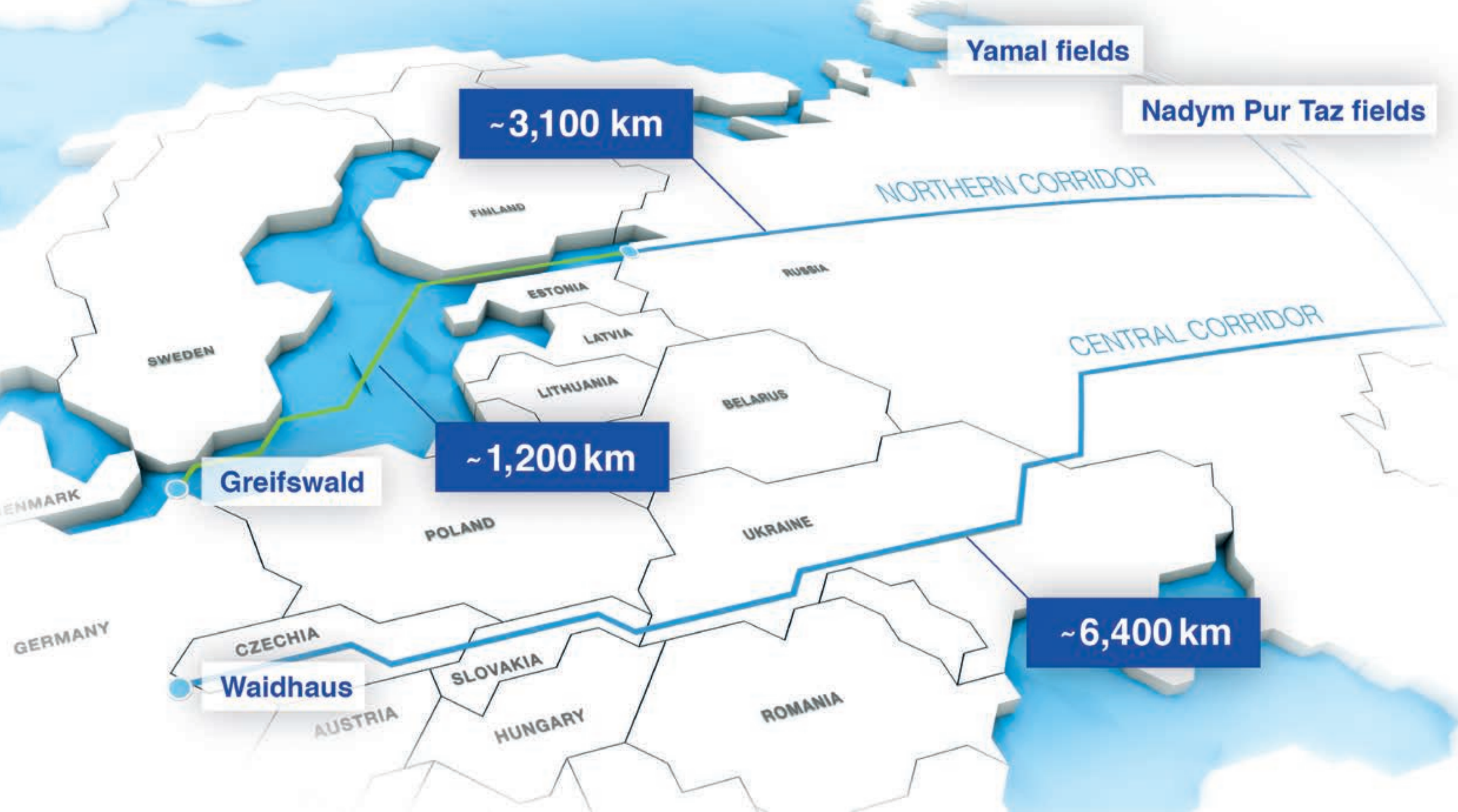
Nord Stream 2
Committed. Reliable. Safe.

# Onshore Construction in Russia

## An Innovative Solution to Ensure Minimal Environmental Impact




*A direct connection to the new Yamal peninsula fields.*

# The Best Option for Europe's Future Gas Supply

**Nord Stream 2 is the shortest route to the European market and the most competitive delivery option. Based on proven, safe and sustainable technology, it needs less energy than the alternatives and saves $CO_2$ emissions.**

Nord Stream 2 compares favourably to both liquid natural gas (LNG) and to onshore pipelines – the latter requiring significant land usage, longer construction times and burning more gas for interim compression.

Much like the existing Nord Stream Pipeline, the Northern corridor that feeds the Nord Stream 2 Pipeline is substantially shorter than the Central corridor – thus requiring fewer compressor stations along its route. Greenhouse gas (GHG) emissions are 61 percent lower than those of the central corridor pipeline routes used to transport Russian gas to Europe.

Modern pipeline systems in the Northern corridor allow for significantly higher pressures and require less fuel gas. The more efficient system leads to lower transport costs for the shipper. Gas transit rates via Nord Stream 2 will be lower than current tariffs, saving more than 60 percent of $CO_2$ emissions.



