexity during hydrotest operations

Therefore the Project arrived at the decision to use a strategy that uses three design pressure values: 220, 200 and 170 barg.

Following the decision by Nord Stream to remove the ISP from the Project design an additional hydraulic assessment was carried out which resulted in the final pressure segmentation design as follows:

- 220 barg from KP 0 to KP 300 approx
- 200 barg from KP 300 approx. to KP 675 approx
- 170 barg from KP 675 approx. to KP 1222

The Project has adopted a segmented design largely for technical and other Project reasons. It should be noted that there is an environmental advantage in using a segmented pipeline design in that reducing pipeline wall thickness (from 41mm to 26.8 mm) significantly reduces the Project's resource consumption and energy requirements. It is estimated that the segmented design strategy will result in a reduction of the Project demand for steel of approximately 8%.

Line Pipe Material - Overview and Base Case Selection

This section examines the alternatives that have been considered with respect to the material used in the construction of the pipelines, and in particular documents any environmental considerations. The choice of material that will be used in the production of the line pipe has been based upon previous experience in the onshore and offshore high diameter and high pressure pipeline industry.

The primary consideration is the safety of the pipeline which involves ensuring that it can withstand local buckling (from external pressures), axial loads and bending loads. After ensuring that these safety considerations have been met, the remaining alternatives have been assessed according to other technical criteria, as outlined in the section below.

Three grades of steel, which have been used previously in the pipeline industry and which are considered to be technically feasible alternatives, have been assessed as potential options for the Project. X 70 has been taken forward as the preferred grade of steel, as it achieves the required technical criteria whilst minimising overall Project resources.

Line Pipe Material - Description and Evaluation of Alternatives

The choice of material to be used in the construction of the line pipe has been driven largely by the DNV design code. Three different grades of steel which are commonly used in the industry have been considered as technically feasible options, as follows:

- X 65
- X 70

- X 80

The criteria which have been used to assess the various merits of the alternatives are listed below:

- Integrity and safety of the pipeline: This is ensured by compliance with DNV criteria
- Weldability: It must be possible for the selected grade to be welded automatically on the laying vessel
- Layability: The selected steel grade and wall thickness must fulfil the offshore layability requirements
- Buckling resistance: The selected steel grade and wall thickness must provide sufficient resistance against buckling
- Track record: The chosen material should have a proven track record in relation to welding / laying

The assessment of these alternatives has been driven by the technical considerations outlined above. The three grades of steel each consume a different quantity of steel and each exhibit a different resistiveness to buckling. Selecting a higher steel grade reduces the Project's steel consumption since the wall thickness can be reduced. This favours X80 to X70 and X70 to X65. The advantage of X80 in terms of material consumption is counteracted by the fact that X 80 is not as resistant against buckling and that there is less experience in welding and laying this material in the offshore industry.

Internal Pipe Coating Material - Overview and Base Case Selection

An internal "flow" coating will be applied to reduce the hydraulic friction between the pipe and the gas it carries, thereby improving the flow conditions and helping to maintain the pressure along the pipeline.

Alternative options with regard to the internal flow coating to be used by the Project have been assessed, including the use of no flow coating, and the production of a coating with a lower roughness specification. A maximum internal roughness of 5 μm will be specified, producing a significantly more efficient gas flow along the pipelines’ route.

Internal Pipe Coating Material - Description and Evaluation of Alternatives

The alternative option to the use of an internal flow coating is to use no flow coating within the pipelines. Other internal flow coating alternatives that were considered are related to the maximum internal roughness to be achieved as a result of the coating (>8 μm is standard practice).

The option not to use an internal flow coating in the pipelines would lead to an extreme pressure drop along the length of the pipeline. This would require a significant increase in the inlet gas pressure and/or midstream compression to ensure operations of the pipeline. Therefore from a technical perspective it is essential to use an internal coating.

The standard specifications for flow coatings do not set a maximum roughness. Depending on the flow coat material, grade values between 8 to 12 μm can be expected. Nord Stream has examined an alternative maximum internal roughness of 5 μm. The effect of this would be a significantly increased amount of gas being transported using the same inlet pressure at Vyborg. This increases the efficiency of the gas transport, i.e. lower emissions at the compressor station to transport the same amount of gas.

External Anticorrosion Pipe Coating Material - Overview and Base Case Selection

This section details the appraisal of the alternatives considered for the external anticorrosion pipe coating methods. The pipeline will receive an external coating which is intended to protect it from corrosion during its 50 year lifetime in the Baltic Sea. The coating is chosen for its service, handling and installation performance.

Three coating systems have been presented as technically feasible alternatives to protect the pipe from corrosion, incl. Polyethylene (3LPE), Polypropylene (3LPP) and Asphalt Enamel (AE). All three coating systems can in principle be used with acceptable results provided that they are properly specified, adequate materials are used and applied and that the coated pipes are carefully handled and installed. Environmental impacts are not expected to occur in association with the use of the PE/PP systems.

In conclusion, the 3LPE system has been selected (based on DNV design code compliance) for its improved material properties at low temperatures, its reliable track record in the industry and for its environmental credentials.

External Anticorrosion Pipe Coating Material - Description and Evaluation of Alternatives

Three methods of anticorrosion pipe coating, commonly used in similar pipeline Projects, have been considered. They are:

- Three layer Polyethylene (3LPE) with FBE primer layer
- Three layer Polypropylene (3LPP) with FBE primer layer
- Asphalt Enamel (AE)

Each method outlined above is considered to be technically feasible, and the preferred method has been chosen based on its performance in the following key areas:

- Established track record
- Whether the coating has failed in the field for some reason
- Compatibility with field joint method
- Performance at low temperatures

The following text summarises the technical advantages and disadvantages of each coating method according to the above criteria:

Three layer Polyethylene (3LPE)

- Well established
- A few bonding failures have been reported
- The pipe laying contractor has expressed the opinion that performing field joints is easier with this material than with 3LPP
- Better handling and transport performance at low temperatures than 3LPP

Three layer Polypropylene (3LPP)

- Well established
- Some failures regarding field joint coatings have been reported, however only in connection with incorrect system selection or application
- There are uncertainties with this method in regard to compatibility with field joint systems at low temperatures (below -20°C). Softening additives may be necessary
- Excellent performance in transport, handling, installation and operation

Asphalt Enamel (AE)

- Has been established for longer than the other methods
- No failures have been reported from North Sea applications
- Coating application sites are limited
- Transport and handling below -10°C and above 20 °C should be avoided
- Environmental impact must be considered

The potential for environmental impacts from the external anticorrosion coating systems stemming from the potential for harmful compounds to seep into the marine environment (via the process of diffusion through the concrete coating) have to be considered for Asphalt Enamel only. The FBE and PE/PP material grades are certified and in use for tap water pipelines worldwide, which qualifies these materials.

Concrete Weight Coating - Overview and Base Case Selection

This section examines the technical alternatives that have been considered in relation to the external concrete weight coating.

The role of the concrete weight coating is to provide stability on the seabed as well as providing protection. A weight of approximately one tonne per running metre of the pipeline is required in order to counteract the buoyancy of the sea water and ensure stability.

