ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT (ESIA) FOR PRINOS OFFSHORE DEVELOPMENT PROJECT

Chapter 6 Project Description

TABLE OF CONTENTS

TABLES

DIAGRAMS

MAPS

FIGURES

PHOTOS

DRAWINGS

ABBREVIATIONS

AG	Associated Gas
API	American Petroleum Institute
BA	Breathing Air
BASF	Triethylene glycol
BOP	Blow Out Preventor
CCR	Central Control Room
DES	Drilling Equipment Set
EIS	Environmental Impact Study
ENERGEAN	Energean Oil & Gas S.A.
EOR	Enhanced Oil Recovery
ERD	Extended Reach Drill
ESD	Emergency Shut Down
ESIA	Environmental & Social Impact Assessment
ESP	Electric Submercible Pump
FEED	Front End Engineering Design
HSE	Health, Safety and Environment
HZW	Hazardous Waste
IOR	Improved Oil Recovery
MCC	Motor Control Center
MPFM	Multi-Phase Flow Meter
MPME	Most Probable Maximum Extreme
NAG	Non-Associated Gas
NDT	Non Distractive Testing
NORMs	Natural Occurring Radioactive Materials
NUI	Normally Unattended Installations
PAR	Personnel Access Ramp
PFD	Process Flow Diagram
QRA	Quantitive Risk Assessment

ROV	Remotely Operated Vehicle
SIP	Self-Installing Platform
SPT	SPT Offshore BV
TEG	Triethylene Glycol
TUTU	Topsides Umbillicals Termination Unit
UPS	Uninterruptible Power Supply
WMP	Waste Management Plan
WW	Waste Water

6 PROJECT DETAILED DESCRIPTION

6.1 EXISTING FACILITIES

6.1.1 Overview

Because a unified offshore permit is being sought that combines the existing facilities, which are already permitted, with the new proposed facilities, the existing facilities have been included in this ESIA. Note that because these existing facilities are in their operations phase, this ESIA has considered their potential impacts to resources and receptors through the evaluation of current baseline conditions. For this reason, the only additional activities associated with the existing facilities that will be assessed in the Assessment and Evaluation of Environmental and Social Impacts Chapter will be those that have not yet occurred: any unplanned events such as large oil spills and abandonment. Note that specific abandonment activities for the existing platforms and pipelines are discussed with the abandonment activities for the new facilities.

Energean is currently engaged in the exploration, production and exploitation of hydrocarbons as per the concession agreement ratified by the Greek parliament with Law 2779/1999 (as amended by the ratifying Laws 4135/2013, 4296/2014) covering the offshore areas of Prinos and South Kavala situated within the Gulf of Kavala, Greece.

To date eight separate hydrocarbon deposits have been discovered in the Gulf of Kavala. Three of these (South Kavala, Prinos and Prinos North) are in production. Epsilon has been appraised and is ready to be developed. These deposits contain a wide variety of hydrocarbons. South Kavala contains sweet lean gas with a small volume of API 61 condensate. API refers to an American Petroleum Institute rating system for the density of the hydrocarbon. Two unappraised discoveries (Athos and Zeta) contain light sweet oil and associated gas. The remaining fields contain sour crude (crude oil with high hydrogen sulphide content is referred to as sour crude) and associated gas. Sour crude quality varies from 37 API in Epsilon, through 28 API in Prinos, 21 in Prinos North and 12 in Amotheus. Amotheus sits outside the area operated by Energean and is the only discovery in the Nestos sub-basin.

Initial processing of the produced reservoir fluids is conducted on the offshore Prinos Complex, primarily the Delta platform. Oil, water and gas are separated in a single stage of separation. Produced gas is dried before flowing under available pressure energy to shore for further treatment. Produced crude oil is dehydrated and then pumped to shore to ensure no gas breakout occurs in the pipeline. Produced water is treated and cleaned (of oil and hydrogen sulfide) before being discharged to sea at the seabed in line with environmental permit conditions and set limits. On the Prinos Complex there is also equipment to abstract seawater, treat it and inject it into reservoirs in order to maintain reservoir pressure. There is also equipment for compressing sweet gas in the wells to assist production, the technique known as gas lift. Partially processed oil and gas are sent to the onshore Sigma plant processing facility via pipelines for further processing and export. Electricity is sent to the offshore complex via two (2) independent medium voltage submarine cables.

The Prinos Complex is made up of four platforms. Alpha and Beta are production or drilling platforms each containing twelve (12) drilling slots, that can be used for production or injection wells. Delta platform contains all of the processing equipment and the control room. A small jacket bridge linked to Delta contains a remote flare. The Prinos North field is exploited via an Extended Reach Well drilled from Alpha platform. South Kavala is exploited via a production platform identical to Alpha and Beta. This platform contains two (2) wells plus equipment to compress and dry produced gas. South Kavala platform is unmanned and operated remotely from Delta.

Kappa platform is located in the Gulf of Kavala, above the sweet (no hydrogen sulfide content) natural gas deposit of South Kavala, 12 km to the southeast of the Prinos platforms complex. Currently the Kappa platform is produced intermittently.

Partially processed oil and gas is transported through submarine pipelines to the onshore plant, called Sigma plant. The Sigma plant includes units for 1) converting produced sour gas to sweet gas producing sulfur by a chemical reaction of hydrogen sulfide, 2) for the dehydration, desalination, stabilization and storage of the produced crude oil and 3) facilities in order to safely load treated oil to tankers.

It is noted that for the current operations described there is a prohibition area of 500 m radius over the pipeline routes and the platforms. This is presented in the official naval charts (map below), where a total area of 39.71 km^2 is defined as an exclusion zone for all marine activities.

Moreover, power and gas are currently imported into Sigma from national infrastructure. Sigma is equipped with a 17 MW power plant but is not operated as all produced gas is used for steam production at Sigma and for gas lifting offshore production wells. If gas production increases significantly, excess gas will either be exported for sale purposes or used for Sigma's energy requirements. Stabilised crude is loaded to tankers through Energean’s own offshore loading terminal that lies in a distance of about 3 km to the south of Sigma. Sulphur is sold locally.

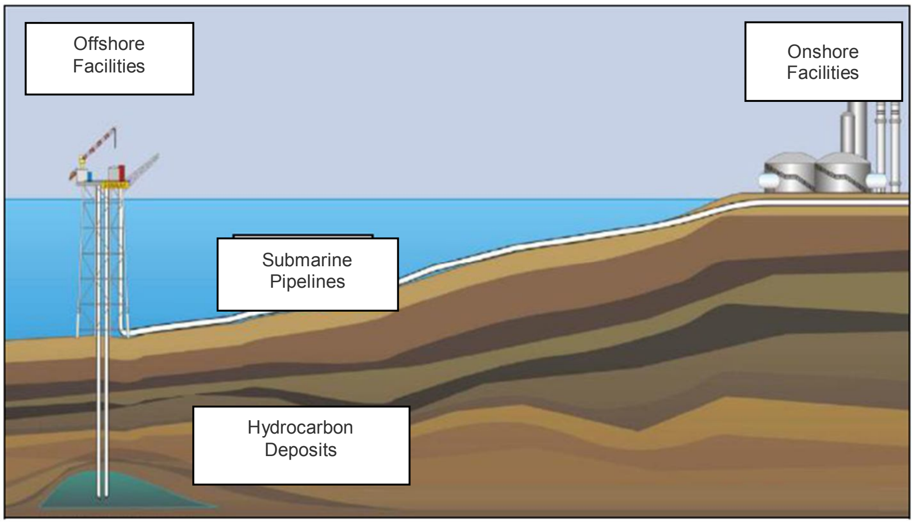
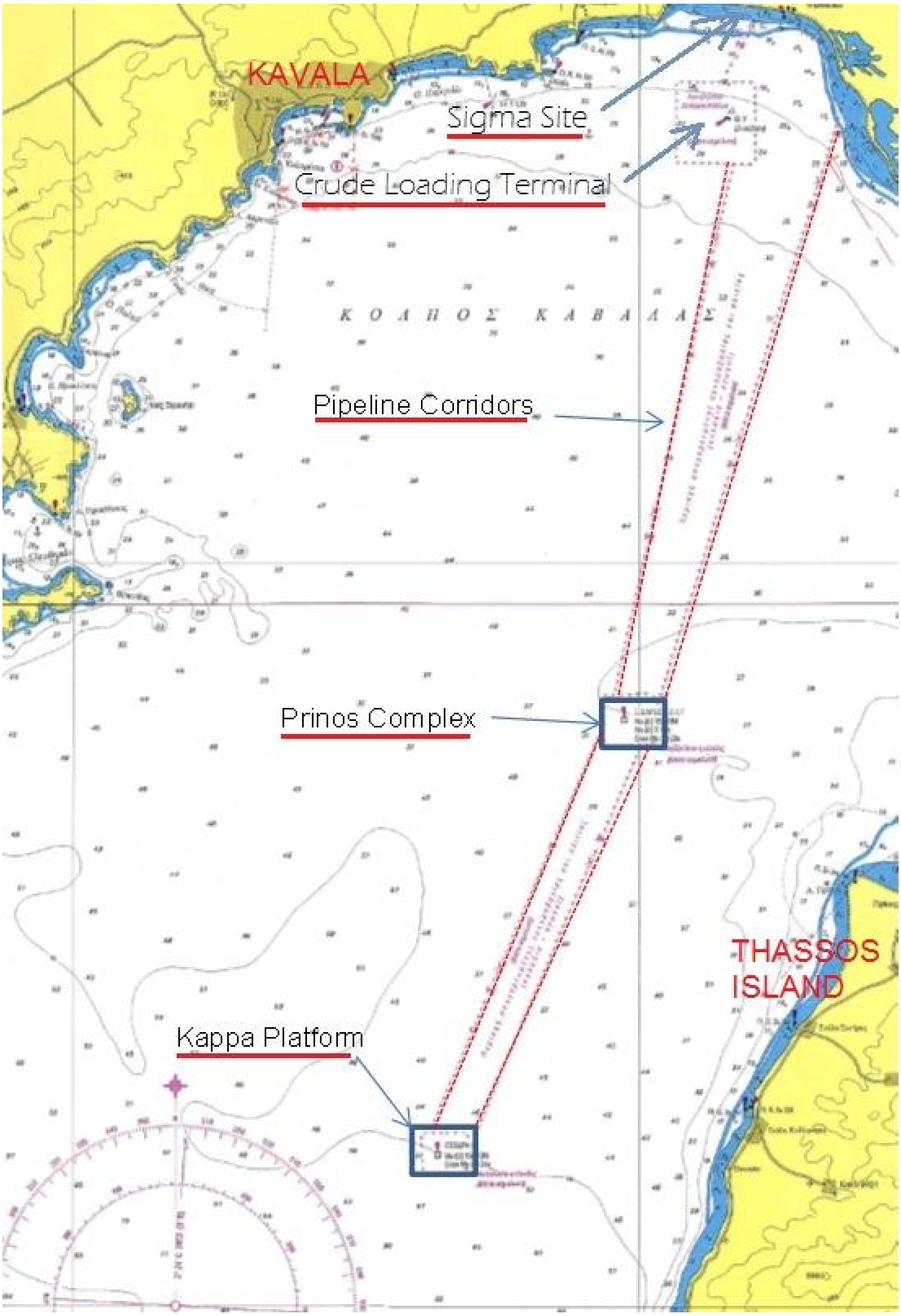


Figure 6-1: Existing facilities arrangements



Map 6-1: Existing facilities of Prinos and South Kavala fields

6.1.2 Hydrocarbon extraction

The reservoir is a geological structure consisting of high porosity rock (commonly sandstone) covered by impermeable rocks (shales or evaporates). Hydrocarbons are located within the porosity of the formation at relatively high pressures and temperatures such that there is often no separation between gaseous and liquid phases (depending on the hydrocarbon fluids phase behaviour). Gas is liberated from the oil as the hydrocarbons flow to surface and the pressure declines. In an oil field produced gas is commonly referred to as Associated Gas (or AG). In a gas field where no oil is present it is referred to as Non-Associated Gas (or NAG).