# Starting in the Kurgalsky Peninsula

**The proposed pipeline crosses a small section of the southern part of the Kurgalsky nature reserve in Russia. Nord Stream 2 is fully aware of its responsibility towards this sensitive and protected habitat, which is characterised by a rich diversity of flora and fauna.**

The starting point of the pipeline system is in Russia's Narva Bay in the Kingisepp distict of the Leningrad region. At this location, the pipeline route crosses a protected area, the Kurgalsky peninsula, over a distance of approximately 6.2 km, of which approximately 3.7 km are onshore and 2.5 km offshore.

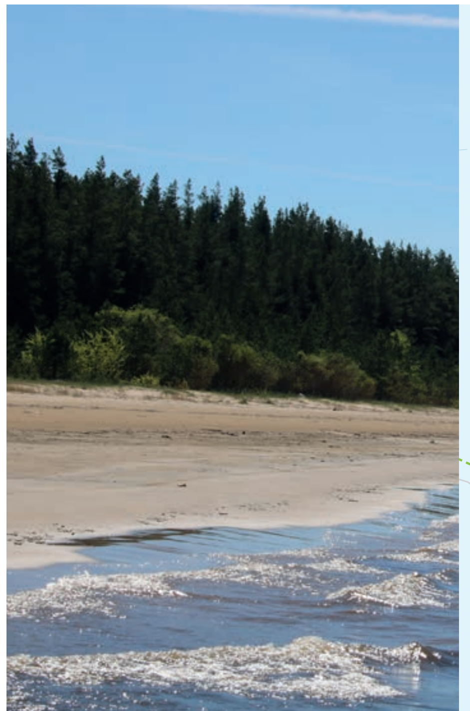
Onshore construction will affect approximately **0.15 percent** of the territory of the Kurgalsky reserve.

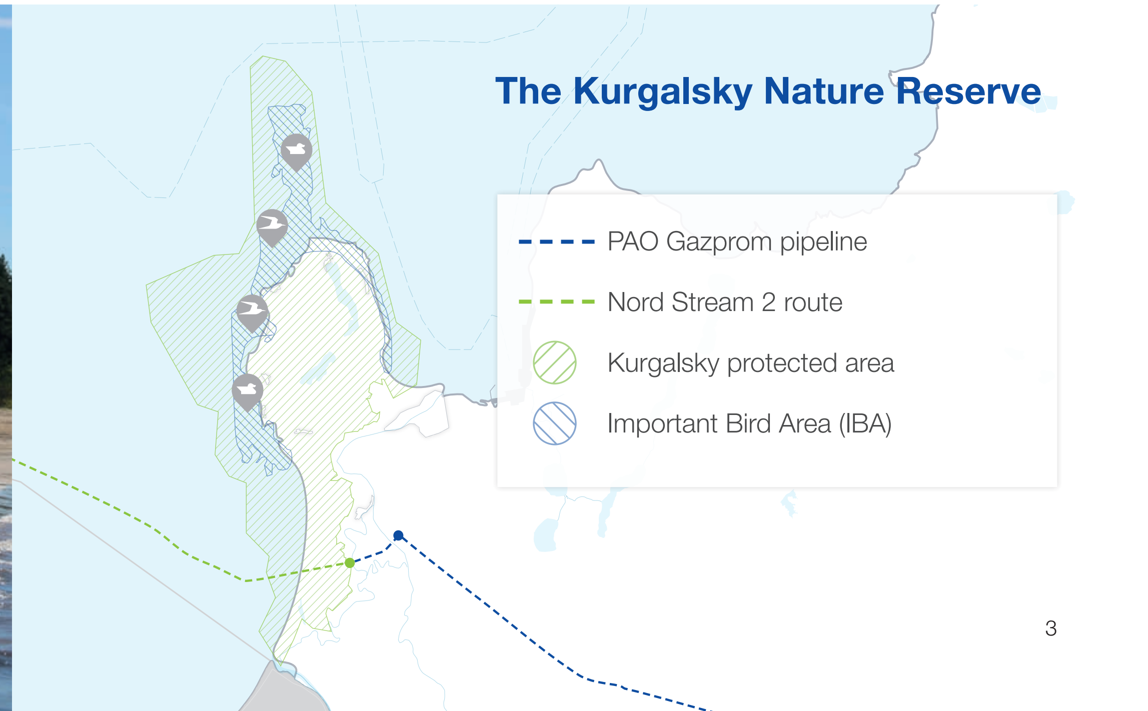
The Kurgalsky reserve is a regionally protected area, or "zakaznik". It is also a Ramsar site and part of the HELCOM network of coastal and marine protected areas in the Baltic Sea.

The onshore section of the Nord Stream 2 Pipeline crosses approximately 3.7 km of the protected area, through three main natural habitats: a coastal forest belt, a forested relict dune and the marginal part of an extensive swamp (Kader bog).

At the onset of the project, before survey activities began, a standard methodology for the construction of the onshore section of the pipeline was envisaged. It was based on the successful track record of the Nord Stream Project, which was completed in 2012.

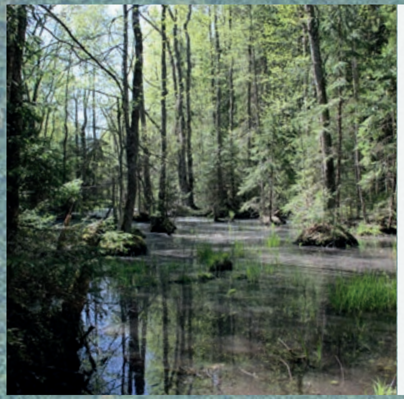
This included the clearance of an 85 to 100 m wide construction corridor, excavation of two trenches, fabrication of the pipelines alongside the trench and installation of the pipelines within each trench. After installation, the trenches are backfilled and the ground conditions and the vegetation are restored.