The concrete coating specification with respect to thickness, density and reinforcement has been made in accordance with DNV to ensure the integrity and safety of the pipelines over the lifespan of 50 years.

The concrete coating for the pipelines will consist of a mix of cement, water and aggregate (including crushed rock, sand, gravel and iron ore), reinforced by steel bars welded to cages with a minimum bar diameter of 5.0 mm. The cement used for the concrete will be a Portland cement type suitable for marine use, in accordance with ASTM C 150 Type II. The coating will have a thickness of 60-110 mm and a maximum density of 3,040 kg/m3. Iron ore constitutes approximately 70% of the weight of the coating. No additives are used for these kinds of concrete coatings.

Concrete Weight Coating - Description and Evaluation of Alternatives

For the Nord Stream Project the concrete coating is applied at the coating yards. Therefore the concrete is fully cured, when the pipeline is installed at the seabed.

Concrete coatings are cured either by moisture barrier or by steam treatment if accelerated curing sequences are necessary. There is no difference in terms of environmental impacts resulting from these design alternatives. Nord Stream has selected steam treatment to cure the concrete.

Since the two alternative methods of curing are both environmentally benign, no assessment of alternatives is relevant.

To summarise, the decision-making process regarding the specific concrete weight coating composition has taken into account any potential environmental impacts. No additives or hazardous compounds will be used in the concrete weight coating for the Project so as to avoid any possible detrimental environmental effects arising were these compounds to be released into the marine environment. It is therefore expected that the chosen concrete weight coating composition will have no negative impact on the marine environment. Environmental impacts of concrete coating may only result from the release of compounds from spill of concrete, which only consists of natural materials, as described above.

Field Joint Coating - Overview and Base Case Selection

This section examines the technical alternatives that have been considered regarding the field joint coating system to be used for the Project.

The pipelines, having been pre-coated internally at the fabrication sites and externally at the weight coating yards, are transported to the offshore construction site (see section **Logistics**) where they are welded together (producing a field joint). A gap in the external anticorrosion coating and the concrete coating of approximately 40 cm is provided to allow the welding to take place, leaving a total gap of approximately 80 cm when the two pipe sections are joined. To fill in the remaining space between the concrete coatings on each side of the field joint and to protect the joint against corrosion, a field joint coating and protective shroud is applied around the pipe joints.

Several field joint coating methods have been assessed. The assessment process examined the performance of the alternatives against various criteria (as set out below). No environmental impacts are anticipated from any of the alternatives.

Polyethylene heat shrink sleeve without a primer layer has been chosen for the following technical reasons:

- It has become the standard field joint coating for large diameter concrete coated trunklines laid over the last 10 years
- It is suitable for a 50 year design life
- It is completely compatible with the 3LPE anticorrosion coating
- It is fully compliant with DNV RP-F102 Datasheet 1-B
- It allows for an optimal cycle time (providing the required speed for the pipe laying process)
- It is suitable for application on pipeline lay barges of the type that will be used for the Project

Field Joint Coating - Description and Evaluation of Alternatives

Several field joint coating methods are considered technically feasible. These are based on methods which are common place in the pipeline industry. The possible alternatives that have been assessed include:

- Variants of heat-shrink-sleeve (polypropylene, polyethylene)
- Tape wrap of polyethylene and polypropylene tape

Both sets of variants have also been assessed without/with Fusion Bonded Epoxy- or two component liquid epoxy-primer.

In addition to ensuring that the selected method provides the field joint protection required for compliance with the DNV design code (both anticorrosion and mechanical protection), the alternatives have been assessed for their performance against the following criteria:

- Existence of an established track record
- Longevity of protection (i.e. its suitability for the 50 year design life of the Project)
- Compatibility with anticorrosion coating
- Optimum cycle time (providing the required speed for the pipe laying process)
- Suitability for application on the lay barge

In addition, consideration has been given to stakeholder concerns regarding the durability of field joint moulding forms and the potential environmental impact of floating moulding forms. It is foreseen that any moulding forms used will be melted together to ensure that they remain in place over the field joint over the lifespan of the pipeline.

No environmental impacts are anticipated as a result of the use of any of the field joint coating techniques under consideration. Since environmental criteria have not been a significant consideration in the selection of alternatives, no assessment of alternatives is considered relevant.

Cathodic Protection - Overview and Base Case Selection

This section examines the alternative cathodic protection methods which have been assessed to determine the preferred anode material for use in the cathodic protection system.

The cathodic protection system is designed to deliver additional corrosion protection during the design lifetime of the pipelines. Corrosion of steel in seawater is an electrochemical process. The principle of cathodic protection is to impose a galvanic element where the pipeline is the cathode. To achieve cathodic protection it is common practice to connect the pipelines to sacrificial anodes made from metals that have a lower natural potential than steel.

A number of factors have played a part in the decision process, including technical durability and environmental considerations. Testing has been carried out by DNV, an independent laboratory in order to examine the suitability of an aluminium and zinc alloy as the anode material. These tests have concluded, that whilst aluminium alloys may be used for the majority of the pipeline route (approximately 70% of the distance), zinc alloys must be used for the parts of the pipelines' route with very low average salinity (approximately 30% of the overall distance).

The dimensions of the anodes depend on various parameters which are outlined below. Currently, six different designs of aluminium anodes and four different designs of zinc anodes are planned.

Cathodic Protection - Description and Evaluation of Alternatives

The alternative methods which have been considered by the Project for the cathodic protection system are based around the choice of either aluminium or zinc as the preferred anode material and the dimensions of the anodes.

The design of the cathodic protection system must take into account various parameters, including:

- Whether it has an established track record
- Choice of external anticorrosion coating and field joint material
- Pipeline dimensions (including the thickness of the concrete weight coating)
- Pipeline design lifetime
- Specific environmental characteristics of the Baltic Sea in relation to the possible increase in the degradation of the external anticorrosion coating
- Specific environmental characteristics of the Baltic Sea (specifically the low salinity and low oxygen content) in relation to the performance of the anode materials
- Environmental impact of the alloy materials on the marine environment

The choice of dimensions for the anodes will depend on parameters such as the dimension of the pipeline, the thickness of the concrete weight coating, pipeline design life, type of external anticorrosion coating, environmental conditions at the sea floor, and choice of anode material.

Anode alloys developed for marine applications are designed to perform in seawater with an alkaline pH, high salinity and significant oxygen content. The common material employed in such environments is aluminium. In contrast, the conditions at the bottom of the Baltic Sea are generally very low in oxygen content and have a low salinity. In these environments, aluminium anodes could become inefficient. Therefore, the employment of zinc as anode material has been considered by the Project. Testing has been carried out in order to assess the suitability of zinc alloy and two aluminium alloys for use in the Baltic. The following results were obtained:

- The standard zinc anode material produced satisfactory results. The average efficiency was 98%. Standard values can be used for the design
- One of the aluminium alloys gave results that were not acceptable. The average efficiency was 59%.
- The other aluminium alloy produced an average efficiency of 74%. The recorded anode potentials were, however, acceptable

For the purposes of the Project, the efficiency of the anodes has been the governing design factor and it has been concluded from these tests that aluminium anodes can effectively be used for the cathodic protection system for much of the pipeline system. However, the tests were carried out at a temperature of 10 ºC and at a salinity of 1.2 % and some stretches of the pipelines' route will have a salinity which is significantly below this. Therefore, in these areas (where average salinity falls below 0.8 %) testing has shown that the only viable technical alternative is to use zinc anodes as the aluminium alternative will not work efficiently.

