



## 3.0 CHAPTER C – DESCRIPTION OF ACTIONS STEMMING FROM PERFORMANCE OF THE APPLICATION

### 3.1 General

Noble Energy and its Co-Venturers are developing the offshore Leviathan Field in the Levantine Basin to provide gas to:

- A. The Israeli domestic gas market by tie-in to the Israeli Natural Gas Lines (INGL) infrastructure. Initial capacity for domestic supply will be 1,200 MMscfd; and
- B. Regional gas users by (new) subsea pipelines to regional gas receivers. Capacity for regional supply will be 900 MMscfd.

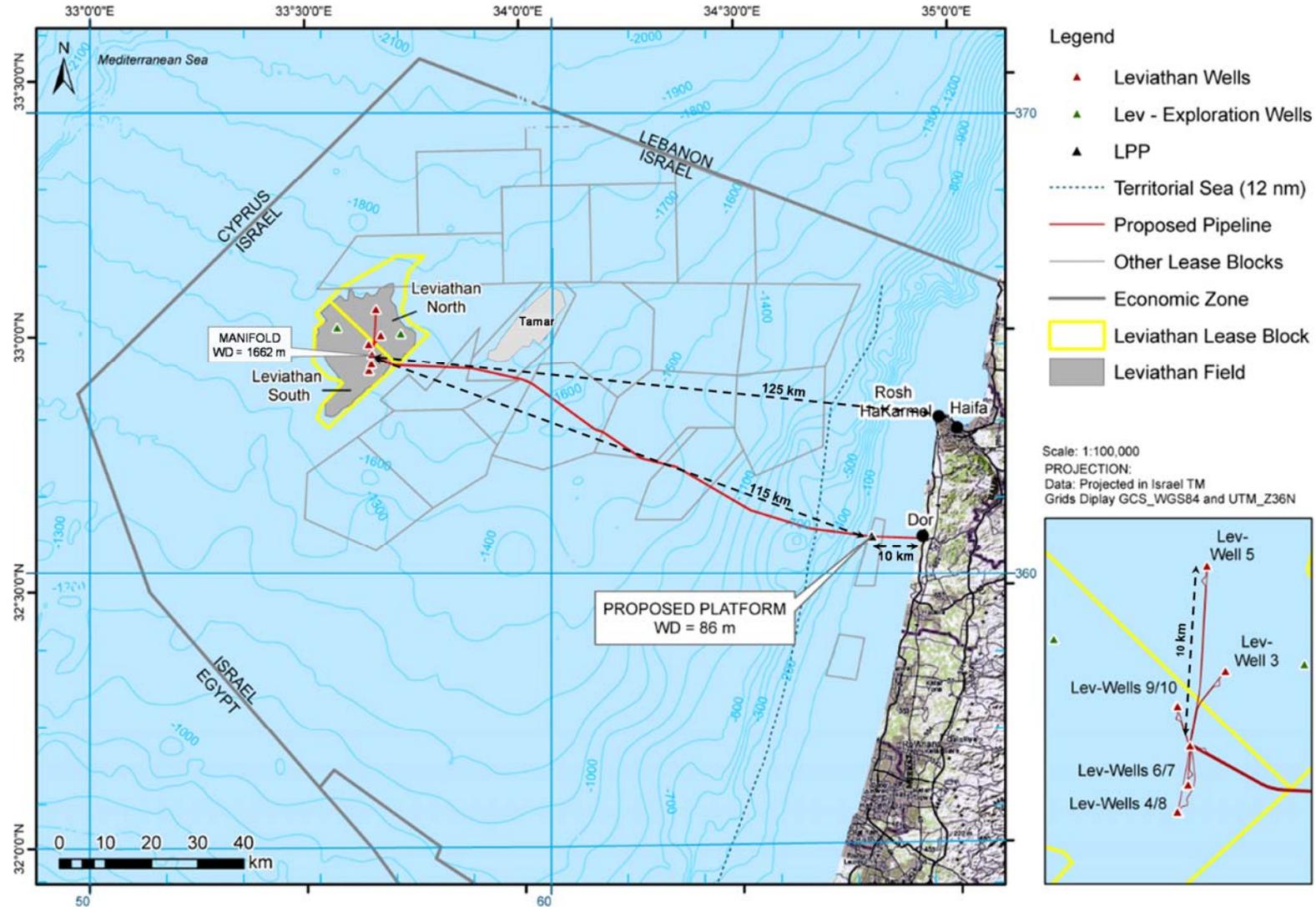
The total nameplate capacity of the Leviathan production system will be 2,100 MMscfd.

The Leviathan Field is located approximately 125 km off the coast of northern Israel in the I/15 Leviathan North and I / 14 Leviathan South leases. Leviathan is located to the west of the producing Tamar Field which is being produced as a subsea tieback to a nearshore platform off the coast of southern Israel. Water depths in the Leviathan area range from 1,540 to 1,800 meters. The location of the Leviathan Field and the proposed infrastructure is provided in Figure 3-1 with straight line distances included between points of interest / reference, these do not necessarily reflect pipeline lengths. Note that only the Leviathan-5 well is shown in this figure as this is the well which lies furthest from the Infield Gathering Manifold (detailed further below). The location of the Tamar Field is included for reference.

This assessment is based on the Leviathan Field Development Plan (FDP) as it exists at the time of preparation of this assessment. Specifics of the FDP may be updated as required as the project progresses through Front End Engineering Design (FEED) and the subsequent Detailed Design phase.



Figure 3-1 Leviathan Field Location in the Eastern Mediterranean





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Development of the Leviathan Field is envisaged as a subsea tieback of approximately 117.5 km to a dedicated LPP located within Israeli territorial waters.

Production wells will be arranged in clusters around a central Infield Gathering Manifold with all initial production wells lying within a 10 km radius of the Infield Gathering Manifold. The LPP will be a fixed platform (steel jacket) with all the necessary receiving, processing and export facilities required to supply gas directly to both the Israeli domestic market, and regional gas importers. The LPP will be approximately 10 km from the nearest Israeli coastline (Dor) and will export gas to the Israeli domestic market by way of a subsea pipeline from the LPP to an onshore tie-in point to the Israeli Natural Gas Line (INGL) system (at Dor). The tie-in point for connection to the INGL system lies approximately 1.5 km from the shore crossing location, with up to 2 km of onshore pipeline between the Coastal Valve Station (CVS) at the shore crossing, and the INGL tie-in point.

The subsea tieback concept has previously been proven through the development of the nearby Tamar Field which features a 150 km multiphase production system tied-back to a fixed platform off the coast of Ashdod. A schematic of the proposed development of the Leviathan Field is shown in Figure 3-2.





Production from the Leviathan Field will be through high-rate subsea wells into a subsea production infrastructure that will transport the production fluids to the shallow water LPP where the gas will be processed. Processed gas for the Israeli Natural Gas Lines (INGL) will be exported by a 32" pipeline to an onshore tie-in valve station at Dor. Gas for regional export will be compressed on the LPP and exported via dedicated pipelines which are yet to be defined.

Gas condensates (co-produced with Leviathan gas) will be stabilized on the LPP and exported by a dedicated pipeline to shore which is the preferred route to market at this stage. Markets for Leviathan condensate include the Bazan operated refinery in Haifa.

The Project will develop the Leviathan Field through parallel infrastructure for domestic supply and regional export. Gas for domestic supply will be routed from the subsea wells via infield flowlines to an Infield Gathering Manifold where it will be directed into two (2) 18" 117.5 km production pipelines to the LPP in Israeli territorial waters. At the LPP gas for the domestic market will be processed through the Domestic Supply Module (DSM) and ultimately exported to the onshore INGL tie-in.

Gas for regional export will be produced through the same infield subsea infrastructure utilized for domestic gas production, however at the Infield Gathering Manifold gas for regional export will be routed through a single 117.5 km 20" production pipeline to the LPP. At the LPP, gas for regional export will be processed through the Regional Export Module (REM) and ultimately routed to regional consumers through dedicated subsea pipelines.

The LPP will be a manned facility with all processing and utility functions required to:

- Process the Leviathan gas to either domestic or regional supply specifications;
- Provide production chemicals and controls to the infield infrastructure; and
- Support a total crew of up to 140 Persons On Board (POB).

Cross connections will be in place on the LPP to enable gas processed through either of the production modules to be routed to any available sales route.

The FDP calls for up to eight (8) production wells to be in place for first gas to supply gas to both the Domestic Supply and Regional Export Modules. These initial wells will serve to further increase understanding of the Leviathan reservoir and will guide the drilling and placement of future infill wells to maximize ultimate recovery from the field. Current reservoir modelling indicates that up to 29 wells [including the initial eight (8)] will be required to fully produce the field.

This document covers all infrastructure required to produce the initial eight (8) wells and route production to the LPP. Consideration to future wells will be limited to briefly describing how they may be tied into the production system at a later date.

The scope of this assessment is any infrastructure associated with the production of the Leviathan Field that lies upstream of the LPP risers. This covers all infield and transmission infrastructure up to, and including their tie-in points at the LPP riser bases. Note that drilling and tree installation is not within the scope of this document and has previously been assessed in the Environmental



Impact Report for Production Drilling, Production Tests and Completion on the Leviathan Field (Noble Energy Mediterranean Ltd, 2016a).

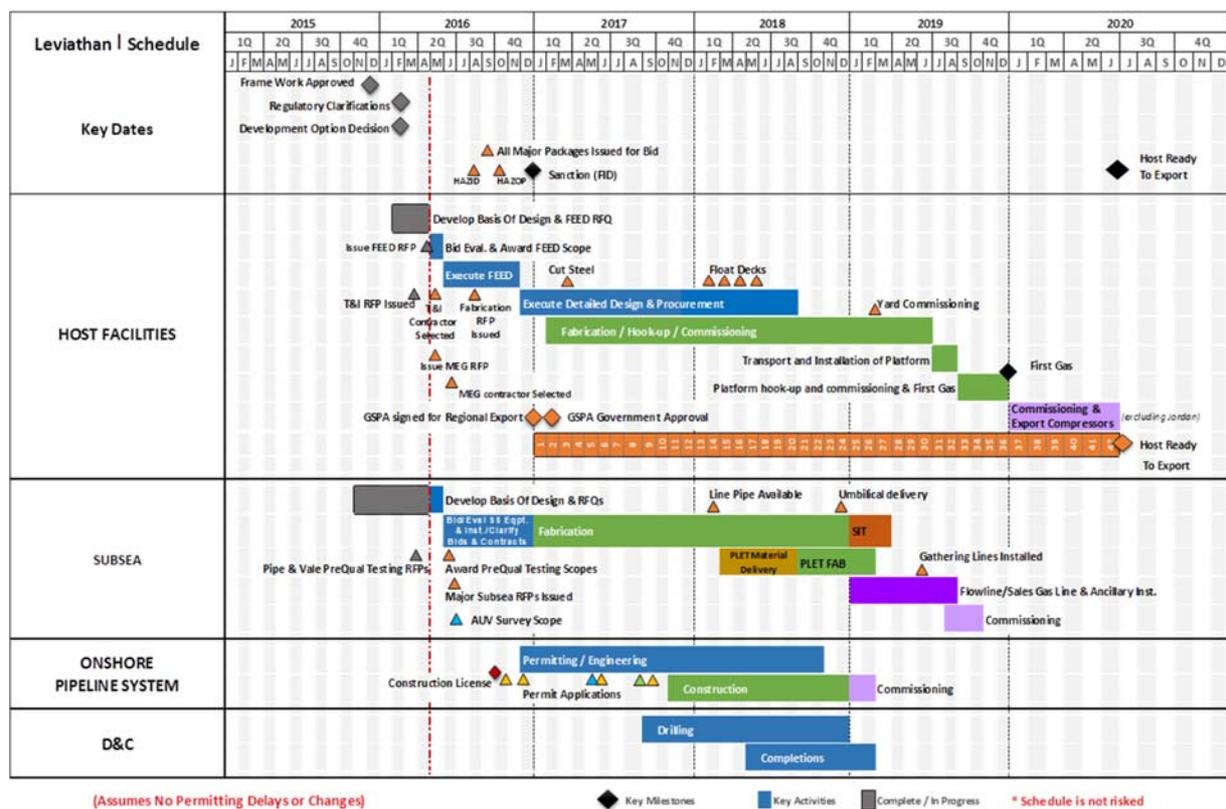
The Leviathan Field development is planned for 30 years. Future facility modifications are beyond the scope of this document.

The sections that follow will provide a detailed description of the infrastructure, which falls within the scope of this assessment.

### Project Schedule

The FDP for the Leviathan Field is targeting first gas for domestic supply at the end of 2019. Regional export from the LPP is targeted to be available by July 2020. The overall development schedule is shown in Figure 3-3 and indicates that installation of submarine infrastructure will occur between Q1 2018 and Q3 2019.

Figure 3-3: Leviathan Development Schedule





### 3.2 Description of the Application

This section considers all Leviathan Production facilities which exist in the Application area and describes the development through its' Project stages from installation to operations.