# Onshore Pipeline Construction

## Tailored to the environmental conditions of each natural area

### 1 COASTAL FOREST BELT

The coastal forest belt extends over approximately 1 km from the shoreline of Narva Bay up to a relict dune, which has an elevation of up to 20 m above sea level. Within the forest the swampy terrain provides perfect conditions for conifer trees, mosses, ferns and small bushes. These provide a suitable habitat for invertebrates, mammals and birds.

### 2 NATURAL PINE FOREST ON THE SAND DUNE

Approximately 1 km from the shoreline and over a length of 500 m the landscape is characterised by a relict (or inactive) dune. The vegetation on the western section of the dune consists of pine forest with a ground rich in grasses and lichens. Some interesting rare flora can be found here, along with rodents and larger mammals that prefer drier conditions.

### 3 MODIFIED HABITAT ON THE SAND DUNE

The eastern flank of the relict dune was partially destroyed by a fire in 2006 and has since been replanted with pine. The ground cover is being partly recolonised by heather and juvenile birches. Fire-related soil erosion prevents fast regeneration of the natural conditions and attracts pioneering species.

### 4 MARGINAL PART OF THE KADER BOG

The land between the relict dune and the gas inlet facility is flat and has lacustrine (lake-related) origins. The western part of this section is hydrologically connected with Kader bog, the wetland that extends to the South. The Eastern part, was drained in the past but has recently been returning to swampy conditions though it was severely damaged in the 2006 fire. Vegetation consists mainly of juvenile birches, low pines and shrubs that provide an important bird habitat.

# Considering Alternative Construction Methods

**We have chosen the most environmentally compatible trenchbox construction method after comprehensive evaluation of every option and constraint. This method was then further optimised by applying innovative, tailored solutions for the conditions present in this specific area.**

When the Nord Stream 2 engineers, surveyors and environmental specialists started taking a closer look at the topographic, hydrological and ecological conditions, as well as the legal status of the Kurgalsky protected area, it became clear that a certain amount of lateral thinking was required and that a less conventional construction methodology should be sought.

The purpose of the assessment of alternative construction methods was to minimise the footprint of the project in the delicate ecological habitats along the pipeline's route. Specifically, the functional objectives of the alternative methods were to minimise the need for forest clearance and the size of the area that would be temporarily affected by the construction activities. The alternative solutions that were considered included Microtunnelling, Conventional Tunnelling, Horizontal Directional Drilling (HDD), Direct Pipe and others, generally referred to as "trenchless techniques".

Of all trenchless techniques that were evaluated, only microtunnelling was considered to be theoretically feasible over the required distance. Therefore a design was developed and a risk assessment was carried out to determine the compatibility of such an installation with the risk acceptability criteria embraced by Nord Stream 2, together with the resulting environmental impact.

The microtunnel design and pipeline installation analysis indicated that a microtunnel through the entire onshore section of the protected area (3.7 km + approximately 700 m offshore to reach a suitable water depth for pipelaying) would not be feasible.

A shorter microtunnel through the most sensitive habitats (2.3 km) would be theoretically feasible but has hardly ever been constructed before in similar ground conditions. Furthermore, the uncertainties associated with the local geology and hydrology resulted in high constructability risks, which in turn create risks to personnel safety and the environment. An even shorter microtunnel (1.5 km) would not have achieved the environmental protection objectives (such as the avoidance of trees clearance) because of the location of the entry and exit pits required for the two microtunnels.

## Starting point

Alternative construction methods have been extensively investigated to design the best, safest and most environmentally friendly route.

# Minimising Our Footprint by 50 Percent

**Innovative logistics and construction methods to limit the impact and the width of the planned corridor are a priority. This reduces the construction area by nearly 50 percent.**

The last factor that determines the overall width of the construction corridor for the twin pipeline is the need to store excavated soil before reinstatement of the trench. As a result of the high water level throughout most of the onshore section of the pipeline route, the excavated soil is likely to be very wet and therefore have a very low angle of repose. This means that the excavated soil storage area would have a much larger footprint than dry soil.

This factor will be minimised in the most environmentally critical sections by storing soil within retaining structures alongside the trench or transporting excavated soil from the trench to a specific storage area outside the Kurgalsky protected area.

These measures will optimise the working width within the protected area. Nord Stream 2's objective was to reduce the working width by approximately 50 percent, and we sought reputable contractors who would be able to develop the right engineering solution for this aim.

## Conclusion

After thorough examination of all avaliable options, the most sustainable method has been selected.

S. Serdyukov,
Chief Technical Officer of Nord Stream 2 AG

“It's nearly impossible to build an infrastructure project without environmental impacts. But it's our aspiration to minimise the impacts, especially in a protected area like Kurgalsky. Furthermore, it is our responsibility to come up with feasible and innovative construction methods. Beyond that, we are willing to invest in the long-term development of the entire region and we will develop further programmes of compensatory measures to ensure the delivery of a sustainable project.”





# A Brand New Technical Solution

**Nord Stream 2 has appointed a world-leading contractor to develop a design that takes into account the requirements for minimising the corridor and any other environmental impacts associated with the construction.**

The environmental objectives defined by Nord Stream 2 were to develop a construction method with the smallest possible footprint within the Kurgalsky protected area.

