ENVIRONMENTAL IMPACT ASSESSMENT

PROJECT:

NEPTUN DEEP

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OMV Petrom S.A

Romgaz Black Sea Limited

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

CHAPTER 3 – DESCRIPTION OF RELEVANT ALTERNATIVES

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CHAPTER 3 DESCRIPTION OF RESONABLE ALTERNATIVES

3.1 DESCRIPTION OF RESONABLE ALTERNATIVES TO THE PROPOSED PROJECT

3.1.1 „Zero" alternative

The zero alternative consists of non-implementation of the proposed Neptun Deep project. Non-implementation of the project means that will be no development of Domino and Pelican South natural gas fields and the construction and operation of onshore and offshore gas related infrastructure will not be performed.

The potential impacts (adverse or positive) that might be generated by project implementation will not occur and the current onshore, coastal, and offshore environmental and social conditions will remain unchanged.

In the next two decades, the Neptun Deep project, the largest offshore project in Romania, is expected to bring ~EUR 20 bn as contributions to the state budget. It will make the country the EU's largest gas producer. The development of these resources would bring consistent economic value to the country, with estimated investments of up to EUR 4 bn, made by the two partners. According to data from an impact study ordered by OMV Petrom, the project will generate and maintain at the country level ~ 9,000 jobs (direct, indirect & induced jobs). The study has been prepared by Consilium Policy Advisors Group (CPAG), a company that is specialized in macroeconomic analysis. The study is based on "Leontief" input output methodology that is internationally best practice.

If the project is not undertaken and completed, the objectives of strengthening the country's energy security and of additional revenues to local and national budgets will not be finally met.

3.1.2 Description of design concept alternatives studied for the selection of the current proposed development concept

During the early project stages of concept evaluation and selection, options to develop the gas reservoirs found in the Domino and Pelican South fields were further developed to understand the facilities and technologies required, confirm the ability to achieve business objectives, assess financial attractiveness, and identify potential safety and environmental risks and issues including those associated with major accident hazards.

Several engineering concepts were considered at this early stage including consideration of aspects such as:

- Risk reduction associated with major accident hazards;
- The potential location of the gas processing facilities (onshore vs offshore);
- Whether the gas processing facilities could be designed to be operated as an unmanned facility;

- Whether the wellheads were located on the seabed or on an offshore platform;
- Hazards associated with the location of flowlines, pipelines, and processing facilities;
- Overall reduction in GHG (Greenhouse Gas) emissions through use of mbest avaiable technology.

Initially, the project concept was envisioned with the minimum offshore facilities including a well gathering platform, a gas pipeline to shore and a staffed onshore treatment plant that included facilities such as gas dehydration, power generation and relief systems. After further assessment and better understanding of the socioeconomic and environmental drivers of the region, the concept evolved to a safer design which minimized the process footprint of the onshore facilities, moving most of the equipment offshore, and optimizing the offshore platform design in order to accomplish a normally unmanned production concept, where the operations and maintenance crew only need periodic visits to perform their planned activities, and the offshore platform would be fully controlled from the onshore via a digital twin technogolgyAlso, a number of concepts for the selection and design of systems and equipment were evaluated during the concept selection phase and early design. n terms of performance and environmental protection, a number of independent Best Available Techniques (BAT) assessments have been completed, addressing:

- Flare, gas dispersion and valve actuation systems;
- Electricity and heat generation; and
- Chemicals and discharges into the sea.

The independent BAT reports included the assessment of various technical alternatives, with a focus on environmental performance, technical applicability and financial criteria. The results of these studies were used in the design concept selection process. BAT reports are presented in Annex N.

The results of the BAT evaluations and selection process resulted in the dersign basis described in Chapter 2, which involves the subsea connection of the Domino and Pelican South reservoirs to the unmanned offshore production platform, followed by the transportation of dehydrated gas through the production pipeline to the onshore metering station (NGMS) for transfer into the Romanian National Transmission System (NTS). This option best aligns with the overall business objectives when considering factors such as risks and environmental concerns, personnel and community safety, technology availability, and commercial considerations.

3.1.3 Description of the Offshore Options Considered

3.1.3.1 Alternatives analyzed for the location of the offshore production platform and drilling centres

The offshore SWP will be located on the continental shelf approximately 160 km east of Constanta, in the area of the Pelican reservoir. The platform location was selected in order to minimise the potential of encountering shallow gas hazards. The proposed location of the platform was selected where shallow gas was least likely to be found. Other factors considered in the initial selection of the platform location included:

- Proximity to the drill centres;
- Clearance distance from drilling rig mooring pattern; and
- Clearance from other geohazards.

An evaluation has been conducted to assess the drilling shallow hazards and supported the selection of the proposed locations of the Domino and Pelican South drill centres. The locations of the drill centres were selected to minimise drilling shallow hazards and flow assurance requirements for longer flowlines and engineering rework.

3.1.3.2 Power Generation at SWP

Offshore power is an integral part of the offshore gas development as it is necessary to meet the energy demand for offshore processing and associated facilities at the normally unattended SWP.

The offshore power system refers to facilities for power generation and distribution for normal operation as well as dedicated power available for essential services. The estimated energy load of the offshore facility is approximate 8.5 MW. The majority of the power demand is for powering the direct electric heating (DEH) of the Domino in-field pipeline, and the electric heat tracing of the Pelican flexible in-field pipeline.

A Best Available Technique (BAT)[1] assessment to evaluate three main alternatives for electricity generation on the production platform was conducted, which included:

Option 1: Offshore Generation using GTGs. Option 1 consists of 3 Gas Turbine Generators (GTGs) with 2 GTGs running in parallel to meet the energy demand, while the third is used as back-up. This offers a solution with the least environmental impacts associated with GHG emissions and/or pollutants (including NOx, SOx and particulates) as these emissions will be generated 165 km away from people and communities. Use of GTGs with a spare unit (N+1) for offshore power generation is a standard practice and offers simplicity and a robust/reliable and proven design.

Option 2: Offshore Generation using Gas Internal Combustion (IC) (Reciprocating) Engines. Option 2 consists of using multiple internal combustion engines fuelled with fuel gas to generate power. Five to six engines would be required to cover the power needs. This alternative has lower GHG and polluting emissions than the base case due to a higher efficiency of IC engines however, this is negated by the carbon footprint due to the increased maintenance requirement for multiple units being less reliable with the complexity of the design in the number of units required to cover the power needs.

Option 3: Power from the Main Grid Onshore. Option 3 would require the installation of a sub-station onshore, a subsea power cable to the SWP, and a station on the SWP. Power from shore is increasingly implemented in the oil and gas industry around the world, but its benefits for the environment as a whole highly depend on the electricity mix in each country. There would be no direct GHG and/ or polluting emissions offshore but the indirect GHG emissions in Romania are potentially higher than direct emissions from the GTG. Environmental benefits are dependent on the carbon intensity of the local electricity grid and there would still be emissions and costs associated with running cables from shore to power individual platforms. In terms of feasibility, this option is the least favourable due to the significantly large distance from shore.

Each selected technology has been assessed for its environmental impact, feasibility (the option satisfies all defined constraints and requirements to enable a solution to go ahead), operational complexity (this criterion leads to increased interventions i.e., inspection, repair and maintenance), facility complexity (addresses increase in equipment, which ultimately causes increase in platform size and weight as well as likelihood of switching from normally unattended installation to manned facility), robustness/ reliability (level of robustness: the ability of the equipment to withstand harsh conditions, such as cold weather climate, shutdown, and restart, level of flexibility: easy to adapt to highly varying water quantity and quality) and Capex/Opex (a high-level capital, operation, and maintenance costs). The technical alternatives were compared and ranked in order to select the preferred option in line with the BAT requirements.

3.1.3.2 Offshore Flaring and venting

Flaring and/or venting is an integral part of offshore gas development for the safe and efficient operation of offshore platforms. Flaring and/or venting is used to manage excess hydrocarbons produced during O&G operations, which can be dangerous for the safety of the operations. Flaring involves the controlled burning of gases that are not used for production, while venting involves the release of gases directly into the atmosphere. The SWP design has considered various flaring and venting options. The BAT evaluation included assessment of the following alternative solutions for offshore flaring and venting:

Option 1: Flaring of both Continuous and Non-Routine Releases (1 Long Boom only). By flaring the gas from both continuous, Low Pressure (LP) gas and High Pressure (HP) non-routine releases, through separate headers and flare stacks, all the gas is combusted when released to the atmosphere. This reduces the impact of GHG emissions by combusting all the gases before release and is regarded as an industry standard for offshore developments while offering a simple design solution. The base case is easy to operate, has a high reliability and low maintenance requirement due to the very simple equipment needing only monitoring and sampling of gas streams to flare to ensure regulatory requirements are met.

Option 2: Flaring of Continuous Sources and Venting of Non-Routine Releases (2 Booms). This option consists of flaring the gas from continuous, LP sources, and venting the HP non-routine releases. The flaring and venting would happen at two different systems (headers and stacks), separated to prevent accidental ignition of the vent gas. This option only combusts continuous releases and discharges both CO2 and methane to the atmosphere, which increases environmental impact from a GHG emissions release perspective. This alternative with two separate booms for flare and vent stack is somewhat complex due to the requirement for a separate boom for flare and vent further increasing structural weight and complexity.

Option 3: Cold Venting of both Continuous and Non-Routine Releases (1 Short Boom only). This option consists of the use of a common vent system to release both the continuous, LP gas and the HP nonroutine releases though a common vent boom. Despite the low CAPEX and simple design, significantly higher GHG emissions are generated as all the gas is released to the atmosphere without being combusted, generating methane which in terms of GHG impact is a 25x bigger contributor than CO2.

Option 4: Recovery and Compression of all Continuous Sources and Flaring of Non-Routine Releases (1 Long Boom). This option consists of two separate flare systems (headers and stacks) for continuous sources and for non-routine releases. The gas from all the continuous sources will be recovered and used as a part of the fuel gas system through two separate Fuel Gas Recovery Units (FGRUs) for HP and LP systems, with flare stacks used as an alternative route. This alternative requires additional power, equipment, significant deck space and maintenance requirements.

Option 5: Recovery and Compression of Continuous LP Sources and Flaring of HP Continuous and Non-Routine Releases (1 Long Boom). This option consists of two separate flare systems (header / stack) for continuous sources and for non-routine releases. The gas from continuous LP sources will be recovered and used as part of the fuel gas system through a single FGRU. High-pressure continuous and non-routine releases are released through flare. This alternative requires additional power, equipment, significant deck space and maintenance requirements.

Each selected technology has been assessed for its environmental impact, feasibility (the option satisfies all defined constraints and requirements to enable a solution to go ahead), operational complexity (this criterion leads to increased interventions i.e., inspection, repair and maintenance), facility complexity (addresses increase in equipment, which ultimately causes increase in platform size and weight as well as likelihood of switching from normally unattended installation to manned facility), robustness/ reliability (level of robustness: the ability of the equipment to withstand harsh conditions, such as cold weather climate, shutdown, and restart, level of flexibility: easy to adapt to highly varying water quantity and quality) and Capex/Opex (a high-level capital, operation, and maintenance costs). The technical alternatives were compared and ranked in order to select the preferred option in line with the BAT requirements.