#### 3.2.1 General

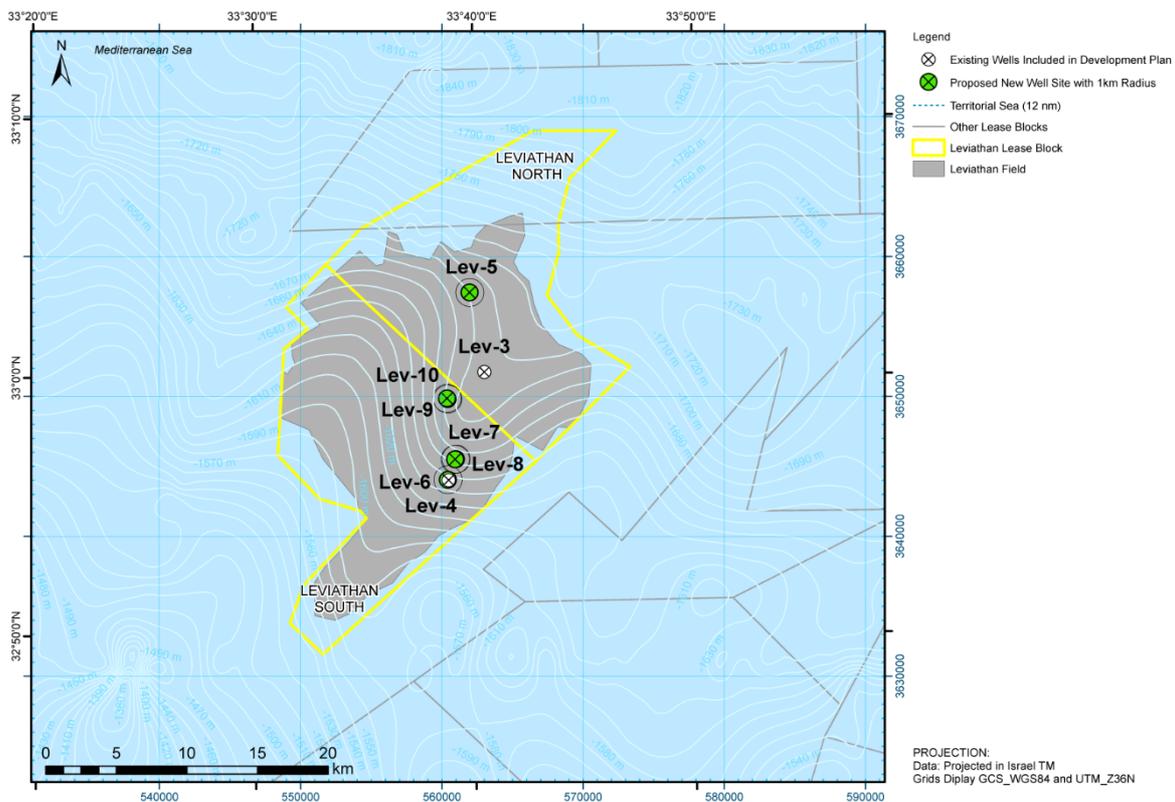
##### Development Wells, Wellheads and Xmas Trees

Due to the water depth at the Leviathan Field all wells will be drilled from dynamically positioned drilling vessels and completed as subsea wells with wellheads and Xmas trees installed on the seabed.

The plan for development calls for up to eight (8) wells at first gas, broadly arranged across the Leviathan Field into two (2) clusters [one (1) north and one (1) south] with a satellite well (Leviathan-5) located towards the northern limit of the field. The first eight (8) production wells on the Leviathan Field are to be numbered as Leviathan-3 through to Leviathan-10, Leviathan-1 and Leviathan-2 were exploration wells and will not be re-used for development. Details of the drilling process and well design are available in the Leviathan Drilling EIA (Noble Energy Mediterranean Ltd, 2016a).

The locations of Leviathan-3 through to Leviathan-10 are shown in Figure 3-4.

**Figure 3-4: Map of Leviathan Production Wells for First Gas**





Following the initial production phase, additional development wells will be drilled into the Leviathan Field to maintain production and optimize reserve recovery. The final requirement, timing, and placement of future wells will be determined by the reservoir performance observed during the initial production phase. Preliminary reservoir simulations indicate that up to 21 additional wells will be required.

### **Wellhead and Xmas Tree Installation**

Installation of wellheads and trees form part of the drilling process and as such this activity is not within the scope of this assessment. The reader is referred to the Leviathan Drilling EIA for further information (Noble Energy Mediterranean Ltd, 2016a).

Commissioning of Xmas tree mounted valves is included under pre-commissioning and commissioning activities of the infield controls system (Section 3.2.1.3).

### **Infield Facilities, Installation, Tie-in, Pre-Commissioning & Commissioning**

The development of the Leviathan Field will utilize subsea infrastructure to produce and gather reservoir fluids prior to their transmission to the shallow water LPP. Additional infield structures and umbilicals will be required to provide services and controls to the production facilities.

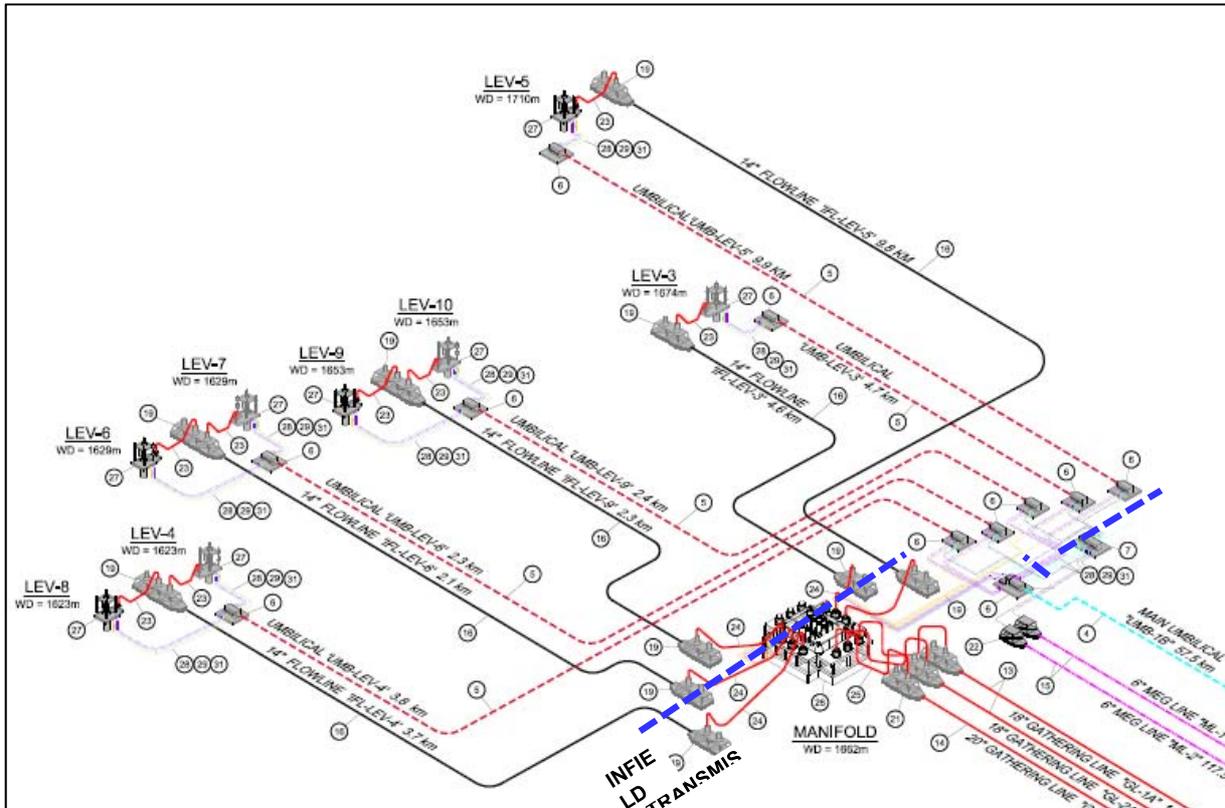
The infield infrastructure required for development of the Leviathan Field through the initial eight (8) wells includes the following elements:

- Infield production flowlines from wellheads to tie-in location;
- Infield tie-in jumpers;
- A single three header six (6) slot Infield Gathering Manifold;
- Infield SDU for distribution of MEG to the infield umbilicals; and
- Infield umbilicals, Umbilical Termination Assemblies (UTAs) and flying leads.

Note that the Subsea Distribution Unit associated with the primary umbilical from the LPP to the field is included within the transmission facilities (Section 3.2.2).

The infield infrastructure to be in place for first gas is shown in Figure 3-5.

Figure 3-5: Infield Production Infrastructure Schematic



The anticipated installation, tie-in, pre-commissioning, and commissioning activities associated with the infield subsea infrastructure are detailed in the subsequent sections.

### Pre-Installation Survey

Geophysical and Hazard Surveys have previously been carried out at the Leviathan Field in order to obtain site-specific engineering data on the infield area. Although this data was collected prior to the selection of the nearshore LPP development concept, it covers the entirety of the Leviathan Field.

The existing pre-installation survey consisted of a Bathymetric Survey, a Side Scan Sonar Survey and sediment sampling across the field’s areal extent. The aim of the survey was to identify geological conditions, seafloor and shallow hazards, existing pipelines and cables, and bathymetric information, which could be used during the design and installation of subsea infrastructure. Aside from that associated with the Leviathan Field exploration and appraisal wells, the only infrastructure in the infield area is the MED NAUTILUS telecommunication cables.

The Leviathan Field is located in an area where seabed faulting and active draining channels are present. Where possible infield flowlines will be routed to avoid crossing faults and channels, however where this is not possible, engineered crossings will be designed as appropriate.



### 3.2.1.1 Support Vessels

Finalized installation, tie-in and commissioning plans, and associated schedules will be developed by the Engineering Procurement and Construction (EPC) contractor following contract award. However, the activities associated with infield construction operations are anticipated to require the following marine vessels:

- DP Pipelay Vessel (e.g., Allseas Solitaire);
- Pipe Supply Vessel - to transport pipe sections between the in-country storage site and the Pipelay vessel;
- OCV (e.g. BOA Sub C) - to install subsea structures, umbilicals and tie-in jumpers;
- MSV with ROV capability (e.g. Siem Stingray) - to support pipeline and structure installation, and perform commissioning activities; and
- Standby and Supply vessels.

In addition, weekly crew transfers for the pipelay vessel are expected to be performed by helicopter, nominally a Sikorsky-61N.

Table 3-1 provides an estimate of vessel use during the infield installation, tie-in, pre-commissioning and commissioning activities associated with the Leviathan Field development. This is based on the installation campaign further in the following sections. Vessel fuel use is estimated based on typical vessels available within each category and is assumed to be marine diesel for vessels and Jet A for helicopters.

Assumptions relating to vessel durations and fuel use are provided in Appendix D.



**Table 3-1 Vessel Use for Infield Facilities Installation, Pre-Commissioning and Commissioning**

Vessel	Nº of vessels	Working period (days)	Schedule Activity	Fuel Consumption (Te / day)	Total Fuel Use (Te)
DP Pipelay Vessel	1	18	1	130	2,340
Pipe Supply Vessel	1	18	1	15	270
Offshore Construction Vessel	1	60	2,3,4	51	3060
Multipurpose Support Vessel with ROV	1	84	All	26	2184
Standby vessel	1	84	All	2.4	201.6
Supply vessel <sup>Note 1</sup>	2	84	All	12	1008
Helicopter	1	5 hrs	1	0.40 Te / hr	2.0
<b>Total</b>					<b>9065.6</b>
<p><b>Schedule Activity:</b>                      Activity 1: Flowline and Infield PLET Installation (18 Days)                      Activity 2: Gathering Manifold and Pile Installation (3 Days)                      Activity 3: Infield Umbilical and Controls Structure Installation (13 Days)                      Activity 4: Flowline and Umbilical Tie-ins (44 Days)                      Activity 5: Production System Pre-Commissioning and Commissioning (6 Days)                      Activity 6: Controls Pre-Commissioning and Commissioning (Performed as part of overall controls commissioning)</p> <p><b>Notes:</b>                      Note 1: Two (2) supply vessels are assumed based on there always being one (1) vessel in transit.</p>					

### 3.2.1.2 Infield Infrastructure and Installation

#### Infield Production Flowlines

Infield production flowlines will link the subsea wellheads to the Infield Gathering Manifold. For the initial eight (8) production wells, flowlines will run directly from the subsea wellhead(s) to the Infield Gathering Manifold. Future wells will be tied into the subsea production system by daisy chaining new flowlines into the infrastructure in place for first gas, through spare tie-in points on the infield flowline Pipeline End Terminations (PLETs – see below). This is required in order to enable the tie in of up to 29 development wells into the single six (6) slot Infield Gathering Manifold.

Flowlines will be of 14” diameter and of rigid construction. The total flowline length for the initial eight (8) development wells will be 22.5 km, with the longest individual flowline measuring 9.8 km.



Each flowline will feature a PLET at each end. PLETs will facilitate the installation of tie-in jumpers to connect the flowline to the subsea wellhead(s) at one end, and the Infield Gathering Manifold at the other.

All infield PLETs (upstream of the Infield Gathering Manifold) will be designed with a spare tie-in slot to enable future flowlines/ wells to be tied into the initial infrastructure. Infield PLETs will be relatively lightweight structures and as such will be installed on mudmat foundations.

The estimated land-take attributable to flowlines and infield PLETs is provided in Table 3-2, based on the calculation provided in Appendix C.1.

**Table 3-2: Infield Flowline and PLET Land Take**

Description	Location	Wells Tied-in	Land Take (m <sup>2</sup> )
Flowlines (22.5 km) <sup>Note 1</sup>	Distributed	All	8,001
PLET - Single	Infield Gathering Manifold	Lev-3	90
PLET - Single	Infield Gathering Manifold	Lev-4 / Lev-8	90
PLET - Single	Infield Gathering Manifold	Lev-5	90
PLET - Single	Infield Gathering Manifold	Lev-6 / Lev-7	90
PLET - Single	Infield Gathering Manifold	Lev-9 / Lev-10	90
PLET - Single	Lev-3	Lev-3	90
PLET - Single	Lev-5	Lev-5	90
PLET - Twin	Lev-4 / Lev-8	Lev-4 / Lev-8	120
PLET - Twin	Lev-6 / Lev-7	Lev-6 / Lev-7	120
PLET - Twin	Lev-9 / Lev-10	Lev-9 / Lev-10	120
<b>Total</b>			<b>8,991</b>

Notes: 1. Flowline land take is based on the full 14" diameter of flowlines giving a land take per unit of 0.36 m<sup>2</sup> / m.

Infield flowline pipe will be fabricated in sections (typically 12 m) at an out of country fabrication yard and shipped to in-country port facilities for storage until they are required at the infield location. Flowline sections will be transported from the in-country storage location to the Pipelay Vessel by supply vessels fitted with pedestal cranes.

Flowlines will be installed dry on the seabed by a Dynamically Positioned (DP) Pipelay Vessel (discussed further under Section 3.2.2), which is expected to achieve an average lay rate of three (3) km / day. Due to the water depth (>1,600 m) no trenching or burial of infield lines is required. Further, the benign hydrodynamic conditions at the field will allow the flowlines and PLETs to rest on the seabed due to weight alone, with no additional anchoring required.



Pipeline may be by either the J-lay or the S-lay method subject to EPC contractor selection; selection of either method is not expected to significantly alter the environmental impact of flowline installation operations.