The potential environmental impacts which may arise from the cathodic protection system are connected to the release of metal ions from the anode material into the marine environment during the lifetime of the pipelines. The release rate of metal ions will depend on:

- The total quantity of anode material
- The content of metals in the anode material
- The attraction level of anodes; this depends on the condition of the external anticorrosion coating. If the coating remains undamaged, there will be no release of anode metal ions

From an environmental perspective, aluminium alloys are the preferred alternative to zinc alloys for the following reasons:

- The requirement for anode material is approximately 2½ times larger for zinc than for aluminium
- The zinc anodes contain a more significant proportion of cadmium and lead which are considered potentially harmful elements in the marine environment

- The aluminium anodes have a lower content of cadmium, and otherwise contain no harmful metals

Cadmium and lead have both been identified as toxic and bioaccumulative substances, and are included in both the Helsinki Commission (HELCOM) list of hazardous substances for immediate priority action as well as the EU's list of priority substances in the field of water policy. In both the zinc and aluminium alloys, however, the concentration of toxic metals is expected to be low, and the toxic effects limited due to the very small quantities involved and the long time period over which release of the elements will occur. An assessment of the metal ions released from the aluminium based anodes has been carried out. This assessment reports a conservative estimate that the concentration of cadmium caused by the release of cadmium to the sea close to the pipelines is likely to be over two orders of magnitude lower than naturally occurring background cadmium levels.

Logistics - Overview and Base Case Selection

The Nord Stream Project will require considerable logistical activities including land-based treatment and storage of pipes and materials as well as transport to the storage facilities and installation sites.

It should be noted that this section applies to the logistics of pipe sections for the first pipeline. Although it is likely that the same manufacturing and coating plants will be used for the second pipeline, the tendering will be carried out at a later stage of the Project and may therefore vary from the approach described in this section.

The two parallel, 1,220 km long pipelines will each consist of 100,000 pipeline sections or joints (each approximately 12.2 m) with a total weight of approx. 4.7 million tonnes after weight coating. These pipeline joints will be manufactured and treated with an internal and external pre-coating at existing production plants in Germany and Russia. After the pre-coating stage the pipeline sections will be transported to weight coating plants and subsequently onto stockyards where they will be stored prior to being shipped offshore for use in the pipeline construction process.

Nord Stream proposes to operate interim stockyards at the two new weight coating plants, Kotka in Finland, and Sassnitz-Mukran in Germany. The three additional stockyards will be developed in existing ports at intervals along the Baltic coast in order to reduce the required shipping routes to a maximum of 100 nautical miles. These interim stockyards are planned to be located in Hanko in Finland, Slite and Karlskrona in Sweden.

The chosen weight coating and storage locations (Kotka in Finland, and Sassnitz-Mukran in Germany) as well as the interim stockyards (Hanko in Finland, Slite in Gotland, Sweden and Karlskrona in Sweden) are illustrated in **Figure 6.21**.

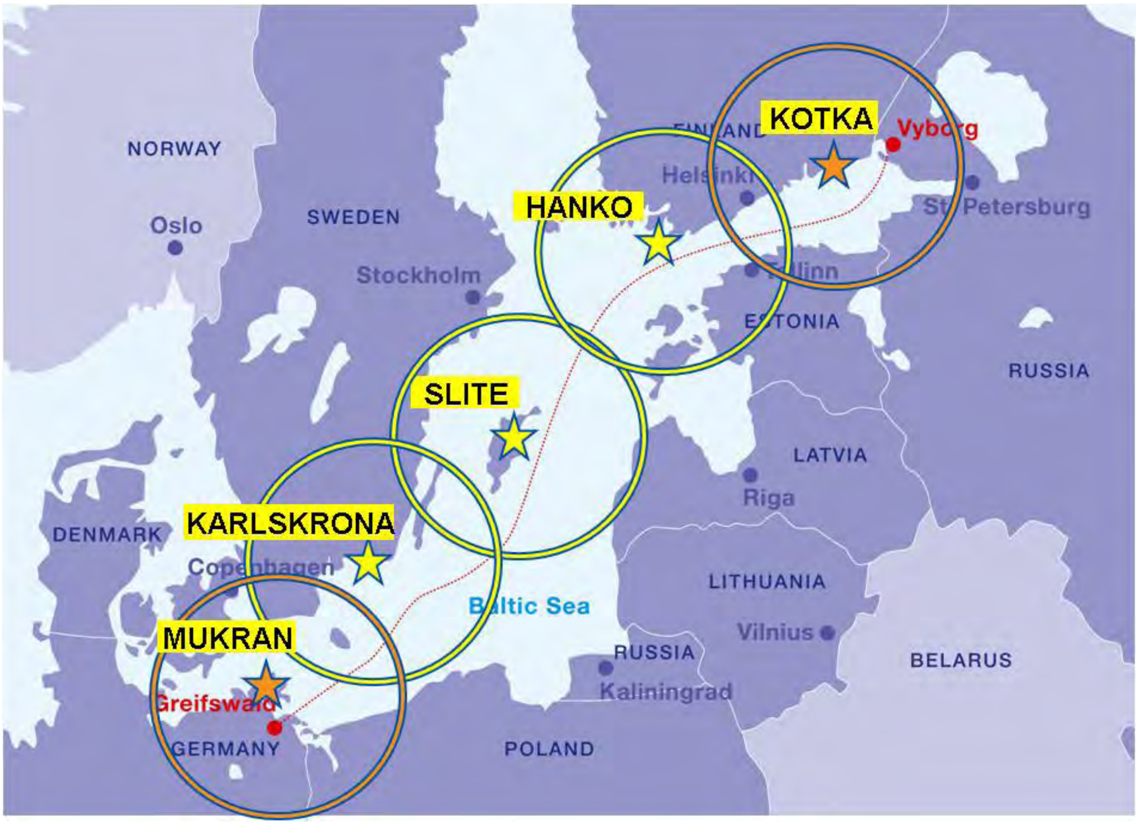


Figure 6.21 Location of Proposed Weight Coating and Marshalling Yard Facilities

The process of selecting the two new weight coating plants and the three interim stockyards has been largely driven by minimising the need for transportation. The selected Nord Stream logistics strategy is deemed environmentally preferable to the feasible alternative which would be to use existing weight coating and marshalling yards. This is on the basis that it significantly reduces the requirement to transport pipeline sections large distances over land and maximises the environmental preferable option to use rail transportation. In addition, the logistics strategy reduces shipping distances significantly from that required were existing marshalling yards to be used.

