PROJECT:

EastMed Pipeline Project

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Abbreviations

Abbreviation	Description
3LPP	Three-Layer-Polypropylene
A&R	Abandonment and Recovery
ASME	American Society of Mechanical Engineers
API	American Petroleum Institute
AUV	Autonomous Underwater Vehicles
AW	Atlantic Water
BAT	Best Available Techniques
BEP	Best Environmental Practices
BSCM	Billion Square Cubic Meter
BSW	Black Sea Water
BVS	Block Valve Station
CAPEX	Capital expenditure
CCS1	Cross-country Section from LF3 in Lakonia to LF4 at the southern coast of the Gulf of Patras
CCS1a	Cross-country Section from LF3 in Lakonia to Compressor station CS3 in Achaia
CSS1b	Cross-country Section from Compressor station CS3 in Achaia to LF4 at the southern coast of the Gulf of Patras
CCS2	Cross-country Section from LF5 in Akarnania to Florovouni in Thesprotia
CDW	Cretan Deep Water
CEF	Connecting Europe Facility
CLC	Corine Land Cover
CS	Compressor Station
CS3	Compressor Station in Achaia
CS1/MS1	Compressor and metering station in Cyprus
CS2/MS2	Compressor and metering station in Crete
CS2/MS2 N	Compressor and metering station in Crete (Northern)
CWC	Concrete Weight Coating
DER	Digital Environmental Register
DIN	Deutches Institut Fur Normung E.V. (German National Standard)
DIPA	Directorate of Environmental Licensing

Abbreviation	Description
DMS	Detailed Marine Survey
DP	Design pressure
DTM	Digital Terrain Model
DYPO	Directorate of Infrastructure and Environmental Protection
EastMed	Eastern Mediterranean
EAK	Emergency Key Access
EBRD	European Bank for Reconstruction and Development
EC	European Commission
ECC	European Economic Community
ECP	EastMed Compression Platform
EN	European Norm
ERM	Environmental Resource Management
ESD	Emergency Shutdown System
ESDA	National Waste Management Plan
ESEK	Greek National Plan for Energy and Climate
ESIA	Environmental and Social Impact Assessment
EU	European Union
FEED	Front End Engineering Design
FBE	Fusion Bonded Epoxy
FMECA	Failure Mode, Effects and Criticality Analysis
FOC	Fiber Optic Cable
GEETHA	General Staff of National Defence
GG	Government Gazette
GIS	Geographic Information System
GPXSAA	General Framework for Spatial Planning and Sustainable Development
GVA	Gross Value Added
HDD	Horizontal Directional Drilling
HHRM	Hellenic Hydrocarbon Resources Management
HIPPS	High Integrity Pressure Protection System
HNHS	Hellenic Navy Hydrographic Service

Abbreviation	Description
HSE	Health, Safety and Environment
HSS	Heat Shrink Sleeves
ICCP	Impressed current cathodic protection
ICE	Institution of Civil Engineers
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IPPC	Integrated Pollution Prevention and Control (EU Directive)
ISO	International Organization for Standardization
ITA	Inline Tee Assembly
JMD	Joint Ministerial Decision
LF	Landfall: the nearshore and coastal section of the offshore pipeline towards the coast, starting from the water depth of 25 m
LF1	Landfall in Cyprus
LF2	Landfall in Crete
LF3	Landfall in southern Peloponnese
LF4	Landfall at the southern coast of the Gulf of Patras
LF5	Landfall at the north coast of the Gulf of Patras.
LAT	Lowest Astronomical Tide
LIV	Levantine Intermediate Water
LS	Landfall station: a small valve station, onshore, close to the landfall site (beaching station).
LS01	Landfall station in Cyprus
LS01N	Landfall station in Cyprus (Northern line)
LS02/LS02N	Landfall station in Crete
LS03	Landfall station in southern Peloponnese
LS04	Landfall station at the southern coast of the Gulf of Patras
LS05	Landfall station at the north coast of the Gulf of Patras.
MARPOL	International Convention for the Prevention of Pollution from Ships
MBES	Multi Beam Echo Sounder
MCDA	Multi-criteria Decision Analysis
MD	Ministerial Decision

Abbreviation	Description
MEG	Monoethylene glycol
MOP	Maximum operating pressure
MSL	Mean Sea Level
MS	Metering Station
MS1a/PRS	Metering station and Pressure reduction station in Cyprus
MS4/PRS4	Metering station and Pressure reduction station in Greece
MSP	Marine Spatial Planning
NASA	National Aeronautics and Space Administration
NG	Natural Gas
NW	North-Western
O&G	Oil and Gas
O&M	Operation and Maintenance
OHW	Ordinary High Water
OPEX	Operating Expense
OSPAR	Oslo-Paris
OSS1	Offshore trunkline section from ECP to sub-sea Tie-in point in Cypriot waters
OSS1a	Offshore pipeline section from sub-sea Tie-in point in Cypriot waters to LF1
OSS1b	Offshore trunkline section from Cypriot offshore gas field to Cyprus
OSS2/OSS2N	Offshore trunkline section from Cyprus to Crete
OSS3/OSS3N	Offshore trunkline section from Crete to a landfall in Peloponnese
OSS4	Offshore trunkline section crossing the Gulf of Patras
P/V	Photo voltaic
PAKP	Preliminary Flood Risk Assessment
PCI	Project of Common Interest
PESDA	Regional Waste Management Plan
PFDHA	Probabilistic Fault Displacement Hazard Assessment
PGA	Peak Ground Acceleration
PIMS	Pipeline Integrity Management System
PLET	Pipeline End Termination
PLONOR	Pose Little or No Risk

Abbreviation	Description
PP	Polypropylene
PPC	Public Power Corporation
PPS	Pipeline Protection Strip
PPXSAA	Framework for Spatial Planning and Sustainable Development
PR	Performance Requirements
pSCI	proposed Sites of Community Importance
PSV	Platform Supply Vessels
PTS	Permanent Threshold Shift
QRA	Quantitative Risk Assessment
RAE	Regulatory Authority for Energy
RCC	Remote Control and Communication
RES	Renewable Energy Sources
RFSPSD	Regional Framework for Spatial Planning and Sustainable Development
RMS	Reconnaissance Marine Survey
ROV	Remotely Operated Vehicles
R.U.	Regional Unit
SBP	Sub Bottom Profiler
SCADA	Supervisory Control And Data Acquisition
SCI	Site of Community Importance
SDF	Standard Data Form
SDLAP	River Basin Management Plans
SE	South-Eastern
SEL	Sound Exposure Level
SGC	Southern Gas Corridor
SI	International System of Units
SMS	Safety Management System
SPL	Sound Pressure Level
SPT	System Pressure Test
SSS	Side Scan Sonar
STAKOD	Statistical Classification of the Branches of Economic Activity

Abbreviation	Description
STP	Standard Conditions (Temperature: 15.56 °C, Pressure: 1.01325 bara)
SXOOAP	Open City Spatial Housing Organization Plan
TBM	Tunnel Boring Machine
TTS	Temporary Threshold Shift
WD	Water Depth
YPEN	Ministry of Environment and Energy
ZDYKP	Potentially High Flood Risk Zones

6 DETAILED DESCRIPTION OF THE PROJECT

6.1 Purpose of this Section

This Chapter provides a technical description of the EastMed Pipeline Project presenting details regarding design, construction and operation of the Project with a particular focus on the Greek section of the Project.

The section is structured as follows:

- General Project Overview, presenting a synopsis of the complete EastMed Pipeline Project and its main components;
- Description of the main components associated with the Greek section of the Project;
- Detailed description of Project's construction, operation and decommissioning phases, including environmental parameters, such as waste, emissions, etc; and
- Short description of possible non routine events and environmental risks, as derived from the preliminary safety study of the Project.

6.1.1 Assumptions and Limitations

The Project Description is based on the technical input and engineering design documents available at the time this ESIA was prepared and is considered sufficient for the purposes of the ESIA Report (i.e. perform an accurate impact assessment) as it provides an overall technical description but also specific details to evaluate the magnitude and type of operations associated with the Project development and operation.

According to the provisions of Art. 7 of L. 4014/2011 (Procedure for final study assessment and implementation study of a project or activity), if more accurate data is derived that may have environmental impact, a Final Design Compliance File or a Technical Environmental Study shall be submitted according to the design modifications.

It should be noted that this ESIA considers the reasonable worst case in terms of potential environmental and social impacts. This means that the ESIA identifies the likely significant effects arising from the largest possible footprint of the Project, corresponding to a maximum design capacity of 21 BSCM/yr up to Megalopoli and 20 BSCM/yr from Megalopoli to Florovouni.

Connection to electricity grid needs to be established for commissioning of the Project's main stations. It is noted that technical data for power supply lines are not currently available. Most of the stations (Crete and Megalopoli facilities) are very close to power plan stations (Atherinolakkos and

Megalopoli power plants, respectively) whilst CS3 (Achaia) is in close proximity to existing power supply lines. As such, connection to the power grid is likely to include a small section of new power lines only. The necessary works shall be presented and impacts assessed, if and as required, in a separate environmental licensing procedure.

6.2 Project Overview

6.2.1 Project Synopsis

The EastMed-Poseidon Pipeline Project will connect eastern Mediterranean natural gas sources to the European energy system through a dedicated connection via a completely new route, integrating markets along the way and enhancing diversification.

The EastMed Pipeline shall consist of a Southern Line and a Northern Line to deliver gas from Israeli and Cypriot sources, respectively, to the Poseidon Pipeline System compressor station that is located in north-western Greece and from there to Italy.

The entire EastMed-Poseidon Pipeline Project is about 2,200 km long (EastMed Pipeline is about 2,000); the 1,440-km offshore gas pipeline will link Israel, Cyprus and Greece via Crete, before traversing 540 km through the Greek mainland to reach Italy via the Poseidon Pipeline 210 km long. Overview of EastMed Pipeline Project components are separated into three main sections:

A. Southern Line of EastMed (Israel → Cyprus → Greece):

- OSS1 Subsea trunk line from EastMed Compressor Platform (ECP) in Israeli to Inline Tee Assembly (ITA) in Cypriot waters,
- OSS1a subsea branch pipeline from the subsea tie-in point ITA to Cyprus landfall LF1. Here a short onshore pipeline section will connect the metering and pressure reduction station (MS1a/PRS) and the landfall station (LS01), in order to receive high pressure gas from the OSS1a branch pipeline and to deliver it at conditions suitable for Cypriot domestic use (1 BSCM/yr),
- OSS2 Subsea trunk line from the subsea tie-in point ITA to landfall LF2 in Crete (Greece). Here a short onshore pipeline section will connect the landfall with compressor and metering station in Crete (CS2/MS2),
- OSS3 Subsea trunk line from LF2 to LF3 in Peloponnese (Greece);

B. Northern Line of EastMed (Cyprus → Greece):

- OSS1b Subsea trunk line from Cypriot offshore gas field to landfall LF1 in Cyprus. Here a short onshore pipeline section will connect the compressor and metering station (CS1/MS1) and the landfall station (LS01N), in order to receive and recompress the gas for onward transport toward Crete,

- OSS2N Short onshore pipeline section and a long Subsea trunk line from the compressor and metering station (CS1/MS1) in Cyprus to landfall LF2 in Crete. Here a short onshore pipeline section will connect the landfall with compressor and metering station in Crete (CS2/MS2),
- OSS3N Subsea trunk line from LF2 to LF3 in Peloponnese (Greece).

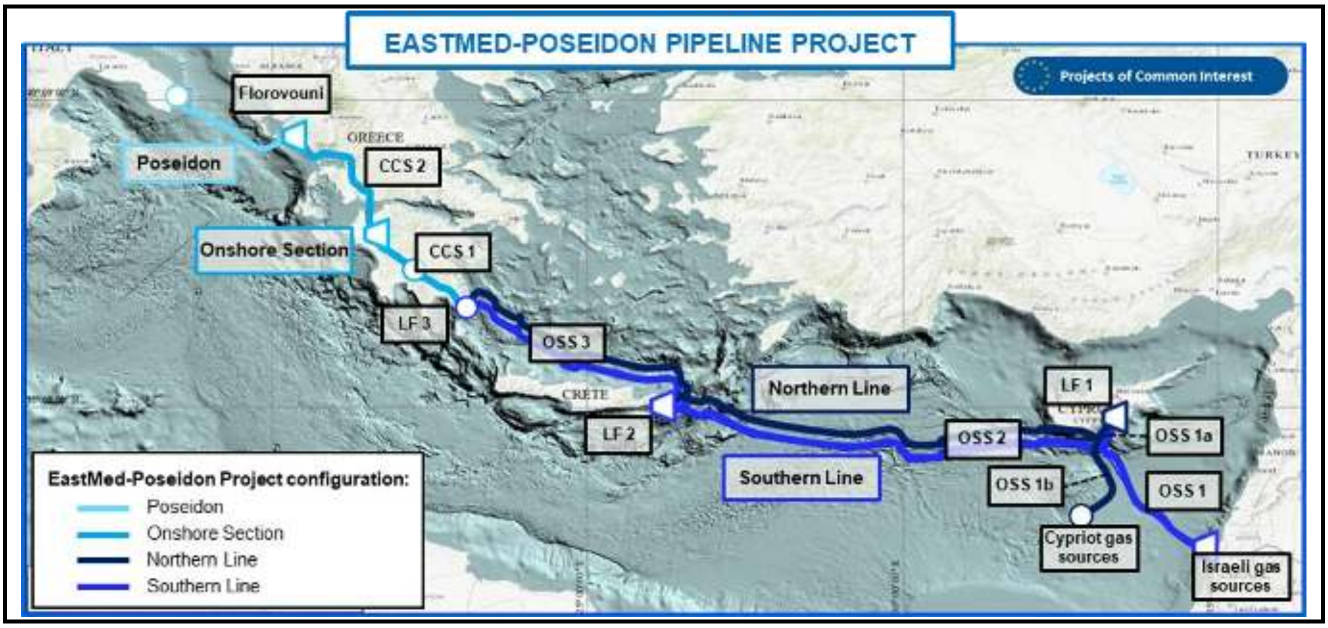
It is noted that Southern and Northern Lines are independent pipelines and upstream of Crete there is no shared infrastructure between the two Lines. In Crete (compressor station CS2/MS2, CS2/MS2 N), gas will be commingled and a dual pipeline system will be involved, comprised of OSS3 and OSS3N running parallel from landfall LF2 in Crete to landfall LF3 in Laconia (Peloponnese), crossing the waters among the regions.

The Northern and Southern Lines are shown in Figure 6-1 below where the offshore sections of the Southern Line and Northern Line are indicated in blue and dark blue, respectively.

C. Combined Lines of EastMed (Crete → Greek border):

- At landfall LF3 in Laconia, gas flow streams from the two pipelines will be combined into a single large diameter pipeline system for ultimate carriage to the Poseidon compressor station at Florovouni in North-West Greece. This system includes:
  - Onshore trunk line CCS1 from LF3 to LF4
  - Subsea trunk line OSS4 crossing the Gulf of Patras between LF4 and LF5,
  - Onshore trunk line CCS2 from landfall station LF5 to Florovouni[1].
  - The - large diameter pipeline of the Combined Line is shown in Figure 6-1 in light blue.

[1] Compressor Station of POSEIDON system at Florovouni of NW Greece, belongs to another project of the same Owner and has received environmental permitting through a separate procedure (ETA: ΥΠΕΝ/ΔΙΠΑ/35872/2373/07-06-2019/ ΑΔΑ: ΩΠΝ34653Π8-4Ι9)



Source: EastMed, 2020

Figure 6-1 EastMed Pipeline Northern and Southern Lines and Combined Line

The main components of each line are described briefly in the following paragraphs.

6.2.1.1 *Southern Line*

The Southern Line (i.e. from the gas source in Israeli waters to continental Greece) comprises the following main components:

Table 6-1 Southern Line Main Components

Component	Description	Location	Design Capacity [BSCM /yr]
ECP	EastMed Compression Platform in Israeli waters	Israel	12
OSS1 – OSS2	Subsea trunk line from the ECP to Crete (dual diameter 30”+26”), including short onshore pipeline section and landfall station at LF2 in Crete	Israel -> Crete	12
OSS1a	Subsea 12.75” diameter branch pipeline from the subsea Tie-in point in Cypriot waters to LF1 in Cyprus including subsea tie-in arrangement and short onshore pipeline section and landfall station at LF1 in Cyprus	Subsea tie-in point -> Cyprus	1

Component	Description	Location	Design Capacity [BSCM /yr]
MS1a/PRS	Metering and Pressure Reduction Station with functionality to receive high pressure gas from the OSS1a branch pipeline and to deliver at conditions suitable for Cypriot domestic use	Cyprus	1
CS2/MS2	Compressor and Metering station in Crete with functionality to receive gas from the OSS1-OSS2 trunk line and to recompress this gas for onward transport toward the Greek mainland	Greece (Crete)	11
OSS3	Subsea trunk line from Crete to LF3 landfall in Peloponnese (diameter 28'') including short onshore pipeline section and landfall station at LF2 in Crete and short onshore pipeline section at LF3 in Peloponnese	Crete -> Peloponnese	11[2]
MS4/ PRS4	Megalopoli Metering Station / Pressure Reduction Station with functionality to measure and regulate the flow before the tie-in to the national gas grid including a branch Line from Megalopoli MS4/PRS4 to the tie-in to the national gas grid, the Megalopoli branch downstream of MS4/PRS4 is a component of the project.	Peloponnese	1

Source: P616-000-DB=BDS-01_3_Design Basis Memorandum – Pipeline and Facilities

6.2.1.2 *Northern Line*

The Northern Line (i.e. from the gas field in Cypriot waters to continental Greece) comprises the following main components:

Table 6-2 Northern Line Main Components

Component	Description	Location	Design Capacity [BSCM /yr]
FPSO	Floating production storage and offloading unit (FPSO) located at the Cypriot gas field	Offshore Cyprus	-
OSS1b	Subsea trunk line from Cypriot offshore gas field to Cyprus, diameter 24'', including short onshore pipeline section and landfall station at LF1 in Cyprus	Cyprus	10

[2] For the Southern line's design, the design capacity of OSS3 is 11 BSCM/yr. However, for the Combined (Northern & Southern lines) design, the design capacity for OSS3/OSS3N is 10.5 BSCM/yr for each pipe.

Component	Description	Location	Design Capacity [BSCM /yr]
CS1/MS1	Compressor and Metering Station in Cyprus with functionality to receive gas from the OSS1b trunk line and to recompress this gas for onward transport toward the compressor and metering station in Crete (CS2/MS2 N)	Cyprus	10
OSS2N	Subsea 26" diameter trunk line from Cyprus to Crete including short onshore pipeline section and landfall station at LF1 in Cyprus and short onshore pipeline section and landfall station at LF2 in Crete	Cyprus -> Greece (Crete)	10
CS2/MS2 N	Compressor and Metering station with functionality to receive gas from the OSS2N trunk line and to recompress this gas for onward transport toward the Greek mainland	Greece (Crete)	10
OSS3N	Subsea trunk line from Crete to landfall LF3 in Peloponnese (diameter 28'') including short onshore pipeline section and landfall station at LF2 in Crete and short onshore pipeline section at LF3 in Peloponnese	Crete -> Peloponnese	10[3]

Source: P616-000-DB=BDS-01_3_Design Basis Memorandum – Pipeline and Facilities

6.2.1.3 *Combined Line*

The Combined Line comprises the following components:

Table 6-3 Combined Line Components

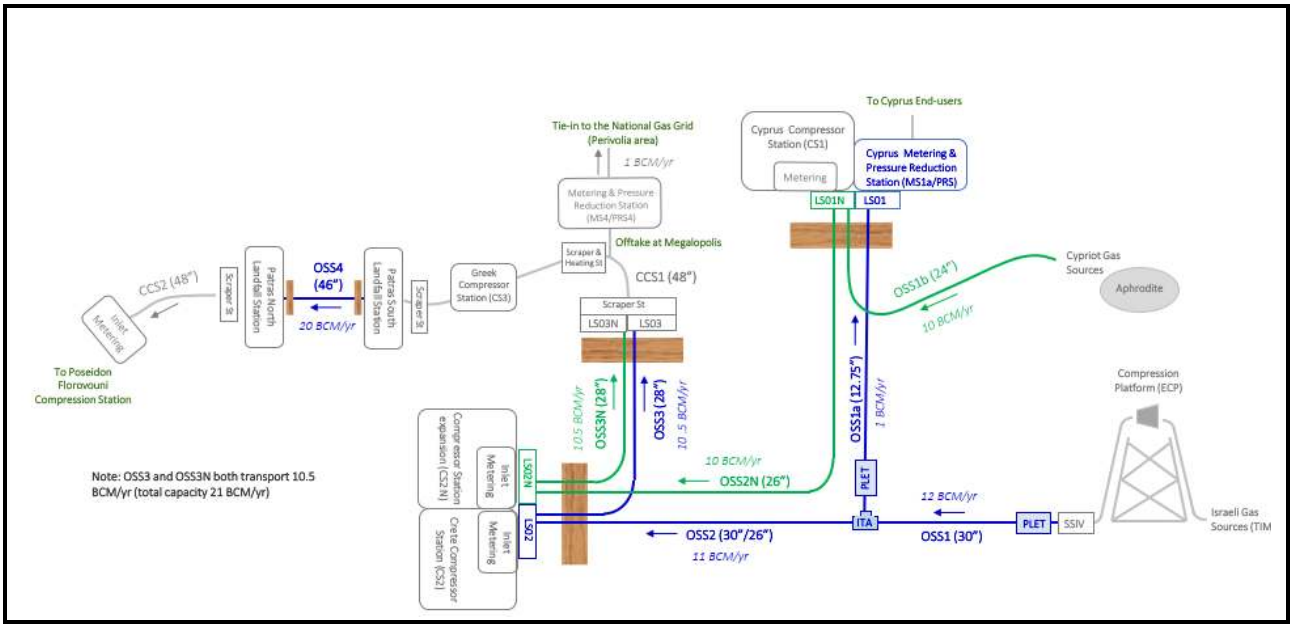
Component	Description	Location	Design Capacity [BSCM/yr]
CCS1a	Onshore trunk line from LF3 Stations in Laconia to Megalopoli including landfall stations and scraper stations at LF3 and multiple block valve stations at regular intervals along the pipeline	Peloponnese	21/20
	Heating Station in Megalopolis	Peloponnese	20
CCS1b	Onshore trunk line from Megalopoli to LF4 including landfall station and scraper station at LF4 and multiple	Peloponnese	20

[3] For the Northern line's design, the design capacity of OSS3N is 10 BSCM/yr. However, for the Combined (Northern & Southern lines) design, the design capacity for OSS3/OSS3N is 10.5 BSCM/yr for each pipe.

Component	Description	Location	Design Capacity [BSCM/yr]
	block valve stations at regular intervals along the pipeline		
CS3	Compressor station in Peloponnese with functionality to recompress gas for onward transport toward the Poseidon compressor station at Florovouni in north-west Greece	Peloponnese	20
OSS4	Subsea trunk line (diameter 46'') crossing the Gulf of Patras between LF4 and LF5 including short onshore pipeline sections at LF4 and LF5	Gulf of Patras	20
CCS2	Onshore trunk line from LF5 Station in Akarnania to Florovouni in Thesprotia including landfall station and scraper station near LF5 and multiple blockvalve stations at regular intervals along the pipeline	West Greece	20
	Florovouni Metering Station in Thesprotia	Thespotria Region	20
O&M Base	Dispatching and Operations and Maintenance (O&M) Base in Achaia Regional Unit	Peloponnese	

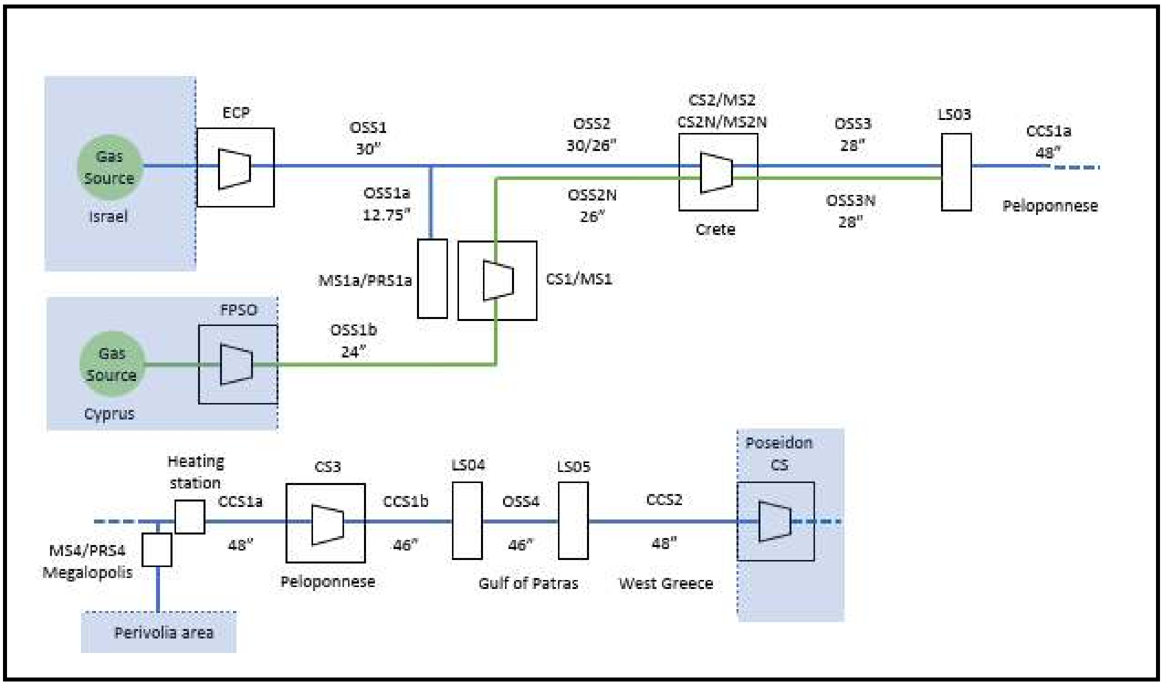
Source: P616-000-DB=BDS-01_3_Design Basis Memorandum – Pipeline and Facilities

The system schematic for the whole Project is presented in Figure 6-2. All system components which are part of the Southern Line are shown in blue (exception to this is OSS4, which is part of the Combined Line), while the ones that are part of the Northern Line are in green. Figure 6-3 shows facilities within the EastMed Project boundaries.



Source: 00225-Ev32A-TEN-00052_2, System Description Note

Figure 6-2 System Schematic – Combined Southern and Northern Lines

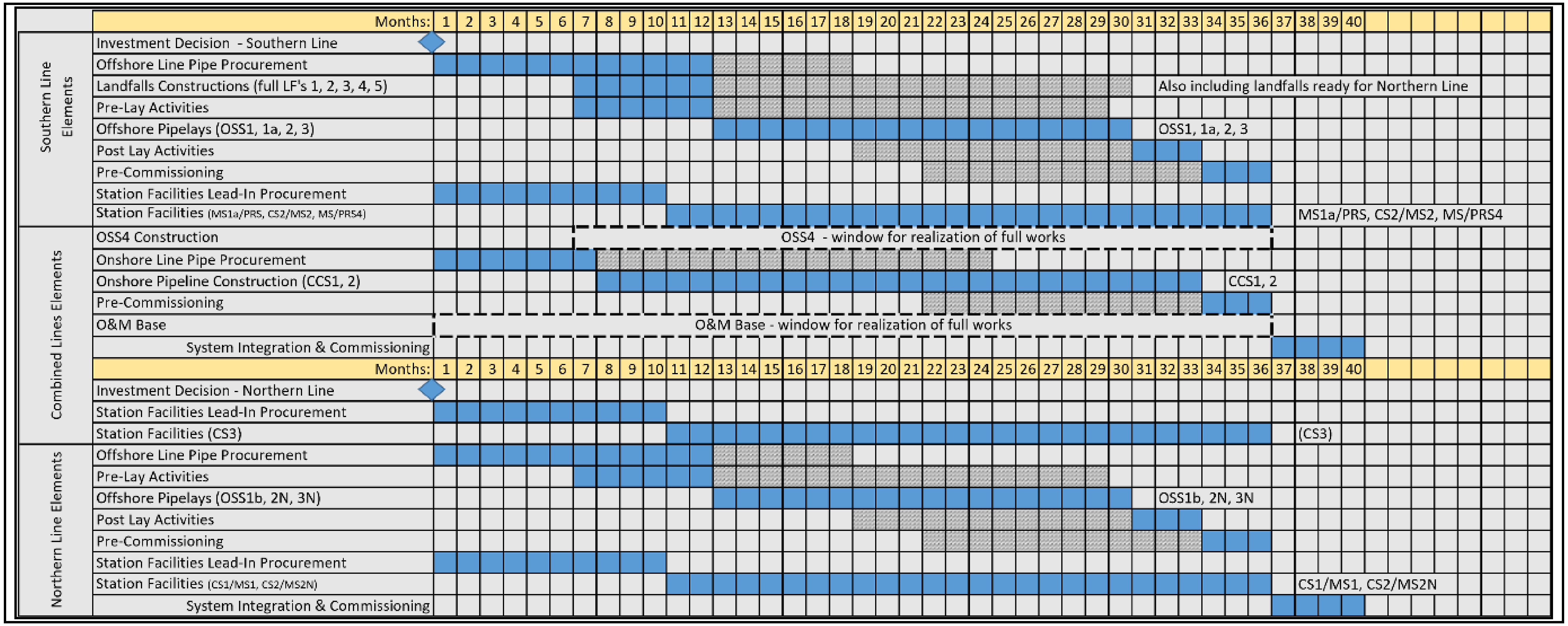


Source: E780-00225-Ev32A-TEN-00056_3, Initial Steady state hydraulic analysis report

Figure 6-3 Facilities within the EastMed Project Boundaries

6.2.2 Project Schedule

Overall construction of the EastMed Pipeline Project (Cyprus and Greece) is anticipated to last approximately 3 years for construction of related infrastructure (Figure 6-4). Project execution is envisaged to commence in January 2024 and commissioning is expected to start after December 2026.



Source: IG Poseidon I, 2021

The figure represents an estimate of each Project activity duration, from construction authorization to commissioning. The schedule doesn't provide a precise timeline as the Northern and Southern Lines are independent pipelines.

Figure 6-4 Indicative Duration of Project Activities (Greece and Cyprus)

The final, specific construction schedule will depend on various technical and contractual aspects, which may take into account relevant environmental and socioeconomic factors. Pipeline construction is a sequential process and would last only a limited time at specific locations along the route, depending on the different construction fronts; whereas construction of the Main Stations is expected to be a continuous activity at each of the station sites. Moreover, the installation of the Southern and Northern Lines might not be performed simultaneously, except for the shore crossings at LF2 and LF3.

6.2.3 Gas Properties

The EastMed Pipeline Project will transport natural gas which is a naturally occurring gas mixture consisting primarily of methane. Other hydrocarbons and accompanying substances (e.g. ethane, propane, butane, pentane, hexane, carbon dioxide, nitrogen and traces of sulphur) are typically present in proportions that can vary from 0% to 25%.

Three gas compositions have been considered for the initial steady state analyses for the Project, namely:

- Israeli Gas - for the Southern Line up to CS2/MS2;
- EastMed Gas - for the Northern Line up to CS2 MS2 N; and
- Combined Gas - for the Southern and Northern Lines downstream of CS2/MS2 and CS2 MS2 N common plot and the Combined Line. This composition is a mixture of the Israeli and EastMed gas compositions.

The gas composition for Israeli Gas and EastMed Gas is tabulated in Table 6-4. It can be observed that the gas composition contains negligible amounts of water.

Table 6-4 Gas Composition

Component	EastMed Gas Proportion (mol %)	Israeli Gas Proportion (mol %)
H_2O	0.0007	0.0008
Glycol	0.0000	0.0000
Nitrogen	0.2504	0.2284
CO2	0.1896	0.1383
Methane	98.8678	98.9692
Ethane	0.3583	0.3564
Propane	0.1477	0.1441
i-Butane	0.0389	0.0394

Component	EastMed Gas Proportion (mol %)	Israeli Gas Proportion (mol %)
n-Butane	0.0385	0.0371
i-Pentane	0.0278	0.0205
n-Pentane	0.0092	0.0097
n-Hexane	0.0163	0.0150
Mcyclopentane	0.0027	-
Benzene	0.0001	-
n-Heptane	0.0335	0.0256
Mcyclohexane	0.0029	-
Toluene	0.0003	-
n-Octane	0.0121	0.0117
E-Benzene	0.0002	-
m-Xylene	0.0003	-
o-Xylene	0.0001	-
n-Nonane	0.0021	0.0030
n-Decane	0.0004	0.0007
n-C11	0.0001	0.0001
n-C12	<0.00001	<0.00001
C13+	<0.00001	<0.00001
O2	<0.00001	<0.00001
Total	100.00	100.00

Source: P616-000-DB-BDS-01_3, Design Basis Memorandum – Pipeline and Facilities

Fluid properties for both gases, Israeli and EastMed gas, are shown in Table 6-5.

Table 6-5 Fluid Properties

Property	EastMed Gas	Israeli Gas
Molecular Weight	16.33	16.30
Density at STP (kg/m^3)	0.691	0.689

Source: P616-000-DB-BDS-01_3, Design Basis Memorandum – Pipeline and Facilities

The hydraulic analysis for the pipelines downstream of CS2/MS2, CS2/MS2N considers one gas composition that is a mixture of the Israeli and EastMed gas compositions, which is referred to as Combined Gas composition. The mixture is a ratio of 1.31:1 Israeli Gas to EastMed Gas.

6.2.4 Design Philosophy

The design philosophy is to ensure that the gas transport system meets all safety requirements of the main national and European codes and standards and that impacts on the natural and social environment are kept to a minimum. The design life of the onshore/offshore pipeline system is 50 years and minimum 25 years for the facilities. These are common values for onshore/offshore pipeline systems. The original pipeline design life shall be verified by a re-qualification at the end of a 40-year period from initial installation or sooner. Re-qualification means that the pipeline condition is assessed relative to its originally installed condition.

The pipeline and stations will be designed in accordance with requirements resulting from:

- National and local regulations;
- International standards for pipeline construction and operation;
- Safety of the people and personnel living/working close to pipeline infrastructure;
- Protection of the environment;
- Protection of property and facilities;
- Geotechnical, corrosivity and hydrographical conditions;
- Requirements for construction, operation and maintenance; and
- Third party activities.

The design pressure will be between 231 and 363 barg, sufficient for the EastMed Pipeline Project overall export capacity of 21 BSCM/yr + 1 BSCM/yr to Cypriot domestic use. The final design pressure will be defined after finalisation of an iterative technical study considering all relevant parameters. However, it is anticipated that any changes will be very small deviations around the design parameters described in this document and will not result in significant changes to the size and design of the main Project components.

For each section of the EastMed pipeline system, the MOP (maximum operating pressure) and DP (design pressure) to be considered for design are presented in the following table.

Table 6-6 Summary of EastMed Pipeline Pressures

Parameter	OSS1-OSS2	OSS2N	OSS3	OSS3N	CCS1	Megalopoli Branch Line	OSS4	CCS2
MOP (barg)	345	345	220	220	95	75	95	95

Parameter	OSS1-OSS2	OSS2N	OSS3	OSS3N	CCS1	Megalopoli Branch Line	OSS4	CCS2
DP (barg)	363	363	231	231	100	80	100	100

Source: P616-000-DB-BDS-01_3, Design Basis Memorandum – Pipeline and Facilities, 000225-Ev-32A-BOD-00053_03, Project Design Basis and 00225-Ev32A-BOD-00302_01, Project Design Basis – Northern System

Routing of the EastMed Pipeline Project took into consideration all technical aspects (e.g. slopes, geohazards, crossings), environmental and social constraints investigated and alternate corridors/areas (see Chapter 7 on Project Alternatives).

The following table illustrates technical data related to Project operation.

Table 6-7 Operating design data

Design Data	Value
Air temperature	Max. summer in shade +44 °C/ Minimum winter -20 °C
Max soil temperature at 1.5 depth	+24°C
Min. soil temperature at 1.5 depth	+6 °C
Design snow load	According to EN 1991-1-3 and Greek Regulations
Design wind load	According to Eurocode 1, EN 1991-1-4 and Greek Regulations
Seismic load of pipeline	According to Seismic Hazard Assessment Study
Seismic load of buildings/structures	According to EN 1998-1and EAK 2000 and Amendments.
Seismic Risk Zone	I or II
Design Ground Acceleration	0.16 g or 0.24 g
Importance Category	Class IV to EN 1998-1

Source: ASPROFOS, 2021

6.2.5 Applicable Codes and Standards

The applicable codes and standards for the Project design are presented below. These combine national laws/requirements as well as international design codes as needed.

6.2.5.1 Onshore Section

As EastMed will cross European territory, the pipeline system will be designed within the EN (Euro Norm) framework.

- European Standard: EN 1594: 2013; and
- International Design Code for guidance: ASME B31.8.

Construction material for the piping arrangements is grade L485 carbon steel (or API 5L X70) for all pipe sizes.

Only steel pipes and sections of steel piping will be used.

The materials of the main parts of the pipes are in full compliance with the following construction codes:

- EN ISO 3183, Petroleum and Natural Gas Industries. Steel Pipe for Pipeline Transportation Systems (Oil and Gas Industries. Steel Transmission Pipelines);
- EN ISO 3183, for pipeline transmission systems;
- EN 14141, for valves; and
- EN 14870, for pipe bending, coating and flanges.

The following codes apply for stations:

- EN 1594 Gas supply systems – pipelines for maximum operating pressure over 16 bar functional requirements;
- EN 1776 Gas supply systems – natural gas measuring stations – functional requirements;
- EN 12186 Gas supply systems – gas pressure regulating stations for transmission and distribution - functional requirements; and
- EN 12583 Gas supply systems – compressor stations – functional requirements.

Additional requirements are identified in the future in the Project implementation study phase.

- Greek legislative and regulatory framework:
  - ➢ Greek Technical Regulation "Gas Transmission Network that operates at a maximum pressure of over 16 bar. Ministerial Decision D3/A/4303/PE; 26510/12 (GG 603/B/05.03.12) as amended by D3/A/8857/2012 (GG 20126/b/20.06.12),
  - ➢ Law 4001/GG 179 A/22.8.2011 "On the Operation of the Electricity and Gas Energy Markets, on Research, Production and Hydrocarbon Transmission Networks and Other provisions",
  - ➢ Law 4014/GG 209/A/21.09.2011 - Environmental licensing of projects and activities.

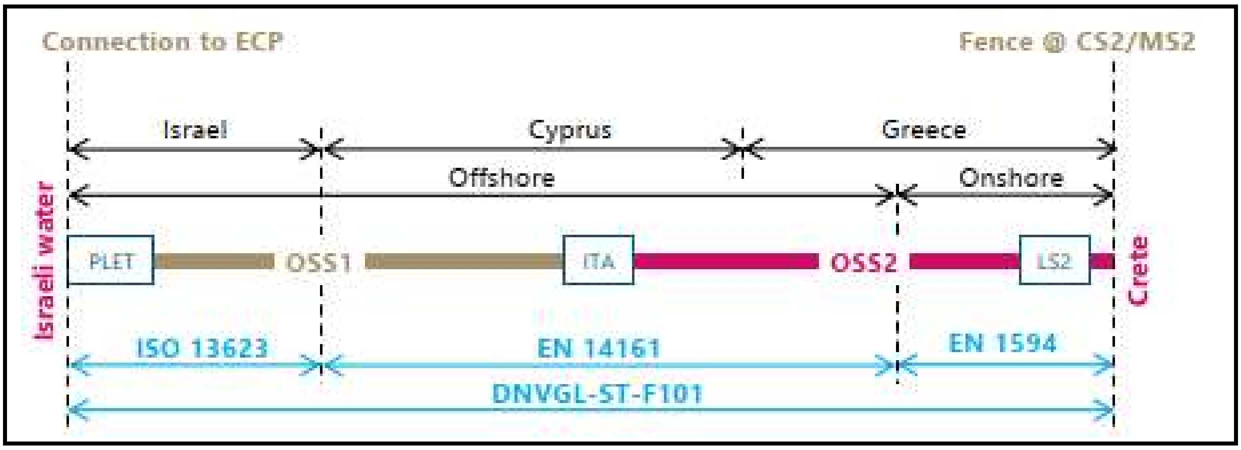
6.2.5.2 *Offshore Section*

- European standards (EN):
  - ➢ As EastMed will cross European territory, the pipeline system shall be designed within the EN (Euro Norm) framework,

- European Standard EN 14161:2011 is applicable for the offshore sections in EU (i.e., Cypriot and Greek) waters;

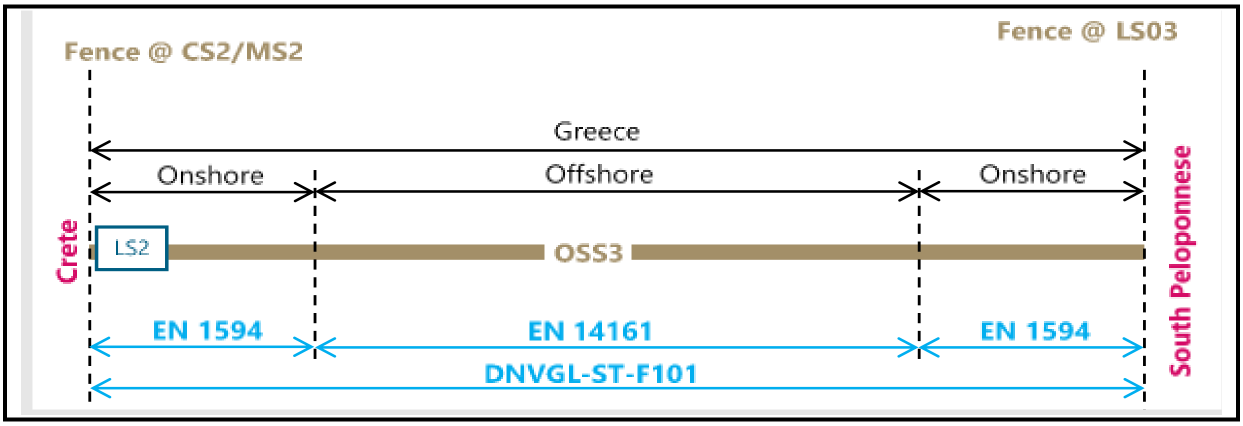
- International design codes:
  - Since EN standards are not design handbooks or a code of practice, DNVGL-ST-F101 (2017) is selected as the primary pipeline design code for the complete offshore pipeline system, including the short onshore parts of the offshore pipelines,
  - This code is intended to comply with EN 14161 but there are some intentional deviations. It provides the additional detailed guidelines needed for this Project.

The above design code framework is schematically shown in Figure 6-5, Figure 6-6 and Figure 6-7 for the EastMed Pipeline Project within Greek territory.



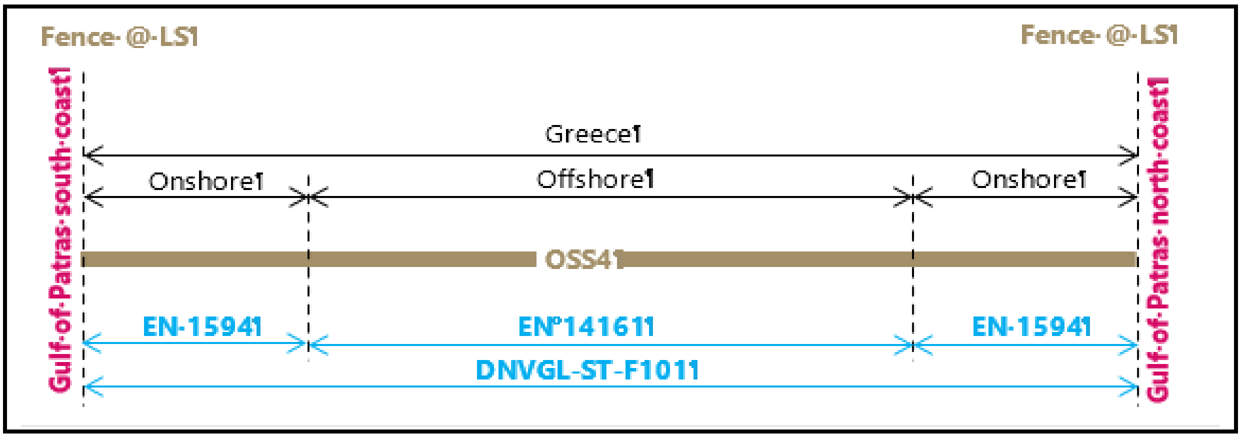
Source: 000225-Ev-32A-BOD-00053_03, Project Design Basis

Figure 6-5 Schematic Overview of Design Codes for OSS1 – OSS2



Source: 000225-Ev-32A-BOD-00053_03, Project Design Basis

Figure 6-6 Schematic Overview of Design Codes for OSS3



Source: 000225-Ev-32A-BOD-00053_03, Project Design Basis

Figure 6-7 Schematic Overview of Design Codes for OSS4

Applicable directives, standards, codes and guidelines relevant to environmental protection include, but are not limited to, the following:

- Directive 2010/75/EU “Directive on Industrial Emissions”;
- 2008/50/EC European Parliament Directive on ambient air quality;
- EU 2003/10/EC of the European Parliament and the Council. The minimum health and safety requirements regarding worker exposure to the risks arising from physical agents (noise);
- 2000/14/EC European Parliament Directive on Noise; and

- 2008/1/EC European Parliament Directive concerning integrated pollution prevention and control (the IPPC Directive).
- EN ISO 4871 Declaration and verification of noise emission values of machinery;
- EN 21680 Noise levels for electrical rotating machines;
- IEC 225 Specification for Octave-Band and Fractional-Octave-Band-Analog and Digital Filters;
- IEC 651 Recommendations for Sound-Level Meters; and
- ISO Standards Acoustics-Inc: Basic Standards, Methods of Noise Handbook 35 Measurement, Audiometry and Human exposure to noise.

Design will comply with BAT- principles (Best Available Techniques).

Generally, the key codes and standards relevant to safety to be applied include, but are not limited to, the following:

- CEN/TS 15173;
- CEN/TS 15174 Guideline for Safety Management Systems for natural gas transmission pipelines; and
- DIN EN 16348 Gas infrastructure - Safety Management System (SMS) for gas transmission infrastructure and Pipeline Integrity Management System (PIMS) for gas transmission pipelines - Functional requirements.

Also, a list of material codes and standards relevant for line pipe, coatings and welding can be found in the Project material specifications.

Finally, the prevailing code regarding quality issues is ISO 9001: Quality Management Systems – Requirements, 2015.

6.3 Main Project Components in Greece

6.3.1 Overview

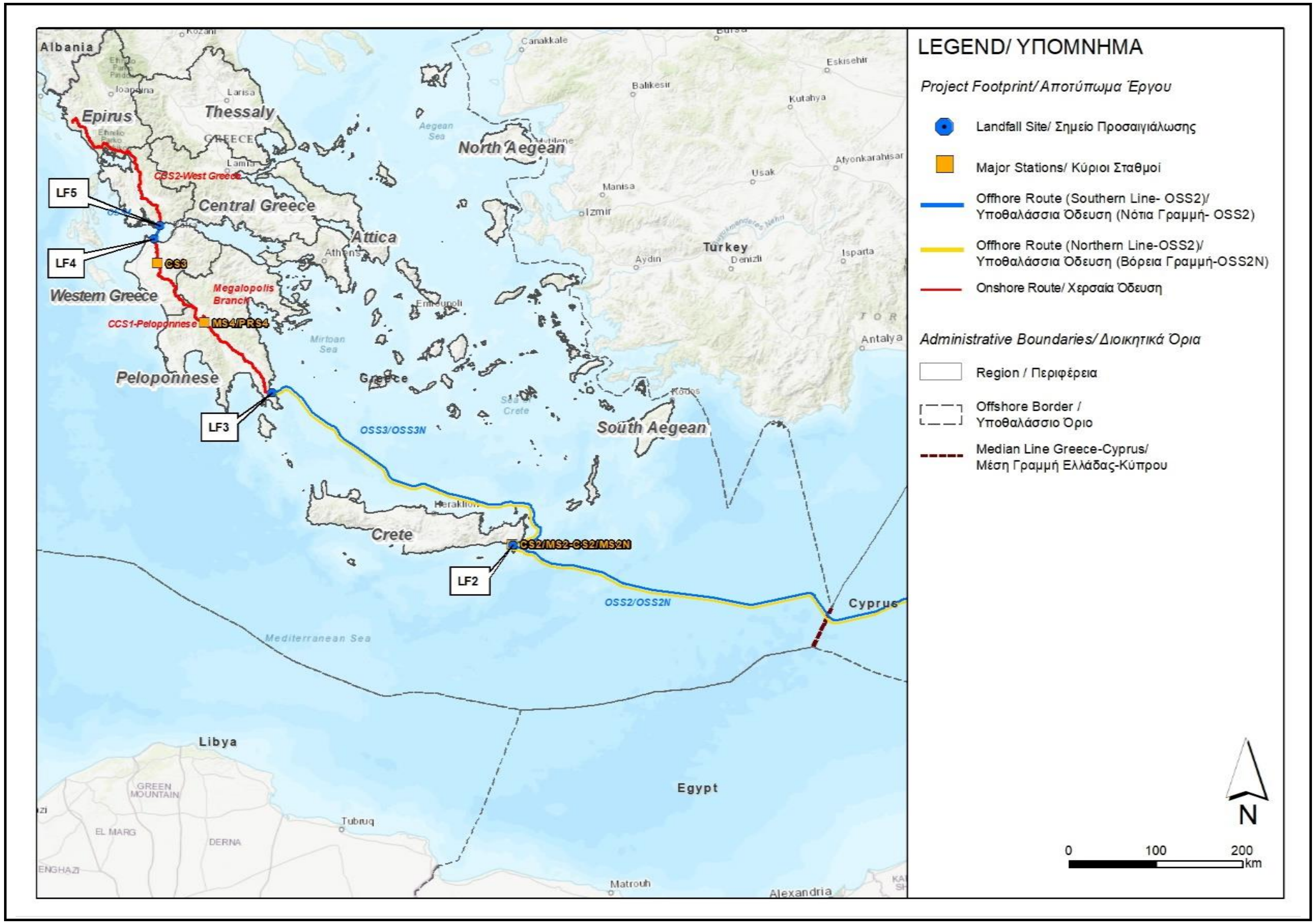
The components of the Greek Section of the EastMed Pipeline Project are summarized in Table 6-8 and depicted in Figure 6-8.

Table 6-8 Main Greek Section Project Components (in Successive Order from East to West)

Component	Description
OSS2 / OSS2 N	Pipeline System OSS2/OSS2N, (26”) that stretches 392km across the eastern Mediterranean Sea, from the middle of the sea straits between Greece and Cyprus to the designated landfall in Crete (LF2), reaching a maximum depth of

Component	Description
	approximately 3,000 m, 200 km after entering in Greek territory and almost 500 km from the start of the OSS2/OSS2N route.
LF2	Landfall in Crete.
CS2/MS2 and CS2/MS2 N	Compressor and Metering Station at Crete, which willl host – in the same fenced area – two separate units that will be used for compressing and metering/regulating purposes of the Southern and Northern Lines.
OSS3/OSS3N	Pipeline System OSS3/OSS3N (28") starts from the selected landfall in south-eastern Crete, LF2, and by crossing the Cretan Fore-Arc Basin and the Hellenic Margin, ends at landfall LF3 in south-eastern Peloponnese. At this location there is also a short onshore section to the landfall station (LS03). Pipeline's total length is 427 km and the maximum water depth is 1,590 m, and located at almost 15 km from the start.
LF3	Landfall in southern Peloponnese
CCS1	Cross country pipeline (48"/46") crossing Peloponnese from LF3 stations in Laconia region to LF4 (coast of Gulf of Patras); its length is approximately 300 km (Maximum elevation ~ 704 m)
MS4/PRS4	A Metering and Pressure Regulating Station in the wider area of Megalopoli. The Megalopolis branch downstream MS4/PRS4 is a component of the project.
Heating Station	For a supply of 21 BSCM / year, downstream of LS03, a gas heating station is required to ensure that the gas temperature remains at least 5 ° C above the dew point along the route. This station will be installed in Megalopolis on the same plot as the Metering and Pressure Regulating Station MS4 / PRS4.
CS3	In order to achieve transmission capacity 21/20 BSCM/year, a Compressor Station in the area of Peloponnese (CS3), as it is considered at approximately 35 km upstream from LS04, with total installed capacity of 70 MW.
LF4	Landfall at the southern coast of the Gulf of Patras
OSS4	The OSS4 offshore section for passage of the Gulf of Patras will be approximately 17 km long with a diameter of 46''. The maximum depth is 141 m.
LF5	Landfall at the north coast of the Gulf of Patras.
CCS2	Cross country pipeline (48") crossing west Greece from Aitolo-Akarnania region (coast of Gulf of Patras) to Thesprotia prefecture is approximately 235 km long (Maximum elevation ~ 863 m). The end of the EastMed Pipeline Project is at the Poseidon compressor station in Florovouni, Thesprotia

Source: IGI, 2021



Source: ASPROFOS, 2021.