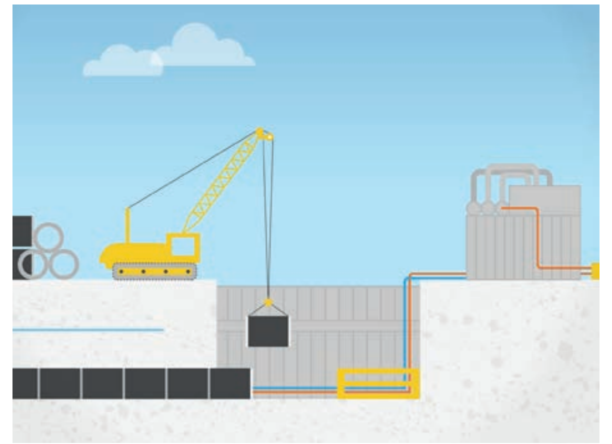
Operating in a vulnerable environment and under strict environmental criteria demands an innovative solution to minimise impacts. Following an in-depth Constructability Study, the contractor came up with a method that will have a substantially smaller environmental impact than the conventional approach.

The method relies on trench boxes to maintain vertical trench walls and reduce the width of the trench, allowing the pipelines to be laid within a 30-metre swath, or right of way, through the most sensitive habitat. In addition to reducing the footprint this method will also reduce approximately 70 percent of the excavated material when compared to a conventional unsupported trench. The method requires the pipelines to be installed in a flooded trench, limiting the dewatering required during construction. This ensures that groundwater levels during and after construction will not be altered, keeping surface hydrology in its natural condition as well.

The pipeline will be installed as two strings pulled from the pipe-lay barge anchored nearshore and a temporary welding station established adjacent to the gas inlet facility. The two strings will be welded together on the eastern margin of the dune. This installation method requires almost no heavy equipment on site during pipeline installation, significantly lowering noise emissions and associated disturbances during the pipeline installation phase.

This construction method has never been implemented in Russia on this scale. The knowledge transfer and experience will be a valuable resource in planning future projects in sensitive areas.





### Microtunnelling

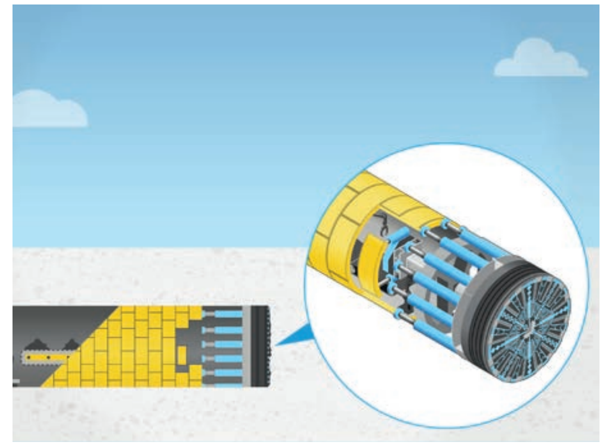
Microtunnelling consists of ground excavation with a tunnel boring machine, behind which prefabricated concrete rings are installed. The tunnel boring machine and the rings are progressively pushed through the ground by a jacking unit until the desired length of the tunnel is completed. After construction of the tunnel the gas pipeline is fabricated and pulled through the tunnel itself.

ⓧ Microtunnelling can be a high risk construction technique due to the uncertain soil conditions that can be encountered. Any construction difficulties would also lead to personnel safety issues because access inside the microtunnel would be required.


### Horizontal Directional Drilling

Horizontal Directional Drilling consists of ground excavation with the aid of an auger, which initially drills a pilot hole of small diameter. The hole is subsequently enlarged to the required diameter. The excavation is kept lubricated and stable by injecting mud that has the same or higher density as the ground that is being excavated. After completion of the bore, the gas pipeline is pulled through the bore, displacing the mud that filled the cavity.

ⓧ The length over which horizontal directional drilling would have to be performed is extreme and the risk of environmental damage as a result of breakthrough of drilling muds to the surface is unacceptable for Nord Stream 2. In the presence of different soil conditions, such as hard rock or dry sediments, it could have been considered.



### Conventional Tunnelling

Conventional Tunnelling consists of ground excavation with a tunnel boring machine. As the tunnelling machine advances, concrete segments are installed behind the machine, grouted together and anchored to the surrounding ground.

ⓧ Whereas conventional large diameter tunneling would be a feasible technique, the environmental impacts associated with the establishment of a tunneling construction site and the requirements for disposal of large volumes of soil would be far greater than its environmental benefits.

### Direct Pipe

Direct Pipe is a variation of the microtunnelling technique where instead of concrete rings the boring machine is pushed directly by sections of the gas pipeline, through which drilled material is recovered. Upon completion of the excavation, the boring machine is disconnected from the gas pipeline and normal pipelaying is continued.

ⓧ The direct pipe technique has the same technical uncertainties and safety risks associated with microtunnelling and, in addition, would require the gas pipeline to be used as a service conduit. This could potentially affect the long term integrity of the pipeline.