Logistics - Description and Evaluation of Alternatives

The Nord Stream logistical operations have a potentially considerable environmental (as well as technical) aspect due to the degree of transport required and hence the associated use of fuel and resulting emissions. Therefore, environmental considerations associated with the alternative Nord Stream logistics strategies have been appraised as part of the alternatives selection process. The overall goal in terms of environmental performance has been to reduce onshore and offshore transportation of the pipeline sections.

The Project has examined the potential options for reducing, as far as reasonably practical, the distance over which the pipeline sections will have to be transported. This has highlighted that the main options for reducing transport requirements are related to the following aspects of the logistics chain:

- Weight coating locations
- Interim storage locations

The scope of viable options is limited since the coating and logistics processes require specific infrastructure that is not widely available in the Baltic Sea area close to the Nord Stream Route. In addition, the manufacturing of pipes needs to be performed at existing facilities in Europe. The logistics chain is summarised in **Figure 6.22**.

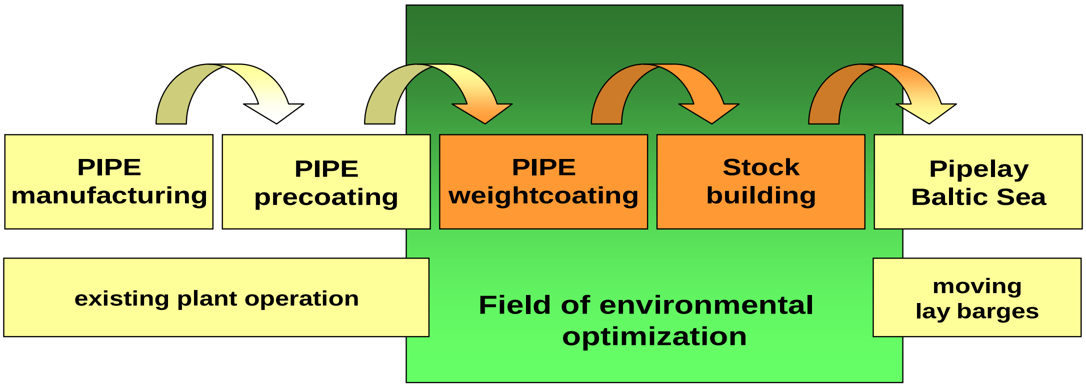


Figure 6.22 Logistics Chain

Factors in the consideration of different logistics alternatives have included:

- Distance to pipe fabrication sites
- Usage of train connections / existing transport infrastructure
- Harbour water depth (must be greater than 8 m to enable vessel access)
- Distance to the Nord Stream Route

The locations of the weight coating plants as well as the interim stockyard locations were chosen from an initial selection of 68 harbours and have been assessed as most suitable according to the criteria outlined above.

Weight Coating

The required infrastructure in terms of coating plants required for weight coating the pipeline sections does not exist at the Baltic Sea coast. Weight coating plants are located at sites located farther around Europe, and therefore using these existing facilities would entail significant transport logistics to move the coated pipeline sections from those plants to the storage sites at the Baltic coast.

The process of weight coating the pipe sections approximately doubles the weight and adds one tonne per metre in weight (in order to counteract buoyancy), as well as considerable size to the uncoated pipes. The logistical effort is therefore much larger for weight coated than for pipes without the final weight coat.

Establishing new weight coating plants on the Baltic Sea coastline would significantly reduce the requirement to transport the heavy concrete coated pipeline sections over land and/or over sea. If existing weight coating plants were used, the pipeline sections would need to be transported over much longer distances as they would require transport from the pre-coating plants to existing weight coating plants apart the Baltic Coast, then to the coastal stockyards and finally to the lay barges.

The strategy of developing new weight coating plants at the Baltic coast and also using these as stockyards minimises the overall transport of the pipeline sections. This will have significant environmental benefits compared to using existing weight coating plants as it will reduce fuel use and associated emissions.

Following this, coating plants with flexible machinery and equipment would have to be built by Nord Stream’s contractors at suitable locations at the coast. The pre-coated pipeline sections would then need to be transported to these sites by train (so as to reduce road miles).

Transporting the pipeline sections from the pre-coating plants to the new weight coating plants at the coast by train is deemed to be environmentally preferable to road transport which would result in much more significant transport emissions.

Interim Stockyards

After application of the weight coating, the pipeline sections will be transhipped by coaster vessels to a number of stockyards where they will be stored prior to transport offshore. The pipeline sections are finally loaded onto pipe carrying vessels that transport the pipes to the lay barges where they are used in the pipeline installation process. The pipe laying process requires a continuous flow of ships in order to supply pipe sections for the laying process.

The transport capacity of a coaster vessel is by factor three larger than the capacity of a pipe carrier vessel. Following that, sailing distances and subsequent ship movements can be significantly reduced by selecting additional interim stockyards close to the Nord Stream Route.

Nord Stream has examined how to minimise the number of vessel movements within the Baltic Sea in order to reduce overall transport impacts such as vessel emissions and shipping congestion. The study showed that in total five stockyards should be operated to reduce the maximum distance from those final destinations to the offshore lay barges to an optimum level.

Developing another three new stockyards (in addition to the two coating yards planned to be used as stockyards) at coastal locations across the Baltic is deemed to be an environmentally preferable option to using just two yards (at the new weight coating plants) or existing yards abroad. If the Project were to use existing plants/yards (the closest of which is Farsund in Norway) the average sailing distance would be a minimum of 600 nautical miles – resulting in a high number of pipe carrier movements.

The use of three interim stockyards will significantly reduce the requirement for vessel sailing distances in the Baltic. By using five yards in total the sailing distances are reduced to less than 100 nautical miles from stockyard to lay barge which is deemed to be an optimal level both from a logistical and environmental point of view.

Preparation of Seabed - Overview and Base Case Selection

Due to the seabed conditions in the Baltic Sea seabed intervention works are required at certain locations before and after pipe lay to ensure that the pipelines have a stable foundation on the seabed and are protected to avoid the following:

- Excessive movement due to hydrodynamic loading
- Stress/fatigue due to free-span development caused by an uneven seabed
- Impacts from shipping traffic
- Impacts from fishing gear, e.g. trawls
- Excessive movement (lateral and upheaval buckling) due to compressive pipeline loading

Extensive route optimisation has been carried out to limit the amount of seabed intervention required. However, the need for seabed intervention cannot be avoided completely, and therefore some intervention works are needed. Such works are traditionally provided by trenching (and dredging) or by gravel placement. At certain locations, however, where the load of the gravel exceeds the bearing capacity of the soil below, trenching or gravel placement are not sufficient. Under these circumstances alternative solutions have to be introduced, i.e. installation of additional support structures.

From the dredging alternatives considered, the Project has decided that the most suitable type of dredger is the Backhoe Dredger because of its capability of dredging each soil type, high flexibility and precise execution of the trench design. Where the precision of the dredging is not of highest importance a Trailing Hopper Suction Dredger was selected because of its high dredging performance and lower turbidity to minimise the environmental impact. The Bucket Ladder Dredger and Grab Dredger will also be employed.