Figure 6-8 Project Overview

For the various expected types of EastMed facilities the following indicative required dimensions/total area are anticipated:

Table 6-9 Indicative Dimensions / Area Requirements for Facilities in Greece

Item No	Facility Type	Number of Facilities	Indicative Dimensions Required (Length x Width)	Indicative Area Required	Remarks
1	Block Valve Stations	15	62 m x 65 m 40 m x 30 m	96,000 m^2	Assuming application of Law 4001 /2011 for required area of minimum 500 m^2 in areas outside approved town plan limits
2	Landfall Stations and Scraper Stations in common plots	3 (LS03/SS01, LS04, LS05/SS04)	62 m x 65 m 40 m x 30 m	22,000 m^2	Assuming application of Law 4001 /2011 for required area of minimum 500 m^2 in areas outside approved town plan limits
3	Scraper Stations in dedicated plot (Launcher and Receiver)	2 (SS05, SS-Perivolia)	62 m x 65 m	9,000 m^2	-

Item No	Facility Type	Number of Facilities	Indicative Dimensions Required (Length x Width)	Indicative Area Required	Remarks
4	Compressor, Scraper and Landfall Stations (in common plots)	3 (CS2/MS2- CS2/MS2 N - LS02, MS4/PRS4-HS-SS02, CS3/SS03)	-	330,000 m^2	-
5	Operations and Maintenance Base and Dispatching Centre	1	177 m x 181 m	32,000 m^2	-

Source: ASPROFOS, 2022 based on the available geospatial data.

6.3.2 Pipeline

Technical characteristics of the Greek EastMed pipeline segments are summarised in the following table.

Table 6-10 Summary of Investigated Pipeline Sections

Section	Pipe Size (inch)	Flow Rate (BSCM/y)	Length (km) (approx.)	Maximum Depth (m)
OSS2/OSS2N	2 x 26	11/10	392	approx. 3,000
OSS3/OSS3N	2 x 28	10.5/10.5	429	approx. 1,590
CCS1a-1 (up to MS4/PRS4 in Megalopoli)	48	21	138	-
Megalopoli Branch	16	1	10	-
CCS1a-2 (from MS4/PRS4 up to CS3 in Achaia)	48	20	127	-
CCS1b	46	20	35	-
OSS4	46	20	17	approx. 140
CCS2	48	20	233	-

Source: IGI, 2021

6.3.2.1 *Offshore Section*

The Offshore Section includes deep-water sections of the pipelines up to the 40 m water depth contour line at the landfalls.

The part of the Project under consideration (EastMed-Offshore Section – Greek Section) has a total length of approximately 838 km..

From a technical point of view, the two lines (Southern and Northern) are independent but parts of a unique project system, and from an environmental point of view, they should be considered as one pipeline for most environmental and social parameters. Therefore, unless a clear distinction is necessary, the term "**Line OSS2/OSS2N**" is introduced to describe pipelines OSS2 and OSS2N as one integrated pipeline system; similarly, the term "**Line OSS3/OSS3N**" for the OSS3 and OSS3N pipelines.

As such, the Line OSS2/OSS2N (Greek Section) route stretches 392.21 km across the eastern Mediterranean Sea, from the middle of the sea between Greece and Cyprus to the designated landfall in Crete (LF2). It has a diameter of 2x26'' and a transfer capacity of 21 BSCM/yr (11 BSCM/yr for OSS2 and 10 BSCM/yr for OSS2N). Similarly, OSS3/OSS3N route stretches 428.75 km across the Aegean Sea, from the landfall in south-eastern Crete (LF2) to the designated landfall in south-east Peloponnese (LF3). It has a diameter of 2x28'' and a transfer capacity of 21 BSCM/yr (the design capacity for OSS3/OSS3N is 10.5 BScm/yr for each pipe.). The OSS4 section (at Gulf of Patras) is 46" in diameter and approximately 17 km in length.

6.3.2.2 *Nearshore Section*

The nearshore zone extends from the shoreline at each landfall location to the 40 m water depth contour. The nearshore pipeline sections are approximately 5 km in length, and the diameters vary as follows:

- LF2:
  - 2 pipelines (OSS2/OSS2N) incoming (26"),
  - 2 pipelines (OSS3/OSS3N) out-going (28");
- LF3: 2 pipelines (OSS3/OSS3N) incoming (28");
- LF4: 1 pipeline (OSS4) out-going (46"); and
- LF5: 1 pipeline (OSS5) incoming (46").

The nearshore pipelines will be buried in the shore approach areas for protection against external factors and for pipeline stability. A minimum burial depth of 1.5 m cover on top of the pipeline is adopted (see section 6.4.3.2).

The landfall shore crossing construction technique is described in detail in the relevant section (see Section 6.4.3.2)

6.3.2.3 *Onshore Section*

The onshore pipeline section is approximately 540 km in length with a diameter of 46”/48". The design pressure of the main pipeline is 100 barg. The Megalopoli Branch is approximately 10 km in length and has a diameter of 16”. Its design pressure is 80 barg.

The pipeline shall be installed in accordance with ELOT EN1594. Typically, the onshore pipeline will be buried. The standard soil covers of the buried onshore pipeline (measured from top of pipe) shall be at least 1 m to comply with the Greek Technical Regulation of Natural Gas Transmission System with pressure greater than 16 bars - Ministerial Decision. Δ3/Α/ΟΙΚ.4303 ΠΕ 26510, as amended by Ministerial Decision Δ3/Α/8857 (GOV. GAZ. 2026/B/20.06.2012 and by Ministerial Decision ΥΠΕΝ/ΔΥΔΡ/89630/650/6-12-2018 (GOV.GAZ 5908/Β’/31-12-2018.

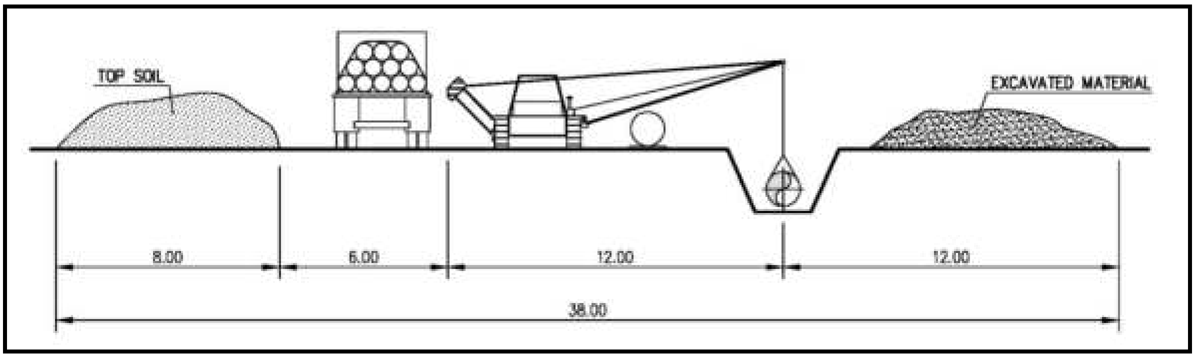
In most cases at crossings, there are also requirements for increased route cover due to applicable codes and standards. The depth of cover will be increased as required at road and service crossings to ensure the minimum clearances are maintained and highway authority/utility requirements are met.

If Quantitative Risk Assessment QRA will identify potential risk of damage or interference from third parties, additional protective measures shall be adopted. Protection could be one or more of the following:

- Increased route depth;
- Protective concrete slabs;
- Increased pipe wall thickness; and
- Casing where required by legislation or relevant authority.

If the new pipeline must be installed in parallel with existing corridors of another pipelines, all construction and operational risks associated with close proximity shall be taken into consideration. Within Greek territory the minimum separation distance will be in accordance with the pipeline operator’s requirements and in accordance with the Greek Technical Regulation (refer to DESFA specifications and Standard Drawings). For gas or hazardous liquid pipelines, a minimum separation distance of 16m (centreline to centreline) shall be considered.

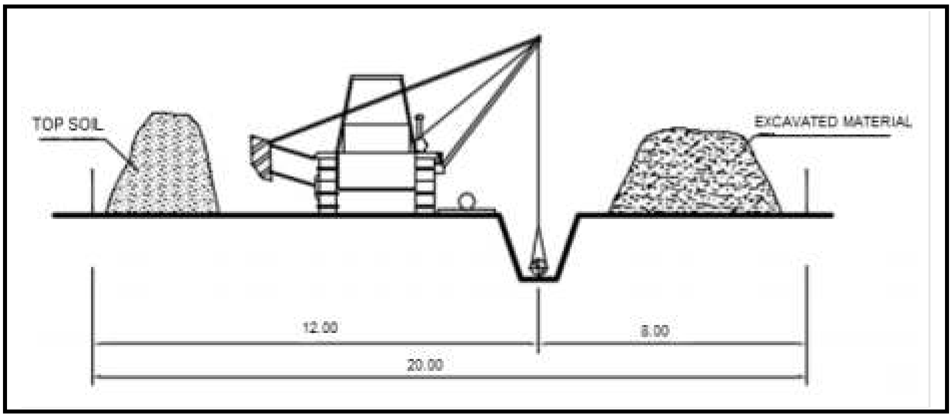
The working strip is the temporary corridor along the pipeline where construction takes place. It must be wide enough to allow all activities to be carried out safely whilst providing sufficient room to store topsoil and trench material separately and keeping agricultural crop losses to a minimum. The width of the working strip is proportional to the diameter of the pipeline to be installed. It follows that the greater the pipe diameter, the greater the extracted trench material that has to be stored. The width of the working strip is also determined by the size of the heavy machinery needed to safely lift and lower pipe into the trench and dig the trench. The width of the working strip in open country for pipelines with nominal diameter (ND) 48'' and 46'' will be 38 m.



Source: P616-000-DB-BDS-01_3, Design Basis Memorandum – Pipeline and Facilities

Figure 6-9 Regular Working Strip in Open Country for Pipeline ND 48" and 46"

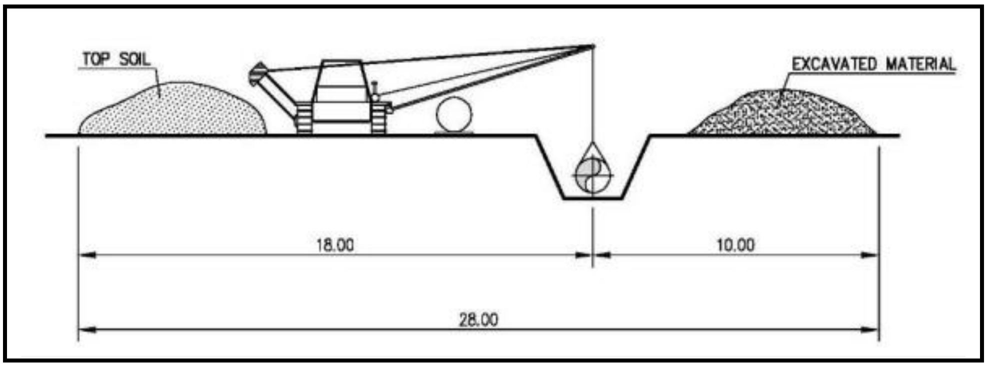
The width of the working strip in open country for pipeline of ND 16'' will be 20 m.



Source: P616-000-DB-BDS-01_3, Design Basis Memorandum – Pipeline and Facilities

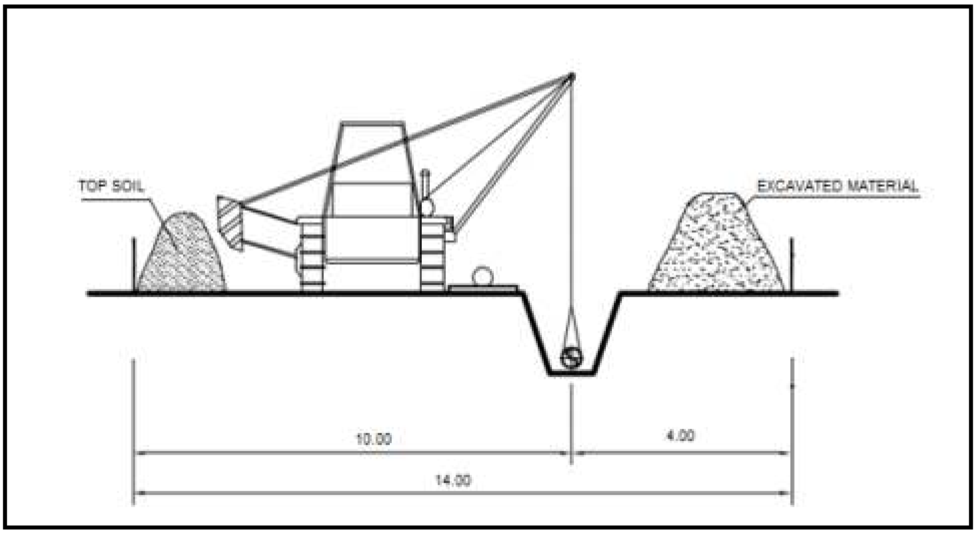
Figure 6-10 Regular Working Strip in Open Country for Pipeline ND 16"

The width of the spread zone along areas planted with permanent crops (e.g. vineyards, olive trees, etc.) for pipeline with ND 48'' and 46'' will be reduced to 28 m and for pipeline with ND 16'' will be reduced to 14 m in order to minimise impacts on the plantations.



Source: P616-000-DB-BDS-01_3, Design Basis Memorandum – Pipeline and Facilities

Figure 6-11 Reduced Working Strip (with Topsoil Stripping) for Pipeline ND 48" and 46"

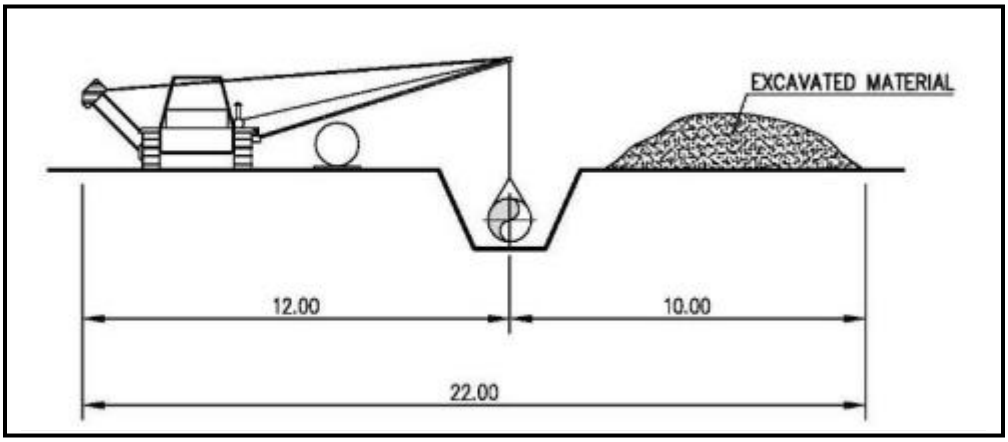


Source: P616-000-DB-BDS-01_3, Design Basis Memorandum – Pipeline and Facilities

Figure 6-12 Reduced Working Strip (with Topsoil Stripping) for Pipeline ND 16"

As summarised in Table 6-11, the width of the working strip for construction of pipelines with ND 48'' and 46'' can be reduced to 22 m in forest and mountainous areas where there is usually no need for topsoil storage and to 28 m in areas with permanent plantations (with topsoil stripping).

For pipelines with ND 16'' the regular working strip (in open country and agricultural areas planted with annual crops) is 20 m which is reduced to 14 m in areas planted by permanent plantations and without topsoil stripping (forest areas).



Source: P616-000-DB-BDS-01_3, Design Basis Memorandum – Pipeline and Facilities

Figure 6-13 Reduced Working Strip (without Topsoil Stripping) for Pipeline ND 48" and 46"

The areas where this reduced working strip will be applied will be carefully defined in order to reduce the impacts of the pipeline construction along these areas as much as possible, as well as to minimise impacts on the construction progress (e.g. delays) and to ensure that all activities along the reduced zone will be safely executed.

Furthermore, the width of the working strip will be increased when a trenchless construction method is applied at crossings of major infrastructure or rivers in order to accommodate relevant equipment for construction works (e.g. horizontal directional drilling (HDD), direct pipe, microtunnel, boring method).

Table 6-11 Summary of Working Strip width

Diameter of the pipelines (inches)	Regular Working Strip (m)	Reduced Working Strip (m)	Reduced Working Strip without Topsoil Stripping (m)	Boring methods (Area Required) (m^2)	HDD (Area Required) (m^2)
48 and 46	38	28	22	45 x 50 and 45 x 30 (each side)	100 x 100
16	20	14	14	40 x 40 and 40 x 20 (each side)	100 x 100

Source: IGI Poseidon, 2021

6.3.2.4 *Pipeline Materials*

This paragraph presents the requirements and selection process of the following items in the pipeline system:

- Line pipe;
- Buckle arrestors;
- Induction bends;
- External anti-corrosion coating;
- Internal flow coating;
- Field joint coating;
- Concrete weight coating;
- Sacrificial anodes; and
- Isolation joints.

The general overall philosophy and the system approach for material selection is based on sound engineering practice, integrity and reliability of the items, and health, safety and environmental (HSE) aspects.

Buckle arrestors are used in the pipeline to limit the maximum distance over which a buckle can propagate in the event of local buckling. For small diameter pipes, seamless/forged buckle arrestors may be feasible as well. The dimensions and spacing of buckle arrestors are functions of water depth, pipeline installation method and economics, i.e. a trade-off between the replacement costs of a certain length of pipeline and the capital costs of buckle arrestors.

Hot induction bends are produced from mother pipe that is the same grade as the line pipe used for the straight sections. Despite having the same grade, mother pipe normally is not made from standard project line pipe due to different requirements in the chemistry of the steel.

External anti-corrosion coating is required to protect the pipeline from external corrosion and from mechanical impact. The protection from external corrosion is also supported by sacrificial anodes for the offshore pipeline and by impressed current cathodic protection (ICCP) for the short onshore pipeline sections. The recommended external anti-corrosion coating for the EastMed pipeline is three-layer polypropylene (3LPP) coating system due to its good mechanical properties with a wide temperature range and excellent track record in similar project conditions. Fusion-bonded epoxy (FBE) with a flame sprayed PP is foreseen for buckle arrestor assemblies and the reducer assembly, and an airless sprayed high build epoxy for hot induction bends.

All 3LPP coated pipes will receive a rough layer to ensure extra grip in the tensioners during installation and for anchoring the CWC layer to the pipe.

Internal flow coating will be applied on the internal surface of the pipeline to enhance hydraulic performance of the long distance pipeline system. This coating provides additional benefits during pre-commissioning. The selected internal flow coating is a high solid volume solvent-free liquid epoxy coating due to the good coating quality and HSE considerations.

Field joint coating provides corrosion protection and mechanical protection in the girth weld area. Injection molded polypropylene on top of a fusion bonded epoxy layer provides good coating quality. However, the curing time is relatively long and relatively costly. Another suitable alternative is polypropylene heat shrink sleeves (HSS) applied on top of a liquid epoxy layer, considering ease of application and proven track record. Where concrete weight coating is applied, molded solid polyurethane (PU) or a suitable alternative will be applied as infill on top of the HSS.

Where required, concrete weight coating (CWC) will be applied to improve pipeline stability and to offer mechanical protection to the external coating. CWC thickness depends on installation locations of the specific pipe sections but is assumed between 50 mm and 120 mm.

The selected sacrificial anodes, applied as a secondary protection from external corrosion, is an aluminium-zinc-indium (Al-Zn-In) alloy based on the high electrochemical capacity and good track record in similar project conditions. The shape of the sacrificial anodes will be half-shell bracelet anodes. In the concrete coated pipeline sections, the sacrificial anode will be flush mounted with the adjacent coating system.

Monolithic isolating joints will be used to separate the onshore pipeline cathodic protection system from the offshore one. The isolation joints will be a fully welded system designed to provide an effective electrical barrier and be part of a pressure containing system and are supplied complete with welded pup pieces made from project line pipe material.

6.3.2.5 *Location Classification and Design Factors*

6.3.2.5.1 General

The design of the pipeline changes in accordance with the type and proximity of receptors found along the route, the design of the pipeline being thus related to class location. The pipeline location Classes and Design Factors will be in accordance with Greek regulations enhanced where appropriate by the guidance given by ASME B31.8 regarding population density and crossings.

6.3.2.5.2 Location Classification Requirements

<u>Onshore Pipeline</u>

According to the Greek "Technical Regulation of Natural Gas Transmission System with pressure greater than 16 bars", GG 603/5-3-2012 as amended by Ministerial Decision (GG 5908/B/31-12-

2018), a four tier location classification system is used (location classes 1, 2, 3 and 4). All buildings intended for human occupation located within a 400 m wide zone centred on the pipeline are considered to determine location classes. For any 1600 m length of pipeline, the number of features and properties within the zone is used as a basis for assigning the location class.

The following location classification system is based on the requirements detailed in the Greek regulation.

The location class requirements are presented (for 400 m wide, 1600 m long zones) in Table 6-12:

Table 6-12 Location Class Requirements for Onshore Pipelines

Location Class	Location Class Requirements
Location Class 1	10 or fewer buildings intended for human occupancy
Location Class 2	More than 10 but fewer than 46 buildings intended for human occupancy
Location Class 3	46 or more buildings intended for human occupancy, or any building or area within 200 m from the pipeline centreline, where regular concentrated gatherings of people may occur. A concentrated gathering is defined as a group of 20 or more people. This requirement may apply to religious buildings, schools, playgrounds, recreation areas ,theatres, etc.
Location Class 4	Areas with multi-storey buildings (4 or more levels) intended for human occupancy

Source: ASPROFOS, 2022

When a highly localised cluster of buildings intended for human occupancy indicates that a 1.6 km length of pipeline should be assigned a location class of 2 or 3, the location class 2 or 3 will be terminated 200 m from the nearest building in the cluster. Location class 4 will be delimited 200 m from the nearest multi-storey building (4 or more levels above ground).

Offshore Pipeline

In accordance with DNVGL-ST-F101, the offshore pipeline system is classified into the following location classes:

Table 6-13 Location Class for Offshore Pipeline

Location Class	Location Class Requirements
Location Class 1	Areas where no frequent human activity is anticipated along the pipeline route. Offshore pipeline sections more than 500 m away from landfalls and offshore source platform
Location Class 2	Areas with frequent human activity: landfalls (up to 500 m from shore)

Source: ASPROFOS, 2022

- The offshore pipeline system can be divided into multiple zones to facilitate the description of areas with similar design requirements or morphology or for practical reasons;
- The shore approach zone is assigned for design analyses which depend on the influence of wave action. The shore approach zone is the portion of the pipeline starting from the landfall point and extending to the farthest position offshore, where sea conditions are significantly affected by the coast. The shore approach zone extends from the shoreline at each landfall location to approximately 25 m water depth contour; and
- For survey purposes a nearshore section has been designated as a corridor of defined width, centred on and aligned with the pipeline routes, extending from the shoreline to the 20 m LAT contour. The nearshore section coincides with the shore approach zone.

6.3.2.5.3 Design Factor Requirements

EN Standards and international design codes applicable to the offshore design do not indicate further design factor requirements; however, for the onshore section the minimum design factor classes will be in accordance with the Greek "Technical Regulation of Natural Gas Transmission System with pressure greater than 16 bars", GG 603/5-3-2012 as amended by Ministerial Decision (GG 5908/B/31-12-2018). This regulation indicates that the application of category zones is related to the use of maximum / design safety factors, which set the maximum permissible stresses to be developed in the transmission system for the respective maximum operating pressure. The design factor related to class location is presented to the table below.

Table 6-14 Design Factor

Class location	Design Factor
1	0.72
2	0.60
3	0.50

Class location	Design Factor
4	0.40

Source: P616-000-BD-DBS-01_3, Design Basis Memorandum – Pipeline and Facilities

The following additional design factor requirements will apply at specific crossings.

In areas with class location 1 a design factor 0.60 or less will apply:

- When crossing swamps, rivers, streams;
- When crossing railway lines with casing; and
- When crossing highways and paved public roads.

In areas with class location 2, a design factor 0.50 or less will apply:

- When crossing highway sand paved public roads;
- When crossing railway lines;
- In the absence of any guidance from the applicable codes, the following design factors will be applied for other specific locations / crossings. These assumptions are in accordance with good practice;
- Pipe used for HDD crossings will have a design factor of 0.50 at class locations 1, 2 and 3;
- At crossings of any active seismic fault the design factor will be defined during the detailed engineering design phase and will extend at either side of each fault at a length specified in the relevant seismic study; and
- In mountainous areas with large ground elevation differences thicker pipeline (i.e. application of design factors with lower value) will be considered for the optimization of hydrostatic test sectioning.

The following table summarises the pipeline design factors to be used for Greek territory, including localised design factors applicable at various pipeline crossings (road, railway, river, HDD crossings, etc.)

Table 6-15 Design Factors for Pipeline and Crossings(1)

Class Location	Pipeline Design Factor	Railways (with Casing)	Existing or Future Highways & Public Roads (without Casing)	Unpaved Roads (without Casing)	HDD Crossings (2)	Swamps, Rivers and Streams
1	0.72	0.60	0.60	0.72	0.50	0.60
2	0.60	0.50	0.50	0.60	0.50	0.60

Class Location	Pipeline Design Factor	Railways (with Casing)	Existing or Future Highways & Public Roads (without Casing)	Unpaved Roads (without Casing)	HDD Crossings (2)	Swamps, Rivers and Streams
3	0.50					
4	0.40					

Source: P616-000-BD-DBS-01_3, Design Basis Memorandum – Pipeline and Facilities

Notes:

(1) Minimum design factors in accordance with the requirements of ELOT EN 1594, ASME B31.8 and Greek Technical Regulation of Natural Gas Transmission System with pressure greater than 16 bars - Ministerial Decision. Δ3/Α/ΟΙΚ.4303 ΠΕ 26510 (GOV. GAZ 603 /5.3.2012) as amended by Ministerial Decision Δ3/Α/8857 (GOV. GAZ. 2026/Β/20.06.2012) and by Ministerial Decision ΥΠΕΝ/ΔΥΔΡ/89630/650/6-12-2018 (GOV.GAZ 5908/B'/31-12-2018). Where more stringent, Greek Regulations have been applied.

(2) Codes do not offer guidance for HDD crossings. The DF of 0.50 has been used in accordance with good practice.

6.3.3 Line Valve Stations

6.3.3.1 Landfall Block Valve Stations (LSs)

The landfall block valve stations (LS) are located in the following areas:

- In the area of Atherinolakkos, in Crete (inside the compressor plot, LS02);
- In the southern Peloponnese (500 m north of the settlement of Agios Fokas in the municipality of Monemvasia, LS03);
- In the area south of the Gulf of Patras (2.5 km northwest of the settlement of Kalamaki in the municipality of Western Achaia LS04); and
- In the area north of the Gulf of Patras (3.1 km southeast of the settlement of Galatas in the municipality of Nafpaktia, LS05).

The purpose of the landfall stations (LSs) is to cover the requirements for transition between the offshore pipeline and the facilities and the pipeline onshore. The LSs are equipped with a pneumatic actuated (gas-over-oil) full bore block valve in the main line, a by-pass of the main valve, equipped with two ball and one gate throttling valve, to enable pressure equalisation on both sides of the main valve before opening. This configuration is applicable for each offshore pipeline coming onshore. All valves of the LSs will be installed underground.

Temperature gauges will be foreseen on both sides of the bypass valve to monitor the arrival temperature of the gas from the upstream pipeline section and enable checking the temperature drop when filling the downstream side. Temperatures upstream and downstream of the main valve is also transmitted to the control centres (main and backup).

Pressure will also be monitored (via pressure gauges and pressure transmitters) on both sides of the bypass valve. No venting facilities will be foreseen in the landfall stations. Also, if required, the system will be vented to upstream / downstream compressor stations where complete venting systems are installed.

Layouts of a landfall stations are provided in the relevant ANNEX 6B.

Specifically, LS02 (Southern Line) and LS02N (Northern Line) due to the short distance from LF2,are planned to be installed within the plot of the main stations CS2/MS2, Cs2/MS2 N. LS02 and LS02N will be equipped with pneumatic actuated (gas-over-oil) full bore block valves in the main lines, a by-pass of each main valve, equipped with two ball and one gate throttling valves, to enable pressure equalization on both sides of the main valve before opening. All valves of LS-02and LS-02Nwill be installed underground.

At LS03, when both Southern and Northern Lines become operable, two block valves with bypass arrangement will be installed. The two incoming offshore pipelines will be connected to the 48” onshore pipeline using tees. A pressure protection system (HIPPS) will be foreseen in LS03, to protect the downstream onshore pipeline from being overpressured from the upstream high pressure offshore section OSS3. The pressure indication from the three pressure instruments will, in case of overpressure in a two-out-of-three voting configuration will force the HIPPS dedicated ESV valve to close, in order to protect the downstream sections from overpressure. In the highly unlikely case that the first section of CCS1a (between LS03 and the first BVS) will be vented, the gas for re-pressurising this section will be from the next onshore segment and not from OSS3; in this way the need of a gas heater on the landfall valve by-pass, to compensate the significant Joule-Thomson effect of the high pressure gas accumulated in OSS3 is avoided.

6.3.3.2 *Block Valve Stations (BVS)*

The block valve stations are installed along the pipeline so that the pipeline can be isolated for maintenance or emergency reasons during operation. As the placement of the valves for the pipeline partitioning is determined, special emphasis is placed on locations where there is unobstructed access to the valves.

To determine the number of block valve stations, the following factors should be considered:

- The amount of gas release due to repair and maintenance blowdowns, leaks or ruptures;
- The time to blow down an isolated section;
- The impact of gas release on the area;
- Continuity of service;
- System operating and maintenance flexibility;
- Future development in the vicinity of the pipeline; and
- Significant conditions that may adversely affect line operation and security of the line.

It should be noted that according to the Design Code ELOT EN 1594 "Gas supply systems - Pipelines for maximum operating pressure over 16 bar – Functional Requirements" and the Greek Technical Regulation "Natural Gas Transmission Systems Operating at a maximum Pressure of over 16 Bar" no restrictions regarding spacing between BVS's are specified.

As per ASME B31.8 paragraph 846.1 terms, spacing between BVSs shall not exceed the following, taking into consideration the location class of the selected station sites:

- 32 km in areas predominantly location class 1;
- 24 km in areas predominantly location class 2;
- 16 km in areas predominantly location class 3; and
- 8 km in areas predominantly location class 4.

Spacing for sectionalising BVSs along the pipeline route (i.e. maximum distances) will also consider better site accessibility, adjusting the spacing slightly if required. Accessibility from main roads shall be also of primary consideration.

At this stage of design, there is provision for 15 BVS stations along sections CCS1 and CCS2. The maximum distance between two stations cannot be more than 32 km (when the location class is 1), and 8 km (when the location class is 4).Along Section CCS1, the maximum actually selected distance between two successive BVS (BVS-2 and BVS-3) is about 30 km, whilst the distance between BVSs varies in general from 20 to 29 km, except in few cases, where it is less than 20 km. Along section CCS2, the maximum selected distance between two successive proposed BVS's (BVS-15 and BVS-16) is approximately 31 km (at location class 1), while the distance between BVS's varies in general from 27 to 29 Km.

BVS stations are not manned and include a building (indicative dimensions 4.00 mx 4.00 m) in addition to the mechanical equipment (valves etc.). The plot is fenced. The block valve stations must be accessible for maintenance purposes during the operation phase of the pipeline.

The space required to install a block valve station varies from 4,000-9,200 m^2.

General layouts of block valve stations are provided in the relevant ANNEX 6C.

6.3.3.3 *Scraper Stations (SS)*

The SS have been designed for the use of permanent scraper launcher and receiver traps and to permit isolation, venting, de-pressurization and scraper operations. The locations of the SS have been defined, taking into consideration the necessity for inspection and maintenance of the pipeline system.

Scraper launcher and receiver stations will be installed at the following locations:

<u>CCS1</u>

- At inlet and outlet of the landfall station at Agios Fokas LF3 area (KP 0.30 of CCS1) at south-east Peloponnese;
- At the inlet and outlet of Heating / Metering/Regulating Station, and at the beginning of Megalopoli Branch pipeline (KP 138.43 of CCS1);
- At the inlet and outlet of CS3 (KP 265.17 of CCS1) ; and
- At Perivolia, at the end of the Megalopoli Branch pipeline (KP 9.89 of branch)

<u>CCS2</u>

- At LF5 – North of Patraikos Gulf at the inlet and outlet of the landfall station at Galatas (KP 0.59 of CCS2); and
- At Eleochori, an intermediate point in the section of pipeline (KP 118.13 of CCS2)

At the inlet and outlet of the compressor station at Florovouni (KP 233.13 of CCS2) the scraper stations will be designed for the use of permanent scraper launcher / receiver traps. The traps will be designed for bi-directional scraper operations; therefore, launchers and receivers will be identical.

The selected plot for installation of a SS should preferably located in a non-flooding area.

As far as the SSs' configuration, each scraper station will include the following:

- Permanent universal scraper trap with quick closing door and vent closure, installed on foundations; full bore weld end isolation valve;
- Kicker line with isolation valve for driving pigs connected to the major barrel of the scraper trap;
- Balance line to enable filling and pressurisation of the scraper trap barrel on both sides of the pig at the same time;
- Vent line with valve to vent stack for depressurising/degassing pipeline;
- Pig signallers to indicate the passage of pigs into or out of the trap;
- Pipework to or from the compressor station (when installed within a compressor station);

- Pipework to or from the corresponding scraper launcher or receiver (when installed within a scraper station), including a block valve configuration.

The scraper launchers and receivers will be equipped with pressure indicators, pig signallers and safety locks with vent line to prevent unintentional opening of the quick closing door.

Drain lines will be incorporated into the scraper traps in order to drain off liquid moved through the pipeline by pigs.

The bypass and vent valves are to be gate throttling, or plug valves.

The distance between valve and vent stack will be determined based on gas dispersion, vent stacks. The heat radiation threshold to the operators, similarly to a block valve stations, is set at a maximum of 9.46 kW/m², which is the permissible design level per API 521 for trained personnel with protective clothing (NOMEX) in emergencies. Piping to the vent stack will be buried.

The requirement for a thermal relief valve on scraper trap units will be assessed during the design phase based on solar heating on pipework that could have locked in gas. Relief valves are a potential source of failure and will only be fitted when there is a credible risk of overpressure

Table 6-16 Location of Pig Traps

System	Pipeline Segment	Pig Launcher Location	Pig Receiver Location
Southern Line	OSS1 – OSS2	ECP (Israel)	LF2 (East Crete)
	OSS3	LF2 (East Crete)	LF3 (South Peloponnese)
Combined Line	CCS1	LF3 at South Peloponnese	MS4/PRS4 (Megalopolis)
	CCS1	MS4/PRS4 (Megalopolis)	CS3
	OSS4	CS3	LF5
	CCS2	LF5	Municipality of Amfilochia (North Aitoloakarnania)
	CCS2	Municipality of Amfilochia (North Aitoloakarnania)	Poseidon CS (Florovouni)
Northern Line	OSS2N	LF1N (Cyprus)	LF2N (East Crete)
	OSS3N	LF2N (East Crete)	LF3N (South Peloponnese)

Source: ASPROFOS, 2022.

In normal operation the scraper stations will be unstaffed with the mainline valves in open position. The pigging operation will involve manual intervention and therefore local manual operation will be required.

General layouts of a scraper stations are provided in the relevant ANNEX 6D.

6.3.4 Main Stations

6.3.4.1 Compressor Stations

Introduction

Compressor stations are installed on pipelines of great length in order to provide the required pressure for gas transmission. Considering that there are limitations on the maximum allowable operating pressure for the pipes, more than one compressor station is required along the pipe.

Gas transmission is achieved by increasing the pressure in the compressor stations. Compressor stations mainly consist of gas treatment plants (separation filters), metering plants, compression and cooling plants. Compressor station plants consume the most energy and are considered the core of a gas transmission system.

The compressor station outside the compressor unit includes a gas cooler, power supply, water supply system, alarm, fire extinguishing system, shut-off valves, filters, etc.

6.3.4.2 Applicable standards

- **EN 12583**: Gas supply system - Compressor stations - Operating requirements;
- **API STD 616**: Gas Turbines for Petroleum, Chemical, and Gas Industry Services;
- **API STD 617**: Centrifugal compressors for the petroleum, chemical and gas industries;
- **API 610**: Centrifugal compressors for the oil industry;
- **EN ISO 10439** for Centrifugal Compressors;
- **EN 50443**: Effects of electromagnetic radiation caused by high voltages, high voltage AC power supply systems;
- **ICE/EN 60801**: Electromagnetic compatibility for industry - process measurement and equipment control;
- **EN 61000**: Electromagnetic compatibility;
- **ISO 3977-1**: Gas turbines — Procurement — Part 1: General introduction and definitions;
- **ISO 3977-2**: Gas turbines — Procurement — Part 2: Standard reference conditions and ratings;
- **EN ISO 10439-1**: Petroleum, petrochemical and natural gas industries - Axial and centrifugal compressors and expander-compressors - Part 1: General requirements; and
- **EN ISO 10439-2**: Petroleum, petrochemical and natural gas industries - Axial and centrifugal compressors and expander-compressors - Part 2: Non integrally geared centrifugal and axial compressors.

6.3.4.3 *Building Facilities*

A separate building is required for the housing needs of the station control system. Also, the fuel, lubricant and compressed air unit are located inside the building. Air-cooled heat exchangers as well as emergency valves are installed outside the building. The heating units of the building are located in a different location.

The additional elements of a compressor station are as follows[4] :

- Gas inlet / outlet device;
- Compressor building with gas turbines and compressors;
- Fuel measurement and adjustment unit;
- Air-cooled heat exchanger;
- Lubricant oil exchanger; and
- Ventilation chimney.

When designing, it is preferable to install the minimum possible number of gas turbines.

The maximum power, for each turbine, according to ISO, is set to 25.2MW for CS2, 25.2MW for CS2N and 17.5 MW for CS3.

A general compressor station, consists of:

1. Pipe inspection gauges (Pig) traps;
2. Filters;
3. Fuel gas heaters;
4. Turbine-compressor buildings;
5. Gas coolers;
6. Control building; and
7. Maintenance building and warehouse.

[4] "Preliminary Design Report - Onshore"

Source: : IGI Poseidon, 2022

Figure 6-14 CS2 / MS2, CS2 / MS2 N Station - General Layout

Source: : IGI Poseidon, 2022

Figure 6-15 CS3 Station - General Layout

Each compressor station will mainly be comprised of facilities for gas treatment (filter separators), metering, compression and cooling. The size of the land plot required for as compressor station varies from 16.8-10.8 ha. The area required for the compressor station buildings, facilities such as piping, vents and coolers, and other infrastructure, such as roads, is approximately 25%. The remaining area will remain empty.

Details are provided in the relevant ANNEX 6E.

6.3.4.4 *Fire Extinguishing System*

Each compressor station is equipped with a complete, autonomous fire extinguishing system consisting of the following:

- Firefighting network;
- A fully automated, autonomous water supply system for firefighting (fire detection);
- Autonomous carbon dioxide suppression system ("CO_2 fire suppression system") for the power plants and boiler rooms of the control building and the auxiliary facility building;
- An "Inergen" type fire extinguishing system for the control room and the RCC building;
- Fire alarm system;
- Fire hydrants; and
- Portable and wheeled fire extinguishers.

6.3.4.5 *Utilities*

More specifically, the compression stations in Greece generally include the following utility systems:

- Vent (cold vent) system for emergency release and depressurisation of the facilities;
- Process drain system for collection of liquid hydrocarbons;
- Open drain system for collection of rain / spilled fluids;
- Rainwater collection system (from the areas where rain water cannot go to soil);
- Sanitary drain system for collection of sanitary waste / fluids;
- Instrument and utility air system for valve actuators, tool-air and nitrogen production;
- Nitrogen system for secondary seal flush of the compressors and purging of vent system;
- Diesel system;
- Potable water system for domestic use; and
- Utility water for use in the plant.

6.3.4.6 *Drainage and Effluent Management*

General effluent management considerations are described below. The specific drainage and effluent treatment philosophy at the compressor stations is outlined here.

The following types of wastewater are taken into consideration in developing the drainage philosophy:

- uncontaminated storm water;
- sanitary wastewater; and
- oily water.

The systems for handling these different groups of waste water are outlined in the following sub-sections.

6.3.4.6.1 Rainwater

Rain water and surface water run-off will be non-polluted water arising from the following areas:

- building and shelter roofs;
- roads and traffic areas; and
- areas beside roads and traffic areas.

The rain water system deals with uncontaminated runoff from buildings roofs, roads and paved areas, as well as from all other areas outside the tank bunds and catchment basins. Rainwater from these areas is considered clean water, not requiring any treatment. Based on EN 752, rainwater will be collected by curb stones and gullies in the sewerage system and will be discharged in nearby rivers following the requirements of responsible authorities. If necessary, retention of rain water is considered with sewer with storage capacity according to EN 752.

6.3.4.6.2 Sanitary Sewer (Wastewater)

Waste water will arise from the sanitation facilities within the buildings. Water from the sanitation facilities will be collected within the wastewater system.

The average sanitary waste water during operation is estimated at 700m^3/yr for each compressor station.

Sanitary water is collected from several drains and collected to a Waste Water Storage tank. Since the public network is not available in the Compressor Stations' areas, the effluent of the Waste Water Storage tank shall be collected by trucks and discharged to proper locations.

6.3.4.6.3 Oily Water

Oily water will arise from the following areas:

- floor drains from compressor area;
- buildings;
- floor drains from the metering station;

- floor drains from gas in/outlet facilities (pig launcher and receiver);
- floor drains from diesel area (emergency diesel generator and back-up generator) and diesel unloading area;
- floor drains from condensate loading area; and
- floor drains from purified water unloading area.

Effluents from floor drains of buildings will be treated by separators before being discharged into storm water systems. The separator will be designed in accordance with EN-858. No oily water occurs in normal plant operation, therefore the separators are installed to deal with non-routine or emergency events.

The following tables present sources of oily wastes within compressor and metering stations. Oily wastes arise from tank discharging and maintenance works.

Table 6-17 Sources of Oily Wastewater in Compressor Stations

Stored Material	Location	Quantity Stored On-Site CS2 / CS2N	Quantity Stored On-Site CS3	Pathways
Diesel Oil	Diesel Storage Tank	50 m^3	25 m^3	containment basin
Diesel oil	Emergency Diesel Generator	1.0 m^3	0.5 m^3	containment basin
Condensates	Condensate Storage Tank	30 m^3 + 30 m^3	15 m^3	double walled tank
Lubricants	Backup Generator	14 m^3	7 m^3	containment basin
Lubricants	Turbocompressor Units	22 m^3x 7 units	6 m^3x 4 units	containment basin
Oil	Water/Oil Separator	n/a	n/a	containment basin
Wastewater from GT washing	Washing Water Tank	7 basins x 0.6 m^3	4 basins x 0.6 m^3	containment basin
Detergents for GT washing	GT Building	n/a	n/a	containment basin
Detergents for GT washing	Storage Area	6 m^3	2 m^3	containment basin

Source: IGI, 2021

6.3.4.7 *Compressor Stations of the EastMed Pipeline Project*

The new compressor stations (CS) that will be located in the Greek onshore area are the following:

- Compressor station in Crete (single plot where CS2 and CS2N are included); and

- Compressor station in Achaia (CS3).

Compressors will be centrifugal with dry air sealing devices. The power of the compressors comes from gas turbines that are supplied with natural gas (NG) and are located inside the compressor stations. The number and size of the gas turbines will be optimised to provide the necessary energy requirements for the desired operating parameters of the pipeline. Additional units that will be on standby in case of fault are also included.

The gas turbine fuel is NG which is supplied from the pipeline. The exhaust gases of the gas turbines will be discharged into the atmosphere through one chimney per gas turbine (with a minimum height of about 20 m). Also, a ventilation chimney is designed for each station through which natural gas can be released in case of unexpected overpressure in the system or in case of emergency.

The compressor stations (CSs) will have an installed capacity of approximately 4x25.2=100.8 MW for CS2, 3x25.2=75.6 MW for CS2N and 4x17.5=70 MW for CS3 which will originate from multiple (+1 back up common spare) compression units.

Based on PD GG 293/D/1989, the minimum distance of the CS from the boundary of a declared settlement corresponds to 500m from the boundaries of the settlement, as applicable (for medium and high nuisance installations).

Table 6-18 Basic Technical Data for Compressor Stations

Parameter	CS2	CS2N	CS3
Total flow (BSCM/yr)	11[5]	10	20
No. of compressors operating	3	3	3
No. of spare compressors	1		1
Gas flow per compressor (Sm3/hr)	465,083	422,723	776,569
Required power (MW) per compressor	17.6	14.7	10.0
ISO power (MW) per compressor at site conditions	25.2	25.2	17.5
Minimum Total installed ISO power (MW)	4* x 25.2 = 100.8	3 x 25.2 = 75,6	4 x 17.5 = 70
Annual Fuel gas Consumption (MMSm3/yr)	115	96	70
No. of stages	1	1	1
* this results from the 3 operating compressor units and the 1 spare.			

[5] CS2 referred to Southern Line (11 BSCM/Y) and CS2 N referred to Northern Line (10 BSCM/Y), whilst the Combine Line has 10.5 BSCSM/Y for each one.

Source: P617-000-BD-DBS-01_3, Design Basis Memorandum – Facilities and E780_00225-Ev31A-TDR-00051_2_System Consolidation Report

CS2

The Station in Crete will host the following facilities:

- Compressor and Metering Station CS2/MS2 (for Southern line operation);
- Landfall Station LS02 and Scraper Station (for Southern line operation);
- Compressor and Metering Station CS2/MS2N (for Northern line operation); and
- Landfall Station LS02N and Scraper Station (for Northern line operation).

The Compressor and Metering Station CS2/MS2 will be installed for the Southern line operation and will be capable of receiving, metering and compressing natural gas coming from the Israeli sources via the offshore pipeline OSS2 to be forwarded onwards to Peloponnese, at a flowrate of 11 BSCM/yr

The Compressor Station/Metering Station/Scraper Station facilities comprise of the following major components:

- Scraper Station (Launcher and Receiver);
- Station isolation valves and main line bypass valves;
- Filter separators;
- Compressor and driver units;
- Air coolers;
- Lube oil coolers;
- Fuel gas skid;
- Vent stack(s);
- Administration and Maintenance building; and
- Electrical and Control building.

Mechanical Utilities building

- Fire water tank and pump station; and
- Electrical Diesel Generators and fuel tank.

For the operation of the Northern Line, Compressor and Metering Station CS2/MS2N will also be located in the same plot, capable of receiving, metering and compressing the natural gas. coming from Cypriot sources.

Both stations in operation will handle gas through Southern and Northern Lines resulting in a total flowrate of 21 BSCM/yr.

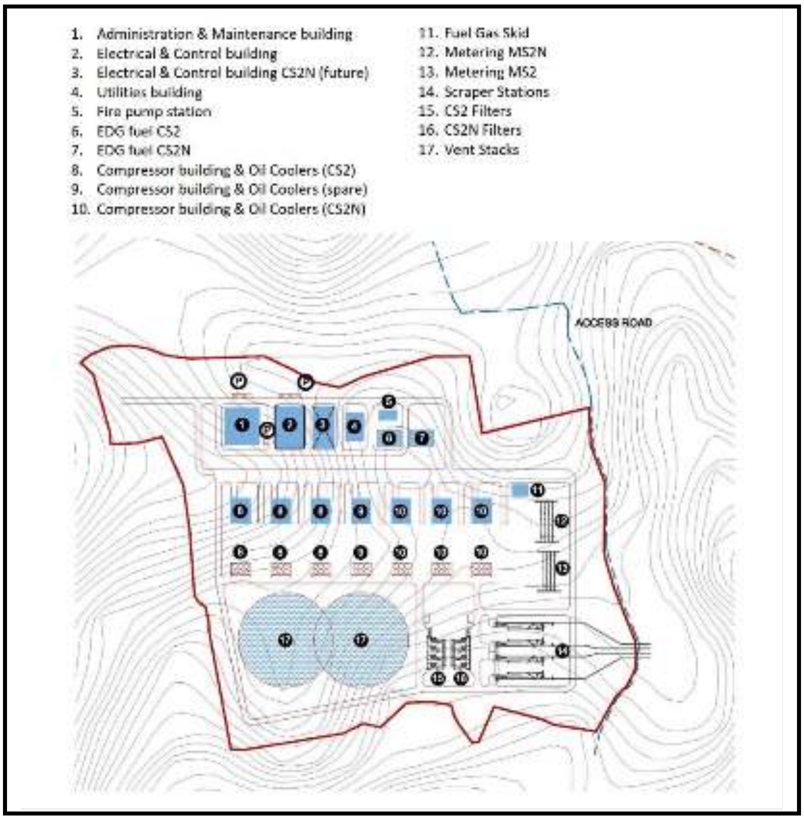
The two stations will "share" only the following equipment/buildings:

- the vent stack(s);
- the 'administration, workshop and storage building';
- the control room (provision for a future electrical building engaged to this station); and
- the spare turbocompressor unit.

LS02 and LS02N

Due to short distance of the CS2/MS2, CS2/MS2 N plot from LF2, the plot will also host the landfall stations LS02 (Southern Line) and LS02N (Northern Line). LS02 and LS02N will be equipped with pneumatic actuated (gas-over-oil) full bore block valves in the main lines, a by-pass of each main valve, equipped with two ball and one gate throttling valves, to enable pressure equalisation on both sides of the main valve before opening.

All valves of LS02 and LS02N will be installed underground.



Source: P617-340-RP-TOP-02_3, 12.07.2021. Site Selection Report for Compressor and Metering Stations CS2/MS2 and CS2/MS2 N.

Figure 6-16 Indicative Preliminary Layout on Proposed Plot for CS2

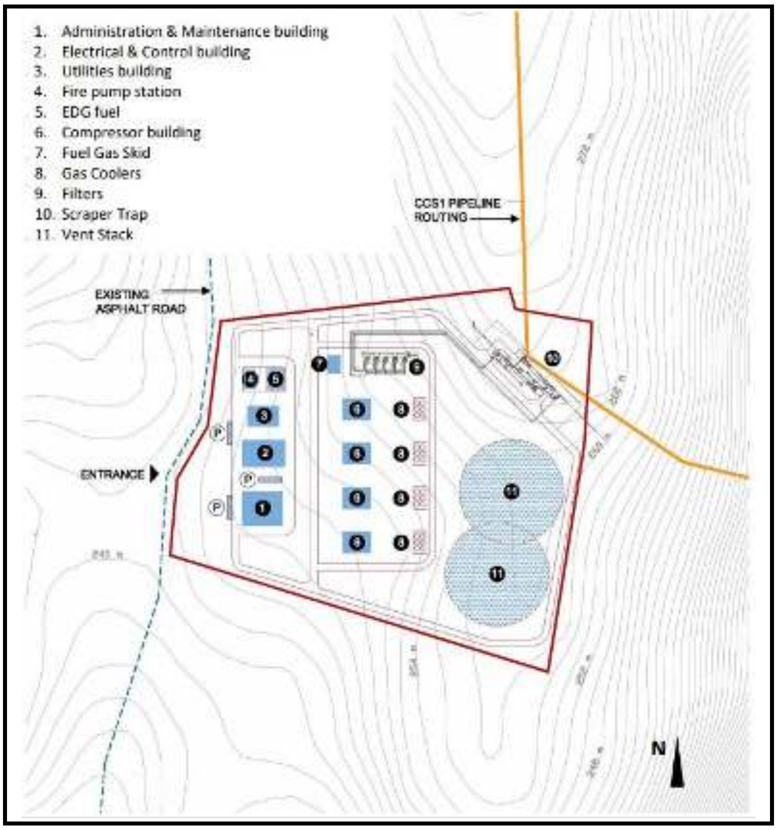
CS3

Compressor station CS3 will be installed for the 'Combined Line' operation and will be capable of receiving and compressing the natural gas coming from the specified sources via offshore pipelines OSS3 and OSS3N and onshore pipeline CCS1 to be forwarded onwards to the compressor station of Poseidon Pipeline Project, at Florovouni..