3.1.3.3 Chemical Storage

A variety of chemicals are used in enhancing production of oil and gas from offshore platforms. The storage of offshore chemicals is therefore an important aspect to ensure operational safety, mitigate equipment damage and for process treatment. For Neptun Deep, the design has identified the need to have chemical storage of corrosion inhibitor, antifoam, scale inhibitor, TEG, and methanol. Small volume chemicals typically stored in tote tanks and cylinders were excluded from the BAT assessment. Diesel storage system is also not considered as crane pedestal storage is considered industry best practice.

Chemical storage provides a means for the safekeeping of production and utility chemicals. The chemicals storage requires proper management and barriers against accidental spills to provide safety measures and prevent environmental impact on the seabed, in the water column and to the atmosphere as pollutants and / or GHG emissions.

The BAT evaluation included the following alternative solutions for storage of chemicals at the SWP:

Option 1: Jacket Leg Storage. This option considers large storage of chemicals (methanol and TEG) in the jacket leg of the offshore platform with the rest of the chemicals stored in on-deck stainless steel tanks. This offers an effective solution for passive gravity storage capacity, effectively utilising space on the offshore platform with a minimum addition of materials as the platform legs are already in place to structurally support the weight of the platform. This eliminates the need for deck tanks therefore saving weight and space on topsides.

Option 2: On-Deck Storage. This option would require all chemicals to be stored in on-deck storage tanks and would need additional deck space which is limited on the SWP. This would add significant weight and space requirements and may increase the size of the SWP. This would significantly increase the CAPEX for an unattended installation, such as the SWP where passive processes are required with minimal intervention.

Option 3: In-Deck Storage (Underslung Tank). An under-slung tank storage is a type of storage tank that is suspended from the underside of a structure, such as a platform process deck. Under-slung tank storage is commonly used in situations where it is necessary to store chemicals on a platform, in a compact, space-efficient manner. This option consists of storing methanol in an underslung tank below the deck and the rest of the chemicals in on-deck storage tanks. This however has limited storage capacity as it is typically smaller than an on-deck tank, has height restrictions as it requires a certain amount of clearance beneath the tank to avoid causing obstacles on the lower deck, is difficult to access for maintenance or inspection as it is suspended from the underside of the process topside deck. Underslung tanks are also more vulnerable to damage from extreme weather and are more expensive to install and maintain than on deck tanks.

Option 4: Suspended below Seawater Level Storage. This option requires methanol to be stored in a suspended tank below the waterline whilst the rest of the chemicals are stored in on-deck tanks. This system would present buoyancy limitations when loading and unloading as well as a potential risk to the attached leg structure over time, adding to the complexity of operations.

Option 5: Subsea Storage. This option comprises a series of subsea storage tanks containing methanol and TEG with the rest of the chemicals stored in on-deck storage tanks. This would eliminate the need for additional deck tanks saving weight and space on the topsides. This option does however require a HP subsea chemical injection pump with leakage control, to prevent substances from leaking into the environment adding complexity to the design. Storage modules must also be equipped with permanent double fluid barriers consisting of a liner material featuring very high chemical compatibility with commonly used production chemicals. Other limiting factors include the difficulty in access, the complexity of refilling operations as well as rare field proven reference to date.

Option 6: Onshore Storage and Umbilical. This option requires all chemicals to be stored in tanks in an onshore facility with a 165 km umbilical connecting to the offshore platform. This option does eliminate the requirement for deck storage however, the length of the umbilical would add extensive CAPEX and installation complexity, as the umbilical would require trenching, additional manning, and infrastructure for installation. The onshore facility would also require injection pumps designed for the required pumping length.

Each selected technology has been assessed for its environmental impact, feasibility (the option satisfies all defined constraints and requirements to enable a solution to go ahead), operational complexity (this criterion leads to increased interventions i.e., inspection, repair and maintenance), facility complexity (addresses increase in equipment, which ultimately causes increase in platform size and weight as well as likelihood of switching from normally unattended installation to manned facility), robustness/ reliability (level of robustness: the ability of the equipment to withstand harsh conditions, such as cold weather climate, shutdown, and restart, level of flexibility: easy to adapt to highly varying water quantity and quality) and Capex/Opex (a high-level capital, operation, and maintenance costs). The technical alternatives were compared and ranked in order to select the preferred option in line with the BAT requirements.

3.1.3.4 Open drains system

The main purpose of the rainwater drainage system is to collect, analyse and treat (if required) the potentially contaminated rainwater in a way which is most viable environmentally, operationally, and financially. There is no closed drain system included in the SWP drains design as the SWP is normally unattended, therefore it is expected that no wastewaters will be produced during normal operation and only during maintenance activities. All process effluents from maintenance activities will be captured in tote tanks and returned to shore for appropriate disposal. This approach eliminates a closed drain system because all drainage sources are manually operated and can be managed during the short maintenance periods.

The SWP incorporates an open drain system design. As the platform is free of hydrocarbon liquids, rainwater that falls on open deck grating and stairs, will not be collected but washed directly to the sea surface as it is not expected to be oil contaminated. The areas that are expected to see lube oil, or machine oils or fuel oils, shall be decked or plated to capture potentially oil contaminated rainwater runoff to prevent oil discharge to the sea.

Rainwater on decked/plated areas around process equipment will be captured and diverted into an open drain system. Similarly, any wash down effluent that falls into decked areas (near equipment) and plated areas (like the helideck), will be captured, and diverted into the open drain system.

The BAT evaluation included an initial assessment to determine the most favourable solution of the following disposal options:

Option 1: Jacket Leg Storage. This option considers collecting the effluents generated from the SWP drains including rainwater, potentially contaminated water, and any other sump drains (like lube oil etc.). The total effluent will be lifted by a hydraulically driven caisson pump for transfer to the support vessel FSV for onshore disposal. No oil and water separation system is provided in this option as treatment and disposal is by a third party onshore. Storage of drained effluents in the jacket leg of the SWP is an effective method of utilising space on the SWP with a minimum addition of materials as the legs are already designed to structurally support the weight of the SWP. This option offers an effective solution for gravity drainage systems on platforms with limited deck space and is a common solution for unmanned platforms offering passive gravity storage capacity eliminating the need for deck tanks and associated equipment such as low sheer lift pumps. Jacket leg storage does not require additional space nor increases weight on the platform, offers the benefit of storage without any significant increase in materials use (only a double bottom tank plate).

Option 2: In-Deck Storage (Underslung Tank). An under-slung tank storage is a type of storage tank that is suspended from the underside of a structure, such as a platform process deck and can be used to ensure that open systems can gravity feed into the tank for storage without the need for pumping, as this can cause mixing of oil and rainwater forming emulsions and making oil and water separation more difficult to treat. Under-slung tank storage is commonly used in situations where it is necessary to store liquids in a compact and space-efficient manner. This option however has limited storage capacity as it is typically smaller than an on-deck tank, has height restrictions as it requires a certain amount of clearance beneath the tank to avoid causing obstacles on the lower deck, is difficult to access for maintenance or inspection as it is suspended from the underside of the process topside deck. Underslung tanks are also more vulnerable to damage from extreme weather and are more expensive to install and maintain than on deck tanks.

Option 3: On-Deck Storage. This option would require additional space on the top-deck, which is limited on the SWP. As the drains are gravity fed, the potentially oil contaminated rainwater would need to be pumped to the on-deck tank for storage, causing mixing of oil and water forming emulsions, which are difficult to separate. The additional equipment and on-deck storage adds significant weight and would lead to an increase in size of the SWP which would significantly increase the CAPEX. As the SWP is an unattended installation, passive processes are required with minimal intervention.

Option 2 and **3** were discounted for further consideration due to their limitations and complications. Option 1 Jacket Leg Storage open drains routing and disposal options were then considered, and these are discussed below:

Option 1.1 : Effluents Storage in the Jacket Leg (Without Analysis) and Shipped Onshore. This option considers collecting the effluents generated from the SWP drains including rainwater, potentially contaminated water, and any other sump drains (like lube oil etc.). The total effluent will be lifted by a hydraulically driven caisson pump for transfer to the FSV for onshore disposal. No oil and water separation system is provided in this option as treatment and disposal is by a third party onshore. This alternative is deemed the worst environmental option due to the increased number of FSV visits required for drained effluent transportation to shore and the increased risk of spillages.

Option 1.2 : **Effluent Storage and Treatment Overboard using OIW Separation with Discharge into the Sea.** This option considers collecting all the effluents generated onboard the SWP with treatment using techniques e.g., an oil and water separator with treated effluent discharged overboard to the sea. Any recovered oil will be collected and directed to a storage tank to a FSV for periodic shipping to onshore. Although this alternative is deemed the best environmental option due to the lower power demand and requirement to only transport separated oil to shore using FSVs, there is a need for additional equipment and increased maintenance.

Option 1.3: Effluents Onboard Storage, Analysis And Discharge To Sea Or Ship Onshore. This option considers collecting open drain effluents from the SWP grated and plated surfaces deemed potentially oil contaminated rainwater runoff. The open drain jacket-leg tank will be emptied every 3 months (during planned maintenance visits). The collected drain liquids are to be analysed to verify that the hydrocarbon content is <15 ppm OIW, utilising an online analyser on the caisson pump discharge line. With confirmation of acceptable hydrocarbon content, the pump will then be routed to the PW discharge caisson downstream of the sample point for discharge to sea. In the case of increasing hydrocarbon content to >15 ppm at the analyser, discharge to sea of drain water will be stopped. The remainder of the sump contents will be pumped to a maintenance vessel for disposal onshore. This option is considered to be the most feasible option due to the limited number of vessels required to transport the drained effluents to onshore, increased reliability and lowest maintenance requirements.

3.1.3.5 Hydrate Management

Hydrate formation in subsea pipelines is a well-known issue that every developer must overcome during field life. As the raw production fluids start cooling (normally around 25 °C), depending on water cut and pressure, hydrates start to form and can plug the pipeline. Formation of hydrates can be avoided by keeping the fluids warm, removing water or by injecting thermodynamic inhibitors. The formation of hydrates in subsea pipelines needs to be managed considering environmental, operational, and financial viability.

The BAT evaluation included assessment of the following hydrate inhibition options:

Option 1: Direct Electrical Heating (DEH). This option considers the continuous heating of the Domino field flowline by forcing single-phase current directly through the pipe steel with a piggy-back cable. During normal operation, the Pelican field does not require any hydrate management solution as it is expected that thee flow will be warm enough to avoid hydrates. However, Electric Heat Tracing will be required for start-up and shutdown scenarios. The production fluids will enter the inlet separator at the SWP, with the separated saturated gas routed to the dehydration unit (TEG contactor). The gas comes into contact with "Lean TEG" within the process to remove water. The dry gas is then routed to shore. The PW from the inlet separator is sent to the PW separation units and is eventually discharged overboard. The base case is considered the most robust, reliable, and least complicated option due to the negligible maintenance requirements.