The assessment of alternatives selected ploughing as the only suitable method for post-lay trenching. This is due to the large diameter of the pipelines at 48 inch. Additionally, it can be assumed that the turbidity caused by this method is lower than the turbidity caused by jetting and cutting.

Gravel placement will be taken forward as the main intervention method for free-span correction. Blasting and cutting have been rejected by the Project due to the significant environmental impacts associated with these methods. Gravel placement will be carried out using material extracted from quarries on land with the exact location for the extraction of the rock still to be determined. Types of gravel placement works that are envisaged for seabed intervention include gravel supports (pre-lay and post-lay) and gravel cover (post-lay).

In spite of all efforts to re-route the pipelines, support structures alternative to gravel berms are required at several locations along the pipeline route (details of these locations are given in **Chapter 4.5**). Supports will be composed of a base steel frame and two foldable mudmats, which are connected by hinges. The minimum required dimensions are 11 m x 18 m. The structure will be covered by a layer of gravel.

Preparation of Seabed - Description and Evaluation of Alternatives

Alternative options that have been considered by the Project are described below:

- Trenching
- Gravel placement
- Additional support structures
- Blasting and cutting

Figure 6.23 provides a graphical illustration of the way in which these considerations are applied.

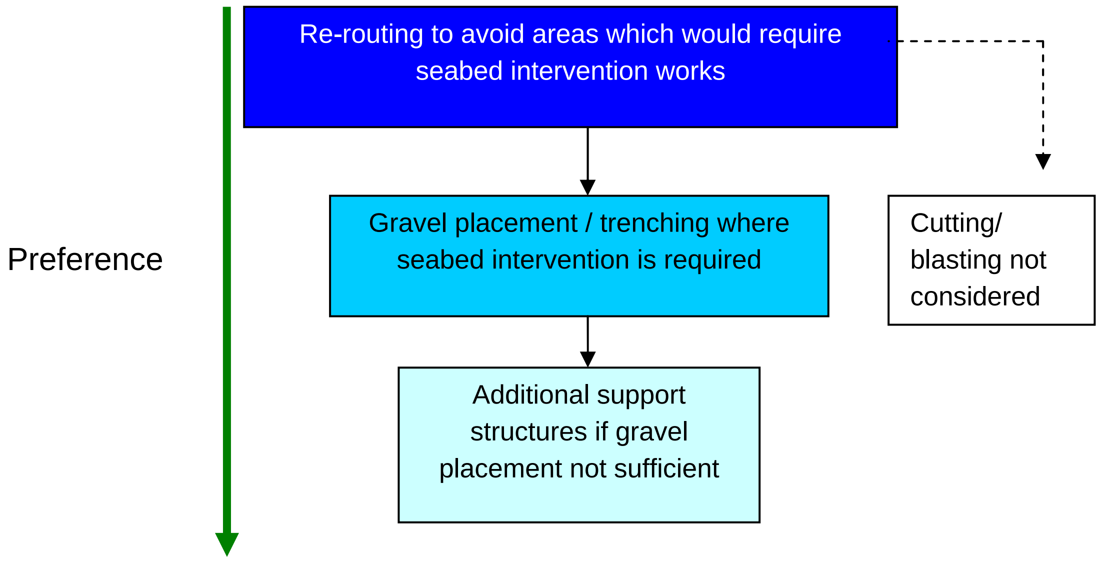


Figure 6.23 Strategy to Selecting Option for Seabed Preparation

Trenching

The offshore installation of the pipelines in some areas (especially in shallow waters) require additional stabilisation and/or protection which can be obtained by trenching the pipeline into the sea bottom and (if required) backfill the trench.

Trenching can be performed either prior to pipeline installation by means of constructing (dredging) a pre-cut trench (*pre-lay*) or following the pipelay operation after the pipeline has been laid on the sea bottom (*post-lay*).

Alternatives considered for *pre-lay trenching* methods have essentially involved selecting an appropriate type of dredger; types of dredgers include trailing hopper suction dredgers, cutter suction dredgers, bucket ladder dredgers, grab dredgers, and backhoe dredgers.

The following assessment was made in comparing options. The assessment involved taking into account technical suitability, environmental protection and equipment availability:

- The Trailing Hopper Suction Dredger is flexible deployable; the dredging speed depends on the distance to the dumping ground. However, it is only suitable for loose sediments and not suitable at low water depths

- The Cutter Suction Dredger is capable of dredging almost all sediment types (without cobbles and boulders). It has a precise dredging performance, and the fastest dredging speed. However, flexibility is limited due to the associated hydraulic transport of dredged material (via pipeline) and furthermore this method could results in high turbidity during dispensing

- The Bucket Ladder Dredger is capable of dredging almost all sediments and results in very precise dredging. However, it requires a high level of maintenance. Furthermore it is noisy, weather-dependent and results in high turbidity

- The Grab Dredger is flexible and can operate in lowest water depths. It is appropriate for all soil types. However it results in an imprecise cut. This method results in low turbidity when closed buckets are used or medium turbidity when open buckets are used

- The Backhoe Dredger results in a precise cut, is flexible and can be used in all soil types. A large spread of different types is available and the method can be operated in low water depths. This method results in low turbidity with closed buckets or medium turbidity with open buckets

The Project has concluded that for pre-lay seabed intervention works, the most suitable type of dredger to be used for the excavation of the trench are Backhoe Dredgers, equipped with closed buckets or with open buckets of different sizes because of its capability of dredging each soil type, high flexibility and precise execution of the trench design. In all other cases where the precision of the dredging is not of highest importance (i.e. top soil, re-dredging on dumping site) a Trailing Hopper Suction Dredger was selected because of its high dredging performance and lower turbidity to minimise the environmental impact. A Grab Dredger can preferably be utilised in order to handle stones and boulders.

The Cutter Suction Dredger was rejected as an alternative due to its limited operational flexibility and the high turbidity that could be generated during material disposal.

Options for *post-lay trenching* include application of the following alternative methods:

- Ploughing which involves ploughing the seabed using vessel-mounted plough equipment

- Jetting which involves the principle of liquefaction where, by introducing water and air under the pipeline along a length, the sand is “fluidised” by a pipe guided jet sled, allowing the pipeline to sink of its own weight

- Using mechanical trenching machines which take their support from sleds on tracks at the sides and are guided by the pipeline. The material is excavated by rotating trenchers beneath the pipe and placed at the side

The advantages and disadvantages of each are discussed below.