Hydrocarbons are extracted from a reservoir by wells. A well is effectively a series of pipes of reducing diameter that are cemented into place. A Drilling Rig is used to construct a well. Drilling rigs can be mobile (move from location to location) or fixed (dedicated to a particular structure/field). The existing facilities include wells that have been drilled historically, but there is also ongoing drilling of new wells in these locations, which have already been permitted and assessed in an EIS.

The total number of personnel working onshore is 146 and the total number of personnel working offshore is 90 employees. 3 shifts, each working for 8 hours during the 24 hours day operations. The day working personnel is supported by 31 contractors working in the plant on a permanent base. The offshore crew changes are carried out by the company's crew boats and the onshore crew changes by busses.

6.1.3 Platform 'Kappa'

Kappa platform is located in the Gulf of Kavala, above the sweet (no hydrogen sulfide content) natural gas deposit of South Kavala, 12 km to the southeast of the Prinos platforms complex. The deposit is located at a depth of 1,700 m; produced gas has a methane content (CH_4) exceeding 80%.

The Kappa platform is a 4-legged steel jacket equipped with two (2) decks. Sea depth at the point is reaching 52 m.

Kappa hosts two wells (SK-3B, SK-4) which are located on the lower deck and processing equipment mainly on the lower but also on the upper deck.

Gas from the Kappa wells flows to a horizontal separator where free condensate is removed. The gas is then compressed to 12 bar by a screw compressor and cooled and condensed liquids removed in a discharge separator. Gas is then passed through a glycol contactor to remove water. The combined gas and condensate production stream flows multi-phase to Prinos Delta where it mixes with dried sour gas from that facility. Small quantities of water are removed on Kappa. Entrained condensate is separated by gravity in a skim pile before water (about 150-200lt/d) is discharged to sea.

The process flow diagram (PFD) 523-2700-P-002 is presented in Annex 2.

A small gas compressor (C-666 B) also assists the production and transport of natural gas by increasing the pressure gradient between the separator (V-171B) and the pipeline (12 and 8 bar respectively). For this operation, there are two generators of 440 KW each (one in operation and one on standby mode).

Kappa is operated remotely from Prinos Delta, without the presence of any local personnel. The two platforms are connected with a 6'' submarine pipeline with a length of 12 km, transporting sweet dehydrated natural gas to Delta upper 20-30 bar operating pressure.

Currently the Kappa platform is produced intermittently. Average production length is about 10 days per month, with durations being longer in the summer months and shorter in the winter. Energean is reviewing options to bring Kappa back into full production.

The operational license for the South Kavala field expired in November 2015. The Greek government is examining options to convert the field into a site for gas storage. It is expected that Energean will be request to manage and maintain the facility and hence although it is not a core asset has been covered by the current EIS.

Focus has been on the fields and facilities containing sour crude as these have significantly more potential for causing environmental impacts than a low-pressure sweet gas field with little free liquid content.

Photo 6-1: Kappa platform

6.1.4 Platforms 'Alpha', 'Beta' and 'Delta'

The Prinos deposit is located in the Kavala Gulf, approximately 8 km to the west - northwest of the Prinos lighthouse of the island of Thasos, at the southern edge of the Kavala Bay and approximately 18 km to the south of the city of Kavala.

It is a crude oil deposit with dissolved sour natural gas, which means that the deposit has a high content of hydrogen sulfide. This toxic gas and the presence of water, gives corrosive properties to the produced liquids and, in low temperatures, it contributes to the formation of hydrates.

The specifications of the materials that have been used for the construction of the equipment are such that they have the ability to limit the corrosive action of the hydrogen sulfide to a minimum. In addition, all safety equipment of the platforms and the personal safety measures for the personnel have been designed taking into account the presence of hydrogen sulfide, in order to limit and mitigate all possible risks.

The Prinos platforms complex comprises:

- **Two production platforms** - **Alpha** and **Beta**, each one having slots for 12 wells. These platforms have been designed so that they can house Energean's drilling, work-over and service rigs. Alpha has been recently upgraded to allow it to host the Drilling Equipment Set of Energean's tender assisted drilling barge, the 'Energean Force'.

Photo 6-2: Platform Alpha

Photo 6-3: Platform Beta

- **One processing platform - Delta,** where the following procedures are performed:
  - ⇨ Separation of the production phases - sour crude oil, water and natural gas;
  - ⇨ Dehydration of the crude oil via electrostatic separation;
  - ⇨ Transport of sour crude oil to the land facilities by means of a pump and an 8” submarine pipeline;
  - ⇨ Dehydration of sour natural gas with triethylene glycol (TEG);
  - ⇨ Transport of sour natural gas from the platform Delta to the land facilities, via a submarine pipeline with a diameter of 12”;
  - ⇨ Processing of the water produced (removal of hydrocarbon residues and removal of hydrogen sulfide) and disposal at sea;
  - ⇨ Injection of sea water into the Prinos reservoir, in order to maintain pressure;
  - ⇨ Compression of sweet gas transported offshore from Sigma to be used as gas lift in the Prinos wells.

Photo 6-4: Platform Delta

Alpha and Beta, as well as the flare structure, are connected to Delta via bridges. These support the pipelines and provide for access to the personnel. The platforms are equipped with all required support systems for proper and safe operation. Power is supplied to the platforms from the land facilities via two submarine cables, each one of which being able to cover the needs of the platforms.

The Prinos Complex has no permanent accommodation. Due to high levels of H_2S content in the deposits and the potential risk in the event of a release, staff sleeping offshore would be subject to unacceptable levels of risk. All staff instead is based onshore transferring to the platforms as dictated by their work shift. Boat transportation is used instead of helicopters to minimize risks. Production staff is split into 5 teams that cover a full 24-hour period in three shifts. Each team comprises 10 people. Maintenance work is undertaken on day shifts only Monday to Friday. Maintenance staff travels to and from shore as required.

Energean's tender assisted barge, the Energean Force, contains accommodation for 126 people. The accommodation unit is located approximately 100m from the platform complex in a location that cannot be impacted by H_2S releases. The accommodation module is pressurized with air inlets protected by CH_4 and H_2S monitors and automatically closing louvres. All staff carries personnel BA equipment in case of emergency. Drilling staff work 12-hour shifts either for 28 days on / 28 days off or 14 days on / 4 days off.

6.1.4.1 Platform "Delta" topside facilities

6.1.4.1.1 Separation of the three oil phases

Three, three-phase separators are located on the upper deck of the Delta: V-101A & B and V-107. V-101A & B separators are operated in parallel and effect primary separation of the combined Alpha and Beta production stream; V-107 is a test separator and is used periodically to evaluate the production of individual wells. The test separator is equipped with instruments for measuring the flow of gas, crude oil and water. Tests can be performed without effecting flow from the other wells. The separators operate at a pressure between 12 and 17 barg and a temperature of 80°C.

Since separation in the 1st stage separators is not perfect, further processing at Delta is necessary. The factors that do not allow perfect separation in the first place are:

- Existence of crude oil/water emulsions, contained in the crude oil phase;
- The separated natural gas is saturated with water vapor;
- The separated produced water is saturated with hydrogen sulfide and contains hydrocarbon droplets.

The process flow diagram (PFD) is presented in 523-2000-P-002A in Annex 2.

6.1.4.1.2 Crude oil dehydration

The dehydrator V-102 is located on the middle deck of Delta; flow to this vessel is by gravity from the 1st stage separators located on the upper deck.

Separated crude oil and emulsions are transported to V-102. Demulsifier chemical is added at the entrance of V-102, while an anti-corrosive agent is added at the exit (for the protection of the 8” pipeline from internal corrosion). The dehydrator operates under a pressure between 12.5 and 17.5 bar (g) and a temperature of 80ºC.

Produced water remains in V-102 for approximately 30 minutes, while the crude residence time is 40 minutes. This is a sufficient period to allow the emulsions to be broken. Following dissipation of the emulsions water droplets agglomerate and sink to the bottom, whereas the crude oil rises to the oil layer. The method used for the separation is electrostatic separation.

Crude oil is transported from the dehydrator to the land facilities by means of two centrifugal pumps, (one is a backup pump), through a submarine 8” pipeline, with a length of approximately 18 km.

The process flow diagram is presented in 523-2000-P-002A in Annex 2.

6.1.4.1.3 Dehydration of sour gas

The gas separated in V-101A & B and V-107 (when in operation), is transported to the sour gas dehydration unit, where water is removed. This takes place in order to avoid any issue with internal corrosion of the 12” submarine gas transport pipeline, as well as in order to avoid any issues caused by blockage of the pipeline due to the formation of hydrates.

The gas dehydration process includes the following stages:

- Cooling of the gas at 50°C with the air coolers E-101A & B;
- Collection of concentrates in the container V103A and redirection of the concentrates, by the pumps P-103C & D, to the separators V-101A & B;
- Absorption of the water at tower V-104, where the incoming gas comes into contact with glycol (TEG);
- Recovery and recirculation of the glycol (low pressure separator V-109, filters F-104A & B, reboiler E-102, warm/cool glycol exchanger E-103, recirculation pumps P-105A & B and air cooler E-104).

Following dehydration, the sour gas is mixed with the sweet gas from the Kappa and, flows via the 12” submarine pipeline (without compression) to the shore facilities.

The process flow diagrams are presented in 523-2000-P-002A and 523-2000-P-002B in Annex 2.

6.1.4.1.4 Treatment of produced water

Produced water from separators V-101A & B and V-107 is transported to de-oiler M-111. This is a horizontal vessel (diameter of 1,850 mm x 7.625 mm length) that performs the following functions:

- Separation and removal of small gas and hydrogen sulfide quantities, which are generated as the water flashes from the high pressure of the separators to atmospheric pressure of the de-oiler;
- Separation of oil droplets from the water via gravity and with the help of special agglomerating plastic nets;
- Collection of oil and removal to the oil collector M-166;
- Removal of water and transfer to the second in-line de-oiler, M-111 B.

The agglomerating part of the de-oiler provides a large contact surface, where the oil droplets attach, join each other, rise to the surface and create an oil layer. The oil is collected in the oil collector and from there it is transported to the oil collector M-166 and, subsequently, to the oily water and oil collection vessel V-133.

When a sufficient amount of liquid is collected, the automatic level monitoring system activates one or both pumps, P-133 A & B, depending on the level, which returns the liquids from V-133 to the entrance of separators V-101 A/B.