### **Infield Tie-in Jumpers**

Infield tie-in jumpers (here in referred to as jumpers) will connect the subsea production structures (subsea wellheads and Infield Gathering Manifold) to their respective PLETs on the infield flowlines. All jumpers will be of rigid steel pipe construction.

Due to the project water depth all jumpers will be designed for diverless connection with ROV support. During installation, jumpers will be allowed to free flood with seawater. Following installation, the jumpers will be flushed with MEG to displace seawater and protect the internal surfaces from seawater corrosion and biogenic growth. MEG discharge during flushing operations is discussed further below.

An OCV will be used for jumper installation. An example of an OCV being considered for this project is the BOA Sub C. Installation will be supported by the use of ROVs and an associated support vessel, which is expected to be of an MSV design, equipped for ROV deployment and recovery. An example of such a vessel is the Siem Stingray as shown in Figure 3-6.

**Figure 3-6: Siem Stingray – ROV / Multipurpose Support Vessel**





Jumpers will be fabricated at a location within Israel and subsequently transported to the infield location by either cargo barge, supply vessel or on the deck space of the OCV used to install them.

Due to the project water depth and benign seabed conditions, jumper protection (in the form of concrete mattresses) or mid-point anchoring is not required and as such will not be used.

### **Infield Gathering Manifold**

The Infield Gathering Manifold will be a six (6) slot manifold with three (3) production headers of 16" nominal diameter. Actuated valves on the manifold will allow any of the six (6) slots to be routed to any production header, thus allowing the operations team to alter the distribution of gas routed to the domestic supply and regional export production pipelines without the need for ROV intervention.

The Infield Gathering Manifold will have approximate dimensions of 10 m by 20 m (W x L) with a total area in the region of 200 m<sup>2</sup>. The dry weight of the complete structure is expected to be in the region of 350 Te and will thus necessitate a piled foundation. It is intended to install the Infield Gathering Manifold on a single six (6) m diameter suction pile; suction piling is preferred at this water depth due to ease of installation when compared to driven piles. The use of a single suction pile has the added benefit of reducing the total land take associated with the gathering manifold, as the manifold itself will not sit on the seabed. As such the land take attributable to the Infield Gathering Manifold is limited to that of the six (6) m diameter suction pile (28 m<sup>2</sup>).

The Infield Gathering Manifold and associated suction pile will be installed from an OCV using the main crane facilities. Due to the manifold weight, installation is expected to require multiple offshore lifts to ensure total lift weight does not exceed crane capacity. A total of three (3) lifts are considered in this assessment based on:

- Lift 1: Suction Pile Installation;
- Lift 2: Manifold Support Structure Installation; and
- Lift 3: Manifold Installation.

It is possible that fewer lifts will be required however this will be determined following installation contractor selection.

The Infield Gathering Manifold will be fabricated at an out of country fabrication yard and shipped to in-country port facilities for storage. It is expected that it will be transported to site on the deck of the OCV from which it will ultimately be installed from. In addition to the OCV, ROVs and associated supports vessel will be required during the installation.

An alternative to transport to site on the OCV is transportation by towed cargo barge. This decision will be made during the EPC Engineering phase but is not considered to materially impact the environmental impact of the project.



### Infield Subsea Distribution Unit – MEG

An infield SDU will be installed local to the Infield Gathering Manifold for the purpose of receiving and distributing MEG from the 6” MEG supply lines (two (2) of) to the infield umbilicals.

The SDU will be installed onto a mudmat foundation and secured in place by its submerged weight with no piling required. The land take associated with the SDU and its mudmat foundation is estimated at 97 m<sup>2</sup>. Installation will be from an OCV that will already be in the field for the purpose of umbilical and structures installation. Operational support will be required from ROVs and an MSV.

### Infield Umbilicals and Flying Leads

Hydraulic and electrical flying leads will transmit controls signals, MEG, and chemicals from the SDUs (one (1) by MEG SDU and one (1) by controls SDU) located close to the Infield Gathering Manifold to the infield UTAs. From the UTAs these will be further routed to the subsea wellheads via the Infield Umbilicals. This will enable hydraulic actuation of Xmas tree mounted valves and chemical injection into the production fluids.

Additional hydraulic and electrical flying leads will connect the Infield Gathering Manifold to the SDUs to enable control and monitoring of manifold mounted valves.

Infield umbilicals will be multi-cored electrohydraulic systems with a total of six (6) electrical power cores and 14 super-duplex stainless steel tubes for conveying hydraulic fluids and chemicals. All cores and tubes will be bundled into a single infield umbilical with a high density polyethylene protective outer coating giving an approximate outer diameter of 7.2” (180 mm). A detailed list of infield umbilical cores is provided in Table 3-3.

**Table 3-3: Infield Umbilical Cores**

Core N°	Service	Size (ID)	Notes <sup>1</sup>
1-6	6x Power Supply	6x 6 mm <sup>2</sup>	Shielded
7-10	4x Hydraulics	4x ½”	Installed HW540P filled
11	Scale Inhibitor	½”	Installed SST5007 filled
12-15	Auxiliary, Annulus and Methanol	4x 1”	Installed SST5007 filled
16-18	3x MEG + (CI) supply	3x 1¼”	Installed SST5007 filled
19	Spare 1	1¼”	Installed SST5007 filled
20	Spare 2	1”	Installed SST5007 filled

Notes: 1. Where reference is made to cores being installed either HW540P or SST5007 filled, this refers to the specific chemicals “Macdermid Oceanic HW540P” and “MacDermid Oceanic SST5007” respectively. Final chemical selection will be made by the EPC contractor.

All infield umbilicals will feature UTAs at each end to enable tie-in (by flying leads) to the relevant structures. A total of 10 UTAs will be installed infield, with each one installed on a 21.7 m<sup>2</sup> mudmat foundation with no requirement for additional anchoring in the form of piles. This gives a total land take for infield UTAs of 217 m<sup>2</sup>.



The total length of infield umbilicals required for the initial eight (8) production wells is approximately 22.8 km. Based on a 180 mm diameter the total land take for the infield umbilicals is estimated at 4,152 m<sup>2</sup>. When considered with the UTA land take, this gives a total land take attributable to infield umbilicals of 4,369 m<sup>2</sup>.

All infield umbilicals will be laid directly onto the seabed from an OCV equipped for flexible lay operations. Prior to installation all hydraulic fluid lines will be filled with MacDermid Oceanic HW540P which is the selected hydraulic fluid for the Leviathan development. This will act to protect hydraulic cores during installation and minimizes pre-commissioning activities associated with these cores. Further, all chemical and service cores will be filled with MacDermid Oceanic SST5007 prior to installation to a) protect them during installation, b) prevent microbial infection, and c) provide a test fluid for future pre-commissioning activities. Both MacDermid Oceanic HW540P and MacDermid Oceanic SST5007 are water based fluids.

The Material Safety Data Sheet (MSDS) for MacDermid Oceanic HW540P and MacDermid Oceanic SST5007 are provided in Appendix C.2.

Infield umbilical installation operations will be supported by ROVs and an associated MSV. Future infill wells will require additional infield umbilicals and UTAs of a similar design to those discussed above.

### **Pre-Commissioning and Commissioning**

Following installation, the infield infrastructure will require pre-commissioning and commissioning prior to first gas. It should be noted that all infield infrastructure (excluding wells) will be commissioned after the transmission facilities (see Section 3.2.2) and as such nitrogen for commissioning of the infield flowlines will be available from the packed production pipelines.

Pre-commissioning and commissioning activities typically include:

- Pre-commissioning: Flooding, Cleaning, Gauging and Hydrotesting; and
- Commissioning: Dewatering and Drying.

Pre-commissioning and commissioning activities specifically required for the Leviathan Field development will be determined during detailed design.

The project schedule provided in Figure 3-3 indicates that subsea facilities will require pre-commissioning and commissioning during H2 2019. This is reliant on the project progressing as currently expected and is subject to change depending on project progress. Further definition of anticipated pre-commissioning and commissioning dates will be determined during the detailed engineering phase of the project.

Preliminary estimates of pre-commissioning and commissioning durations associated with the infield facilities are presented in Section 3.2.1.1.

### **Production System**

The commissioning philosophy for the infield production system is as follows:



- Pre-commission infield flowlines prior to jumper installation by way of subsea pumping, and subsea pig launch and receive at the infield PLETs;
- Following jumper installation, subsea connectors will be leak tested and the jumpers flushed with MEG to displace free flood seawater. This action will complete infield pre-commissioning as all jumpers will be cleaned and hydro-tested prior to installation; and
- Commission (dewater and nitrogen purge) the entire infield production system by routing nitrogen from the nitrogen packed production pipelines through the Infield Gathering Manifold and into the infield flowlines and jumpers.

Pre-commissioning flooding will utilize filtered and chemically treated seawater. Indicative chemicals to be used for this purpose are:

- Roemex RX5227: Combined oxygen scavenger, corrosion inhibitor and biocide – typically dosed at 1,000 ppm; and
- Roemex RX9025: Leak tracer dye – typically dosed at 50 ppm.

Both of these chemicals are classified as Gold chemicals under the OCNS which indicates that they present a relatively low hazard to the environment, final chemical selection will be made during the detailed design phase of the project. For the purpose of this assessment the Roemex chemicals stated above are considered throughout this chapter as typical examples of chemicals that may be used.

As part of the pre-commissioning procedure the infield flowlines will be cleaned through the use of pigs. This will drive various construction and welding residue/ debris from the flowlines and into the subsea pig receivers. This will not be released to the environment, but retrieved to the surface in the pig receivers; this will subsequently be transported to shore and disposed of as appropriate.

Pre-commissioning of the tie-in jumpers will necessitate MEG discharge to the environment to ensure seawater is adequately displaced. The total MEG discharge per jumper is estimated at 10 m<sup>3</sup>. This discharge will occur local to the jumper.

During dewatering and drying of the infield production system the chemically treated seawater used for pre-commissioning activities will be discharged to the marine environment at the wellhead ends of the flowlines. Low volumes of MEG will also be discharged in this operation.

Table 3-4 provides an estimate of the infield releases during pre-commissioning and commissioning operations associated with the tie-in of the initial eight (8) development wells. Future well tie-ins and flowline commissioning will result in incremental discharges of similar fluids.



**Table 3-4: Infield Pre-commissioning and Commissioning Releases**

Pre-commissioning			
Location	Discharge	Volume (m <sup>3</sup> )	Notes
Gathering Manifold	MEG	50	MEG discharge associated with infield jumper displacement. A total of 5jumpers will be displaced at this location.
Wellheads	MEG	80 (10 at each Wellhead)	MEG Discharge associated with jumper displacement. One (1) jumper to be displaced at each well-head.
Commissioning			
Location	Discharge	Volume (m <sup>3</sup> )	Notes
Leviathan 3	Chemically Treated Seawater	440	Displaced hydrotest water containing a cocktail of: a) RX5227 (or equiv.) at 1,000 ppm b) RX9025 (or equiv.) at 50 ppm c) Low volumes of MEG. Final chemical use is subject to confirmation during detailed design.
Leviathan 4 / 8	Chemically Treated Seawater	360	
Leviathan 5	Chemically Treated Seawater	940	
Leviathan 6 / 7	Chemically Treated Seawater	200	
Leviathan 9 / 10	Chemically Treated Seawater	220	

Pre-commissioning and commissioning activities on the infield production system will be supported by ROVs launched and controlled from a surface based MSV.

### 3.2.1.3 Controls Distribution System

Pre-commissioning and commissioning activities for the infield controls system will involve pressure testing of all equipment, displacement of storage fluid and functionality checking. This will be performed in conjunction with the pre-commissioning and commissioning of the primary umbilical that will run from the LPP to the Controls SDU (see section 3.2.2).

Pressure testing will be performed from an MSV or dedicated commissioning vessel located at the LPP end of the primary umbilical. Pressure testing will be performed as per standard hydrotest procedures, however the test fluid will be that present during umbilical installation, either MacDermid Oceanic HW540P or MacDermid Oceanic SST5007, both of which are water based.

Storage fluid displacement and function checking of the infield controls system for the initial eight (8) development wells will be performed as part of the wider controls system commissioning process to be performed from the LPP. During storage fluid displacement, the umbilical storage fluid will be displaced from all non-hydraulic cores other than the two (2) spare cores. Details of the infield umbilical cores to be displaced are provided in Table 3-5.



**Table 3-5: Infield Umbilical Cores for Pre-Commissioning Operations**

Core №	Service	Size (ID)	Notes <sup>1</sup>
11	Scale Inhibitor	½"	Installed SST5007 filled
12	Auxiliary	1"	Installed SST5007 filled
13	Annulus Service Line	1"	Installed SST5007 filled
14	Methanol 1	1"	Installed SST5007 filled
15	Methanol 2	1"	Installed SST5007 filled
16	MEG + CI 1	1¼"	Installed SST5007 filled
17	MEG + CI 2	1¼"	Installed SST5007 filled
18	MEG + CI 3	1¼"	Installed SST5007 filled
19 / 20	Spare cores that will be left SST5007 filled until required		

Notes: 1. Where reference is made to cores being installed SST5007 filled, this refers to the specific chemical "MacDermid Oceanic SST5007". Final chemical selection will be made by the EPC contractor.

Storage fluid from the infield umbilicals will be discharged at the wellhead end of the infield umbilical. An alternative method of storage fluid displacement is to route the fluid into the flowlines and production pipelines for displacement back to the LPP. A decision on the preferred routing of displaced fluid will be made in future phases of design

For the initial eight (8) development wells there will be MacDermid Oceanic SST5007 discharge at each of the following locations:

- Leviathan-3;
- Leviathan-4 / 8;
- Leviathan-5;
- Leviathan-6 / 7; and
- Leviathan-9 / 10.

Approximate discharge volumes of MacDermid Oceanic SST5007 based on core diameter and infield umbilical length are provided in Table 3-6.

Following storage chemical displacement of the entire controls system (for displacement of the primary umbilical see Section 3.2.2.2) the system will be function tested by hydraulically energizing all actuated valves in the subsea infrastructure. Due to the open-loop nature of the Leviathan controls system this will result in low volume discharges of hydraulic fluid (MacDermid Oceanic HW540P) at all valve locations.