Option 2: MEG/TEG System with Stripping of MEG/TEG from the PW. This option considers MEG/TEG injection at the well, which flows with the production fluid to the SWP to prevent hydrate formation in the flowlines. At the SWP, the MEG/TEG will be regenerated in a topside stripping and re-boiling process. In a similar way to the base case, the fluids enter the inlet separator at SWP, but PW is not discharged overboard. This option will require more energy over the lifetime of the project as PW rates are expected to increase in later field life. Emissions are also expected to be the highest for this alternative. Due to the addition of the MEG/TEG regeneration system, an increased need for maintenance will be created for a normally unmanned structure with MEG top ups required which will increase the risk of spillage..

Option 3: Depressurisation System with No Heating and Methanol Injection for Shutdown (Pelican field). This option requires the depressurisation of the Pelican flowline as a hydrate mitigation strategy, which due to the short length of the Pelican pipeline is feasible. However, depressurisation of the Domino flowline without electric heating is not viable due to the length and total accumulated liquid in the line. As the system is pressurised on restart, hydrates will form which would result in a blockage. Therefore, this option is only valid for the Pelican flowline and would need to be combined with the base case for the Domino flowline (continuous DEH). Operationally, the Pelican flowline would be depressurised whenever the production is shut-in to avoid hydrate formation. There will also be injection of methanol into the Pelican riser base, the wellbore, trees, manifolds, and jumpers after shut-in. On restart, there would be injection of Methanol at the trees until the fluid temperatures increases above the hydrate formation temperature. This alternative also includes venting of the content of the Pelican flowline, (~ 2.5 Mscf (ca. 47 t) of gas) whenever there is a shut-in. Despite this alternative having the same equipment as the base case, it is more complex as there are 2 flowlines which are operated differently during shutdown and restart. Repeated depressurisation of the flexible line may also cause fatigue issues and render this solution less reliable.

3.1.3.6 Selection of chemicals used

Studies on production fluids have identified inorganic scale deposition, in-line corrosion and foaming as the main flow assurance risks during the operations phase, for the Neptun Deep Development. The main production chemicals identified for use during facility operation include Scale Inhibitor (SI), Corrosion Inhibitor (CI) and Antifoam (AF).

SIs are chemical substances used to prevent the formation of mineral deposits, known as scales, that can accumulate in equipment and pipelines used in the gas production process. These scales are usually composed of minerals such as calcium carbonate, barium sulphate, and strontium sulphate, which can form solid deposits and reduce the efficiency of the production process. SIs work by either preventing the formation of the scales or by destabilising them so they can be removed more easily. They are typically injected into the gas production system, upstream of the point of scale formation and are designed to be effective at very low concentrations. The occurrence of the mineral deposit Calcium carbonate ($CaCO_3$) was determined as the main flow assurance risk during production of formation water. The products were tested under simulated field conditions using a Dynamic Scale Loop (DSL) to determine the Minimum Inhibitor Concentration (MIC). SIs are injected at Pelican and Domino drill centres upstream of the choke on the subsea xmas tree (XT), on detection of formation water from subsea wet gas flowmeters.

CIs are chemical substances used to prevent or minimise the degradation of equipment and infrastructure caused by the presence of corrosive substances, such as gases, liquids, and solids. Corrosion can occur in various forms, including uniform corrosion, pitting corrosion, and stress corrosion cracking, and can lead to significant equipment damage, safety risks, environmental risks, and production downtime. CIs are designed to mitigate these risks by either forming a protective film on the surface of the equipment or by modifying the chemical environment to reduce the corrosion rate. CI is only injected at a single injection point location, at the most upstream producing Domino manifold (DODC1 or DODC2). There is no requirement for CI at Pelican.

AF agents are used to prevent or control foam formation that can occur during the production, processing, and transportation of produced hydrocarbon gas. Foam can be a problem in gas production because it can reduce production rates, interfere with process control, and lead to equipment failure. AF agents are typically surfactants that are added to the gas production process to break down foam bubbles and prevent them from re-forming. They work by reducing the surface tension of the foam, allowing the gas to escape more easily, and preventing the build-up of foam in the system. AF is injected at the separator as required to bring foaming under control once it occurs; AF injection is not expected during normal operations.

Four international oilfield chemicals companies (Schlumberger, Clariant, ChampionX and Baker Hughes), pre-qualified by OMVP, were invited to provide product samples (CI, SI and AF) with detailed product information to select the best product in terms of highest technical performance, lowest environmental impact alongside other considerations such as application compliance and non-performance criteria. Of the 20 product samples, 7 were initially eliminated based on substitution and aquatic warnings or ecotoxicity. The remaining 13 samples were composed of 4 SIs, 3 CIs and 3 AF and these are presented in Table 3.1 .

The BAT evaluation included assessment of each of the group of chemicals (SI, CI, AF) to select the optimum products.

Table 3.1 Producers list and and chemical products

Alternativa	Producător	Tip produs	ID produs
1	Schlumberger	Scale Inhibitor	DS-49022
2	Clariant	Scale Inhibitor	SCALETREAT DF 8386
3	Champion X	Scale Inhibitor	SCAL 12504A
4	Champion X	Scale Inhibitor	SCAL 13370A
5	Baker Hughes	Scale Inhibitor	Subsea 729
1	Schlumberger	Corrosion Inhibitor	DS -1622
2	Clariant	Corrosion Inhibitor	CORRTREAT12606
3	Champion X	Corrosion Inhibitor	CORR 12452A
4	Champion X	Corrosion Inhibitor	CORR 16229A
1	Schlumberger	Antifoam	DF -9084
2	Clariant	Antifoam	FOAM TREAT 12201
3	Champion X	Antifoam	AFMR20400A
4	Champion X	Antifoam	AFMR12889AA

Scale Inhibitor

The BAT evaluation included assessment of the following SI options:

Option 1: Schlumberger DS-49022. This product was found to be technically feasible, but with a high neat corrosivity giving it a higher operational complexity as it would need to be transferred from shore to the SWP by tote tanks and managed under procedure, limiting the risk of spills.

Option 2: Clariant SCALETREAT DF 8386. This product was deemed low feasibility due to its poor inhibition performance and with a high neat corrosivity giving it a higher operational complexity as it would need to be transferred from shore to the SWP by tote tanks and managed under procedure, limiting the risk of spills.

Option 3: ChampionX SCAL12504A. This product was found to be technically feasible, but with a high neat corrosivity giving it a higher operational complexity as it would need to be transferred from shore to the SWP by tote tanks and managed under procedure, limiting the risk of spills.

Option 4: ChampionX SCAL13370A. This product was found to be technically feasible, had the lowest ecotoxicity potential and the least operational complexity as it did not have high neat corrosivity.

Option 5: Baker Hughes Subsea 729. This product was deemed low feasibility due to its poor inhibition performance and with a high neat corrosivity giving it a higher operational complexity as it would need to be transferred from shore to the SWP by tote tanks and managed under procedure, limiting the risk of spills.

The independent BAT assessment concluded that Option 4 (ChampionX SCAL13370A) is the most favourable option followed by Option 1 (Schlumberger DS-49022) for the Neptun Deep Project.

Corrosion Inhibitor

The BAT evaluation included assessment of the following CI options with a required dose rate for corrosion protection of 6 ppm:

Option 1: Schlumberger DS-1622. Although this product is considered more harmful than Champion X products and responded the slowest in tests to determine the response time of product to offer necessary protection, it still has low operational complexity and a higher feasibility based on early screening level NTPA001 testing conducted by OMV labs.

Option 2: Clariant CORRTREAT 12606. This product is deemed the most harmful of all the products tested with high corrosivity, comes with a H412 warning for the undiluted product causing operational complexity, has low feasibility based on early screening level NTPA001 testing conducted by OMV labs, and responded slowly when tested against response time of product to offer necessary protection.

Option 3: ChampionX CORR12452A. This product is deemed the least harmful of all the products tested with low operational complexity, a higher feasibility based on early screening level NTPA001 testing conducted by OMV labs and responded quickly when tested against response time of product to offer necessary protection.

Option 4: ChampionX CORR16229SP. Although this product is the second least harmful and responded quickly when tested against response time of product to offer necessary protection, and low operational complexity it does come with a H412 warning for the undiluted product causing operational complexity and was found to have low feasibility based on early screening level NTPA001 testing conducted by OMV labs.

The independent BAT assessment concluded that Option 1 (Schlumberger DS-1622) and Option 3 (ChampionX CORR12452A) to be equality favourable for the Neptun Deep Project.

Antifoam

The BAT evaluation included assessment of the following AF options:

Option 1: Schlumberger DF-9084. This product was found to be technically feasible and had lower ecotoxicity.

Option 2: Clariant FOAMTREAT 12201. This product was found to be technically feasible however has a higher ecotoxicity than the other three chemicals.

Option 3: ChampionX AFMR20400A. This product was found to be technically feasible and had lower ecotoxicity.

Option 4: ChampionX AFMR12889A. This product was found to be technically feasible and had lower ecotoxicity however is corrosive with respect to carbon steel in neat form.

The independent BAT assessment concluded that **Option 1** (Schlumberger DF-9084) and **Option 3** (ChampionX AFMR12889A) to be favourable for the Neptun Deep Project.

Based on the overall BAT analysis, two chemical package vendors were shortlisted, given that both ChampionX chemicals and Schlumberger products have been ranked either first or second choice for all three chemicals assessed.

As an outcome of the PW discharge modelling, and given that the selection of a single vendor of chemicals is desirable from both a commercial and operational perspective, it was recommended that the following ChampionX chemical package be carried forward:

- Scale inhibitor: ChampionX SCAL 13370A;
- Corrosion inhibitor: ChampionX CORR12452A;
- Antifoam: ChampionX AFMR20400A.

3.1.3.7 Produced water discharge

There are several potential options that can be evaluated to identify the most probable Best Available Technique (BAT) alternative for wastewater (PW) disposal.

The offshore concepts considered included:

Option 1: Caisson only. Offshore treatment and wastewater disposal overboard via a caisson in a water depth of 90 m.

Option 2: Pipeline Discharge at Depth. Offshore treatment and wastewater disposal overboard via a caisson in a water depth >130 m towards the Domino field in the anoxic zone. An additional pipeline (~ 1.8 km) is required to reach this depth.

Option 3: Aquifer Re-Injection via a Platform. Offshore treatment and wastewater disposal in an aquifer via a new dedicated platform. For the 10,000 bwpd it is assumed that a single water disposal well would be drilled. This option requires a stable geological formation for reinjection and additional topside water injection equipment.

Option 4: Aquifer Re-Injection via Subsea. Offshore treatment and wastewater disposal in an aquifer at the Pelican reservoir. An additional subsea well at Pelican would be drilled. This option requires a stable geological formation for reinjection.