Water from the coalescence section of the de-oiler is transported to the quiescent zone at the back of the vessel, where any oil droplets are separated through the force of gravity and subsequently it is transported to the hydrogen sulfide stripper V-111.

Despite the fact that the first de-oiler M-111 normally achieves full retention of oil, a second de-oiler is installed in series, of a similar design but with significantly larger capacity, the M-111B de-oiler (diameter 2,700 mm x 6,650 mm length) operates at zero pressure. The second in-line de-oiler M-111B safeguards the water discharge quality should any mal operation of the upstream separation equipment occur. In normal operation no oil is removed from this vessel.

The capacity of the two de-oilers, currently installed in series, is 164 m^3/hr (3,936 m^3/d). The two de-oilers can operate in parallel with a total capacity of 238 m^3/hr (5,712 m^3/d).

The hydrogen sulfide stripper V-111 is a tower with a height of 30 m with 35 trays, and operates at an almost zero pressure and at a temperature of 77°C. Residual hydrogen sulfide is removed from the produced water in this tower.

Hydrogen sulfide removal is achieved by means of a sweet natural gas stream. The addition of hydrochloric and citric acid at the entrance of the stripper, contributes to the removal of hydrogen sulfide and the avoidance of the formation of scale inside the stripper.

The stripper has been designed for a total produced water rate of up to 100 m^3/hr (2,400 m^3/d). When the produced water exceeds 100 m^3/hr, the excess quantity of produced water is directed immediately to the skim pile M-164, after having passed through the de-oilers M-111 and M-111 B. Currently and in the future, the quantity of produced water does not exceed 100 m^3/hr.

The high capacity and the good performance of the de-oilers of platform Delta (M-111, M-111 B) means that the water produced at the exit of the de-oilers - which subsequently enters the stripper V-111, contains minimum residue of hydrogen sulfide, which can, in turn, be removed at the separator M-164 (skim pile) and the subsea settlement tank TK-164, where the treated water ends up. This fact permits the avoidance of the operation of the stripper V-111 when water flow is low.

The produced water injection system is designed to reduce the concentration of oil in water to 10 ppm. Routine sampling is undertaken to confirm that this level is achieved. The actual concentration of water discharged to the sea is somewhat below this level as due to residence time in the skim pile and subsea settlement tank additional oil droplets coalesce and segregated oil pumped back to the platform.

The process flow diagrams are presented in 523-2000-P-003, 523-2000-P-045A and P-045D in Annex 2.

Photo 6-5: Skim pile M-111

Photo 6-6: Skim pile M-111B

Photo 6-7: Stripper V-111

Photo 6-8: Skim pile M-164

6.1.4.1.5 Sea water injection system

Seawater is injected to the Prinos reservoir in order to maintain pressure, and hence increase recovery rates. This assembly comprises the following equipment:

- Sea water suction pumps P-121 A/B/C/D, with a capacity of 135 m^3/hr each, with a differential pressure of 9.5 bar;
- Filtering system, which includes three first stage filters S-121 A/B/C, two sand filters of dual flow, the F-121 A/B, and two filters F-122 A/B, equipped with customized special filtration cartridges that allow retention of up to 5 microns;
- In order to control development of marine organisms, chlorination systems are used (hypochlorite generators CH-121 A/B) and supply of special biocides;
- One vacuum degassing tower DA-121, which removes the oxygen and the carbon dioxide dissolved in the seawater, protecting the pipelines and the piping of the production and the injection wells from corrosion.
- Auxiliary seawater injection pumps P-118AA and P-123 AA/BB/CC and main injection pumps P-123 A /B/C, with a capacity of 100 m^3/hr each one, with a final discharge pressure 290 barg.

The process flow diagram is presented in 523-2000-P-008 in Annex 2.

6.1.4.1.6 Gas lift system

Prinos wells require artificial lift to enable them to produce to surface. To date gas lift has been used for artificial lift on Prinos. A gas lift system was retrofitted on the facility in the early 1990's as reservoir pressures fell and water cuts increased.

Sweet gas from Kappa or from the onshore facilities is used in the gas lift system. Injection is normally at 125 bar, though when kicking off wells the pressure can be increased to 178 bar.

The gas lift system comprised the following five (5) compressors and the respective gas distribution network to the production drills:

- C-121: Test gas lift compressor with a supply of 1,120 Nm^3/hr

- C-122: Kick-off gas lift compressor with a supply of 1,120 Nm^3/hr
- C-123: Main gas lift compressor with a supply of 8,956 Nm^3/hr
- C-124: Kick-off gas lift compressor with a supply of 1,532 Nm^3/hr
- C-125: Main gas lift compressor with a supply of 8,043 Nm^3/hr

The process flow diagram is presented in 523-2000-P-002C in Annex 2.

6.1.4.2 Platform "Delta" support systems

6.1.4.2.1 Cooling water system

Cooling water requirements of motors with radiators are satisfied by the use of seawater, drawn by the pump P-171.

In addition, cooling water may be taken from the firefighting water system, from pumps P-161, P-162 and P-163 D. Finally, water may be supplied to the platform Delta from the Valiant Energy supply vessel, with the use of its own pump.

The water from the radiators discharges directly to sea.

Table 6-1: Water use

Source	Average consumption (m^3/d)						Maximum consumption (m^3/d)					
	Distribution network	Surface water	Underground water	Recycling	Total (1+2+3+4)	Seawater	Distribution network	Surface water	Underground water	Recycling	Total (7+8+9-10)	Seawater
Usage	1	2	3	4	5	6	7	8	9	10	11	12
Process	-	-	-	-	-	-	-	-	-	-	-	-
Cooling	-	-	-	-	-	1,200	-	-	-	-	-	1,440
Injection	-	-	-	-	-	1,500	-	-	-	-	-	3,000
Potable	10	-	-	-	10	-	15	-	-	-	15	-
Total	10	-	-	-	10	2,700	15	-	-	-	15	4,440

The process flow diagrams are presented in 523-2000-P-040, P-041 and P-041A in Annex 2.

6.1.4.2.2 Fuel gas system

Natural gas is consumed at Delta:

- By the glycol reboiler for the dehydration of sour natural gas;
- By the produced water stripper V-111;
- By the flare in order to ensure safe operation (pilots and purge);

Gas consumed is sourced either from the inlet line from Kappa or from the line from shore feeding the Prinos gas lift system.

Total gas consumption is presented in the table below (fuel consumption).

6.1.4.2.3 Diesel fuel system

Diesel is stored in the interior of the southeastern leg of Delta. The tank has an internal diameter of 1 m, a height of 7.6 m and a capacity of 5.8 m^3.

It is equipped with a ventilator, a draining system, an overflow, a level sight glass and high and low level switches that activate the respective alarm. The ventilation system consists of a 2” line, a flame catcher and an open-air vent.

Table 6-2: Fuel gas system

Fuel type	Production (tons / month)	Consumption		
		Steam generation (tons / month)	Other usages (tons / month)	Total (tons / month)
Gasoline	-	-	-	-
Diesel	-	-	79	79
Fuel oil 1,500’’	-	-	-	-
Fuel oil 3,500’’	-	-	-	-
LPG	-	-	-	-
Coal gas	-	-	-	-
Natural gas	-	-	67	67
Solid fuels type	-	-	-	-

The process flow diagram is presented in 523-2000-P-002A in Annex 2.

6.1.4.2.4 Instruments air system

The platform instrument air system comprises three, two stage compressors used, with a capacity of 295 and 370 Nm^3/hr. Each compressor has the capability to cover the needs of the platform independently.

They share an air dryer system.

6.1.4.2.5 Potable water system

The potable water system supplies water to the taps and the eye-washers at each of the platforms. It also supplies water for rinsing the air nozzles at the degasser of Delta. The system includes filling lines, pumps, pressure container, distribution lines and relevant instruments. Potable water is delivered to the platform complex by boat and is bunkered into dedicated storage tanks. Water in the tanks is treated with UV radiation to minimize bacterial growth. Energean’s supply boats have dedicated storage tanks for the transfer of potable water. Water is supplied to the boats at the Sigma plant. This water is from the local government distribution system.

6.1.4.2.6 Breathing air system

Specific muster stations exist on all platforms for emergencies, such as hydrogen sulfide leaks, fire, etc. These stations are equipped with 50 lt / 200 bar (g) breathing air cylinder assemblies.

In emergency situations personnel muster at these stations donning their personal breathing apparatus. These cascade systems allow personnel to connect their personal breathing apparatus and have breathing air for a longer period of time, as well as to refill their personal cylinders.

The available capacity of the cascade system is sufficient for the correction of any problems or the evacuation of the platform and the removal of all personnel.

In addition to the fixed breathing air systems, the platforms are also equipped with a large number of independent devices lasting for 30 minutes, in the event of intervention - rescue.

6.1.4.2.7 Storing and handling of hydrochloric acid

Hydrochloric acid is stored in the V-114 tank, which supplies acid to the produced water line at the hydrogen sulfide stripper V-111.

The acid is handled by means of three portable hydrochloric acid storage containers (V-803, V-808, and V-811), which are mounted on the "LIMIN PRINOS" barge.

The process flow diagram is presented in 523-2000-P-019A in Annex 2.

6.1.4.2.8 Emergency generator

A diesel emergency generator is permanently connected to the power network of the Prinos platforms. This starts automatically in case of a power outage at the platforms. It turns on automatically if voltage is lost at the 400 V bar and it is ready to supply power to selected pump motors and all uninterruptible power supply systems (UPS).

The generator is driven by a diesel motor, with a power of 135 KVA and supplies power to the following systems:

- One instruments air compressor;
- One firefighting water electric pump;
- The diesel fuel transport pump;
- The uninterruptible power supply systems (UPS) of the platform;
- The positive pressure conservation system at the housing of the generator itself.

6.1.4.2.9 Power supply substation / network

Power is supplied to the electric network of the platforms via the onshore substation and the two submarine cables at a voltage of 20 KV. At Delta the voltage is transformed to 6.3 KV and subsequently to 400/230 V.

Four uninterruptible power supply systems (UPS) are located on Delta each with a power of 7.5

KW, they operate under 24 VDC, 110 VDC, 110 VAC, and 230 VAC voltages, supplying power to control instruments, the emergency shutdown system, all local switches and the emergency lighting system, respectively. They provide independence for at least 2 hours, in order to allow the emergency generator to start, which normally requires a few seconds and provides powers to the UPS chargers.

Power is supplied to the navigational aids of platform "Delta" through a different batteries assembly, with an independence of 8 days.