Actuated subsea control valves to be energized during commissioning operations include:

- Wellhead / Xmas tree mounted valves; and
- Infield Gathering Manifold mounted valves.



Hydraulic fluid discharge from commissioning all valves on a single Xmas tree is estimated at 18 liters. For the initial eight (8) development wells this corresponds to a total discharge of 288 liters of MacDermid Oceanic HW540P.

Hydraulic fluid discharge from commissioning all valves on the Infield Gathering Manifold is estimated at 117 liters.

Beyond the discharges associated with wellhead and manifold valve commissioning there are no further discharges of MacDermid Oceanic HW540P hydraulic fluid associated with infield umbilical commissioning activities.

All discharges associated with pre-commissioning and commissioning activities of the infield umbilicals are estimated in Table 3-6 and will be subjected to gaining the necessary approvals from the authorities.

Any infill wells (future) that are subsequently tied into the Leviathan production infrastructure will be subject to similar pre-commissioning and commissioning procedures to those discussed above. As such future wells will result in incremental discharges.



**Table 3-6: Discharge Sites and Volumes for Infield Umbilical Pre-Commissioning and Commissioning**

Pre-commissioning		
Discharge Location	Discharge Volume (Liters)	Chemical
Lev-3	3600	MacDermid Oceanic SST5007
Lev-4 / 8	2900	
Lev-5	7600	
Lev-6 / 7	1800	
Lev-9 / 10	1800	
Commissioning		
Gathering Manifold	117	MacDermid Oceanic HW540P
Lev-3	18	
Lev-4 / 8	36	
Lev-5	18	
Lev-6 / 7	36	
Lev-9 / 10	36	

The MSDSs for MacDermid Oceanic HW540P and MacDermid Oceanic SST5007 are provided in Appendix C.2.

### 3.2.2 Transmission Facilities Installation, Tie-in and Commissioning

In order to transport Leviathan production from the Infield Gathering Manifold to the LPP located in Israeli territorial waters transmission pipelines shall be installed. The development will utilize the following production infrastructure:

- Two (2) by 18" 117.5 km rigid steel production pipelines for production to the DSM;
- Two (2) by 18" Pipeline End Terminals (PLETs) located at the infield end of the DSM production pipelines;
- Two (2) by 18" Sub-Sea Isolation Valves (SSIVs) and structures at the LPP end of the DSM production pipelines;
- One (1) by 20" 117.5 km rigid steel production pipeline for production to the REM;



- One (1) by 20" PLET located at the infield end of the REM production pipeline; and
- One (1) by 20" SSIV and structure at the LPP end of the REM production pipeline.

In addition to the production infrastructure, additional subsea infrastructure will be required to supply services and controls from the LPP to the infield infrastructure and SSIVs. This will primarily consist of:

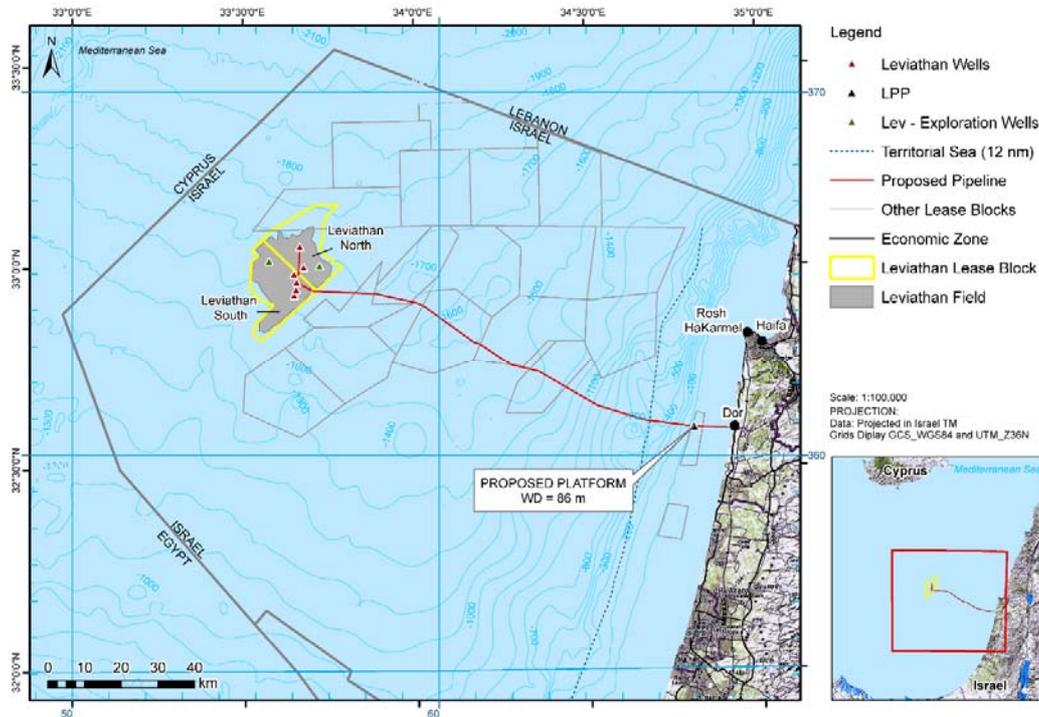
- Two (2) by 6" 117.5 km rigid steel MEG supply lines, installed either as standalone lines, or piggybacked onto the 18" DSM production pipelines;
- Two (2) by 6" PLETs at the infield end of the MEG supply lines;
- One (1) by 117.5 km primary umbilical of electrohydraulic design – Installed as two (2) lengths of umbilical (one (1) by 60 km and one (1) by 57.5 km) joined with UTAs and flying leads at the mid-point;
- One (1) by Controls SDU at the infield end of the primary umbilical;
- One (1) by independent umbilical to provide electrohydraulic connection between the LPP and the SSIVs; and
- One (1) by UTA local to the SSIVs to facilitate controls tie-ins.

All transmission pipelines (production and MEG supply) and umbilicals shall be laid into a single transmission corridor from the LPP to the Leviathan Field. This transmission corridor will be up to 600 m wide. The selected corridor routing is shown in Figure 3-7. The total corridor length from the LPP to the Infield Gathering Manifold is approximately 117.5 km.

It should be noted that the planned installation of the transmission lines (production pipelines, MEG supply lines and primary umbilical) will occur prior to the installation of the infield facilities. This will enable commissioning activities on the infield facilities to be completed either; from the LPP, or from a vessel located in close proximity to the LPP.



Figure 3-7: Gathering Facilities Route



### 3.2.2.1 Installation of Submarine Production Infrastructure

This section describes activities and methodologies associated with the installation and commissioning of the submarine infrastructure required for the transmission of production fluids, chemicals and controls between the infield facilities and the LPP (i.e. pipelines, umbilicals and isolation systems). It further describes the supply and support services required during the installation phase of development.

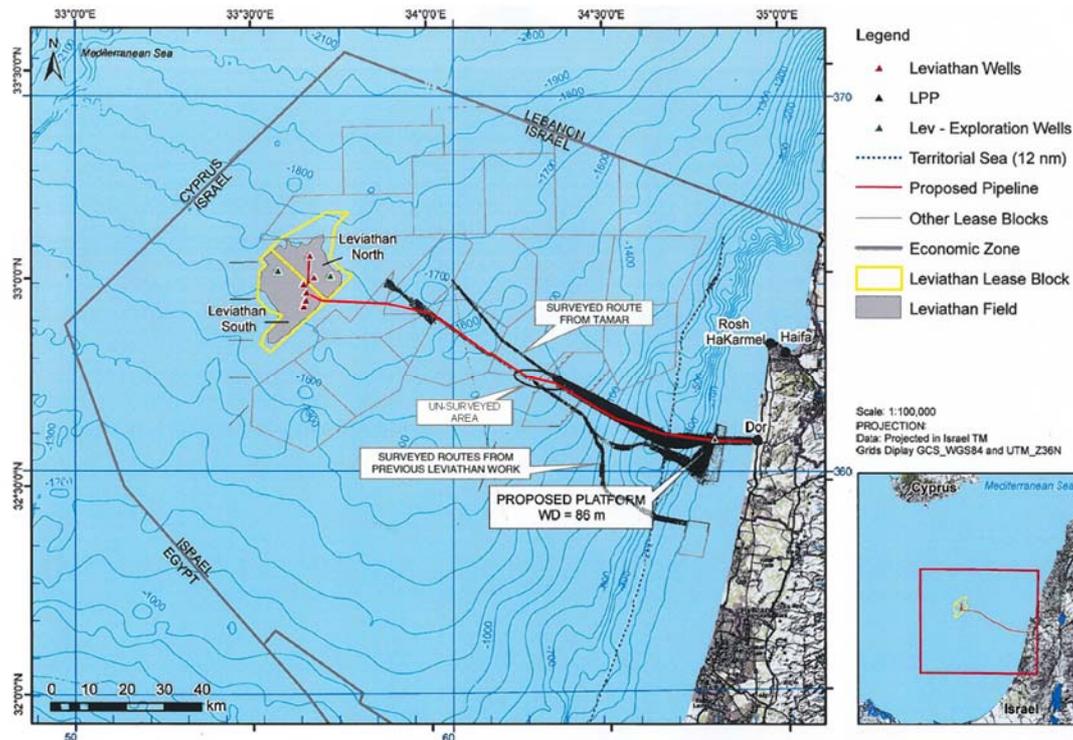
#### Pipeline Route and Pre-installation Survey

Since the discovery of commercial quantities of gas in the Tamar and Leviathan Fields a number of potential pipeline corridors have been surveyed to assess suitability for piping gas from the fields to northern Israel. Figure 3-8 shows the pipeline corridors that have been surveyed to date, with the selected route for the Leviathan development overlaid for reference. This shows that the majority of the route for transmission lines from the Infield Gathering Manifold to the northern TAMA block has previously been surveyed. There is a short length of the route, where the corridor jumps from the previously surveyed Leviathan corridor to the previously surveyed (but unused) Tamar corridor, that has not been extensively surveyed.

Although not shown in Figure 3-8, the infield area, and the area directly to the east of it has previously been subject to preliminary surveying (identifying location of channels etc.), however some additional survey work may be required along the finalized transmission corridor. Additional surveying of this area is expected to be completed in conjunction with any other survey work required along the transmission route.



Figure 3-8: Surveyed Pipeline Routes



The surveys performed on the previously proposed pipeline routes have been Geophysical and Hazard Surveys to obtain site-specific engineering data of the seafloor conditions along the proposed corridors. The aim of these surveys is to identify geological conditions, seafloor and shallow hazards, existing pipelines and cables and bathymetry information, all of which is used to help determine the design and installation of subsea infrastructure.

In order to confirm the findings of the previous surveys and to fill in any un-surveyed areas, additional survey work is planned for summer 2016. This will primarily consist of a Bathymetric Survey and a Side Scan Sonar Survey performed from an Autonomous Underwater Vessel (AUV).

The Leviathan pipeline corridor is located in an area where faulting is present. Where possible transmission pipelines have been routed to avoid major channel / fault crossings, however where this is not possible, engineered crossings will be developed as required.

Water depths along the transmission pipeline corridor range from 1,660 m at the Infield Gathering Manifold, to approximately 600 m at territorial waters, and down to 86 m immediately adjacent to the LPP. Due to the water depth, and large diameter thick walled production pipelines, no pipeline burial, trenching or armoring will be utilized. Umbilicals, and standalone MEG supply lines (if required) will also not be subject to trenching or burial.



All SSIVs and pipeline tie-ins at the LPP end of the transmission pipelines will lie within the 500 m platform exclusion zone and as such will not require protection from external actions unrelated to platform operations. A dropped object study to be performed during detailed design will determine any requirement for protection from dropped objects originating from platform operations.

## Pipeline / Umbilical Installation and Tie-In

### Production Pipelines

The production pipelines [two (2) by 18” and one (1) by 20”] will each be approximately 117.5 km long and will link the Infield Gathering Manifold to the LPP in Israeli territorial waters.

The production pipelines will be of rigid construction and will be installed directly onto the seabed with no trenching or burial required at any location along the pipeline route. Each pipeline will feature a PLET at the infield location and a valved diver assisted tie-in point at the LPP end to enable tie-in to the SSIV structure.

Each PLET will be installed onto a dedicated mudmat foundation with an estimated land take per PLET of 110 m<sup>2</sup>. The valved diver assisted tie-in points will sit directly on the seabed with no additional foundations (mudmat or piles).

Tie-in jumpers will be required to make the connections between the deepwater PLETs and the Infield Gathering Manifold. Connections local to the LPP will be made with tie-in spools.

Each production pipeline will require one (1) set of tie-in jumpers / spools. All jumpers and spools will be of rigid construction and will match the nominal diameter of the production pipeline they are associated with. Wall thickness of jumpers and spools will be as per that determined by design. Deepwater jumpers will feature diverless connections, while spools around the LPP will utilize diver assisted connections.

Estimated land take associated with the production pipelines is provided in Table 3-7. The land take associated with pipelines is calculated based on the full pipeline diameter.

**Table 3-7: Production Pipeline and PLET Land Take**

Item	Land Take (m <sup>2</sup> )
2x DSM 18” Pipelines (117.5 km each)	107,442
2x DSM 18” PLETs	220
1x REM 20” Pipelines (117.5 km)	59,690
1x REM 20” PLET	110
<b>Total</b>	<b>167,462</b>

The production pipelines will be fabricated in 12 m sections at an out of country fabrication yard and shipped to in-country port facilities for storage until they are required onsite for installation. Pipeline sections will be transported from the in-country storage location to the pipelay vessel by a pipelay supply vessel fitted with a pedestal crane.



Production pipelines will be installed dry on the seabed, with no anchoring required along the route. Pipelay may be by either the S-lay or J-lay method which differ primarily in the way that the pipeline is allowed to flex during installation. Final selection of the lay method will be made by the EPC contractor following contract award. For the purpose of this document S-lay is assumed, however the incremental impact of reverting to J-lay are not considered significant.

It is anticipated that the same DP Pipelay Vessel that will be used for flowline installation will be used for the production pipelines. The Allseas Solitaire is considered a representative vessel at this stage as the large diameter, thick walled production pipelines, combined with the project water depth will drive the selection of a high specification vessel. Final vessel selection will not be made until the EPC contract is awarded, however an average lay rate of three (3) km / day is anticipated with an additional two (2) days allowed per pipeline for start-up and lay down.