Compressor station CS3 is required only for the 'Combined Line' where both Southern and Northern Line will be in operation, for onward transport toward the compressor station at Florovouni in north-west Greece (Poseidon Pipeline Project).

As the CS3 station will be installed downstream from the take-off point for the Megalopoli MS4/PRS4 station and relevant branch line up to the tie-in to the national gas grid (with design capacity of 1 BSCM/yr), the CS3 station will be able to handle 20 BSCM/yr of natural gas.

The major components of CS3 are the same as described on CS2.



Source: E780_P616-360-RP-TOP-01_3, 30.06.2021. Site Visit and Site Selection Report for Compressor Station CS3.

Figure 6-17 Indicative Preliminary Layout on Proposed Plot for CS3

6.3.4.8 *Metering Station*

A metering station consists of the following elements:

- Metering;
- Pressure Control / Safeguarding; and
- Pressure Regulating / Start-Up.

Due to the limited number of components in the station the function of the metering, pressure control / safeguarding and pressure regulating / start-up are combined in the process trains.

The purpose of the metering unit is to measure the quantity/quality of gas being transferred between the upstream pipeline operator and EastMed. The (combined) metering unit consists of the following components:

- Scrubbers;
- Start-up heaters;
- Pressure control valves;
- Metering runs;
- Sampling and analyzing systems; and
- Pressure safeguarding system.

The purpose of the sampling system is to accurately determine and log the properties of the gas (composition, heating value etc.).

The purpose of the scrubbers is to ensure that any liquids/solids from the upstream (pipeline) system do not end up in the metering run.

Ultrasonic pay meter will be applied with an ultrasonic check meter.

The start-up heater and pressure control valve are only used during start-up after a system trip (i.e. the flow in the pipeline has stopped and pipeline pressure has settled-out). During such scenario the pressure control valve is active to ensure slow start-up and to ensure that the normal operating pressure in the downstream pipeline is not exceeded. The heater is active to compensate for the temperature drop (JT-effect) at the pressure control valve.

The purpose of the safeguarding system (HIPPS) is to ensure that the metering station cannot cause a too high pressure in the downstream pipeline system (system downstream battery limit).

The metering station also includes the following utility systems:

- Vent (cold vent) system (for emergency release of gas);
- Process drain system (for collection of liquid hydrocarbons);
- Open drain system (for collection of rain / spilled fluids) to water/oil separator;

- Rain water collection system (from the areas where rain water cannot go to soil);
- Sanitary drain system (for collection of sanitary waste / fluids) to septic tank;
- Instrument and utility air system (for valve actuators and tool-air);
- Nitrogen system (for purging of vent system); and
- Diesel system (for diesel supply to emergency diesel gen set).

The metering unit is installed in an n + 1 configuration to ensure that the overall availability of the system is adequate.

The following metering stations have been designed for the Greek section of the EastMed Pipeline Project:

- Two metering stations in Crete, at the same location as the compressor station (MS2 and MS2N, one for CS2 and the other for CS2N), and
- A metering station in the broader area of Megalopoli (MS4).

The metering station of EastMed in Crete will be located inside the compressor station while the one in the area of Megalopoli in an individual position.

A general layout of a Metering Station is provided in the relevant ANNEX 6F.

Table 6-19 Basic Technical Data for Metering Stations

Parameter	MS2	MS2 N	MS4
Flow capacity	11[6] BSCM/yr	10 BSCM/yr	1 BSCM/yr
Inlet pressure (max)	77 barg	77 barg	93 barg
Inlet temperature (min)	1.9 °C	3.4 °C	0 °C
Outlet (delivery) pressure (min)	75 barg	75 barg	25 barg
Outlet temperature (min)	1.9 °C	3.4 °C	3 °C

Source: P616-000-BD-DBS-01_3, Design Basis Memorandum – Pipeline and Facilities E780_00225-Ev31A-TDR-00051_2_System Consolidation Report

The following table present sources of oily wastes within metering stations. Oily wastes arise from maintenance works:

[6] CS2 referred to Southern Line (11 BSCM/Y) and CS2 N referred to Northern Line (10 BSCM/Y), whilst the Combined Line has 10.5 BSCSM/Y for each one.

Table 6-20 Sources of Oily Wastewater in Metering Stations

Stored Material	Location	Quantity stored On-Site MS4	Pathways
Diesel Oil	Diesel Storage Tank	2.5 m^3	double walled tank
Diesel oil	Emergency Diesel Generator	0.5 m^3	containment basin
Condensates	Condensate Storage Tank	3.7 m^3	double walled tank
Oil	Water/Oil Separator	n/a	containment basin

Source: IGI Poseidon, 2021

6.3.4.9 *Heating Station*

Gas will be heated for the combined operation of the Southern and Northern Lines when the 48/46-inch cross-country pipeline allows transportation of 21 BSCM/yr up to the Metering station in Megalopoli and 20 BSCM/yr from there onwards in order to avoid condensation inside the pipeline.

The heating station location is in Megalopolis within the same plot as MS4/PRS4.

So, for the total flow of 21 BSCM/yr downstream of LS03, a gas heating station will be required to ensure the gas temperature remains at least 5 °C above the dew point along the route.

The heating station will include gas /water heat exchangers. Basic operation data for the exchanger operation is provided in below tables.

Table 6-21 GRS Design Data – Combined Southern and Northern Line

Parameter	Value
Flow capacity	20 BSCM/yr
Inlet Pressure	73.6 barg
Pressure drop (max)	2 barg
Inlet temperature (min)	1.2 °C
Outlet temperature (max)	7 °C

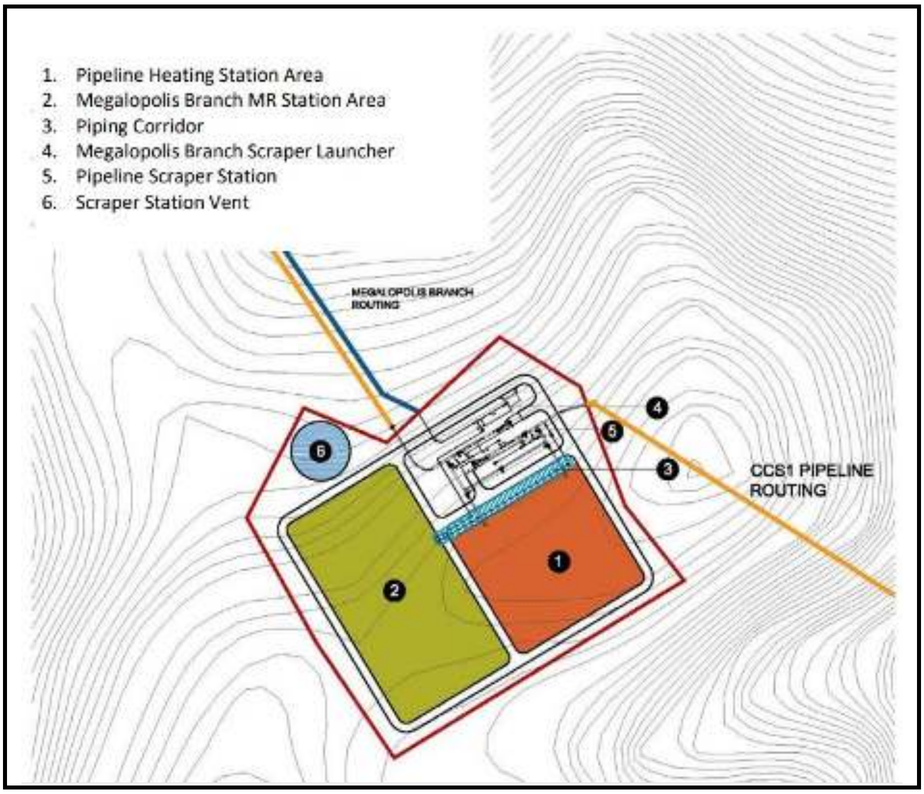
Source: P616-370-DB-BDS-01_2_ Design Basis Memorandum – Heating Station

Table 6-22 GRS Results – Combined Southern and Northern Line

Parameter	Value
Required Total Station Heating Duty (MW)	25.4
Annual Fuel gas Consumption ($MMSm^3$/yr)	21.2

Source: E780_00225-Ev31A-TDR-00051_2_System Consolidation Report

A general layout of a heating station is provided in the relevant ANNEX 6H.



Source: E780_P616-300-RP-TOP-01_3, 20.04.2021. Site Visit and Site Selection Report for Megalopoli Metering & Pressure Reduction Station MS4 / PRS4 and Heating Station.

Figure 6-18 Indicative Preliminary Layout on Proposed Plot for MS4 / PRS4 and Heating Station

6.3.5 Operations & Maintenance Base (O&M) – Dispatching Centre

The proper operation of the gas transmission system requires the construction of facilities that include the buildings for the Control, Operation and Maintenance of the pipeline (MDC and O&M: Main Dispatching and Operation & Maintenance Center (s)). For this reason, it is planned to install a main O&M base, in the wider area of Western Achaia, which will be manned 24 hours a day, 365 days a year. A backup dispatching center (BDC), which will duplicate all the functions of the main control center, except the training for the pipeline and the interfaces with the business systems and the maintenance systems, is planned to be installed in Crete, at the CS2/ MS2 station. The O&M bases will be constructed in at a proper location in the wider area of the pipeline route.

The main functions for the O&M base are:

- Monitoring, control and operation of the EastMed pipeline from a dedicated control room;

- Provide base for field maintenance and patrol crews;
- Provide basic maintenance and repair facilities of pipeline components including pipes, pipe fittings, pipeline instruments and cathodic protection equipment;
- Provide warehouse facilities for pipeline system spare parts; and
- Provide office space and facilities for technical and administrative personnel.

The number of the required facilities and the proper location of these facilities along the pipeline route depends on length of pipeline, location of the pipeline stations and other project specific characteristics. For the specific Project, one main O&M Base is foreseen to be located in western Greece Region. More specifically, the main O&M base is proposed to be located in the wider area of the municipality of West Achaia, taking into consideration the major site selection criteria for such installation, such as availability of sufficient area to accommodate the foreseen facilities, location not far away from pipeline route, proximity to major highway junction to facilitate ease of access to the centre, from the centre to remote stations and use of existing local road network, easier permitting / authorisation process to build, easy interconnection with existing/available utilities, etc.

The O&M base is a compound consisting of a series of buildings and outdoor facilities that serve the pipeline system. The buildings will provide sufficient working space for at least 30 employees.

The following buildings are foreseen:

- Office Building;
- Maintenance (Utilities) Building;
- Maintenance (Workshops) Building;
- Garage Building;
- Warehouse Building; and
- Security Office.

The other facilities of the Dispatching and O&M Centre are:

- Underground water tank and pump station;
- Outdoor Storage Area (Pipe stack);
- Outdoor employee and visitor Parking Area;
- Outdoor truck Parking Area;
- Wastewater treatment unit; and
- Borehole, if required.

Remote Control and Communication (RCC), Supervisory Control and Data Acquisition (SCADA) and Telecommunication systems will be installed for control and monitoring of the EastMed pipeline system. All stations will be equipped for fully unstaffed operation and will be remote-controlled from the dispatching centre.

The station consists of the aforementioned 6 building entities and outdoor utilities. The buildings will be arranged on a compound to facilitate intercommunication and employees' mobility. Inside the plot, a network of asphalt roads will be provided to cover all facilities, as well as entry-exit to and from the station. The entire compound is enclosed by a high security fence and is accessed through a main entrance. The buildings' surrounding area will be paved and equipped with ramps to ensure accessibility. Unpaved areas of the station will be planted to restore the character of the landscape and enhance the working environment.

In general, station buildings will be configured as single-story cast in situ reinforced concrete structures with masonry infills and thermal insulation. The roofs will be flat pitched and will be accessible for necessary maintenance works. The material rendering of the buildings will ensure durability, functionality and ease of maintenance, while aesthetically they will have minimum visible impact on their environment. All buildings will be equipped with swing/swivel windows to improve building security, weather-tightness and thermal insulation.

<u>Office Building</u>

Approximate area: 1,000 m^2

The Office Building of the Dispatching and O&M Centre will accommodate all necessary office spaces for administrative, engineering and assisting personnel, as well as meeting room, break room, sanitary rooms and building mechanical areas.

<u>Maintenance (Utilities) Building</u>

Approximate area: 410 m^2

This building is the central plant for hot water, chilled water and electric power, supplied through the necessary networks to all buildings of the Dispatching and O&M Centre.

<u>Maintenance (Workshop) Building:</u>

Approximate area: 490 m^2

The building accommodates all electrical, instrument and mechanical workshops, as well as sanitary facilities..

<u>Garage Building:</u>

Approximate area: 410 m^2

The building will provide a closed parking space for at least two jeeps and two lorries, suitable for vehicle loading and unloading, fitting of snow chains, etc.

Warehouse:

Approximate area: 410 m^2.

The building shall provide closed central storage facilities.

Guardhouse:

Approximate area: 20 m^2

This structure is to be located at the main entrance of the Dispatching and O&M Centre and will provide a small security office and restroom facilities for use by security personnel, which control access to the facility.

In the outdoor areas of the plot al least the following utilities will be provided to serve the Station operation:

Water Tank and Pump Station:

A buried underground structure will be provided which accommodates the required water storage tank and pump station facilities to cover the fire fighting and service water needs of the Dispatching and O&M Centre.

Wastewater:

A wastewater treatment package unit will be established and designed to ensure the wastewater from the Dispatching and O&M Centre meets legislation requirements prior to disposal.

Pipe Stack Area:

An outdoor area of approximately 2,000 m^2 will be designated for pipe storage.

Parking Areas:

Outdoor employee and visitor Parking Area, as well as parking for two trucks are included.

It is estimated that for the O&M base buildings, the outdoor storage area and the necessary surrounding area including roads, a land of approximately 32,000 m^2 is required.

Source: P616-400-RP-TOP-01_3, 20.04.2021. Site Survey Report for Dispatching and O&M Centre

Figure 6-19 Indicative Preliminary Layout on Proposed Plot for Dispatching and O&M Centre

The design of the O&M base will be in full conformance with European Codes and Standards, and with all valid Greek Building Code Regulations (New Greek General Building Terms Regulation, Greek Building Requirements Regulation, Greek Regulation for the Energy Efficiency of Buildings, Greek Regulation for Fire Resistance Requirements of Buildings, etc). Structural design will be in compliance with Eurocodes and relevant Greek National Annexes. Seismic loads will be determined based on seismic response spectrum parameters, such as seismic zone, peak ground acceleration, soil class, importance factor, behaviour factor, damping and spectral amplification factor, defined in Eurocode 8 (EN 1998) and in the relevant Greek National Annex. Seismic loads of buildings or structures will be determined by considering an importance factor which corresponds to importance category IV according to EN 1998.

It is noted that for the licencing of the Operation and Maintenance Buildings, the licencing procedure foreseen by Greek legislation will be followed in the next phase of the Project and once their technical characteristics have been finalised. To date, data are classified into Category B projects and activities and no ESIA assessment is required, but they are subject to standard environmental commitments.

6.4 Project Construction

6.4.1 Project Construction Overview

6.4.1.1 Project Timeline

Tentatively, project execution is anticipated for 2024 in Greece. The final, specific construction schedule depends on various technical variables (permitting procedure, contractor(s) awards, etc.) and on environmental and socioeconomic factors, such as biodiversity sensitive periods (e.g. bird nesting and breeding).

Should construction commence in 2024, commissioning of the Project will then take place after December 2026. That is, Project construction is expected to take approximately 3 years.

Table 6-23 provides a summary of the expected planning for the major Project component construction. It is highlighted that pipeline construction is a sequential procedure, meaning that construction duration at a specific location will be much shorter than the overall durations indicated in Table 6-23.

Table 6-23 Overall Duration of Construction of Project Components

Project Component	Duration of Construction
Approx. 840 km offshore pipeline	Approx. 30 months including pipe procurement, pre-lay activities and post-lay activities.
5 short onshore sections	Approx. 24 months including construction of landfall sites, pipeyards establishment, preparatory works (preparation of working strip, trenching, etc), testing, LS, etc.
Approx 550 km onshore underground pipeline	Approx. 36 months including construction sites and pipeyards establishment, preparatory works (preparation of working strip, trenching, etc.), testing, BVS, etc.
Southern Line Facilities	36 months
Northern Line Facilities	36 months
Pre-Construction Activities	6 months
Construction sites	4 months

Project Component	Duration of Construction
Marshalling yards	24 months overlapped with pipeline installation activities
Pre-commissioning	3 months
* For both Southern and Northern Lines: Construction of the two Lines will not be performed simultaneously, except for the shore crossings LF2, LF3.	

Source: IGI, 2021

6.4.1.2 *Machinery and Equipment*

6.4.1.2.1 Onshore

Onshore project construction is a conventional civil engineering project not requiring unusual equipment or construction techniques. The major items of construction equipment needed are bulldozers, heavy excavators, spoil removal trucks, large, heavy lift cranes, standby generators, excavators, side booms/pipe layers, rock breakers, etc.

Table 6-24 summarises the most typical onshore construction equipment.

Table 6-24 Typical Construction Equipment

Type of Equipment		
Excavator	Air Compressor	Side-boom
Backhoe loader	Pipe facing machine	Pipe bending machine
Crane	Sand blasting set	Engine generator
Dozer	Dewatering pump	Pay-welder
Dump truck	Air dryer	Pile driver
Motor grader	Feeding pump	Concrete mixer
Forklift	Lifting pump	Concrete pump
Stringing tractor	Pipelayer	Soil compactor

Source: ASPROFOS, 2022

6.4.1.2.2 Offshore and Nearshore

The offshore construction activities will require a number of vessels. The main vessels will be the pipeline installation vessel, such as an anchored pipelay vessel or a dynamically positioned lay vessel.

Table 6-25 Typical Construction Equipment - Offshore/Nearshore

Type of Equipment
Deepwater pipe lay vessel
Intermediate water depth S-lay vessel
Shallow water S-lay vessel

Type of Equipment
Platform supply vessels (PSV)
Multi-purpose support vessel (MSV)
Pipe supply vessel/Pipe bulk carrier
Pipe delivery vessel

Source: IGI Poseidon, 2021

The main difference between anchored and dynamically positioned pipelay vessels is the way the position and movement is maintained while laying pipes. Anchored vessels make use of anchors which are positioned by tugs; whereas dynamically positioned vessels make use of a dynamic positioning system, a computer controlled system which automatically maintains the vessel position and heading by using its own propellers and thrusters, with no anchor handling tugs involved. Three different pipe lay vessels are anticipated during offshore pipeline construction activities, one for shallow waters (from 5 to 30 m WD), one for intermediate and deep waters (from 30 to 1,600 m WD), and one for deep waters (from 50 to 3,000 m WD). The nearshore pipe lay vessels will be barges, specialised because their flat bottoms allow operation in shallow water (up to 20/30 m WD).

Other vessels will be needed in the construction activities, such as supply vessels to provide the material needed, crew change vessels to ensure the crew shift, pipe carrier vessels, barges, cutter suction dredgers for trenching and dredging works in the nearshore section, tugs to assist anchored pipelay vessels, etc.

No anchored vessel will be involved for the offshore activities, while the presence of moored vessels in the nearshore area is not excluded. As a conservative approach, for the purpose of this ESIA, it is assumed that moored vessels will be used in the nearshore area, up to 20-50 m, and dynamically positioned vessels at greater water depths (> 50 m).

More details on vessels operation are reported in Section 6.4.2.1.

6.4.1.3 *Marshalling and Storage Yards*

Based on current design data, the marshalling yards will serve as a line-pipe logistics base only. Fabrication activities like multi jointing, anode installation and coating of pipe joints will be done at locations other than the marshalling yard—for instance, on board the installation vessel. Thus, a total marshalling-yard area of about 30 ha is necessary to stockpile the designated quantity of line pipe and other items needed for all sections of the Southern Line simultaneously, whilst for the Northern Line an area of 30 ha is estimated. Considering that the construction of Northern and Southern Line components will not be done simultaneously, the marshalling yards used for the Southern Line can be used for the Northern Line. Also, in order to ensure a smooth supply to the pipelay barge, marshalling yards will be used as a buffer between the pipe mills / coating yards and the pipelay vessel. The key functions for a marshalling yard are:

- Storage location for materials procured, mainly coated line pipe joints; this requires the availability of sufficient flat terrain;
- Access for the pipe carriers and supply vessels; this requires port facilities to unload mid-sized cargo vessels carrying coated pipe joints and to load these pipe joints onto supply vessels for transport to the pipelay vessel; and

According to the design of the project (FEED), use of the port of Astakos in Greece could be the marshalling yard for the entire OSS3 and OSS4 pipelines, and for a section of the OSS2 pipelines. The total stockpiling area will be about 18 ha. Alternatively, instead of Astakos port, the port of Thisvi or the port of Heraklion could be considered; however, Heraklion port has smaller capacity since it is an important destination for cruise ships and ferries, a fact that may interfere with pipe-supply operations. The port of Patras could be an option, especially for OSS4 section as the quantities of pipe needed are limited and its vicinity to the route. Also, the port of Piraeus could be considered as an alternative for supplying pipe to OSS3 and OSS4

The Greek storage and marshalling yard will make use of existing port facilities, ensuring many advantages:

- Reduction of amount of infrastructure development;
- Provision of quayside facilities/manpower;
- Provision of pilotage; and
- Bunkerage and tug services.

Table 6-26 Tentative List of Marshalling Yards

Yard Number	Supply Section	Location (Municipality)	Area (ha)		Active Time (months)
			Open	Enclosed	
1	OSS1-OSS2, OSS3 & OSS4	Astakos (Amphilochia)	35	2.0	36
2	OSS1-OSS2, OSS3 & OSS4	Heraklion *	5	N/A	36
3	OSS1-OSS2, OSS3 & OSS4	Thisvi*	N/A	N/A	36
4	OSS4	Patras*	8	0.8	12

Yard Number	Supply Section	Location (Municipality)	Area (ha)		Active Time (months)
			Open	Enclosed	
5	OSS3 & OSS4	Piraeus*	7	5.0	24
* these ports are mentioned as alternatives					

Source: 00225-Ev80A-TDR-00224_2 - Marshalling Yard Logistics Desktop Evaluation

Regarding the construction of the onshore pipeline sections CCS1 and CCS2, the pipes will be transported from the manufacturer(s) via sea shipments at the main ports of the area (Patra, Igoumenista and Astakos) and then to the main Marshalling Yards that will be located close to the main ports and will have sufficient pipe storage capacity to provide buffer storage in case of construction delays.

Small areas could be rented within the port areas for temporary storage before transferring to the main marshalling yards. However, this option should be investigated in cooperation with the port authorities.

From the main marshalling yards, the pipes will be transported to the local storage yards near the construction sites along the pipeline route. Their location will be selected close to main roads near the pipeline route to provide easy access. Delivery of materials to the storage yards will be in accordance with the construction time schedule. All relevant transportation will be limited to daylight hours as much as possible.

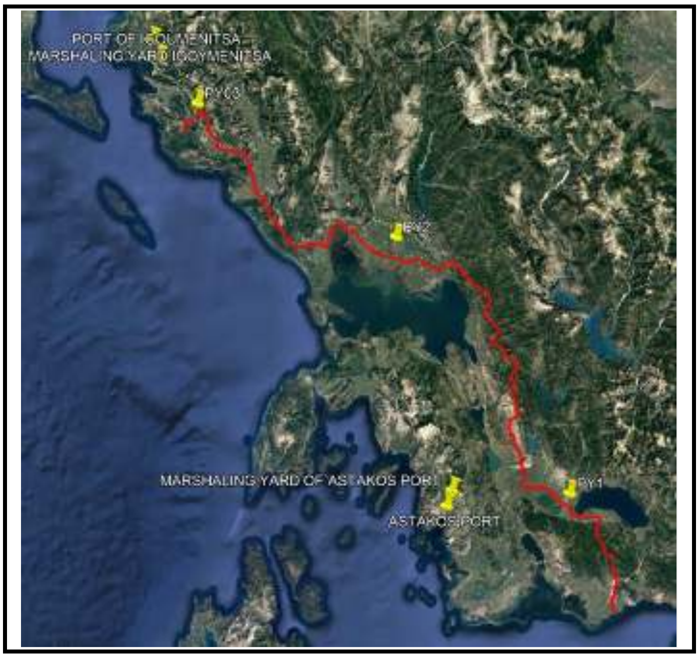
Specifically, pipes will be stored in such a way as to prevent corrosion and other degradation, prevent rolling and ensure stability of the pipe stacks. Pipes will be stacked in three levels at the most.

All storage yards will be fenced, lighted and guarded.

The following figures present an overview of the proposed locations for pipe yards along the CCS1 and CCS2 pipeline routes and access roads that will be used for the transportation of the material from the ports to the pipe yards. The following access roads will serve the transportation: Olympia Odos, Highway Corinthos-Tripoli -Kalamata, Lefktro-Sparti branch, National road Patra-Pyrgos and Ionia Odos motorway.

Source: IGI Poseidon S.A., 2021

Figure 6-20 Pipe Yards Along CCS1 Pipeline



Source: IGI Poseidon, S.A., 2021

Figure 6-21 Pipe Yards Along CCS2 Pipeline

The appointed construction contractor will have the opportunity to optimise the number and location of the planned pipe yards.

Taking into consideration that the EPC onshore pipeline contract will have a duration of thirty-six (36) months and construction of the temporary facilities will last approximately six (6) months, the active time of the temporary facilities will be thirty (30) months. All installations are of a temporary character and will be removed completely (including foundations) after the construction period. The entire area will be vegetated after demobilisation of infrastructure.

The short onshore sections at the landfalls are considered as part of the offshore sections and the storage requirements will be covered along with the main offshore sections.

Regarding the main facilities:

a) For CS2/MS2 and MS4/PRS4 in Greece, the temporary facilities are considered to be located within the stations' area; and
b) For CS3, the temporary facilities are considered to be located in a separate plot in the proximity of the stations.

Table 6-27 Tentative List of Pipe Yards for Continental Pipeline Sections

Number	Location (Municipality)	Section	Distance from Pipeline Section (m)	Area (m^2)
PY1	Monemvasia	CCS1	899	24,528
PY2	Sparti	CCS1	202	53,665
PY3	Megalopoli	CCS1	2,936	51,710
PY4	Archaia Olympia	CCS1	368	59,678
PY5	Dytiki Achaia	CCS1	1,017	58,229
MY1	Dytiki Achaia	CCS1	8,508	26,964
PY1	Agrinio	CCS2	269	48,353
PY2	Arta	CCS2	2,258	28,315
PY3	Igoumenitsa	CCS2	595	47,990
MY1	Xiromero	CCS2	18,032	22,619
MY2	Igoumenitsa	CCS2	18,950	34,035

Source: IGI Poseidon, 2021

6.4.1.4 *Construction Sites*

Construction site facilities are required mostly for construction personnel (e.g. construction crews, machinery operators, management and maintenance staff). Furthermore, company and third party inspection personnel will be considered. Apart from offices the construction sites will be equipped with a workshop for maintenance and stores for supply of pipeline construction logistics, machinery and equipment and with a helicopter landing place in case of emergency.

To define the design basis of the construction sites, IFC and EBRD guidance notes for workers' are set as a minimum standard. The main function of the construction sites is to ensure adequate working space for office and construction site staff to cater for necessary processes involved with the construction sites (Workshop, Truck Parking, Filling Station and Storage, etc.).

The design is based on the assumptions that no accommodation facilities will be foreseen and almost no infrastructure would be available in close proximity to the locations so that these sites must be as self-sufficient as possible. For the permitting process, it is assumed that the construction sites will be operated during the entire project construction phase. In the majority of the pipeline route, the RoW and facility plots will be used as construction sites. At special crossing locations the crossing construction sites are estimated to be 100X100 m^2 if the HDD crossing method will be applied, whilst the area of the entry pit for the boring method is estimated as 50X40 and the exit pit 30X40.

The following figures present an overview of the proposed locations for construction sites along the CCS1 and CCS2 pipeline routes and access roads that will be used for transportation of the material from the ports to the pipe yards. The following access roads will serve the transportation: Olympia Odos, Highway Corinthos-Tripoli -Kalamata, Lefktro-Sparti branch, National road Patra-Pyrgos and Ionia Odos motorway.

Source: IGI Poseidon, S.A., 2021

Figure 6-22 Construction Sites Along CCS1 Pipeline

Source: IGI Poseidon, S.A., 2021

Figure 6-23 Construction Sites Along CCS2 Pipeline

The appointed construction contractor will have the opportunity to optimise the number and location of the planned l construction sites. The construction sites areas are bordered with fences, gates and secured entrance areas. Paved areas are planned with gravel, concrete, pavement or asphalt surfaces. Lawned surfaces are provided for the office areas both for aesthetic reasons and reduce dust potential. All buildings (except workshops and stores) will be constructed using portable container units. Construction site lighting is foreseen. If municipal water supply is unavailable, suitable reservoirs (preferably underground) will be provided and potable water can be delivered by trucks. If possible, wells should be sunk. Wastewater disposal can be realised by septic tanks or if possible by a local wastewater system. The power supply can be ensured by diesel generators if no local power grid exists.

Taking into consideration that the onshore pipeline construction will have a duration of thirty-six (36) months and construction of the temporary facilities will last approximately six (6) months, the active time of the temporary facilities will be thirty (30) months. All installations are of a temporary character and will be removed completely (including foundations) after the construction period. The entire area will be reinstated after demobilisation of infrastructure.

Table 6-28 Tentative List of Construction Sites

Number	Location (Municipality)	Section	Distance from Pipeline Section (m)	Area (m^2)
Site-01	Evrotas	CCS1	453.225	53,135
Site-02	Megalopoli	CCS1	3,118.474	49,123
Site-03	Dytiki Achaia	CCS1	319.373	49,598
Site-01	Agrinio	CCS2	211.967	40,941
Site-02	Arta	CCS2	2,782.665	50,301

Source: IGI Poseidon, 2021.

As already mentioned, regarding the main facilities:

c) For CS2/MS2 and MS4/PRS4 in Greece, the temporary facilities are considered to be located within the station areas; and
d) For CS3, the temporary facilities are considered to be located in a separate plot in the proximity of the stations.

6.4.1.5 *Transportation of Goods and Project Accessibility*

6.4.1.5.1 Onshore

Transportation of Goods for Pipeline

Construction related traffic will use the existing road network and the upgraded roads to access the construction sites. From then on, traffic will use the construction strip as much as possible. Materials, such as prefabricated pipe joints, welding provisions, etc., will be stored at established storage yards. Materials will then be transported on heavy goods vehicles from these locations to the construction corridor. The main goods transported are the pipes. Each pipe will be around 12 to 18 m long and could weigh between 7 and 22 tonnes. Materials for civil construction will be temporarily stored within the construction corridor.

All pipes will be distributed to the storage yards along the pipeline route directly from the nearest port. Transportation will be provided by regular trailers as all yards are accessible via national roads.

Local access is mostly provided by existing roads, which are mainly in good condition. No new roads are required; the use of existing roads is considered sufficient. However, these might be upgraded to facilitate the transfer of heavy vehicles carrying the equipment and materials needed for the construction of the Project.

Heavy excavators, bulldozers and other special equipment will be required to prepare the construction working strip, to excavate the trench and lay the pipeline. An indicative estimate of construction traffic (per day) is presented below based on experience of other similar pipeline project construction. This traffic should be considered as an estimate of the traffic per day and per spread during construction (see Table 6-29).

Table 6-29 Indicative Construction Traffic Plan – Onshore Pipeline (Estimate per Spread and Day).

Number of Vehicles	Vehicle Description	Indicative Daily Movements to Each Site	Description	Comments
2	Light vehicles (4X4, etc.)	60	Approximately 30 two-way movements	60 movements per day to transport workers to site (15 two-way movements in the morning and 15 two-way movements in the evening)
4	Trucks	100	Approx. 50 two-way movements	100 one-way per day to bring material to the construction working corridor (pipe sections, sand for sand bedding, etc.)

Number of Vehicles	Vehicle Description	Indicative Daily Movements to Each Site	Description	Comments
4	Trucks	20	Approx. 10 two-way movements	20 movements per day to take material away from construction working corridor (e.g. excavated rocks which cannot be backfilled, clearing and grading (timber).
9	Trucks	10	Approx. 5 two-way movements	10 one-way per day to move construction equipment (such as bending machines, pipe layers and excavators). However, fewer movements for construction equipment should be expected, since these will be transported along the construction working corridor as much as possible.

Source: Asprofos, 2021

Contractor shall develop a Traffic Management Plan in consultation with competent authorities and municipalities, and implement it throughout construction.

<u>Transportation of Goods for Stations</u>

Similar to the one provided for the pipeline, heavy excavators, bulldozers and other special equipment will be required to prepare the station sites, to level the area, and perform other civil works. An indicative estimate of construction traffic (per day) is presented below, based on experience of other similar project construction. This traffic should be considered as an estimate of the traffic per day and per spread during construction (see Table 6-30).

Table 6-30 Indicative Construction Traffic Plan – Stations (Estimate per Spread and Day).

Number of Vehicles	Vehicle Type Description	Indicative Daily Movements to each site	Description	Comments
2	Light vehicles (4X4, etc.)	120	Approximately 60 two-way movements	120 movements per day to transport workers to site (60 two-way movements in the morning and 60 two-way movements in the evening)
4	Trucks	100	Approx. 50 two-way movements	100 one-way per day to bring material to each station site area
4	Trucks	20	Approx. 10 two-way movements	20 movements per day to take material away from construction

Number of Vehicles	Vehicle Type Description	Indicative Daily Movements to each site	Description	Comments
				working corridor (e.g. excavated rocks which cannot be backfilled, clearing and grading (timber).
9	Trucks	20	Approx. 10 two way movements	20 one-way per day to move construction equipment (such as construction machines) and station equipment.

Source: Asprofos, 2022

Contractor shall develop a Traffic Management Plan in consultation with the competent authorities and municipalities that is implemented throughout construction.

<u>Access to Stations</u>

Permanent access is required to the stations for construction works as well as for operation and maintenance. No new roads will be constructed, only improvements that might be necessary along the access roads. The heaviest transport units will be the Turbo Compressors with a total weight of 30 tons.

The transport routes for the stations are as follows:

- For CS2 and CS2N (Atherinolakos) from the Heraklion port the transport route follows the National Road; and
- For CS3 (Achaia) from the Astako port or Patra port or Piraeus port the transport route follows the National Road.

6.4.1.5.2 Offshore

The pipe joints and other items, which have been stored at the marshalling yards will be transferred onto supply vessels, which sail to and feed the installation vessels. Pipelay—and consequently feeding the installation vessel—is a continuous process. Table 6-31 provides an estimate of the number of shiploads needed to transport all line pipe from the marshalling yards to the installation vessel for each project section.

Table 6-31 Shiploads Needed for Each Pipeline Section

Offshore Pipeline Section	Number of shiploads for DWCC of 2,500 tons
OSS2	241

Offshore Pipeline Section	Number of shiploads for DWCC of 2,500 tons
OSS3	85
OSS4	11

Source: 00225-Ev80A-TDR-00224_1 - Marshalling Yard Logistics Desktop Evaluation

The number of pipe-supply vessels needed for continuous supply to the installation vessel has been estimated conservatively for PSV—DWCC of 2,500 tons and lay rate of about 5[7] km per day. The results are presented in Table 6-32.

Table 6-32 PSVs Needed for continuous line-pipe supply if the lay rate is 5 km/day

Marshalling Yard Location	Number of Pipe-Supply Vessels for DWCC of 2,500 Tons		
	OSS2 & OSS2 N	OSS3 & OSS3 N	OSS4
Heraklion	12	8	10
Astakos	18	8	3
Thisvi	20	10	4
Patras	18	10	2
Piraeus	14	6	10

Source: 00225-Ev80A-TDR-00224_2 - Marshalling Yard Logistics Desktop Evaluation

The number of PSVs is based on an average distance between the marshalling yard and the installation vessel for each pipe section (see Table 6-33).

Table 6-33 Sailing Distance Between Ports and Pipeline Sections

Marshalling Yard Location	Distance to Pipeline Section (km)		
	OSS2 & OSS2 N	OSS3 & OSS3 N	OSS4
Heraklion	650	550	590
Astakos	1,290	610	70
Thisvi	1,430	740	150
Patras	1,320	620	20
Piraeus	950	340	580

Source: 00225-Ev80A-TDR-00224_1 - Marshalling Yard Logistics Desktop Evaluation

[7] 5km/day is conservative considering the amount of vessels

6.4.1.6 *Services and Utilities*

Services and utilities (i.e., water supply, wastewater and sanitation, electricity supply, potable water supply, and solid waste management) will be provided through the local networks. If necessary, relevant infrastructure (e.g. transmission lines, water pipes, waste collection, etc.) will be extended to the work sites.

If there is a need to perform extensive infrastructure works for temporary services and utilities provision, i.e. power supply, a separate environmental permitting procedure will be followed, as and if required by relevant legislation.

6.4.2 Construction of the Pipeline

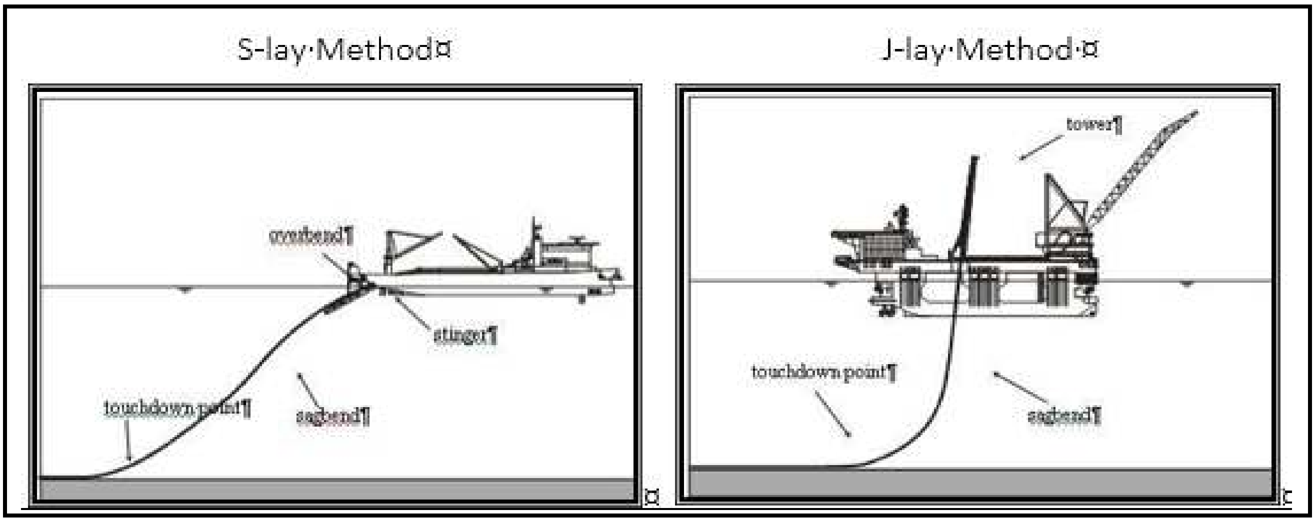
6.4.2.1 *Offshore Section*

The following section describes the two pipeline installation methods that might be used, the pre-lay and post lay activities, the laydown method and the sequence applied for the Greek offshore section, the potential seabed intervention works and repair activities that may be carried out along the pipeline.

6.4.2.1.1 Installation Methods (S-lay and J-lay)

The preferred offshore pipeline installation method for Eastmed Project is the “S-lay”, where the pipe is spanning from the vessel to the seabed in an S-like shape (Figure 6-24). To guide the pipe, it is supported on rollers by a stinger structure extending from the vessel into the water. The stinger is generally constructed as an open truss framework and may be rigid or articulated. The welding stations on an S-lay vessel are placed along the vessel axis and are orientated horizontally, which allows for relatively efficient offshore pipe string fabrication.

The “J-lay” installation method is recognized by the absence of the stinger and the high departure angle (Figure 6-24). The pipe is closer to the vertical on board the vessel than to the horizontal axis. Pipe joints, usually pre-fabricated multiple-joint strings, are lined up in a tower construction that is called the J-lay tower. J-lay is only applicable for deep water, where a long section of the pipe is suspended below the vessel in a catenary shape. The capacities of these vessels are set to suit this functionality. Compared to other installation methods, the tension capacity of the vessel is very high, but is specialised for holding the weight of the pipe string in deep water rather than for maintaining an acceptable pipe shape through the water column. J-lay equipment currently available can handle pipe diameters up to 32 inches.



Source: 00225-Ev80A-TDR-00325_1 – Pipeline Installation Methodology Report – Northern System

Figure 6-24 Offshore pipeline installation methods

In principle, the pipeline is simply placed on the bottom of the sea; however according to the current design level, few areas along the pipeline may require pre-lay or post-lay intervention to allow pipe installation and safe operation; that is ensuring pipeline stability and integrity or protection against external threats. Seabed features or specific pipe sections that may require seabed intervention and the proposed method are described in the related subsection below. The installed offshore pipeline is notified to all competent authorities and bodies to be included in the naval restriction maps (nautical charts).

The S-Lay method is the chosen installation technique for all offshore pipelines of the EastMed Pipeline Project. Nonetheless, J-Lay cannot be excluded as an option.

In order to assess the possibility of installing of the offshore pipelines, several analyses have been performed for each pipeline at critical locations in terms of water depth and / or pipe properties (i.e. weight, coating or wall thickness). For the deepwater pipelines of EastMed, the following key aspects are described:

- High tension requirements: high top tensions are reported especially for the deepwater portions of OSS2;
- High slope angles: mainly east of Crete, there will be a requirement for OSS2 and OSS3 pipelines that pipelay progresses both up-slope and down-slope with slope angles up to 30°-35°;
- Water depth variations: major water depth variations are found especially in the area east and north of Crete

During the installation of the offshore pipeline, it may be needed to perform some seabed intervention work (described in a sub-section below) in order to overcome the irregularities met on the seafloor surface (e.g. freespan, hoverangs, bumps, etc.). The type of work and the methodology to be used will be assessed on a case-by-case basis in a more advanced phase of the Project.

Pipeline Installation Vessels

For installation of the total offshore EastMed pipeline system, the following three types of S-lay pipelay vessels are distinguished:

a) High Capacity S-lay vessel:

  I. This is a semi-submersible or ship shaped vessel with a high-tension capacity capable of laying pipe in ultra-deep and deep water.
  II. These S-lay vessels employ large capacity tensioning systems and steep departure angle stingers to support the pipe to the seabed. These vessels could already start pipelay activities in shallow water, although shallow water, depending on water depth, may require a different stinger configuration (i.e. radius) than ultra-deep water.
  III. These vessels are dynamically positioned

b) Medium Capacity S-lay vessel:

  I. This is a semi-submersible or ship shaped vessel with a medium tension capacity, capable of working in a water depth range starting at 20 m to 30 m and continuing to intermediate to deep water, where the maximum water depth affect the pipeline configuration and specific vessel capabilities,
  II. Compared to the high capacity S-lay vessels, these vessels employ lower capacity tensioning systems and typically have a shorter stinger and are therefore not able to reach a steep departure angle,
  III. These vessels may be either anchored or dynamically positioned;

c) Shallow Water ("Lower Capacity") S-lay vessel:

  I. This is a relatively small, flat-bottom lay vessel with low tension capacity capable of working in a water depth range of 5 m to at least 30 m,
  II. Compared to the high and medium capacity S-lay vessels, these vessels employ lower capacity tensioning systems and typically have a shorter stinger,
  III. These barges typically use anchors for positioning / propulsion.

6.4.2.1.2 Pre-lay Activities

Before pipeline laydown, various activities need to be carried out to prepare the vessels and the pipes for the installation. The pipes will be transported from the storage area to the installation point. Welding will be performed on board the vessel, while advancing along the lay route in accordance with the rate of pipeline welding.

Pre-lay activities include:

- Mobilisation report containing certificates and documentation pertaining to port and sea trials as well as calibrations. Copies of manufacturer or test house calibration certificates will be included;
- Pre-lay survey;
- Inspection and testing;
- Pipe joint load out plans, including logistics and transport;
- Offshore loading;
- Stack height requirements (limits and locations onshore and offshore); and
- Line pipe bevelling and cleaning.

Firing line on board pipe lay vessel typically will include the following working stations:

- Line pipe storage station;
- Line pipe bevelling, cleaning and inspection station;
- Line-up station;
- Bead weld stations;
- Welding stations;
- Tensioner(s);
- Non-destructive testing (NDT) station;
- Blasting station;
- Field joint coating station;
- Coating repair station;
- Anode installation station; and
- Loose material installation station (such as buoyancy tanks, etc.).

6.4.2.1.3 Pipeline Laydown

Upon reaching the pre-determined target location on the seabed, the pipeline will be terminated, lowered onto the seabed and left ready for a subsequent recovery; for example, for midline above/surface tie-in operation. General laydown procedure will include:

- Installation of transponders and determining pipeline final cut to length while approaching to laydown target;
- Insertion of pipeline pup pieces and welding the laydown head (possibly completed with flange assembly) onto the pipeline as required;
- Finishing NDT check on all pipeline welds, anode installations and field joint coating;
- Checking the laydown head and making sure that the check valve and ball valve are in good condition and properly installed;
- Weld the laydown head to the flange assembly;
- Lay down the pipeline using the dedicated hook, winch, cable, rigging set and transponder in laydown target box in line with laydown parameters; and
- Conducting final check of pipeline position on seabed (survey).

<u>Pipeline Monitoring and Control</u>

Pipeline configuration monitoring can be realised on board a barge by:

- Stress/strain analysis (pipe lay data for sag bend and over bend) prepared in advance for various lay configurations;
- Barge station keeping data;
- Barge ramp data (stinger and barge roller boxes set-up);
- Tension data in relation to stress/strain calculation results;
- Roller box load data and control by load cells;
- Tip clearance data (sonar scan of stinger tip) and camera monitoring of rollers;
- Field weld (joint) sequential numbering/marking;
- Touchdown monitoring by ROV; and
- Weather forecast.

<u>Pipeline Abandonment and Recovery</u>

The pipeline installation vessel will have an abandonment and recovery (A&R) system to lower the pipeline to the seabed safely and subsequently recover it. Pipeline abandonment can occur for the following reasons:

- Regular laydown (e.g. for hand-over from one vessel to another vessel);
- Modification stinger settings of S-lay vessel;
- Equipment failure;
- Weather related (excessive vessel motions or insufficient dynamic positioned (DP) station keeping capacity); and
- Dry or wet buckle.

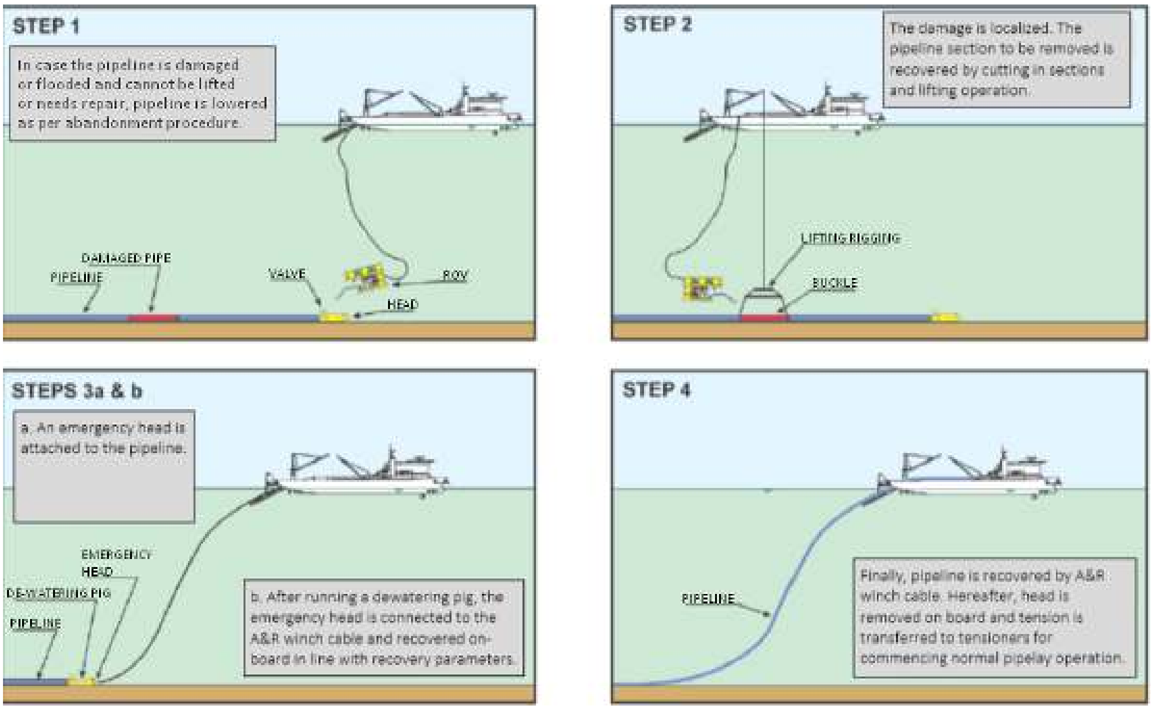
Given the above reasons for pipeline abandonment, the A&R system of the pipelay vessel should have sufficient capacity to abandon and recover an empty pipeline. During the pipeline abandonment procedure, the tension at the start of the abandonment is the governing factor as the tension reduces when the pipeline is lowered to the seabed. The abandonment procedure is performed by paying out the cable and offsetting the vessel away from the touch down point in such steps that all vessel and pipeline criteria are met throughout the process.

In the unlikely event of collapse of the pipeline cross-section (e.g. loss of station-keeping capabilities or mechanical failure), the weight that must be supported by the lay vessel increases significantly for both the "dry buckle" and the "wet buckle" scenarios. Almost none of existing deepwater pipelay vessels are capable of holding the weight of the flooded pipeline with its normal tensioner or hang-off system in (ultra-deepwater). As a consequence, the pipelay vessel cannot recover the damaged section of pipeline by reversing the pipelay process until the buckle is removed. Instead it requires lay down of the buckled pipeline in a controlled manner followed by remedial work on the seabed before pipelay can be continued. Several recent deepwater pipelines have been installed without the vessel having sufficient capacity to hold a flooded pipe. Rather the installation procedures have focused on immediate detection of buckles followed by rapid abandonment of the pipeline. A Contingency (pipeline damage repair) Procedure will be in place, during lay-down activities at sea. The subsection below further addresses flooding contingency.

Typical contingency scenarios include:

- Dry Buckle: is a buckle or damage (dent) to the pipeline that is caused by unknown accidental loads where the pipeline wall is not broken and it does not result in any leakage of the product pipeline. An unacceptable dry buckle will be assessed and if possible pipeline will be retrieved on board by cutting back until the dry buckled section is retrieved. Hereafter, normal pipelay will be continued. When a dry buckle occurs that cannot be recovered onboard the vessel safely, the pipe is laid onto the seabed (abandoned) in a controlled manner and flooded with water. When the pipe is completely filled with water, the buckled section is removed and a pipe recovery tool is installed to recover the pipeline on board. From this point the procedure is identical to the wet buckle recovery procedure; and
- Wet Buckle: is a buckle or damage to pipeline that leads to uncontrolled flooding of the pipeline with water. When a wet buckle occurs, the pipe is cut beyond the buckled section and recovered using a diverless pipeline recovery tool, for example. Typically, after recovery, the pipe is hung off the vessel and the dewatering head is welded onto the pipeline. Subsequently the pipe is laid down and dewatered by sending a pig from the dewatering head. After the dewatering operation, completed pipeline will be recovered and normal lay will be continued. Note that in deep water the flooded pipeline cannot be recovered by the pipelay vessel. By means of a contingency

dewatering spread positioned onshore, the pipeline will be dewatered prior to recovery by the lay vessel.



Source: EM-620-20-PL-RPT-001_2-EastMed Feasibility Study – Preliminary Design Report- Offshore

Figure 6-25 Pipeline Contingency Dewatering and Recovery

EastMed Installation Scenarios

For OSS1-OSS2, the following pipelay scenario is assumed:

- Shore pull and nearshore pipelay performed by high capacity S-lay vessel at LF2; and
- Continue normal lay towards Cyprus by high capacity S-lay vessel, followed by lay down at EastMed Compression Platform (ECP). Tie-in at ECP may be executed by a support construction vessel.