- Ploughing: Maximum trench depths that can be achieved using single-pass ploughing are in the magnitude of 1.5 to 2.5 m. This means that, in areas where fine sand can fill back into the trench before the pipeline settles down, multiple passes may be necessary to achieve the desired burial depth. The minimum water depth for ploughing initiation is approximately 15 to 20 m. Since modern ploughs are actively controlled by hydraulic actuators, the trench depth can be controlled by a plough pilot on board the support vessel

- Jetting: Jetting works best in soft materials like fine sands or silts. This method has its limitations for Nord Stream in respect of the large pipeline diameter and the long length; furthermore the turbidity caused by this method is significantly higher than using a plough
- Mechanical Trenching Machines: The limitation of this method is the large pipe diameter and the turbidity caused by this method which is also higher than using a plough

The outcome of this alternatives assessment was to select ploughing as the only technically suitable method for post-lay trenching; largely due to the significant diameter of the pipelines (48 inch). However additionally, it should be noted that the turbidity resulting from this method is significantly lower than the other two methods considered, therefore it is the preferred method from an environmental perspective.

Gravel Placement

Due to the uneven seabed in some areas in the Baltic Sea, gravel placement is required to restrict stress due to free-span development and to ensure local dynamic stability. Gravel is placed in order to locally reshape the seabed to ensure the long term integrity of the pipeline.

Gravel works are primarily required as follows:

- Gravel supports for free-span correction (pre-lay and post-lay)
- Gravel cover (post-lay) as additional stabilisation of the pipeline after pipe-laying (for certain sections)
- Gravel basement at locations where major pipe sections are welded together (tie-in)
- Gravel supports for cable crossings

Post-lay gravel placement is generally preferred over pre-lay gravel placement because the gravel volumes can be adjusted to the actual conditions around the laid pipeline, hence minimising gravel requirement.

However, it should be noted that pre-lay gravel placement is required for stress/free span correction, gravel basement for tie-ins and gravel supports at cable crossings.

Additional Support Structures

Under certain seabed conditions, in soft clay with a low bearing capacity, the required pipeline stability can not at all be obtained by gravel placement as the load of the gravel exceeds the bearing capacity of the soil below. Under these circumstances alternative support structures in combination with gravel placement may be required.

Alternatives considered as to the type of support structure included the design of the structures, the materials to be used, whether to use pre- or post- lay installation and the extent to which the structures are covered with gravel. Materials that can be utilised include e.g. mud-mats, foam bricks, high-density polyethylene (HDPE) pipes.

A detailed stability analysis has been carried out in terms of support structure size, vertical and lateral sliding stability as well as immediate and consolidation settlement.

No major difference in environmental impacts is expected from the different design alternatives.

Based on the assessment of various alternative structures a conceptual design has been defined which fulfills the following requirements:

- Provides adequate structural resistance under design loading condition
- Provides required bearing capacity with a certain safety factor
- Facilitates operations during installation phase

The basic alternative support structure is composed of two parts, a base steel frame and two foldable mudmats, which are connected by hinges.

Blasting/Cutting

The Project decided early in the consideration of technical alternatives that no blasting will be performed during pipeline installation works because of its significant potential environmental impact. Blasting has the potential to result in adverse impacts on the seabed over a much larger area then more targeted works such as gravel dumping. In addition the impacts of blasting (as a result of the emissions of very high levels of underwater noise) can cause significant damage to marine species such as marine mammals, fish and seabirds.

Similarly cutting has not been considered as an alternative option due to the environmental reasons, as well as the fact that the nature of the seabed in certain areas (GoF) means that cutting is not a viable option.

Offshore and Shallow Water Pipeline Installation - Overview and Base Case Selection

Offshore pipelines can be laid using various techniques and vessels, the selection of which are influenced by technical pipeline construction parameters (such as pipeline design) as well as physical conditions such as water depth and seabed geomorphology.

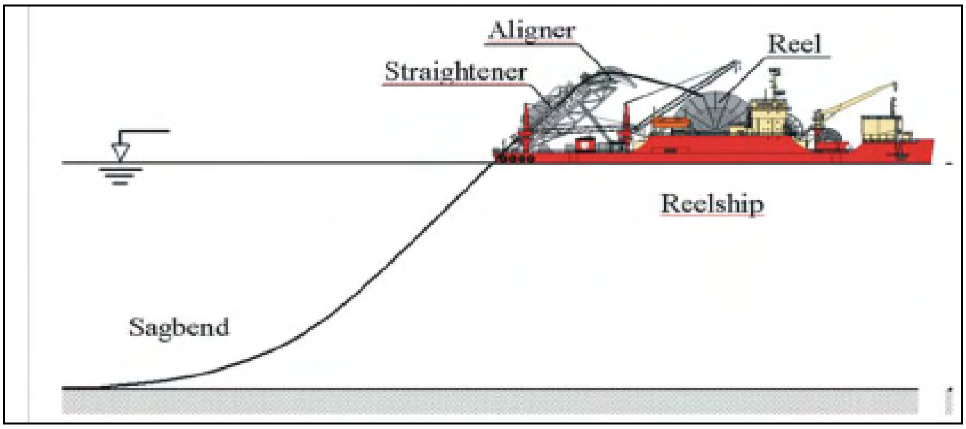
Due to water depth considerations and pipeline size the S-lay method is the only viable technical alternative for the installation of the Nord Stream pipelines. For the near shore pipe-laying approach in Germany, a flat bottomed, anchored S-lay vessel will be used.

Offshore and Shallow Water Pipeline Installation - Description and Evaluation of Alternatives

Pipelay barges are widely used in the construction and laying of offshore gas pipelines. All the main construction and installation activities such as beveling, welding, Non Destructive Examination (NDE) and field joint coating are performed onboard the pipelay barge, which moves forward as the pipeline is joined onboard the pipelay barge and installed on the seabed. Pipelay barges can lay offshore pipelines using the following alternative methods (some of these are illustrated in **Figure 6.24**):

- S-lay (maximum pipeline diameter 60 inches; used for trunk lines)
- J-lay (maximum pipeline diameter 32 inches; used for deepwater pipelines)
- Reeling (maximum pipeline diameter 19 inches; used for flow lines)

The Reelship Technique



The S-laying and J-laying Techniques

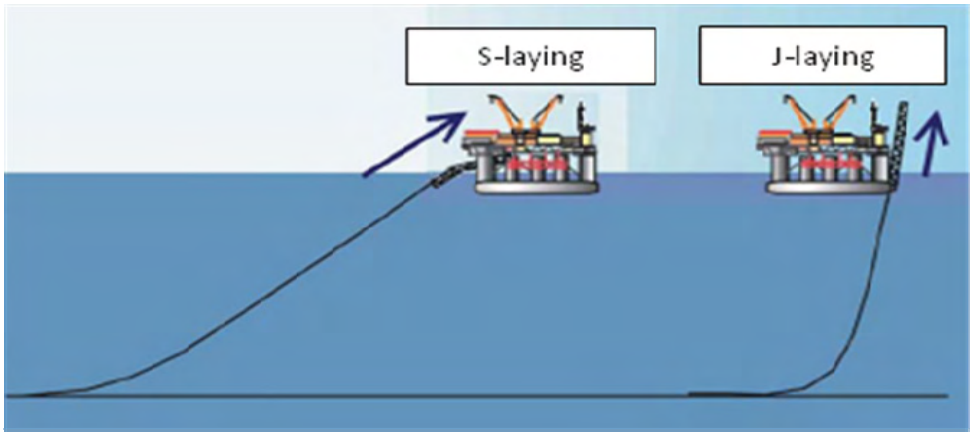


Figure 6.24 Typical Pipeline Installation Methods

The selection of the appropriate offshore pipeline laying method has been influenced by the particular pipeline construction parameters and physical conditions. For example, the reel lay method is only appropriate for laying small pipelines with a diameter of up to around 18 inches, whereas the two Nord Stream pipelines are 48 inches in diameter. The J-lay is particularly appropriate for deeper water, with the pipeline being welded in a tower and then lowered in a virtually vertical position. However, the J-lay method is only feasible for pipelines up to approximately 32 inches in diameter. The only type of vessel which can lay concrete weight coated line pipe is an S-lay vessel.