Option 5: Storage & Ship Movement. Offshore storage and boat transfer to an onshore plant. This is a “hybrid” option where the water would be stored offshore, and a boat would then transfer onshore. This option requires additional vessel transport for shipment to shore of the PW and the increased vessel transport will result in increased emissions to air of GHG and NOx.

Each selected technology has been evaluated in terms of its environmental impact, feasibility (the alternative meets all defined constraints and requirements to allow for a viable solution), complexity (this criterion leads to increased facility complexity, addressing equipment growth, which ultimately results in increased platform size and weight, as well as the potential transition from an normally unmanned facility to a manned facility), robustness/reliability (level of robustness: equipment's ability to withstand harsh conditions such as cold weather, shutdown and restart, level of flexibility: ease of adaptation to highly variable water quantity and quality), and Capex/Opex (high-level capital, operation, and maintenance costs). The technical alternatives have been compared and ranked to select the preferred alternative in accordance with BAT requirements.

3.1.3.8 Hydrostatic Test

The production flowlines connecting the subsea wellheads and manifolds at the Domino and Pelican South Drill Centres to the SWP will undergo hydrostatic testing before commissioning to ensure that the system can hold line pressure above the maximum allowable operating pressure rating. Similarly, the natural gas pipeline extending from the onshore NGMS to the SWP will undergo similar hydrostatic testing.

An estimated total volume of 72,441 m3 of hydrostatic test water will be discharged from the Pelican pipeline (120 m^3), the Domino pipeline (4,790 m^3), and the sales gas pipeline to shore (67,543 m^3). For the hydrostatic test water, there are only two available alternatives, which have been evaluated according to BAT requirements:

Option 1: Discharge of Hydrotest Water into the Anoxic Zone of the Black Sea

Discharge of Hydrotest Water into the Anoxic Zone of the Black Sea. Upon completion of pressure tests, the hydrostatic test water is planned to be discharged into the Black Sea at the DODC2 location situated deep in the Black Sea anoxic waters at a depth of over 950 m. As this is a significant volume of water and a one-time event, it is not feasible to be brought onshore for treatment. Disposal into the anoxic layer is considered best practice as the waters are essentially void of oxygen-consuming species and thus eliminates adverse effects to marine flora and fauna.

Option 2: Hydrotest the GPP from Offshore to Onshore. This option would require an offshore tanker for the receipt, storage, and disposal of over 500,000 bbls of treated seawater. In addition, dewatering equipment would be required onshore and with the limited plot plan area, would increase the project CAPEX/OPEX with the risks associated with increased handling of wastewater e.g., risk of groundwater contamination through leaks and spills.

3.1.3.9 Subsea Valve Actuation

For Neptun Deep, subsea valves on the wellheads utilise the pressure of a control (hydraulic) fluid to actuate. The pressurised control fluid is supplied from the SWP via the umbilicals. The hydraulic fluid is typically an aqueous ethylene glycol solution. The BAT evaluation included assessment of the following disposal options:

Option 1: Hydraulic Open Loop. A small quantity of used hydraulic fluid is released to sea when closing or opening valves on the well trees. Every time the valve is closed, a piston full of fluid is released. The selected hydraulic fluid is water based and designed to minimise environmental impact. The Domino and GPP SSIVs are direct hydraulic systems and do not discharge hydraulic fluid into the marine environment. This is returned to the topsides hydraulic reservoirs due to the relatively small distance from the subsea SSIV to the topsides HPU for this system.

Option 2: Hydraulic Closed Loop. The hydraulic actuation system for closed loop is the same as that for open loop, with the difference that the used fluid is recycled to the topsides in a closed loop. Closed loop is rarely used because the back pressure on the return line slows or prevents the valve from closing creating a system that is slow to react. The step out distance of Domino also makes this option impractical as subsea accumulators would be required which can reduce the reliability of the system. There would also be an increase in maintenance, and a reduction in response time with an added impact on the umbilical design and topsides weight to house the returns lines.

Option 3: Electrical. Electrical actuation uses a linear stepping motor to drive the piston and open the valve. The piston is held in place with an electromagnet while required to stay open. When the electric power is turned off, the electromagnetic force is released, and the spring returns the piston to its start position. The electricity is generated on the topsides and applied to the actuator; however, these systems are not suitable for subsea application; The step out distance, technology readiness for large bore valves actuation, CAPEX and OPEX impacts of large electrical umbilicals to transmit power to actuate E-Actuators makes this option impractical.

The options were assessed in terms of environmental performance (discharges to sea, emissions to air/GHG), technical applicability (e.g., reliability, operability, and maintainability), and financial criteria (capital and operating expenditures). The technical alternatives were compared and ranked in order to select the preferred option in line with BAT requirements.

3.1.3.10 Description of the selection process for the offshore pipeline route

The route of the production pipeline has been developed based on the location of the SWP and a pipeline routing study conducted by a third-party contractor during FEED. The general criteria applicable to all pipeline routings has been applied:

- Minimise the route length and the number of intersection points (route bends).
- Avoid wherever possible restricted offshore areas such as anchorages, sanctuaries, shipping lanes, military areas, mining activities etc.
- Consider the limitations of the installation equipment with regard to the lay curvature, i.e., lateral stability of curved pipeline sections.
- Avoid where possible pipeline, cable and utilities crossings and provide adequate clearance to adjacent pipelines and cables.
- Follow a smooth seabed profile avoiding, wherever possible, rock outcrops, soft soils, abrupt breaks of slope, steep gradients and pockmarks and associated undulations, which could give rise to spanning and uncertain soil conditions.
- Consider conservative routing along cross slopes, dynamic slopes and other geohazards such as active tectonic faults.
- Provide straight sections at the following locations to aid pipeline installation: i) pipeline initiation and termination points, ii) in between two consecutive pipe bends, iii) pipeline/cable crossings.

The pipeline routing also included an assessment of the following aspects:

- Data from geophysical surveys performed within the studied area;
- Bathymetry data;
- Seafloor features surveys (faults, shallow gas, gas escape features, depressions depths, sea floor scars, pock marks, undulating seabed, sand dunes, patches of seagrass and rock outcrop);
- Results of the geotechnical surveys performed within the studied area;
- Pipeline data;
- SWP tie-in details
- Onshore NGMS pipeline tie-in details.
- Third party activities (i) existing or anticipated cable crossings, (ii) fishing areas, (iii) shipping infrastructure, (iv) sensitive and protected areas, and (v) other constraints like

wrecks, debris, trawl scars, etc. and showed that the pipeline route avoids any archaeologically relevant elements such as shipwrecks.

The following routing activities were conducted prior to the final identification of the selected pipeline route:

- Pre-FEED and Concept Select Phase[1]: The development concept included a 36-inch production pipeline, 6-inch MEG line and FOC running from the SWP to shore. A landfall was designed to avoid the protected coastal areas, with the Tuzla landfall option pipeline length approximating 156 km.

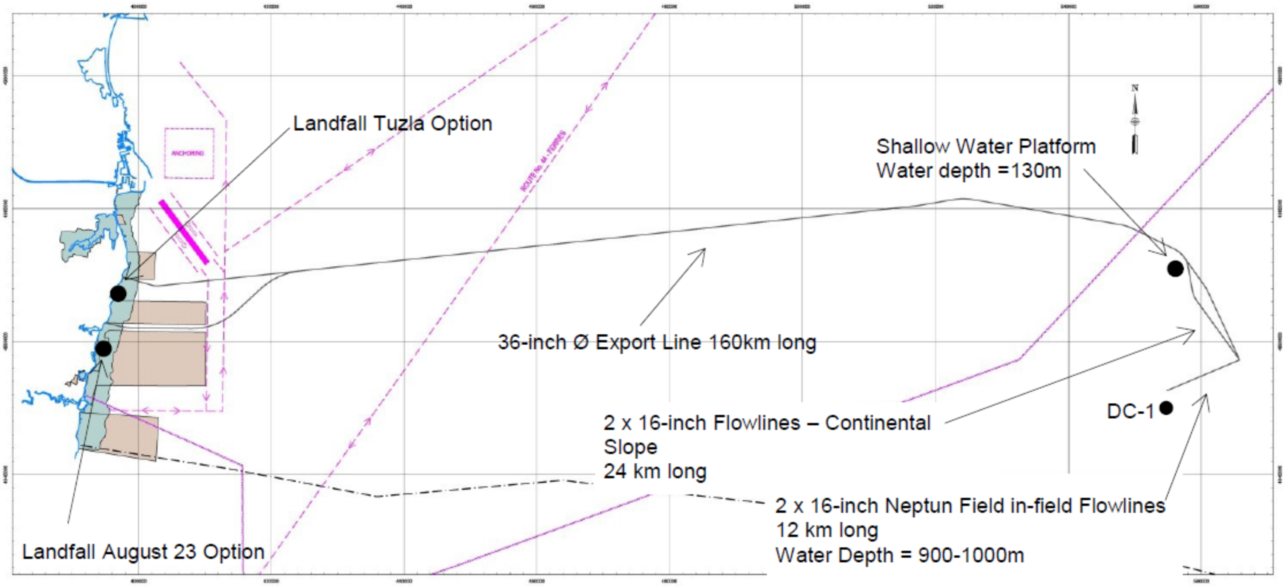

Figure 3. 1 Pre-FEED and Concept Select Phase

- Pre-FEED Follow-up Phase (up to Early 2017): As the field development plan matured, this resulted in a 30-inch production pipeline and FOC running from the SWP to shore. Based on the outcome of a geophysical survey, a route option sketch was developed to avoid areas of rough seabed whilst maintaining the survey centreline, where possible. The majority of the re-routing compared to the survey centreline occurs in the first 50 km from the SWP. This route was the start of the FEED optimisation work.

[1] INTECSEA, 2013-2014

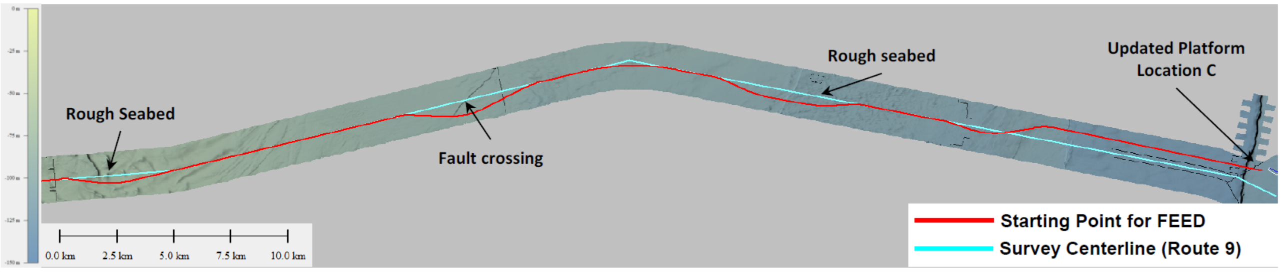

Figure 3. 2 Pre-FEED Follow-up Phase

- FEED Route Development: During FEED, the route was further assessed in terms of encountered geohazards and bottom roughness, and the optimised route deviated from the original route:
  - A different platform location.
  - Additional survey data conducted with a larger coverage available in the SWP area; this data was used as input for the pipeline route definition at the first fault crossing location near the platform.
  - Inclusion of the onshore pipeline route between tunnel entry point and tie-in location at NGMS.
  - A reduced number of Intersection Points (IP's), i.e., pipeline curvatures.
  - An optimised route alignment in areas where rough seabed terrain is encountered, mainly the first section where multiple faults are crossed and the section between KP 45 to 80, with rough seabed terrain; snapshots of the optimised route for these sections are presented below.