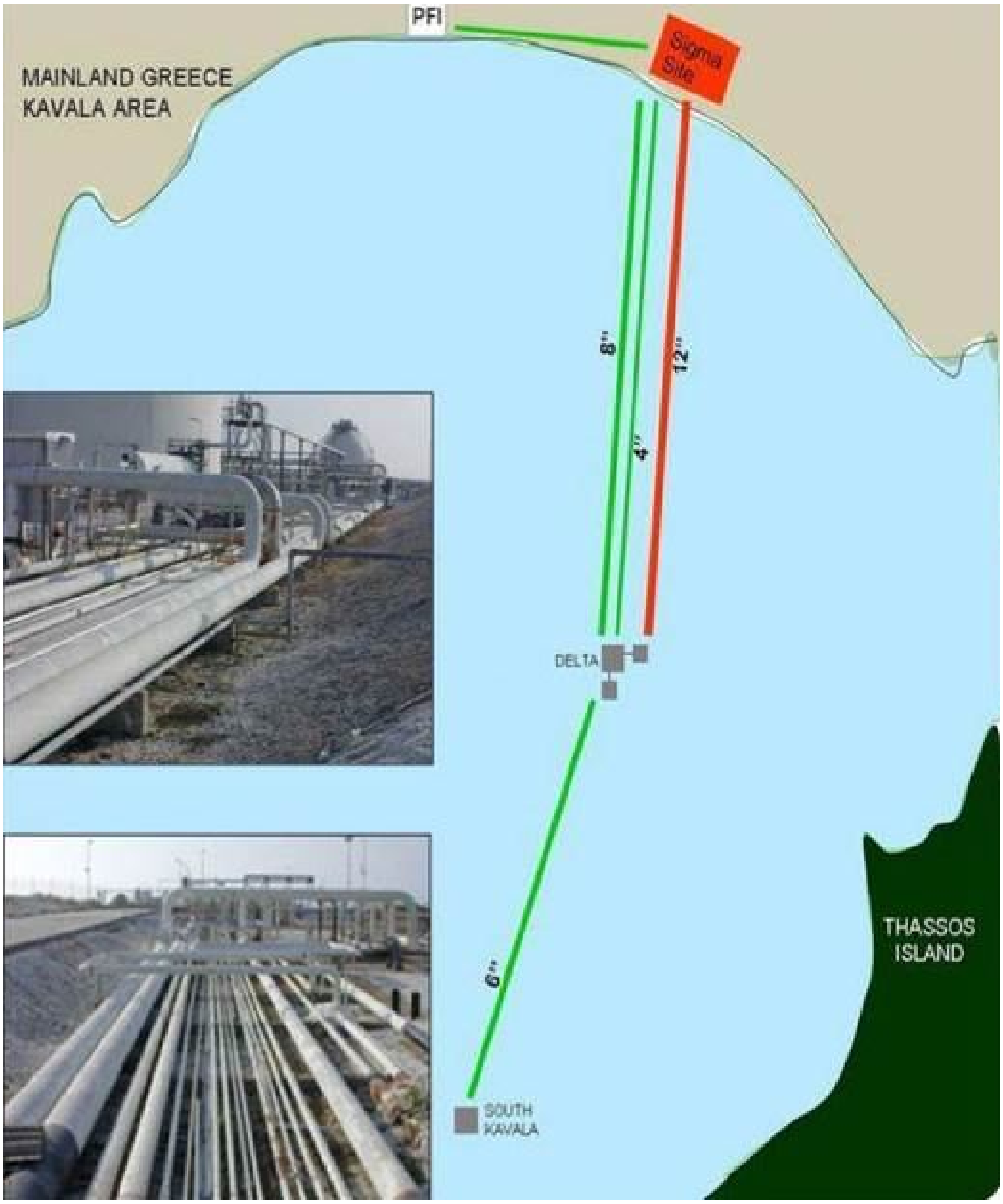
Table 6-3: Power consumption

Installed power	8,000 KW
Maximum power demand	4,000 KW
Average power consumption	96,000 KWh/d
	2,900 MWh / month
Mains voltage (low / medium)	0.4 / 6.3 and 20 KV

6.1.5 Submarine hydrocarbon pipelines

The company uses four pipelines for the transport of hydrocarbons as follows:

- Submarine pipeline with a diameter of 6" and a length of 12 km for the transport of sweet, dehydrated gas from platform "Kappa" to platform "Delta" (operating pressure 8-12 bar (g));
- Submarine pipeline with a diameter of 12" and a length of 18 km for the transport of sour, dehydrated natural gas from platform "Delta" to the land facilities (operating pressure 8-12 bar (g));
- Submarine pipeline with a diameter of 8" and a length of 18 km for the transport of sour, dehydrated sour crude oil from platform "Delta" to the land facilities (operating pressure 25-60 bar (g));
- Submarine pipeline with a diameter of 5.3" and a length of 18 km for the recirculation of sweet natural gas from the land facilities to platform "Delta" for injecting gas to the production drills (operating pressure 20-35 bar (g)).



Map 6-2: Existing submarine pipeline connections between offshore facilities and offshore – onshore facilities

The submarine pipelines for the transport of sour crude oil and sour natural gas are equipped, at both ends, with special type 'Axelson' valves, which automatically shut off when the pipeline pressure drops below a predetermined value, protecting thus the sea from any possible leak of oil or gas, in case of partial or total breach.

In addition, automatic valves are installed, which can automatically isolate the pipelines using independent low-pressure switches. In the case of the sour natural gas pipeline, the isolation of the pipeline in the event of low pressure is followed by the transport-controlled combustion of the content pipeline at the flare.

The current pipelines are coated with concrete over their full length for protection from corrosion and external impacts. Close to the platform complex the lines are covered with rock for additional protection from dropped objects including the anchors of the supply boats that approach the platforms. In water depths below 20m (from a location approximately 7 km north of Deltra platform to shore) the lines are buried for additional protection from small boat anchors and trawler "boards". The oil and sour gas pipelines have been designed so that they can be intelligently pigged to allow internal condition to be assessed. Energean is planning to intelligently pig these lines next in 2016. Previous surveys have shown minimum corrosion. An exclusion zone has been established to prevent fishing over the pipelines but this is not strictly enforced by the local authorities. Routine external inspections of the non-buried sections have identified minor damage to the concrete coating in the past caused most likely by trawler boards. When damage is identified the concrete coating is repaired by divers. No failures of the pipelines have occurred to date due to external impacts.

6.1.6 'Limin Prinos' barge

The enterprise is supported by the towable barge 'Limin Prinos', with a length of 54 m, a width of 15,54 m and depth of 3 m.

It is equipped with fifteen compartments (tanks) with a capacity of 150 m^3 each. Four of them always remain empty, six of them contain water and the remaining five serve the platforms Alpha and Beta, when repair or cleaning activities are performed at the wells, in addition at Delta, when vessel cleaning activities take place.

The barge is equipped with a small gas / liquid separator from which flashed gasses are routed via flexible pipe to the Prinos complex flare. Vapors from the fixed compartment are passed through a caustic scrubber to remove hydrogen sulfide before being vented to atmosphere.

Liquid waste is transported from the platforms to the land facilities by the barge for treatment at the existing plant approximately 12-15 times per year (in total 5,000 to 8,000 m^3 per year).

Photo 6-9: Barge 'Limin Prinos'

6.2 FUTURE FACILITIES

Energean intends to increase oil production from its Prinos concession area by implementing the Prinos Area Development Strategy that includes execution of the Prinos Area Development Project. The relevant Field Development Plan comprises the following elements:

- Development of a drilling resource;
- Infill drilling in the Prinos field;
- Obtain sub-surface data to underpin subsequent development areas; and
- Develop the Epsilon satellite field (with one platform - Lamda).

Further potential activities including the installation of a second platform at Prinos North (Omicron) will depend on interpretation of the newly acquired 3D seismic, data gathered from the ongoing infill campaign as well as studies to investigate the EOR potential of Prinos.

In the following paragraphs, the approach taken for the development and the equipment foreseen to be installed will be described.

6.2.1 Overview

For the development of the new Oil Fields (satellite fields), the plan currently foresees the installation of Self-Installing Platforms (SIP2s) in two different project execution phases. During the first firm phase, the Lamda platform will be installed at the Epsilon field. Subsequently, the Omicron platform might be installed south of the Prinos North field. The two platforms will be essentially identical. The second phase has yet to be approved by Energean as discussed above.

Each SIP2 will be a Normally Unattended Installations (NUI) and thus will contain a base minimum of equipment.

During the development of Epsilon, the Lamda platform will be installed and production drilling will begin. Production flow will be directed to the Delta complex. Gas lift and water injection will not be required initially however relevant pipelines and facilities will be pre-installed.

In total five production and four injection wells are envisaged in the P50 (including deeper volumes) case. If deeper volumes are not proven then two less wells would be required (i.e. 4 producers and 3 injectors). The base plan envisages use of water injection for pressure support. All water injection wells will be back produced initially. This will increase early production rates as well as providing an area of lower pressure into which water can be injected with existing pumps. The facility has been designed to enable conversion of the production wells from gas lift to ESP lift at some point when pressures and water cuts have stabilized. Room for a gas injection compressor has also been allocated should a sour WAG scheme be implemented in the future. The platform will be equipped with a spare set of risers to enable a subsequent satellite (notionally Athos) to be tied back to Delta via Lamda.

The Prinos North area may also be developed in a second phase via an identical SIP2 structure.

This platform, designated Omicron, would be connected back to Delta via a multiphase production line and a power/chemical utility umbilical and to Lamda for the gas lift line and water injection line. The production line will tie in to the production line coming from Lamda to Delta just prior to connection of this line to the Delta riser.

The Prinos oil field reservoirs and planned development layout for Prions area are presented in Annex 2.

The Project Area for the assessment of new facilities is provided in Chapter 1, Introduction.

The Project consists of the following planned and potential installations:

- Planned new Installations in Epsilon Field comprise the following:
    - ⇨ Lambda Platform – SIP2 type (Self-Installing Platform 2) and attendant equipment (topside facilities)
    - ⇨ Connection of Lambda Platform with the existing Delta platform through offshore hydrocarbon pipelines (buried)
    - ⇨ Umbilical between Lambda and Delta Platform transporting power, data and chemicals
    - ⇨ Modifications to Delta Platform
- Potential new Installations at Prinos North Area (later project phase) comprise the following:
    - ⇨ Omicron Platform – SIP2 and attendant equipment (topside facilities)
    - ⇨ Connection of Omicron Platform to existing Delta Platform, through offshore hydrocarbon pipelines (buried)
    - ⇨ Umbilical between Omicron with the existing Delta Platform

The new installations and the Field Layout are provided in diagrams 293902-SPL-SUB-DR-90100-001/002/003 presented in Annex 2.

Similarly to what is currently defined as a prohibition area of 500 m radius over current operations (existing operating facilities in place), the same is expected to be designated for the new additional facilities. Therefore, before the construction of the project, a Navigation new exclusion zone will be defined in collaboration with the Naval Authorities (Port Authority and the Coast Guard under the supervision of the relevant Ministries).

Based on the above, the new planned facilities and the potentially further developments are expected to define an additional area of 8.67 km^2 which when added to the existing ones (excluding overlaps) it will confine a total of 46.34 km^2 (conditional to the naval authorities' decisions).

6.2.2 Project time schedule

6.2.2.1 Overview

The Prinos Area Development project commenced in Q3 2013 when an initial conceptual design contract was awarded to Exodus (UK) to investigate options for developing the Epsilon field. Exodus proposed a traditional jacket structure with interconnecting pipelines tied back to Delta. Due to the remote nature of Greece and hence the high cost of mobilising support vessels from the North Sea or Persian Gulf, the installation costs associated with such an approach were higher than the fabrication costs. Wells were assumed to be drilled from a hired jack-up.

In early 2014 Energean's technical staff reviewed the Exodus base proposal internally. Options to use move novel platform structures and pipeline installation techniques were investigated. The use of conductor supported platforms, self-installing floating towers monopoles, suction piles etc. were examined. As well as providing significant installation cost savings these approaches also opened up the possibility of employing Greek contractors for significant elements of the scope. With the financial down turn in Greece this represented an opportunity to benefit the local economy and also obtain lower construction costs.