The depth of water throughout the Nord Stream Route varies from shallow coastal water at the landfall sites up to a maximum of 210 m. Given the depth of water in the area and the large diameter of the pipelines (48 inches), and the need for weight coating, the S-lay installation technique is the only feasible option for offshore pipeline installation in the Baltic Sea. For shallow water, a flat bottomed vessel is needed.

Landfall Installation - Overview and Base Case Selection

As the pipeline is brought ashore at the Germany and Russia landfalls, various pipeline installation activities must be carried out including site preparation, construction of supports and foundations, pipe installation, backfilling over the pipeline and reinstatement of worksites.

As described in Offshore and Shallow Water Pipeline Installation, the Project has selected the alternative of using an adapted S-lay installation method for laying the pipeline at the German landfall. This is the preferred method from both a technical and schedule perspective as well as for environmental reasons.

Environmental sensitivities at the German landfall (for example the Natura 2000 designation) have driven additional technological choices e.g. using a cofferdam for construction, in an attempt to reduce erosion and incursion into sensitive habitats.

Landfall Installation - Description and Evaluation of Alternatives

The alternative methods available for landfall installation are primarily driven by technical and physical constraints (such as metocean, geological and biodiversity conditions) associated with the locations selected for the landfall.

The selection of the German landfall location has been more complex than the Russian landfall, for example given that the Greifswalder Bodden is in a protected area (see **Chapter 8**). For this reason, the Project adopted a philosophy to restrict these construction methods that cause turbidity to be carried out only from mid-May to December.

With regard to the German landfall, three alternatives have been assessed: a tunnel, the ‘float and sink’ method and the S-lay method from pipelay vessels.

- The alternative to create a tunnel for the landfall would require use of a pipe tunnelling process with an internal diameter of 4,000 mm and a tunnel length of 12,600 m. Six boring machines would be required. Once constructed, and once the tunnel had been flooded with water, the pipelines would be floated into the tunnel

- The ‘float and sink’ alternative would involve pipeline strings with a length of approximately 500 m being produced on land. The construction period for this alternative would be around two years. The prefabricated pipestrings would be floated (attached to the construction vessel) to the landfall location where they would be welded and lowered in a controlled manner to the seabottom

- The S-lay method involves fabrication of the pipe strings using standard pipe joints onboard a flat bottomed barge and lowering of these pipe strings to the seabed, as described in section Offshore and Shallow Water Pipeline Installation

The tunnel solution was not taken forward for a range of environmental and logistical reasons. The construction would require a long construction period of approximately three years (which would also mean that construction would have to take place during the environmentally sensitive period of January to mid-May, as discussed above). Environmental considerations were highly relevant in this decision-making process as follows:

- Due to the required three year construction period there would be a risk of consequences to sensitive species (e.g. grey seals in the Greifswalder Bodden) over a longer time period than other installation methods that require a shorter time period
- The proposed tunnel shaft in the shallow water in front of the Freesendorfer meadows is a major bird resting ground and low noise area
- Dredging of a temporary access channel to the tunnel shaft would be needed that would impact the protected area during the three year construction period
- Due to the technical equipment needed (landward manufacturing ramp for the dual pipe string) there would need to be serious incursion into the grey dunes Natura 2000 designated site at the landfall point
- Visual effects, noise and emissions, traffic supply would mean that large areas of the eastern Bodden and the Bodden marginal well would be affected during the three year construction period

With regard to the "float and sink" method the evaluation concluded that, although the method is technically feasible, it has a number of technical risks and challenges. To manage these risks anchor piles would be required along the proposed route which would result in localised impacts on seabed sediment conditions. In addition, some specialist equipment would also be required which would impact the proposed construction schedule. The technical challenges may cause a second construction season (mid-May to December), i.e. a longer period the landfall environment is impacted by the Project.

In considering which installation alternative to take forward for pipelaying at the landfall, the S-lay method was deemed environmentally preferable to the tunnel and the ‘float and sink’ methods, for the following reasons:

- In contrast to the tunnel process the S-lay procedure has been assessed as having fewer environmental impacts

- In contrast to the "float and sink" method the S-lay method does not leave any permanent infrastructure behind and construction is possible within one installation season

In addition, at the German landfall the option to use a cofferdam was selected (as an alternative to using no cofferdam) in order to minimise the amount of dredging required and hence limit the impact on the coastline.

As a result of these physical conditions at the Russian landfall only one technical installation alternative has been considered; the standard pull technique and hence no assessment of different alternatives has been carried out.

Pre-commissioning - Overview and Base Case Selection

Pre-commissioning activities are carried out before the pipelines are filled with gas in order to prepare them for commercial operation and ensure pipeline integrity. The pre-commissioning activities include: flooding, cleaning and gauging of the pipelines, a system pressure test, and dewatering and drying of the pipelines.

Environmental considerations have been a key driver in selecting the base case for pre-commissioning in respect to alternatives considered for the general set up of pre-commissioning activities, the options for water treatment as well as the water intake and discharge location.

With respect to the residual risk resulting from a pressure test with natural or inert gas, the system pressure test will be done with the use of sea water.

The location for intake and discharge of testing water will be at the Russian landfall (base case) due to the preferable water quality (lower salinity) and better physical conditions (less enclosed coastline with deeper water) to encourage rapid dilution and dispersion of the discharged testing water.

Concerning water treatment, adding only oxygen scavenger and caustic soda to the testing water, was selected as the base case in order to minimise the potential impacts on water quality and marine biodiversity as a result of the discharge of testing waters. A test program to evaluate the option of using no additives but only fresh water is currently ongoing.

Concerning dewatering and drying, based on the technical risks associated with the use of a glycol train the concept of using compressed air has been selected; using dry air from a temporary compressor station at Greifswald. The drying air will be vented at the Russian landfall.

Pre-commissioning - Description and Evaluation of Alternatives

General

An important part of the pre-commissioning activities is to perform a pressure test of the system to prove the integrity of the pipeline. Four alternatives for the system pressure test have been considered:

- To waive the system pressure test
- To use sea water for the test
- To use natural gas for the test
- To use inert gas for the test

Alternatives to the commonly performed hydrostatic pressure test must meet an acceptable standard in respect of safety and integrity of the pipeline.

The first alternative – to waive the system pressure test altogether – has been assessed by the Project as no preferred option since it would not ensure that the necessary standard of proving pipeline safety and integrity is met. The option to waive the pressure test has therefore been excluded from further considerations.