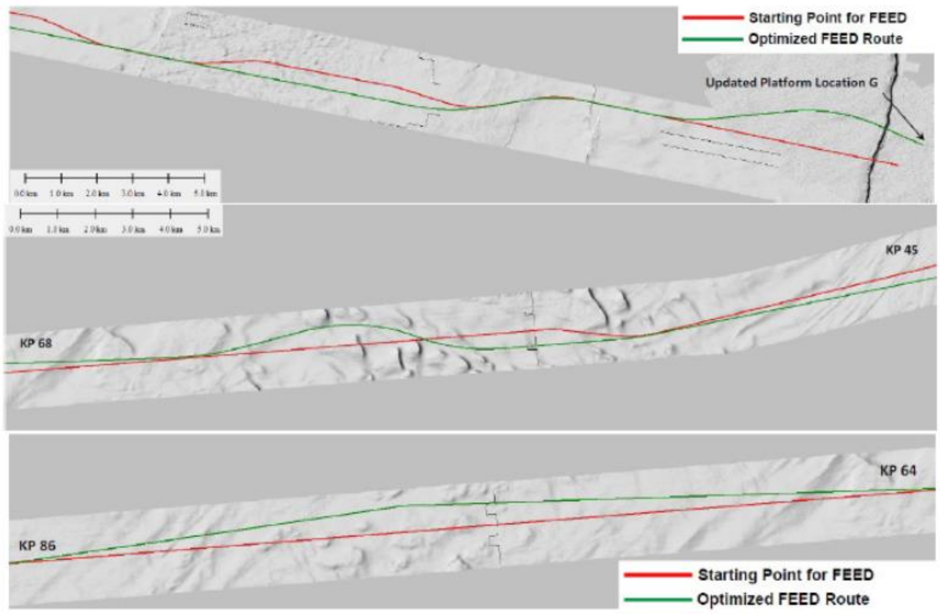

Figure 3. 3 FEED Route Development

The route of the FOC, running between the onshore CCR and the SWP, follows a similar route alignment as the GPP with an offset of 30 m along most of the offshore route. The offset is increased up to ~52 m when approaching the SWP to accommodate the respective tie-in locations. For the onshore and shore approach sections, the FOC is routed in close proximity to the pipeline as the FOC will be installed in the same trench and tunnel.

Based on the general criteria applicable to all pipeline routings being applied in the development of the final route and the level of assessment undertaken, the pipeline route is deemed the best fit when considering the general criteria and input data described above.

3.1.4 Description of onshore alternatives

3.1.4.1 The alternatives analyzed for the onshore location

The current development concept (offshore subsea equipment, offshore SWP and onshore NGMS connected by a GPP from offshore to shore) and process flow (natural gas production) through the Pelican South and Domino drilling centres, delivery of produced gas to the SWP facilities via separate flowlines from drilling centres, gas separation at the SWP, transportation of the processed natural gas from the SWP to the onshore NGMS site via GPP and delivery of sales gas to the Romanian NTS) have been applied to all studied options. This section evaluates the available options for shore approach and the onshore location.

The BAT evaluation included assessment of 4 potential sites located along the Black Sea coast from north to south:

Option 1: Site located within the administrative area of Tuzla locality. This site is mainly for agricultural use and is located between the National Road DN39 (located at ~ 1.8 km to the west of site limit) and Black Sea coast (located at ~ 60 m to the east of site limit). The site area is crossed by the railway line Constanta – Mangalia and local roads (e.g., communal road DC4). The site can be currently accessed by using the existing communal or local roads that are connected to the National Road DN39. Tuzla Airport is located to the northwest of the western limit of the site at ~ 2 km distance. The site has a mainly flat topography, with the highest elevation recorded on the western part of the site and slope inclination decreasing towards the east. No existent surface water body has been identified within the site limits. No onshore archaeological sites were identified within the site limits, as per archaeological investigations performed onsite. This site is adjacent to a protected area.

Option 2: Site located within the area of Cap Midia. The site is located within the Midia industrial area (Petromidia oil refinery, terminal) and has an intensive industrial use with the potential burden of historical pollution. A military base (''Unitatea Militara nr. 08153 Capu Midia – Tabara de Instructie si Poligon de Trageri Sol – Aer'') is present within the area and the potential risk of crossing the military base and field of fire has been considered. The site is also in close proximity to a natural protected area – Rezervatia Biosferei Delta Dunarii (UNESCO natural protected area).

Option 3: Site located within the administrative area of 23 August locality, close to the Black Sea front (East of site) and the land use is mainly agricultural. The railway line CF 800 Constanta -

Mangalia is located within the site proximity (250 m away from the sea front) and presents calcareous cavernous geological conditions. The sea front wall is exposed to natural erosion processes with no consolidation/ stabilisation works. The execution of onshore facilities (including pipeline corridor and shore crossing) can be impacted by the local soil and subsoil conditions and sea front erosion activating landslide processes in the sea front area. The geotechnical investigations performed on site revealed the presence of a calcareous rock layer impacted by an intensive karstification process due to the presence of Black Sea waters. This presents a safety construction risk that should be avoided, as per current safety construction guidelines.

Option 4: Site located within the administrative area of 2 Mai locality. The site area is located between 2 Mai and Vama Veche localities and the natural protected area ROSCI0269 ''Rezervația Marină 2 Mai – Vama Veche'' is located along the Black Sea coast. The construction/ installation works (e.g., shore crossing) fall within the natural protected area limits. The biodiversity and habitats presented inside the natural protected area may also be potentially significantly impacted by the works as undercrossing the protected area in its entire length is not possible. No existing access roads were identified within the investigated area.

The alternatives were assessed in terms of environmental criteria (e.g., site location, current site conditions, proximity to residential areas and natural protected areas, potential historical pollution, etc.) and potential impact generated by project construction and operation on environment and adjacent natural protected areas; socio-economic criteria (e.g., current development of the area, land use (agricultural or barren), access to the site, proximity to the transportation infrastructure); design criteria (complexity of technical solutions required to be implemented upon each potential site limitation/restriction); construction criteria (potential difficulties in execution due to the complexity of technical solutions required to be implemented on site, including the potential of using the latest shore crossing technologies (e.g., micro-tunnelling)); and operational criteria (facilitate operations and maintenance works). The alternatives were compared and ranked in order to select the preferred option in line with BAT requirements.

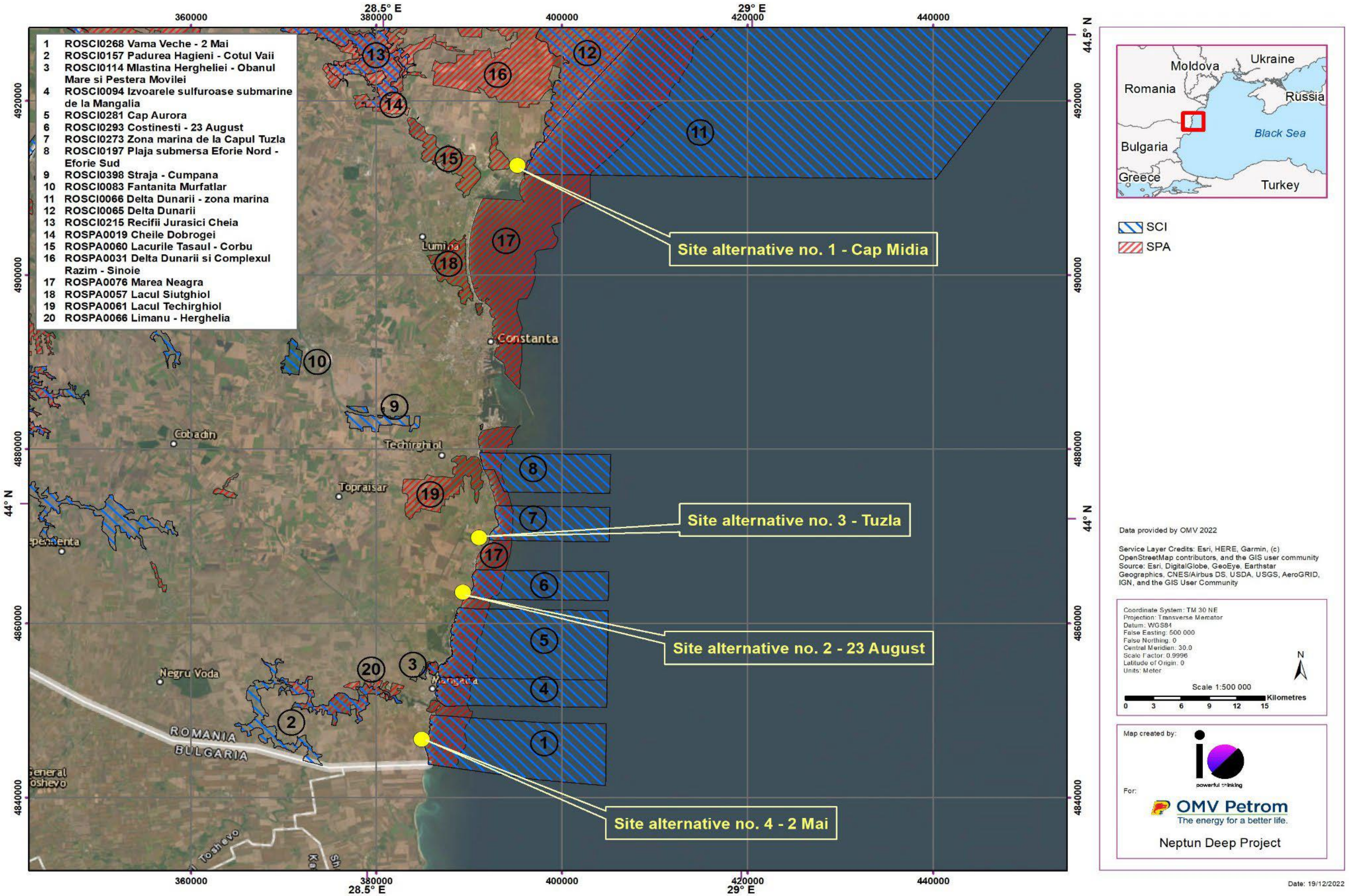

Figure 3. 4 General Location of the Studied Onshore Site Alternatives

3.1.4.2 Shore crossing

The alternatives for installing the pipeline at the shoreline crossing have been evaluated in the BAT assessment and include the following alternatives:

Option 1: Micro-tunnelling. This is a trenchless construction method in which a borehole is excavated, and pipes laid simultaneously using remote guidance, pipe jacking, and continuous support. This option initiates with an excavation of an offshore reception pit and pipe trench. The pit is backfilled with gravel and ballast material placed over the tunnel end to secure it against flotation. Tunnelling is then carried out until the Tunnel Boring Machine (TBM) reaches the reception pit and is considered fully constructed, with conduits pre-installed. The Micro-Tunnelling Boring Machine (MTBM) is operated from a control panel, normally located on the surface. Personnel entry is not required for routine operations. Micro-tunnelling requires minimal excavation as only a small entry and exit pit at each end of the pipeline needs to be excavated, and the ground between these points is left undisturbed. Operationally, it is highly accurate (+/-10mm) and offers greater pipeline integrity due to the straight or curved pit to pit design, reducing risk of fracture.