For OSS2N, the following pipelay scenario is assumed:

- Campaign 1 – together with Southern Line pipelay activities:
  - Shore pull at Cyprus (LF1) and nearshore pipelay by shallow water S-lay vessel;
- Campaign 2 – assuming that Northern Line will be completed at a later stage:
  - Recovery of pre-installed nearshore pipeline section at LF2 by high capacity S-lay vessel and normal lay towards Cyprus (LF1), followed by laydown nearshore Cyprus,

- Above Water Tie-In (AWTI) performed by shallow water S-lay vessel.

For OSS3, the following pipelay scenario is assumed:

- Shore pull and nearshore pipelay performed by Medium Capacity S-lay vessel at LF2;
- Continue normal lay towards LF3 (Peloponnese) by Medium Capacity S-lay vessel followed by lay down nearshore Peloponnese;
- Shore pull and nearshore pipelay performed by shallow water S-lay vessel at LF3; and
- AWTI performed by shallow water S-lay vessel.

For OSS3N, the following pipelay scenario is assumed:

Campaign 1 – together with Southern Line pipelay activities:

- Shore pull at Crete (LF2) and nearshore pipelay by shallow water S-lay vessel; this can be the same S-lay vessel as envisaged for the OSS1-OSS2 and/or OSS3 nearshore pipelay activities,
- Shore pull at Peloponnese (LF3) and nearshore pipelay by shallow water S-lay vessel; this can be the same S-lay vessel as envisaged for the OSS3 nearshore pipelay activities:

Given that OSS4 is a relatively short pipeline (~17km) the pipeline installation could be on the mobilisation of a single Medium Capacity S-lay vessel. In such case, the following pipelay scenario is assumed:

- Shore pull at LF5 followed by normal lay by a Medium Capacity S-lay vessel;
- Continue normal lay towards LF4, followed by lay-down nearshore LF4;
- Shore pull and nearshore pipelay at LF4; and
- AWTI at LF4 by a Medium Capacity S-lay vessel.

The deepwater installation vessel will install up to 3 km of line pipe per day.

Multi-vessel operation can be performed simultaneously providing flexibility in planning.

During the installation activities, different types of support vessel will be involved in order to assist the pipe lay vessel in its activity; these are:

- Platform supply vessel (PSV): transporting goods, tools, equipment and personnel;
- Multipurpose service vessel (MSV): cargo vessel with different supporting functions;
- Pipe supply vessels/pipe bulk carrier: transporting a continuous flow of line pipe to the pipe lay vessel; and
- Barges and tugs: supporting the pipe lay vessel during the installation activities.

According to the current design level few areas along the pipeline may require pre-lay or post-lay intervention to allow pipe installation and safe operation; that is ensuring pipeline stability and integrity or protection against external threats. Northern and Southern pipelines will be laid on the seabed in parallel, with a maximum distance of 100 m between the pipes. Near the LF2 and LF3 landfall sites, the pipelines approach each other to enter the same shore crossing causeway per site.

During the pipe-lay process, a navigational Safety Exclusion Zone is proposed of 2 km radius (1.1 nautical miles (NM)) centered on the pipe-lay vessel. The navigational Safety Exclusion Zone will be agreed with the relevant maritime authorities who will, in turn, ensure that it is communicated to vessels in passage in the vicinity of the pipe-lay vessel. The pipe-lay vessel will be equipped with navigation lights, radar and radio communications. Due to the construction spread advancing along the pipeline route as the pipe is laid, regular consultation will be undertaken by the contractor with the appropriate marine authorities to inform them of the location of the construction spread. The marine authorities will then be responsible for informing marine traffic of the location of the pipe-laying activities and the position of the associated navigational Safety Exclusion Zone.

6.4.2.1.4 Post Lay Activities

Survey Activities

The following survey activities are envisaged to be performed as part of the installation:

- As-laid survey;
- Remedial work survey; and
- As-built survey.

Field Reporting

During the course of the Project, field data books (e.g. detailed survey information that needs to be compiled on board the survey vessel covering the various survey tasks) will be collected. Relevant information could be extracted from these data books for inclusion in the final as-built reports. The data books will cover a number of topics such as:

- As-laid, as-trenched and other surveys will be carried out on a daily basis as the construction program progresses. The survey results will contain the position, KP value and a brief description on the status of field joints, anodes, free spans, damage, depth of burial after trenching, debris, etc.; and
- Quality histograms and statistics in order to provide evidence with regard to adherence to accuracy specifications.

6.4.2.1.5 Tie-Ins

Above Water Surface Tie-ins

An above water tie-in is the means of connecting two pipe ends to complete the pipeline system installation. Typically, the tie-in will be performed in relatively shallow water.

Prior to the tie-in operation, the pipeline ends are laid onto the seabed in a controlled manner. A certain amount of over length is added to the pipeline segments so that they can be recovered and joined on the installation vessel. Prior to abandoning the pipeline ends onto the seabed, clamps are pre-installed for subsequent recovery of the pipeline using davits.

To perform the tie-in, davits are used to pick up the pipe ends and to bring them to a work platform along side the lay vessel. The abandonment / pull heads are removed and the pipe is prepared and aligned. Next, the tie-in weld above water is executed, and after weld acceptance and field joint coating, the pipeline is lowered onto the seabed. The barge is moved sideward to avoid overstressing the pipe steel. The excess length of pipeline at the tie-in results in a "bulge" in the route. Figure 6-26shows an actual surface tie-in being performed. A surface tie-in for a 32-inch diameter pipeline is preferably performed at water depths of approximately 30 m.

Source: Allseas, 2018

Figure 6-26 Surface Tie-In

The tie-ins envisaged for the pipeline sections in Greece are the following:

- OSS3, nearshore SE Peloponnese to connect the pre-installed landfall section with the offshore section (installed from LF2, Crete); and
- OSS4, nearshore Gulf of Patras to connect the pre-installed landfall section with the offshore section (installed from LF5).

Subsea Tie-ins

No subsea tie-ins are expected in the Greek part of the EastMed Pipeline Project.

6.4.2.1.6 Seabed Intervention Works and Repairs Activities

Seabed Intervention Works

In general, major part of the pipeline is to be laid directly on the seabed, minimizing seabed disturbance across the Greek offshore area. However, seabed intervention works are expected to be required in specific areas, either before or after pipe-laying to allow pipe installation and safe operation; that is ensuring pipeline stability and integrity or protection against external threats.

Intervention works can vary, depending on the nature of the area to intervene, as well as other factors such as water depth, burial depth or sediment conditions. Seabed features or specific pipe sections that may require seabed intervention are the following:

- Shallow water sections or landfalls;
- Crossing of existing infrastructure; based on the positions of known existing cables;
- Irregular seabed causing unacceptable pipeline free spans;
- Hot pipe section with tendency to buckle;
- Sections at risk of interaction with fishing gear or impact from shipping activities; and
- Geohazards.

The seabed intervention methods can be divided in two main categories, Pre and Post lay intervention methods. The range of possible equipment and methodologies to carry out seabed intervention works is large and its applicability also varies significantly. Table 6-34 summarizes the intervention methods considered for the offshore section of the EastMed Pipeline and the main application limitations.

To identify exact locations where seabed intervention works shall be required, Detailed Marine Surveys (DMSs) data will be used. Before the construction of the Project, these seabed intervention areas shall be mapped and the construction method for each one shall be decided and issued, as part of detailed design by EPCI contractor.

Especially regarding free spans mitigation, key areas are:

- Fault area – SE Crete (OSS2, OSS3);
- Crete continental margin (OSS3);
- Peloponnese continental slope (OSS3);
- Gulf of Patras (OSS4) to a lesser extent, but a combination of significant seabed features with the shipping and fishing activity in shallow water, will require protection of free spans.

The following remarks for free span mitigation can be made:

- Especially long spans exhibiting a big gap with the seabed are difficult and costly to mitigate by seabed intervention. For such spans, VIV (Vortex Induced Vibrations) suppression devices like helical strakes could be considered. These strakes would be preferably installed on the pipelay vessel;
- The length of free spans is partly driven by the residual lay tension. A combination of steep slopes in deep water and stiff/heavy pipes are expected to generate significant number of free spans that may or may not need to be rectified. Potential reduction of bottom tension to reduce free span mitigation, will be limited by equipment capabilities and can only be estimated by chosen EPCI contractor during detail design phase. A combination of micro re-routing and bottom tension reduction, where feasible, may have some effect on the number of free spans requiring mitigation.

Table 6-34 Summary of Seabed Intervention Methods

Timing	Method	Equipment	Soil type	Water Depth	Applicability Span Type
Pre Lay	Dredging	Bucket, Grab, Backhoe Dredger	Any	< 20 to 50 m	ULS and VIV
		Cutter Suction Dredger	Any except rock	< 50 m	ULS and VIV
		Trailing Suction Hopper Dredger	Any except rock	< 150 m	ULS and VIV
	Supports	Mattresses: support vessel with crane and deck space	Any	Range of crane or ROV	ULS and VIV
		Rock dump: rock dumping vessel	Any	Up to max WD	ULS and VIV
		Rigid supports (steel structure on base plate): support vessel with crane and deck space	Soft soils (low bearing capacity)	Range of crane or ROV	Crossings
Post lay	Trenching	Jetters deployed from support vessel with A-frame	Soils that can be fluidized or blasted away	Up to max WD	Any except crossings
		Mechanical Cutters deployed from support vessel	Soft and hard soils (up to soft rock)	< 350 m	Any except crossings
		Plough deployed from support vessel with A-frame	Soils with good bearing capacity (not soft clays)	< 1,000 m	Any span types except crossings and rough terrains.
	Subsea Excavation	Tools and control can be shipped or flown in containers to support vessel with A-frame or crane	Any (including stiff clay)	Range of crane or ROV	Any except crossings protection
	Mass flow Excavation	Tools and control can be shipped or flown in containers to support vessel with A-frame or crane	Soil that can be fluidized or blasted away	Range of crane or ROV	Any except crossings protection
	Rock Dumping	Appropriate rock dumping vessel and nearby rock supply	Any	Up to max WD	Rock berm: where protection is required for full length of span (i.e. crossings and trawlable spans) Spot rock dump: to restrain pipe avoiding buckling (e.g. triggered by trawl gear)
	Mattresses (cover)	Support vessel with crane and deck space	Any	Range of crane or ROV	VIV, protection in fishing areas and to laterally restrain pipe
	Supports	Mechanical Supports installed by support vessel	Any	Range of crane or ROV	ULS and VIV (with large span heights)
		Grout Bags installed by support vessel	Any	Range of crane or ROV	ULS and VIV
	Strakes	Support vessel with ROV	Any	Range of ROV	VIV

Source: IGI, 2021

<u>Subsea Repair Activities</u>

In the unlikely event of a wet buckle and the subsequent abandonment of the (partially) flooded pipeline, a repair exercise will be undertaken before pipelay can continue.

Before recovering the pipeline on-board the vessel, it will be necessary to carry out remedial measures on the seabed. The pipeline will be cut at the buckle location and recovered in two sections. To allow a damaged or buckled pipeline to be cut, prepared and recovered, the cut location of the line must be clear of the seabed. This can be done by jetting or dredging the soil away from under the pipe or by lifting the line clear of the seabed using a contingency lifting frame.

The cut can be made by a diamond wire cutter. Such tools are operated by ROV and need to be either mobilised offshore or standby in case they are needed. Subsequently, specific internal pipeline lifting tools / ball grab type tools are required to create a pipe attachment and a lift point at the cut pipe end, after which the A&R system can be connected. In case of a flooded pipeline (i.e. no flooding prevention system or failure of flooding prevention system), the pipeline should be de-watered.

6.4.2.1.7 Indicative Schedule

Typical pipelay rates are on the order of 3 km per day.

Table 6-35 Indicative Construction Time of OSS2 and OSS2 N

<table>
<tr><th colspan="7">OSS2 and OSS2 N</th></tr>
<tr><td>Section</td><td colspan="2">LF2 Construction</td><td>Pipelay</td><td>Survey, Pipelay Support</td><td colspan="2">Pre-commissioning</td></tr>
<tr><td rowspan="2">Offshore</td><td>Pre-lay dredging</td><td>5-7 weeks</td><td rowspan="2">30-40 weeks</td><td rowspan="2">48-62 weeks</td><td colspan="2" rowspan="2">-</td></tr>
<tr><td>Post-lay backfilling</td><td>2-4 weeks</td></tr>
<tr><td rowspan="3">Onshore</td><td>Site preparation & bund construction</td><td>8-16 weeks</td><td rowspan="3">-</td><td rowspan="3">-</td><td>Pre-Packing</td><td>40-60 days</td></tr>
<tr><td>Pull in operation</td><td>1week</td><td rowspan="2">Drying, Venting & N2 Purging</td><td rowspan="2">50-76 days</td></tr>
<tr><td>Site reinstatement</td><td>4-8 weeks</td></tr>
</table>

Source: ASPROFOS, 2021; Allseas, 2021

Table 6-36 Indicative Construction Time of OSS3 and OSS3 N

OSS3 and OSS3 N									
Site	LF2 Construction		LF3 Construction		Pipelay	Survey, {ipelay Support	AWTI	Pre-commissioning	
Offshore	-		Pre-lay dredging	4-6 weeks	15-22 weeks	24-30 weeks	1-2 weeks -	-	
			Post-lay backfilling	2-4 weeks					
Onshore	Pull–in	1 week	Site preparation & bund construction	10-24 weeks	-	-	-	Pre-Packing	12 days
			Pull in operation	1 week				Drying, Venting & N2 Purging	21 days
			Site reinstatemen t	6-10 weeks					

Source: ASPROFOS, 2022; Allseas, 2021

Table 6-37 Indicative Construction Time of OSS4

OSS3 and OSS3 N									
Section	LF4 Construction		LF5 Construction		Pipelay	Survey, Pipelay Support	AWTI	Pre-commissioning	
Offshore	Pre-lay dredging	3-5 weeks	Pre-lay dredging	3-5 weeks	2-4 weeks	3-5 weeks	1-2 weeks	-	
	Post-lay backfilling	2-3 weeks	Post-lay backfilling	2-3 weeks					
Onshore	Site preparation, cofferdam installation	12-20 weeks	Site preparation, cofferdam installation	12-20 weeks	-	-	-	FCG	2-3 days
								SPT conventi-onal	1-2 days
	Pull in operation	1 week	Pull in operation	1 week				Dewatering, venting, drying, N2 purging	10-18 days
	Cofferdam removal and reinstatement	7-14 weeks	Cofferdam removal and reinstatement	7-14 weeks					

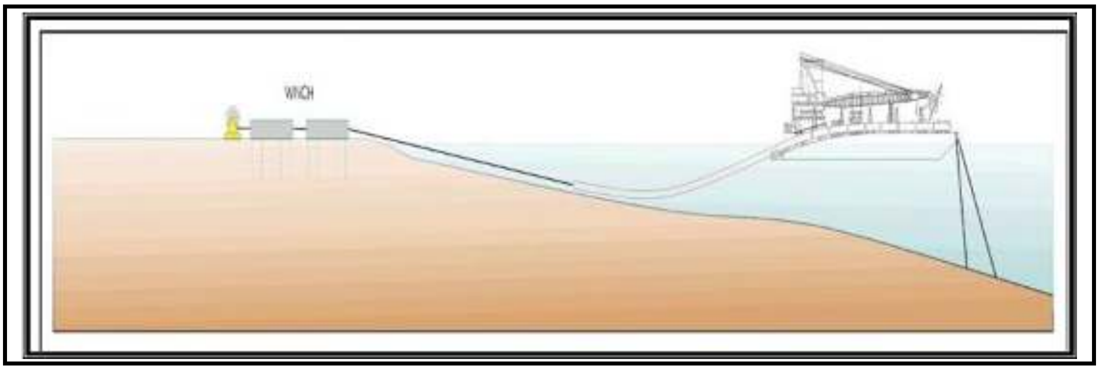
Source: ASPROFOS, 2021; Allseas,2021

6.4.2.2 *Nearshore Section*

6.4.2.2.1 Construction Methods

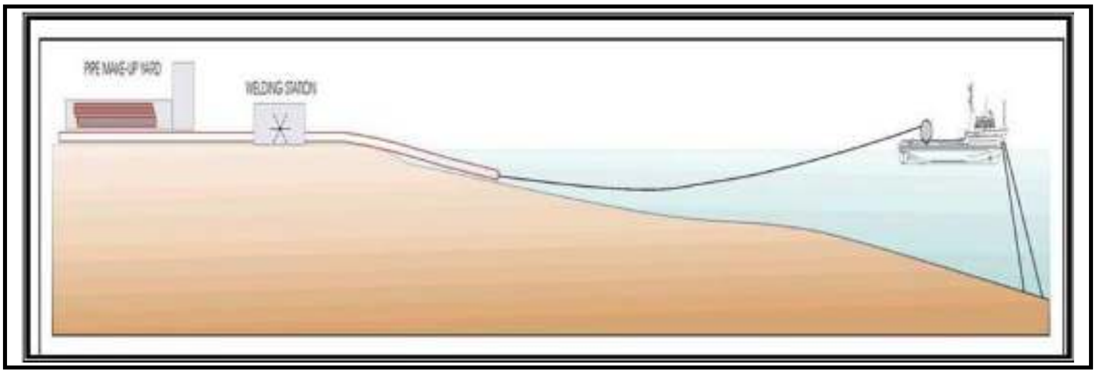
Shore crossing construction methods are presented in the relevant section, and pipeline installation onto the sea bottom within a trench is described below. One of the following methods can be used:

- **Shore Pulling Method.** Pipeline is assembled on a barge stationed offshore and the pipeline section is pulled through a pre-dredged trench using land based cable winches. Typically, this method includes offshore mooring of the barge and stringing the pipeline that has been assembled on the barge, pulling towards the shore using land based winches. The site needed onshore for winches, cable drums, power generators, support equipment and construction installations is approximately 2,000 m². Also, an additional area will be required for temporary storage of the trenched material;
- **Barge Pulling Method.** Pipeline sections are assembled and fully prepared onshore, and then the pipeline string is pulled offshore by a barge equipped with the required winches. The construction site needed for pipeline storage, welding, etc. is larger than the one required in the previously described method, and it is estimated around 10,000 m². A land strip approximately 300 – 500 m long is estimated for placement of the pipeline strings. This land strip could be located along the onshore construction working strip; and
- **Barge Pulling via Sheave Block**. This third method consists of the combination of the two previously mentioned methods, as it involves both pipeline construction and winching being performed onboard the barge. Like the shore pulling method, the pipeline is constructed on the barge moored offshore and then pulled to shore through a pre-dredged trench. The pulling cable winch goes through an onshore sheave block and back to the barge. The method is technically more demanding than the two methods described above and is used only where there are serious restrictions regarding the available workspace at landfall locations.



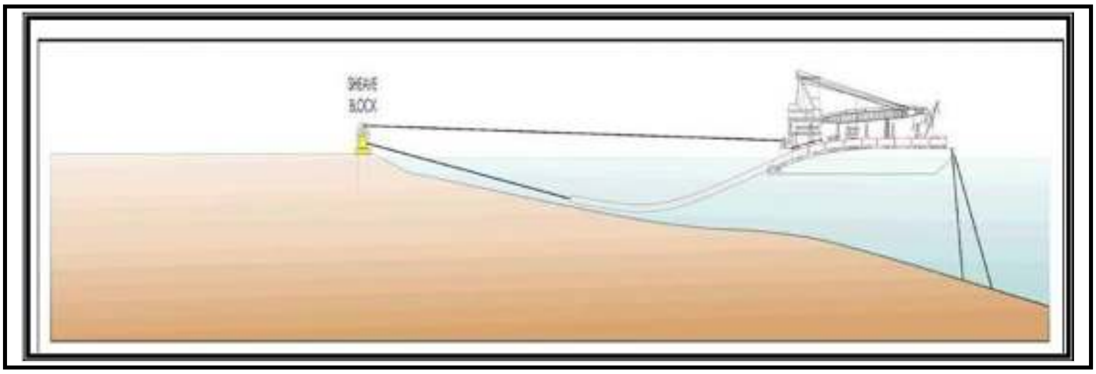
Source: EastMed Feasibility Study -Preliminary Design Report –Offshore (EM-620-20-PL-RPT-001, REV 2)

Figure 6-27 Shore Pulling Method



Source: EastMed Feasibility Study -Preliminary Design Report –Offshore (EM-620-20-PL-RPT-001, REV 2)

Figure 6-28 Barge Pulling Method



Source: EastMed Feasibility Study -Preliminary Design Report –Offshore (EM-620-20-PL-RPT-001, REV 2)

Figure 6-29 Barge Pulling via Sheave Block

Regarding accessibility, the following are noted: as mentioned, it is envisaged that no new access roads will be required. Existing roads might be improved and the working strip will be used as the main access roads for the shore crossing construction site. Especially for the shore construction site, heavy equipment could be transported by shallow vessels. However, given the specific works at the landfall sites, the EPC contractor may deem it necessary to construct a temporary access to the landfall site for personnel, materials, equipment, etc. In such a case (as well as in other places with special characteristics where the EPC contractor may deem temporary construction access necessary), all necessary permits will be acquired by the EPC contractor.

Table 6-38 Comparison of Alternative Pulling Methods at the Landfall Sites (Shore Crossing)

Pulling Method	Advantages	Disadvantages
Shore Pulling Method	Requires less extensive onshore installations The high pulling capacity land based winch and the cable of sufficient length can easily be installed onshore.	Requires close coordination between the onshore and offshore crews. Requires transportation and installation of one or more high pulling capacity winches.
Barge Pulling Method	Mobilisation of the installation barge of the pre-constructed pipeline parts can wait until the pipeline strings are welded onshore and are ready for pulling. Short installation duration; hence cost minimisation	The available pulling capacity is limited by the power of the onboard winches. A large onshore construction site is required for pipeline string assembly (welding and preconstruction).
Barge Pulling via Sheave Block	Does not require onshore winching installations. All key operations are controlled onboard the barge.	The length required for the pulling wire is about twice the length required for the shore pulling method with a land based winch. Available pulling capacity is limited by the power of the onboard winches.

Source: IGI, 2021

6.4.2.2.2 Indicative Schedule

The estimated total duration of the shore crossing construction activities is 6-8 months.

No construction activities are performed during the tourist season (June – August) in order to minimise impacts on tourism in the area during this short period.

6.4.2.3 *Onshore Section*

The basic method of constructing onshore gas pipelines is generally known as the spread technique, which is an "open cut" method and is widely used throughout the world. A typical sequence for onshore pipeline construction is illustrated in Figure 6-30.

Source: ASPROFOS,2021

Figure 6-30 Typical Pipeline Construction Sequence

This method can be broken down into several phases:

- Route survey and layout;
- Working strip preparation (clearing, grading, topsoil stripping);
- Trench excavation;
- Pipeline handling, hauling and stringing;
- Pipeline bending;
- Pipeline welding and weldt testing, applying field joint coating;
- Pipeline laying;
- Backfilling;
- Hydrotest; and
- Reinstatement.

A survey control system in the form of permanent ground markers (PGM) will be installed. All survey works will be tied into this control system and the accuracy of the PGM control system will be confirmed.

The work includes removal of all trees, bushes, hedges and other obstacles from the construction working strip. A restricted working strip shall apply where there are physical constraints or where the contractor chooses to reduce the working strip to benefit particular operations. A larger working strip may be necessary where a particular operation may benefit from additional space. The working strip should be set up before work commences.

6.4.2.4 *Pre-Construction Activities*

As previously described, before starting any construction work, conditions existing along the pipeline footprint will be surveyed, including topographic and photographic records. These records will be used to ensure full reinstatement of the lands used temporarily. All infrastructure above and below ground will be identified and recorded in collaboration with the landowner (and/ or other stakeholders) to prevent accidental damage during pipeline construction and ensure proper restoration. Existing third party services will be located, marked, and either safeguarded or diverted. Warning posts will be erected for overhead cables and temporary crossing points clearly identified.

Pre-construction activities include detailed design of the project, identifying specific construction methods and procurement of necessary materials quantities, elaboration of safety studies, and establishment of construction worksites.

6.4.3 Construction Methods at Crossings

6.4.3.1 *Overview*

The pipeline route crosses many areas requiring specialised construction approaches.

Many crossings with existing and planned submarine cables have been identified along the Eastmed offshore pipeline routes whilst the continental pipeline route crosses several road types, railroad lines, water bodies (including channels, watercourses, streams and creeks). Other pipeline crossings include crossings with channels, irrigation channels, telecommunication lines, electrical lines, water lines, gas lines and other infrastructure.

Where necessary, construction methods that avoid interference or visible long term impacts will be used for crossings in order to minimise impacts on traffic and the environment.

Crossings will be installed in parallel with or in front of the mainline working corridor. In general, such projects involve separate crews to install bore crossings for roads and highways along the pipeline corridor. These crews perform the excavation, welding, and installation of the crossing pipe. Pipeline crossings will be tested to ensure tightness and strength.

Increased burial depths at important crossings (roads, rivers, railways) and steep slopes will help maintain the safety and structural integrity of the pipeline.

The requirements and technical instructions of the competent authorities will be taken into account in the detailed design and construction of crossings.

The detailed data of the continental crossings are provided in the related crossing lists for CCS1 and CCS2 sections respectively.

Table 6-39 and Table 6-40 summarise different types of crossings for CCS1 and CCS2, respectively.

Table 6-39 List of Crossings for CCS1

Crossing Method	Crossing Type	Crossing Comment
Boring Without Casing	Highway, National Road(asphalt paved ≥2 lanes)	6 Major crossings
Open cut	Highway, National Road(asphalt paved ≥2 lanes)	7 Major crossing
Boring Without Casing	Main Road (asphalt paved , 2 lanes)	9 Major crossings
Open cut	Main Road (asphalt paved , 2 lanes)	6 crossings only 1 is characterised as a Major one
Boring Without Casing	Secondary Asphalt Paved Roads	8 crossings of which 3 are characterised as a Major one
Open cut	Secondary Asphalt Paved Roads	119 crossings only 1 is characterised as a Major one
Within Boring Without Casing	Secondary Asphalt Paved Roads	5 crossings only 1 is characterised as a Major one
Within Direct Pipe	Secondary Asphalt Paved Roads	2 Minor crossings
Open cut	Gravel Paved	80 Minor crossings
Within Boring Without Casing	Gravel Paved	1 Minor crossing
Open cut	Un paved /Dirt Road	538 Minor crossings
Within Boring Without Casing	Un paved /Dirt Road	1 Minor crossing
Open cut	Large Rivers (Crossing Width ≥30m)	2 Major crossings
Direct Pipe	Large Rivers (Crossing Width ≥30m)	1 Major crossing
Open cut	Rivers (Crossing Width<30m-≥5)	37 crossings of which 9 are characterised as a Major
Open cut	Channel and Ditch (Crossing Width <5m)	76 Minor crossings

Crossing Method	Crossing Type	Crossing Comment
Open cut	Concrete Irrigation Channel	1 Major crossing and 1 Minor crossing
Boring With Casing	Single trackline	2 Major crossings
Open cut	Electricity Lines	90 Minor crossing
Open cut	Water Lines	2 Minor crossing

Source: P616-100-LS-PLN-02_2_CCS2 – Peloponnese Crossing List

Table 6-40 List of Crossings for CCS2

Crossing Method	Crossing Type	Crossing Comment
Within Direct Pipe	Highway, National Road (asphalt paved ≥2 lanes)	1 Major crossing
Boring Without Casing	Highway, National Road (asphalt paved ≥2 lanes)	1 Major crossing
Boring Without Casing	Main Road (asphalt paved, 2 lanes)	9 Major crossing
Boring Without Casing	Secondary Asphalt Paved Roads	11 Majorcrossings
Open cut	Secondary Asphalt Paved Roads	64 Minor crossings
Within Boring Without Casing	Secondary Asphalt Paved Roads	1 Minor crossing
Within Direct Pipe	Secondary Asphalt Paved Roads	2 Minor crossing
Within HDD	Secondary Asphalt Paved Roads	3 Minor crossings
Open Cut	Gravel Paved	97 Minor crossing
Within Boring Without Casing	Gravel Paved	4 Minor crossings
Within Direct Pipe	Gravel Paved	3 Minor crossings
Within HDD	Gravel Paved	1 Minor crossing
Open Cut	Un paved /Dirt Road	411 Minor crossings
Within Boring Without Casing	Un paved /Dirt Road	6 Minor crossings
Within Direct Pipe	Un paved /Dirt Road	6 Minor crossings
Within HDD	Secondary Asphalt Paved Roads	3 Minor crossings
Within HDD	Un paved /Dirt Road	18 Minor crossings
Direct Pipe	Large Rivers (Crossing Width ≥30m)	2 Major crossings
HDD	Channel and Ditch (Crossing Width <5m)	7 Minor crossings
HDD	Large Rivers (Crossing Width ≥30m)	4 Major crossings
HDD	Rivers (Crossing Width <30m-≥5)	11 Major crossings

Crossing Method	Crossing Type	Crossing Comment
Open Cut	Rivers (Crossing Width<30m-≥5)	42 crossings of which 5 are characterized as a Major
Within Boring Without Casing	Rivers (Crossing Width <30m-≥5)	3 Minor crossings
Within HDD	Rivers (Crossing Width <30m-≥5)	8 Minor crossings
Open Cut	Channel and Ditch (Crossing Width <5m)	179 Minor crossings
Within Boring Without Casing	Channel and Ditch (Crossing Width <5m)	12Minor crossings
Within Direct Pipe	Channel and Ditch (Crossing Width <5m)	2 Minor crossings
Within HDD	Channel and Ditch (Crossing Width <5m)	8 Minor crossings
Boring Without Casing	Concrete Irrigation Channel	1 Major crossing
Open Cut	Concrete Irrigation Channel	35 Minor crossings
Within Boring Without Casing	Concrete Irrigation Channel	3 Minor crossings
Within Direct Pipe	Concrete Irrigation Channel	1 Major crossing
Within HDD	Concrete Irrigation Channel	1 Minor crossing
Open Cut	Single track line	2 Minor crossings
Open Cut	Telecommunication lines	1 Minor crossing
Open Cut	Electricity Lines	106 Minor crossings
Boring Without Casing	Water Lines	1 Major crossing
Within Boring Without Casing	Water Lines	1Minor crossing
Open Cut	Water Lines	1 Minor crossing

Source: P616-100-LS-PLN-06_2_CCS2 – West Greece Crossing List

Table 6-41 summarises different types of crossings for Megalopoli Branch.

Table 6-41 List of Crossings for Megalopoli branch

Crossing Method	Crossing Type	Crossing Comment
Boring Without Casing	Highway, National Road(asphalt paved ≥2 lanes)	1 Major crossing
Boring Without Casing	Main Road (asphalt paved , 2 lanes)	1 Major crossing
Boring Without Casing	Secondary Asphalt Paved Roads	2 Minor crossings
Open cut	Secondary Asphalt Paved Roads	4 Minor crossings

Open cut	Gravel Paved	4 Minor crossings
Open cut	Unpaved /Dirt Road	25 Minor crossings
Open cut	Rivers (Crossing Width<30m-≥5)	4 Minor crossings
Open cut	Channel and Ditch (Crossing Width <5m)	13 Minor crossings
Boring With Casing	Single track line	1 Major crossing
Open cut	Electricity Lines	1 Minor crossing
Open cut	Gas Lines	1 Minor crossing

Source: P616-100-LS-PLN-10_2_Megalopoli Branch Crossing List

ANNEX 6J show schematics for typical crossings techniques.

Table 6-42 summarises different types of crossings for OSS2/OSS2N, OSS3/OSS3N, and OSS4 pipelines accordingly.

Table 6-42 List of Crossings for OSS2, OSS3 and OSS4

Potential Crossing Type	Crossed Facility Type	Service Status	Burial Status	Crossing Status
		OSS2/OSS2N		
- (1)	Power Cable	6 Planned	All Exposed	Planned
Type 3, 4 or 5 (2)	Fiber Optic Cable	4 In service	All Exposed	Provisional,
Type 1		4 Out of Service	All Exposed	
Type 1	Coaxial Cable	1 Out of service	Exposed	Provisional
Type 3, 4 or 5 (2)	Fiber Optic – Coaxial Cable	3 In Service	All Exposed	Provisional
		OSS3/OSS3N		
Type 2	Fiber Optic Cable	11 In Service	9 Buried	Provisional
Type 3, 4 or 5 (2)			2 Exposed	Provisional
Type 1		5 Out of Service	3 Buried	Provisional
Type 1			2 Exposed	Provisional
- (1)		2 Planned	Buried	Planned
n/a		n/a	Buried	Provisional
- (1)	Power Cable	2 Planned	Buried	Planned
Type 3, 4 or 5 (2)		Under construction	Exposed	Provisional
Type 1	Coaxial Cable	3 Out of Service	Buried	Provisional
n/a		n/a	Buried	Provisional

Potential Crossing Type	Crossed Facility Type	Service Status	Burial Status	Crossing Status
n/a	Submarine Cable	n/a	2 Buried	Provisional
n/a			1 Exposed	Provisional
OSS4				
	Submarine Cable	Unknown	Buried	Provisional

Notes:
(1) Project's Offshore crossing design addresses the existing cable crossings along the pipeline route. The status of these planned cables shall be monitored,by the Contractor, if they are installed prior to the installation of EastMed offshore pipelines.
(2) Please see Table 6-50
(3) Crossing construction works normally consist of installing supports on both sides of the existing cables prior to pipeline installation. Contractor shall be responsible for performing all necessary pre-crossing construction activities prior to offshore pipeline installation, in accordance with DNVGL-ST-F101 (2017). In addition, post-lay crossing construction activities shall also be performed by the contractor where required.

Source: IGI Poseidon, 2021

6.4.3.2 *Shore crossing (Landfall sites)*

The shore crossing is the intersection area between the offshore and onshore part of a pipeline, where special construction techniques are required. The size of this intersection area depends on local circumstances such as bathymetry, topography, metocean conditions, seabed characteristics (e.g. seabed material, morphology) and environmental conditions. Generally, the area runs from a water depth of around 10 to 20 meters to the onshore end of the beach. Note that in general the same methodology applies for all landfalls.

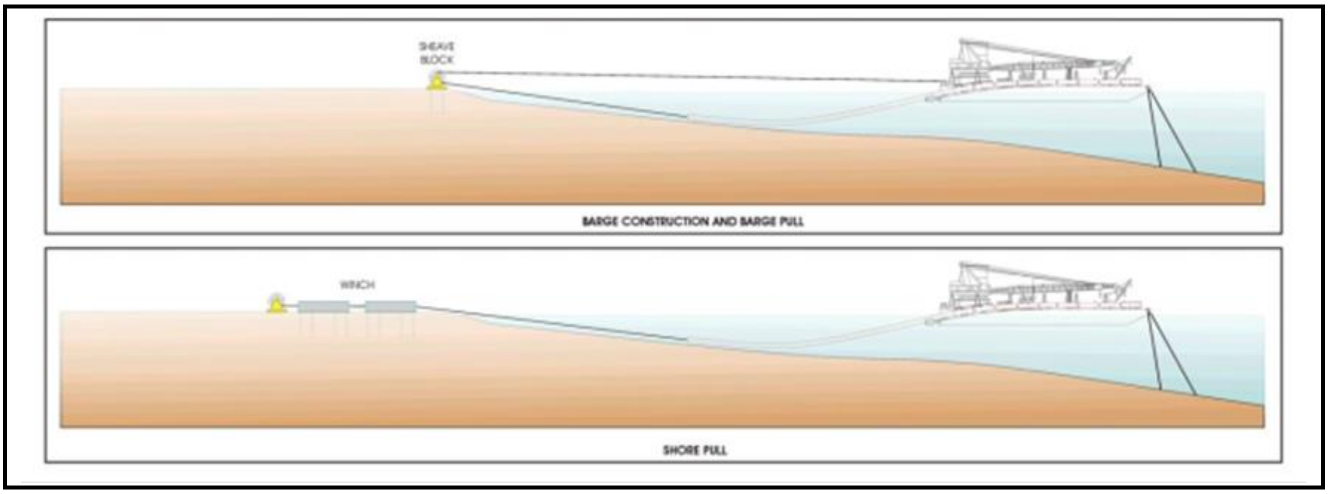
6.4.3.2.1 Construction Method

Open cut is the proposed construction methodology for shore crossings at EastMed landfall locations. In addition, at crossings OSS2 and OSS2 N will be installed simultaneously and the same applies for OSS3 and OSS3 N.

The open cut construction methodology is a common technique where, generally, the nearshore section is trenched by a combination of dredging equipment (e.g. deeper sections by cutter suction dredger or trailing suction hopper dredger and shallower sections by pontoon-based backhoe) and the onshore section by common excavators to enable the pipeline to be pulled ashore at a required depth of burial. To enable the use of heavy equipment, the landfall requires a sufficiently sized beach (preferably minimum 50 metres to shoreline and minimum 100 metres wide) and good access. To minimise dredging volumes and to protect the trench from natural backfilling during the period between trench excavation and pipeline installation, a cofferdam is often used. If the subsoil is not suitable for sheet piles, a causeway can be created by using rock boulders or gravel of sufficient size to secure a stable dam during the installation process.

Main steps involved in landfall construction include:

- **Step 1:** Mobilisation of construction equipment to the landfall site;
- **Step 2:** Construction of a cofferdam or construction of causeway at landfall sites.
  A conservative approach is adopted at this stage of the project, where cofferdams and causeways are installed on both sides of the pipeline corridor. If natural backfilling is limited and excavation of the trench is possible with one single cofferdam/causeway, one cofferdam/causeway can be considered;
- **Step 3:** Trenching using excavation equipment suitable for hard soil and/or rocky soil conditions (e.g. backhoe equipped with hydraulic hammer / chisel, cutter suction dredger) will be employed. The trench bottom should be levelled to provide an even and continuous pipe support and shall be clear of debris immediately prior to laying/pulling the pipe. The trench dimensions should be sufficient to accommodate any natural backfilling in the period between excavation and pipeline installation.
- **Step 4:** During pull-in, (Figure 6-31 depicts the pipe pull options) the pipeline joints are welded on board the lay vessel and pulled towards the trench by means of a cable running to shore.
  The pull-in pipeline installation methodology is considered feasible at all landfall locations.
  Survey and dredging equipment will be on site until completion of the pipeline pull operation and will survey, dredge and re-survey the trench as required to ensure that the required depth of pipeline cover will be achieved.
  At landfall sites, it is practical to install all pipelines in the same trench from a construction point of view. This will minimise the amount of excavation activities;



Source: EastMed Feasibility Study -Preliminary Design Report –Offshore (EM-620-20-PL-RPT-001, REV 2)

Figure 6-31 Schematic Pipe Pull Options

- **Step 5:** An S-lay installation vessel will perform the pipe pull and will continue pipe laying;. The shore pull operation and subsequent shallow water pipelay is performed by a shallow water S-lay vessel. Depending on the adopted offshore installation scenario, the pipeline will be laid down in a water depth suitable to perform a surface tie-in or to be recovered by a larger S-lay vessel to continue pipelay activities into deeper water;
- **Step 6:** Backfill trench with suitable (engineered) backfill material to prevent liquefaction and to ensure backfill stability; backfilling shall not commence until completion of the as-laid survey of the pipeline and removal of any pipeline buoyancy aids. A granular bedding material will be placed under the pipe at free spans in such a manner that any gap under the pipe is effectively filled. Excavated material may be used where possible; and
- **Step 7:** Demobilise causeways/cofferdams and reinstate construction site.

Construction of the pipelines at shore crossing can be executed offline from the offshore pipelaying and are accomplished in advance to provide pre-assembled pipeline ends ready for the connection (AWTI - Above Water Tie In) with the deep-water pipeline.

Assuming access to shore and availability of general utilities is granted, shore crossings are usually executed in sequence like:

- installation of the linear winch and pipeline rollers, construction of the relevant causeways, excavation of the open trench: 3-4 months;
- pipeline pulling from the shallow water lay barge: 1 month;
- backfilling of the trench and reinstatement of the shore: 2-3 months;

Each landfall shore crossing can be executed independently, while pipeline pulling depends on the availability and schedule of the shallow water lay barge. AWTI is usually executed by a shallow water lay barge according to relevant construction schedule with no intervention from shore.

Trenching and backfilling of the pipeline as laid, if required, can be executed by specialised naval assets with no intervention from shore.

Table 6-43 Summary of Cofferdam/Trench Dimensionspresents a summary of the trench dimensions at the landfalls:

Table 6-43 Summary of Cofferdam/Trench Dimensions

Landfall	Location	Pipeline Characteristics	Cofferdam Size			Nearshore Trenching		
		(number & diameter)	Length (m)	Width (m)	Depth (m)	Length of Trench (m)	Width (m)	Depth (m)
LF2	Crete	4 (2x26”/2x28”)	n.a.	n.a.	n.a.	300	50	2,5
LF3	Peloponnese	2 (2x28”)	n.a.	n.a.	n.a.	600	30	2,5
LF4	South Patras Gulf	1 (1x46”)	200	21	5	1000	15	3
LF5	North Patras Gulf	1 (1x46”)	200	21	5	1000	15	3

Source: IGI Poseidon, 2021

6.4.3.2.2 Specific landfall sites

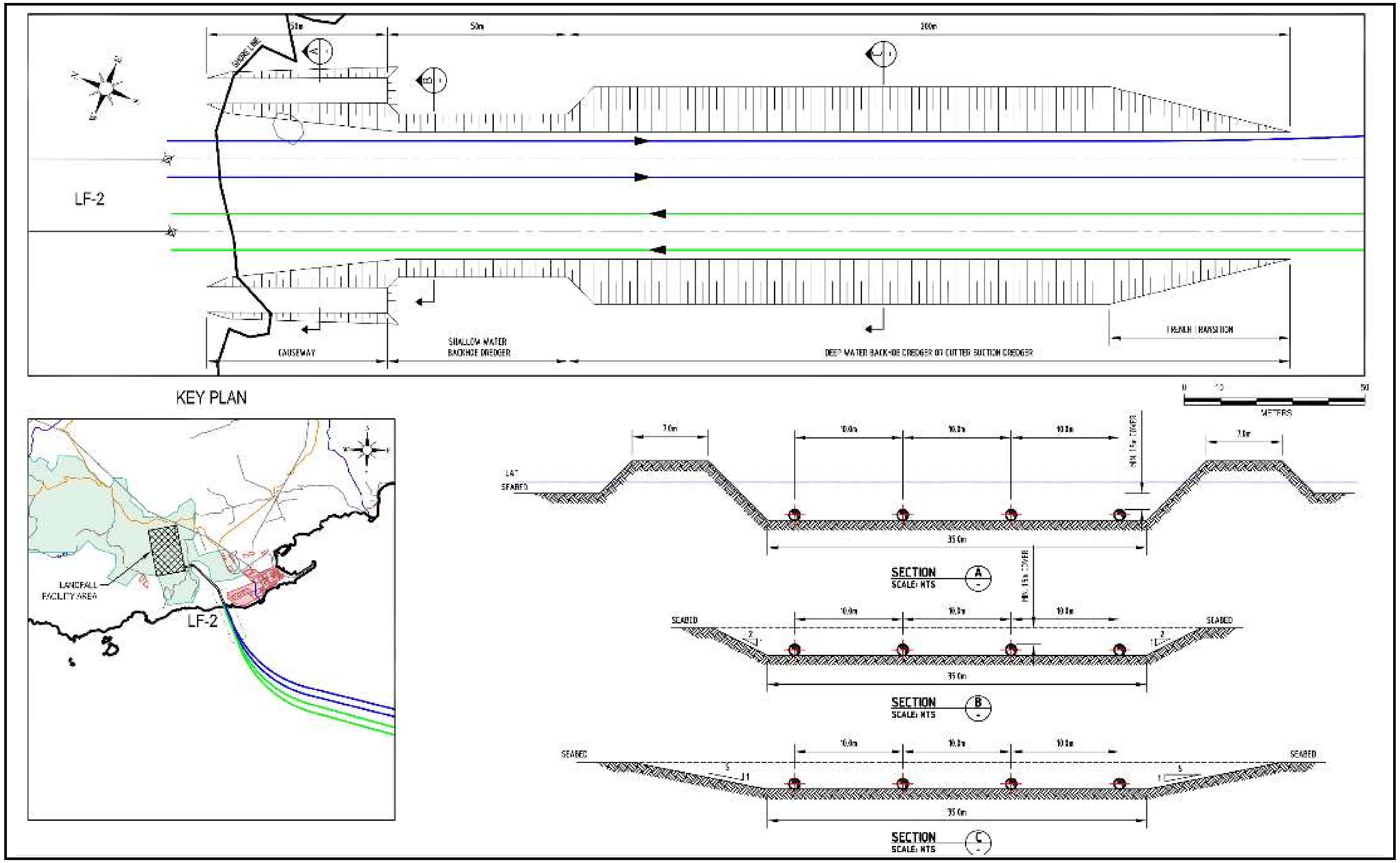
6.4.3.2.2.1 LF2

LF2 at Atherinolakos will accommodate 4 lines, i.e. OSS2 and OSS3 (Southern Line), OSS2N and OSS3N (Northern Line), that will be placed in one trench and thus shore crossing construction activities for the Southern and Northern Lines will be performed in one construction campaign. The continental shelf is relatively small along the eastern coast of Crete. In particular, it is 100 m wide at LF2. The rocky coastline at LF2 dips quickly towards deeper waters with slope angles up to 25 degrees. The landfall area is relatively small with the PPC property boundary east and rocky cliffs to the west. The onshore pipeline is routed upslope just after the landfall location. The ridge west of the landfall location is approximately 50 metres in height with gradients over 25 degrees. The pipeline is further routed over cultivated land and through olive orchards. The average gradient is small; however, localised gradients can go up to 10 degrees. The onshore facilities are located within relative flat olive orchards.

A causeway would be constructed from trench excavation material on each side of the trench to prevent natural backfilling of the trench. Preferably these causeways should be extended beyond the surf zone. Construction of a cofferdam is not preferred because of the hard soils anticipated onshore and offshore. Further excavation of the trench can be performed by a shallow water backhoe, deep water backhoe (possibly on a pontoon) or heightened backhoe with increasing water depth. A suction cutter dredger may be needed to excavate the trench in -/water depths beyond 6 to 7 m. It should be noted that the excavation equipment used will be largely dependent on the contractor selected. The preliminary length of the causeway is assessed at 50 m with further trenching of 250 m.

Onshore pre-fabrication of pipe strings in a “stringing yard” and subsequently performing a pull-out is not preferred. A pipe-lay vessel will be employed to perform the shore crossing (pull from vessel to shore) and subsequently install the pipeline from LF2 towards LF1 and LF3 for OSS2 and OSS3, respectively. It should be noted that the steep slope dictates the lay direction being to LF1 and LF3.

Overview of LF2 Design is reported in Figure 6-32.



Source: Intecsea, 2020

Figure 6-32 Overview of Landfall 2 Design

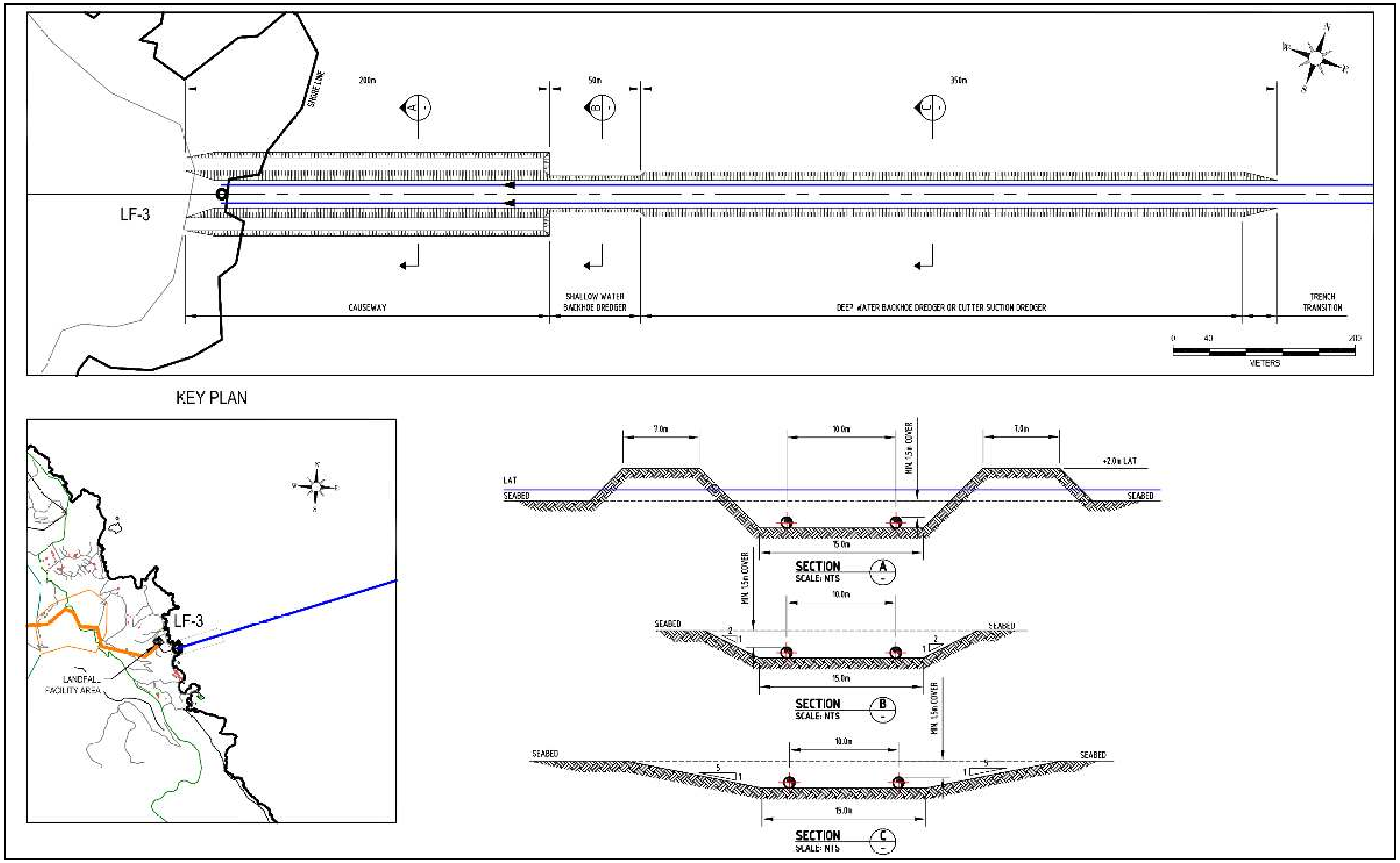
6.4.3.2.2.2 LF3

LF3 at Agios Fokas will accommodate 2 lines, OSS3 (Southern Line) and OSS3N (Northern Line) that will be placed in one trench and thus shore crossing construction activities for Southern and Northern Lines will be performed in one construction campaign. LF3 is located at a rocky coastline. The onshore pipeline is further routed over shrub land and meadows along with some agricultural land. The average onshore gradient is small, approximately 2 degrees. The landfall facility is located near LF3, within a relatively flat area. An onshore sandy flat area can be seen just onshore at LF3, which may serve as the construction area for pipeline installation. The shore approach of LF3 is straight and continuously sloping. Slope angle is on average 4 degrees. No clear shelf break can be identified at the pipeline shore approach route to LF3.

Rocky terrain overlain with sediments is expected nearshore LF3; in addition, various outcrops have been identified in the nearshore area. For these conditions, the proposed construction method is the traditional open cut method with causeways. A length of 200 m is proposed for the causeways, followed by a 400 m trench. The pipelines are installed in a pre-dredged trench prepared by a backhoe and in deeper waters by a cutter suction dredger to 25 m water depth.

Overview of LF3 Design is reported in Figure 6-33.

The construction methodology described above (i.e. open trench) represents the proposed scenario where trenching and backfilling activities are implemented to stabilize the pipeline laid on the seafloor and avoid buckling. The open trench technique foresees a maximum digging depth of 3 meters and the storage of these sediments in appropriate temporary or permanent areas (see Section 6.4.3.2.4 on *Management of Dredged Material*). This technique is in accordancewith the design knowledge resulting from the studies carried to date.



Source: Intecsea, 2020

Figure 6-33 Overview of Landfall 3 Design

6.4.3.2.2.3 LF4

Similarly, for LF4 at Lakopetra, the area consists of a flat coastline with sand, sandstone and conglomerates, and a gentle sandy slope behind the coastline. LF4 is located between two tourist areas 300 m to the east and 700 m to the west. This may result in additional permitting requirements, such a limited construction period (outside the tourist season). A landfall station (LS04) is planned to be located immediately south of LF4. The average gradient of the area south of LF4 is small; however, localised gradients can go up to 10 degrees.