A typical DP S-lay vessel features a tunnel structure or 'firing line', on its main deck which allows for pipe handling, welding & non-destructive testing (NDT), grit blasting and coating (as appropriate) as well as the maintenance of tension on the pipeline. These vessels are capable of offshore pipe loading from supply vessels while simultaneous pipelay continues. The 300 m long Allseas Solitaire is shown in Figure 3-9 performing simultaneous pipe loading and pipelay.

**Figure 3-9: Allseas Solitaire – Dynamically Positioned Pipelay Vessel**



For the purpose of this assessment it is assumed that all tie-in jumpers / spools associated with the production pipelines will be installed from an OCV. This operation will require ROV / diver support (depending on water depth) and the associated support vessels. The option of installing jumpers / spools from an MSV may be reviewed by the EPC contractor following contract award.



**Subsea Isolation Valves (SSIVs)**

SSIVs will be installed on each of the large diameter production pipelines in order to enable the LPP to be rapidly isolated from the hydrocarbon inventory of the pipelines in the event of an emergency event on the LPP. SSIV location is subject to a dropped object study, but it is anticipated that all SSIVs [total of three (3)] will be located within 100 m of the LPP and will thus lie within the LPP’s exclusion zone (500 m).

Each SSIV will feature an integrated protection structure which will also house the SSIV tie-in points to enable diver assisted tie-ins. The structures will be installed onto the seabed with mudmat foundations which are estimated at eight (8) m by eight (8) m, giving a total footprint per SSIV of 64 m<sup>2</sup>. Total land take attributable to all three SSIVs is therefore 192 m<sup>2</sup>.

For the purpose of this assessment SSIVs are assumed to be installed from an OCV with diver assistance during positioning and touchdown. Each SSIV will be installed in a single lift. Installation operations will necessitate the usual support vessels in the form of an MSV (for supporting diver operations), and supply and standby vessels.

**MEG Supply Lines**

Two (2) 6” MEG supply lines will be required in order to supply MEG from the LPP to the infield SDU from where it will be routed to the wells via the infield umbilicals. The infield MEG SDU has previously been discussed in Section 3.2.1.3. Each MEG supply line will feature a PLET at the infield location and a valved diver assisted tie-in point at the LPP end to enable tie-in to the LPP riser.

The MEG supply lines will be installed either as:

- Standalone lines laid onto the seabed within the transmission corridor; or
- As piggyback lines on the two (2) 18” DSM production pipelines.

Estimated land-take associated with standalone MEG supply pipelines is provided in Table 3-8 based on the standard outer diameter for 6” nominal bore pipe of 6.625”. There will be no land take associated with the MEG supply lines (excluding PLETs) if they are installed in a piggyback configuration on the DSM production pipelines.

**Table 3-8: Incremental Land Take for Standalone MEG Supply Pipelines**

Item	Land Take (m <sup>2</sup> )
2x 6” Standalone MEG supply pipelines (117.5 km each)	39,545

Irrespective of the configuration selected, MEG supply lines will be installed from a DP Pipelay Vessel (assumed to be the same as that used for production pipeline installation) in either an S-lay or J-lay method. Final vessel selection and lay method will be decided following EPC contractor award. If a piggyback configuration is selected then the MEG supply lines will be laid simultaneously with the DSM production pipelines, thus reducing the overall installation duration. Conversely if standalone MEG supply lines are selected, then it is assumed that pipelay will



proceed at an average lay rate of three (3) km / day with an additional two (2) days allowed per pipeline for start-up and lay down

Line pipe for the MEG supply lines will be fabricated in 12 m (or similar) sections at an out of country fabrication yard and shipped to in-country port facilities for storage until they are required onsite for installation. Pipeline sections will be transported from the in-country storage location to the pipelay vessel by a pipelay supply vessel fitted with a pedestal crane.

MEG supply lines will be installed dry, with no anchoring required along the route. For the purpose of this assessment, S-lay is assumed, however the incremental impacts of reverting to J-lay (either as standalone or piggybacked) are not considered significant.

PLETs will be installed onto dedicated mudmat foundations while the valved diver assisted tie-in points will sit directly on the seabed with no additional foundations (mudmat or piles). Each MEG supply PLET [two (2) off total] will demand an estimated subsea land take of 36 m<sup>2</sup>.

Tie-in jumpers will be required at the deepwater end to make the connections between the deepwater PLETs and the MEG SDU. Connections around the LPP will be made with tie-in spools.

Each MEG supply line will require one (1) set of tie-in jumpers / spools. The deepwater MEG jumpers will be of flexible construction with diver-less connections while the shallow water tie-in spools will be of rigid construction with diver assisted connections. Wall thickness of jumpers and spools will be as per that determined by design.

For the purpose of this assessment, jumpers are assumed to be installed from an OCV; however, it is possible that an MSV may have the required crane capacity (this will be confirmed by the EPC contractor following contact award). Should an MSV be used in place of an OCV, this will reduce vessel presence and emissions arising from this activity. Deepwater jumper installation will require ROV support, while shallow water spools will necessitate diver assistance. Support vessels in the form of an MSV (to support ROV / diver operations), a supply and a standby vessel will be required.

### **Primary Umbilical**

The primary umbilical from the LPP to the infield controls distribution unit will be of an electrohydraulic design. This will run parallel to the transmission pipelines, and like the pipelines will not be trenched or buried.

The primary umbilical will be constructed at an out of country location in two (2) lengths. These are; a 60 km section from the LPP to an intermediate UTA, and a 57.5 km section from a second intermediate UTA to the infield Controls SDU. UTAs will be installed on mudmat foundations with a seabed take of approximately 22 m<sup>2</sup> each. The two (2) intermediate UTAs will be joined with hydraulic and electrical flying leads. The Controls SDU will be installed in close proximity to the MEG SDU and will utilize a mudmat foundation, thus resulting in an estimated land take of 97 m<sup>2</sup>.



The umbilical will consist of a number of elements for the purpose of conveying control fluid and chemicals, transmitting electrical currents, and protection from impacts and corrosion. The total diameter of the umbilical is expected to be approximately 160 mm giving a total land take over the length of the umbilical (117.5 km) of approximately 19,041 m<sup>2</sup>, increasing to 19,182 m<sup>2</sup> when the UTAs and SDU are considered.

The primary umbilical will be installed onto the seabed by reel lay from an OCV; such a vessel will also be capable of installing the UTAs and SDU from on-deck cranes as required. An example OCV that may be used for this work is the BOA Sub C as shown in Figure 3-10.

**Figure 3-10: BOA Sub C – Offshore Construction Vessel**



An average lay speed of 9.6 km / day is considered feasible for this type of flexible lay operation. During installation all steel tubes will be liquid filled (either with MacDermid Oceanic HW540P or MacDermid Oceanic SST5007) to prevent seawater ingress and damage due to installation stresses. The planned umbilical has a total of 17 cores as detailed in Table 3-9.



**Table 3-9: Primary Umbilical Cores**

Core N°	Service	Size (ID)	Notes <sup>1</sup>
1-4	4x Power Supply	25 mm <sup>2</sup> (each)	No Shield / Armor
5-6	3x Fiber Optics Cable	16 way (each)	Armored
8-9	2x LP Hydraulic	1" (each)	Installed HW540P filled
10-11	2x HP Hydraulic	½" (each)	Installed HW540P filled
12	Scale Inhibitor	½"	Installed SST5007 filled
13	Auxiliary	1"	Installed SST5007 filled
14-15	2x Methanol	1" (each)	Installed SST5007 filled
16-17	2x Spare	1" (each)	Installed SST5007 filled

Notes: 1. Where reference is made to cores being installed either HW540P or SST5007 filled, this refers to the specific chemicals "MacDermid Oceanic HW540P" and "MacDermid Oceanic SST5007" respectively. Final chemical selection will be made by the EPC contractor.

### **SSIV Umbilical and UTA**

A short length (approx. 100 m) of umbilical will run from the LPP to a dedicated SSIV UTA in order to provide hydraulics and services to the SSIVs on the production pipelines. The UTA will lie within the LPPs marine exclusion zone.

The SSIV umbilical will feature a combination of ½" ID tubes, electrical conductors and 8-way fiber optic cables. The ½" ID tubes will be configured so as to allow a closed loop controls system to be implemented on the SSIVs whereby any hydraulic fluid discharged from the valve actuators will be routed back to the LPP topsides as opposed to vented to the surrounding marine environment. A closed loop system is feasible for this section of infrastructure due to the proximity to the LPP, relatively shallow water depth at the SSIVs, and limited function of the SSIV umbilical.

Preliminary calculations indicate an external diameter of approximately six (6) inches (152 mm) for the SSIV umbilical.

The land take associated with the SSIV UTA is estimated at 21.7 m<sup>2</sup> (as per all other UTAs). The land take directly associated with the length of umbilical is conservatively estimated at 15.2 m<sup>2</sup> based on an umbilical length of 100 m.

The SSIV umbilical and its associated UTA is anticipated to be installed from the same OCV to be used to lay the primary umbilical running from the LPP to the infield facilities. Installation will be completed with diver assistance, supported by an MSV and the same Supply and Standby vessels anticipated for all construction operations. Installation of tie-in flying leads (from the SSIV UTA to the SSIVs) is expected to utilize the same marine spread, with the exception of the OCV which will not be required for this work.



### 3.2.2.2 Pre-Commissioning and Commissioning Methodology

Transmission facilities will undergo various pre-commissioning and commissioning activities depending on their function. These are detailed in the following sections based on typical pre-commissioning and commissioning activities, these will be finalized during future detailed design.

The project schedule (provided in Figure 3-3) indicates that all subsea facilities will require pre-commissioning and commissioning during H2 2019. This is reliant on the project progressing as currently expected and is subject to change depending on project progress. Further definition of anticipated pre-commissioning and commissioning dates will be determined during the detailed engineering phase of the project.

Preliminary estimates of pre-commissioning and commissioning durations associated with the transmission facilities are presented in Table 3-12.

#### Pipelines

Typically, rigid pipelines (production and MEG) require cleaning, gauging, hydrotesting, and dewatering to prepare them for operational service. Additionally production pipelines are typically dried to remove any remaining water. Cleaning, gauging and hydrotesting are pre-commissioning activities, while dewatering and drying are considered commissioning activities.

The general pipeline pre-commissioning and commissioning philosophy to be applied to the rigid transmission pipelines is:

- Pre-commission all pipelines prior to tie-in jumper / spool installation by:
  - Free flooding all rigid pipelines with treated seawater from the deepwater PLET to the LPP end; and,
  - Cleaning, gauging and hydrotesting all rigid pipelines from the LPP end (subsea pig launch) to the deepwater PLET (subsea pig receive).
- Commission production pipelines prior to jumper installation by:
  - Dewatering and drying the lines with a dewatering pig train (launched subsea at the LPP end and received subsea at the deepwater PLET) driven by compressed nitrogen; and
  - Purge and pack the production lines with nitrogen. Packed nitrogen will be used for later commissioning activities of jumpers, manifolds and infield flowlines.
- Install production pipeline jumpers / spools and leak test connections. Dewater and purge jumpers with nitrogen from the pipelines; and
- Commission the MEG pipelines following jumper installation by circulating MEG from the LPP topsides (with the assistance of a commissioning vessel) down one pipeline, through a crossover connection at the deepwater end and back to the LPP. MEG supply lines will be left MEG filled ready for start-up.



All water used for either flooding or hydrotesting of pipelines will be filtered and chemically treated prior to use to protect the pipeline materials in the event of a commissioning delay. Indicative chemicals to be used for this purpose are:

- Roemex RX5227: Combined oxygen scavenger, corrosion inhibitor and biocide – typically dosed at 1,000 ppm; and
- Roemex RX9025: Leak tracer dye – typically dosed at 50 ppm.

Both of these chemicals are classified as Gold chemicals under the OCNS which indicates that they present a relatively low hazard to the environment.

Pipeline cleaning and gauging will result in the discharge of the initial fill of flooding water and its associated chemicals. Residual oils and soluble material on the internal pipeline surfaces will be discharged with the chemically treated flooding water during the cleaning operation.

Dewatering and drying of the production pipelines will result in the discharge of chemically treated seawater (used for hydrotesting) at the deepwater PLET. Additionally, small volumes of MEG will likely be discharged during this operation.

Dewatering of the MEG pipelines will be performed as a round trip operation and as such chemically treated hydrotest water will be produced at the LPP location. This water will be discharged locally at the LPP, subject to obtaining the necessary permits and approvals.

In addition to those discharges associated with cleaning, gauging, and drying, there will be small volume discharges of MEG immediately following jumper installation. This is associated with the flushing of jumpers to prevent seawater corrosion or biogenic growth. The discharge of MEG is estimated at 10 m<sup>3</sup> per jumper.

Table 3-10 provides details of the environmental releases during pre-commissioning and commissioning operations associated with the transmission pipelines (production and MEG).



**Table 3-10: Infield Pre-commissioning and Commissioning Releases**

Pre-commissioning			
Location	Discharge	Volume (m <sup>3</sup> )	Notes
Deepwater MEG PLETs	MEG	20	MEG Discharge associated with jumper flushing for two (2) MEG supply jumpers.
Deepwater MEG PLETs	Chemically Treated Seawater (Flooding)	4,150	Displaced flood water containing a cocktail of: a) RX5227 (or equiv.) at 1000 ppm; b) RX9025 (or equiv.) at 50 ppm.
Deepwater Production PLETs	MEG	30	MEG Discharge associated with jumper flushing for three (3) production jumpers.
Deepwater Production PLETs	Chemically Treated Seawater (Flooding)	60,450	Displaced flood water containing a cocktail of: a) RX5227 (or equiv.) at 1000 ppm; b) RX9025 (or equiv.) at 50 ppm.
Commissioning			
Location	Discharge	Volume (m <sup>3</sup> )	Notes
Deepwater Production PLETs	Chemically Treated Seawater (Hydrotest)	60,450	Displaced hydrotest water containing a cocktail of: a) RX5227 (or equiv.) at 1,000 ppm; b) RX9025 (or equiv.) at 50 ppm; c) Low volumes of MEG.
LPP (from MEG pipelines)	Chemically Treated Seawater (Hydrotest)	4,150	

Pre-commissioning and commissioning activities on the transmission pipeline system will be supported by ROVs launched and controlled from a surface based MSV.