Illustrations on this page indicative only





# Developing an Innovative and Tailored Method for Sensitive Areas

**Our engineering teams face a number of challenges that include meeting all legal requirements and standards, minimising the environmental footprint and avoiding construction risks and failures – all while guaranteeing that the pipeline is built successfully.**

Reduced width of each trench from 12 to 3.5 m.

At first glance, a trenchless construction technique would appear to be the answer to construction and environmental concerns. But close evaluation of the risks associated with the potential failure of these techniques, which would lead to severe environmental impacts, led Nord Stream 2 to focus its engineering efforts towards an open cut methodology that would minimise its environmental footprint. Specialist contractors seeking innovative solutions focused on the following:

> The width of the trench
> The space requirements to accommodate construction equipment
> Excavated soil storage requirements
> Limiting construction equipment and personnel

Minimised roads for heavy vehicles.

To reduce the extent of excavation and the overall working area, a temporary trench retaining structure (trench box) has been proposed. Because trench box walls are mostly vertical, the overall width of each trench can be reduced from 12 m to about 3.5 m. Conventional mechanical excavators can install trench boxes, which minimises the need for heavy vehicular access. Additionally, the installation does not produce significant noise or vibration.

Reduced the need for onshore pipelay equipment.

The second requirement to reduce the construction footprint is to remove the need for conventional onshore pipelay equipment (pipe transporters, side booms, welding stations etc.) from the construction corridor. This can only be achieved if the pipeline is fabricated on board a laybarge or at an onshore fabrication site and pulled through the trench by a winch. Given the weight of the Nord Stream 2 Pipeline and the distance of the pull, this operation can only be performed by means of pulling the pipeline through a flooded trench thus using the buoyancy of the pipeline to reduce the required pulling force and the friction between the pipe and the base of the trench.

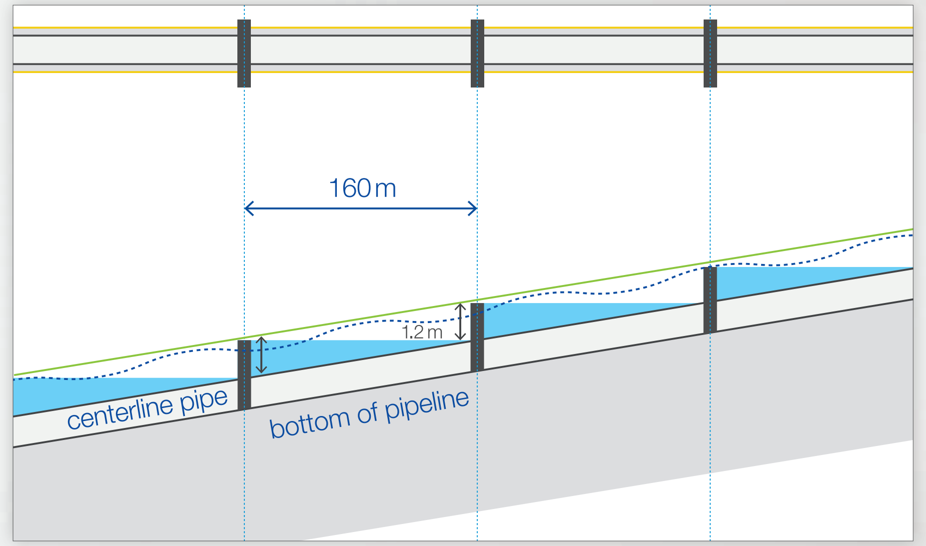
The average water level in the trench is generally required to follow the natural groundwater level. Due to the natural slope in the area, the trenches will be divided into sections, each isolated and controlled by dams with watertight seals. This will also prevent seawater and groundwater from mixing.

At the dune, excavation will ensure that the pipeline's given levels of vertical resilient bending are maintained. The right of way in this section will extend over a length of 400 metres.

# A Next Generation Construction Method for Sensitive Areas

**Safeguarding a Sensitive Habitat**

The trench box method requires pipe fabrication to take place at two locations rather than alongside the trench. One location will be on the laybarge. The second location will be at the gas inlet terminal. This construction layout means that fewer vehicles will need to access the pipeline corridor and therefore a narrower width is required. The use of the natural groundwater level to flood the trenches means that the area will not need to be dewatered, thus safeguarding the habitats which rely on a high water table for their survival. After installation of the pipelines the trench boxes will be extracted, the trench will be backfilled and a vegetation cover will be reinstated.




*The trench box system will be fitted with a series of seals to ensure that each section is flooded so that the pipeline can be pulled in a fully flooded trench.*