The shore approach is long, flat and sandy or clayey. For these conditions, the proposed shore crossing construction method for LF4 is the traditional open cut method with sheet piled cofferdams. The pipeline is installed in a pre-dredged trench prepared by a backhoe or trailer suction hopper dredger in deeper waters, typically to a 25 m water depth. The current assessment shows the sheet piled cofferdam for LF4 is at least 200 m, followed by a 1,000 m trench.

Overview of LF4 Design is reported in Figure 6-34.

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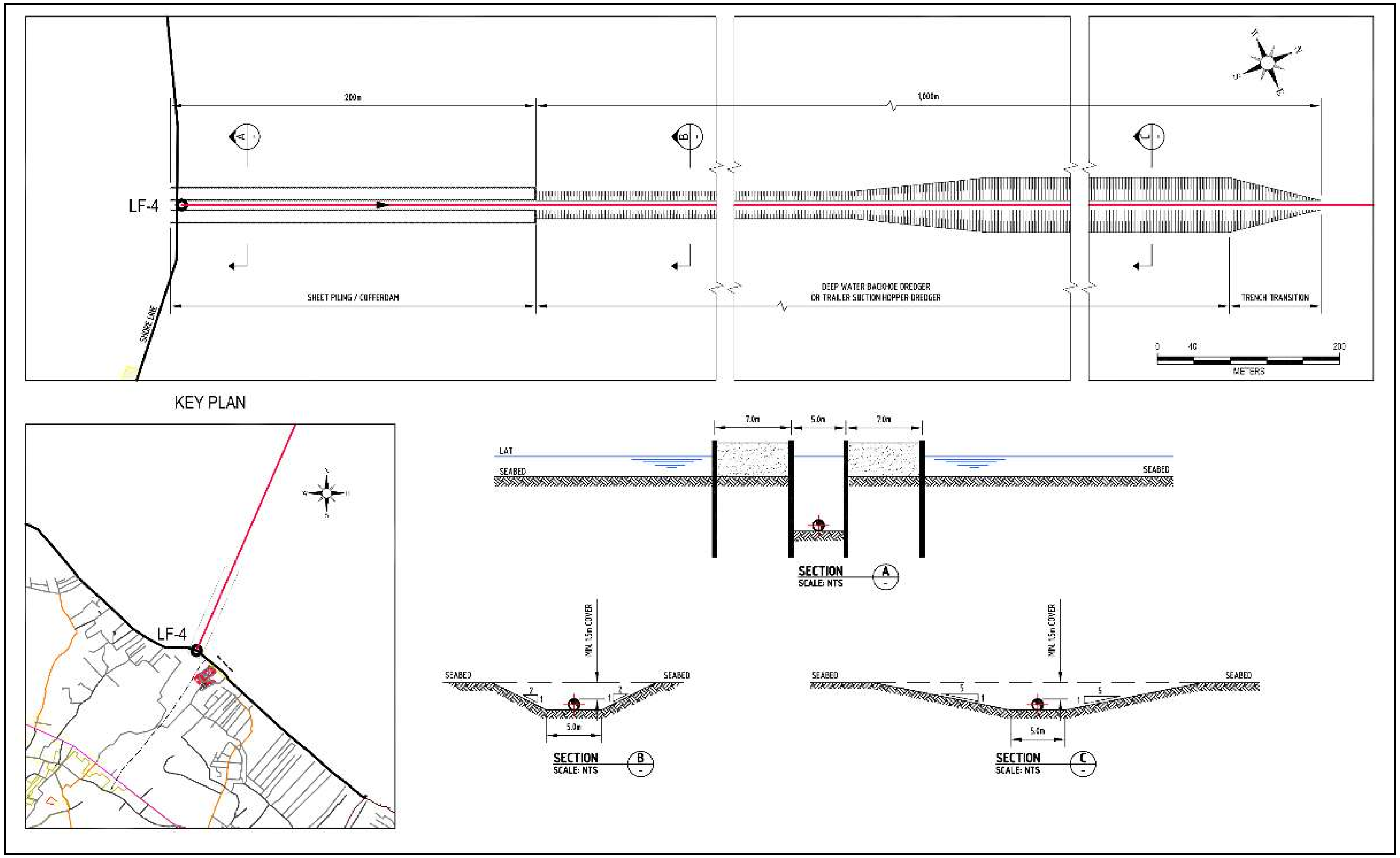


Source: Intecsea, 2020

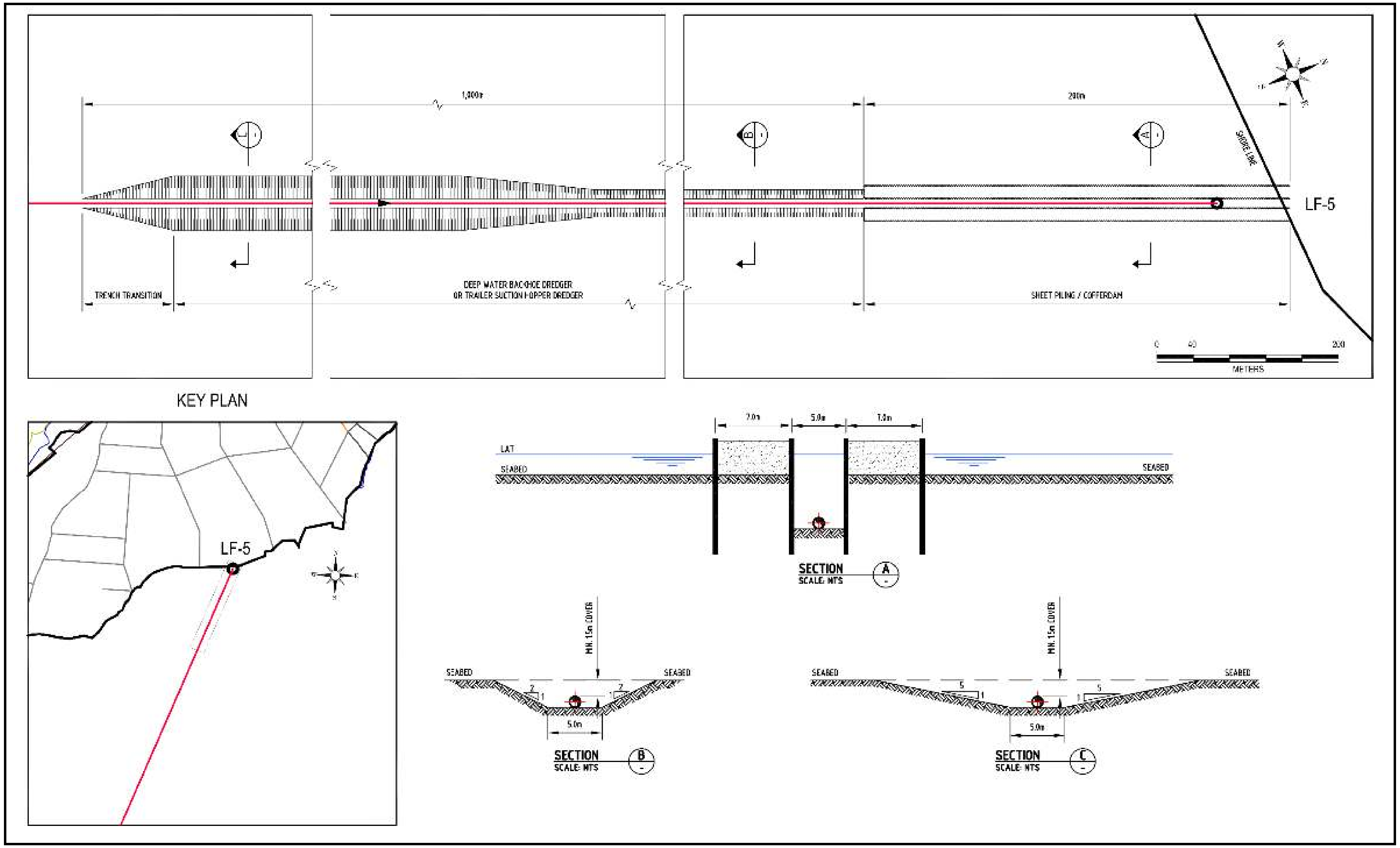
Figure 6-34 Overview of Landfall 4 Design

6.4.3.2.2.4 LF5

Finally, LF5 is located in a flat area consisting mainly of clay, sand and silts. No nearby existing infrastructure can be seen, and the general area is agricultural. After the landfall, the route continues onshore within relatively flat, cultivated land towards a landfall station (LS05). The average gradient is 7 degrees.

The Gulf of Patras is approximately 100 m deep with slope angles below 2 degrees. The seafloor is gentle and continuously sloping towards the centre of the gulf. The LF5 shore approach is long, flat and sandy – clayey. For these conditions, the proposed shore crossing construction method for LF5 is the traditional open cut method with sheet piled cofferdams. The pipeline is installed in a pre-dredged trench prepared by a backhoe or trailer suction hopper dredger in deeper waters, typically to a 25 m water depth. The current assessment shows the sheet piled cofferdam for LF5 is at least 200 m, followed by a 1000 m trench.

Overview of LF5 Design is reported in Figure 6-35.



Source: Intecsea, 2020

Figure 6-35 Overview of Landfall 5 Design

6.4.3.2.3 Summary of the Construciton Methods at Landfalls

Key characteristics related to the open-cut construction at each landfall is presented in Table 6-44.

Table 6-44 Shore Crossing Technical Requirements at Each Landfall Area

Landfall	Offshore Construction (Dredging and Pipelay)	Land Occupation (m^2)	Use of Cofferdam?
LF2 (Crete)	A short trench is required (approx. 300m) due to the steep seabed gradient, resulting in minimum seabed groundworks for pipeline stability/protection purposes. LF2 will accommodate 4 lines, i.e. OSS2 and OSS3 (Southern Line), OSS2N and OSS3N (Northern Line). All lines will be placed in one trench and thus shore crossing construction activities for Southern and Northern Lines will be performed in one construction campaign.	Construction site: 30,000m^2 Excavated trench – backfill soil stored in a dedicated area of 5,000 m^2 Pre-commissioning site: 12,000 m^2	No
LF3 (Peloponnese)	A trench of 500mx 15m is required. LF3 will accommodate 2 lines, OSS3 (Southern Line) and OSS3N (Northern Line). All lines will be placed in one trench and thus shore crossing construction activities for Southern and Northern Lines will be performed in one construction campaign.	Construction site: 30,000m^2 Excavated trench – backfill soil stored in a dedicated area of 8,000 m^2 Pre-commissioning site: 3,500 m^2	No
LF4 (South Patras)	Trenching of 1,200 m pipeline section is required for stability and protection reasons.	Construction site: 30,000m^2 Excavated trench – backfill soil stored in a dedicated area of 5,000 m^2 Pre-commissioning site: 4,500 m^2	Yes

Landfall	Offshore Construction (Dredging and Pipelay)	Land Occupation (m^2)	Use of Cofferdam?
LF5 (North Patras)	The nearshore area is wide and flat. Trenching of 3,000 m pipeline section is required for stability and protection reasons. Excessive pipeline spanning is not expected in the nearshore area that could influence shore crossing layout dimension.	Construction site: 30,000m^2 Excavated trench – backfill soil stored in a dedicated area of 8,000 m^2 Pre-commissioning site: 7,000 m^2	Yes

Source: IGI, 2021

Indicative Schedule

The estimated total duration of each shore crossing construction activities is 6-8 months.

No construction activities are performed during the tourist season (June – August) in order to minimise impacts on tourism in the area during this short period.

6.4.3.2.4 Management of Dredged Material

Dredged material will be generated by the trenching activities performed during the excavation works needed for the construction of the landfalls and the installation of the offshore pipelines in the nearshore areas. This material will consist of seabed sediment and the approximate excavated volume is shown in Table 6-45.

Table 6-45 Estimate Excavated Material from Landfalls Construction

Landfall	Excavated Material (m^3)
LF2	20,000 – 40,000
LF3	20,000 – 35,000
LF4	40,000 – 75,000
LF5	125,000 – 175,000

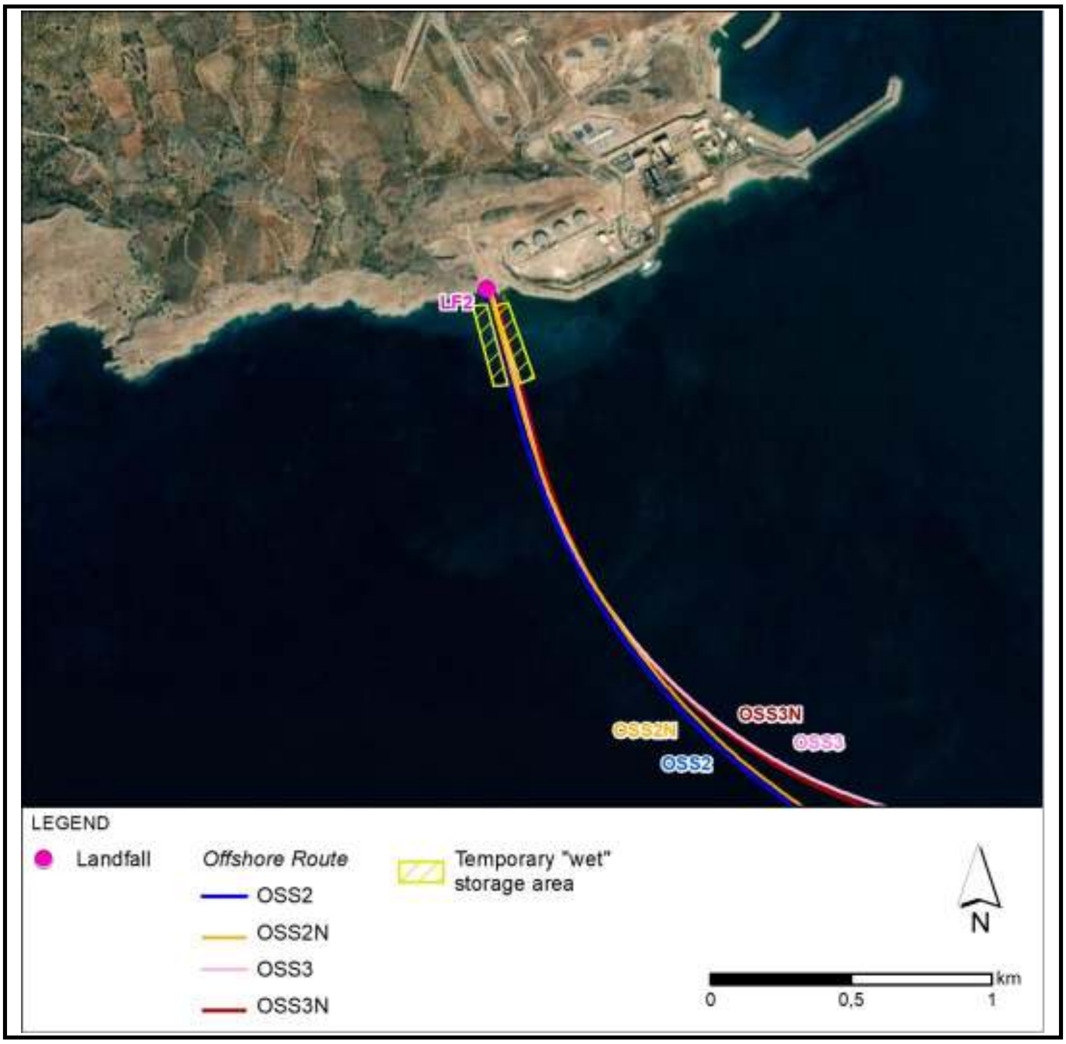
The proposed methodologies for the management fo the dredged material at each landfall are described below:

LF2- The excavated material from LF2 construction will be "wet" stored at each side of the trench and re-used at a later stage for backfilling. This technique, named *side casting*, is largely used in similar projects and allows faster construction time.

LF3, LF4 and LF5 - The excavated material from LF3, LF4 and LF5 constructions will be loaded on (split-hopper) barges and either wet stored at seabed in a temporary offshore storage site, or disposed in a selected offshore disposal site. In the first scenario, the material could be recovered by a dredger from the offshore site and used for backfilling. In the second scenario, the excavated sediment will be disposed at the selected offshore site and backfilled with appropriate and certificated engineered material.

In case a Trailer Suction Hopper Dredger (TSHD) is employed, no barges will be used, but the TSHD will sail to the offshore area and discharge its load by opening its bottom doors.

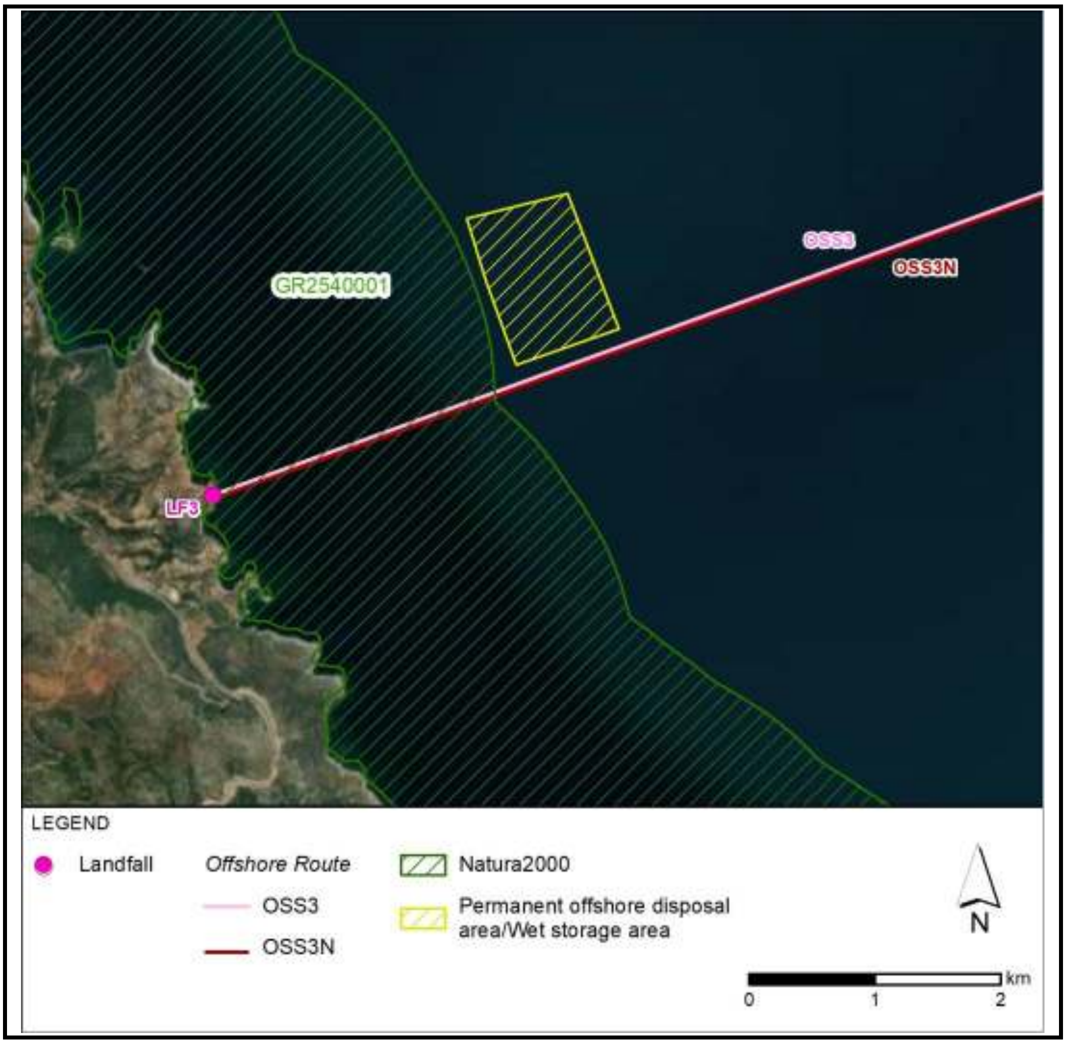
The proposed location for the temporary offshore storage areas for each landfall are shown in Figure 6-36, Figure 6-37, Figure 6-38 and Figure 6-39



Source: IGI Poseidon, 2021

Figure 6-36 Dredged Material Storage Areas – LF2

The indicative area for storing the material dredged from LF2 (Figure 6-36) construction is considered to be the best option, from environmental and technical perspective. Indeed, the identified area is characterized by a rocky and flat seabed with no significant ecological value.



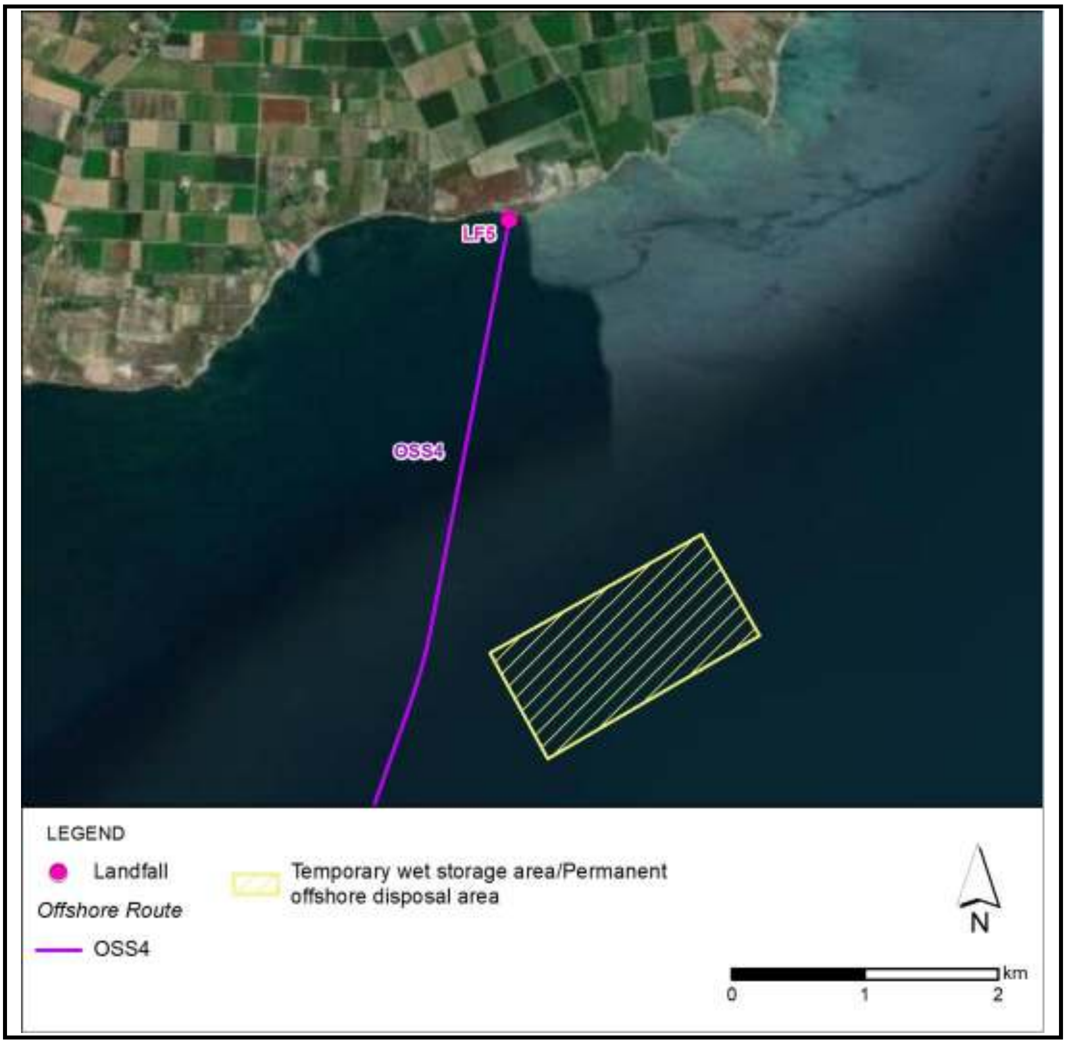
Source: IGI Poseidon, 2021

Figure 6-37 Dredged Material Areas – LF3

It is noted that the indicative area that will be used for either storing or disposing the material dredged from LF3 (Figure 6-37) is located outside the Natura 2000 Area (code: GR2540001). The area was selected with the purpose of minimizing the impacts on the marine environment (e.g.: bioconstructions, marine phanerogams) and avoiding steep seabed profiles.

Source: IGI Poseidon, 2021

Figure 6-38 Dredged Material Areas – LF4



Source: IGI Poseidon, 2021

Figure 6-39 Dredged Material Areas – LF5

The indicative areas for the management of dredged material at LF4 (Figure 6-38) and LF5 (Figure 6-39) were selected with the purpose of avoiding *P.oceanica* meadows, boulders or bioconstructions.

The dredged material will be handled following the requirements listed in OSPAR guidelines for Management of Dredged Material at Sea and "Updating Guidelines on Management of Dredged Materials, COP20, 20-12-2017, Decision IG 23/12" (see Section 3 Legal Framework and related Annex).

6.4.3.3 *Watercourse Crossings*

In general, crossing techniques can be divided into open cut (i.e. dry or wet, where the trench is directly dug across the feature) and trenchless crossing methods which prevent surface disturbance (e.g. HDD).

According to the current design, all river crossings are planned with the open-cut technique unless trenchless techniques are required due to environmental, technical and engineering constraints. Especially, river crossing by means of the dry open cut method is going to be used mainly in the case of small or shallow rivers featured by small water flow rate. Crucial for the application of this crossing method is to take advantage of the dry season (i.e. typically summer and early autumn) during which the river flow is minimised. Open cut method may require diversion of water flow by means of retaining dams in order to install the pipeline in a dry and open trench or in a dry and shored up trench. Propping and shoring up of trenches will be performed (as required) in order to reduce excavations at river / watercourse crossings.

The wet open cut (or wet trench) method will be used at crossings with rivers / watercourses, where the dry open cut method cannot be applied for various reasons, such as in cases where water flow diversion is not possible by means of retaining dams in order to install the pipeline in a dry trench (due to high water flow/velocity, lack of required workspace, etc.) or where the HDD method or 'direct pipe' technique are not feasible for various reasons (e.g. significant crossing length, adverse soil conditions at the crossing area, high cost, etc.).

The design of the river crossing is significantly influenced by environmental issues related to the ecosystem of the river to be crossed. It is noted that not only the river crossing location but also the whole crossing design and the step-by-step procedure to be followed for installation of the pipeline at the river crossing area must be approved by the relevant authorities.

The advantages of open cut include no generation of toxic waste, applicability in all terrain, low cost et al. The most important one, in terms of environmental impacts, is the fact that the crossing construction takes as little time as possible (few days), meaning that the disturbance and all duration-relative impacts to environmental parameters are the minimum possible. On the contrary, disadvantages include temporary changes in riverbed morphology, temporary and reversible modifications to flow regime (in case of wet open cut) and clearance of riparian habitats (if and where present).

On the other hand, trenchless crossing techniques (e.g. HDD) advantages include no interaction with the water body engaged, no modification to the riverbed morphology or to the flow regime. Nevertheless, trenchless methods include (a) much higher costs than open cut methods, (b) geotechnical considerations, i.e. the geotechnical conditions of the crossing area need to be appropriate for the trenchless technique and (c) space limitations, i.e trenchless methods need much more space to be temporarily occupied. The most important aspect, however, is the time needed to prepare, perform, and complete the river crossing with a trenchless method (2-3 months).

Furthermore, the nuisance to the environment surrounding the water body from trenchless crossing activities may be higher and/ or more significant than those of the open cut. For example, the presence of the trenchless construction site in the same area for 2-3 months may cause greater and longer noise nuisance to natural biodiversity and social receptors than the open cut. Also, if the HDD is used as the crossing method, special measures should be considered to contain the disposal of drilling residues and bentonite, etc. As such, if the conservation status or the economic dependencies of the river crossed are not significant, the sheer presence of the trenchless construction site in the specific area is simply much more negative than the impacts on the riparian ecosystem induced by the open cut method.

At open cut river crossings and other special areas, sediment control techniques such as sediment barriers, in-stream weirs or weighted geotextile will be installed to minimise sediment flow, which will minimise the environmental impact. It is estimated that a total of 44 perennial river crossings will be required. Table 6-46 provides a summary of the river crossing points crossed as determined by basic design of the Project.

The open cut method is the preferred option for crossing watercourses as this is proven and safe technology. The method differs slightly depending on the size of the crossing (see Figure 6-40). Major rivers, as shown in Table 6-47 below will be crossed using the trenchless technique, such as horizontal directional drilling (HDD), provided that geotechnical conditions allow it (subject to further geotechnical investigations) (see Figure 6-41). HDD is a technique that avoids impacts to the river itself (i.e. banks, riverbed, water quality) and loss of riparian vegetation. The HDD method is used where ground conditions permit and where disruption to others will be unacceptable or where there will be significant damage to the environment using open cut methods.Specifically, rivers within Natura 2000 sites will be crossed by HDD because they are protected areas.

ANNEX 6J shows schematics for typical river crossings techniques.

6.4.3.3.1 Open Cut Method for River Crossings

Rivers are generally crossed by excavating an open trench and installing a siphon. The pipe trench is excavated by means of excavators operating from floating pontoons. The defined height and the width of the pipe trench are continuously monitored and documented by means of echo soundings. The excavated material is stored temporarily in designated and approved places. The pipeline section for the river crossing is constructed on the river bank and then pulled into position using a winch located on the opposite river bank. After checking that the pipeline is in the correct position, the pipe trench is backfilled and any sheet piles are removed. Pipes with increased wall thickness and a "reinforced PE coating" are used for the crossings as they will have to withstand the additional weight of the overlying river bed material and water. Buoyancy control is achieved by means of a reinforced concrete coating which also serves to mechanically protect the PE coating during the pulling-in process. The following table indicates the locations where open cut will be implemented.

Table 6-46 River Crossing Points with Open Trench

s/n	Crossing Method	WaterCourse Name	Crossing Type	Location of Crossing Point (Related IP and Distance (m)	Kilometer Chainage	Pipeline Section
MC0006	Open Cut	-	RV2	IP0240+136.77	59.76	CCS1
MC0007	Open Cut	Ravine	RV2	IP0252+482.32	65.48	CCS1
MC0008	Open Cut	Tributary of Evrotas No 1	RV2	IP0257+99.87	69.42	CCS1
C0228	Open Cut	-	RV2	IP0264+944.10	72.30	CCS1
MC0009	Open Cut	Tributary of Evrotas No 2	RV2	IP0265+1,097.59	73.42	CCS1
C0284	Open Cut	-	RV2	IP0338+164.29	94.13	CCS1
MC0011	Open Cut	Oinous River (Tributare of Evrotas)	RV2	IP0359+50.98	96.93	CCS1
C0333	Open Cut	-	RV2	IP0372+59.09	99.53	CCS1
C0334	Open Cut	-	RV2	IP0373+112.26	99.67	CCS1
C0338	Open Cut	-	RV2	IP0376+52.52	100.22	CCS1
MC0014	Open Cut	River Evrotas	RV2	IP0380+293.99	101.29	CCS1
C0354	Open Cut	-	RV2	IP0391+189.72	104.12	CCS1
C0356	Open Cut	-	RV2	IP0393+34.11	104.58	CCS1
C0375	Open Cut	-	RV2	IP0432+428.81	111.76	CCS1

s/n	Crossing Method	WaterCourse Name	Crossing Type	Location of Crossing Point (Related IP and Distance (m)	Kilometer Chainage	Pipeline Section
C0390	Open Cut	-	RV2	IP0448+68.36	116.72	CCS1
C0399	Open Cut	-	RV2	IP0466+16.77	120.36	CCS1
C0424	Open Cut	-	RV2	IP0489+140.35	124.97	CCS1
C0440	Open Cut	-	RV2	IP0510+92.57	128.08	CCS1
C0464	Open Cut	Koutifarina Stream	RV2	IP0551+56.61	140.44	CCS1
MC0023	Open Cut	Xerilas Stream	RV2	IP0577+172.77	146.28	CCS1
C0498	Open Cut	-	RV2	IP0622+149.71	154.05	CCS1
C0499	Open Cut	Plataka Stream	RV2	IP0624+133.33	154.50	CCS1
C0550	Open Cut	-	RV2	IP0736+86.22	171.97	CCS1
C0632	Open Cut	-	RV2	IP0861+23.96	194.81	CCS1
C0634	Open Cut	Roggozitiko Stream	RV2	IP0862+241.83	195.16	CCS1
MC0026	Direct Pipe	Alfios River	RV1	IP0907+475.74	202.37	CCS1
MC0027	Open Cut	Erimanthos River	RV1	IP0910+177.75	204.17	CCS1
C0692	Open Cut	-	RV2	IP0935+198.86	210.57	CCS1
C0713	Open Cut	-	RV2	IP0978+39.44	217.50	CCS1
MC0030	Open Cut	Ravine	RV2	IP1032+128.09	231.49	CCS1
MC0031	Open Cut	Ladonas River	RV1	IP1128+151.87	247.46	CCS1
C0803	Open Cut	Ntaraiiko Stream	RV2	IP1138+48.68	249.93	CCS1

s/n	Crossing Method	WaterCourse Name	Crossing Type	Location of Crossing Point (Related IP and Distance (m)	Kilometer Chainage	Pipeline Section
C0820	Open Cut	Bikiza Stream	RV2	IP1156+31.59	255.17	CCS1
C0825	Open Cut	-	RV2	IP1163+44.82	256.60	CCS1
C0836	Open Cut	-	RV2	IP1183+55.07	258.69	CCS1
C0846	Open Cut	-	RV2	IP1209+84.12	262.06	CCS1
MC0032	Open Cut	Pinios River of Ilia	RV2	IP1215+73.02	263.29	CCS1
C0858	Open Cut	-	RV2	IP1220+196.93	264.53	CCS1
C0859	Open Cut	-	RV2	IP1221+99.26	264.67	CCS1
C0860	Open Cut	-	RV2	IP1222+40.76	264.79	CCS1
C0006-BR	Open Cut	Koutifarina Stream	RV2	IP4003+162.15	0.76	Megalopoli Branch
C0010-BR	Open Cut	-	RV2	IP4005+245.91	1.41	Megalopoli Branch
C0024-BR	Open Cut	River Alfeios (Rofias)	RV2	IP4023+47.73	4.49	Megalopoli Branch
C0036-BR	Open Cut	-	RV2	IP4030+180.29	6.66	Megalopoli Branch

Source: E780-P616-100-LS-PLN-02_2_CCS1-Peloponnese Crossing list (IFU) & E780-P616-100-LS-PLN-06_2_CCS2-West Greece - Crossing list (IFU)

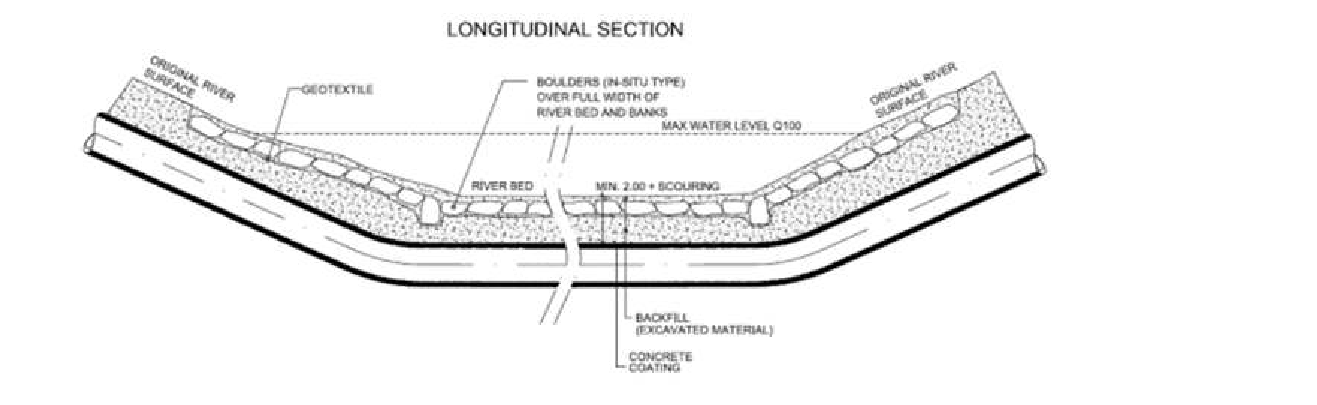
Regarding smaller rivers and streams, a temporary passage is erected across the watercourse after preparing the working strip. This passage principally consists of an earth dam which, depending on the water level, is equipped with pipes to ensure the unhindered flow of water. This passage is dimensioned for a low to medium water flow and is flooded in case of high water levels.

The pipeline section is pre-fabricated on the river bank together with its concrete casing.

The trench is then excavated across the watercourse to accommodate the pipeline (see Figure 6-40). Excavation of the trench is likely to make the water turbid. However, in smaller streams with a surface width of between 3-5 m this turbidity will last for approximately half a day only. For bigger crossings sediment curtains can be installed in order to prevent the sediment plume from travelling downstream. Specific measures, such as sediment barriers, and seasonal limitations, such as construction only in low flow conditions, are usually implemented to minimise the mobilisation of fine particulate materials downstream.

The prefabricated section of pipeline will then be lifted into place, and the pipe trench is backfilled using the stored excavation material. This will again make the water turbid, with the duration of the work being limited to a few hours for smaller streams. In streams where an infiltration from the river into the groundwater is possible, clay barriers at the river banks are used to seal the pipeline trench. The river bed is then restored to its original state.

The river banks are then restored incorporating stabilisation of the river bank slopes (erosion control systems). Slope stabilisation is dimensioned according to the expected flood run-off, with bank protection being defined as a function of the water depth and the inclination of the water run. In order to construct bank protection in accordance with ecological aspects, natural measures for stabilising the river bank are given preference. When stones are used to stabilise the river bank, they are subsequently covered with humus to facilitate a natural vegetation cover.



Source: ASPROFOS, 2021

Figure 6-40 Indicative Open-Cut River Crossing

6.4.3.3.2 Trenchless Method for Rivers and Streams

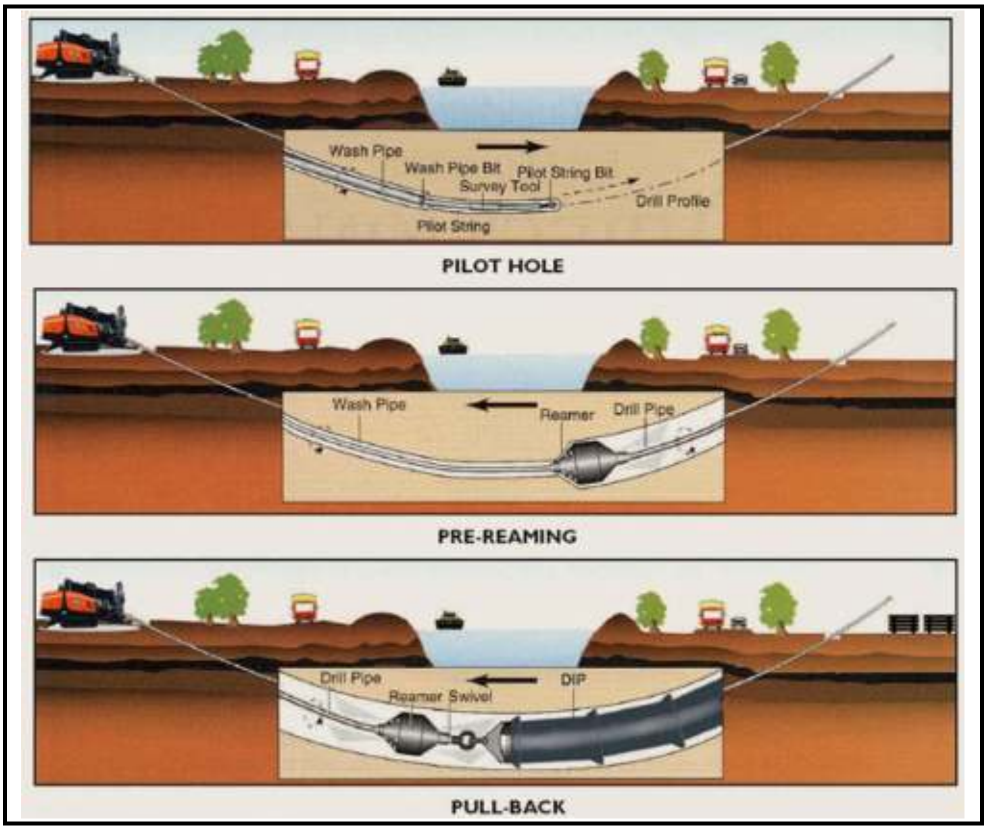
Although the open cut method is also the preferred and simplest method for larger rivers which have significant width, large water volumes and sensitive ecosystems downstream and so long as soil conditions allow, HDD will be employed, or alternatively microtunneling which is another trenchless crossing method.

Table 6-47 River Crossing Points with Trenchless Method

s/n	Crossing Method	WaterCourse Name (Natura Site)	Crossing Type	Location of Crossing Point (Related IP and Distance (m)	Kilometer Chainage	Pipeline Section
MC0026	Direct Pipe	Alfios River	Large Rivers (Crossing Width≥30m)	IP0907+475.74	202.37	CCS1
MC0103	Direct Pipe	River Evinos	Large Rivers (Crossing Width≥30m)	IP2024+969.13	8.77	CCS2
MC0109	HDD	Water Canal Trichonida - Lisimachia	Large Rivers (Crossing Width≥30m)	IP2153+1,009.99	37.28	CCS2
MC0114	Direct Pipe	River Acheloos	Large Rivers (Crossing Width≥30m)	IP2188+1,711.2	57.14	CCS2
MC0116	Boring Without Casing	Artificial Concrete Irrigation Channel	Concrete Irrigation Channel	IP2192+609.36	59.84	CCS2
MC0121	HDD	River Arachthos	Large Rivers (Crossing Width≥30m)	IP2513+909.18	134.91	CCS2
MC0126	HDD	River Louros	Large Rivers (Crossing Width≥30m)	IP2578+551.52	159.82	CCS2
MC0127	HDD	Tributary of River Louros	Rivers (Crossing Width<30m-≥5)	IP2580+728.38	161.92	CCS2
MC0129	HDD	Irrigation Ditch	Rivers (Crossing Width<30m-≥5)	IP2584+944.7	167.34	CCS2
MC0133	HDD	River Acherontas	Large Rivers (Crossing Width≥30m)	IP2672+410.51	196.43	CCS2
MC0135	HDD	Vouvopotamos River	Rivers (Crossing Width<30m-≥5)	IP2676+1,610.02	201.55	CCS2

Source: E780-P616-100-LS-PLN-02_2_CCS1-Peloponnese Crossing list (IFU) & E780-P616-100-LS-PLN-06_2_CCS2-West Greece - Crossing list (IFU)

The HDD tunneling method is illustrated in Figure 6-41. HDD is a trenchless crossing method which begins with boring a small diameter, horizontal hole (pilot hole) under the crossing obstacle (e.g. a river) with a steel drill rod. When the steel drill rod emerges on the opposite side of the crossing, a special cutter, called a back reamer, is attached and pulled back through the pilot hole. The reamer bores out the pilot hole so that the pipe can be pulled through. The pipe is usually pulled through from the side of the crossing opposite the drill rig. Usually a drilling mud, such as fluid bentonite clay (an inert, non-toxic substance), is forced down the hole to stabilise the hole and remove soil cuttings. Bentonite provides lubrication to the hole drilling and also provides stability and support for the borehole.



Source: ASPROFOS, 2022

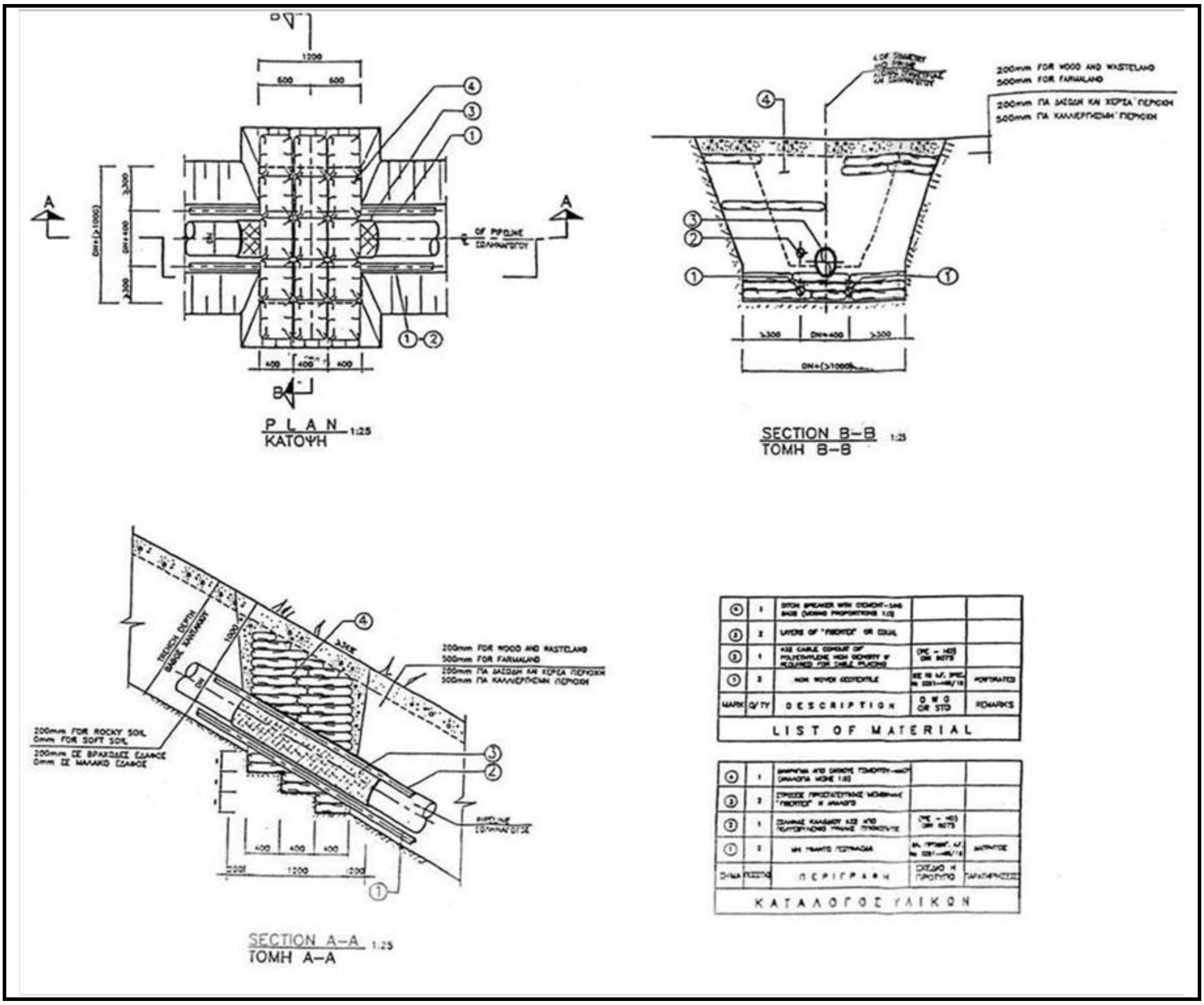
Figure 6-41 Typical HDD River Crossing

6.4.3.3.3 Pipeline Protection and Pipeline Stabilisation against Landslide and Instability

There are many areas that are challenging for a pipeline due to geo-hazards; particularly landslides, earth flows and erosion gullies. After removing the natural cover for the trench, especially in hilly areas, the strip must be prepared by excavation or landfill measures. In case of bad ground conditions the slopes need to be stabilised and eventually drained.

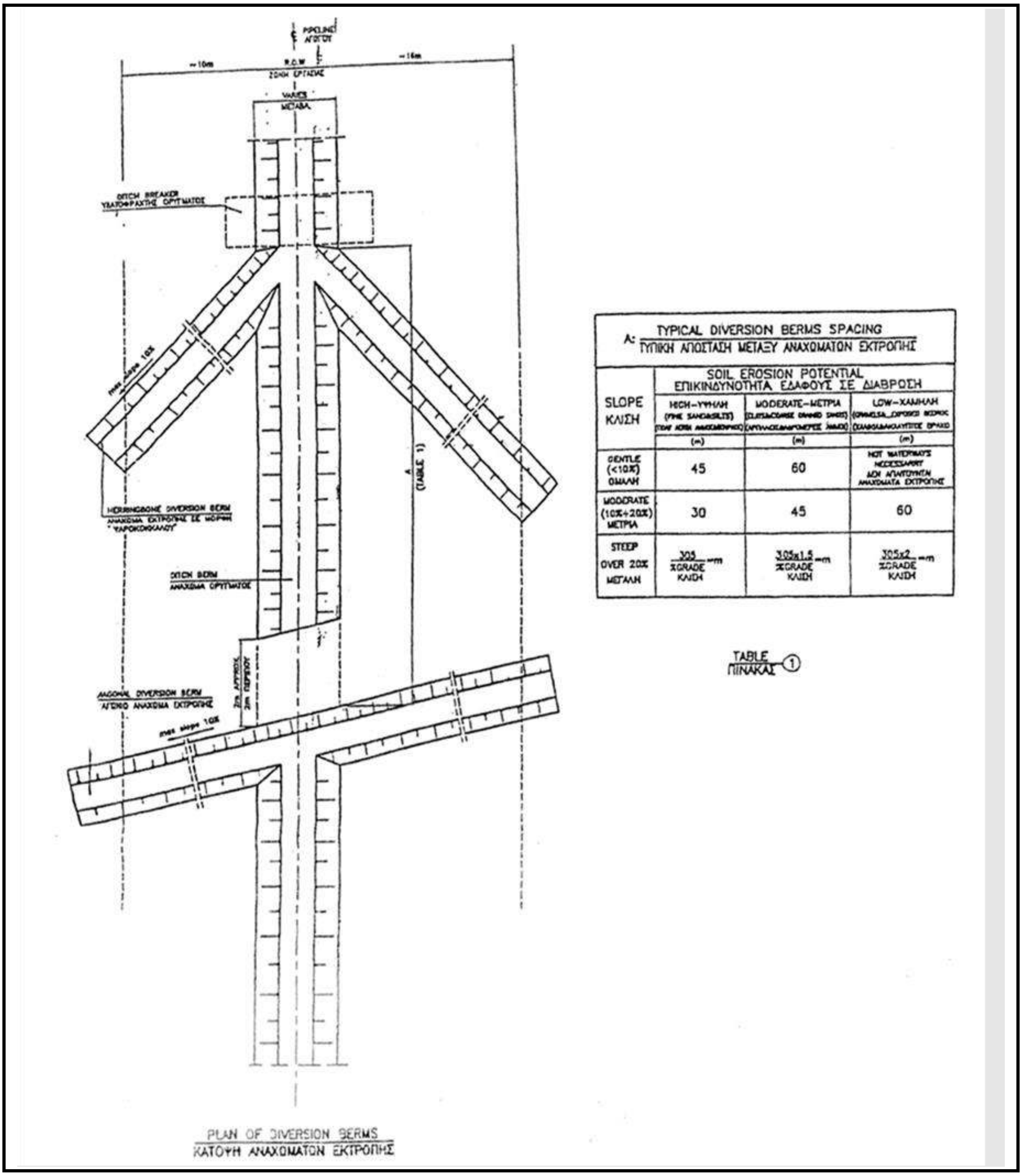
Adequate protection measures will also be implemented at river banks to prevent instability and erosion of the river bank. This will be implemented upstream and downstream of the river crossings and may include a combination of the installation of vegetation, geotextiles and stones as appropriate.

The following figures are indicative of the available techniques.