In order to minimize the environmental impact of hydrotest discharge the discharge ports on PLETs will be designed to direct discharges vertically upwards to prevent seabed disturbance or scouring.

Disposal of the hydrotest water to the marine environment will be subject to discussions with MoEP and obtaining the appropriate permits and approvals.

### Primary Umbilical

Pre-commissioning and commissioning activities for the primary umbilical will involve pressure testing, displacement of storage fluid and functionality checking. All of these activities will be performed in conjunction with analogous commissioning activities on the infield umbilicals.

Pressure testing will be performed from an MSV or dedicated commissioning vessel located adjacent to the LPP. Pressure testing will be performed as per standard hydrotest procedures, however the test fluid will be that present from umbilical installation (either MacDermid Oceanic HW540P or MacDermid Oceanic SST5007) which is water based.



Following pressure testing all cores filled with storage fluid (MacDermid Oceanic SST5007) will be displaced with the relevant service chemical. This will be performed from the LPP with MSV or commissioning vessel support as required. During this operation the inventory of storage fluid will be discharged from all non-hydraulic control cores, with the exception of the two (2) spare cores which will be left under storage conditions. Details of the primary umbilical cores to be displaced are provided in Table 3-11.

**Table 3-11: Infield Umbilical Cores for Pre-Commissioning Operations**

Core №	Service	Size (ID)	Notes <sup>1</sup>	Inventory (m <sup>3</sup> )
12	Scale Inhibitor	½"	Installed SST5007 filled	14
13	Auxiliary	1"	Installed SST5007 filled	58
14	Methanol 1	1"	Installed SST5007 filled	58
15	Methanol 2	1"	Installed SST5007 filled	58
<b>Total</b>				<b>188</b>

Notes: 1. Where reference is made to cores being installed either HW540P or SST5007 filled, this refers to the specific chemicals "MacDermid Oceanic HW540P" and "MacDermid Oceanic SST5007" respectively. Final chemical selection will be made by the EPC contractor.

The intention is that umbilical storage fluid from the primary umbilical will be discharged at the infield Controls SDU. Subsequent to displacement of the primary umbilical cores the infield umbilical cores will be displaced to the wellheads as per Section 3.2.1.3. An alternative method of storage fluid displacement is to route this fluid into the flowlines and production pipelines for displacement back to the LPP. A decision on the preferred routing of displaced fluid will be made in future phases of design.

The total discharge of MacDermid Oceanic SST5007 at the infield SDU is estimated at 188 m<sup>3</sup>. This operation will be subject to obtaining dedicated permits from MoEP.

Following pressure testing and storage fluid displacement, the primary umbilical will be function tested in conjunction with the infield umbilicals to complete commissioning activities. During function testing there will be low volume discharges of hydraulic fluid at multiple infield locations (See Section 3.2.1.3); however there will be no discharges from the primary umbilical.

**SSIV Umbilical and Controls**

The SSIVs and associated controls infrastructure will be designed based on a closed loop controls system. As such, during commissioning all fluids displaced from the umbilical will be received on the LPP where they will be processed, re-used or discharged in a manner which is appropriate to their environmental toxicity.

Pre-commissioning and commissioning of the SSIV umbilical will follow the same procedure as that for the primary umbilical, but with no discharges at the subsea infrastructure. No incremental



vessel time is considered in relation to pre-commissioning and commissioning of the SSIV umbilical as this is expected to occur simultaneously to that of the primary umbilical.

### 3.2.2.3 Support Vessels for Pipeline Installation, Tie-in and Commissioning

The transmission facilities installation, tie-in and commissioning activities will require support from a variety of vessels including:

- DP Pipelay Vessel (e.g. Allseas Solitaire);
- Pipe Supply Vessel - to transport pipe sections between the in-country storage site and the Pipelay Vessel;
- OCV (e.g. BOA Sub C) - to install subsea structures, umbilicals and tie-in jumpers;
- ROV / MSV (e.g. Siem Stingray) - to support pipeline and structure installation, and perform commissioning activities. Where diver assisted operations are to be used the MSV is assumed to act as the dive support vessel for this work; and
- Standby and Supply Vessels.

In addition, weekly crew changes for the pipelay vessel are expected to be performed by helicopter, nominally a Sikorsky-61N.

Table 3-12 provides an estimate of the vessel use based on the installation campaign described above and assumes that the MEG supply lines are installed as per the piggyback configuration being considered. Table 3-13 provides the incremental vessel use associated with installing the MEG supply lines as standalone lines.

Fuel use figures are estimated based on typical vessels available within each category. Fuel used is assumed to be marine diesel for water based vessels and Jet A for helicopter use.

Appendix D details the assumptions made when calculating fuel use.



**Table 3-12 Vessel Use for Pipeline Installation, Pre-Commissioning and Commissioning**

Vessel	No of vessels	Working period (days)	Schedule Activity	Fuel Consumption (Te / day)	Total Fuel Use (Te)
DP Pipelay Vessel	1	123	1,2	130	15,990
Pipe Supply Vessel	1	123	1,2	15	1,845
Offshore Construction Vessel	1	50	3,4	51	2,550
Multipurpose Support Vessel with ROV	1	242	All	26	6,292
Standby Vessel	1	242	All	2.4	580.8
Supply Vessel <sup>Note 1</sup>	2	242	All	12	2,904
Helicopter	1	35 hrs	1,2	0.4 Te / hr	14.0
<b>Total</b>					<b>30,175</b>
<p><b>Schedule Activity:</b>                      Activity 1: DSM Pipelines (inc. piggy backed MEG lines) and PLET Installation (82 Days)                      Activity 2: REM Pipeline and PLET Installation (41 days)                      Activity 3: Primary and SSIV Umbilical and Structures Installation (19 days)                      Activity 4: SSIV Installation, Pipeline and Umbilical Tie-ins (31 Days)                      Activity 5: Production System Pre-Commissioning and Commissioning (30 Days)                      Activity 6: MEG System Pre-Commissioning and Commissioning (16 Days)                      Activity 7: Controls System Pre-Commissioning and Commissioning (23 Days)</p> <p><b>Notes:</b>                      Note 1: Two (2) supply vessels are assumed based on there always being one (1) vessel in transit.</p>					



**Table 3-13: Incremental Vessel Use for Standalone MEG Pipeline Installation, Pre-Commissioning and Commissioning**

Vessel	No of vessels	Working period (days)	Fuel Consumption (Te / day)	Total Fuel Use (Te)
DP Pipelay Vessel	1	82	130	10,660
Pipe Supply Vessel	1	82	15	1,230
Offshore Construction Vessel	1	0	51	0
Multipurpose Support Vessel with ROV	1	82	26	2,132
Standby Vessel	1	82	2.4	197
Supply Vessel <sup>Note 1</sup>	2	82	12	984
Helicopter	1	23 hrs	0.4 Te / hr	9.2
<b>Total</b>				<b><u>15,212</u></b>
<p><b>Notes:</b>                      Note 1: Two (2) supply vessels are assumed based on there always being one (1) vessel in transit.</p>				

### 3.2.3 Other Infrastructures

Aside from those facilities detailed in Sections 3.2.1 and 3.2.2 for infield and transmission purposes, there will be no additional production or controls infrastructure installed upstream of the LPP. However, in order to facilitate pipeline / umbilical crossings of seabed features the following will be developed:

- Channel crossings; and
- Pipeline / Cable crossings.

The above are considered in the following sections.

#### 3.2.3.1 Channel Crossings

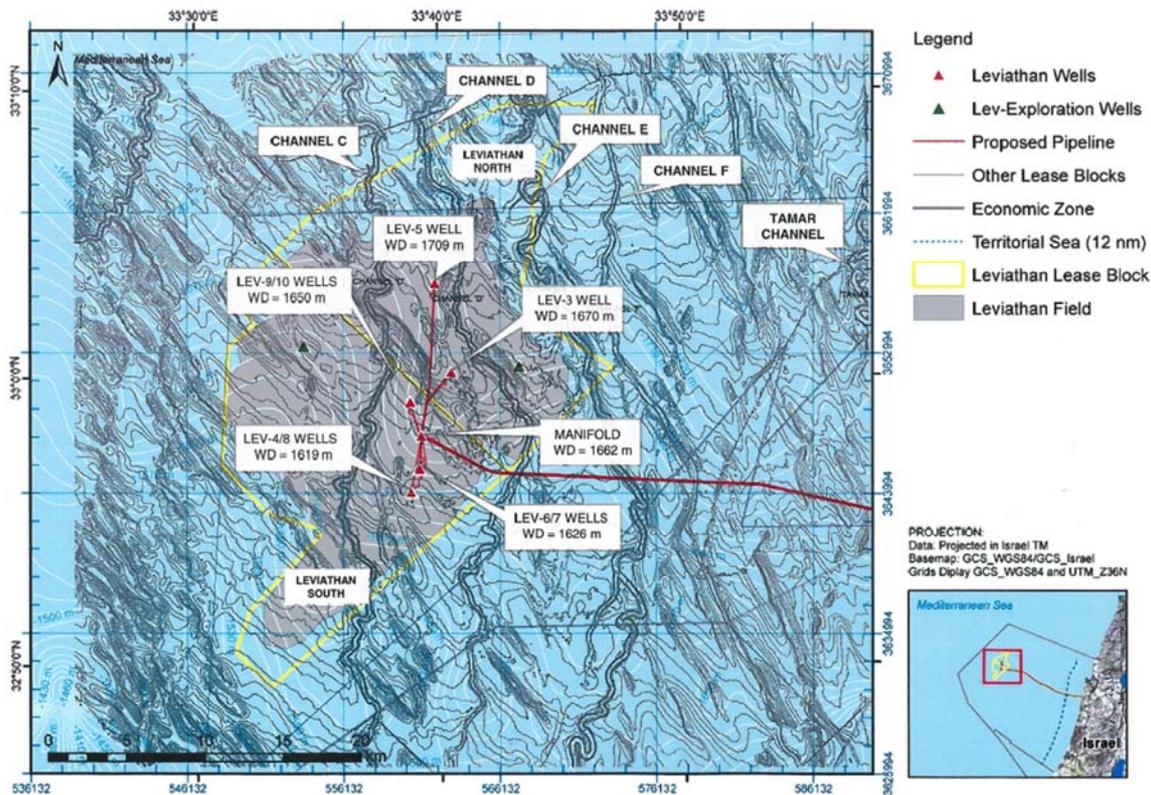
There are three (3) substantial seabed channels that must be crossed by the transmission pipelines in order to connect the Infield Gathering Manifold to the LPP. The channels identified lie between the Infield Gathering Manifold in the west, and the Tamar production system in the east and are shown in Figure 3-11. The three (3) channels referred to above are:

- Channel D;
- Channel E; and
- The Tamar Channel.



In addition, the transmission pipelines will cross the poorly defined channel F which lies between channel E and the Tamar channel. Further channels that have not been identified at this stage may also require crossing by the transmission pipelines.

**Figure 3-11: Seabed Channels for Pipeline Crossings**



Based on the three (3) channels identified above, there will be a total of 18 channel crossings if the MEG supply lines are installed as standalone lines, or 12 crossings if they are installed as piggyback lines on the 18" DSM production pipelines.

Crossing of channels requires dedicated engineered solutions in order to minimize pipeline stresses as a result of free-spans and their associated hydrodynamic affects.

A range of concepts are being considered to enable channel crossing, these are outlined below:

### Increased Wall Thickness

The simplest option for mitigating stresses arising from free-spans is to increase the pipeline wall thickness around these areas to increase the maximum stress capacity of the line pipe. The effectiveness of this option may be limited to shorter free-spans where spanning loads (either



static or dynamic) are not so great. Implementation of this option will not pose any incremental environmental impacts.

### Increased Pipelay Tension

Where static or dynamic loads arising from free-spans lead to unacceptable pipeline strain (deformation) this may be effectively mitigated by increasing the tension on the pipeline during the pipelay operation. Utilizing increased lay tension ensures the pipeline is pulled tight across the free-span, thus minimizing the deflection in the unsupported section. Where this option is suitable, it will not pose any incremental environmental impact.

### Pipeline Buoyancy and Strakes

Where a free-span cannot be avoided, and the resultant pipeline stresses lead to unacceptable pipeline deformation, distributed buoyancy modules may be installed directly onto the pipeline at the span to reduce static stresses and resultant strains. Further, where vortex induced dynamic stresses are present, additional vortex shedding features (strakes) may be installed to reduce the impact of these dynamic loads.

Should this option be implemented there is no perceived incremental environmental impact.

### Seabed Dredging

Where none of the options identified above are either sufficient to mitigate pipeline stresses, or attractive from a project stand-point, pre-lay excavation and dredging may be implemented to alter the seabed bathymetry at the channel crossing location. This option consists of physically moving seabed sediment to create a dredged installation corridor at the channel crossing location. This will allow the pipelines to cross the channel while minimizing, or removing entirely, the number and length of free-spans.

Dredging and excavation will be performed in advance of pipelay and it will be up to the DP Pipelay Vessel to ensure pipelines are laid into the dredged corridor(s) where they cross the identified seabed channels.

A portion of the excavated material may be used to infill low-points around the crossing, while the majority will be disposed of at a designated area offshore. Implementation of a deepwater dredging solution will result in:

- Increased water turbidity local to the excavation and disposal sites;
- Deposition of fine sediments local to the excavation and disposal sites;
- Seabed coverage at the disposal site due to volume of material to be relocated; and
- Modification to the seabed bathymetry and local hydrodynamics.