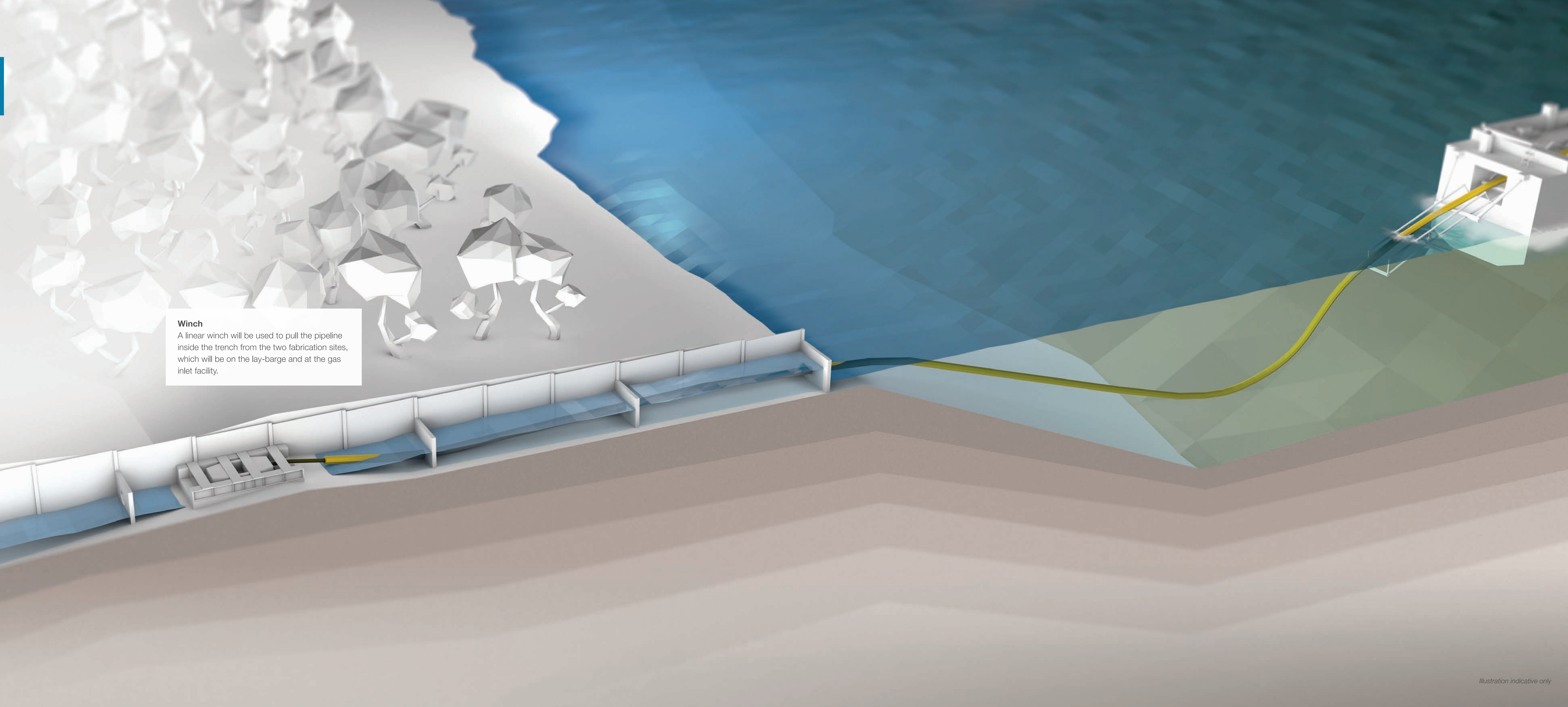
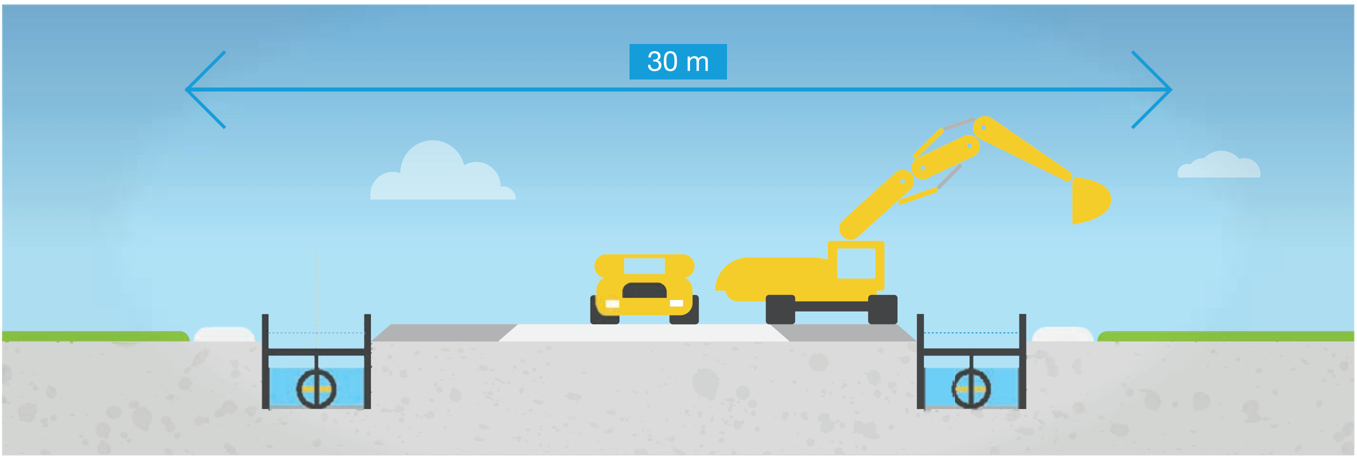
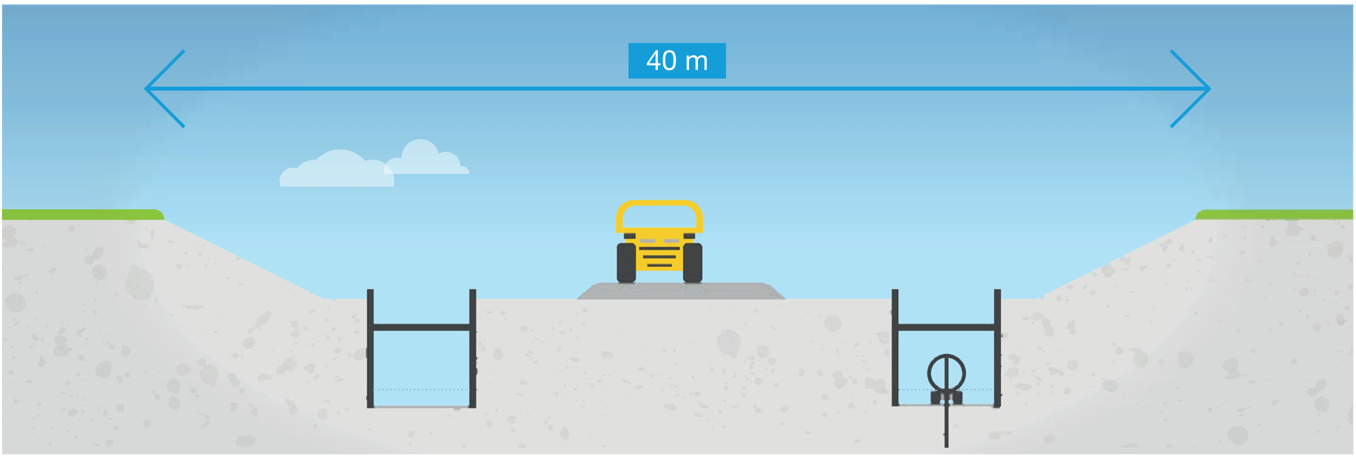