In parallel options to drill the required wells were investigated with the eventual purchase of the Energean Force barge in Q3 2014.

This new drilling facility was upgraded and refurbished between October 2014 and June 2015. In parallel the Prinos Alpha platform was modified to allow the Energean Force DES to be installed. The rig was moved to and rigged up on Prinos Alpha during summer 2014 and drilling commenced September 2014.

FEED work associated with the Lamda and Omicron platforms to be installed at Epsilon and Prinos North respectively, commenced during Q4 2014. This work continued through to the end September 2015. Two sub-structure options were examined in detail with SPT's SIP2 design being selected narrowly ahead of GMC's SIFT. Both represented significant savings over a traditional approach. The SIP2 design was finally adopted as it was seen to offer lower installation risk. The SIFT design was seen to be better suited for slightly deeper waters. Detailed design contracts for topside and sub-structure work were awarded October 2015. Work on the Omicron platform ceased at the end of FEED. Omicron was taken through FEED even though it has yet to be sanctioned as this provided significant cost advantages compared with undertaking a separate FEED later. It ensured that both platforms could be identical.

Work to identify potential local fabricators of the topside, substructure, pipelines and umbilicals commenced at a very early stage of the concept work. A number of well-managed, experienced companies have been identified over the last 18 months and some of these have been awarded small work scopes associated with the upgrade of the Prinos platforms and the tender barge. A comprehensive contracting strategy was developed late 2014 in parallel with FEED work. This was structured to ensure local companies could compete whilst ensuring bids could also still be attracted from foreign entities.

Currently the Epsilon development project is progressing through detailed design. Good budgetary estimates have been obtained demonstrating the significant cost reduction potential of using Greek enterprises. Geophysical and geotechnical studies have been undertaken to define final platform location and confirm pipeline routing. A small, well experienced, Project Management team is in the process of mobilization. Work to finalise the safety and environmental risk elements of the project are well advanced allowing the ESIA to be prepared ready for submittal to the Greek authorities in early March 2016. Approval of the ESIA and issuing of permits is expected by end of June 2016.

Detailed design is planned to last 6 months, completing end Q1 2016. In parallel the major contracts will be tendered. Contracts will not be awarded until detailed design is complete ensuring no changes in work scopes post award. Where possible lump sum bids will be sought. Transportation and installation contracts are being negotiated with SPT, the sub-structure designer, so as to minimize risks during these critical periods. Procurement will commence following detailed design subject to final funding. Construction and fabrication for the main elements is forecast to be between 6 to 9 months and hence these contracts need to be awarded June 2016 for a January 2017 installation or 4 months later for an April installation. Final installation date will be driven by the number of wells to be undertaken in the Prinos Alpha campaign.

By using the SIP2 design and by installing the pipelines by the towed method from a shore construction site, the installation fleet required will be very small. Required vessels are located in Greece and hence there is no urgency in identifying a firm installation window. The SIP2 is relatively insensitive to weather conditions during installation.

The potential for delaying installation to April introduces significant float into the schedule that will allow risk levels to be reduced and should result in further cost reductions. There is an opportunity to refine the design based upon newly acquired met ocean data that reduces uncertainty on environmental conditions to be employed.

The figure below illustrates the overall schedule assuming the later installation date is finally adopted.

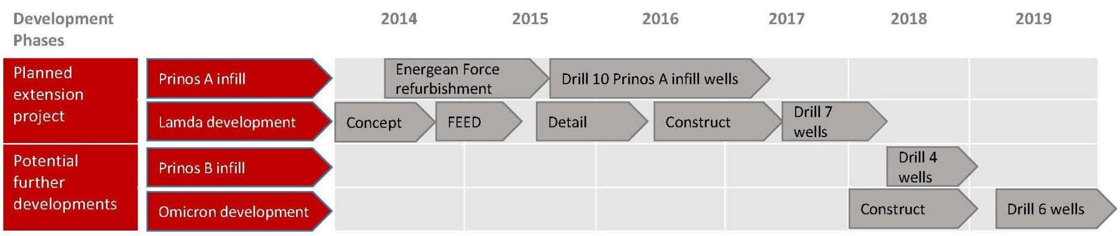


Figure 6-2: Overall schedule of operations in Prinos development area

Note that this ESIA present details on the activities that will occur for the following phases: construction, operation and abandonment. Summaries of the schedules for each phase are provided in the following subsections.

6.2.2.2 Construction schedule

Detailed design contracts were awarded for the topsides, pipeline and sub-structure scopes associated with the Lamda satellite platform in October 2015. Design work is due to last for around six (6) to seven (7) months. Lamda platform has to be installed and ready to accept the Energean Force rig late April 2017. This date could move forward or backwards based upon completion time of the ongoing drilling programme on the Prinos Alpha platform. It is assumed currently that the Prinos infill campaign will comprise ten (10) wells and that all activities will be completed on the Alpha platform. Detailed design will be therefore be complete approximately twelve (12) to thirteen (13) months earlier than the date installation has to be completed.

Estimates received to date from potential fabrication contractors for the topsides, sub-structure and pipelines indicate a six (6) month construction period with an additional two (2) to three (3) months to procure steel. To meet an installation date of mid-April 2017 construction contracts need to be awarded early July 2016. Currently the project schedule therefore carries roughly three (3) months of float between the end of detailed design and award of the main construction contracts. Part of this float could be eroded if the Prinos drilling campaign progresses more efficiently than expected. Drilling performance will be known well before the end of detailed design. There is therefore currently no foreseen reason to tender and award these contracts in parallel with detailed design, a common practice to accelerate schedule, which introduces a degree of risk. Long lead items (electrical switchgear, platform crane) will be ordered nine (9) to twelve (12) months before required on site, again after detailed design has been completed. It is possible that the pipelines and the umbilical cable can be installed post platform installation moving them well off the critical path. The pipelines and umbilicals are not required until the first well has been drilled: some 10 weeks after platform installation. It is also possible that they may be installed prior to platform installation to avoid clashes with the mooring system. In this case these items would be procured towards the end of detailed design.

6.2.2.3 Operations

Recent inspections of the platform sub-structures have indicated that remaining life (based upon corrosion and fatigue) is greater than 20 years. Planned refurbishment (re-painting) of the topsides structure and the low levels of internal corrosion seen in vessels and pipework give confidence that surface equipment can be operated for the full duration of the planned expansion project.

6.2.2.4 Abandonment

The existing Prinos licenses run to 2034. Considering the future and potential projects that can be expected in the Prinos basin it is unlikely that any of the Prinos complex facilities will be abandoned before this date. The new platforms will serve smaller accumulations but have been designed to allow them to be moved cheaply to other locations in the basin.

The only field that could be abandoned in this time frame would be the Kappa structure on South Kavala gas field. This field is largely depleted. The Greek authorities are considering using the facility as the basis of a gas storage scheme which would mean its abandonment would be delayed indefinitely. Energean is reviewing use of this facility as the basis of developing small oil reserves in the area.

6.2.3 Project Components

6.2.3.1 Lamda / Omicron platforms: Self Installing Platforms 2 (SIP2)

As described above, Energean plans to install up to two (2) new satellite platforms close to its existing Prinos complex. SPT Offshore's SIP2 (Self Installing Platform 2) concept has been selected as the most cost effective type for these new facilities. The first platform (Lamda) will be installed in Q2 2017. The decision as to whether the second platform (Omicron) is required has yet to be taken. Details are provided to allow this potential additional project to be permitted.

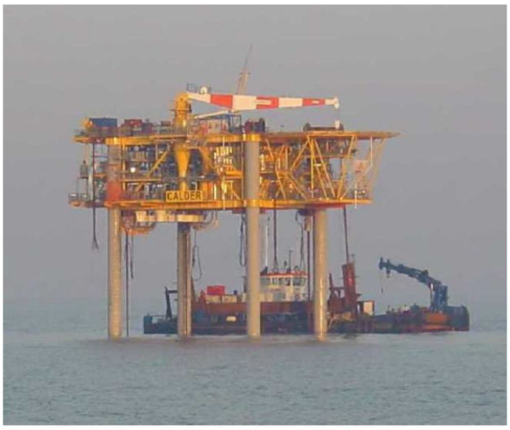
Table 6-4: SIP2 platforms Coordinates

Geographic Coordinates (WGS'84)	Longitude	Latitude
Omicron SIP2 platform	24°29'46.84''	40°49'3.81''
Lamda SIP2 platform	24°27'20.45''	40°48'38.34''

The SIP2 platform concept has been developed by a Netherlands based company, SPT Offshore BV. A number of SIP2 platforms have been successfully installed by SPT Offshore in the southern North Sea to date.

Those platform types can be employed cost effectively in shallow water depths up to about 45 m. Some typical examples are shown below:

Stage 10 F3FA As-installed



Calder Installed

Photo 6-10: Examples of SIP2 platforms installed

The SIP2 design allows for installation without the need for mobilization of a large supporting fleet. Traditional jackets with driven piles, particularly in shallow water can cost as much to install as to build. The organization of external resources such as crane barges, piling spreads etc. also increases interfaces and hence schedule risk. The SIP2 platform is assembled onshore and floated to location on a relatively standard barge readily available in most locations. At site the platform "self-installs" in a matter of a few days, rather than a few weeks which is the norm. The installation itself is relatively weather insensitive, particularly when compared with the conditions required for heavy crane lifts, topside float-overs etc. In principle the SIP2 is equivalent to a jack-up drilling unit, except that it is not equipped with sufficient permanent buoyancy to float, and has more substantial suction anchors (suction piles) to enable it to be designed for permanent installation and does not have permanently installed jacking systems to raise and lower the deck to water level and lift the legs out of the water. Like a jack-up it can be moved from location; making it particularly attractive for fields with a short production life and also facilitating eventual abandonment. Clearly these aspects significantly reduce its environmental footprint, as it is in effect completely recyclable unlike a traditional jacket.

The Lamda and Omicron SIP2's consist of 4 cylindrical legs each equipped with a suction pile to fix the legs (and hence topsides) to the seabed. The legs are made separately and are not attached together as in a traditional jacket. The legs are connected via the topsides deck. The legs, suction anchors and topside structure are built separately and then assembled onshore prior to installation offshore. The size of the topside is driven by the size of the installation barge to be employed. Once assembled, the platform sits on the installation barge with the legs out of the water and the suction cans in the water. The length of the platform therefore has to be slightly greater than the width of the installation barge. Stability of the assembled platform on the installation barge drives the minimum size achievable.

The topside structure can be equipped with multiple decks as per a conventional platform and the maximum weight is again a function purely of the installation barge selected. The largest difference between the SIP2 topsides and a conventional platform is the way in which it mates with the legs. Conventional topside sits on top of a substructure with its main load bearing columns positioned over the sub-structures legs. In the SIP2 the legs slot through cylindrical sleeves incorporated in the topsides. These sleeves pass through the full height of the topside.

The SIP2 assembly onshore involves lifting the legs (one by one) and dropping them through the sleeves and holding them in place at the base of the topside structure. The assembled topside/leg structure is then skidded onto the transportation barge located at a quayside adjacent to the assembly location. The assembled unit sits on a support frame located on the barge. The suction anchors are then welded onto the bottom of the legs whilst the barge sits at the quay. The lower part of the suction anchors sit below the water level increasing the draft and width and hence stability of the installation barge.