Option 2: Open Cut. In open cut pipeline installation, a trench is excavated for each length of pipe. The ground is cut to the depth of the pipeline with large volumes of soil excavated. Following installation, the dugout area is filled back up and the surface restored to its original condition as much as possible. Traditional open cut methods require a large amount of excavation as trenches need to be dug along the entire length of the pipeline route. Due to the amount of excavation that is required for open cut installations, mounds of spoil either need to sit at the site or be trucked out during works and trucked back in for backfilling. This results in a large amount of environmental disruption to flora and fauna and can be disruptive to the community.

Option 3: Horizontal Directional Drilling (HDD). HDD is a guided trenchless installation method involving the drilling of a pilot borehole along a designated bore path. The hole is then enlarged to the desired diameter during reaming phases and the preassembled pipeline is pulled into the borehole. A drilling fluid (slurry or bentonite suspension) is used to support the borehole and transport cuttings during the process. This method does not require excavation of entry/exit shafts, however sufficient storage must be available at the site for pipes and auxiliary equipment. HDD is best suited to clay-based soils, non-cohesive sand, and silt because of its ability to stay suspended in the drilling fluid. Bends can become weak points leading to increased risk in pipeline fracture. It is limited in gravelly soils with high permeability or fractured rock with large cavities as proper slurry circulation cannot be maintained. If slurry seeps into the surrounding formation, cuttings cannot be transported sufficiently and may lead to borehole collapse and environmental contamination. When used in shallow ground, HDD can cause ground movements such as heaving or collapse with loss of drilling fluid. The high degree of weathered rock and associated permeabilities in this area could impact this methods compatibility for the shore crossing. HDD has a moderate accuracy (+/-100mm) and a lower capex but requires regular maintenance to mitigate fractures at bends in the pipeline.

Option 4: Direct Pipe. This option combines HDD and micro-tunnelling to install pipelines in one run. The pipe is clamped and pushed by a pipe thruster from the launch pit and a TBM is mounted in front of the pipe head to drill and steer into the soil. This means the borehole is drilled at the same time as the pipeline is installed. Depending on soil conditions, the TBM can be equipped with cutting tools and unlike HDD, direct pipe allows for installation through hard and soft rock, unstable soil, and large boulders as there is no need for borehole wall support. A slurry circuit is installed in the pipe to transport the excavated material to the surface. The direct pipe machine is controlled by an operator on the surface and is constantly monitored to keep it in the design line and grade. The trailing end of the direct pipe machine has a lubrication ring to transition between the machine and pipe. As for micro-tunnelling, the larger tunnel diameter of 2m is recommended due to the repeat bentonite injections. This option offers some advantages including (i) it is unlikely to cause ground instabilities as tunnel is always supported by the MTBM, (ii) it may be faster than HDD & micro-tunnelling (no time wasted in coupling pipes or drilling rods),(iii) has high accuracy and used in various ground types and (iv) it could be cheaper in areas where hydraulic fracture is prohibited or coarse gravel. The disadvantages include (i) risk of prolonged mechanical failure during drilling where P/L could adhere to the side of its tunnel and (ii) the method is more expensive than HDD and makes it prohibitive.

Option 5: Pipe Ramming. Pipe ramming is a trenchless option of pipe installation that drives a pipe through the ground with a percussive hammer. The hammer is attached to an open-ended casing and the spoil within the casing is removed when the casing is fully driven into place. This option can also be used to dislodge the pipe should it become stuck during an HDD process and can be used in a variety of soil conditions, although tends to be more time-consuming in harder soil conditions. The main disadvantage of pipe ramming is the lack of precision.

Option 6: Auger Boring. Auger boring involves a casing pipe being jacked into the ground while rotating helical augers remove the excavated soil. A cutting edge is attached to the auger within the casing pipe and hydraulic jacks used to rotate and penetrate the soil. The technique initiates from a launch pit which must be sized to accommodate safe auger boring machine operation and a usable length of pipe. Typical auger boring machines are designed for casing pipes that range from 102 mm to 2,830 mm in diameter and distances of ~200 m. The required installation length for the Neptun Deep shore crossing is 890 m with a 762 mm P/L dia., which is outside of the auger bore range.

The options were assessed in terms of environmental performance (discharges to sea, emissions to air/GHG), technical applicability (e.g., reliability, operability, and maintainability), and financial criteria (capital and operating expenditures). The technical alternatives were compared and ranked to select the preferred option in line with BAT requirements.

3.1.4.3 Gas Heating

A gas heater is required between the NGMS Filter Separator and the NGMS gas metering skid, to heat the incoming cold gas from the offshore production pipeline to meet the NTS minimum entry specifications of 0°C.

Three heaters are required, in a 3 x 33% process configuration with a design duty of around 6 MW.

The BAT evaluation included assessment of the following gas heating options:

Option 1: Electric Heater. An electric heater is a device that generates heat using electricity instead of natural gas or other fuels. These heaters are commonly used in industrial applications and work by passing an electric current through a resistive element, such as a metal wire or ceramic plate. Many types of industrial heaters exist, including circulation heaters, and/ or immersion heaters. For the Neptun Deep Project NGMS onshore application, a Chromalox circulation type electrical heater was considered, which is designed to heat a flowing gas or liquid using in-line or side-arm piping configuration.

Option 2: Gas Fired Heater. A fired heater is a device that uses natural gas as fuel to generate heat. For the NGMS onshore application, a Sigma Thermal convection-style direct fired heater has been proposed. Radiant heat transfer is minimised in this type of heater by recirculating large volumes of flue gas to mix with newly combusted gases, resulting in a mixed gas temperature of approximately 1,400 °F entering the coil section. Compared to radiant heat transfer, convection heat transfer gives more even and predictable heat distribution over the heat transfer coil surface. Using a convection-style heater eliminates problems with hot spots commonly found in radiant tube sections, which ultimately results in a longer tube life and lower likelihood of local tube failures. As an added benefit, this convection-style heater offers a hot stand-by mode of operation. During periods when the process medium is not flowing, the heater has the ability to maintain a nominal combustion chamber temperature up to ~550 °F. This mode of operation minimises the startup time at the beginning of every regeneration cycle.

Each selected technology has been assessed for its environmental impact, feasibility (the option satisfies all defined constraints and requirements to enable a solution to go ahead), operational complexity (this criterion leads to increased) facility complexity (addresses increase in equipment, which ultimately causes increase in platform size and weight as well as likelihood of switching from normally unattended installation to manned facility), robustness/ reliability (level of robustness: the ability of the equipment to withstand harsh conditions, such as cold weather climate, shutdown, and restart, level of flexibility: easy to adapt to highly varying water quantity and quality) and Capex/Opex (reported treatment, a high-level capital, operation, and maintenance costs). The technical alternatives were compared and ranked in order to select the preferred option in line with the BAT requirements.

3.2 EVALUATION OF THE ALTERNATIVES

3.2.1 Evaluation of the Alternatives for Offshore

3.2.1.1 Evaluation of Alternatives for Power Generation on the Offshore Production Platform

Each selected technology has been evaluated in terms of its environmental impact, feasibility (whether the alternative meets all defined constraints and requirements to allow for a viable solution), operational complexity (this criterion leads to increased facility complexity, including equipment growth, ultimately resulting in increased platform size and weight, and the possibility of transitioning from an unmanned facility to a manned one), robustness/reliability (level of robustness: equipment's ability to withstand harsh conditions such as cold weather, shutdown, and restart; level of flexibility: ease of adapting to significant variations in water quantity and quality), and capital and operating costs (overall capital, operational, and maintenance costs). Technical alternatives have been compared and ranked to select the Preferred Alternative in accordance with Best Available Techniques (BAT) requirements.

The independent BAT assessment has concluded that Alternative 1 (Electricity generation using gas turbine generators (GTG).) for power generation represents the Best Available Techniques specific to the Neptun Deep Project.

3.2.1.2 Evaluation of alternatives for Gas Dispersion and Flaring System

The independent assessment of BAT concluded that Alternative 1 (Burning both continuous and intermittent emissions on a single tall support arm) represents the Best Available Techniques (BAT) specific to the Neptun Deep Project..

3.2.1.3 Evaluation of alternatives regarding chemical storage

Based on the conclusions of the independent BAT (Best Available Techniques) assessment, Alternative 1 (storing methanol and TEG in the platform support legs and storing other chemicals on the deck) is considered the BAT specific to the project for chemical substances storage at SWP.

3.2.1.4 Evaluation of open drain system alternatives

Based on the conclusions of the independent BAT evaluation, Alternative 1 (storing methanol and TEG in the platform's support legs and storing other chemicals on the deck) is considered the BAT specific to the project for chemical storage at SWP (Subsea Wellhead Platform).

3.2.1.5 Evaluation of alternatives for Hydrate Management

The independent BAT assessment concluded that Alternative 1 (Direct Electric Heating - DEH) represents the Best Available Techniques specific to the Neptun Deep Project.

3.2.1.6 Selection of chemical products used

Following the modeling of the wastewater (PW) discharge and considering that selecting a single supplier of chemical products is desired from a commercial and operational perspective, the following ChampionX chemical products were chosen:

- Scale inhibitor: ChampionX SCAL 13370A;
- Corrosion inhibitor: ChampionX CORR 12452A;
- Antifoam : Champion X AFMR20400A.

3.2.1.7 Discharge of PW

The independent evaluation of BAT concluded that Alternative 1 (discharge at 90 m depth) for the disposal of wastewater (PW) is the specific BAT for the Neptun Deep Project.

3.2.1.8 Evaluation of alternatives for the discharge of water from hydrostatic testing

Applying the BAT methodology, Alternative 1 (discharge into the anoxic zone of the Black Sea) for hydrostatic testing water is the Best Available Technique (BAT) specific to the Neptun Deep Project.

3.2.1.9 Subsea valves

Based on the conclusions of the BAT evaluation, Alternative 1 (Hydraulic Open Circuit) is considered BAT specific to the project for operating subsea valves.