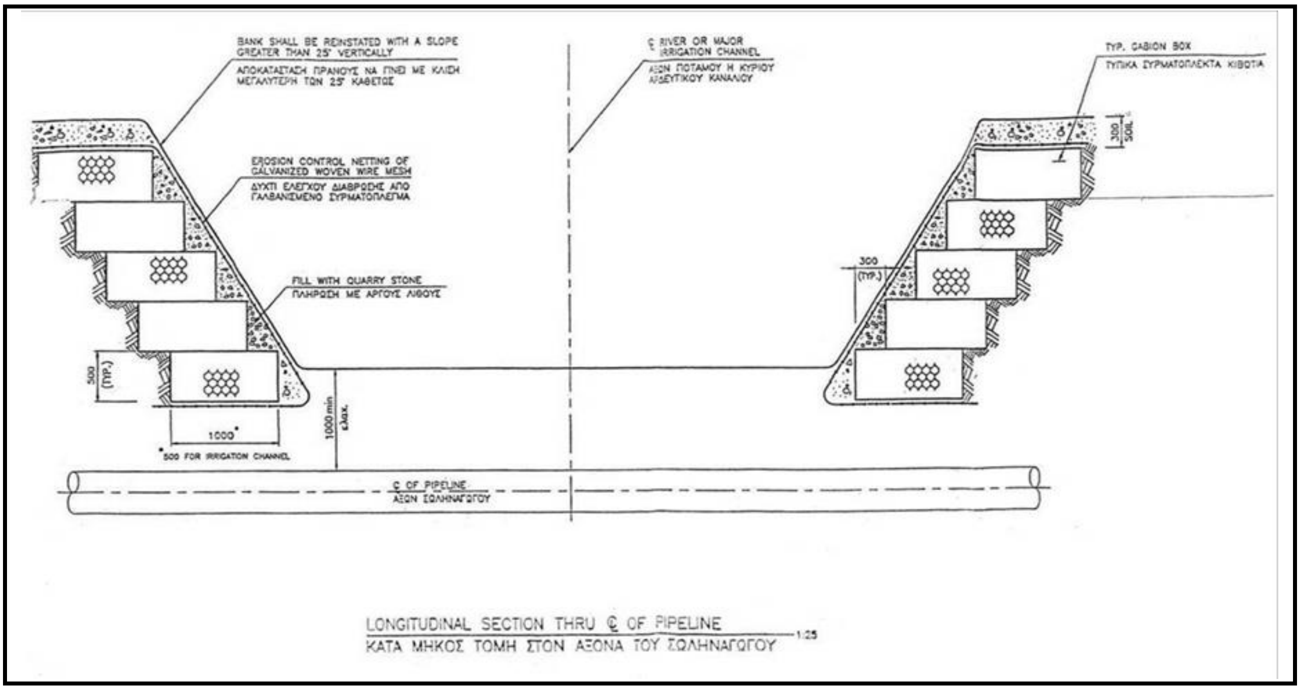
Source: ASPROFOS, 2022

Figure 6-42 Anticorrosion Protection Using Ditch Breakers with Cement – Sand Bags.



Source: ASPROFOS, 2021

Figure 6-43 Surface Runoff and Anti-Erosion Protection Using Diversion Berms



Source: ASPROFOS, 2021

Figure 6-44 Slope Protection using Gabions

Topsoil Handling

A important method against landslide is topsoil handling. Specifically after the pre-entry survey, the first operation to be carried out at the onshore site is topsoil stripping.

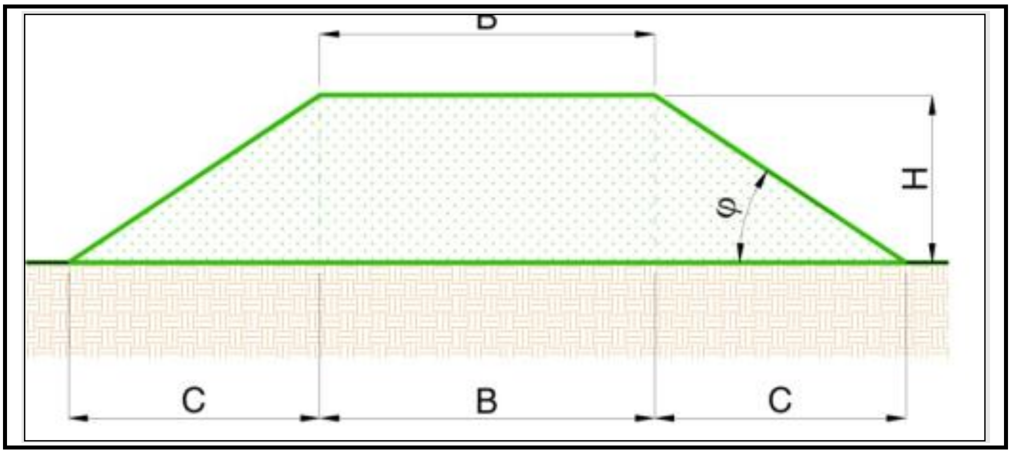
Topsoil will be removed by means of suitable earth moving equipment (such as excavators and loaders) from the entire surface of the area, with the only exception being the areas designated for topsoil storage. The average depth of the topsoil strip to be removed is 0.2 m but this will be adapted to local soil conditions.

If, due to weather events, the topsoil is considered too wet to be worked during stripping without resulting in harmful effects on its structure, works are suspended until such time that the topsoil is dry enough to be handled without causing long-term damage.

In areas where topsoil removal interferes with outcrops of hard rock, the top part of soil and rock is, as far as practicable, screened and crushed preserving the fine fraction (humus and gravel) and setting it aside together with the topsoil. At the end of the reinstatement operations, the part previously set aside will be replaced as the top layer as stony matrix with humus.

The topsoil removed will be stockpiled within the area for temporary storage until site reinstatement.

Topsoil stockpiles will be no more than 2.0 m high in order to prevent erosion and protect them from degradation or excessive compaction. The slope angle of the stockpiles will be close to the angle of repose of the topsoil.



Source: IGI, 2021

Figure 6-45 Sketch of Topsoil Stockpiles

6.4.3.3.4 *Construction in Areas with High Water Table*

For construction in areas of high groundwater table, the pipe trench will require dewatering to ensure a dry work zone. The new pipeline will be fitted with buoyancy control in the form of either concrete weighting or a piled foundation to prevent the pipeline from floating on the water table during operation.

6.4.3.4 *Road Crossings*

Crossing techniques can be divided into open cut (where the trench is dug directly across the feature), and trenchless crossing methods which prevent surface disturbance. Trenchless crossing methods include jack and bore, thrust-boring, auger boring, micro-tunneling and horizontal directional drilling (HDD). These methods are used where ground conditions permit, and where disruption to others will be unacceptable or where there will be significant damage to the environment from the use of open cut methods.

Road crossings are planned with the open-cut technique unless trenchless techniques are required due to environmental, technical and engineering constraints.

6.4.3.4.1 Open Trench Method

According to design output and subject to relevant authority requirements and/or network operator, an open trench construction procedure will be used for pipeline crossings.

When utilising an open trench crossing method, the carrier pipe may be installed with or without casing. The use of casing pipe should be minimised to the extent possible as it may cause adverse effects on the cathodic protection system.

The minimum pipeline or casing cover will comply with relevant authorities' requirements. In any case it shall not be less than 1.00 m. In cases of installation without casing where the specified minimum cover cannot be achieved due to construction constraints, additional mechanical protection measures, such as concrete coating or reinforced concrete slab bridging, will be implemented to protect the carrier pipe from future excavation and imposed loads.

All excavated material which is unsuitable for backfilling will be hauled off the construction site and disposed of in accordance with all in force laws and regulations. The trench will be backfilled immediately after pipe lowering-in..

6.4.3.4.2 Trenchless Methods

Where open trench methods are prohibitive, and where approved by the relevant authorities and/or network operator, a trenchless construction procedure will be used for pipeline crossings at specified locations. Where trenchless methods are specified, pipeline crossings will be constructed using either the auger boring or the thrust boring technique, or any other method approved (e.g. HDD). The suitability of either method will be finally assessed based on actual geotechnical and site conditions and consideration of relevant authority requirements.

Pipeline crossing construction using trenchless methods will involve construction of launcher and receiver pits with adequate dimensions for the boring method and the equipment to be employed, including any supplementary trench required for installation of casing or carrier pipe and removal of excavated material. All necessary precautions will be taken to ensure boring pit wall stability. Adequate propping and shoring will be provided where required.

The excavated launcher and receiver pits will be continuously dewatered during construction by pumping. Pumped water will be disposed of in accordance with all local laws and regulations.

Where a high groundwater table is encountered during construction, continuous dewatering will be applied until the pipeline installation is complete. The groundwater table mustbe maintained 600 mm below the casing or carrier pipe at all times. When needed, dewatering may be initiated prior to any excavation.

Existing storm water sewers will only be used to discharge water from dewatering operations when relevant permit has been obtained from the storm sewer operator/owner. Filters or sediment control devices will be installed to ensure that the existing sewer system is not adversely affected by construction debris or sediment.

A suitable foundation will be provided on the launcher pit for the boring equipment. The boring equipment must be properly supported in order to avoid any settlements during boring operation and ensure accurate boring alignment. Fencing barriers will be installed adjacent to boring pits, open excavations, equipment and supplies to prohibit pedestrian access to the worksite.

When utilising trenchless methods, the carrier pipe may be installed with or without casing subject to relevant authority approval. In uncased borings a suitable construction method must be implemented in order to ensure that the carrier pipe coating is not damaged during installation. At crossings made with HDD (without casing) an increased thickness of the three layer PP pipeline coating will be foreseen.

For auger borings the diameter of the auger will not exceed the external diameter of the casing or carrier pipe by more than 2% or 25 mm, whichever is less.

Considerable jacking forces may be required to install pipe when using trenchless methods. The allowable jacking strength capacity of installed pipe will be capable of withstanding the maximum jacking forces imposed by the operation. The specified allowable jacking capacity of the casing pipe will be at least 3 times greater than the maximum jacking forces imposed by jacking operations.

Lubrication fluids, consisting of a mixture of water and bentonite or bentonite/polymer, will be used in the annular space between the casing or carrier pipe being installed and the native soil to reduce friction and corresponding jacking forces on the pipe.

The auger will operate approximately 0.50 m ahead of the leading end of the casing or carrier pipe already installed, so that a core of unbroken earth is maintained. The length and thickness of this core will be sufficient to ensure that material from outside the pipe cannot collapse inside, or be washed in, leaving cavities on the installed pipe perimeter. During boring in soft soil conditions or in cohesionless soils, special care must be exercised and suitable measures employed to avoid the creation of cavities over the pipe.

The boring operation will be continuous. Any interruption in boring (e.g. for the connection of a new pipe string) will be kept as short as possible.

The boring pressure will be continuously monitored and recorded. Boring alignment and elevation will also be monitored and recorded at intervals not exceeding 4 m. Maximum allowed deviation in alignment and elevation will be 15 mm for every 5 m of boring. The final deviation of the boring should not exceed the ROW limits and should not prevent proper support of the carrier pipe. Any deviation of the installed pipe at the crossing from the specified axis will be compensated for in the adjacent bends.

Boring using carrier pipes in rock is not allowed. Casing pipes without coating will be used in rocky areas. In such cases the internal diameter of the casing pipe will provide sufficient working space inside the casing pipe for the rock to be removed by manual mining methods. In any case the auger drill bit will be suitable for the hardness of the rock formations encountered.

After completing casing pipe installation, the carrier pipe will be inserted within the casing pipe. The carrier pipe will be supported by insulating spacers firmly attached to the carrier pipe. Insulating spacer spacing will be designed to support the weight of the carrier pipe full of water. In any case their spacing will not exceed 2.0 metres. A clearance of 0.50 m will be reserved at each end for fitting plastic pad supports.

The construction method will ensure that there is no contact between the carrier pipe and the steel casing pipe. Two HDPE conduits will be secured to the top side of the carrier pipe. Prior to backfilling the duct will be tested. Watertight end seals will be fitted at each end of the casing pipe after installation of the carrier pipe.

Prior to backfilling, special care will be exercised for the proper support of the carrier pipe at the two ends at the exit from the casing pipe. The soft soil below the carrier pipe will be removed for a length of at least 5.0 metres from the edge of the casing pipe and at a depth of 0.50 metres and will be replaced by compacted quarry sand material. The material will be placed in layers not exceeding the 0.30 m loose thickness and will be properly compacted. The height of the compacted material wuill exceed the bottom of the casing pipe for at least 50 mm ensuring that the casing pipe is evenly and properly supported.

Properly compacted quarry or river sand will be used as padding material for the carrier pipe at both ends of casing bored. Any additional requirements imposed by the relevant authorities shall be observed.

6.4.3.5 *Marine Crossings*

In total, 49 marine crossings with existing utilities have been identified along the Greek seciton of EastMed Pipeline Project. Table 6-48 reports the location, water depth, sevice and crossing status of the marine crossings identified for OSS2/OSS2N, OSS3/OSS3N and OSS4. .

Table 6-48 List of Offshore Crossings

s/n	Type	Service Status	Water Depth (m)	Burial Status	KP	Crossing Status	Pipeline Section
2-18	Power Cable	Planned	2,534.00	Exposed	195.89	Planned	OSS2/OSS 2N
2-19	Power Cable	Planned	2,555.00	Exposed	199.95	Planned	OSS2/OSS 2N
2-20	Fiber Optic Cable	In Service	2,486.00	Exposed	207.38	Provisional	OSS2/OSS 2N
2-21	Fiber Optic Cable	In Service	2,573.00	Exposed	225.04	Provisional	OSS2/OSS 2N
2-22	Fiber Optic Cable	Out of Service	2,567.00	Exposed	236.78	Provisional	OSS2/OSS 2N
2-23	Power Cable	Planned	2,786.00	Exposed	295.47	Planned	OSS2/OSS 2N
2-24	Fiber Optic Cable	Out of Service	2,797.00	Exposed	297.02	Provisional	OSS2/OSS 2N
2-25	Power Cable	Planned	2,785.00	Exposed	298.41	Planned	OSS2/OSS 2N
2-26	Power Cable	Planned	2,600.00	Exposed	347.70	Planned	OSS2/OSS 2N
2-27	Power Cable	Planned	2,661.00	Exposed	350.93	Planned	OSS2/OSS 2N
2-28	Fiber Optic Cable	Out of Service	2,575.00	Exposed	405.35	Provisional	OSS2/OSS 2N
2-29	Fiber Optic - Coaxial Cable	In Service	2,392.00	Exposed	455.11	Provisional	OSS2/OSS 2N
2-30	Coaxial Cable	Out of Service	2,513.00	Exposed	488.11	Provisional	OSS2/OSS 2N
2-31	Fiber Optic - Coaxial Cable	In Service	2,544.00	Exposed	522.51	Provisional	OSS2/OSS 2N
2-32	Fiber Optic Cable	Out of Service	2,560.00	Exposed	527.18	Provisional	OSS2/OSS 2N
2-33	Fiber Optic Cable	In Service	2,564.00	Exposed	527.36	Provisional	OSS2/OSS 2N
2-34	Fiber Optic Cable	Out of Service	2,572.00	Exposed	527.62	Provisional	OSS2/OSS 2N

s/n	Type	Service Status	Water Depth (m)	Burial Status	KP	Crossing Status	Pipeline Section
2-35	Fiber Optic Cable	In Service	2,644.00	Exposed	539.74	Provisional	OSS2/OSS 2N
2-36	Fiber Optic - Coaxial Cable	In Service	2,185.00	Exposed	629.58	Provisional	OSS2/OSS 2N
3-1	Fiber Optic Cable	In Service	740.00	Buried	55.36	Provisional	OSS3/OSS 3N
3-2	Fiber Optic Cable	In Service	206.00	Buried	67.23	Provisional	OSS3/OSS 3N
3-3	Power Cable	Planned	248.00	Buried	71.22	Planned	OSS3/OSS 3N
3-4	Power Cable	Planned	292.00	Buried	71.94	Planned	OSS3/OSS 3N
3-5	Submarine Cable	N/A	913.00	Buried	92.63	Provisional	OSS3/OSS 3N
3-6	Submarine Cable	N/A	1083.00	Exposed	97.18	Provisional	OSS3/OSS 3N
3-7	Fiber Optic Cable	In Service	866.00	Buried	115.68	Provisional	OSS3/OSS 3N
3-8	Submarine Cable	N/A	584.00	Buried	164.90	Provisional	OSS3/OSS 3N
3-9	Coaxial Cable	Out of Service - Decommissioned	588.00	Buried	164.99	Provisional	OSS3/OSS 3N
3-10	Fiber Optic Cable	Out of Service	590.00	Buried	165.05	Provisional	OSS3/OSS 3N
3-11	Fiber Optic Cable	Out of Service	682.00	Buried	170.97	Provisional	OSS3/OSS 3N
3-12	Fiber Optic Cable	Service Status	667.00	Buried	176.19	Provisional	OSS3/OSS 3N
3-13	Fiber Optic Cable	Planned	724.00	Buried	185.18	Provisional	OSS3/OSS 3N
3-14	Coaxial Cable	Planned	969.00	Buried	210.80	Provisional	OSS3/OSS 3N
3-15	Fiber Optic Cable	In Service	933.00	Buried	214.41	Provisional	OSS3/OSS 3N

s/n	Type	Service Status	Water Depth (m)	Burial Status	KP	Crossing Status	Pipeline Section
3-16	Coaxial Cable	Out of Service	896.00	Buried	215.57	Provisional	OSS3/OSS 3N
3-17	Fiber Optic Cable	Out of Service	1,060.00	Exposed	235.51	Provisional	OSS3/OSS 3N
3-18	Power Cable	Under constructi on	1,091.00	Exposed	244.48	Provisional	OSS3/OSS 3N
3-19	Fiber Optic Cable	In Service	927.00	Buried	251.67	Provisional	OSS3/OSS 3N
3-20	Coaxial Cable	Out of Service	943.00	Buried	253.29	Provisional	OSS3/OSS 3N
3-21	Fiber Optic Cable	In Service	1,066.00	Exposed	254.21	Provisional	OSS3/OSS 3N
3-22	Fiber Optic Cable	In Service	1,133.00	Exposed	261.87	Provisional	OSS3/OSS 3N
3-23	Fiber Optic Cable	N/A	992.00	Buried	277.10	Provisional	OSS3/OSS 3N
3-24	Fiber Optic Cable	Out of Service	1,025.00	Exposed	306.67	Provisional	OSS3/OSS 3N
3-25	Fiber Optic Cable	In Service	888.00	Buried	314.54	Provisional	OSS3/OSS 3N
3-26	Fiber Optic Cable	In Service	875.00	Buried	319.30	Provisional	OSS3/OSS 3N
3-27	Fiber Optic Cable	Planned	813.00	Buried	342.67	Planned	OSS3/OSS 3N
3-28	Fiber Optic Cable	Planned	565.00	Buried	370.82	Planned	OSS3/OSS 3N
3-29	Fiber Optic Cable	In Service	519.00	Buried	397.44	Provisional	OSS3/OSS 3N
4-1	Submarine Cable	Unknown	86.00	Buried	4.55	Provisional	OSS4

Source: 00225-Ev32A-BOD-00053_1_Project Design Basis IGI, 2021

6.4.3.5.1 Out-of-service cables

Unless otherwise specified by the cable owners, the out-of-service cables, whether the cable is buried or exposed, will be crossed with a concrete mattress installed on the top of the cable at the crossing location. This is to protect the external coating of pipeline and to ensure that a separation of at least 0.3 m is created between the pipeline and cable as stipulated in Section 5.2.1.2 of DNVGL-ST-F10.

Concrete mattress can be eliminated if the out-of-service cable crossing location cannot be detected during the pre-lay survey; in this case, the cable is likely deeply buried.

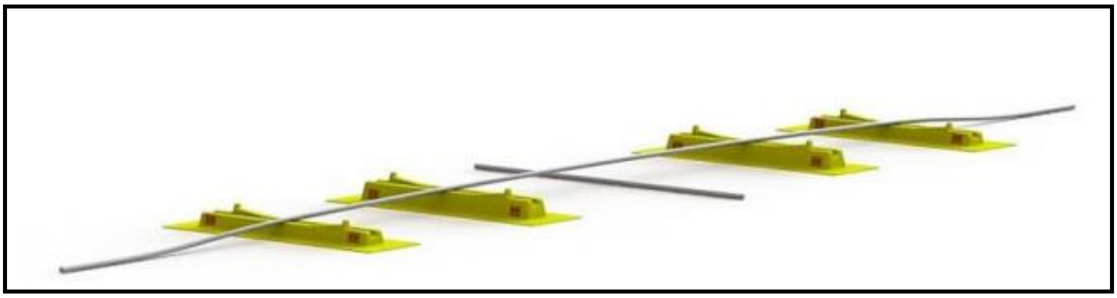
Construction sequence at out-of-service cable location:

For each out-of-service cable crossing location, the construction sequence is assumed as follows:

- Install the concrete mattresses on top of the out-of-service cable at the crossing position;
- Install the pipeline over the concrete mattresses and cross the cable.

6.4.3.5.2 In-service cable

For the in-service cables, to avoid any damage and to ensure that a separation of at least 0.3 m is created, the conventional bridging structure will be applied at the crossing locations. The main components of the conventional bridging structure are that one or two supports (concrete mattress or steel support) are pre-installed on each side of the cable (or pipeline) to form the bridge structure as indicated in Figure 6-46.



Source: 00225-Ev62A-DEG-00194_3_Cable Crossing Design Premise, 2021

Figure 6-46 Crossing with sleepers

No support should come into direct contact with the cable unless with cable owner's approval. Therefore, no mattress should be placed over the in-service cables regardless whether they are exposed on the seabed or buried.

The seabed embedment of the supports will be estimated to determine what support heights are needed to fulfil the 0.3 m height separation between existing cable/pipeline and EastMed pipeline after settlement of the supports. The minimum required elevation heights after settlement are presented in Table 6-49.

Table 6-49 Minimum primary support elevation – after settlement-

Cable status	Primary Support Elevation
Exposed	0.35 m
Buried	0.30 m

Source: 00225-Ev62A-DEG-00194_3_Cable Crossing Design Premise, 2021

Construction sequence at in-service cable location:

For each in-service cable crossing location, the construction sequence is assumed as follows:

- Install the minimum required number of supports (flexible or rigid), on each side of the cable at the crossing position;
- Install the pipeline over the supports and cross the cable/pipeline;
- Install the post-lay protective rock berm, if required.

The crossing types are summarized in Table 6-50.

Table 6-50 Summary of Crossing types-

Crossing type	Layout	Material	Existing Facility	Remarks
Type 1	Mattress on top of cable	Concrete	Out of Service Cable, exposed or buried	Subject to the agreement with cable owner to put mattress on top of the cable
Type 2	1 flexible support on each side	Concrete	In Service cable buried	Flexible mattress or beam-type mattress, depending on the local soil condition
Type 3	1 rigid support on each side	Steel (1)	In Service cable exposed	For in-service cable/pipeline at the hot-end, or with soft soil condition
Type 4	2 supports on each side	Steel (1)	In Service cable exposed	Only if required, e.g. with very soft soil, sharing loading, reduction of free span length, etc
Type 5	Support(s) with rock berm	Steel (2)and rock berm	In Service cable exposed	Only if required due to fishing activities

Notes:
(1) The support could also be made of concrete or GRP, subject to detailed design.
(2) Concrete mattress could be used as the supports prior to rockdump with the suitable soil condition.

Source: 00225-Ev62A-DEG-00194_3_Cable Crossing Design Premise, 2021

For any crossing case, the support height and spacing shallbe designed to ensure that the allowable span lengths are not exceeded for installation, pre-commissioning and operation phases.

For any crossing case, a pipeline integrity assessment shallbe performed as per DNVGL-ST-F101 for the crossing configuration under installation, pre-commissioning and operation phases.

Note that for the pipeline subject to system pressure test replacement, post-lay intervention works (e.g., rock dumping, and installation of protective structures) shall be performed with a documented acceptable risk of damage to the pipeline system.

6.4.4 Construction of Line Valve Stations (BVS, SS)

6.4.4.1 Location

There will be approximately 4 LSs that 1 will be located within the compressor and metering station in Crete, 15 BVSs and 7 scraper stations, that 5 of these will be located within the compressor stations, the metering station and / or landfall station. Final design (e.g. number and distance between BVSs, etc/) will be performed later and depends on pipeline preliminary risk assessment, accessibility, national and international standards and an agreed operation and maintenance concept. A BVS will require land ranging from 0. 4. to 0.9 ha and site access while the SS will require land ranging from 0.42 ha to 0.52 ha.

Aboveground components of the remotely operated valves will only be some monitoring components and energy supply equipment (diesel emergency generators and solar panels), all fenced.

The locations of the BVSs and SSs are shown in Figure 6-47 and Figure 6-48. Also, Table 6-51 summarises all line stations (BVSs and SS).

Source: P616-000-RP-PLN-11_2_ Onshore Pipeline Route Assessment Report - CCS1 - Peloponnese (IFU)

Figure 6-47 Overview of LSs, BVs and SSs locations along Onshore EastMed Pipeline – CCS1 Peloponnese Section

Source: P616-000-RP-PLN-12_2_ Onshore Pipeline Route Assessment Report – CCS2 – West Greece (IFU)

Figure 6-48 Overview of LSs, BVs and SSs locations along Onshore EastMed Pipeline – CCS2 West Greece Section

Table 6-51 Block Valve (BVS) and Scraper Stations (SS) Overview

Pipeline Segment	Code	Name	Region	Regional Unit	Municipality	Municipal Entity	Permanent Occupation (m^2)	Temporary Occupation (construction)(m^2)
	LS02	LS02	Crete	Lasithi	Siteia	Lefki	178,288.33[8]	27,572.85[9]
CCS1-Peloponnese	LS03/SS01	LS03/SS01-Monemvasia	Peloponnese	Lakonia	Monemvasias	Monemvasias	4,000	4,000
CCS1-Peloponnese	BVS02	BVS02-Monemvasia	Peloponnese	Lakonia	Monemvasias	Molaon	4,088	4,088
CCS1-Peloponnese	BVS03	BVS03-Evrota	Peloponnese	Lakonia	Evrota	Gerontiron	4,026	4,026
CCS1-Peloponnese	BVS04	BVS04-Sparti	Peloponnese	Lakonia	Sparti	Therapnon	6,793	6,793
CCS1-Peloponnese	BVS05	BVS05-Sparti	Peloponnese	Lakonia	Sparti	Pellanas	6,263	6,263
CCS1-Peloponnese	SS02 (MS4/PRS4)		Peloponnese		Megalopoli		52,761[10]	52,761[11]
CCS1-Peloponnese	BVS07	BVS07-Megalopoli	Peloponnese	Arkadia	Megalopoli	Gortynos	4,166	4,166

[8] This area value includes CS2 / MS2 CS2 / MS2 N sites
[9] This area value includes CS2 / MS2 CS2 / MS2 N sites
[10] This area value includes SSs, M/R for Megalopoli Branch & future Heating station sites.
[11] This area value includes SSs, M/R for Megalopoli Branch & future Heating station sites.

Pipeline Segment	Code	Name	Region	Regional Unit	Municipality	Municipal Entity	Permanent Occupation (m^2)	Temporary Occupation (construction)(m^2)
CCS1-Peloponnese	BVS08	BVS08-Andritsaina - Krestena	Western Greece	Ilia	Andritsaina – Krestena	Alifeiras	5,974	5,974
CCS1-Peloponnese	BVS09	BVS09-Archaia Olimpia	Western Greece	Ilia	Archaia Olympia	Folois	9,223	9,223
CCS1-Peloponnese	BVS10	BVS10-Ilida	Western Greece	Ilia	Pyrgos	Olenis	5,113	5,113
CCS1-Peloponnese	SS03/CS3		Western Greece	Achaia	Dytiki Achaia		108,374	108,374
CCS1-Peloponnese	BVS12	BVS12-Dytiki Achaia	Western Greece	Achaia	Dytiki Achaia	Movris	7,508	7,508
CCS1-Peloponnese	LS04	LS04-Dytiki Achaia	Western Greece	Achaia	Dytiki Achaia	Larissou	4,050	4,050
CCS2-West Greece	LS05/SS04	LS05/SS04-Nafpaktos	Western Greece	Aitolokarnania	Nafpaktos	Chalkeias	14,235	14,235
CCS2-West Greece	BVS15	BVS15-Agrinio	Western Greece	Aitolokarnania	Agrinio	Arakynthou	5,863	5,863
CCS2-West Greece	BVS16	BVS16-Agrinio	Western Greece	Aitolokarnania	Agrinio	Stratou	8,417	8,417
CCS2-West Greece	BVS17	BVS17-Amfilochia	Western Greece	Aitolokarnania	Amfilochia	Amfilochias	5,166	5,166

Pipeline Segment	Code	Name	Region	Regional Unit	Municipality	Municipal Entity	Permanent Occupation (m^2)	Temporary Occupation (construction)(m^2)
CCS2-West Greece	SS05	SS05-Amfilochia	Western Greece	Aitolokarnania	Amfilochia	Menidiou	5,194	5,194
CCS2-West Greece	BVS19	BVS19-Arta	Epirus	Arta	Arta	Amvrakikou	9,111	9,111
CCS2-West Greece	BVS20	BVS20-Preveza	Epirus	Preveza	Preveza	Zaloggou	8,387	8,387
CCS2-West Greece	BVS21	BVS21-Igoumenitsa	Epirus	Thesprotia	Igoumenitsa	Margaritiou	5,457	5,457
CCS2-West Greece	SS06	SS06-Florovouni	Epirus	Thesprotia	Igoumenitsa	Perdikas	*	*
Megalopoli Branch	SS Perivolia	SS Perivolia	Peloponnese	Arkadia	Megalopoli	Megalopoli	4,208	4,208
* Within the plot of Poseidon Compressor Station at Florovouni								

Source: P616-000-RP-PLN-11_2_ Onshore Pipeline Route Assessment Report - CCS1 - Peloponnese (IFU) & P616-000-RP-PLN-12_2_ Onshore Pipeline Route Assessment Report – CCS2 – West Greece (IFU); IGI, 2021

6.4.4.2 *Layout and Configuration*

Typical fence and layout of a BVS and SS is illustrated in APPENDICES 6.C and 6.D.

6.4.4.3 *Construction Method*

The following construction steps are usually recognised in such facilities:

- Preparation of the construction site;
- Earthworks;
- Preparation of foundations;
- Erection of equipment and building;
- Laying of cables and electrical works;
- Piping and mechanical works; and
- Installation of operational and instrumentation systems.

6.4.4.4 *Construction Duration and Timing*

Table 6-52 Block Valve (BVS) and Scraper Stations (SS) Overview

Type	Total Number	Construction Time per Site (Months)	Workforce Requirements (as a mean for reference
BVS	15	2 – 3 months	100 people (mean workforce) in total*
SS	7	2 – 3 months	
* Based on previous experience, the above-mentioned mean workforce is estimated in total, whilst the workforce per site would be 15-20 people.			

Source: IGI Poseidon 2021

6.4.4.5 *Construction Equipment*

Equipment used for the construction of the BVSs and SSs comprised mainly of the conventional construction equipment described in Section 6.4.1.2.

6.4.5 Construction of Compressor Stations and Metering Stations

6.4.5.1 Location

The locations of Main Stations are shown on the maps in ANNEX 6K.

Table 6-53 Main StationsOverview

Code	Region	Regional Unit	Municipality	Municipal Entity	Permanent Occupation (m^2)	Temporary Occupation (construction)(m^2)
CS2/ MS2 & CS2/MS2 N	Crete	Lasithi	Siteia	Lefki	178,288.33	27,572.85
CS3	W.Greece	Achaia	W.Achaia	Larisos	110,364.60	25,489.43
MS4/PRS4 &	Peloponnese	Arcadia	Megalopoli	Falaisia	65,369.98	13,124.79
Heating Station	Peloponnese	Arcadia	Megalopoli	Falaisia	13,124.79	10,930

Source: IGI Poseidon, 2021

6.4.5.2 Layout and Configuration

Layout plans of project stations are shown in ANNEX 6E, ANNEX 6F, ANNEX 6G.

6.4.5.3 Construction Duration and Timing

Table 6-54 Construction Duration and Timing for stations

Type	Total Number	Construction Time per Site (Months)	Indicative Workforce Requirements
CS/ MS	2 in Crete	30	600
CS	1 in Achaia	30	600
MS4/PRS4 & Heating Station	1 in Megalopoli	20	70

Source: IGI Poseidon, 2021

6.4.5.4 Construction Method

The following construction steps are usually recognised in such facilities:

- Surveying;
- Preparation of temporary facilities such as storage areas, offices and accommodation facilities;

- Preparation of the construction site;
- Earthworks;
- Preparation of foundations (including piling where required);
- Erection of equipment and buildings (installation of underground structures might require the use of sheet piling for stabilisation of construction pits);
- Laying of cables, electrical works;
- Piping and mechanical works;
- Construction of internal roads and areas (if any);
- Installation of operational and instrumentation systems;
- Commissioning; and
- Operation.

6.4.5.5 *Construction Equipment*

The equipment used for the construction of the stations is comprised mainly of the conventional construction equipment described in Section 6.4.1.2.

6.4.6 *Construction of Operation and Maintenance Base - Dispatching Centre*

6.4.6.1 *Location*

The proposed plot for the Dispatching and O&M Centre installation is located 2,300 m south-west of the Niforeika and 750 m south of Kalamaki settlements, in front of a dirt road, which should be asphalt paved. The plot is located approximately 900 m north-east of the asphalt road connecting the settlements of Limnochori and Kalamaki, which leads after 1,300 m to the provincial Kato Achaia-Araxos road, and approximately 35 km away from the city of Patras (~40 minutes driving through National Roads Patra-Pirgos and E55). Morphologically, the area is flat ,and its average elevation is approximately 27 m above sea level. The land plot is not located within forestry or sensitive environmental areas (e.g. Natura, wild life refuge, National Park), and based on the available data it does not present any archaeological interest. It is ~32,000 sq. m. and sited within private land.

Table 6-55 Location of Operation and Maintenance Base

Pipeline Segment	Code	Region	Regional Unit	Municipality	Municipal Entity	Permanent Occupation (m2)	Temporary Occupation (construction)(m^2)
Operations Base	O&M	W.Greece	Achaia	W.Achaia	Momvris	32,000	32,000

Source:IGI Poseidon, 2021

6.4.6.2 *Layout and Configuration*

General layout of the Operation and Maintenance Base presented in Figure 6-49

Source: IGI Poseidon, 2021

Figure 6-49 Schematic Layout of the Operation and Maintenance Base

6.4.6.3 *Construction Duration and Timing*

Table 6-56 Construction Duration and Timing

	Total number	Construction Time per Site (Months)	Workforce Requirements (as a Mean for Reference)
Operation and Maintenance Base	1	20	70

Source: IGI Poseidon, 2021

6.4.6.4 *Construction Method*

The following construction steps are usually recognised in such facilities:

- Surveying;
- Preparation of temporary facilities such as storage areas, offices and accommodation facilities;
- Preparation of the construction site;
- Earthworks;
- Preparation of foundations (including piling where required);
- Erection of equipment and buildings (installation of underground structures might require the use of sheet piling for stabilisation of construction pits);
- Laying of cables, electrical works;
- Piping and mechanical works;
- Construction of internal roads and areas (if any);
- Installation of operational and instrumentation systems;
- Commissioning; and
- Operation.

6.4.6.5 *Construction Equipment*

The equipment used for the construction of the stations is comprised mainly of the conventional construction equipment described in Section 6.4.1.2.

6.4.7 Pre-Commissioning Activities

Pre-commissioning is the process of proving the ability of a pipeline and piping systems to contain gas without leaking. It is the series of processes carried out on the pipeline before the gas is introduced.

One of these processes is the verification of the condition of the pipeline through:

- Conventional SPT with the use of water (e.g. hydrotesting); and
- SPT Replacement.

Table 6-57 Pre-Commissioning Methods shows the selected methodology to be applied for the pre-commissioning of the sections of Eastmed Pipeline Project within the Greek jurisdiction. A general description of the SPT options investigated is provided. Section 6.4.7.3 describes the selected approach for the investigated project.

Table 6-57 Pre-Commissioning Methods

Pipeline Segment	Pre-commissioning Method	Remarks
OSS2 / OSS2 N	Replacement of SPT for offshore section, whereby cleaning and gauging will be performed using MEG as medium	These segments are very long and will consist of large-diameter pipe in very deep water. Both have a significant internal volume that would need to be filled with water for pressure testing. Not conducting the SPT prevents the need to deal with this large volume of water, the need for special equipment and the environmental impacts associated with water disposal after testing.
Short Onshore Section in Crete	Conventional SPT (Hydrotesting)	
OSS3 / OSS3 N	Replacement of SPT for offshore section, whereby cleaning and gauging will be performed using MEG as medium	These segments are very long and will consist of large-diameter pipe in very deep water. Both have a significant internal volume that would need to be filled with water for pressure testing. . Not conducting the SPT prevents the need to deal with this large volume of water, the need for special equipment and the environmental impacts associated with water disposal after testing.
CCS1	Conventional SPT (Hydrotesting)	
OSS4	Conventional SPT (Hydrotesting).	OSS4 is a short section in shallow water. The potential benefits associated with replacing the SPT are limited and do not outweigh the drawbacks.
CCS2	Conventional SPT (Hydrotesting)	

Source: IGI Poseidon, 2021

The associated facilities (e.g. compressor, metering, pressure regulating, heating stations) are not subject to this procedure since these facilities include equipment that has been pre-tested during its manufacturing.

6.4.7.1 *Pre-Commissioning with Conventional SPT (Hydrotesting)*

Hydrotesting (or hydrostatic testing) is the most common method for testing pipeline integrity and checking for any potential leaks prior to commissioning. The test involves placing water inside the pipeline at a certain pressure for a certain time to confirm pipeline strength and tightness.

The activities to be carried out before and after the hydrotest are repeated here:

- Before hydrotest:
  - Flooding and cleaning,
  - Gauging;
- During hydrotest:
  - Leak detection;
- After hydrotest:
  - Dewatering,
  - Drying,
  - Purging.

Pressurisation is achieved during a hydrotest by pumping water into the pipeline section being tested. According to DNV-OS-F101, the system pressure test should be 1.15 times the design pressure with a hold period of 24 hrs. Pressurisation is then carried out with a high pressure pump.

After the pipeline has been filled and pressurised and all the necessary parameters have been measured, the pipeline is dewatered and dried.

- **Flooding, Cleaning and Gauging**. After the pipeline is initially flooded, it will be cleaned and gauged. Typically, cleaning and gauging are performed as a single operation together with flooding. Cleaning involves sending a series of pigs through the pipe section to remove any debris (typically weld slag and pipe mill scale, where the latter is expected only in a very limited amount due to the internal coating) from inside the pipeline. One pig bounds the air and water, and another series of pigs can be used to clean the internal pipe-wall. Clean water is pumped in front of the pig train to moisten the debris. Pipeline internal gauging is used to ensure the inner diameter of the pipeline is free from obstructions and excessive ovality. A gauging pig is equipped with a device to determine its location in case it does not reach the pig receiver. If a gauging pig becomes stuck in the pipeline, it is freed, the pipe defect is located and eliminated, and the gauging operation is repeated. An alternative gauging method could be used that will pinpoint any defect. Gauging can be performed with an electronic calliper tool for this purpose, optionally combined with a geometry pig to confirm the pipeline geometry as built. The gauging and geometry pigs may be run in the same train as the flooding and flushing pigs; pig speed for this operation should be between 0.3 m/s and 1 m/s. The pipeline system configuration should be designed to allow for pigging in forward or reverse direction. This is achieved by barred tees, lock-open check valves, eliminating non-piggable wye pieces, and designing the pig receivers so that they can also be used as launchers. This philosophy provides benefits during pre-commissioning and possible future repair scenarios;

- **Dewatering**. The recommended method for dewatering is to use compressed air. This method uses compressed air to drive a pig train through the pipeline while displacing the hydrotest water. The pig train consists of multiple compartments separated by pigs. Some are filled with fresh water to flush the salt from the pipe wall, and some are filled with air. The air is oil free and dry with a dewpoint of at least -65 °C at atmospheric pressure and an oil content no greater than 0.01 ppmW;
- **Drying and Purging**. The dewatering pig train leaves a small film of water approximately 0.05 mm thick in the pipe. The absence of water in the pipeline is necessary in order to prevent the possible formation of methane hydrate. The drying method is air drying which usually employs swabbing pigs to help spread out the water so that it has a larger surface area in order to be more easily collected; and
- **Discharge/Disposal Options**. Following successful testing, the used water is discharged back into a receiving water body after having passed a sedimentation pool, through which the water will flow very slowly. These pools are sized to provide a retention time of 5 minutes, which is considered enough time to allow the solid particles to be cleaned out of the pipe, to settle and remain in the bottom of the pond. The discharge rate after finalisation of hydrotests will follow the same rules as applicable for abstraction. Hence the same water bodies will be taken into consideration for discharge. Environmental effects are expected to be minimal or negligible when discharge rates are under 10% of the receiving river flow. Discharged water will be free of any chemicals. The contractor for hydrotesting will obtain written approvals from the local authorities and landowner(s) where the hydrotest water will be discharged; water will not be returned to any watercourse without permission of the appropriate local authorities.

6.4.7.2 *Pre-Commissioning with SPT Replacement*

The aim of the REPLACE methodology is to provide a robust basis for replacing the SPT with other means that ensure that the overall safety level of the pipeline system for which the test is to be replaced is equal to or better than that of an equivalent system that implements the SPT.

Consideration of SPT replacement starts early in the design timeline and continues through the offshore pipeline installation phase. The methodology describes the REPLACE activities to be undertaken in each phase of the project. For EastMed Pipeline Project, which is currently in the Front End Engineering Design (FEED) phase, the activities to be performed comprise:

- Assessment of SPT Replacement prerequisites;
- Assessment of SPT Replacement requisites;
- Risks and opportunities assessment;
- Initial FMECA; and
- Preparation of initial SPT Replacement plan.

6.4.7.2.1 Prerequisites

The following prerequisites must be satisfied when replacing the system pressure test under the REPLACE methodology:

1. The pipeline system will comply with all aspects of DNVGL-ST-F101;
2. Line-pipe material will be carbon-manganese steel pipe with yield strength of 485MPa or lower;
3. For seam-welded pipe, the SAWL method will be applied and the pipe will be expanded to above 0.5%;
4. The mill pressure test will be performed;
5. Non-welded connections will be leak tested after installation in the pipeline system to 5% above the local incidental pressure;
6. Welding will not be performed with cellulosic electrodes;
7. Girth welds will be inspected by automated ultrasonic testing (AUT); and
8. The pipeline system's design will be based on well-proven solutions with a good track record and will not include any new design elements.

6.4.7.2.2 Requisites

In addition to the prerequisites, the following requisites will be satisfied and included in the FMECA and the SPT Replacement plan.

1. Pipeline sections in location class 2 (i.e. near platform or in areas with frequent human activity) will be assessed using a quantitative risk assessment (QRA) which focuses on the loss of containment;
2. Girth welds will not be exposed to accumulated plastic strains of more than 2.0% before commissioning. This means that pipelines installed through reel lay cannot qualify for the SPT Replacement methodology. The associated nominal strain in the pipeline is expected to be no more than 0.4%;

3. The diameter-to-thickness ratio (D/t) should be less than 45;
4. A minimum of two installation parameters will be monitored and logged during installation. Each of these parameters will allow for calculation of pipeline load effects and configuration;
5. Fatigue damage of line-pipe welds incurred during transportation will be evaluated;
6. Post-lay intervention works (e.g., trenching, backfilling, rock dumping, pulling of sheet piles and installation of protective structures) will be performed with a documented acceptable risk of damage to the pipeline system;
7. Pipeline condition with an emphasis on cleanliness, dryness and corrosion will be addressed in the SPT Replacement plan;
8. A third party will be engaged from the evaluation stage to completion of the closeout stage and be actively involved in the decision processes regarding the SPT Replacement methodology; and
9. An inspection-and-testing regime will be established to demonstrate that the specified requirements in the SPT Replacement plan have consistently been satisfied during manufacturing, fabrication and installation. This is part of the quality-control planning.

6.4.7.2.3 Risks and Opportunities Assessment

The goal of this activity is to evaluate and document the risks and opportunities associated with the SPT Replacement methodology. The main objectives are:

- Understand and substantiate the primary reasons for replacing the SPT;
- Ensure that necessary information is available to decide on the implementation of the SPT Replacement methodology;
- Identify required additional safeguards and technology gaps;
- Identify the requirements of contingency plans that are specific for the SPT Replacement methodology; and
- Identify if and how the SPT Replacement methodology may affect quality-management and procurement strategies, and other contractual aspects.

6.4.7.2.4 Failure-Mode, Effects and Criticality Analysis

The objective of the FMECA is to compare the safety level associated with a pipeline for which the SPT is performed to that of the same pipeline for which the SPT Replacement methodology is applied, meaning that the SPT has been replaced by other means. The FMECA considers all failure modes related to loss of containment that may occur during the SPT and would thus normally be detected during execution of the SPT. A distinction is made between failure modes that lead to small leaks and others that result in a large release of contents. The FMECA aims to identify requirements for additional safeguards to ensure that the safety of the pipeline system is not adversely affected by not conducting the SPT.

6.4.7.2.5 SPT Replacement plan

The SPT Replacement plan describes the actions required to ensure that all prerequisites, requisites and additional safeguards identified in the FMECA are implemented and documented to demonstrate compliance to stakeholders and authorities. The REPLACE plan is maintained throughout the Project lifecycle and is updated as the technical definition and execution plans develop.

Should the SPT be replaced (i.e. from SPT Replacement option), the pre-commissioning procedure changes. Certain steps can be omitted, and additional safeguards will be taken on board. In that case, the typical pre-commissioning procedure consists of the following (sequential) activities:

- **Pressurising**. The pipeline will be pressurised using dry air to create back pressure ahead of the cleaning and gauging pig train, which will be introduced in the system in the next step. Back pressure is necessary to ensure the pig-train speed can be controlled on steep slopes. The required back pressure will be assessed in detailed design. The size of the compressor spread determines the time needed for the pressurisation phase. Upon completion of the pressurising step, the pipeline is filled with dry air at elevated pressure;
- **Cleaning and gauging.** Cleaning and gauging activities are, ideally, conducted using a single pig run—a second run may be necessary if too much debris is found in the pig train's last slug after the first run. The pig train will consist of a series of pigs with clearing and gauging (CG) functionalities. The series of pigs will be separated by slugs of monoethylene glycol (MEG)—not by slugs of water. MEG is hygroscopic and will absorb condensed water in the pipeline. For this reason, MEG inhibits against hydrates and is a so-called "hydrate-control fluid". The pig train will be propelled by a large slug of nitrogen (with a high purity of, for instance, 95%) of several tens of kilometres followed by ultra-dry air. Now the pipeline is chemically conditioned and a drying step is no longer needed. Upon completion of the pig run, the system is filled with dry air at elevated pressure;
- **Depressurisation.** After successful receipt of all pigs (see the above CG step), the pipeline system will be depressurised by venting to atmospheric pressure from both ends of the pipeline. Upon completion of the depressurisation, the system is filled with dry air at ambient pressure; and
- **Nitrogen purging.** Next, the system will be purged with a nitrogen-rich gas mixture of very high purity (e.g., 98%) to avoid an explosive gas–air interface. The mixture is pumped into the pipeline at low pressure to displace the air contents. Once the oxygen level measured at the outlet is sufficiently low, nitrogen purging is halted. Upon completion of nitrogen purging, the pipeline system is filled with inert gas, slightly above ambient pressure. This means that pre-commissioning has been completed and the system is ready to receive hydrocarbon gas.

This SPT Replacement Methodology was successfully used in TurkStream and Nord Stream 2 Pipeline projects, removes the need for seawater and the risk associated with lateral buckling concerning the conventional method. This procedure can be amended if necessary, depending on specific project requirements..

6.4.7.3 *EastMed System Pressure Test Response*

Each offshore pipeline segments comprising the Greek section of the EastMed Pipeline Project has been assessed individually in accordance with the SPT Replacement methodology.

Based on the System Pressure Test Replacement Study (E780-00225-Ev32A-TDR-00055, Rev.02), it has been concluded that, for OSS2, OSS2N, OSS3 and OSS3N project components, it is beneficial not to pressure test the system applying the conventional hydrotesting SPT because of the risk associated with lateral buckling. For the remaining Project components, conventional SPT (hydrotresting) is applied.

Hydrotest sections will have a length varying between 3 km to 9 km each. It is estimated that approximately 50 hydrotests will be carried out for CCS1, 38 for CCS2 and 2 for Megalopoli Branch.

Each hydrotest will be completed in 7-10 days.

Short onshore sections at the landfalls will be pre-commissioned with conventional hydrotesting method using freshwater, following EN 1594 standard. At the end of pre-commissioning phase, the small amount of water will be discharged in compliance with national regulations.

ANNEX Q provides the relevant maps presenting the available water sources.

Pre-commissioning of the **offshore** OSS4 section is expected to require a total of 11 days. Similarly, the pre-commissioning of the other offshore project components is expected to require a total of 57 to 84 days. Pre-commissioning will be finished before commissioning activities.

6.4.7.4 *Main Equipment for Pre-Commissioning*

6.4.7.4.1 Pigs

Irrespective of the selected pre-commissioning method, multiple pig runs will be performed during pre-commissioning. It is anticipated that the pigs will be designed specifically for Project conditions based on the following:

- High quality type pigs; the sealing discs will be resistant to wear and capable of long runs (e.g. over 700 km for OSS2);
- Pigs Will be designed to prevent damage to internal flow coating of pipelines;
- Pig tracking / location devices with the highest level of accuracy and reliability within the industry Will be incorporated in each train (first and last pig).

6.4.7.5 *Water Supply System*

A water supply system will be employed for the scenario in which the pipelines will be flooded and subsequently pressure tested, i.e. traditional pre-commissioning methodology.

The water supply system will include a water winning system for flooding, filters, water tanks, flooding pumps and all necessary temporary piping, valves and instruments.

In addition, pressurisation pumps will be employed to pressurise the pipeline up to the system pressure test level. The hydrotesting equipment will also include a pressure gauge, recorder and flow meter.

6.4.7.5.1 *Water Abstraction Sources for Conventional SPT*

As far as the onshore pipeline segment, inland water sources with larger amounts of water flow have been considered for water abstraction and discharge. Water reservoirs will not be used as a source for testing water. For the offshore and nearshore segments, the most likely option is the use of sea water.

Table 6-58 shows the potential water sources identified along the pipeline route and the volumes required for hydrotesting for each main section.

The timing for hydrostatic testing activities will consider the seasonal changes of river flows and the reduced flows during the summer months.

The quantity of water used for hydrotest, considering the complete onshore section, is approximately 600,490.4 m^3. This volume of water is the maximum that could be used. However, it is best international practice to transfer water between hydraulic test sections and re-use it as much as possible so the final volume is expected to be much smaller.

The contractor for the hydrotest will obtain written approvals from local authorities and landowner(s) or users regarding hydrotest water abstraction and disposal.

Table 6-58 Water Requirements for Hydrotest Sections

Pipeline Spread		Water Source	Approx. Volume Required (m^3)	Pipeline Section
From KP	To KP			
0	50	Evrotas	54,900	CCS1
50	100	Evrotas	54,900	CCS1
100	130	Evrotas	32,940	CCS1
130	150	Alfeios	21,960	CCS1
150	200	Alfeios	54,900	CCS1

Pipeline Spread		Water Source	Approx. Volume Required (m^3)	Pipeline Section
From KP	To KP			
200	250	Pineiakos Ladonas	54,900	CCS1
250	300	Pineiakos Ladonas – Pineios	50,500	CCS1
			18,451	OSS4
0	35	Evinos	38,430	CCS2
35	55	Water Canal of Trichonida	21,960	CCS2
55	70	Acheloos	16,470	CCS2
70	135	Arachthos & Louros	71,370	CCS2
135	200	Louros	71,370	CCS2
200	233	Louros & Acherontas	36,234	CCS2
0	4	Alfeios	492	Megalopoli Branch
4	9.8	Alfeios	713.4	Megalopoli Branch

Source: IGI Poseidon,2021

As the conventional SPT approach involves the use of water (either inland or sea), it should be noted that inland water providing the compliance of its physicochemical characteristics with what was described earlier does not pose any risk to pipeline integrity. The water used needs to be free of contaminants and with pH between 5 and 8) and no additives, corrosion inhibitors or chemicals are envisaged to be used.

This is not the case with sea water due to its corrosive behavior. The following options exist regarding seawater composition for hydrotesting purposes:

Filtered seawater (50 micron) + UV sterilisation. Use of chemicals is not envisaged considering that the water residence time should be fewer than 30 days. If the use of chemicals or other additives is deemed unavoidable, these substances will be included in the PLONOR list. The PLONOR list is a list of substances that are deemed to pose little or NO risk (PLONOR) to the environment. The list was developed by the OSPAR committee (known as Oslo – Paris committee) for protection of the marine environment. All chemicals or mixtures on the PLONOR list are allowed to be discharged into the sea in accordance with international industry standards.

6.4.7.5.2 Discharge and Disposal of SPT Mediums

Conventional SPT includes discharge and disposal of large quantities of hydrotesting water.

Water for the **onshore** sections will be discharged back into a receiving water body after having passed a sedimentation pool, through which the water will flow very slowly. These pools are sized to provide a retention time of 5 minutes, which is considered enough time to allow cleaning the solid particles out of the pipe to settle and remain in the bottom of the pond. The discharge rate after finalisation of hydrotests follow the same rules as applicable for abstraction. Hence the same water bodies will be taken into consideration for discharge. Environmental effects are expected to be minimal or negligible when discharge rates are under 10% of the receiving river flow. Discharged water will be free of any chemicals.