Once the suction anchors are fixed, temporary jacking systems are installed to allow the legs to be lowered to the seabed and the topside to be subsequently jacked-up the legs. The unit is then ready for transportation to the installation site.

This is described further in the sections below.

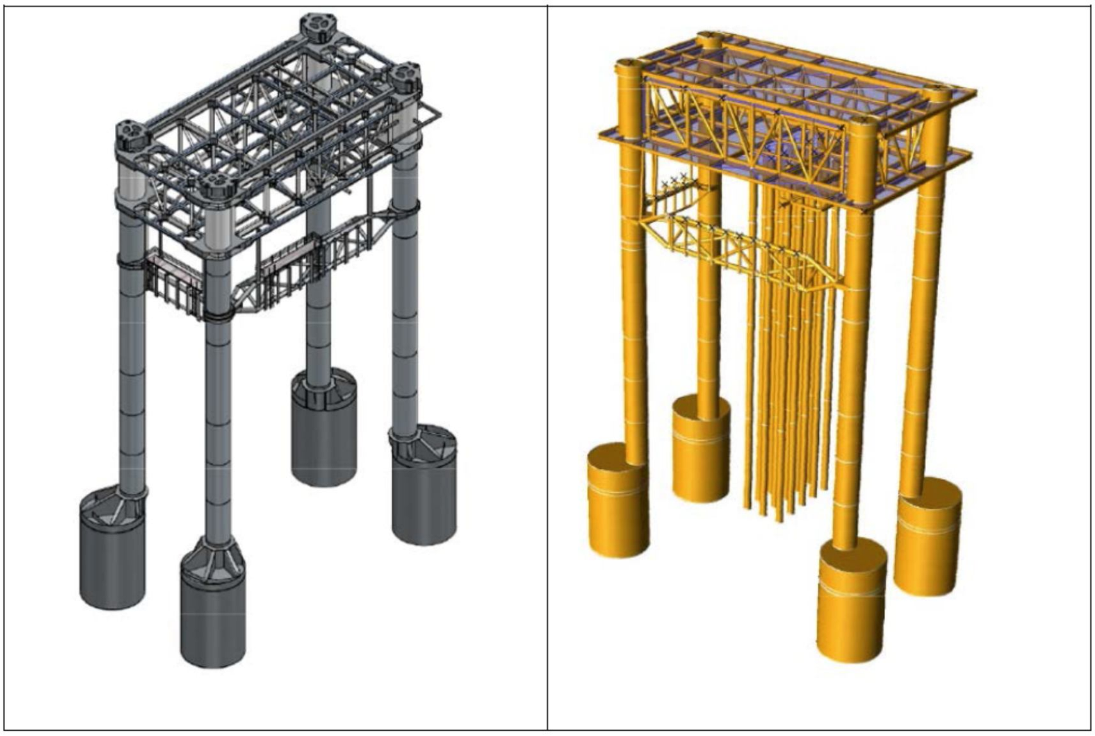


Figure 6-3: General views of initial Lamda SIP2 platform

The platform's overview and general arrangement are provided Annex 2.

The new platforms shall be designed for a minimum operating life of 20 years. The current license for the Prinos area runs until 2034.

Key dimensions of the assembled unit are provided in the table below:

Table 6-5: Summary dimensions of SIP2 platform

Summary key dimensions		
Platform Height overall from Seabed to Top deck	H	55.5m
Max Width of Topside (East to West)	W	22m
Max Length of Topside (North to South)	L	38m
Centre to Centre Distance Legs (East to West)	CCL EW	15m
Centre to Centre Distance Legs (North to South)	CCL NS	32.5m
Leg Length	Lc	53.1m
Leg Diameter	Dc	3m
Diameter Suction Pile	d_sp	8m
Depth Suction Pile	d_sp	11.5m
Thickness Suction Pile	t_sp	0.030m

The Lamda SIP2 platform is designed to be self□installed without the assistance Heavy Lift Vessels.

6.2.3.1.1 SIP2 legs

The SIP2 structure is designed as a typical offshore structure subjected to static equipment loads (including drilling operation loads), waves, wind current and earthquake loadings. Industry standard codes of practice are applied to ensure the structural integrity is maintained throughout the design life, in place, fatigue, ship impact, seismic and transport analyses will be performed. Since the topsides and substructure are integrated, i.e. similar to a jack up, the structural legs are effectively single unbraced columns. The steel legs are simply large diameter tubes, approximately 3 m in diameter, connecting the suction piles to the topside structure. The southern two legs of the SIP2 will also act as carriers for the platform risers and umbilical j-tubes, i.e. the risers and j-tubes will be permanently contained within the legs, which offer the advantage of protection and no exposure to the ocean wind and waves or vessel impact.

Table 6-6: Weight Estimation (structural steel)

Item	Value	Unit
Legs (4 no.)	856	MT
Suction piles (4 no.)	532	MT
Topside	750	MT
Boat landings	107	MT

6.2.3.1.2 Connection of SIP2 legs to topsides

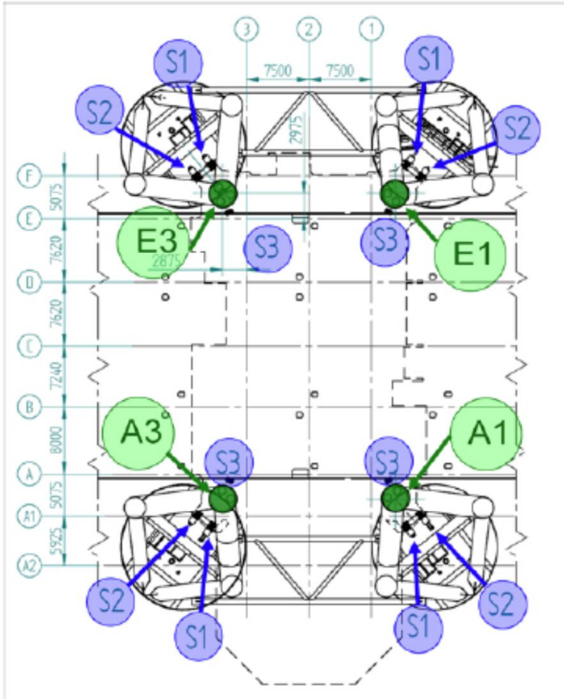
The SIP2 legs will be connected to the topside structure permanently once the topside is in fully elevated position. The legs will be contained within sleeves between the production deck and weather deck elevations, which are an integral part of the topside structure. The sleeves are required to guide the lowering of the legs during installation. Once the topside is at the required height the annulus between the sleeves and the legs will be filled with grout. The connection of the topside primary structure to the legs will be either by high capacity shearpins, or tension bolts.

6.2.3.1.3 Leg jacking system

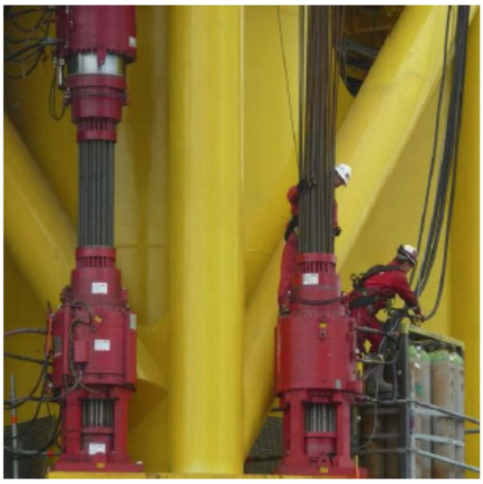
It is envisaged that the strand jack system for the SIP2 will consist of two (2) no. bundles per leg and twenty four (24) no. jacks providing approximately 500MT capacity per leg. Strands will be connected at the top of each leg (leg head anchor block) and to the top of the suction pile (bottom of leg). The breakdown of the no. of jacks as follows:

- Eight (8) no. jacks for leg lowering (offshore operation)
- Eight (8) no. jacks for topsides lifting (provides 100% contingency) (offshore operation)
- Eight (8) jacks for pre stressing the strand jack bundles (fabrication yard operation)
- The typical speed for lowering / lifting is approximately 12 min per metre.

Strand jacking systems are commonly used in both offshore and onshore structural heavy lifting with well-established specialist companies in the market namely MAMMOET and ALE.



F3FA Top View Strand Jacks and Bundles



F3FA Strand Jacks

Figure 6-4: Leg jacking systems

6.2.3.1.4 SIP2 suction anchors

The new satellite platforms will be fixed to the seabed by the use of suction anchors. Suction anchors have been used widely in the offshore oil industry as an alternative to driven piles. Soil samples have been collected in the location selected for installation of the Lamda platform to enable its load bearing strength to be determined. The size (diameter and depth) is a function of the weight and lateral loads to be supported and soil properties. A large suction anchor will be installed on each of the SIP2 legs as described above. At site the legs and suction anchors will be lowered to the seabed where they will self-penetrate the soil to a limited depth due to their own weight. The final penetration to design depth is achieved by discharging water from the body of the suction pile by pre-installed low-pressure pumps. When the target penetration depth is achieved, the pumps are removed.

Suction piles can be removed by reversing this process, leaving no material in or on the seabed. The main design parameters of the suction anchors is summarised below:

Table 6-7: SIP2 suction pile dimensions

Lamda & Omicron SIP2	
OD [m]	8 (TBC)
Penetration [m]	11 (TBC)
Thickness [mm]	30 (TBC)

6.2.3.1.5 Personnel access and interface with the drilling rig ('Energean Force')

Personnel will access the new satellite platforms by boat. No facility for helicopter access (helipad) will be provided. Each SIP2 platform will be equipped with two boat landings on the North and West faces. Provision of two landings will ensure that access is available with most weather directions.

Eight mooring points will be installed around the structure to which the 'Energean Force' drilling rig will be attached when both rigging up and drilling. When rigging up the unit will sit to the west side of the platform. When drilling, it will sit to the north. Access of staff between the drilling barge and the platform will be by gangways and access ramps that form part of the drilling rig equipment.

6.2.3.1.6 Conductors

The platforms will contain a well bay containing fifteen (15) slots (5 x 3 pattern). Wellheads will have a separation of 2.3 m. Currently it is envisaged that the well conductors will be 30" diameter. These will be free standing, i.e. no guide frame will be incorporated sub-sea attached to the SIP2 legs. A template will be installed on the seabed through which the conductors will be driven by the 'Energean Force' rig. Surface wellheads and X-mas trees will be employed. These will be located on the lower main deck of the topsides, by locating the conductors on the inside of the platform they are protected by the large legs as well as on the north and west sides by the boat landings. Boat transport will not be able to access the platforms from the south or east to avoid craft from inadvertently passing between the lower deck and hitting the conductors.

6.2.3.1.7 Risers and J-tube for umbilicals

Risers and j-tubes for umbilical connections will be pre-installed. Risers and j-tubes will be located within the southern legs of the platforms, thus giving excellent protection from vessels. They will exit onto the lower deck of the topsides where they will tie in via emergency shutdown (ESD) valves to surface equipment. They will be terminated at the seabed above the suction piles with flanged connections to which the new pipelines will be installed. Umbilical cables will be pulled through provided j-tubes and terminated on the lower main deck. Each platform will be provided with three (3) risers and one (1) j-tube to enable it to connect to Delta. Connections will also be provided to allow Lamda and Omicron to be crossed connected as well as to allow an additional satellite to be tied back to either platform. These spare connections will be pre-installed to prevent the need to retrofit risers outside the legs at a later date.