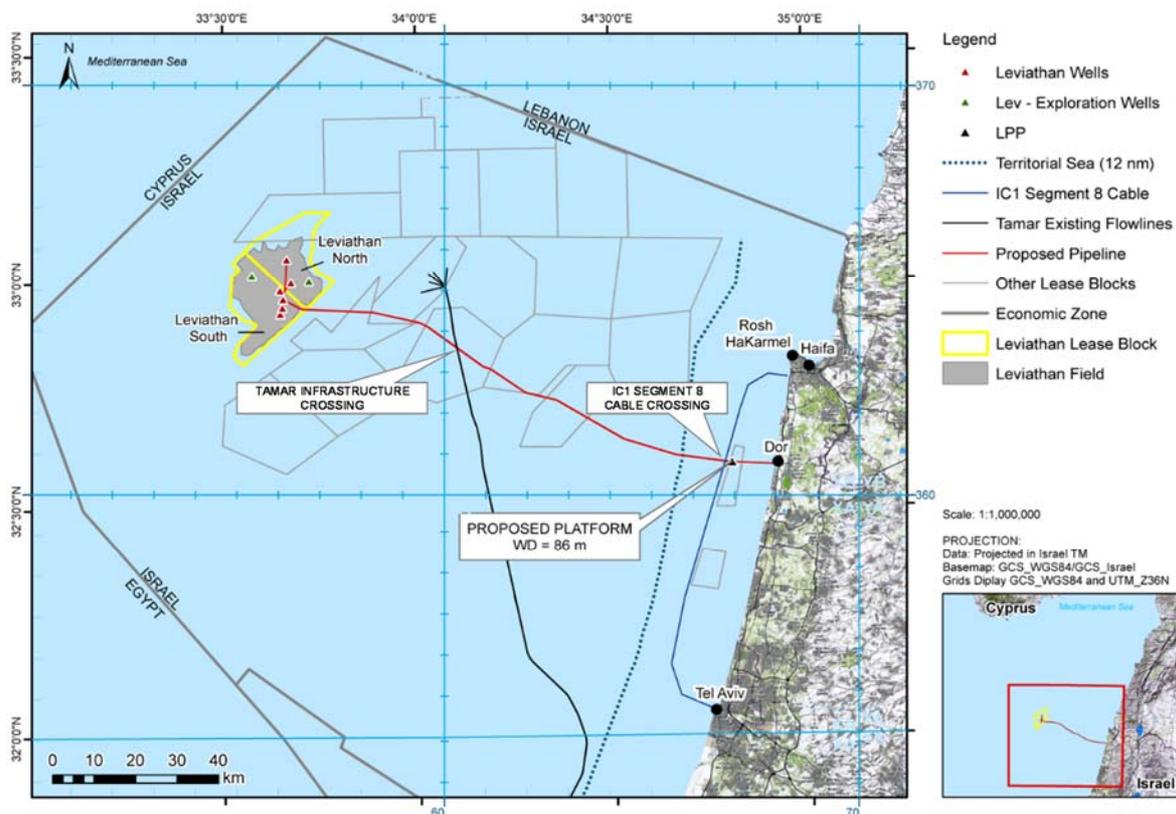


The aspects identified above are expected to be of a relatively concentrated nature without a substantial area of impact. As such only the environment local to the dredging, and disposal sites may be expected to be impacted.

### 3.2.3.2 Pipeline Crossings

The selected corridor routing for the transmission pipelines and the primary umbilical requires the aforementioned infrastructure to cross the existing Tamar production system and the IC1 Segment 8 cable system. The Tamar production system crossing lies approximately 45 km from the Infield Gathering Manifold, and 15 km south-east of the Tamar production manifold, while the IC1 Segment 8 cable runs approximately 2 km west of the LPP. The approximate locations of these existing infrastructures, and their planned crossings, are shown in Figure 3-12.

**Figure 3-12: Existing Infrastructure and Crossing Locations**



The existing Tamar infrastructure that must be crossed consists of:

- Two (2) by 16” production pipelines running between the Tamar Manifold and the Tamar Platform;
- Two (2) by 4.5” MEG supply lines running between the Tamar Platform and the infield infrastructure, these were installed as piggyback lines on the 16” production pipelines; and



- Two (2) primary umbilicals running between the Tamar Platform and the infield infrastructure.

All of the above lie in a single corridor which is approximately 150 m wide. The IC1 Segment 8 cable system is single cable bundle which may be crossed by each pipeline in a single span.

Crossing of the above infrastructure will be by way of engineered crossings consisting of support structures located either side of the infrastructure to be crossed. The Leviathan infrastructure will be subsequently laid over the support structures to allow it to free-span over the crossed infrastructure without contact. This concept has previously been applied on the Tamar project to enable crossing of subsea cables.

The process for infrastructure crossing will be as follows:

1. Locate existing infrastructure using ROV visual or tone monitoring, existing as-built schematics and admiralty charts. Subsequently mark with buoys from the ROV;
2. Place crossing structures either side of infrastructure and secure as determined by seabed conditions;
3. Install Leviathan infrastructure across structures and existing infrastructure while maintaining continuous visual contact with an ROV to ensure no contact is made between infrastructures during installation;
4. Secure Leviathan infrastructure to the crossing structures; and
5. Perform an as built survey and document condition for future reference.

In order to maintain separation, each Leviathan transmission pipeline will require a dedicated set of crossing structures. Where a crossing is developed to support the Leviathan umbilical, this will be designed so as to provide sufficient support to ensure clearance of the crossed infrastructure.

The total number of pipeline crossings is dependent on the final installation method selected for the 6" MEG pipelines. If these pipelines are installed as standalone pipelines within the Leviathan transmission corridor, then the total number of crossings will be 24 (four (4) per line). However, if a piggybacked configuration is selected, the MEG pipelines will be piggybacked onto the 18" DSM production pipelines, and the number of crossings will be reduced to 16.

The crossing support structures will be constructed predominantly from steel and will be designed to ensure that they remain in place and continue to support the Leviathan infrastructure throughout the projects lifespan. Based on the analogous structures used during the Tamar development project, each structure will have the approximate dimensions of nine (9) m x three (3) m (W x L) giving a land take per structure of approximately 27 m<sup>2</sup>. The net effect of pipeline crossings on overall seabed land take is considered negligible as although the crossing structures represent additional footprint, they act to elevate the pipelines away from the seafloor and thus reduce the land take associated with the pipelines.

Crossing support structures will be installed from either the MSV or the OCV with ROV assistance during placement. This will be performed prior to the DP Pipelay Vessel reaching the crossing location to minimize the holding time during pipelay.



Future platform and pipeline operations are beyond the scope of this document and will be addressed in the Noble Energy operations and maintenance plans and procedures.

### 3.2.4 Leak Detection

The production system for full field development of the Leviathan Field will feature in excess of: 352.5 km of subsea production pipelines; 235 km of MEG supply lines; and 117.5 km of electrohydraulic umbilicals. Maintaining system integrity of infrastructure throughout the operations phase is critical to managing the environmental impact of the project. The following measures will be implemented to monitor subsea system integrity:

- Continuous monitoring of arrival pressure and flowrate of production fluids at the LPP to aid in rapid detection of a substantial loss of containment in the subsea production system. A low pressure trip on the LPP inlet facilities will detect any major breach in the pipelines and initiate production shut-down by isolating the system at the wellheads;
- A Production Management System (PMS) will be implemented which will receive and process subsea sensor readings from the infield infrastructure. This will be capable of performing a continuous mass balance on the production system and will thus detect potential leaks;
- Continuous monitoring of MEG pumping rates and inventory levels on the LPP to aid in rapid detection of a substantial loss of containment in the subsea MEG system;
- Continuous monitoring of production chemical consumption rates to aid in detection of loss of containment from umbilical cores;
- Continuous monitoring of hydraulic fluid consumption, with any continuous use indicating a loss of containment from the hydraulic cores within the umbilical;
- Periodic visual surveys, using ROVs, of the production system to identify signs of infrastructure damage or leaks; and
- A pipeline integrity assurance program will be implemented in accordance to Noble Energy's Global Integrity Management Program. This is based on a risk based approach and will consider operational data from other systems operating under analogous conditions.

### 3.2.5 Sources of Discharge into the Sea

Discharges into the marine environment may impact water quality with the potential for negative impacts on local marine ecosystems. Discharges to sea in Israeli economic waters during the construction and operations phases of the Leviathan Field development are detailed in the following sections. Accidental releases with the potential to arise as a result of the project are considered within Section 4.2.

#### 3.2.5.1 Construction

During the construction phase of the Leviathan project the primary sources of discharges to the marine environment will be marine vessels associated with installation and commissioning of the subsea infrastructure. Vessel discharges will include sanitary waste, grey water, organic waste,



and deck runoff. Additionally ballast and bilge water will be discharged at various times throughout the installation campaign. All discharges will be performed in compliance with relevant international and local regulations.

Based on data collected during the drilling of the Leviathan 4 well (Noble Energy Mediterranean Ltd, 2016a) domestic effluent generation rates are estimated on a per person basis and are provided in Table 3-14.

**Table 3-14: Domestic Effluent Generation Rates (per person)**

Discharge Type	Average Daily Rate (liters/day-person)
Sanitary Water	72
Grey Water	250
Organic Food Waste	6

During subsea facilities installation a range of marine vessels will be utilized. The largest of these is expected to be the DP Pipelay Vessel which, based on Allseas Solitaire, will have accommodation for up to 420 persons. This is considered representative as this vessel has previously been utilized on the broadly analogous Tamar development. Other vessels with substantial personnel capabilities include the MSV and the OCV, both of which are likely to have accommodation facilities in excess of 100 POB. Additional personnel located offshore will include those present on smaller vessels, such as supply and standby vessels, which may be expected to house between 20 and 40 POB each.

Based on all vessels being fully manned and in operation simultaneously, the peak offshore man count during the Leviathan development phase is estimated at approximately 700. The peak domestic effluent rates for a total compliment of 700 offshore workers have been estimated and are presented in Table 3-15.

**Table 3-15: Peak Domestic Effluent Rates (700 Persons Offshore)**

Discharge Type	Average Daily Discharge (m <sup>3</sup> / day)
Sanitary Water	50.5
Grey Water	175
Organic Food Waste	4.3

Discharges of Bilge, Ballast and deck water run-off cannot be quantified at this stage; however all of the above will be discharged in compliance with MARPOL 73/78 and Barcelona Convention requirements.

Additional discharges will arise from fluid discharge at the seabed during commissioning of pipelines and control systems. These have previously been quantified in Section 3.2 and are not discussed further in this section.

Discharges to the marine environment associated with the construction and commissioning of the LPP are not within the scope of this assessment, however these will occur. Discharges arising as



a result of construction / commissioning operations on the LPP will occur in the shallow water (approx. 86 m) immediately surrounding the LPP. Any discharges associated with the LPP will be minimized where practicable and will be subject to obtaining the relevant discharge permits prior to discharge occurring.

### 3.2.5.2 Operation

During the operations phase of the Leviathan development there will be no continuous discharges into the marine environment from the subsea production system (upstream of the LPP). This is a result of the closed loop nature of the production system, with no requirement for marine vessel support dedicated to production system operation. Discharges arising from the LPP are specifically excluded from the scope of this assessment.

Intermittent discharges to the marine environment will occur as a result of operation of hydraulically actuated valves on the infield infrastructure. Hydraulic fluid will be vented from these valves when they are allowed to move to their fail safe position, but is not anticipated when they are actuated in the other direction (from fail safe). As such a complete valve cycle (open to close to open, or vice versa) will result in a single discharge event.

The approximate discharge volume associated with a single discharge event from all infield valves (manifold and Xmas tree mounted) is an instantaneous release of 261 liters based on the initial eight (8) development wells. Of this approximately 117 liters is attributable to valves on the Infield Gathering Manifold.

There will be no discharges of hydraulic fluid from the production pipeline SSIVs (located in close proximity to the LPP) as the controls system for this equipment will be of a closed loop configuration with all vented fluids routed to the LPP for treatment, re-use or discharge as appropriate.

Actuation of subsea valves is only anticipated to occur during up-set operations or to enable maintenance and field shutdown. As such it has been nominally assumed that all subsea valves will, on average, be cycled twice per year. This will result in an annual discharge of hydraulic fluid (MacDermid Oceanic HW540P) of 522 liters. This discharge will be in the deepwater infield area (as per common industry practice) and will be distributed across the eight (8) well locations and the single Infield Gathering Manifold location.

Non-routine discharges occurring during Leviathan Field development will include any discharges arising from intervention activities and associated vessel presence. Any such operations will be subject to dedicated assessments and are not considered further within this assessment.

Discharges to the marine environment associated with the operation of the LPP are not within the scope of this assessment, however these will occur. Discharges arising as a result of operations on the LPP will occur in the shallow water (approx. 86 m) immediately surrounding the LPP. Any discharges will be treated to at least the most stringent applicable discharge quality and will be minimized where practicable. All discharges will be logged and subject to obtaining the relevant discharge permits.



### 3.3 Noise Hazards

Noise in the offshore environment may arise from either surface or underwater sources and can impact a wide range of fauna both physically and behaviorally. Noise is defined as unwanted or potentially harmful sound.

Noise sources occurring in Israeli waters associated with the Leviathan development have been identified for the construction and operations and are detailed in the following sections.

#### 3.3.1 Construction Noise Sources

Note that noises arising from drilling activities, particularly underwater noise, is out-with the scope of this assessment. Information pertaining to drilling activities is available in the Leviathan drilling EIA (Noble Energy Mediterranean Ltd, 2016a).

#### Underwater Noise Sources

A large number of vessels will be required over the course of the construction phase which will generate underwater noise levels greater than the background levels. The main sources of underwater noise during the construction phase will be associated with the propulsion systems of the vessels required for these activities. Supply and standby vessels will be required throughout the construction phase, while other vessels will only be on site during specific operations. For example, the pipelay vessel will only be present during the laying of flowlines and pipelines.

Table 3-16 presents the total operational duration of all vessels expected to be required during construction phase (installation, pre-commissioning and commissioning) assuming stand-alone MEG pipelines. These vessels will contribute to underwater noise.