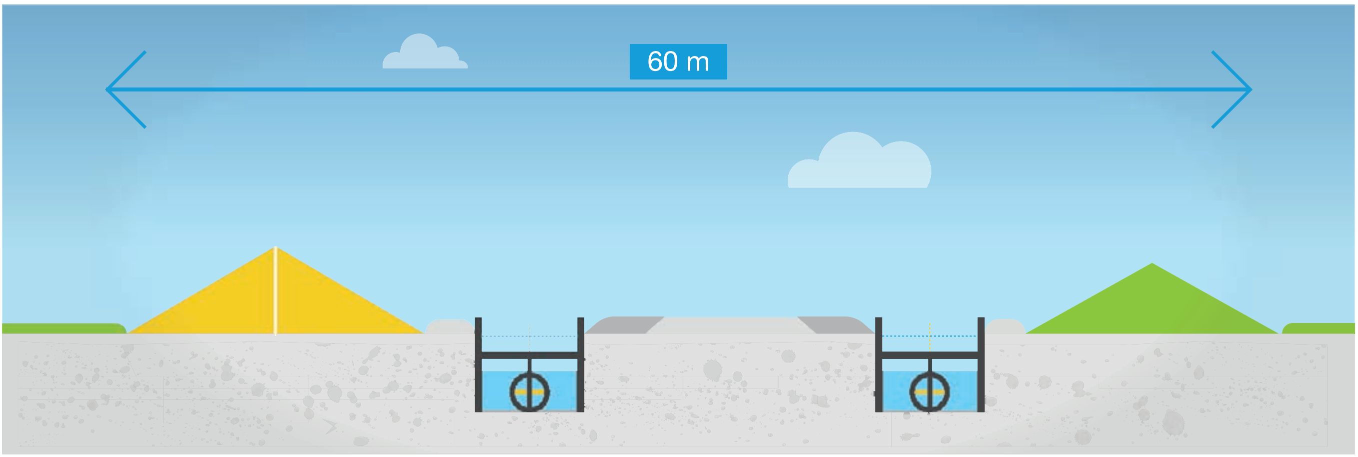

*Illustration indicative only*




Within the coastal forest the width of the right of way will be the bare minimum required for the installation of the pipelines. For a length of 1.3 km the width of the corridor will be 30 m.




Taking into account the given levels of vertical resilient bending of the pipeline, excavation will be required at the dune. The right of way in this section will extend over a length of 400 m.