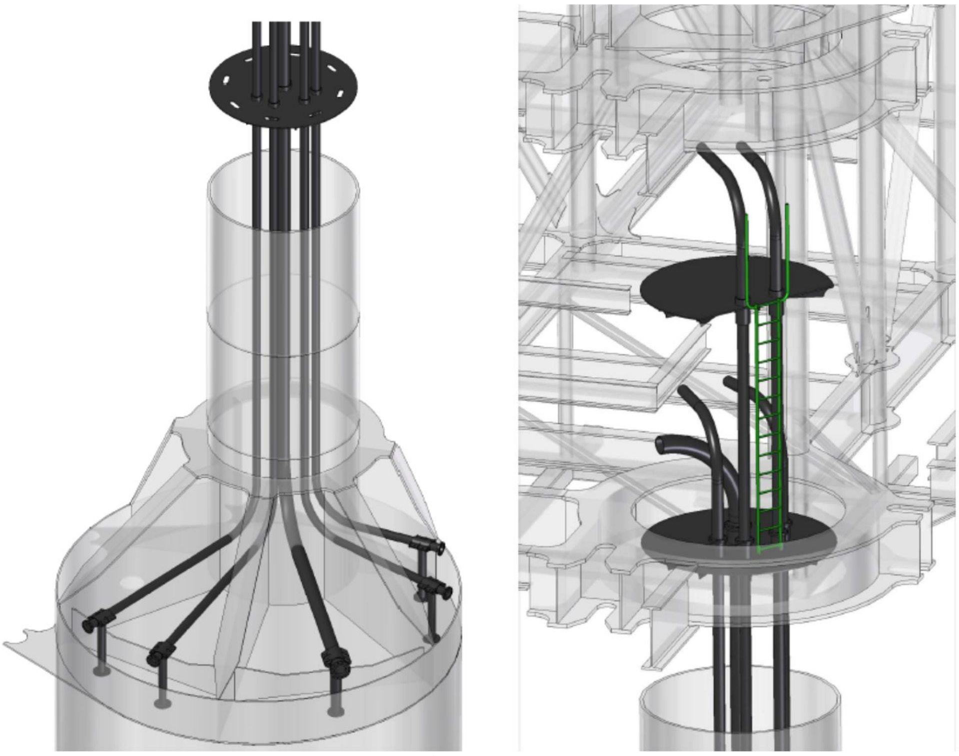


Figure 6-5: Riser and umbilical J-tube configuration

New risers will also be required at Delta. These will be positioned on the south side of the existing jacket structure adjacent to the existing risers.

6.2.3.2 Topsides

The new topsides will comprise two (2) main decks that will fully occupy the space between and around the legs, as well as two (2) smaller partial decks. The lower main deck (production deck) will contain the well bay, flowlines, production, water injection and gas lift manifolds and main electrical and instrument equipment rooms. Provision will be made to extend the east edge of the lower main deck to accommodate future equipment (e.g. ESP control equipment or a gas injection compressor). The upper main deck (or weather deck) will accommodate the crane as well as the skid beams on top of which the 'Energean Force' DES will be located. Hatches above the well bay will allow access to the wells. The deck will be designed to accommodate all necessary equipment for well servicing operations including Coiled Tubing Units.

Below the production deck there will be a small cellar deck that will sit in the splash zone. This will contain the open and closed drain drums and associated pumps. The cellar deck will provide access to the western boat landing. The northern boat landing will be accessible from the western boat landing and the main deck. A mezzanine deck will be located at the south end of the topsides between the two main decks. This will accommodate pig launchers and receivers associated with the risers.

The production deck has been designed to be above the crest of the highest predicted wave. Equipment and platforms located below the main deck will be designed to withstand occasional impact with waves, seawater immersion etc.

The gangway from the 'Energean Force' rig will interface with the SIP2 structure on the production deck. At the north end of the weather deck a support beam will be pre-installed to allow the 'Energean Force' V-door and Personnel Access Ramp (PAR) to be accommodated. Whilst drilling access will be from the north side. The area between the north edge of the weather deck and the rig can be used to store drilling materials or to locate well services equipment whilst drilling is undertaken.

No processing will occur on the satellite platforms. Multiphase well bore fluids (oil, gas and water) will be transferred directly to Delta where separation will occur using existing equipment. Flow from individual wells will be gathered in a manifold linked directly to the export riser. To monitor production either each well will be equipped with a multiphase meter or a test manifold with shared multi-phase meter will be provided. Chokes and valve will be remotely operated from Delta.

Injection water and lift gas imported from Delta will be distributed to individual wells via dedicated manifolds. Chemicals transferred via the new umbilical cable will be injected down-hole or into surface pipework as needed. Control systems will be electro-hydraulic there being no instrument air on the platforms. Power will be imported via the umbilical. No back-up diesel generator will be installed. The platforms will have fixed firewater deluge and breathing air systems. These will only be activated when the facilities are manned, i.e. when they are connected to dedicated support craft ('Energean Force' during drilling and 'Energean Valiant' during well services work).

The platforms have no emergency vent or flare systems and hence no permanently lit flare. All pipework has been rated for closed in well pressures and as there are no installed vessels there is no need for relief valves. Pipework will be welded rather than flanged to minimize leak paths. Intrusive instrumentation will be avoided.

A maintenance flare header and flare is installed but this will normally be disconnected from the live equipment. When surface pipework is to be accessed (maintenance shutdown) the closed drain vessel will be connected by installation of a removable spool. Oil in the topside pipework will be pushed into the export pipeline using a connection from the gas lift import line. Gas lift will then be introduced to the closed drain system and the flare lit. Remaining oil and gas will then be drained to the closed drain vessel with flashed gas sent to flare. Collected oil is stored in the closed drain drum and pumped back to the process system once production commences.

The closed drain flare system can also be used to receive flashed gas from the 'Limin Prinos' barge, when well clean-up operations are undertaken.

Rain and wash down water is caught in an open drain tank. Skimmed oil is pumped to the closed drain vessel. Water is passed via a skim pile to sea.

Plot plans and elevations of the topsides are provided in drawings 20153026-SPT-STR-DRA 0012 to 0019, Annex 2.

6.2.3.3 Pipelines and umbilicals

The pipelines and umbilical cables to be installed have the following features:

Table 6-8: Dimensioning of pipelines and umbilicals

Pipeline / umbilical	Length (m)
Lamda umbilical	3,909
Omicron umbilical	2,693
6" gas lift pipeline from Delta to Lamda	3,537
6" water injection pipeline from Delta to Lamda	3,541
10" production pipeline from Lamda to Delta	3,489
6" water injection pipeline from Lamda to Omicron	3,489
6" gas lift pipeline from Lamda to Omicron	3,489
10" production pipeline from Omicron to Delta	tbd
Wall thickness	
10" pipelines	10.94 mm
6" pipelines	5.29 mm

6.2.3.4 Modifications in 'Delta' platform

Full wellbore fluids will be transported from Lamda and Omicron to Delta as described above. The processing systems on Delta described earlier will be employed to separate and process fluids from the new platforms. The Delta separation system was designed to accommodate up to 30,000 bbls/day of fluids and associated gas. Considering P50 reserves the current development plans see production levels increasing to around 14,000 bopd from the Prinos (Delta platform complex) and Epsilon (Lamda plaftorm) work scopes. The potential development of Prinos North (Omicron platform) would increase peak rates to about 20,000 bopd. **The installed capacity on Delta and at Sigma is therefore sufficient for the new projects with no upgrades.**

The only modifications needed on Delta is the connection of the new Lamda / Omicron riser to the inlet header of the existing 1st stage separators and the connection of the treated injection water and gas lift headers to the export risers. The chemical storage area will be expanded and connected to the umbilical. Power and instrument connections will also interface with the umbilical.

The satellite platforms will make use of the following existing Delta processes:

- Fluid reception equipment, such as:
  - ⇨ Production Separators
- Water Injection equipment, such as:
  - ⇨ Seawater lift pumps;
  - ⇨ Water Treatment;

- ⇨ Water Injection Pumps;
- Gas lift compression;
- Chemicals;
- Electrical Power;
- Hydraulic fluid;
- Control system;
- Telecoms system.

The following summarises the expected project scope on Delta:

- General:
  - ⇨ All new risers will be installed on the south side of Delta Platform, just west of the existing Kappa 6" pipeline riser;
  - ⇨ Existing idle vessel SC-157 C is not considered a suitable slugcatcher for the new service. However, the Three Phase Production Separators V-101 A/B are considered suitable. It may be possible that one of these vessels is dedicated to Epsilon production;
  - ⇨ A new deck structure will be installed at the Delta Mezzanine level, below the existing slug catchers SC-157 A/B/C, with new beams and grating;
  - ⇨ Existing cable trays are full and new racking will be required for all new electrical & instrumentation wiring;
  - ⇨ Control, ESD & telecoms upgrade is required on Delta Control Room to accommodate Epsilon requirements;
  - ⇨ No new F&G detectors required (existing coverage is adequate).
- Production tie-ins (include for):
  - ⇨ Line from top of Riser to new pig receiver. New riser ESD valve;
  - ⇨ New pig receiver with all DB&B valves and kicker lines, bypass line, PSV and tie-in to flare header;
  - ⇨ Line from the pig receiver to the Production Separators tie-in;
  - ⇨ Wires and cables from the Pig Receiver / Production tie-in to Delta Control Room. New trays required;
  - ⇨ New deck for pig receiver.
- Gas Lift tie-ins (include for):
  - ⇨ 4" gas lift line from the compressor area on the Upper Deck of Delta to the new Epsilon risers;
  - ⇨ Wires and cables from the gas lift headers to Delta Control Room. New tray required
- Water Injection tie-ins (include for):
  - ⇨ The 4" seawater injection line from the WI manifold on the Lower Deck of Delta to

the new Epsilon risers;
    - ⇨ Wires and cables from the WI manifold to Delta Control Room. New tray required.
- Umbilical tie-ins (include for):
    - ⇨ Install a Topsides Umbilical Termination Unit (TUTU) on Delta deck convenient for connection to umbilical;
    - ⇨ Run all chemical (corrosion inhibitor, demulsifier and methanol) and hydraulic oil lines (HP, LP and return) from source to TUTU;
    - ⇨ Chemicals transfer line from the chemicals area on the Upper Deck to the new Epsilon risers;
    - ⇨ Fibre optic lines from the Delta Control Room to the TUTU. New trays required;
    - ⇨ Cables from the Delta Control Room to the TUTU area.

In addition to the above activities specifically associated with tie back of the Lamda platform a number of above upgrades will be undertaken to ensure that its continued integrity can be assured and to reflect the QRA work undertaken as part of preparing an HSE Case for the facility. The foremost workscope involves the sandblasting and re-painting of the platform structure. During recent years protective paintwork has deteriorated. With low production rates and a limited remaining lifetime only minor repairs were undertaken. Following completion of the tie-ins of Lamda equipment the whole platform will be repainted to ensure continued integrity.