The three remaining alternatives, use of seawater, natural gas, and inert gas, are comparable with respect to ensuring appropriate strength and integrity of the pipeline. However, the consequences with respect to safety and environmental impact of a total pipeline failure during pre-commissioning vary between these three options; the impacts of a failure occurring during performance of the test are assessed to be considerably higher if natural gas or inert gas is used in comparison to a hydrostatic pressure test with seawater. The consequences of a test failure when using natural gas are expected to be more severe than with inert gas, due to the flammability of natural gas.

The risk of pipeline failure during a pressure test with natural or inert gas will be mitigated by design, fabrication, installation and inspection of the pipeline. However, a residual risk remains in comparison with hydrotesting the pipeline with water.

Water Intake and Discharge

It is common practice to use a hydrostatic pressure test. This requires that the pipeline is water-filled. Due to the amount of water required for the hydrostatic pressure test, seawater is normally used for this purpose. Seawater is pumped into the pipelines through a simple water winning arrangement including filtering and (if required) treatment of the seawater.

For the Nord Stream Project, two locations remain as main alternatives for intake and discharge of testing water, after the ISP was engineered out of the pipeline design concept. These are the German and the Russian Landfall.

As a fall back alternative it might be necessary to perform the testing of the middle therte from the tie-in position KP300 (Finland) to tie-in position KP675 (Sweden). This would include pumping in additional water volume (approximately 5000 m^3 filtered seawater) used for pressurization, at one of the tie-in positions and later discharge of a similar volume. The water might be discharged to the sea or recovered in containers.

In terms of the consideration of alternative locations for water intake and discharge the potentially sensitive nature of the Baltic Sea has been a fundamental criterion in the consideration process. The evaluation process considered the following key areas.

- *The German Landfall:* This landfall is within the Bodden area which is shallow and enclosed. This means that dispersion of discharged testing waters would not take place as quickly or completely as in a more open coastal area. In addition water quality in the area is expected to vary largely over the year, and is generally not technically appropriate for precommissioning operations due to the higher salinity/acidity (approximately pH 8)

- *The Russian Landfall:* This location is expected to be more appropriate in terms of water quality for precommissioning activities then the Bodden area at the German Landfall as salinity is lower. This lower level of salinity is preferable since it results in less precipitation in the pipeline during chemical treatment. This location is also more open and in deeper water than the German landfall area, and consequently more efficient dispersion and dilution of the discharge water is expected

Water Treatment

Pre-commissioning normally includes chemical water treatments to prevent corrosion of the pipelines. The requirements of chemical treatment are very much dependent upon the residence time of the test water in the pipeline.

For the Nord Stream Project, it can be assumed that the water will remain in the pipeline for a minimum period of five months. For such residence times, it is common practice to treat the water with oxygen scavenger, and biocide or sodium hydroxide (caustic soda) to avoid oxygen corrosion and bacterial growth.

Three options have been considered. These are

- No additives

- Adding oxygen scavenger and biocide, e.g. glutaraldehyde

- Adding oxygen scavenger and sodium hydroxide

A detailed assessment of the environmental impacts of discharge of treated water in the landfall areas has been performed by the Project.

In light of viable alternatives, and given the sensitive nature of the Baltic Sea, the use of biocide has been rejected by the Project.

It can be concluded that oxygen scavenger and sodium hydroxide (and reaction products that result from their use) are natural substances which already exist in sea water and are generally of low toxicity in the marine environment. The oxygen scavenger (sodium bisulphate) will react with the oxygen in the water in the pipeline and form sulphate which exists naturally in sea water in high concentrations. Adding sodium hydroxide will increase the alkalinity of the sea water and the formation of calcium carbonate may take place. However, calcium carbonate is a non toxic constituent of natural suspended material in sea water. A discussion around the potential impacts from these substances can be found in **Chapter 9** (Impact Assessment).

Dewatering and Drying

After pressure testing and tie-in the pipelines need to be dewatered and dried. In principle two alternative methods are normally available. Option 1 is to use a pig train (dewatering pigs) and compressed air supplied form a temporary compressor station. Option 2 is to dewater using a glycol train.

The glycol train option is significantly faster but is considered to have much higher technical risks than using compressed air for dewatering and drying.

Neither alternative has any significant environmental implications therefore the consideration of alternatives has been based largely on technical considerations.

Commissioning - Overview and Base Selection

Pipeline commissioning comprises all the activities that take place after the end of pre-commissioning and until the pipelines are ready for natural gas transport (i.e. operation).

As a general commissioning principle the pipelines will be partially filled with nitrogen gas (inert gas) immediately prior to natural gas-filling in order to avoid a mixture of atmospheric air and dry gas. The nitrogen will act to clear the pipeline of atmospheric air prior to the introduction of natural gas. Options for commissioning are primarily driven by considerations such as safety and technical feasibility which are outlined as part of the process of complying with the DNV code.

The Project has selected the use of natural gas injections into atmospheric conditions with the pipeline partially treated with nitrogen as the base case as this is the most technically feasible alternative.

Commissioning - Description and Evaluation of Alternatives

A number of alternatives for pipeline commissioning have been considered. The criteria influencing the selected option included the following requirements:

- Minimise the duration of operations
- Use of conventional or standard equipment
- Minimise temporary pipework
- Maximise safety (good separation of natural gas, nitrogen and air)
- Minimise environmental impacts
- Minimise consumables

Logistical considerations have also been key in assessing various options.

The detailed procedures will be developed during future design but three commissioning alternatives have been considered (all options would start from the compressor station at the Russian landfall). These include:

1. Natural gas injection into atmospheric conditions with the pipeline partially treated with nitrogen (30% of the length)
2. Natural gas injection under pipeline vacuum conditions using nitrogen
3. Use of a pig train with batches of nitrogen

The advantages and disadvantages of these three options include the following:

1. Natural gas injection into atmospheric conditions with the pipeline partially treated with nitrogen (30% of the length). Based on experience with similar pipelines the mixing zone between air and nitrogen would typically be 20 - 25 km and the mixing zone between nitrogen and gas 25 - 30 km. This option uses minimal equipment, does not require the use of pigs, and is fast and simple
2. Natural gas injection under pipeline vacuum conditions using nitrogen; this option uses vacuums at each end, which takes the pressure below the flammable levels. However, it

has a longer duration than option 1 and requires more equipment, therefore is technically more complex

3. Use of a pig train with batches of nitrogen: this requires the pipeline to be pre-pressurised to approximately 12 to 15 bar in order to assure stable pig running conditions. This option has a long duration and higher technical risk

There is little difference in terms of environmental implications between the various alternatives as the main emission would be limited to nitrogen which will not have any environmental impact. Therefore environmental criteria have not been a significant factor in the consideration of these commissioning alternatives.

6.3 Reference List

Helsinki Commission. 2007. Helcom red list of threatened and declining species of lampreys and fishes of the Baltic Sea. Baltic Sea Environmental Proceedings No. 109.