Regarding the offshore section (OSS4), filtered seawater used for flooding, gauging and testing is treated. The water is headed to a tank, filtered, checked according to applicable statutory limits and then discharged. The water treatment is confined in abstracting potential solids, given that no chemicals are used during the whole procedure. The surface area of the tank is calculated to be approximately 600 m². If this area is not available near the coast, the equipment can be placed on a barge which is tied up close to the coast.

In any case:

- The discharge is performed in a controlled manner according to local environmental approvals. An assessment of the likely dispersion rate and extent should be evaluated as part of the pre-commissioning design activities during the EPIC stage of the Project; and
- Prior to discharging the hydrotest fluids, samples are collected and analysed on-site to ensure compliance with permits and other regulations before being discharged to the open sea.

The discharge point will be selected based on:

- Results of dispersion analysis;
- Application of diffuser; and
- Assurance of efficient dispersion into environment.

Continuous discharge is considered possible by developing a discharge plan taking into account the spread capacity of the entire discharge system.

At the end of the pre-commissioning phase, mono ethylene glycol (MEG) will be pushed through the system during the dewatering phase of the hydrotested pipelines and during the cleaning and gauging phase of the others. MEG is normally used to dewater equipment that carries gas (pipelines, jumpers, etc.) in pre-commissioning phase having different uses, such as debris suspension, inhibition of any free water and lubrication of the pig train. The process, known as swabbing, allows absorbing the residual water in the pipelines and applying a glycol/water film on all internal surfaces of the pipelines. The desiccant MEG has also the effect of depressing the freezing point, such as to eliminate the risk of gas hydrates forming during operation.

Regarding OSS3 and OSS3N, the MEG will be pushed through the pipelines during the cleaning and gauging phase. Three slugs of 200 m each are expected to be used, having a total volume of approx. 250 m^3 of MEG each pipeline. Cleaning and gauging operations for OSS3 and OSS3N will be performed from LS02 in Crete to LS03 in Peloponnese.

Regarding OSS4, MEG will be pushed through the system during the dewatering and drying phase in 3 slugs of 300 m length each, having a total volume of 965 m^3. OSS4 will be dewatered and cleaned using MEG pushed through the pipelines from LS05 to LS04..

MEG is a recyclable substance included in the PLONOR list and will be recovered in tanks and reused in the dewatering/cleaning process or disposed by a certified company. Detailed design study will be performed before the construction phase to confirm the exact quantities of MEG to be used.

6.4.8 *Use of Resources and Environmental Interference during Construction and Pre-Commissioning*

6.4.8.1 *Introduction*

No construction materials will be taken from the work sites or the surrounding environment unless licenced by the competent authority. The route design team has made every effort to avoid areas under forest legislation or any other identified valuable environmental resources to the extent possible during the route refinement process. Specific mitigation / preventive measures (e.g. narrowing of construction strip) will be applied in sensitive areas where feasible to minimise impacts.

Use of resources and environmental interference, as presented in the following sections, will be reduced as much as is practicably possible.

6.4.8.2 *Temporary Land Take*

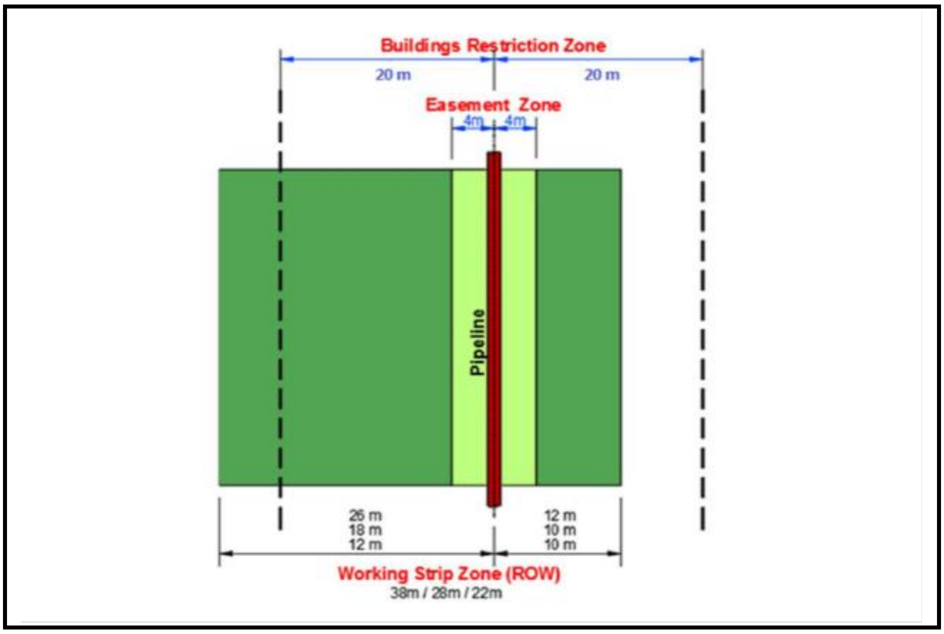
During construction, land will be occupied for:

- Marshalling and storage yards
- Construction sites;
- Working strip; and
- Access roads.

Description of the working strip and its dimensions is reported in section 6.3.2.3

The location of construction sites is adjusted to accommodate any environmental or social constraints which may exist in the surrounding area. In general, public areas of undeveloped and unused land are preferred; however, if private lands are required, arrangements will be made to preserve essential access and rights of way during the construction period and to compensate owners and users.

After construction, most sites will be restored to their original condition where possible. Along the route a permanent pipeline protection strip (PPS) with a width of 8 m (4 m either side of the centreline right of way) will be established (see Section 6.5.4.1 for more details). Cultivation of annual species and associated works (e.g. shallow ploughing) down to a maximum depth of 60 cm will be allowed. However, deep rooted species (e.g. fruit trees, bushes or trees) are not allowed on top of the PPS. Similarly, no houses or construction will be allowed. Exceptions will be made after consultation with relevant authorities and stakeholders (see Figure 6-50).



Source: IGI, 2021

Figure 6-50 Pipeline Zones

Table 6-59 summarises the land required by the Project during construction whilst their locations are shown in ANNEX 6K.

Table 6-59 Land Take of the Project During Construction

Project Component	Temporary Land Take (Total Area) (m^2)	Permanent Land Use (m^2)
Pipeline (543.06) working strip	16,088,951	4,344,480
Main stations (compressor and metering stations)	490,724	490,724
Line stations (15 BVSs and 7 SS)	127,234	127,234
Construction sites	243,098	0
Pipe yards (continental pipeline)	456,086	0
Marshalling yards (offshore sections)	180,000	0
River crossing (HDD method)	108,040	0
Road crossing	155,827	0
Landfall sites (four)	27,000	0

Source: IGI Poseidon, 2021

6.4.8.3 *Project Workforce during Construction*

Workforce, during construction, is presented in Table 6-60.

Table 6-60 Estimated Workforce during Project Construction.

Project Component	Estimated Mean Workforce	Maximum (Peak)
ONSHORE		
Pipeline construction (including temporary facilities for crossings)	450[1]	500[1]
Main stations (compressor and metering stations)	250[2]	600[2]
Line stations (15 BVSs and 7 SS)	100[3]	100[3]
Landfall	48[4]	52[4]
OFFSHORE		
Operations base/port	It depends on the final selection of the appropriate port by EPC, however it could be assumed that no additional staff will be needed as it is planned to use the port's available facilities.	

Project Component	Estimated Mean Workforce	Maximum (Peak)
Vessel crews (combining pipelaying and support vessels)	1,216[5]	2,080[5]
[1]It is assumed that construction of the pipeline will be separated in 3 spreads, and the estimated workforce refers to each one separately. [2]This is the estimated workforce per station. [3] It could be divided in spreads i.e if 2 spreads are working, then the estimated workforce will be 50 people per spread. [4] The estimated workforce is per landfall site. [5] The estimated vessel crews are in total and not per offshore section.		

Source: IGI Poseidon, 2021

6.4.8.4 *Raw Material and Fuel Usage*

6.4.8.4.1 Raw Materials

The bottom of the trench as well as the padding material consists of well graded, round material with an estimated volume of 7,767.9 m³ per km of pipeline route in order to avoid any damage to the pipeline coating. If the excavated material from the trench is suitable (e.g. sandstone) it will be recycled for bedding and padding. Additional padding material will be provided in areas where flysch is encountered.

Sand and aggregate will be obtained from local authorised and approved quarries.

Where excavation disturbs topsoil, the first layer of excavated material (topsoil) will be stored separately so that it can be replaced on the surface when the excavated area is restored.

Regarding the stations (MS and CS), the selected sites are more or less leveled and no extended excavation works will be performed that would result in generation of substantial aggregates.

An estimate of the key materials consumed during the construction phase is shown in Table 6-61. The material types and amounts are based on similar projects and the current status of design.

Table 6-61 Estimated Material Consumption during Construction-Raw Materials Onshore

Material	Quantity (tn)
Steel	420,000
Concrete	12,000
Polyethylene tape	7,500
Sand	690,000
Excavated material	3,187,137.60 m^3
Backfilled material	1,302,954.15 m^3

Source: IGI Poseidon, 2021

Table 6-62 Estimated Material Consumption during Construction-Raw Materials Offshore

Material	Pipeline Section				
	OSS1-OSS2	OSS2 N	OSS3	OSS3 N	OSS4
Steel (mT)	590,000	445,000	207,000	207,000	18,000
Concrete coating (mT)	830	5,360	1,470	1,470	10,810
3 LPP coating (mT)	8,980	6,800	4,230	4,230	290

Source: IGI Poseidon, 2021

6.4.8.4.2 *Fuel Usage*

Heavy equipment and motor engine driven equipment used during the construction phase will be fuelled with diesel. Diesel fuel will be delivered via approved fuel road tankers to the construction sites. An estimated total volume of fuel required for construction activities is given in Table 6-63.

For the vessels, considering construction times are beyond a vessels normal endurance, refuelling at sea will be undertaken via a tanker and all precautions taken to eliminate spills. A boom will be deployed at the stern and bow of the vessel when refuelling is taking place; additionally there will be sufficient absorbents available during the fuelling process whereby, in the unlikely event of any spill occurring it will be dealt with immediately.

Table 6-63 Estimated Material Consumption during Construction – Fuel Usage

Section	Use	Total Quantity
Onshore	Equipment and vehicles	480,000 m3 Diesel
Offshore	Vessels	101,630 t MGO
	Pre-commissioning equipment	16,850 t Diesel

Source: IGI Poseidon, 2021

6.4.8.5 *Water Consumption*

The foreseen water consumption during the construction phase is related primarily to watering construction sites to reduce dust emissions due to earthmoving activities and for civilian uses. In the Pre-commissioning phase, water consumption is related to hydrotesting activities.

Table 6-64 shows the estimated water consumption during the construction and pre-commissioning activities.

Table 6-64 Estimated Water Consumption during Construction

Use	Approx. Volume	Comments
Civil Water	Max 21 m^3/day	60l/person per day (considering 350 people working simultaneously)
Industrial water	5-10 m^3/day	Working strip dust suppression
Industrial water	9,000 m^3/day	Trenchless slurry

Source: Asprofos, 2022

Water consumption details of hydrotesting water offshore and onshore are provided in section 6.4.7.3.1

6.4.8.6 *Air Emissions*

During construction, earth dust particles from soil movement, as well as pollutants from the exhausts of heavy equipment and vehicles will be emitted. Dust will mainly be produced during excavation and backfilling activities. Earthworks take place in worksites for pipeline, compressor station and BVS construction activities. Other sources of dust emission will be traffic movements of trucks, minivans and other heavy equipment on the working strip. Pollutants will be produced by heavy equipment and vehicles due to the fuel combustion in their engines and released in the exhaust gas. The main pollutants produced will be NO_X, CO, dust and SO_X. Refer to Chapter 9 for further detail on construction air emissions and the impact assessment. During the pre-commissioning phase, the main air emission sources are equipment foreseen for the Pre-Commissioning activities (Conventional SPT and SPT Replacement). More details are reported in the assessment section of the ESIA; refer to Chapter 9.

6.4.8.7 *Noise Emissions*

Indicative noise emissions generated by heavy construction equipment at the working strip, worksites and the compressor station site are listed in Table 6-65. The reported noise pressure levels at 1 metre from the source are typical for the equipment considered.

Table 6-65 Typical Noise Levels for Construction Equipment

Type of Equipment	Noise Level (dBA)
Excavator	70 – 84
Backhoe loader	70 – 84
Crane	70 – 84
Pipelayer	70
Side-boom	84 – 99

Type of Equipment	Noise Level (dBA)
Pipe bending machine	60
Engine generator	70 – 84
Pay-welder	70 – 84
Concrete mixer	95
Concrete pump	70 – 84
Soil compactor	70 – 84

Source: IGI Poseidon, 2021

Table 6-66 Typical Noise Levels for Offshore and Nearshore Construction

Type of Equipment	Noise Level (dBA)
Deep water pipelay vessel	84-99
Intermediate water depth S-lay vessel	84-99
Shallow water S-lay vessel	84-99
Support vessel	99-115
LF construction equipment	79 dB at 10 m
Pre-commissioning activities - Alternative SPT	67 – 103 dB at 1m
Pre-commissioning activities – Conventional SPT	79 – 99.2 dB at 1m

Source: IGI Poseidon, 2021

Significant noise generating activities include construction at hard and rocky surfaces where the use of explosives will be necessary. To date, the use of explosives is considered necessary at the following areas:

Table 6-67 Areas Where Explosives shall be Used during Construction

Pipeline Segment	From KP	To KP	Length (m)
CCS1	66.757	15.842	15,174
CCS1	15.979	19.138	3,159
CCS1	19.840	20.322	482
CCS1	21.348	21.845	497
CCS1	23.270	23.780	510
CCS1	24.157	24.811	654
CCS1	25.048	26.218	1,170

Pipeline Segment	From KP	To KP	Length (m)
CCS1	27.172	29.432	2,260
CCS1	41.444	56.744	15,300
CCS1	77.781	86.977	9,196
CCS1	87.255	89.904	2,649
CCS1	90.235	90.586	351
CCS1	93.999	94.455	455
CCS1	95.074	96.687	1,613
CCS1	97.552	101.030	3,478
CCS1	101.643	102.428	785
CCS1	103.142	104.495	1,353
CCS1	104.561	107.329	2,768
CCS1	107.391	107.560	169
CCS1	117.629	118.462	833
CCS1	120.432	122.526	2,094
CCS1	129.362	133.848	4,486
CCS1	134.636	136.962	2,326
CCS1	137.651	137.784	133
CCS1	141.542	142.352	810
CCS1	151.923	151.971	48
CCS1	152.073	152.142	69
CCS1	154.516	154.631	115
CCS1	154.889	155.388	499
CCS1	155.720	156.166	446
CCS1	165.554	165.923	369
CCS1	166.044	166.236	192
CCS1	166.288	166.627	339
CCS1	166.844	167.381	537
CCS1	168.231	169.069	838
CCS1	169.240	170.089	849
CCS1	170.129	171.066	937
CCS1	171.199	171.274	75
CCS1	171.508	171.711	203

Pipeline Segment	From KP	To KP	Length (m)
CCS1	172.230	172.609	379
CCS1	173.112	173.871	759
CCS1	174.242	176.438	2,195
CCS1	178.477	179.580	1,103
CCS1	180.037	180.143	106
CCS1	181.486	182.151	664
CCS1	182.555	182.679	123
CCS1	183.206	184.637	1,430
CCS1	185.189	185.296	107
CCS1	186.658	187.321	662
CCS1	187.813	188.270	457
CCS1	188.475	188.597	121
CCS1	188.987	189.152	165
CCS1	189.254	189.325	71
CCS1	190.092	190.237	145
CCS2	64.302	64.407	104
CCS2	64.674	64.803	128
CCS2	65.124	73.200	8,076
CCS2	182.937	183.602	665
CCS2	183.908	184.180	272
CCS2	186.178	186.633	455
CCS2	188.986	189.784	798
CCS2	190.237	193.085	2,848
CCS2	202.833	203.294	461
CCS2	208.384	209.096	712
CCS2	209.504	210.881	1,376
CCS2	211.308	213.142	1,834
CCS2	224.561	225.018	457
CCS2	226.758	226.993	234
CCS2	227.230	227.285	54
CCS2	229.885	233.127	3,242

Source: IGI Poseidon, 2021:

During the pre-commissioning phase, the main noise sources are equipment foreseen for the SPT activities (Conventional SPT and SPT Replacement). More details are reported in the assessment section of the ESIA; refer to Chapter 9.

Noise emissions generated during the construction phase by construction equipment are identified in the assessment section of the ESIA; refer to Chapter 9.

Marine equipment operation will produce underwater noise (trenching, vessel engines; etc) and aerial noise (vessel and heavy equipment diesel engines, equipment).

6.4.8.8 *Liquid and Solid Waste Generation, Handling and Disposal*

In general, waste management will be carried out closely in line with the legal framework and under consideration of international best practice principles and Greek/EU legislation.

All waste materials will be collected, stored and transported separately in appropriate and approved bins and containers.

Only companies certified by the relevant authorities will be used for transportation, recycling and disposal of waste. A list of certified waste management companies has been obtained from the Ministry of Environment and Energy (MEE), which identifies that it will be possible to manage and dispose off all the likely construction and operation waste streams at facilities within Greece. This process will be closely coordinated with the responsible authorities.

The overall objective is to minimise the impacts of waste generated during construction phase through the following:

- minimise the amount of waste that is generated;
- maximise the amount of waste that is recovered for recycling – including segregation of recyclable wastes at source;
- minimise the amount of waste that is deposited at landfill;
- ensure any hazardous wastes (e.g. used oils, lead-acid batteries) are securely stored and transferred to appropriate facilities;
- ensure all wastes are properly contained, labelled and disposed of in accordance with local regulations;
- avoid dust impacts from handling of construction wastes; and
- waste is disposed of in accordance with the waste management hierarchy in order of preference as follows: reduce, re-use, recycle.

The construction waste management strategy will incorporate the following 'good site practices' which will reduce the risk of impacts arising from waste management activities. The construction waste management plan will cover the following key aspects:

- develop inventory and schedule of likely wastes;
- assessment of local waste management facilities;
- waste minimisation principles;
- waste segregation (liquid and solid/reusable and recyclable);
- maximise reuse/recycle opportunities;
- waste collection, storage and transfer;
- specific disposal procedures for all waste steams identified including waste transfer notes if moved to a licensed offsite facility;
- auditing and reporting procedures; and
- closure process which will include appropriate monitoring and recording.

Most of the excavated soil will be used to backfill the pipeline trench. Excess soil will likely be spread out and contoured along the route in agreement with competent authorities and landowners/ users and according to further engineering studies.

Waste generated during construction is likely to be classified into the following categories for disposal:

- **Inert**. These will include: earth (except for excavated material, which is kept on-site and is destined to be backfilled when the area is restored), building rubble, unused construction material, etc. generated during preparation and restoration of work sites. These wastes pose no risk of pollution, but may be unsightly and need to be disposed of at a controlled disposal site;
- **Domestic**. The offices and administration buildings associated with the work sites (as well as the construction sites) will generate amounts of 'domestic' types of waste (i.e., food waste, paper and packaging, etc.). This will be transported to a controlled municipal waste disposal site;
- **Oily and Hazardous**. These will include: oily wastes associated with vehicle maintenance (waste oil, material collected from waste water interceptors etc); unused or waste chemicals, paints and solvents; materials excavated from contaminated sites (if any); and, any other wastes, sludge or debris that are unsuitable for disposal in a municipal type landfill. Such wastes will be separated for collection and disposal by contractors at authorised sites;
- **Liquid**. These will include:
  - Hydrotest water and Mono-Ethylene-Glycol (MEG) from the pipeline sections (refer to Section 6.4.7),
  - "Black" and "grey" water from storage yards and construction sites,
  - Hazardous liquid wastes (e.g. oils, solvents, etc.),
  - Rainwater run-off from sealed surfaces and roofs,
  - Tunneling machines cooling water.

Detailed lists of the quantities of waste by type during onshore construction are shown in Table 6-68 which describes the typical waste types generated by pipeline construction. Waste type generated and estimated quantities are an assumption based on experience gained from similar projects and the current status of design. During construction +/- deviations are possible.

6.4.8.8.1 Typical Waste Generated during Project Construction and Pre-commissioning

Table 6-68 Typical Waste Generated during Project Construction and Pre-commissioning

Activity	Waste Generation	Approximate Amount*	Disposal Recommendation
Construction sites/storage yards			
Site preparation	Likely to be negligible.	-	-
Operation	Office rubbish, paper, canteen refuse, etc.	(Included in rubbish from yard)	Recycle where possible and send rest to a licensed waste disposal site.
	Rubbish from pipe yards and construction sites	45 tonnes per week	Collect in covered skips to recycle where possible or send to a licensed waste disposal site.
	Scrap metal	45 to 720tonnes	Recycle or sell as scrap.
	Sewage	24 tankers per month	Cesspit to sewer or emptied regularly.
Site reinstatement	Workshop waste, e.g. paints, oil, etc.	45 tonnes	Collect in secure containers and send to a licensed waste treatment or disposal site.
	Concrete foundations, etc.	0 to 600 tonnes	Send to licensed waste disposal site.
Pipeline construction			
Working width preparation	Hedges, timber, vegetation, fence posts, wire, etc.	-	In accordance with applicable legislation
Pipe-string and bending	Pipe-bands and end caps	-	Collect in skips and send to licensed waste disposal or recycling site.
Welding, testing and coating	Spent welding rods, grinding wheels, visors, shot-blast	5 to 10 tonnes per week and per construction spread	Collect in covered skips or tipper trucks and send to licensed waste disposal site.

Activity	Waste Generation	Approximate Amount*	Disposal Recommendation
Trenching, lowering and laying of the pipeline	Soil and rock	Approx. 2,400,000 m^3 for the whole pipeline route	Set aside to be used in backfilling. Excess quantities used to restore abandoned quarries, in coordination with Authorities
Backfilling and grading	Surplus spoil and rock	0 to 3,000 tonnes per day (based on 600 m backfilling per day), dependent on ground conditions	Subject to landowner/ occupier's agreement. Re-use if possible/take to licensed waste disposal site.
Reinstatement	Temporary stone roads Temporary fencing, gates, troughs, etc.		Re-use elsewhere within landholding. Re-use if possible.
Horizontal directional drilling (HDD)	Bentonite, spoil and rock cuttings	0 to 600 tonnes/crossing (depending on whether used)	Store in sumps or storage pits, then dispose of using road truck tankers to licensed waste disposal site.
Thrust-boring	Spoil and rock cuttings	0 to 900 tonnes (depending on whether used)	Dispose of using road truck tankers to licensed waste disposal site.

Activity	Waste Generation	Approximate Amount*	Disposal Recommendation
Main stations construction			
Site preparation	Likely to be negligible	-	-
Backfilling and grading	Surplus spoil and rock	For CS2-MS2 / CS2N – MS2N (m^3): • Total Excavated Material: 145,291.99 • Backfilling Material: 326,338.70 • Net: 181,046.71 (FILL) For CS3(m^3): • Total Excavated Material: 315,029.70 • Backfilling Material: 24,186.45 • Net: 290,843.25 (CUT) For MS4(m^3): • Total Excavated Material: 44,687.43 • Backfilling Material: 29,111.80 • Net: 15,575.63 (CUT)	Subject to owner's agreement. Re-use if possible/take to licensed waste disposal site.
Pre-Commissioning			
Dewatering, cleaning and gauging of the pipelines	MEG	Up to 1,165 tonnes	MEG will be recovered in tanks and recycled/disposed by certified company

Activity	Waste Generation	Approximate Amount*	Disposal Recommendation
Only estimates and estimated ranges for waste quantities can be given at this stage of the Project. These estimates will be refined when detailed design has been finalised and the locations of the construction sites and storage yards have been defined further.			

Source: IGI, 2021

Table 6-69 describes the construction waste inventory for the Project (Landfalls are excluded and are shown in Table 6-70). Waste types and amounts are an assumption based on similar projects and the current status of design. During construction +/- deviations are possible.

Table 6-69 Construction Waste Inventory

Waste Type	EKA Code	Amount (tonnes) *	Disposal
Hazardous			
NDT waste	06 03 13*	> 10	Authorised Waste Manager
Rags and oil absorbents	15 02 02*	100	
Pipeline coating chemicals	07 02 14*	< 12	
Aerosol cans	07 02 14*	< 12	
Batteries Wet, Batteries Dry	16 06 01* & 16 06 02*	<12	
Activated carbon	06 13 02*	<12	
Cables/copper	17 04 09*	6	
Chemicals (Hazardous)			
Adhesives	08 04 09*	< 12	Authorised Waste Manager
General Chemicals	18 01 06*	40	
Freighting foam	07 02 16*	< 12	
Glycols	07 01 03*	< 12	
Solvents	07 03 03*	< 12	
Hydrotest fluids	08 04 15*	< 12	
Diesel, Fuel and Oil Waste (Hazardous)			
Diesel generator lube oil	13 01 11*	20	Authorised Waste Manager
Misc. oils (incl. hydraulic)	13 01 13*	50	
Vehicle and equipment lube oil	13 02 04*	50	
Glycol sludge	07 07 11*	>10	
Light bulbs	20 01 35*	12	
Medical	18 01 03*	12	
Paint sludge	08 01 11*	12	
Paint and cans/brushes	08 01 13*	25	
Non –Hazardous			
Paper and cardboard	20 01 01	100	Recycling
Pipe bands and end caps	20 01 39	100	Municipal Waste Management

Waste Type	EKA Code	Amount (tonnes) *	Disposal
Plastic bottles	17 02 03	300	Recycling
Plastic 'epoxy' drums	08 04 09*	40	Recycling
Polystyrene	15 01 02	150	Recycling
PPE and clothing	15 02 03	<40	Municipal Waste Management
Steel	20 01 40	36	Recycling
Welding materials	20 01 28	80	Recycling
Wood	20 01 38	720	Municipal Waste Management
Aluminium cans	19 12 03	<12	Recycling
Electrical/electronic comps	20 01 36*	<12	Recycling
Filters (water)	20 03 06	12	Municipal Waste Management
Food	20 03 99	2,400	Municipal Waste Management
Inert (Non – Hazardous)			
Bricks and building materials	17 01 02	80	Municipal Waste Management
Concrete/foundations	17 01 01	150	Municipal Waste Management
Glass	17 02 02	<12	Recycling

Source: ASPROFOS, 2021

Table 6-70 Construction Waste Inventory for Landfalls

Waste Type	EKA Code	Approximate Quantity**	Disposal Recommendation**
Oil waste and liquid fuel waste (except edible oils)			
Mineral based non-chlorinated hydraulic oil (*)	13 01 10*	0.1 – 1 tonnes	Recycling
Mineral-based non-chlorinated engine, gear and lubricating oils (*)	13 02 05*	0.1 – 1 tonnes	Recycling
Other engine, gear and lubricating oils (*)	13 02 08*	0.1 – 1 tonnes	Recycling
Other emulsions (*)	13 08 02*	0.1 – 1 tonnes	Disposal
Waste packaging (absorbents, wiping cloths, filter materials and protective clothing not otherwise specified)			
Plastic packaging	15 01 02	0.1 – 1 tonnes	Recycling
Wooden packaging	15 01 03	1 – 10 tonnes	Recycling

Waste Type	EKA Code	Approximate Quantity**	Disposal Recommendation**
Mixed packaging	15 01 06	10 – 30 tonnes	Recycling
Packaging containing residue of or contaminated by dangerous substances (*)	15 01 10*	0.1 - 1 tonnes	Disposal
Absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances (*)	15 02 02*	0.1 – 1 tonnes	Disposal
Wastes not otherwise specified in the list			
Components removed from discarded equipment other than those mentioned in CER 16 02 15	16 02 16	0.01 – 0.1 tonnes	Recycling
Alkaline batteries	16 06 04	0.001 tonnes	Recycling
Aqueous liquid wastes other than those mentioned in CER 16 10 01	16 10 02	TBD	Disposal
Oil filters(*)	16 10 07*	0.01 – 0.1 tonnes	Recycling
Construction and demolition wastes (including excavated soil from contaminated sites)			
Wood	17 02 01	1 – 10 tonnes	Recycling
Plastic	17 02 03	TBD	Recycling
Iron and steel	17 04 05	10 – 50 tonnes	Recycling
Soil and stones other than those mentioned in CER 17 05 03	17 05 04	TBD	Recycling
Mixed construction and demolition wastes other than those mentioned in CER 17 09 01, 17 09 02 and CER 17 09 03	17 09 04	TBD	Recycling
Wastes from human health care			
Waste with collection and disposal subject to special requirements in order to prevent infection(*)	18 01 03*	0.01 – 0.1 tonnes	Disposal
Municipal waste (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions			
Paper and cardboard packaging	20 01 01	0.5 – 2 tonnes	Recycling
Glass	20 01 02	1 -5 tonnes	Recycling
Biodegradable kitchen and canteen waste (food waste)	20 01 08	1 -10 tonnes	Recycling
Fluorescent tubes (*)	20 01 21*	0 – 0.1 tonnes	Recycling

Waste Type	EKA Code	Approximate Quantity**	Disposal Recommendation**
Biodegradable waste	20 02 01	1 – 10 tonnes	Recycling
Mixed municipal waste	20 03 01	1 – 5 tonnes	Recycling
Sewage water	20 03 04	TBD	Disposal
* classified as hazardous waste ** related to recent and previous similar projects on Landfall Site TBD: Quantity of such waste is not quantified due to kind of activities not yet defined in the Project and the number of staff employed			

Source: ASPROFOS, 2021

6.4.8.8.2 Effluents from Vessels in Accordance with Marpol

Table 6-71 describes the standard effluents from vessels in accordance with Marpol

Table 6-71 Summary of Liquid Discharge Estimates from Pipelaying and Support vessels

Waste flow	Main Sources and Approximate Volume Generated	Main Possible Components	Comments
Bilge water disposal	Cleaning out of engine rooms. Bilge water generation variable, depending upon vessel characteristics, discharge volume variable. Small quantities of *oily water* might be generated during the regular vessel activities, such as maintenance activities. Estimated up to approximately 20 m^3/month.	Hydrocarbons, Increased Biochemical Oxygen Demand (BOD)	Bilge water to be processed through an oil-water separator /system to reduce the hydrocarbon content in the water to a maximum of 15 ppm, as required by MARPOL; fitted with an alarm system.

Waste flow	Main Sources and Approximate Volume Generated	Main Possible Components	Comments
Deck drainage	Run-off of rain water. Deck drainage water generation variable depending on vessel characteristics and rainfall amounts; discharge volumes variable, though expected to be low.	Hydrocarbons, cleaning products.	Rain water run-off will depend on the severity of storms and on the direction of the wind compared to the direction that the vessel is travelling in. All discharges will be in compliance with MARPOL 73/78, Annex I. Deck drainage to be monitored and treated to remove oil and grease; discharge not to exceed 15 ppm of oil content.
Grey Water	Dishwasher, showers, laundry, bath and washbasin drains Estimated 220 l per person per day. Total volume: 22 m^3 per day (assuming capacity of 100 people within all vessels).	Increased BOD, solids, detergents	On-board sewage treatment unit to comply with MARPOL 73/78 Annex IV: no floating solids or discoloration of surrounding water; no discharges of treated sewage from vessels within 3 nm of the nearest land. residual chlorine content <1.0 mg/ l
Sewage (Black water)	Water effluent from toilets Estimated 100 l per person per day Total volume: 10 m^3 per day (assuming capacity of 100 people within all vessels)	Microorganisms, nutrients, suspended solids, organic material, pathogens, chlorine	On-board sewage treatment unit to comply with MARPOL 73/78 Annex IV: no floating solids or discoloration of surrounding water; no discharges of treated sewage from vessels within 3 nm of the nearest land. Residual chlorine content <1.0 mg/ l.
Ballast water	Dependent on vessel characteristics and stabilisation needs	Oil and alien organisms	Vessels will discharge ballast water beyond the 200 nautical miles limit, to the extent possible, and at least 50 nm from nearest land in depths over 200 m prior to reaching Greek waters. There will be no de-ballasting in coastal waters.

Source: IGI Poseidon, 2021

Description of the Procedures for Waste and Discharge Management from Vessels in Accordance with MARPOL

The main water streams identified during the offshore part of the Project are the following:

- Seawater intakes (water makers, ballast water, cooling systems, firefighting systems);
- Potable water (potable drinking water and fresh water);
- Water returns (de-ballast waters, cooling system return, firefighting system return, brine from water maker return); and
- Wastewater (black water, grey water and bilge water).

Not all vessels can separate and store the grey separate from the black waters, in which case the effluent shall be disposed of under the general term of "sewage".

In addition to the above streams which result from direct use or transformation of seawater, each vessel will generate oily wastewater accumulating in the engine rooms (bilge) and generally in the lowest space within vessel.

WATER INTAKES

Drinking water will be supplied to each vessel in bottles at regular intervals during the entire Project. In addition to drinking water, sanitary fresh water may be required by the Project vessels for the following purposes:

- Cooking and general galley use;
- Showers and general sanitary use;
- Cleaning activities inside all the vessels; and
- Laundry.

On some vessels, fresh water for galley and sanitary use will be made with the aid of reverse osmosis water maker facilities. In addition, whenever needed, fresh water will be supplied to vessels from shore sources by supply vessels/shuttle tankers.

Cooling water is required for engines and mechanical equipment on a number of vessels in the Project fleet. Cooling water is pumped from the sea, circulated through the equipment cooling or heat-exchange circuits and discharged at sea. Cooling water has no contact with any potential contaminant.

Ballast water is used to stabilise vessels during construction activities. Ballast water is pumped from the sea into dedicated ballast tanks according to vessel trim and stability requirements during both navigation and construction activities. Ballast water has no contact with any potential contaminant. Volumes of ballast water used on vessels depend on operating conditions such as cargo weight and position, vessel draught and water depth. Ballast intake and discharge operations can be very frequent (during pipe laying for instance to compensate for continuous cargo movements on the deck of the vessel) and simultaneous (intake on port side and discharge on starboard side, for instance).

Ballast water management will be conducted in line with the requirements of International Convention for the Control and Management of Ships' Ballast Water and Sediments (IMO, 2004).

Firefighting water intake for testing firefighting systems is foreseen for all vessels equipped with seawater based firefighting systems. Firefighting system tests are planned at regular intervals to ensure that the firefighting system is working adequately in case of a fire emergency. The firefighting water has no contact with any potential contaminant.

WATER RETURNS

The following types of water returns (with reference to the figure above) are foreseen from vessel(s) during Project activities:

- Clean, non-contact water returns that are to be discharged into the sea are coming from the following systems: ballast system, cooling system and the fire control water system, as described above; and
- Water maker brine as a result of processing seawater through a reverse osmosis unit. The unit retains salts from the water that are discharged at sea from the unit itself. It contains concentrated ions that were originally present in sea water and does not therefore add any additional contaminants when discharged at sea.

Table 6-72 Sample of Offshore Construction Vessel Garbage Placard

Waste Classification	Skip Contents
Scrap Metal (Non hazardous)	All scrap metal including swarf, metal shavings, uncontaminated metal cans and tins, metal wires, damaged slings, etc.
Industrial Waste (Non hazardous)	Deck sweepings, plastics, waste flux, concrete spoil, damaged field joint sleeves, excess PU foam, glass, wood, etc.
Domestic Waste (Non hazardous)	Waste food, napkins, paper towels, plastic and paper cups, water bottles, etc.
Special Waste (hazardous)	All oil / chemical / paint contaminated materials including paint tins, oily rags, chemical containers, aerosols, waste mastic, oil spill granules, batteries, medical waste (bagged and sharps bins), exhausted oil, oil filters and oil contaminated materials, etc.

Source: ASPROFOS, 2021

MARPOL 73/78 states that vessels in excess of 100 gross registered tonnage are required to prepare a Garbage Management Plan detailing how each type of waste will be stored. All waste should be stored appropriately, and storage and transfer of wastes are recorded.

Solid waste from vessels shall be stored onboard appropriately in accordance with Annex V of MARPOL 73/78.

General waste storage requirements, as applicable to vessel activities, are the following:

- Waste can be temporarily stored onboard. However, waste shall not be allowed to accumulate at the storage area. Quantities stored shall be kept to an absolute minimum;
- Storage areas will be of adequate size and capacity to accommodate the required number of containers consistent with waste generation routine and collection schedules;
- Waste shall be stored in tightly closed; leakage proof compatible containers made of materials compatible with the waste to be stored;
- Containers shall be selected and designed to prevent health and fire hazards; they shall be kept in approved storage areas to limit possible consequences of spills/leaks;
- Offshore waste skips will be certified in accordance with applicable offshore containers and lifting standards;
- Leaking, corroded or damaged containers shall be emptied into containers in good condition;
- Waste storage areas shall be designed to have spill containment systems and will be protected to avoid run-off;
- Incompatible waste shall not be stored in the same area;
- Containers shall be marked with warning labels to accurately describe their contents, safety precautions and specific response measures to be taken in case of emergency;
- Storage facilities for volatile substances shall be covered;
- All storage areas and handling equipment will be maintained in good order and designed in such a way as to prevent and contain any spillage, as far as practicable;
- Waste storage areas must be routinely inspected for conditions, leaks, and labelling;
- There shall be adequate control of windblown material, pests, odours, etc.;
- Containers and storage area will be cleaned on a regular basis;
- Waste material will be stored such that it will not constitute a fire, health, safety or environment hazard, or be accessible to animals and vectors. All garbage must be placed in plastic bags, tied at the top and deposited inside trash collection points; and
- Waste containers/skips will be color coded.

6.5 Operation Phase

6.5.1 Operating Principles

6.5.1.1 Operating Philosophy

The EastMed Pipeline Project will be controlled from a dedicated main dispatching centre (MDC), located at the O&M Base.

The main functions of the control room will be monitoring, control and operation of the EastMed Pipeline Project via SCADA, among other things. All stations will be designed on the basis that they are unstaffed and controlled remotely.

The design will allow planned and orderly expansion to meet projected data acquisition and equipment needs. The full design will allow modular expansion such that the dispatching centre is easily reconfigured to add processing capacity.

A backup dispatching centre (BDC), located geographically separate from the MDC, will duplicate all functions of the control centre, except for the pipeline trainer and interfaces to the business and maintenance systems.

Compressor stations have been designed for remote operation from the MDC and the BDCs via SCADA (e.g. settings for compressor duty, speed, etc.). At each station, a station control system (SCS) will be provided for local control of all compressors and equipment associated with the station..

6.5.1.2 Selection of Control Method

6.5.1.2.1 Flow Control

Flow control is based on controlling the flow rate in the pipeline. The flow rate is measured, and a signal is sent to the upstream compressors in order to keep the flow rate constant based on a selected setpoint, irrespective of the inlet pressure. The control is made by adjusting the compressor flow rate.

In the flow control scenario, the energy input at the inlet to the pipeline system is the minimum required to achieve the desired gas flow rate through the pipeline system. In other words, the amount of compression is exactly as much as required to achieve the flow rate and the delivery pressure at the outlet of the pipeline system.

This scenario is referred to as “flow control” since the flow rate measured at the receiving facility is used to adjust the degree of compression at the pipeline upstream end.

This operating scenario is commonly applied to transmission pipeline systems where flow rates are relatively constant and where optimisation of the energy input (i.e. compression operating cost) is a priority.

6.5.1.2.2 Pressure Control

Pressure control is based on controlling the pressure at the receiving facility, with the use of a pressure control valve (PCV) upstream of the compressors. The pressure is measured downstream of the valve and a signal is sent to the PCV to open/close in order to maintain the considered pressure set point at the receiving facility downstream of the PCV; control of the export rate is made through adjustments of the control valve opening at the receiving terminal and adjusting the upstream compressor discharge pressure.

In the pressure control scenario, the energy input at the upstream compression facility is greater than the minimum required to achieve the desired gas flow rate through the pipeline system. The gas is compressed to a higher pressure upstream, and downstream there is a pressure let down to match the required inlet pressure to the downstream system (e.g. national gas grid); this scenario “packs” the pipeline to a certain degree requiring a pressure let-down function at the receiving facility.

This scenario is referred to as “pressure control” since the pressure measured at the receiving facility is used to adjust the degree of compression at the pipeline inlet; the goal is to maintain a certain minimum pressure let down at the receiving facility. Alternatively, the goal can be to maintain a constant inventory of gas in the pipeline.

This operating scenario is commonly applied to gas distribution pipeline systems where it is important to be able to react quickly to changes in demand. The excess pressure in the system allows a higher flow rate to be achieved almost instantaneously by opening the throttling valve at the receiving facility.

6.5.1.2.3 Recommended EastMed Control Method

The flow control and pressure control operating principles discussed above are applicable to long-distance gas transportation pipelines and therefore relevant to EastMed. Both methods may be employed depending on the specific section

Given that the compressor station at Florovouni, and hence the downstream system, will be operating in flow control mode, the part of the EastMed system between CS2 and Florovouni should also be operated in flow control mode. This is because most of the system (from LS03 onwards) is a low pressure system with a limited scope for line packing. In addition, the HP/LP interface at LS03 prevents the OSS3 pipeline from being operated at elevated pressure, i.e. OSS3 cannot be packed.

The system upstream of CS2 is a high-pressure system with large pipeline volume (long pipeline lengths) hence provides flexibility in terms of line packing.

The summary of the recommended control type for each section of the EastMed system is presented in Table 6-73.

Table 6-73 Recommended EastMed Control Philosophy

System	Pipeline Segment	Control Type	Reasoning
Southern Line	OSS1-OSS2	Pressure control	To make use of the available large inventory/line-pack in the pipeline. Control with pressure let down provisions at Crete compressor station.
	OSS1a	Pressure control	OSS1a is part of the OSS1-OSS2 system and upstream of CS2, hence requires same control type
	OSS3	Flow control	Pipeline is interfacing a low pressure system hence line packing is not feasible.
	CCS1, OSS4 and CCS2	Flow control	Low pressure part of the system with limited line-packing potential. Control to manage interconnection points with future transmission system operators (TSO)
Northern Line	OSS1b	Pressure control	OSS1b is upstream of CS2, hence requires same control type as rest of the system
	OSS2N	Pressure-control	To make use of the available line-pack in the pipeline and to allow comingling of flow from Southern and Northern Linesat CS2
	OSS3N	Flow control	Same as OSS3. Pipeline runs in parallel with OSS3 pipeline with comingled source at CS2

Source: IGI, 2021

Transient analysis will be performed to assess the ability to provide buffer capacity in the EastMed pipeline system.

6.5.1.3 *Inventory Management*

Under steady state operations, a constant pipeline gas inventory should always be maintained. The principle of constant gas inventory requires that the inlet flow rate matches the outlet flow rate as much as possible. This implies that, once the extra buffer capacity is used up due to sudden and large changes in daily nominations, it would need to be replaced by having more gas inflow into the pipeline than gas outflow. Once the pipeline is packed with extra buffer capacity, a new constant gas inventory is maintained by matching the gas inlet and outlet flow rates.

The inventory in the downstream legs of the system will be quite large. By the time the landfall is reached in Crete there is buffer inventory to react to downstream demand fluctuations. By packing a pipeline segment (e.g. OSS1-OSS2), extra buffer capacity can be provided in the system. This buffer capacity can be used to allow continuity of gas delivery for short durations of ECP downtime or to meet short-term nomination changes by purchaser. A purely free-flow type system would not guarantee this flexibility.

6.5.1.4 *Special Considerations*

Special attention is drawn to the following aspect:

- Crete compressor station CS2 – due to the pressure-control principle of the pipelines upstream of CS2 (i.e. OSS1-OSS2 and OSS1a), there will be a potential for large pressure differential across the pressure let down station. The design will accommodate for high differential pressure/JT cooling at this location, e.g. due to pipeline packing; and
- Interface OSS3 – CCS1 at the south-east Peloponnese landfall.
  At this location, the third offshore pipeline segment (design pressure above 200 barg) delivers gas into the first cross country pipeline segment with a design pressure of 100 barg. A high-pressure protection of the cross-country pipeline (CCS1) is required at this location, when higher pressures are encountered from the offshore pipeline (OSS3) due to changes in 'Steady-State' operating conditions. In normal 'Steady-State' operation the pressure at this facility should be below 95 barg. A start-up heater shall be considered at the landfall station to accommodate for high differential pressure/JT cooling during start-up; and
- Gas offtake in Megalopoli.
  With the combined Southern and Northern Lines both in operation, it is assumed that when less than 1 BSCM/yr or no gas is taken off at Megalopoli, CS2 will export at a reduced flow rate such that the EastMed pipeline downstream of the offtake, including the Poseidon pipeline, will transport not more than the design flow rate of 20 BSCM/yr.

6.5.1.5 *Metering*

6.5.1.5.1 Flow Metering

Design of the metering system will be governed by the following aspects:

- Fiscal metering: this includes metering for commercial (for the purpose of quantifying gas purchase / sale) and fiscal (e.g. for the purpose of taxation) purposes and is required at country inlet, i.e. inlet at Cyprus, Crete and similarly assumed at ECP inlet. Fuel gas deduction to run the turbines will also be metered by fiscal quality flow meters; and

- Technical metering: this covers metering to monitor performance and integrity of the system during operation (leak detection) and is required at pipeline inlet and outlet. However, since fuel gas metering at the facilities is also performed by fiscal quality flow meters, then flow rate in the OSS1, OSS2 and OSS3 can be determined by difference, without the need for separate metering stations at the pipeline inlet and outlet.

6.5.1.5.2 Gas Quality Analysis

Design of the gas analysis system will be governed by the following aspects:

- Commercial/fiscal: Gas quality within the EastMed pipeline system will be constantly monitored to ensure that gas quality meets contractual obligations. This will typically require gas analysers at the fiscal flow meter locations; and
- Operations and leak detection: to maintain operability and integrity of the system. This typically will require gas analysis at the system inlet and at the outlet of each main pipeline segment.

These governing scenarios lead to a configuration of gas analysers at the same locations as those for the fiscal flow meters.

6.5.1.6 Normal/Steady State Operation Principles

The normal mode of operation is to flow gas from the ECP offshore Israel and the FPSO offshore Cyprus to the Poseidon pipeline in western Greece.

During normal operation, the flow rate in and out of the system will be maintained in 'steady state', i.e. equal and following the daily/weekly nominations. Any changes in nominations will be accommodated by ramping down and ramping up flow via the compressors. All mainline valves will be in normally open position. The fluctuations in flow rate, which are considered as part of normal nomination changes, will be relatively small and typically represent 5-10% flow rate changes.

A higher flow fluctuation is considered an upset operation.

The pipelines are not expected to operate at high turndown as part of normal operation. The minimum turndown will be governed by the compressors/facilities (minimum flow of 2.4 BSCM/yr is assumed or 20% of design flowrate from ECP).

6.5.1.7 Transient operation principles

The following sections highlight the anticipated transient operating scenarios applicable to the EastMed pipeline system.

6.5.1.7.1 Ramp Up/Ramp Down

<u>Compressor Station</u>

The ramping down/up of flow at the compressor stations will follow the compressor curve and is normally not an operational concern for the compressors. It is assumed that the compressors can ramp flow up/down from 100% design flow rate to 0% and vice versa in one hour.

<u>Pipelines</u>

Ramp down and ramp up operation, which are considered as upset operations, exclude nomination changes. Situations that could be considered here are, for example, the necessity to suddenly change the pipeline inventory as a result of an emergency.

The pipeline ramp down/up rates and magnitudes need to be defined, i.e. from 100% flow to a certain lower flow rate within specified time frame and vice versa.

Any sudden and large nomination changes can only be met while maintaining a high inventory in the pipeline. A low inventory in the pipeline binds the operator to limited nomination changes.

When the gas inventory needs to be increased or reduced, the ramp up or ramp down operation will be coordinated by the EastMed Control Centre to ensure the gas entering from the compressor station at the ECP and at the system outlet will bring about the required change in gas inventory of the EastMed pipeline.

The data gathered at the Control Centre will be analysed to predict the system response to such changes in pipeline inventory and will confirm that a certain nomination change is feasible within the system design limits.

6.5.1.7.2 Shutdown

Depending on the cause, shutdown can be planned or unplanned. Planned shutdowns include situations such as shutdown for maintenance, annual shutdown campaign or train switchover. Unplanned shutdown includes activation of an emergency shutdown system when one or more process parameters exceed the set limits, in case of fire and gas release or in response to an incident/accident, e.g. a pipeline leak is detected.

As is standard in the oil and gas industry, each of the facilities will have local emergency shutdown (ESD)/ process shutdown (PSD) as part of process control and safeguarding systems. Should there be an incident at a facility, the local ESD/PSD system will be triggered, and the pipeline may be isolated (on both sides) based on the guidance for the safe shutdown of the pipeline and the facilities along the pipeline. An ESD0, i.e. complete shutdown, will be initiated by closure of mainline ESVs. It can be assumed that lower level ESD/PSD (i.e. ESD1, ESD2, etc.) will not directly affect the pipeline, only the facilities.

For planned shutdowns motor operated valves (MOVs) will be used.

<u>Simultaneous Shutdown at Upstream and Downstream Facilities</u>

Due to the lengths of the pipeline segments, simultaneous shutdown for operational reasons at the upstream and downstream facilities is not envisaged. Most likely cause for a shutdown is expected to be due to an unforeseen situation or emergency, e.g. pipeline leakage, or any other breach of pipeline integrity requiring isolation of a pipeline segment.

This would result in a complete stop of flow in the relevant pipeline segment, and possibly cascade further downstream affecting other facilities/pipeline segments.

The shut-in pipeline will settle-out, i.e. pressure at the upstream end will settle to a lower value; whereas the pressure at the downstream end will increase to a higher value.

<u>Shutdown at Upstream Only</u>

The result of shutdown at ECP only is the same as survival time, resulting in unpacking of the pipeline inventory.

Conditions for a shutdown at ECP (e.g. no gas, off-spec gas) will need to be defined in cooperation with the ECP.

<u>Shutdown at Downstream Only</u>

Shutdown at the system outlet will result in the stop of flow at the pipeline outlet but possible continued operation at the pipeline inlet. This will result in pipeline packing.

<u>Shutdown at an Intermediate Facility</u>

Shutdown at any of the intermediate facilities with an ESV present as part of the mainline (CS/LF/BVS) will result in a 'blockage' of flow in the main flow path. If the systems upstream and downstream continue to operate as normal, the upstream side will experience packing while the downstream side will experience unpacking. A careful coordination of the response to this type of shutdown will be necessary to prevent a situation that the system cannot be easily and safely restarted or additional measures would be necessary to for a safe restart (e.g. pressurising with nitrogen).

6.5.1.7.3 Restart

Following a shutdown, the system will need to be restarted to normal operation. The process of restart will depend on a number of factors, such as:

- Cause of shutdown – ESD or maintenance (different valves will need to be reopened);

- Condition of the system, including pressure difference between upstream/downstream – i.e. pressurised or depressurised; and
- Shutdown duration - cold or hot restart.

Restart of the compressors is not considered to be a frequent occurrence, since, in case of a process upset, the compressors would go on recycle as opposed to complete shutdown.

Restart of the pipelines will be performed primarily by the coordinated actions of the upstream and downstream facilities and will constitute restoring the pipeline inventory to a certain degree. Depending on the settle-out condition of the pipeline or its segments, the action might be to first pack the line if it has been previously unpacked/depressurised or unpack if the pipeline has been previously packed.

The most common pipeline restart scenarios will include:

- Restart of a pipeline segment following a pressurised shutdown, where 'pressurised' could mean:
  - Settle out pressure,
  - Packed pressure,
  - Unpacked pressure;
- Restart of a pipeline segment following a depressurised (to atmospheric) shutdown, which includes re-commissioning of the pipeline segment (e.g. following intrusive maintenance).

6.5.1.7.4 Depressurisation

<u>Facilities</u>

The compressor stations (CS) will be equipped with emergency vent systems, which will allow depressurisation of these stations in case of emergency. Venting will be an automatic operation linked to the emergency shutdown system (ESD).

Pig trap stations will have their own pig trap vent system for trap venting and depressurisation. Venting of the pig traps will be a manual operation performed during maintenance and pigging operation.

Block valve stations (BVS) will be equipped with vent lines to allow depressurisation of individual pipeline segments between BVSs to a vent stack at safe location. Venting at the BVSs will be a manual operation.

<u>Pipelines</u>

Depressurisation of the offshore pipeline segments is not envisaged as part of normal operation. If depletion of the pipeline inventory is necessary, this can be achieved by continuing export up to the point that the low pressure limit is reached at the pipeline exit. If further depressurisation is necessary, i.e. to completely empty the pipeline segment, vent system at the upstream and/or downstream facilities should be utilised. It should be noted that these vent systems are designed for depressurisation of the facilities only, but not the pipeline itself. Hence pipeline depressurisation utilising the facilities vent systems is expected to be a slow process.