3.2.2 The alternatives analyzed for the onshore location

3.2.2.1 Alternatives analyzed for the onshore location

Alternative 1 (the current project site located in Tuzla) is considered the BAT (Best Available Technique) specific to the project for the best onshore construction and installation site and for the shore crossing with microtunnel in terms of environmental protection (including protected natural areas, seaside, and beach) and construction and operation safety.

3.2.2.2 Evaluating the alternatives for shore crossing methods

Based on the conclusions of the BAT evaluation, Alternative 1 (microtunneling) is considered the BAT specific to the project for installing the pipeline at the shore crossing.

3.2.2.3 Evaluating the alternatives for the gas heating system

The independent BAT evaluation concluded that Alternative 1 (Electric Heater) for gas heating at NGMS is the Best Available Technique specific to the Neptun Deep Project.

Table 3.2 Analysis of alternatives for the electricity generation system on the platform from an environmental impact perspective

Environmental aspect	**Option 0**	**Option 1** ***Gas Turbine Generator SELECTED OPTION***	**Option 2** ***Generators with internal combustion engines***	**Option 3** ***Shore-based power supply***	**Observation**
Population	Without impact	Without impact	Without impact	Without impact	
Human Health	Without impact	Without impact	Without impact	Without impact	
Biodiversity	Without impact	Without impact	Without impact	The installation of the cable at sea will lead to increased turbidity, and there will also be underwater noise from trenching activities. These factors can lead to the disturbance of marine biodiversity.	
Lands	Without impact	Without impact	Without impact	Without impact	
Soil	Without impact	Without impact	Without impact	Without impact	
Water	Without impact	Without impact	Without impact	The installation of the cable at sea will lead to an increase in turbidity, but this will be localized and occur during the execution of the work.	
Air	Without impact	Air emissions from gas combustion	Air emissions from gas combustion	Without impact	Alternative 1 and 2 will have an impact on the air during operation.
Climate	Without impact	There are greenhouse gas emissions	There are greenhouse gas emissions	Indirect GHG emissions	Alternative 1 and 2 will have an impact on the climate during operation.
Material goods	Without impact	Without impact	Without impact	Without impact	
Cultural heritage	Without impact	Without impact	Without impact	Without impact	
Landscape	Without impact	Without impact	Without impact	Without impact (the cable will be underground)	
Transboundary impact	Without impact	Without impact	Without impact	Without impact	
Infrastructure	Without impact	Without impact	Without impact	Without impact	

Table 3.3 Analysis of alternatives for the flaring and venting on the platform from an environmental impact perspective

Environmental aspect	Option 0	Option 1 *LP and HP Flare System located on a single support arm SELECTED OPTION*	Option 2 *LP Flare and HP Emission Dispersal System located on 2 support arms*	Option 3 *LP/HP Emission Dispersal System located on a single support arm*	Option 4 Continuous LP Emission Recovery, Flare for Intermittent HP Emissions	Option 5 Continuous LP Emission Recovery, Flare for Intermittent HP Emissions	Observations
Population	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Human Health	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Biodiversity	Without impact	The presence of the flare may cause discomfort to aquatic birds.	The presence of the flare boom can cause discomfort to aquatic birds.	The presence of the venting stack can cause discomfort to aquatic birds.	Without impact	Without impact.	
Lands	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Soil	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Water	Without impact	Generating process water from the liquid separator vessel of the flares, which is discharged into the sea through the discharge riser.	Generating process water from the liquid separator vessel of the flare, which is discharged into the sea through the discharge riser.	Without impact	Generating process water from the liquid separator vessel of the flare, which is discharged into the sea through the discharge riser.	Generating process water from the liquid separator vessel of the flare, which is discharged into the sea through the discharge riser.	
Air	Without impact	Polluant emissions from burning the gas	Polluant emissions from burning the gas	Directly evacuates gases into the atmosphere.	Gas recovery requires additional equipment and therefore occupies space on the platform deck. There are	Gas recovery requires additional equipment and consequently occupies space on	

Environmental aspect	Option 0	Option 1 *LP and HP Flare System located on a single support arm SELECTED OPTION*	Option 2 *LP Flare and HP Emission Dispersal System located on 2 support arms*	Option 3 *LP/HP Emission Dispersal System located on a single support arm*	Option 4 Continuous LP Emission Recovery, Flare for Intermittent HP Emissions	Option 5 Continuous LP Emission Recovery, Flare for Intermittent HP Emissions	Observations
					emissions from gas combustion.	the platform deck. There are emissions from gas combustion.	
Climate	Without impact	GHG emissions from gas combustion	There are greenhouse gas emissions from the burning of gases, including CH4 emissions.	Direct release of CH4 into the air is a greenhouse gas emission (GES) since CH4 is a potent greenhouse gas.	There are greenhouse gas emissions (GHG) from burning gases.	There are greenhouse gas emissions from burning gases.	
Material goods	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Cultural heritage	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Landscape	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Transboundary impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Infrastructure	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	

Table 3.4 Analysis of alternatives for chemical storage on the platform in terms of environmental impacts

Environmental aspect	Option 0	Option 1 *Storage in the legs of the jacket SELECTED OPTION*	Option 2 *Storage on the platform deck*	Option 3 *Suspended tank storage*	Option 4 *Subsea suspended tank storage*	Option 5 *Subsea storage*	Option 6 *Onshore storage and umbilical system*	Observations
Population	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Human Health	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Biodiversity	Without impact	Without impact	Without impact	Without impact	Without impact	The installation of the tanks offshore will lead to increased underwater noise, which can disturb marine biodiversity.	The installation of the umbilical system offshore will lead to increased turbidity and underwater noise from trenching activities, which can disturb marine biodiversity.	
Lands	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Soil	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Water	Without impact	Without impact	Without impact	Without impact	Without impact	Accidental chemical spills can lead to the pollution of seawater.	The installation of the umbilical system at sea will lead to an increase in turbidity.	
Air	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	

Environmental aspect	Option 0	Option 1 *Storage in the legs of the jacket SELECTED OPTION*	Option 2 *Storage on the platform deck*	Option 3 *Suspended tank storage*	Option 4 *Subsea suspended tank storage*	Option 5 *Subsea storage*	Option 6 *Onshore storage and umbilical system*	Observations
Climate	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Material good	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Cultural Heritage	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Landscape	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Transboundary impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Infrastructure	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	

Tabel 3. 5 Analysis of alternatives regarding the management of water from the open drainage system from an environmental perspective

Environmental aspect	Option 0	Option 1 *Storage in tanks and transportation to the shore. SELECTED OPTION*	Option 2 *Storage in a tank equipped with hydrocarbon separator and discharge into the sea*	Option 3 Storage of effluents on the platform, analysis, and discharge into the sea (<15 ppm) or transportation to the shore (>15 ppm)	Observations
Population	Without impact	Without impact	Without impact	Without impact	
Human Health	Without impact	Without impact	Without impact	Without impact	
Biodiversity	Without impact	Without impact	Without impact	Without impact	
Lands	Without impact	Without impact	Without impact	Without impact	
Soil	Without impact	Without impact	Without impact	Without impact	
Water	Without impact	Accidental discharges of wastewater from the reservoir can occur in the sea.	Without impact	Without impact	

Environmental aspect	Option 0	Option 1 *Storage in tanks and transportation to the shore. SELECTED OPTION*	Option 2 *Storage in a tank equipped with hydrocarbon separator and discharge into the sea*	Option 3 Storage of effluents on the platform, analysis, and discharge into the sea (<15 ppm) or transportation to the shore (>15 ppm)	Observations
Air	Without impact	Emissions in the air from maritime transportation.	Emissions in the air from maritime transportation.	Emissions in the air from maritime transportation.	
Climate	Without impact	There are greenhouse gas emissions.	There are greenhouse gas emissions.	There are greenhouse gas emissions.	
Material goods	Without impact	Without impact	Without impact	Without impact	
Cultural Heritage	Without impact	Without impact	Without impact	Without impact	
Landscape	Without impact	Without impact	Without impact	Without impact	
Transboundary impact	Without impact	Without impact	Without impact	Without impact	
Infrastructure	Without impact	Without impact	Without impact	Without impact	

Table 3.6 Analysis of alternatives regarding water discharge from an environmental perspective

Environmental aspect	Option 0	Option 1 *Discharge through a 90m deep outfall into the sea. SELECTED OPTION*	Option 2 *Discharge through a pipeline into the sea*	Option 3 *Injection into a new well formation*	Option 4 Injection into an existing well formation	Option 5 Transportation to the shore	Observations
Population	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Human Health	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Biodiversity	Without impact	Effects on marine biodiversity.	Effects on marine biodiversity.	Without impact	Without impact	Without impact	
Lands	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Soil	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Water	Without impact	Modify water quality indicators.	Modify water quality indicators.	Without impact	Without impact	Without impact	

Environmental aspect	Option 0	Option 1 *Discharge through a 90m deep outfall into the sea. SELECTED OPTION*	Option 2 *Discharge through a pipeline into the sea*	Option 3 *Injection into a new well formation*	Option 4 Injection into an existing well formation	Option 5 Transportation to the shore	Observations
Air	Without impact	Without impact	Without impact	Without impact	Without impact	Emissions from maritime transportation.	
Climate	Without impact	Without impact	Without impact	Without impact	Without impact	Emissions from maritime transportation.	
Material goods	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Cultural Heritage	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Landscape	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Transboundary impact	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	
Infrastructure	Without impact	Without impact	Without impact	Without impact	Without impact	Without impact	

Table 3.7 Analysis of alternatives for onshore component placement from an environmental perspective

Environmental aspect	Option 0	Option 1 *Cap Midia Zone*	Option 2 *23 August Zone*	Option 3 *Tuzla Zone SELECTED OPTION*	Option 4 *2 Mai Zone*	Observations
Population	Without impact	During construction, there will be discomfort due to increased traffic, which will hinder access to agricultural land.	During construction, there will be discomfort due to increased traffic, which will hinder access to the land and the beach.	During the construction phase, there will be discomfort due to increased traffic, which will hinder access to the land and the beach. However, during the operational period, there will be an access road to the beach. There	During the construction phase, there will be some inconvenience due to increased traffic, which may hinder access to the land and the beach.	Minimal discomfort during the implementation stage - all alternatives.

Environmental aspect	Option 0	Option 1 *Cap Midia Zone*	Option 2 *23 August Zone*	Option 3 *Tuzla Zone* ***SELECTED OPTION***	Option 4 *2 Mai Zone*	Observations
				will be no construction restrictions due to the location of the production pipeline, as the safety restriction limit of 20 meters, imposed by the current regulations, falls entirely within the project owner's property. To reduce the visual impact during operation, a row of trees will be planted around the NGMS and CCR.		
Human health	Without impact	During the construction period, there may be potential discomfort due to vehicle traffic and noise from the equipment used.				Minimum discomfort during the implementation phase - all alternatives.
Biodiversity	Without impact	The location is situated near a protected natural area - the Danube Delta Biosphere Reserve (UNESCO protected natural area).	The analyzed location is situated in the vicinity of the ROSPA 0076 Black Sea Protected Area.	The nearest protected natural areas are represented by ROSPA0076 Black Sea and ROSCI0273 Marine Area at Capul Tuzla, located approximately 60 meters east from the eastern edge of the site. During the construction of the microtunnel, the protected area will be affected due to the use	The special area of conservation "Rezervația marină 2 Mai - Vama Veche" occupies the entire coastline between the localities of 2 Mai and Vama Veche. The works will be carried out within the boundaries of the protected area, and significant negative effects on biodiversity	Alternative 4 has been rejected due to constraints related to the protected area.