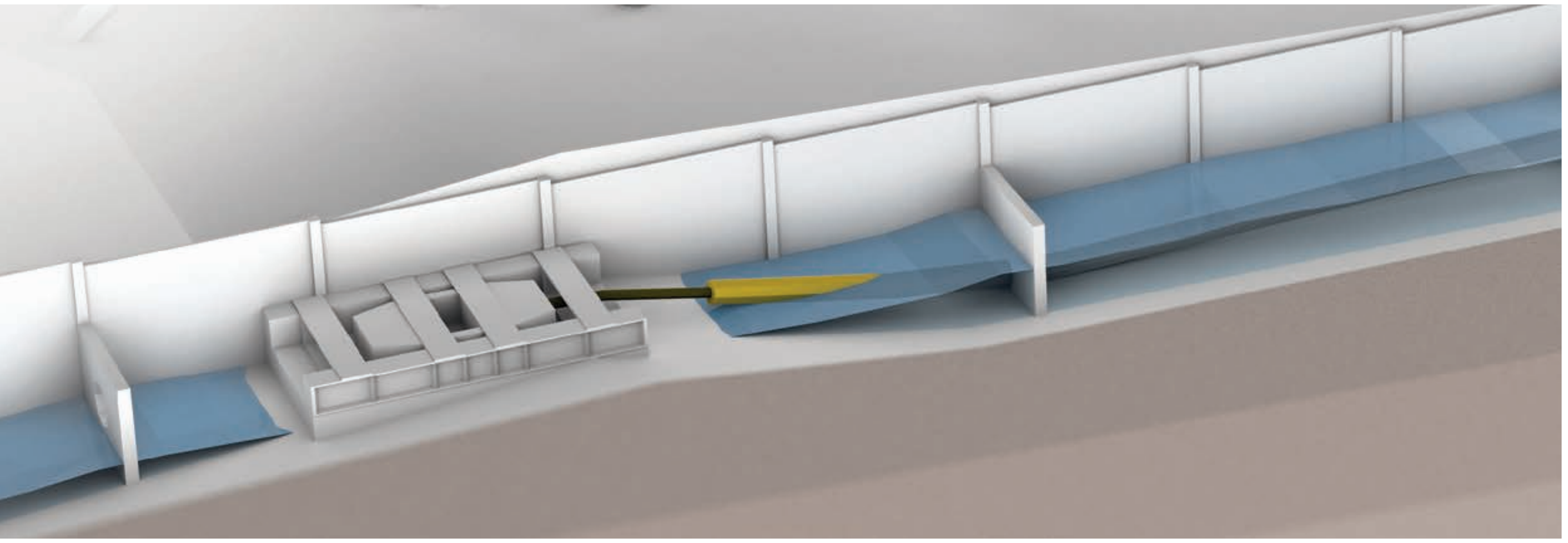

A 60 m right of way will be required east of the dune to store soil. This section will extend over 2 km.

# An Open Construction Solution Reduces Impact

**This innovative method reduces the area of construction and preserves the hydrological characteristics. It will lead to reduced environmental impacts and enable successfull reinstatement of the area after construction.**

Lateral thinking and the application of advanced construction techniques has enabled us to find a safe, reliable and environmentally acceptable design solution that will minimise habitat loss, reduce the severance effect on continuous habitats and preserve the hydrological regime of the area.

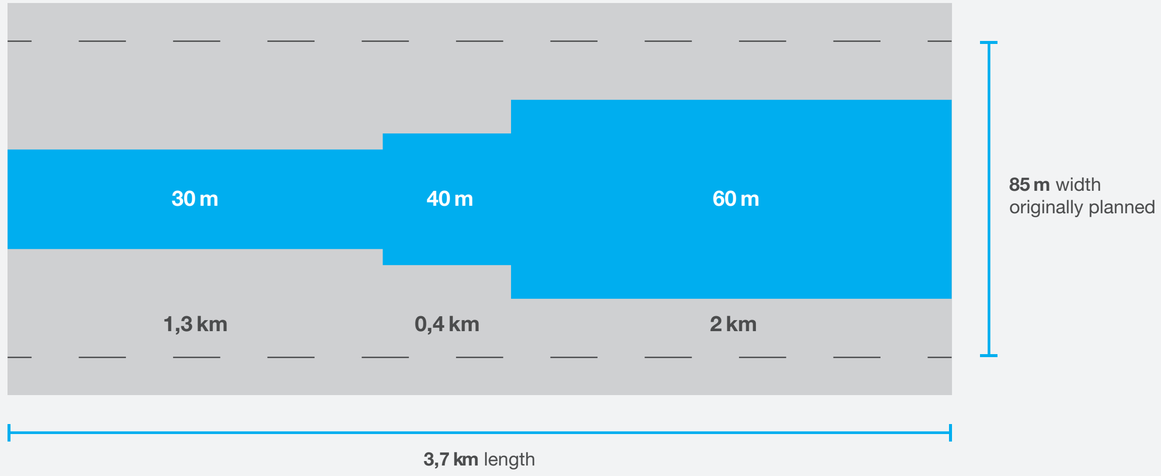
*Examples of the conventional approach used previously.*



*The optimised construction solution for a sensitive area.*

## Our Solution at a Glance

### Illustration of the excavation area




**Less excavation** and less equipment on site

**50** percent reduction in environmental impact

**Lower noise** and **less disturbance** to sensitive fauna

Area will be restored to **natural state** once the project is completed

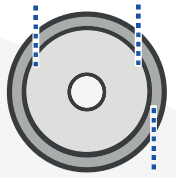
# Russian Landfall in Numbers

Throughput capacity:
**55** billion cubic metres
of gas per annum

**The pipeline** will be approximately
**1,200** km
long, and will run from the Russian coast through the Baltic Sea, reaching landfall in Germany.

Narva Bay route is
**39** km
shorter than the Kolganpya Cape route, meaning work will be concluded faster.

**The Narva Bay route** is far from the habitats of grey and ringed seals.




**The pipelines** will have a constant internal diameter of
**1,153** millimetres
(48 inches) and a wall thickness of up to 41 millimetres.

**2012 - 2017**

Route selection in three steps over a period of
**5** years

**The Narva Bay route** is far from shipping channels, ports and industrial and other facilities, with less impact on ship traffic during construction and reduced risk during operation.

Significantly less dredging (1/4) will be required compared to the Kolganpya Cape route because there is less shallow water and no boulders on the seabed.

Nord Stream 2 invites the region's inhabitants, non-profit organisations and all stakeholders to take part in the dialogue.

**Together we will discuss** what steps can be taken to further improve the quality of life in the Kingiseppsky district of the Leningrad region.



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