**Table 3-16 Installation, Construction and Pre-commissioning Vessel Requirements**

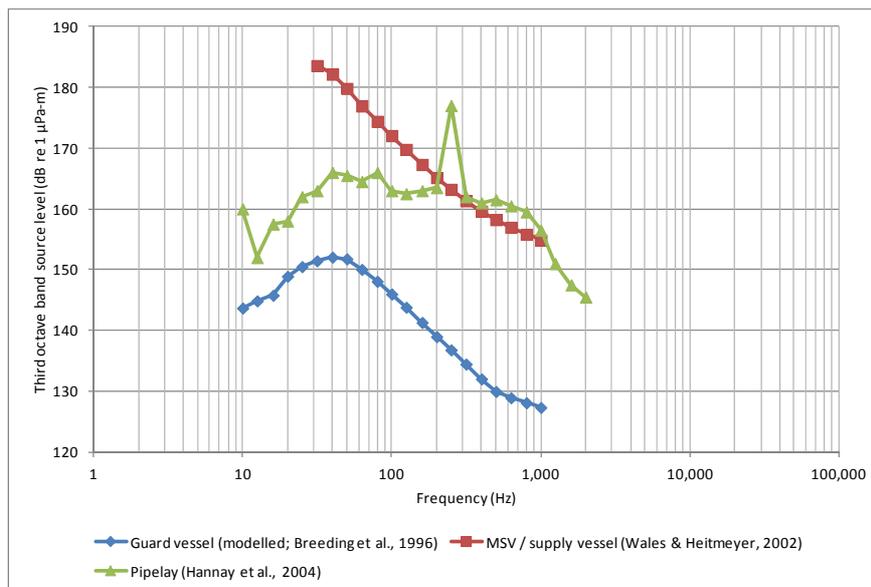
Vessel Operations	No of vessels	Total days on site
Pipelay Vessel	1	223 days
Pipelay Supply Vessel	1	223 days
Offshore Construction Vessel	1	110 days
Multipurpose Support Vessel with ROV	1	408 days
Standby Vessel	1	408 days
Supply Vessel	2	408 days
Helicopter	1	63 hours

Marine noise associated with vessels is characterized by low frequency sound from engine vibrations, broadband sound generated by hydrodynamic flow over a ship's hull and higher frequency tonal noise associated with propeller action and cavitation (Hildebrand, 2009). Noise levels tend to be higher for larger vessels and will increase with increasing vessel speed.



While noise data is not available for specific vessels identified as representative of those that will be used on the Leviathan project, published sound power level spectrum data for typical vessels of a similar type and size is available. Figure 3-13 presents typical sound power level spectra for standby / guard vessels, MSV, and pipelay vessels.

**Figure 3-13: Installation, Commissioning and Pre-commissioning Vessel Underwater Noise Characteristics**



Background levels of ambient noise in the low range spectra (10 – 300 Hz) throughout the world’s oceans is dominated by anthropogenic activities, primarily large scale shipping. Low frequency noise below 300 Hz shows very low attenuation over substantial distances and can result in significant ocean / basin wide background noise levels, even when the measurement site is tens to hundreds of kilometers from the nearest area shipping activity. As a result ambient noise levels in the world’s oceans in the low frequency band (that most associated with anthropogenic activity) range from 80 to 90 dB (re 1 µPa), although this may be expected to be higher in basins close to heavy shipping channels.

Owing to its proximity to the Suez Canal (approx. 200 km) and the shipping lanes associated with it, background noise in the Levantine basin may be expected to be greater than those typically found in the world’s oceans. Potter et al. (1997) measured ambient noise levels in shallow water (i.e., 4 to 5 m depth) offshore Haifa. At low frequencies (a few hundred hertz or less), the ambient noise spectra exhibited characteristics of medium to heavy shipping noise. As such a background noise level of 100 dB (re 1 µPa) is considered in this assessment.

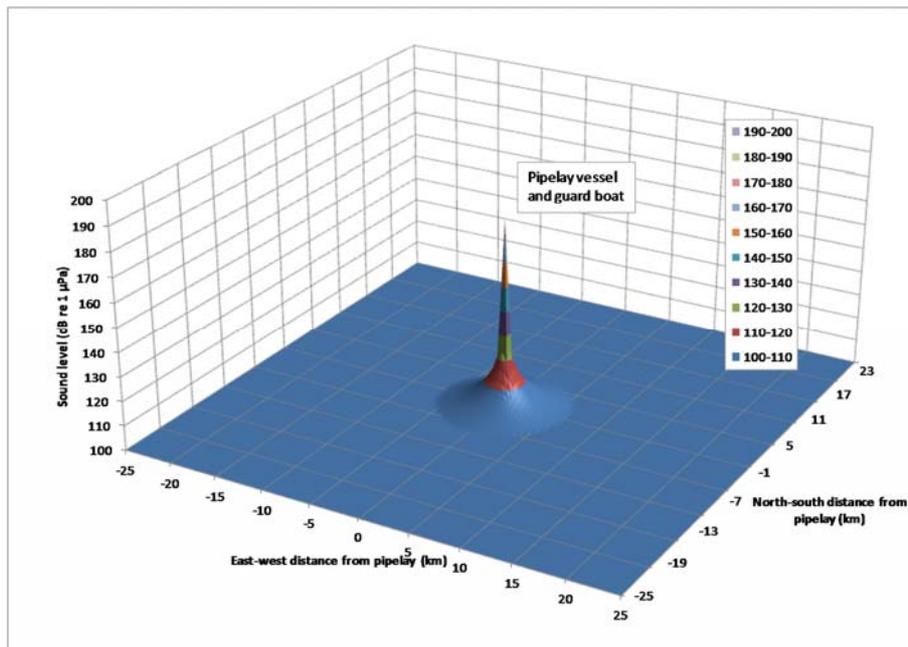
Figure 3-14 and Figure 3-15 show the propagation of underwater noise from the installation vessels anticipated to be used for pipelay activities associated with the Leviathan Field development. Figure 3-14 is based on operations in the deepwater environment, while Figure 3-15 utilizes the same basis but applied to the environment close to Israeli territorial waters. These show that sound generated in either of these environments as a result of Leviathan development activities



will show rapidly decreasing sound pressure (as measured in dB) as it propagates across the environment, until it reaches the assumed background level of 100 dB (re 1  $\mu$ Pa).

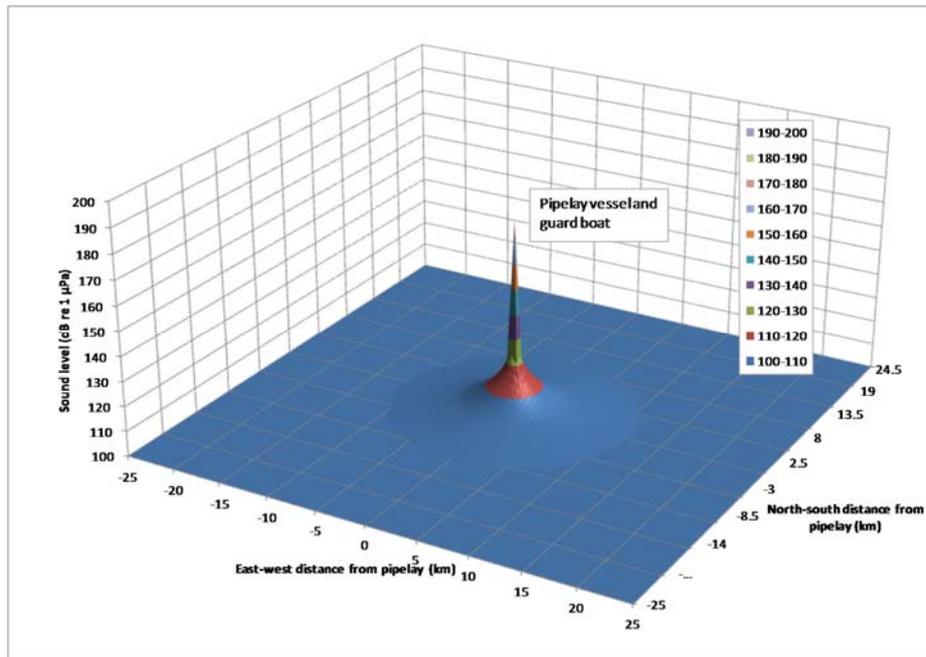
Observable incremental noise as a result of the Leviathan Field development activities is expected to be limited to a radius of approximately 7 km in the deepwater and 12 km in the shallow water. The majority of this area is limited to an incremental noise level of less than 10 dB (re 1  $\mu$ Pa).

**Figure 3-14: Modelled Propagation of Underwater Sound during Pipelay (deep water)**





**Figure 3-15: Modelled Propagation of Underwater Sound during Pipelay (shallow water)**



### Atmospheric Noise Sources

Atmospheric noise sources associated with the construction phase of the Leviathan project will primarily arise from three (3) sources:

1. Vessel propulsion systems;
2. Construction activities on board vessels; and
3. Intermittent helicopter flights to and from construction vessels.

The scope of this Production EIA extends from the LPP (10 km offshore) to the infield infrastructure approximately 125 km offshore. As such atmospheric noises arising from the project are not expected to significantly impact onshore communities. However it should be noted that periodic onshore disturbances will occur as a result of helicopter flights transferring personnel to / from onshore locations to the construction vessels. Transfers are expected to occur once a week during the construction phase and will present only a brief increase in background noise. Further, to minimize the impact of these flights, all scheduled flights will be scheduled during day-time hours and will avoid low flying over populated areas.

Any emergency helicopter flights will be routed by the most direct, approved flight path from their onshore location.

### 3.3.2 Operational Noise Sources

Following field start-up there will be no vessels or surface facilities permanently on station and dedicated to the operation of the subsea production system (the LPP is excluded from this assessment). As such continuous underwater noise sources will be limited to low level noises



associated with multi-phase flow of production fluids through the production system. During normal operation the velocity of gas flowing through the production system will be maintained below conventional limits to minimize pipeline erosion and protective scale stripping. Maintaining velocities below these limits will also act to minimize subsea noise production.

No atmospheric noise sources directly related to the operation of the subsea production system are expected during the operations phase.

### 3.4 Hazardous Materials

Hazardous materials are controlled in Israel by the “Hazardous Substances Law 5753-1993” and its subsequent revisions. This defines “Hazardous Substances” as “a hazardous material or harmful chemical” and is defined as:

- Hazardous material – Any substance identified under Schedule Two of law 5753-1993 be it in its simple form or mixed / blended into other substances.
- Harmful Chemical – Any substance identified under Schedule One of law 5753-1993 be it in its simple form or mixed / blended into other substances.

In general, hazardous materials include the following:

- Substances which contain prescription medicines;
- Substances which have a flash point of less than 55°C;
- Any material which contains components that are deemed to be any of:
  - An oxidant;
  - Toxic;
  - Corrosive;
  - Harmful;
  - An Irritant;
  - Carcinogenic;
  - Infectious;
  - Teratogenic;
  - Mutagenic; or
  - Ecotoxic.

#### 3.4.1 Construction

At the current level of design the hazardous materials and quantities thereof to be used and generated during the production system installation, pre-commissioning and commissioning phases are not known. However, typical hazardous materials associated with offshore construction and commissioning work include; fuel oil / diesel, oil based lubricants, organic solvents, oil contaminated fabrics, medical supplies / wastes, and chemicals used to inhibit water during hydrotest operations.



Hazardous materials will be handled in accordance with company requirements and as a minimum shall conform to national legislation. Where a hazardous material becomes a waste it will be managed through the installation contractors Waste Management Plan (WMP), which itself will be compliant with Noble Energy's asset specific WMP, the requirements of which are laid out in Noble Energy's waste management program (Noble Energy Mediterranean Ltd., 2015).

Hazardous materials associated with the installation and commissioning phase of the project will be assessed in detail during project detailed engineering when the EPC contractor has been selected.

### 3.4.2 Operation

Throughout the Leviathan operational phase, hazardous materials will be present in the production system as liquid and gaseous hydrocarbons. In addition, production chemicals required to manage hydrate formation, pipeline corrosion and scale deposition are expected to be classed as hazardous materials. Further, any solids produced (e.g. sand) from the production wells will be hydrocarbon contaminated and should thus be considered a hazardous material.

During normal operations the Leviathan subsea production system (including chemical injection) will be a closed system with no discharge to the marine environment. If a break of containment is planned for any area of the production system, this will be subject to a dedicated planning and permitting process which does not fall within the scope of this document.

Operational discharges of hydraulic fluid from the controls system are considered under Section 3.2.5.2.

## 3.5 Geological and Seismic Risk Assessment

As per the information presented in Chapter A, the Leviathan Field and the proposed development infrastructure lie in what has historically been a geologically active area.

To ensure geological and seismic risks to the subsea production system are managed the following engineering guidelines / standards will be applied during detailed design of the pipelines:

International Organization for Standards (ISO) 19901-2 shall be applied for the following purposes:

- Estimating seismic load on the pipeline system outside of Israeli territorial waters;
- Estimating seismic load on foundations associated with the pipeline system outside of territorial waters;
- Estimating seismic loads on pressurized components of PLETs and In Line Structures (ILS) outside of territorial waters; and,
- Estimating seismic loads on foundations of equipment located within Israeli territorial waters.



Det Norske Veritas (DNV) standard DNV-OS-F101 shall be applied in order to estimate the seismic response of the pipeline system outside of territorial waters when subject to seismic loads as determined from ISO 19901-2. Guidelines from the Pipeline Research Council International (PRCI), and the Multidisciplinary Center for Earthquake Engineering (MCEER) will be used as appropriate;

DNV-OS-C101 shall be applied to determine limit states for foundation design associated with infrastructure that is located outside of Israeli territorial waters;

ISO 19901-4 shall be applied to determine the seismic design criteria for foundations associated with infrastructure that is located outside of Israeli territorial waters;

American Society of Mechanical Engineers (ASME) standard ASME B31.8 will be applied to determine the seismic design criteria for PLETs and ILS associated with the pipeline infrastructure outside of territorial waters;

Israeli Standard (SI) 413 will be used, in conjunction with the American Society of Civil Engineers (ASCE) standards ACSE 7-05 and ASCE 7-10, to estimate seismic loads for the pipeline system within Israeli territorial waters; and

Nederlandse Norm (NEN) standard NEN-EN 1594 shall be applied, in conjunction with PRCI / MCEER guidelines to determine seismic design criteria for equipment foundations within Israeli territorial waters.

### **3.6 Abandonment of the Field and Dismantling of the Infrastructure**

The production life of the Leviathan Field is expected to be in excess of 30 years and as such abandonment and decommissioning plans for the pipelines, umbilicals and infield structures will not be developed prior to initial production. However, any future decommissioning plans / activities will follow the general principles that all work will be conducted in a manner that is safe, does not reasonably interfere with other users of the sea, and does not cause undue or serious harm or damage to human, marine or coastal environments. Further, all activities will be completed in accordance with the lease requirements associated with the Leviathan development, industry best practice, applicable regulations in place at the time (including MoEP and MEWR requirements and guidelines), and in compliance with industry-wide decommissioning requirements and recommendations.