Environmental aspect	Option 0	Option 1 *Cap Midia Zone*	Option 2 *23 August Zone*	Option 3 *Tuzla Zone* *SELECTED OPTION*	Option 4 *2 Mai Zone*	Observations
				of anchors for stabilizing the pipeline installation barge. The area surrounding the site is mainly used for agricultural purposes and is located within the administrative boundaries of Tuzla commune. The site is situated between the National Road DN39 (located approximately 1.8 km west of the site boundary) and the Black Sea coast (located approximately 60 meters east from the site boundary).	and habitats present in the area are possible.	
Lands	Without impact	The land use category will be changed, and permanent areas will be occupied.	The site is located in the administrative area of 23 August, near the Black Sea shore (located to the east of the site). The land use is primarily agricultural.	The nearest protected natural areas are represented by ROSPA0076 Black Sea and ROSCI0273 Marine Area at Capul Tuzla, located approximately 60 meters east from the eastern edge of the site. During the construction of the microtunnel, the protected area will be affected due to the use	The site is located between the localities of 2 Mai and Vama Veche.	ll the alternatives will change the land use category and permanently occupy surface areas.

Environmental aspect	Option 0	Option 1 *Cap Midia Zone*	Option 2 *23 August Zone*	Option 3 *Tuzla Zone* ***SELECTED OPTION***	Option 4 *2 Mai Zone*	Observations
				of anchors for stabilizing the pipeline installation barge. The area surrounding the site is mainly used for agricultural purposes and is located within the administrative boundaries of Tuzla commune. The site is situated between the National Road DN39 (located approximately 1.8 km west of the site boundary) and the Black Sea coast (located approximately 60 meters east from the site boundary).		
Soil	Without impact	Potential historical pollution of the site due to its proximity to the Rompetrol refinery.	The coastline at the seaside is exposed to natural erosion processes, without any consolidation/stabilization works. Geotechnical investigations carried out on the site revealed the presence of a limestone layer affected by intense karstification due to the presence of the Black Sea waters. The execution of	The soil and subsurface conditions of the selected site are more favorable for the execution of the pipeline corridor and shore crossing.	The shore crossing works will be carried out in the coastal area between the two localities, as there is no corridor available for the pipeline to cross onshore due to the marine reserve.	Due to safety constraints of the construction, alternative 2 for the location has been rejected. Due to potential historical soil contamination, alternative 1 has been rejected.

Environmental aspect	Option 0	Option 1 *Cap Midia Zone*	Option 2 *23 August Zone*	Option 3 *Tuzla Zone* *SELECTED OPTION*	Option 4 *2 Mai Zone*	Observations
			shore crossing works may trigger landslides in the coastal cliff area (unprotected).			
Water	Without impact	There will be no direct effects on the water. In the regulation and measurement station, no gases will be treated, so no produced water will be generated.				The project does not influence the quality of surface water and groundwater.
Air	Without impact	During construction, traffic, soil excavation, and the operation of equipment represent the main sources of air emissions. During the operational phase, emissions will result from traffic and maintenance activities. The noise generated during construction will be temporary and will occur only during the operation of vehicles and equipment. It will be locally perceived.				All alternatives will have an impact on the air during construction.
Climate	Without impact	The main source of greenhouse gas emissions during the construction period is represented by the traffic of vehicles that supply construction materials and the use of equipment for construction purposes. During the operational phase, there will be minor greenhouse gas emissions.				All alternatives will have an impact on the climate during construction.
Material goods	Without impact	During the construction phase, it is necessary to carry out sub-crossings of pipelines, railways, and local roads.				In all alternatives, sub-crossings will be required.
Cultural Heritage	Without impact	Without impact	Without impact	According to the archaeological investigations carried out on the site, no archaeological remains have been identified within the boundaries of this location.	Without impact	The project does not impact the cultural heritage.
Landscape	Without impact	Visual impact	Visual impact	Visual impact	Visual impact	All the alternatives will bring modifications to the landscape.
Transboundary Impact	Without impact	The project cannot have a cross-border impact.				The project does not have a cross-border impact.

Environmental aspect	Option 0	Option 1 *Cap Midia Zone*	Option 2 *23 August Zone*	Option 3 *Tuzla Zone* *SELECTED OPTION*	Option 4 *2 Mai Zone*	Observations
Infrastructure	Without impact	Construction and arrangement of access roads will require the occupation of larger land areas. Local suppliers will be engaged to provide utilities. Difficult access to the National Gas Transport System.	Construction and arrangement of access roads will require the occupation of larger land areas. Local suppliers will be engaged to provide utilities. Easy access to the National Gas Transport System.	Construction and arrangement of access roads will require the occupation of larger land areas. Local suppliers will be engaged to provide utilities. Easy access to the National Gas Transport System.	Access roads need to be arranged. In the investigated area, there are no existing access roads to facilitate the transportation of materials and equipment to the proposed site.	Access roads will need to be arranged for all alternatives.
Other activities in the zone	Without impact	The area includes a military unit and is situated in the industrial zone of Midia (Petromidia oil refinery, terminal).	The CF 800 Constanța - Mangalia railway line is in close proximity to the site, located at a distance of 250 meters from the seashore.	Agricultural activities.	-	Due to the presence of this protected area and other limitations (e.g., potential historical soil pollution, the presence of a military base in the area), this alternative site 1 has been rejected.

3.2.2 The evaluation of technological alternatives

The subsea crossing of the 30-inch production pipeline of the Neptun Deep Project (and Fibre Optic Cable) will be constructed over a length of 890 meters to the launch pit in the onshore area.

Following the evaluation of technological alternatives for the execution of the subsea crossing, alternative 1 (microtunneling) was selected as the best alternative for the shoreline crossing. Alternatives 1 and 2 (direct pipe) have the same environmental effects.

The choice of alternative took into consideration the safety criterion of the workers. Demolition of the bentonite injection pipes requires workers to enter the pipeline along the entire length of the crossing (890 meters) for potential tunnel machine or pump repairs. The tunnel created by the direct pipe technology has a diameter of 56 inches (1.6 meters), while the microtunnel has an interior diameter of 2 meters. For safety reasons related to worker access in the tunnel, the microtunnel alternative was chosen.

Table 3.8 Analysis of alternatives for shoreline subsea crossing from an environmental perspective

Environmental aspect	Option 0	Option 3 *Microtunel* *SELECTED OPTION*	Option 4 *Direct pipe*	Observations
Population	Without impact	During the construction phase, there will be some discomfort due to increased traffic, which may hinder access to the lands and the beach because of the construction site organization. However, during the operation phase, there will be a designated access road to the beach. There will be no construction restrictions because the production pipeline's safety restriction limit of 20 meters, mandated by the current regulations, entirely falls within the project owner's property.	During the construction phase, there will be some discomfort due to increased traffic, which may hinder access to the lands and the beach because of the construction site organization. However, there will be no construction restrictions due to the location of the production pipeline. The safety restriction limit of 20 meters, mandated by the current regulations, falls entirely within the project owner's property.	Minimal discomfort during the implementation phase - all alternatives.
Human health	Without impact	During the construction period, there may be potential discomfort due to vehicle traffic and noise from the equipment and vessels used.		Minimal discomfort during the implementation phase - all alternatives.

Environmental aspect	Option 0	Option 3 *Microtunel* ***SELECTED OPTION***	Option 4 *Direct pipe*	Observations
Biodiversity	Without impact	The receiving station and transition pit are located at sea near the protected area ROSCI0273 Marine Area at Capul Tuzla. During the installation of the pipeline from onshore to the sea, 3 out of the 8 anchors of the used barge will be fixed on the seabed in the protected area, which may have an impact on the sediments. The noise produced during excavation may have effects on marine fauna.	The receiving station and transition pit are located at sea in the vicinity of the protected area ROSCI0273 Marine Area at Capul Tuzla. The noise generated during excavation may have effects on marine fauna.	All alternatives will have an impact on biodiversity.
Lands	Without impact	The site is primarily used for agricultural purposes and is located within the administrative boundaries of Tuzla commune. The location is situated between National Road DN39 (approximately 1.8 km west of the site boundary) and the Black Sea coast (approximately 60 m east from the site boundary).	The site is primarily used for agricultural purposes and is located within the administrative boundaries of Tuzla commune. The location is situated between National Road DN39 (approximately 1.8 km west of the site boundary) and the Black Sea coast (approximately 60 m east of the site boundary).	All the alternatives will change the land use category and permanently occupy land surfaces.
Soil	Without impact	The soil and subsurface conditions of the selected site are more favorable for conducting the subshore crossing. However, during the installation of the pipeline from the shore to the sea, 3 out of the 8 anchors used for the barge will be fixed on the seabed in the area of the	The soil and subsurface conditions of the selected site are more favorable for conducting the subshore crossing.	Due to safety constraints of the construction, alternatives **1** and **2** have been rejected.

Environmental aspect	Option 0	Option 3 *Microtunel* ***SELECTED OPTION***	Option 4 *Direct pipe*	Observations
		protected zone, and they will have an effect on the sediments.		
Water	Without impact	The local turbidity will increase in the area where the excavation for the reception pit and transition trench will be carried out. In accidental situations, there is a potential for accidental hydrocarbon pollution from the equipment or vessels involved in the construction process.	The local turbidity will increase in the area where the excavation for the reception pit will be carried out. In accidental situations, there is a potential for accidental hydrocarbon pollution from the equipment or vessels involved in the construction process.	All the alternatives will have an impact on the water during the construction period.
Air	Without impact	During construction, traffic, soil excavation, and the operation of machinery are the main sources of air emissions. The noise generated during the construction period will be temporary, occurring only during the operation of the equipment. It will be locally felt.		All alternatives will have an impact on the air during construction.
Climate	Without impact	The main source of greenhouse gas emissions during the execution period is represented by the ships and equipment used in the construction.		All alternatives will have an impact on the climate during construction.
Material goods	Without impact	Without impact		All variants do not influence the material goods.
Cultural Heritage	Without impact	Without impact	Without impact	All variants do not influence the cultural heritage.
Landscape	Without impact	Visual impact due to the presence of construction equipment.	Visual impact through the presence of construction equipment	All options will bring visual impact changes only during construction.
Transboundary Impact	Without impact			The project does not have a cross-border impact.
Infrastructure	Without impact	Without impact	Without impact	All options do not influence the infrastructure.