Depressurisation of the onshore pipeline segments is envisaged in case of maintenance or emergency, for example. The vent facilities as part of the BVSs will be used for this purpose.

6.5.1.7.5 Pipeline Packing

Pipeline packing will occur when the system outlet or any intermediate station is closed, while the gas continues to enter the system at the ECP. The pressure in the system will start to increase and continue to do so until one of the following occurs:

- a decision is made by the operator to shut off the gas source;
- a safety system detects pressure in excess of the high-pressure setting, leading to an emergency shutdown; and
- a high-pressure protection system at the high/low pressure interface is activated on detection of high pressure.

6.5.1.7.6 Loss of Gas Supply

Should there be a stop of flow/shutdown at the pipeline inlet, i.e. at ECP, depending on the pipeline inventory, theoretically flow out of the system can continue until a low-pressure boundary limit is reached at the pipeline outlet. After this limit is reached, no further flow is possible. This is commonly referred to as 'survival time'. This operation can be utilised to continue to meet contractual requirements in the short term only. As the inventory is depleted, there is a reduction in the driving force and pressure and hence flow out of the system will also reduce with time.

This operation comes at the expense of reduced/no flexibility as the inventory becomes depleted. The subsequent restart will need to consider the extended time required to fill the pipeline up to normal inventory before normal operation can restart.

Scenarios where a compressor station becomes unavailable, i.e. gas would need to bypass the compressor station, are not considered.

Once the Northern Line is in operation, any potential gas outage at the ECP can be partially compensated by gas flow from the FPSO (up to 10 BSCM/yr).

6.5.1.8 *Commissioning*

Following pre-commissioning, the system will be under a nitrogen blanket (1-2 bar) and ready to receive gas.

The first stage of pressure increase in the Southern Line will be by (possibly) bypassing the ECP and CS2 compressors due to low initial pipeline pressure. It is assumed that the entire pipeline system, i.e. from ECP to tie-in to Poseidon pipeline, will be pressurised as one system using gas from the Israeli source, i.e. back-pressurisation from Greece is not considered. Once a sufficient equalisation pressure is reached (i.e. typically equal to compressor minimum suction pressure), further pressurisation in a controlled manner up to normal operating pressure via the ECP and CS1/CS2 compressors can start.

Commissioning of the Northern Line will occur when the Southern Line is already pressurised and in operation. In the first stage, gas will flow from the FPSO towards Cyprus and from Cyprus to Crete. Back-pressurisation towards the FPSO or from Crete back to Cyprus is not considered. Once sufficient pressure is reached in Crete at the tie-in point with the Southern Line, further pressurisation of the Northern Line up to normal operating pressure will take place via the respective compressors.

Re-commissioning will be required should any parts of the EastMed pipeline system undergo replacement or repair. From a hydraulics perspective, this is same as a re-start.

6.5.1.9 *Pigging Principles*

The gas to be transported will be sales quality dry gas, i.e. sufficiently dew-pointed to prevent liquid dropout. Hence no liquids (water or hydrocarbons) are expected to form under the foreseen operating conditions. Therefore, no requirement for operational pigging for liquid removal is anticipated for normal operation.

Pigging is anticipated to be performed as part of:

- pipeline pre-commissioning;
- internal inspections of the pipeline sections;
- re-commissioning following an incident; and
- pipeline isolation in the case of an emergency, especially in deepwater sections where the nearest isolation valves would be hundreds of kilometres away (e.g. use of smart plugs).

In general, pigging will be performed periodically to inspect the internal condition of the pipeline. The pipeline system must therefore be designed to be fully piggable from pig trap to pig trap. It is common practice to precede inspection pigging with a cleaning pig run to remove any debris/black powder from the pipelines.

The pipeline system will be designed to be piggable using both conventional utility pigs and internal inspection tools. This means:

- Internal diameter should be constant between pig traps to the extent practicable;
- Internal diameter variations, where required, shall be smooth (typical maximum transition slope 1:4) and shall not exceed 5% of the pipeline nominal diameter. Any such diameter variations shall be subject to confirmation by the pipeline system designer;
- All main-line valves shall be full bore;
- All off-takes shall be designed for safe pig passage (e.g. tees shall be barred); and
- No intrusive probes, chemical injection quills or other such fittings shall be placed along the pigging path.

6.5.2 Pipeline Operation

The pipeline control system is the main part of the natural gas transportation operation . The overall control system comprises the following functions:

- Pipeline flow regulation;
- Pipeline parameter monitoring;
- Pipeline pressure safeguarding;
- Telemetry and telecommunications;
- Pipeline leak detection;
- Fire and gas detection and protection;
- Emergency shut down; and
- Emergency response.

A short introduction to each is given in following subsections.

6.5.2.1 *Pipeline Flow Regulation*

The flow regulation system ensures that the pipeline is always operated within its operating standards while fulfilling contractual transportation obligations.

The flow regulation system of the EastMed will automatically alert if the normal operating limits of the pipeline system are approached so that corrective actions, such as adjusting the gas flow, can be initiated.

6.5.2.2 *Pipeline Parameter Monitoring*

Besides pressure monitoring, pipeline transportation system instrumentation continuously measures temperature, gas flow and gas composition at the inlet and the outlet.

These data are transmitted online via the SCADA (supervisory control and data acquisition) system and are continuously evaluated to ensure that all contractual requirements and nominations are fulfilled, to identify unexpected changes at an early stage and to ensure that design limits of the pipeline are not violated. For this purpose, pipeline application software will be used that allows detailed simulation and forecasting of the pipeline operating conditions.

The SCADA system displays the pipeline operating parameters at the main control room as well as at other locations where such information is required.

In case a design limit is approached, the system will automatically generate a pre-alarm to allow corrective actions. In case the design limit is reached despite corrective actions, the safety function of the system will automatically initiate further corrective actions that ensure that the system stays in safe operational mode.

6.5.2.3 *Pipeline Pressure Safeguarding*

The process safeguarding will be designed to:

- ensure that the process parameters of the EastMed pipeline system remain within the design envelope;
- isolate the pipeline segments from the upstream/downstream facilities or systems when there is an absolute necessity to do so; and
- isolate the low-pressure system (via HIPPS) at LS03 from the high-pressure system in case of overpressure.

In order to automatically isolate the system against (high pressure) sources of gas supply, emergency shutdown valves (ESV) will be included at the upstream and downstream ends of a pipeline segment, typically within the fence line of the compressor / receiving stations.

When any of these ESVs are closed, the gas flow is severely reduced or stopped. As this will have operational / financial consequences, activation of these valves should be limited to a few scenarios only, such as detection of high/low temperature, high/low pressure, fire or gas release.

6.5.2.4 *Telemetry and Telecommunications*

The pipeline system communications infrastructure will permit fast, reliable and secure exchange of data (telemetry) and voice messages (telecommunications) between the various facilities and control rooms, which are separated by significant distances.

6.5.2.5 *Pipeline Leak Detection*

A main focus for gas transportation is pipeline safety. Thus considerable effort is undertaken during design and construction to minimise the risk of pipeline failure. Therefore, the probability of a gas leakage during the lifetime of the pipeline is extremely low. Although such an event is highly unlikely to occur, a leak detection system will be installed to allow fast reaction. This system is based on continuous monitoring and evaluation of data from flow rate and mass balance measurements.

If the leak detection system detects a leak, appropriate actions will be initiated immediately. The alert is sent via the supervisory control and data acquisition (SCADA) system.

The entire EastMed Pipeline Project will be monitored, operated and controlled from remote dispatching centres. Two dispatching centres will be installed. The main dispatching centre (MDC) will be housed at the O&M Centre at Achaia Regional Unit. The backup dispatching centre (BDC) will be housed in the station CS2/MS2 at Crete.

The supervisory control and data acquisition (SCADA) System for the EastMed Pipeline Project refers to the system that enables operators of the Project to oversee the entire pipeline operations, providing control, monitoring and data acquisition functions across all sections of the pipeline.

Below the SCADA System, local station control systems (SCS) will be used to oversee the operations within each metering, compressor and heating station, providing control, monitoring and data acquisition functions only for the dedicated station. The SCS will only consolidate local control and monitoring and will not execute commands outside the station where it is located.

SCSs will be self-contained autonomous control systems providing real time monitoring and control, along with alarming, data-logging and reporting functions. SCSs will be implemented only in the compression, metering and heating stations. In all other type of facilities (LS, SS, BVS) simple, real-time monitoring and control over operator panels (OP) and PLCs/RTUs will be implemented.

The SCADA System of the EastMed Pipeline Project will integrate hardware and software modules distributed along several facilities summarised in Table 6-74.

Table 6-74 EastMed SCADA Facilities(Facilities in Greece are marked in bold)

Station Type	Location	Device Type
Main Dispatching Centre (MDC)	Achaia	Redundant SCADA servers Workstations for Real Time Clients Workstations for trainer software
Backup Dispatching Centre (BDC)	Crete	Redundant SCADA servers Workstations for Real Time Clients Workstations for trainer software

Station Type	Location	Device Type
Compression/Metering Station (CS1/MS1, **CS2/MS2, CS2MS2 N**)	Cyprus & Crete	Redundant process PLCs Single I/O Modules Redundant Communication Modules Redundant ESD PLCs (SIL3) Station Control System and Workstations
Metering and Pressure Reduction Station (MS1a/PRS)	Cyprus	Redundant process PLCs Single I/O Modules Redundant Communication Modules Redundant ESD PLCs (SIL3) Station Control System and Workstations
Compression Station (CS3)	Peloponnese	Redundant process PLCs Single I/O Modules Redundant Communication Modules Redundant ESD PLCs (SIL3) Station Control System and Workstations
Landfall Station (LS)	Various Locations	Redundant process PLC /RTU Single I/O Modules Single Communication Module Operator panel
Block Valve Station (BVS)	Various Locations	Redundant process PLC /RTU Single I/O Modules Single Communication Module Operator panel
Scraper Station (SS)	Various Locations	Redundant process PLC /RTU Single I/O Modules Single Communication Module Operator panel
Metering and Pressure Reduction Station (MS4/PRS4)	Megalopoli	Redundant process PLCs Single I/O Modules Redundant Communication Modules Redundant ESD PLCs (SIL3) Station Control System and Workstations

Station Type	Location	Device Type
Heating Station	Megalopoli	Redundant process PLCs Single I/O Modules Redundant Communication Modules Redundant ESD PLCs (SIL3) Station Control System and Workstations
EastMed Compression Platform (ECP)	Israeli Waters	Redundant process PLCs Single I/O Modules Redundant Communication Modules Redundant ESD PLCs (SIL3) Station Control System and Workstations
Metering Station	Florovouni	Automation equipment belonging to other Project.

Source: IGI, 2021

In accordance with the SCADA software, additional application software (modules) will be present in the form of a virtual client, namely the Pipeline Application Server. These modules will support integration with the SCADA software, and in general, they should interact with specific "parts" of the SCADA server, e.g. Data Collector Server, Alarm/Historian Server, GMAS Server, etc. These modules will perform, but not be limited to, the following functionalities:

- Pipeline Model;
- Steady State & Dynamic Simulation;
- Look-Ahead Simulation;
- Consumption Forecast;
- Leak Detection;
- Survival Time Calculation;
- Instrument Analysis & Data Correction;
- Gas Contract Monitoring;
- What-if Analysis;
- Optimization; and
- Flow, Pressure and Temperature Measurement.

6.5.2.6 *Fire and Gas Detection and Protection*

All stations will have local fire and gas detection and protection systems, as applicable international and national standards may determine in the oil and gas industry.

6.5.2.7 *Emergency Shutdown*

Stations will have local emergency shutdown and safety systems, as is standard in the oil and gas industry. The systems will be triggered in case of an emergency such as fire. The gas volume in the pipeline will then be automatically separated by closing the emergency shutdown valve. Additionally, stations will be isolated from the upstream or downstream sections and automatically depressurised by releasing the gas via dedicated vent stacks in a safe location to minimise gas volume in the respective area. The underlying principle here is to stop the supply of gas to a fire.

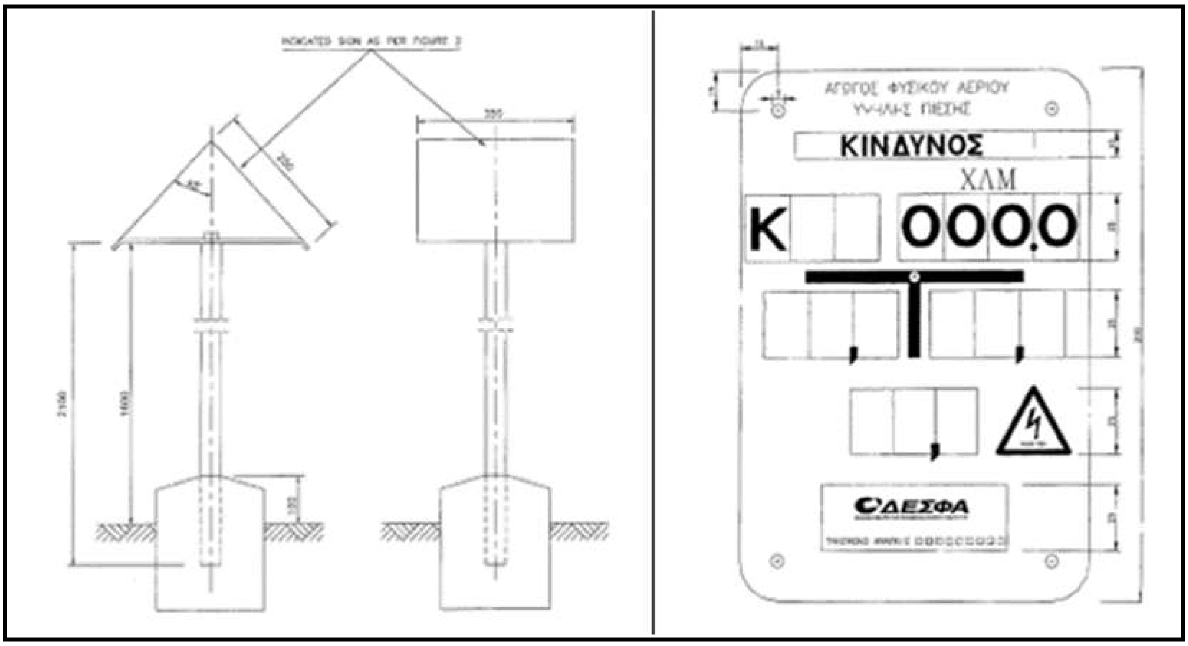
6.5.2.8 *Corrosion Management*

The fluid transported by the EastMed pipeline system is dry gas. In normal operation there is no risk of liquid water dropout and hence no free water will be present in the pipeline. This implies that no electrolyte is present and therefore no internal corrosion will occur. The presence of CO_2 in the dry sweet gas will form no risk of corrosion. Furthermore, the use of flow coating within the pipelines reduces the area of steel that is directly in contact with internal fluids. Based on these conditions, a requirement for corrosion allowance will be determined.

The offshore pipeline will be externally protected by an anti-corrosion coating (including field joint coatings) and bracelet anodes as secondary protection. It is anticipated that the onshore sections will be protected by an impressed current system. The design will ensure that both the offshore and onshore system are adequately protected.

6.5.2.9 *Marking of Pipeline*

The laid pipeline will be permanently marked by poles and proper markers so that its identification is visible even through aerial means, during the operation phase. In addition, warning tape will be laid above the pipeline in the trench. The following figures present the appearance of a typical marker post.



Source: ASPROFOS, 2022

Figure 6-51 Design of a Typical Marker Post for Gas Pipeline

6.5.2.10 *Block Valve Stations*

During normal operation pipeline safety will be operated by a centrally controlled SCADA System. It will, however, also be possible to operate the pipeline safety systems from each compressor station. The pipeline will operate 7 days a week, 24 hours per day. Permanent operators will operate/monitor the pipeline on a shift basis.

The pipeline will be sectioned by BVSs. Their purpose is to isolate sections of the pipeline between two adjacent line valves, either for maintenance or for protection in case of emergency.

6.5.2.11 *Pipeline Inspection and Maintenance*

6.5.2.11.1 Onshore Sections

The Onshore EastMed maintenance and inspection program is developed to minimise risk associated with long term operation, while minimising costs associated with inspection mobilisation and lost production. The inspection program considers both internal and external pipe surfaces for pipelines.

Internally, Onshore EastMed will be inspected by pigs propelled by the gas produced. A suite of pig types is available for wall thickness inspection, geometry and alignment check, cleaning, or pre-commissioning. Inspection of the wall thickness is conducted by intelligent pigs to monitor internal and external corrosion. Profile/mapping pigs are used to monitor the pipeline alignment; this will identify profile changes with respect to the baseline pipeline profile due to external impacts like geohazards. Geometry/calliper pigs are used to monitor pipe out of roundness. In order to establish a baseline for future inspection, it is considered prudent to conduct an intelligent, profile pig and geometry pig run during commissioning or soon after. It should be noted that all these functions may be available in a single intelligent tool. Pigging will allow any minor damage incurred during installation to be recorded and compared against subsequent inspection runs.

The gas to be transported will be sale quality gas with low water content and comparatively low hydrocarbon dew point. No liquid water or liquid hydrocarbons will be formed under any foreseen normal operating pipeline conditions. Consequently, routine pigging to remove liquid accumulation in the pipeline is not expected. However, it is common practice to run cleaning pigs prior to an internal inspection run to ensure that the pipeline is free from debris that could impede the inspection tool. In the event of process upset resulting in off-specification (wet) gas, cleaning pigging may be performed to sweep any liquids out of the pipeline. The pigs used for cleaning should have soft seals so as not to damage the internal coating.

Externally, Onshore EastMed will have regular inspections that cover at least the following verifications of the pipeline condition:

- Survey of the land profile to check for soil erosion and monitor pipeline burial;
- Visual inspection of the above ground pipeline, and associated pipework and fittings for damage to insulation and subsequent corrosion;
- Inspection of the cathodic protection system through voltage measurement and sampling for corrosion control, if possible;
- Inspection of cathocid protection (CP) isolation joints and to test their integrity; and
- Inspection of the surge suppression device between the compressor station and the pig launcher/receiver location.

Some sections of the pipeline may also be routinely excavated to verify the condition of the anti-corrosion coating. This should be coordinated with the internal inspection, which will also identify requirements for pipeline excavation in the event of excessive localised corrosion.

6.5.2.11.2 Offhore Sections

The offshore pipeline system will be monitored and maintained to ensure that it shall remain adequate and operational as designed, constructed and tested throughout its lifetime and in order to minimise environmental and human hazards. Maintenance planning will be performed through a combination of modern management techniques, information systems and innovative technical analyses in order to minimise any risk associated with operation of the installation and equipment in the long run. The integration of scheduled maintenance will be a major component of the project development and will be implemented throughout the operation of the pipeline system.

6.5.3 Project Stations

6.5.3.1 Compressor Stations

Process flow diagrams of the project are included in APPENDIX 6.12.

6.5.3.2 Station Operation

The EastMed Pipeline Project will be controlled from a dedicated main dispatching centre (MDC), located at the O&M Base.

The main functions of the control room will be monitoring, control and operation of the EastMed Pipeline Project via SCADA, among other things. All stations will be designed on the basis that they are unstaffed and controlled remotely.

Compressor stations have been designed for remote operation from the MDC and the BDCs via SCADA (e.g. settings for compressor duty, speed, etc). At each station, a station control system (SCS) will be provided for local control of all compressors and equipment associated with the station.

This operating scenario is commonly applied to transmission pipeline systems where flow rates are relatively constant and where optimisation of the energy input is a priority.

The stations are capable of operating unstaffed but in practice a limited staff is required to be present).

6.5.3.3 Fire Protection Systems

Requirements regarding fire safety and fire protection set by Greek authorities are laid down in state regulations and legislation

The objective of the Fire Detection System is to:

- Provide early detection of fire;
- Provide alarm facilities to alert personnel and activate the firefighting system; and
- Provide specific automatic response in selected high priority alarm situations.

The fire prevention and mitigation philosophy for gas containing systems is mainly based on isolation of the leak source (emergency shut down), removal of the flammable inventory (emergency blow down) and isolation of all potential ignition sources.

In order to ensure a rapid initiation of the isolation and blow-down provisions after the occurrence of the release suitable systems for detection of gas clouds and fires shall be provided.

Systems considered safety critical in protection of personnel; environment or assets may require additional fire protection when potentially exposed to high levels of heat radiation.

The possibility of escalating gas fire into adjacent systems and constructions will be further minimised thanks to the physical distance between the systems. The required physical distance is based on calculations of the safety distances.

The potential of escalation of gas jet fires will be minimised further by creating physical distance between the systems. The required physical distance is based on safety distances calculations.

Main piping will be installed underground as much as possible. ESD valves will be installed in pits. Aboveground main piping may be provided with passive fire protection when required. Buildings (compressor building, service building) that are potentially exposed to the effects of fires will be constructed to resist the expected fire loads for at least 120 minutes (REI 120).

The compressors and turbines will be placed inside compressor buildings to minimise noise. The turbine enclosure within the compressor building will be equipped with a carbon dioxide extinguishing system in accordance with NFPA 12 (Carbon Dioxide).

In general, water based firefighting systems are not opted because they could cause equipment (including firefighting equipment) malfunction.

Under floor spaces for cabling will also be connected to the extinguishing system.

Handheld fire extinguishing equipment, portable and wheeled, will be provided at strategic locations over the plant both outside and inside buildings. The type and size are specified in line with the fire risk at the location.

At block valve, landfall and scraper stations, fire detection will implemented within buildings.

A common convention for alarm categories, colour and audio/visual warning will be employed across the Project.

Portable extinguishers will be spread on site to allow manual fire fighting during manned activities. All fire extinguishers will comply with the Pressure Equipment Directive (PED) 2014/68/EU.

The fire detection system, including detectors, will be certified and adhere to recognised applicable standards, e.g. EN 54.

6.5.3.3.1 Fire Panel

A fire panel will be located in the RCC building and will interface with local fire detection instrumentation.

Each local fire panel will be capable of:

- Continuous monitoring of fire components to detect any incident of fire;
- Initiating audible and visual alarms where required;
- Activate firefighting system; and
- Collating data from the detectors and forwarding alarms to the SCADA system for operator action via the RTU.

High level fire alarms will be displayed on the front of the panel to provide information regarding the status of the system. An override facility will be available at each station for maintenance purposes, to inhibit alarms when changing or testing detectors.

6.5.3.3.2 Power Supply

Each local F&G panel will be powered from the UPS (uninterruptible power supply). In case of power failure, a 24V DC (8 hours autonomy) rechargeable battery pack, installed inside the panels, will automatically (without system interruption) supply the system. The battery will be charged from a charger unit included in the panels. Any malfunction of the battery pack or the charger will be displayed at the panels.

6.5.3.3.3 Fire and Gas Detectors

The following fire and gas detectors will be provided:

- Gas Detectors;
- H_2 Detectors will be provided within the RCC buildings (H_2 Detection will activate RCC ventilation);
- The requirement for hydrocarbon gas detectors in the hazardous areas, e.g. instrumentation cabinets, will be addressed during detail design, based on relevant studies. Detail instructions for operations, will also be included in the Operating Manual;
- Smoke Detectors;
- Smoke detection will be based on optical smoke detectors;
- Smoke detector response times will be less than 5 s;
- Heat Detector; and
- Heat detectors triggered at a pre-determined temperature will be installed in addition to smoke detectors within the RCC buildings.

6.5.3.3.4 Miscellaneous Equipment

- Manual call point will be provided within the RCC buildings for manual initiation of alarms. The manual call point also initiates the fire extinguishing system.

The fire fighting system will consist of:

- Firewater water tank as above;
- Firewater pump station;
- Piping network inside buildings. It will be from galvanised steel pipes according to ELOT EN 10255;
- Piping network above ground outside buildings. It will be from galvanised steel pipes according to ELOT EN 10255 with freezing protection;
- Underground piping network outside buildings. It will be from PE, according to EN 12201;
- Fire water supply network that covers the buildings with fire hose cabinets and automatic sprinkler systems (if required) and the surrounding area with hydrants; and
- Autonomous, self-governed fire suppression systems (CO2, INERGEN or other), for electrical rooms, control rooms and mechanical rooms.

6.5.3.4 *Maintenance*

Maintenance for all equipment on the plant will be defined in the Maintenance plan based on the information and specification of the manufacturer, availability and reliability requirements and the sparing philosophy.

The maintenance strategy is based on the execution of preventive maintenance, the program for which is defined in the maintenance plan and the inspection/and testing program. In later operational life, the maintenance program follows the principle of reliability centred maintenance (RCM) whereby maintenance activities depend on collected reliability and failure data of plant equipment.

Specific maintenance activities will be described in the maintenance manual to be based on actual installed equipment and containing vendor's guidelines.

6.5.3.5 *Monitoring Facilities*

A metering system will be installed in each compressor station which measures the gas flow rate for the purpose of operational control, and as basis for the leak detection system of the main pipeline.

6.5.3.6 *Telecommunication System*

The compressor stations will be equipped with a telecommunication system (TCS). The TCS will be designed to operate under normal conditions with minimum operator actions required. The system design in West Achaia will provide built-in flexibility for future expansion due to future addition of compressor buildings. The TCS will normally operate from an external uninterruptible power supply of 24 V AC.

Telecommunication will be performed via fibre optic cable (SCADA) along the pipeline with a back-up system. Local antennas for the back-up system are part of the stations.

Voice communication will be via a national telecom grid or carried out by mobile phones.

6.5.3.7 *Requirements of IED Directive for the Compressor Stations*

The following section provides an overview of the Project's design compliance with the IED (Industrial Emissions Directive) and specifically with the best available techniques (BAT) regarding the compressor stations.

6.5.3.7.1 Compliance with BAT

The overall design philosophy regarding emission prevention is to reduce the emissions to air, water and soil to zero or as low as reasonably achievable. The design has the following provisions to prevent emissions to air, water and soil.

Emissions to air

The main process equipment has limited continuous emissions of natural gas or other process fluids. The main emission of natural gas is leakage from dry gas seals of the compressors. The application of dry gas seals is the best available technology to minimise compressor seal leakages. The leakage from dry gas seals is further minimised by adequate compressor monitoring and maintenance programs. The leakage rate is dependent on the amount of wear of the dry seals. If the leakage rate is too high and is detected by the continuous measurement of the seal gas flow and pressure, the compressor is stopped automatically.

The expected leakage rate of a dry seal is around 0.7-4.5 kg/hr. It is assumed that each compressor has two dry seals. The leakage is given as a range because it depends on the amount of wear (and thus the age) of the seals. New seals will leak at rates near the lower range limit. Assuming timely replacement of the seals, the actual annual emission of CH_4 in the seal gas is limited to the minimum possible.

Compressors are driven by gas turbines running on natural gas as fuel gas. The exhaust of the gas turbines will represent the main emissions to air.

Vent stacks are used for emergency or maintenance depressurisation. The vent system and stacks are purged with nitrogen.

Maintenance on the process equipment may require depressurisation and should in these cases be carefully planned to minimise the need for depressurisation. Design of instrumentation and equipment should be such that requirement of depressurisation for maintenance is avoided as much as possible by either provisions allowing maintenance without depressurisation or selection of reliable equipment and instrumentation required minimum of maintenance.

Electrical power is supplied from one external power supply cable. As a backup, a gas turbine driven generator is running on 50% load to prevent the compressor station shutting down when the power supply by cable fails. Emissions from the gas turbine exhaust can only be avoided by providing a second independent external electrical power supply cable or allowing a reduced availability of the compressor station. Reduced availability of the compressor station is not considered practicable considering the contractual requirements on availability. The emergency generator will only run during emergencies and for testing purposes. Emissions from the diesel generator will comply with the European Emission limits.

<u>Emissions to water</u>

Areas with the potential of spills of chemical substances, such as diesel and condensate, are provided with a dedicated drain collection system in which collected liquids are routed via a water-oil separator before being discharged to surface water. These areas are the rooms and areas with equipment containing chemical substances and truck (un-)loading areas.

Collected rainwater is discharged to surface water via a sand catcher. Sanitary wastewater is discharged to surface water via a septic tank. The outlet of the water-oil separator and outlet of the septic tank are combined with the discharge of the collected rainwater.

<u>Emissions to soil</u>

Emissions to soil might be caused either by leaks from underground equipment and piping or spills/leaks from above ground equipment containing chemical substances and truck (un-)loading areas.

Underground storage tanks of diesel and condensate are double walled and provided with leak detection. Both tanks and underground piping should be inspected regularly

Above ground equipment containing chemical substances and truck (un-)loading areas are placed on watertight paved areas to collect possible leaks or spills.

Table 6-75 includes an overview of the applicable BAT to the Compressor Station[12].

[12]COMMISSION IMPLEMENTING DECISION (EU) 2017/1442 of 31 July 2017 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants

Table 6-75 BAT Compliance Matrix

Relevant Process	BAT	Technique	Incorporated to the Design	Limits	Remarks
Monitoring	3	n/a	Yes	n/a	Only flue gas, since no flue gas treatments exist
Monitoring	4	Continuous emissions monitoring system	Yes	n/a	Parameters to be monitored are: • NOx • CO
Efficiency	40		Yes	36.5% Net mechanical energy efficiency at full load, in ISO conditions (according to BAT 2)	Lower limit
Emissions	42	Dry low-NOx burners (DLN)	Yes	35 mg/Nm3 (considered as yearly average)	(upper limits) 15% O2 (vol dry)
Emissions	44	Dry low-NOx burners (DLN)	Yes	40 mg/Nm3 (considered as yearly average)	(upper limits) 15% O2 (vol dry)

Source: IGI, 2021

6.5.3.7.2 Requirements for Baseline Report

According to Circular 153914/02.12.2015 (ΑΔΑ: 7ΔΩ14653Π8-8Ο2) regarding baseline report of Art. 18 of JMD 36060/1155/E.103/13 (HGG 1450B), stages 1 - 3 as defined in the 2014/C 136/03 Guidance, must be submitted before construction starts.

Based on 2014/C 136/03:

- Stage 1. During Stage 1 identification of hazardous substances is performed by producing a list of all hazardous substances dealt with inside the installation boundary (either as raw materials, products, intermediaries, by-products, emissions or wastes). Where hazardous substances are listed under trade names the chemical constituents should also be identified. The relative proportion of the largest constituent chemicals should be identified for mixtures or compounds;
- Stage 2. During Stage 2, the relevant hazardous substances from the list produced in Stage 1 are identified, determining the potential pollution risk of each hazardous substance by considering its chemical and physical properties such as: composition, physical state (solid, liquid, and gas), solubility, toxicity, mobility, persistence, etc. This information should be used to determine whether or not the substance has the potential to cause pollution of soil and groundwater. The

data, together with the rationale used to interpret it, should be presented so it is clear in the baseline report why substances have been excluded or included. Where a group of substances display similar characteristics they may be considered together provided that justification for the grouping is given. Where it is clear that the hazardous substances used, produced or released at the installation are incapable of causing contamination of soil and groundwater a baseline report does not need to be produced. The relevant hazardous substances identified should be taken forward to Stage 3 for further consideration; and

- Stage 3. During Stage 3 assessment of the site-specific pollution possibility is made. Each substance brought forward from Stage 2 should be considered in the context of the site to determine whether circumstances exist which may result in the release of the substance in sufficient quantities to represent a pollution risk, either as a result of a single emission or as a result of accumulation from multiple emissions. Specific issues to be considered include: (i) The quantity of each hazardous substance handled, produced or emitted in relation to its environmental effects; (ii) The location of each hazardous substance on the site, e.g. where it is or will be delivered, stored, used, moved around the site, emitted etc., in particular in view of the characteristics of the soil and groundwater at that part of the site;(iii) the presence and integrity of containment mechanisms, nature and condition of site surfacing, location of drains, services or other potential conduits for migration. The method of storage, handling and use of relevant hazardous substances needs to be identified and whether there are any containment mechanisms to prevent emissions occurring, e.g. bunds, hard-standing, handling procedures.

Table 6-76 presents a preliminary list of substances to be used at the compressor stations. The table also identifies which of the substances are 'relevant' within the meaning of Article 22 of the Industrial Emissions Directive: 'Where the activity involves the use, production or release of relevant hazardous substances and having regard to the possibility of soil and groundwater contamination at the site of the installation, the operator shall prepare and submit to the competent authority a baseline report before starting operation of an installation…'.

It needs to be clarified that all liquids stored on-site will be provided with robust primary containment appropriate for each substance. Containment of vessels employed within the process contain dilute quantities of substances identified in the table below and may cause pollution to ground or ground water if released to the environment is described in the relevant table. Secondary containment will comprise either individual bunds which will be sized to 110% of the capacity of the tank or 25% of the total quantity (whichever is the greatest) for all potential hazardous substances. In addition to the above measures, the whole site shall be comprised of built structures on impermeable surface.

Table 6-76 Relevant Hazardous Substances (Source, Pathway, Receptors) Relevant to Baseline Report of Art. 22 of IED for Main Stations

Substance	Location	Use (Raw materials, Products, Intermediaries, By-products, Emissions or Wastes)	Hazardous Properties	Quantity Stored On-Site of CS2 / CS2N	Quantity Stored On-Site of CS3	Pollution Prevention Measures
Diesel Oil	Diesel Storage Tank	Raw material	Flammable liquids, C. 3 H226 Aspiration hazard, C. 1 H304 Skin corrosion/irritation, C.2, H315 Acute toxicity, C.4; Inhalation H332 Carcinogenicity, C. 2 H351 Specific target organ toxicity - repeated exposure, C. 2; Blood.; Liver.; Thymus. H373 Chronic hazards to the aquatic environment, C. 2 H411	50 m^3	50 m^3	double walled tank
Diesel oil	Emergency Diesel Generator			1.0 m^3	0.5 m^3	containment basin

Substance	Location	Use (Raw materials, Products, Intermediaries, By-products, Emissions or Wastes)	Hazardous Properties	Quantity Stored On-Site of CS2 / CS2N	Quantity Stored On-Site of CS3	Pollution Prevention Measures
Condensates	Condensate Storage Tank	Raw material	Flammable Liquid, C.1, H224 Aspiration Hazard, C.1, H304 Carcinogenicity, C.1B, H350 Skin Irritation, C.2, H315 Specific Target Organ Toxicity - STOT, Single Exposure SE, C.3, H336 Hazardous to the aquatic environment, long-term, chronic, C.2, H411	30 m^3 + 30 m^3 m^3	15 m^3	double walled tank
Lubricants	Backup Generator	Raw material		14 m^3	7 m^3	containment basin
Oil	Water/Oil Separator	Waste		1 m3	1 m3	containment basin
Wastewater from GT washing	Washing Water Tank	Waste		7 basins x 0.6 m^3	4 basins x 0.6 m^3	containment basin
Detergents for GT washing	GT Building	Waste		n/a	n/a	containment basin
Detergents for GT washing	Storage Area	Waste		6 m^3	2 m^3	containment basin

Source: IGI Poseidon, 2021

6.5.4 Use of Resources and Environmental Interference during Operation

Use of resources and environmental interference during the Project's operational life, as presented in the following sections, will be reduced as much as is practicably possible. No limitations are expected from the presence of offshore pipelines on the seabed. The offshore pipelines are expected to be partially covered by sediment over time; this natural process (and possible intervention works) will protect the pipes from displacement caused by natural factors and potential entanglement risk caused by human activities. Nearshore pipelines will be buried to 1.50 m of depth to avoid trawling and entanglement of the pipes in fishing gears.

The onshore pipelines will be completely buried and marked. A permanent pipeline protection strip (PPS) will be established.

6.5.4.1 Permanent Land Take

Land will be acquired for permanent Project structures and to allow for operations, maintenance and emergency access throughout the operational life of the Project.

A major criterion of the project design has been that, as far as practicable, permanent infrastructure should be sited on unused land of no particular ecological or cultural value.

Where this has not been possible, effort has still been made to avoid land on which there are dwellings or public infrastructure, or which is of high value as a habitat or for agriculture. In addition, site selection has taken into account access facilities so that the need to upgrade or build new accesses is minimised.

However, according to standards, to ensure the integrity of the pipeline and provide for safety distances to other uses, users and owners of land within the areas defined below will be affected by the following permanent restrictions:

- Pipeline Protection Strip : A permanent pipeline protection strip (PPS) with a width of 8 m will be established (i.e. 4 meters on either side of the centreline). Farming of annual crops and associated shallow ploughing will be allowed, but cultivation of deep rooting system plants such as vineyards, fruit trees, or any other bushes or trees will be restricted. Similarly, no houses and no construction will be allowed. The protection strip will also ensure that access is available for inspection of the pipeline and for pipeline maintenance at any time;
- Safety Zone: Construction of new third party structures along the pipeline will be restricted to a safety zone of 40 m (i.e. 20 m from each side of the centreline). However, it will be possible to re-build greenhouses or irrigation pump houses in this zone following pipeline construction. The preferred route was selected considering the requirement to comply with regulatory provisions

for distances and for meeting specified risk criteria, and distance to settlements also allows sufficient space for future developments of communities neighbouring the pipeline, as far as technically feasible. The detailed safety study will provide the basis for relevant authorities to determine the acceptability of any further future developments in the vicinity of the pipeline; and

- Enlarged Safety Zone: Establishment of new clusters of houses and/or industrial infrastructure will be restricted within a corridor of 400 m (i.e. 200 m to both sides of the centre line). The preferred route was selected considering this constraint, and distance to settlements also allows sufficient space for future developments of communities neighbouring the pipeline.

Table 6-77 summarises the permanent land required by Project components during operation.

Table 6-77 Project Land Take during Operation

Project Component	Permanent Land Take(Total Area) m^2
Pipeline (540 km) EastMed System (PPS)	4,344,480
Main Stations (Compressor Stations and Metering Station, etc.)	490,724
Line Stations (15 BVSs and 7 SS)	127,234
O&Ms	32,000

Source: IGI Poseidon, 2021

6.5.4.2 *Project Workforce during Operation*

Regarding the pipeline, a number of permanent employees for inspection, maintenance and other work will be required, up to about 20 persons. These employees will be based in the O&M bases.

Regarding stations, the workforce during operation is estimated at approximately 25 persons per compressor station.

6.5.4.3 *Fuel and Water Consumption during Operation*

As the compressor stations will be operated with natural gas, no fuel consumption is expected during the operation phase.

After taking into account the Project workforce during operation, the estimated water consumption for domestic use is 210 l/d whilst the estimated grey water would be 50 m^3/yr.

6.5.4.4 *Solid Waste*

During operation, the pipeline itself has no solid waste generating activities.

Waste from the stations is estimated to be around 2000 kg per year.

6.5.4.5 *Air Emissions*

The significant air emission sources are the gas turbine stacks at the compressor stations. Additional secondary sources of emissions can be considered negligible, and are limited to the following: emissions from heating, auxiliary power generation, and the diesel generator, to be operated only for electrical power supply in cases of emergency. For normal operation[13] the maximum concentrations in the flue gas from the gas turbines will be < 50 mg/Nm³[14] for nitrogen oxides (NO_X expressed as NO_2). This low value is achieved due to the installation of dry low-NO_X burners. Based on the maximum value guaranteed by the gas supplier, sulphur content in the gas, and thus the gas turbine fuel, is low, and the concentration of emitted SO_2 will be below 5 mg/Nm³.

Air emissions that will be generated continuously during the operation of compressor stations result from the gas turbine of each compressor unit and are emitted through their exhaust stack. Location of these gas turbines is presented in section

Air emissions characteristics are presented in detail in the Impact Assessment chapter (Chapter 9).

6.5.4.6 *Noise*

Based on applicable legislation (PD 1180/1981), noise limits at the fence line of a facility are determined based on the dominant characteristics of the areas land use (seeTable 6-78).

Table 6-78 Allowable Noise Levels According to P.D. 1180/1981 (HGG A' 293/1981).

Area's Description	Maximum Allowable Noise Level (dBA)
Statutory Industrial Areas	70
Areas where industrial characteristics are dominant	65
Areas where industrial and urban characteristics are equally present	55
Areas where urban characteristics are dominant	50

Source: IGI Poseidon, 2021

6.5.4.7 *Liquid and Solid Waste Generation, Handling and Disposal*

Solid waste during the operation phase is produced mainly from compressor stations The following table presenst the solid waste categorisation.

[13]Normal operation means a load range between 70 % and 100 % of system capacity

[14]Nm³ stands for "normalized cubic meters," which means that the volume referenced to is at a temperature of 273º K and a pressure of 101,3 kPa

Table 6-79 Solid Waste Categorisation from Compressor Stations

EWC Code	Waste Type	Quantity tn/a	Management
16 0601*	Lead batteries	0.3	Disposed of by licenced companies
17 04 05	Iron and steel	6	Recycling
15 01 06	Mixed packaging	1.5	Recycling
17 02 03	Plastic	0.03	Recycling
17 02 02	Glass	0.03	Recycling
20 03 01	Mixed municipal waste	510	Collection by the competent authority
13 02 08*	Other engine, gear and lubricating oils	12	Disposed of by licenced companies
20 01 28	Paint, inks, adhesives and resins other than those mentioned in 20 01 2	0.3	Disposed of by licenced companies
15 02 02*	Absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	0.6	Disposed of by licenced companies
16 03 05	Organic wastes containing dangerous substances	3	Disposed of by licenced companies
15 01 09*	Textile packaging	18	Disposed of by licenced companies
16 02 16	Components removed from discarded equipment other than those mentioned in 16 02 15	1500 items	Recycling

Source: IGI Poseidon, 2021

6.6 Decommissioning Phase

The expected service lifetime of the pipelines is 50 years. It may be possible that life expectancy of the Project is increased as technology further develops during its operation. Nevertheless, it is expected that at some point the pipelines and the facilities will be decommissioned.

Any decommissioning activities will be subject to permitting requirements applicable at that time and subject to consultation with affected owners and stakeholders of affected properties and structures. A plan covering all relevant items will be prepared and approved before any decommissioning works.

The plan will also include an assessment of the environmental impacts of the proposed decommissioning technique and proper mitigation measures.

The Project is designed for a lifetime of up to 50 years. Project components may be modified and upgraded over the years, and various measures may be taken to increase the life expectancy of the Project. However, at some time in the future, the maintenance of the Project will become economically unfavourable and the technology obsolete; consequently, the Project will be demobilised.

The plant and equipment will be dismantled or cut into manageable sections, wiring and electronic boxes removed and handled in accordance with national legislation. Steel sections will be carted away for reuse or reprocessing. Building structures, including pits and culverts, and paved surfaces on the site are demolished, and the used building materials are transported to an approved waste disposal site if they cannot be recycled.

Finally, the area is reinstated by contouring the site to its original slope and undulation, and any scrub and vegetation are planted. The reinstatement will be planned and drafted in co-operation with the relevant authorities, whose approval shall be in hand prior to commencement of any fieldwork. A few years thereafter, the site should appear to be mingling in with the general landscape, and any traces from Project operations would not be detectable.

More specifically, a detailed plan for the decommissioning phase will be submitted to competent authorities for approval in advance of the planned date of end of operation activities, providing details of all necessary activities, in compliance with international best available dismantling practices and technologies available at the time of the execution of the plan.

The current approach foresees that the decommissioning procedure will consist of removal of the pipeline. In specific sections where the removal operation would not be technically feasible or would cause a more adverse impact on the natural or socioeconomic environment than the abandonment underground, the pipeline will be left buried (e.g. OSS4 or other sections of the onshore components of the Project). Nevertheless, regarding the offshore sections, it is expected that at some point the offshore pipeline should be decommissioned. At that point activities will be undertaken in accordance with prevailing legislation, in liaison with the relevant regulatory authorities and taking into account international best practices. This can be expected, for instance, in trenchless crossing sections. In these cases, the section will be made inert by filling up the pipe with appropriate concrete conglomerates or benthonic mixtures (in order to prevent collapse of empty pipeline), provided that the section is welded with caps.

Pipeline decommissioning, like the commissioning of a new pipeline, will be performed through a number of sequential phases that will allow occupation of limited areas at a time, progressively forwarding through the route. The impacts are expected to be similar to the ones evaluated for the construction phase (in a reverse chronological order).

In line with the principles concerning the permanent above-ground facilities, the decommissioning procedure will consist of removal of the structures and reinstatement of the area in a reasonable time frame in order to the return to the previous conditions of the area where this is possible. Of course, the first priority is to reuse materials; some components, though, cannot be reused and they are recycled to the extent possible. Other components are managed as excavation, demolition, construction waste.

6.7 Non Routine Events and Environmental Risks

6.7.1 Non Routine Events Identification

A preliminary risk assessment of the EastMed pipeline route was performed in order to verify pipeline safety.

The preliminary assessment determined that the route was feasible with respect to safety of the pipeline and the nearby population. Furthermore, the most populated sections identified are relatively short, enabling efficient technical risk mitigation to be applied where needed or required (see Chapter 7 Alternative Assessment).

A detailed safety analysis, including quantitative risk analysis (QRA) will be undertaken in the subsequent design phases and will also be part of the licensing processes.

The design has been subjected to rigorous hazard identification (HAZID) studies and hazard and operability (HAZOP) assessments. The findings have been addressed in the design and operational planning.

Without limitation, independent emergency shutdown (ESD) and fire and gas (F&G) systems are provided. Station outlets are equipped with high integrity pressure protection systems (HIPPS) to protect downstream systems.

Detailed emergency response plans shall be part of the operational procedures for the Project.

6.7.2 Safety Measures

The main hazard on the compressor station facilities is the hazard of natural gas in the process equipment. Natural gas, when released from high pressure sources, can result in large gas release that, when ignited, will cause large jet fires or fireballs / explosions (immediate or delayed ignition). Gas releases inside buildings (e.g. compressor buildings) represent a risk of explosion when ignited.

The overall strategy for protection against fire and explosions is to evacuate personnel (when present, the site is normally unstaffed) on site to a safe haven and to prevent further escalation by detection, isolation, blow-down, and active and passive fire/explosion protection.

The active firefighting activities for fire protection on the plant site will be safe for the personnel.. Where active firefighting outside the plant site may be applicable, external fire brigade services will be used. The integrated strategy for protection against fire and explosion consists of the following key aspects:

- The most effective manner to mitigate a release of high pressure gas and (when the release is ignited) jet fires is isolation of the leak and removal of the flammable gas as quickly as possible by rapid depressurisation (blowdown) and remove or limit all possible ignition sources (electrical isolation and explosion proof equipment / Ex-zoning);
- In order to ensure a rapid initiation of the isolation and blowdown provisions after the occurrence of the release, suitable systems for detection of gas clouds and fires will be provided;
- In the period between the initial release followed by ignition (immediate or delayed) and the actual completion of the depressurisation of the isolated section in which the leak occurs, personnel and assets can be affected by the effects of a fire or explosion. Provisions for protection of personnel and assets will be selected on the basis of both effectiveness and suitability; and
- For small incipient fires in and near buildings and near equipment, manual firefighting equipment will be provided at strategic locations.

Provisions for active fire protection are:

- In electrical rooms and in compressor, turbine and diesel generator enclosures, automatic gaseous (CO_2) extinguishing systems will be provided (asset protection);
- Firefighting activities using active fire protection systems on site for fires other than gas fires will only be executed by emergency services such a fire brigade when possible. The necessary firefighting equipment on site will be provided according to requirements of local fire brigade;
- Protection of safety critical equipment against gas fires or explosions will be achieved by passive fire and explosion protection, either by physical distance between source and target, by physical barriers such as fire or blast resistant walls, or by protective coating on equipment. These provisions will also be applied to prevent escalation of the fire or explosion to other main process equipment (subject to asset protection philosophy);

- In any emergency situation of gas release or fire, provisions for proper escape (escape routes, signs, lighting, etc.) will be available for persons on site for a reasonable period in which escape to a safe haven (e.g. assigned muster area) is achieved;
- Safety distances are recommended for the purpose of the plot layout development for the Greece compression and metering station;
- These recommended safety distances serve as a guideline in the plot layout development of the plant. Any deviations from the recommended distances are still accepted if the escalation risks are assessed and proper additional measures (e.g. passive fire protection) are taken to prevent escalation.

6.7.3 Geohazards Register

6.7.3.1 General

Geohazards are defined as features of the natural environment that represent a threat to the integrity of pipeline systems, and especially submarine ones. Such features include faults, unstable slopes, landslides, debris, submarine channels, and turbidity flows. In most cases the risk posed by such features is eliminated simply by (re)routing. Geohazards may include:

- Slope stability and mass movements;
- Faults;
- Hydrodynamic effects (sediment mobility and scouring);
- Tsunami effects;
- Earthquake induced liquefaction and spreading; and
- Pockmarks and gas expulsion activity.

The most significant geohazards in the entire eastern Mediterranean are related to geological processes associated with plate boundaries and to active faulting or slope failure resulting in submarine landslides. These may include:

- Strong ground motions – The EastMed project is located in a highly seismic active area due to migration of the African, Eurasian, Anatolian, and Arabian plates. In general, strong ground motions due to earthquakes do not necessarily cause damage to the pipeline, but may result in phenomena that affect pipeline integrity. As such, it is a trigger mechanism. Phenomena that could be triggered are slope instabilities and associated landslides along areas of strong relief, liquefaction in nearshore sections, and tsunamis;
- Faults – Crossing active faults could cause hazards to the pipeline as the pipeline may be exposed to earthquake-induced ground deformations;

- Slope stability and mass gravity flows – These represent two hazards: i) loss of foundation support and ii) impact from runout debris and/or turbidity currents against pipelines or structures located downslope from the failure;
- Shallow gas and pockmarks – Shallow gas in the soil profile can produce anomalous geotechnical properties, such as reduction of strength and increased compressibility. Pockmarks are conical depressions in the seabed formed by fluid or gas expulsion. The main hazard associated with these features includes expulsion of corrosive fluids and slope instability, but they can also be associated with routing constraints as a consequence of free spans and bottom roughness;
- Bottom current and hydrodynamic effects – These phenomena are mainly present in the Levantine Basin. Such irregularities may locally cause flow acceleration and scouring or other minor erosive processes and mass transport processes;
- Uneven seafloor – Anomalous seabed conditions represent highly variable engineering properties and geohazards relating to bottom roughness and spanning issues for pipelines; and
- Shallow Geotechnical Conditions – The presence of outcrops or sub-outcropping of hardground, as well as sandy layers prone to liquefaction under cyclic loading in shallow water, poses a risk to pipeline integrity.

The above findings should be seen as a preliminary listing. Geohazard risk assessment will be performed based on Detailed Marine Survey data. The following equipment is being used to execute the Detailed Marine Survey:

For water depth from 0-20 m:

- MBES:240 kHz;
- SSS:500 kHz; and
- SBP: Penetration to 10 m or rock head.

For water depth greater than 20 m:

- MBES:200/400 kHz;
- SSS:100 kHz; and
- SBP: Chirp Penetration to 20 m.

However, the Project will be constructed in accordance with applicable European and international regulations to ensure the smooth operation of the system and to minimize the risk of failure. Due to the high level of national, European and international safety standards and modern technology, the transportation of gas today can be considered very safe.

More details are presented at Chapter 8 and Chapter 9.

ANNEX 6A INFOGRAPHIC

ANNEX 6B GENERAL LAYOUT OF LANDFALL STATIONS

ANNEX 6C GENERAL LAYOUT OF BLOCK VALVE STATIONS

ANNEX 6D GENERAL LAYOUT OF SCRAPER STATIONS

ANNEX 6E GENERAL LAYOUT OF COMPRESSOR STATIONS

ANNEX 6F GENERAL LAYOUT OF METERING & PRESSURE REDUCTION STATION MS4/PRS4

ANNEX 6G GENERAL LAYOUT OF DISPATCHING AND O&M CENTER

ANNEX 6H GENERAL LAYOUT OF HEATING STATION

ANNEX 6I GENERAL SECTIONS (PLANS, CROSS SECTIONS, ELEVATIONS)

ANNEX 6J GENERAL DRAWINGS FOR CROSSING TECHNIQUES/ METHODS

ANNEX 6K GENERAL PROCESS FLOW DIAGRAM OF MAIN STATIONS

ANNEX 6L GENERAL BLOCK FLOW DIAGRAM OF MAIN STATIONS

ANNEX 6M SITE PREPARATION WORKS LAYOUT OF COMPRESSOR STATIONS

ANNEX 6N SITE PREPARATION WORKS LAYOUT OF METERING & PRESSURE REDUCTION MS4/PRS4 AND HEATING STATION

ANNEX 6O AVAILABLE WATER SOURCES FOR HYDROTESTING