Other works include the further modernization of the control room to minimize manned attendance levels on the process decks of Delta and the refurbishment of the office area to ensure that it can act as a "safe haven" from unplanned H_2S releases.

6.2.3.5 Drilling rig ('Energean Force')

All planned new wells will be drilled by the 'Energean Force' tender assisted barge. This unit was purchased in August 2014 and mobilized to Greece later that year. The unit was built in 1994 in Singapore and has been owned previously by Pride International and KCA Deutag. It has worked in West Africa and SE Asia for companies such as Nexen and Shell.

Since purchase Energean has fully refurbished the marine, accommodation and drilling systems bringing the unit back into marine classification as well as renewing certification of all drilling systems. In parallel with this refurbishment scope the Prinos Alpha platform has been upgraded to allow the DES set to be accommodated on the weather deck. The unit was rigged up and commissioned Q2/Q3 2015 and is now part the way through the planned Prinos Alpha infill drilling programme.

The rig is planned to move from Prinos Alpha to the Lamda platform early 2017 to drill the development wells of this Prinos satellite field. The technical characteristics of the rig are summarized below:

Table 6-9: Technical characteristics of 'Energean Force'

Design	Barge non self propelled
Flag	Marshal Islands
Port of registration	Majuro
IMO	8771837
Shipyard	Sabah Shipyard, Labuan, Malaysia
Year of delivery	1994
Classification society	BUREAU VERITAS
Overall length	97.6M or 320FT
Overall width (with anchor rack)	32.0M or 105FT
Breath moulded	21.4M or 70FT
Load line draft	5.8M or 34.5FT
Load line displacement	12,040mT
Light ship weight	4,800Mt
Accommodation	120 persons
Engine maker / model	CATERPILLAR
Quantity	5 PCS
Type	Model 3516 TA turbocharged after cooled
Maximum output per engine	1,615 BHP
Continuous output per engine	1,545 BHP
Rotating speed	1,200 RPM
Starting device	Pneumatic starter (150 PSI)
AC generator maker / model	CATERPILLAR
Quantity	5 PCS
Type	Model SR-4AC generator
Total power from 5 sets	7,000 KW/10,000 KVA
Voltage frequency	600V/60HZ/3 phases

Photo 6-11: ‘Energean Force” after refurbishment


Photo 6-12: Preparations for rig up of ‘Energean Force’ to existing Prinos complex

Photo 6-13: Preparations for rig up of ‘Energean Force’ to existing Prinos complex

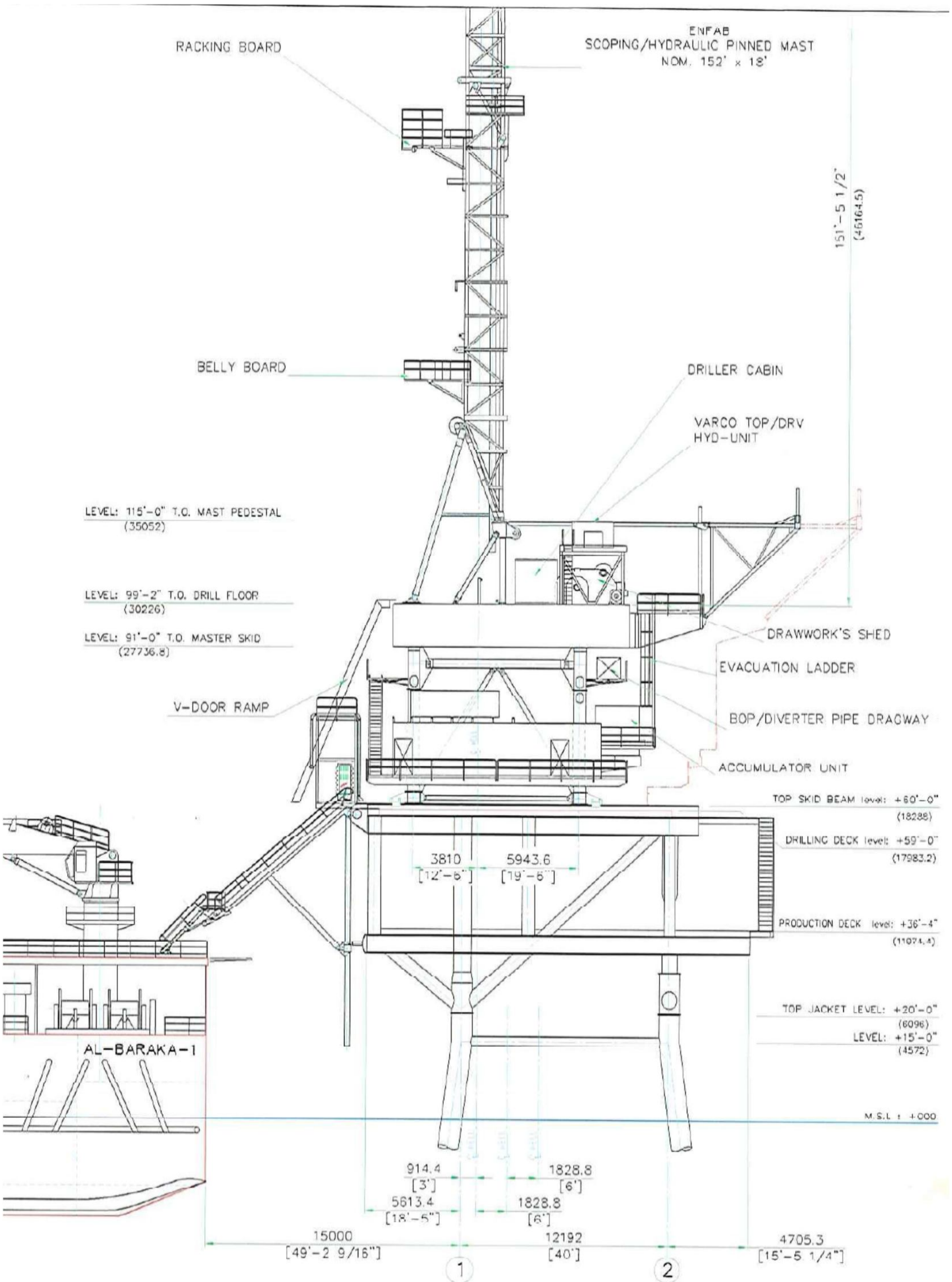


Figure 6-6: Typical barge configurations when in drilling position

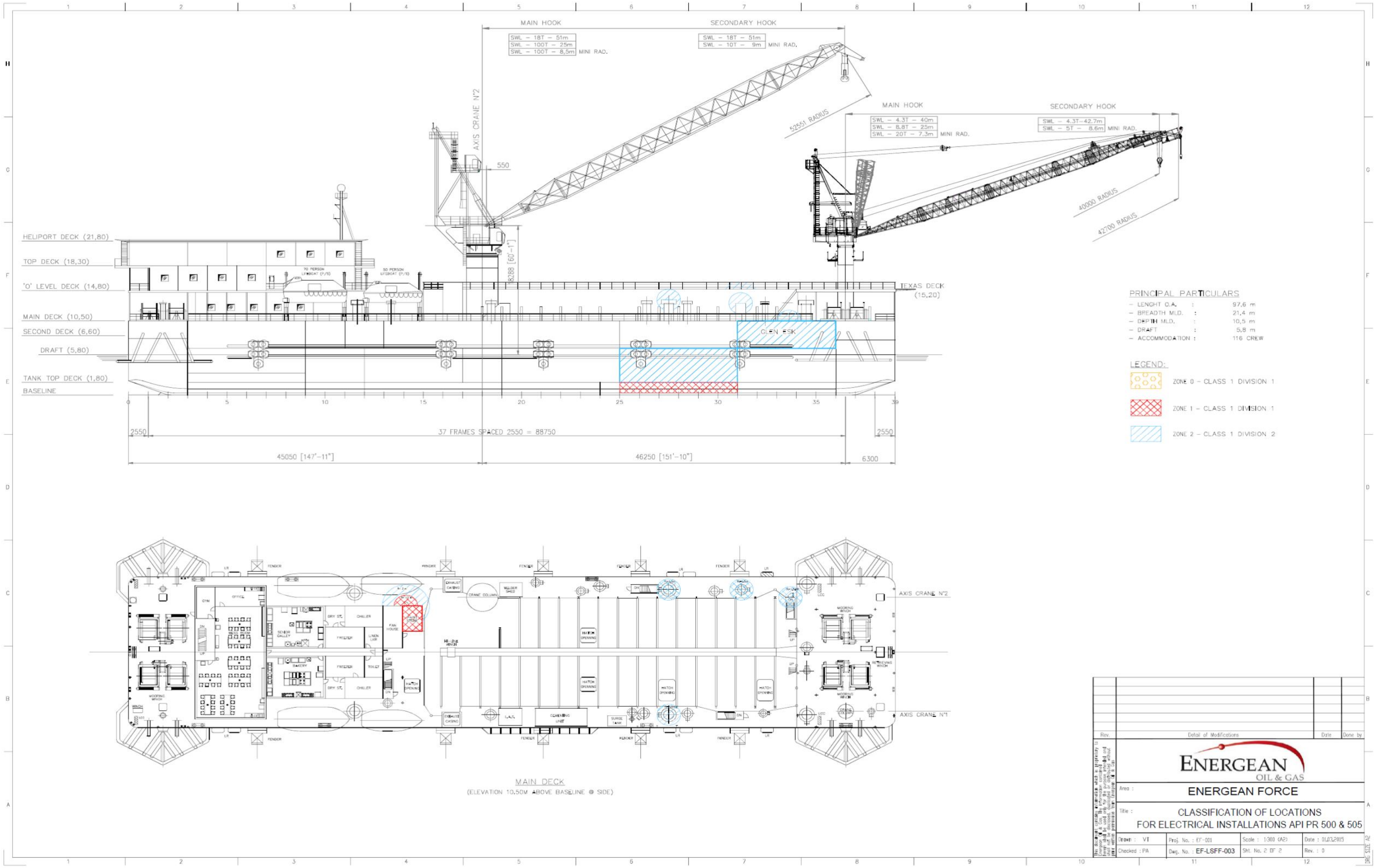


Figure 6-7: 'Energean Force' layout

6.2.3.5.1 'Energean Force' mooring principles

A permanent mooring system has been developed and installed for the 'Energean Force' barge to allow it to stay on location at the Prinos Alpha platform. The system is designed to limit lateral movements of the barge when weather suddenly changes intensity or direction. Movement has to be limited to prevent inadvertent impacts with the jacket. When weather conditions exceed predefined limits the barge pulls off location to a safe distance and drilling ceases. The mooring system has been certified by Bureau Veritas. The same mooring system will be employed at the new satellite locations.

The system is described and illustrated below.

Mooring Line composition: The barge is moored with eight (8) lines, two (2) at each corner. The mooring lines are attached at the barge end to winches capable of holding 1,600 m of wire rope. The winches are equipped with strain gauges to allow the tension on the wire rope to be calculated. The anchoring system attached to each rope is illustrated below. A "flipper-type" anchor is attached by chain to a fixed concrete weight. This in turn is attached by chain to a buoy that floats on the sea surface. The buoy is attached to the winch wire of the barge. The system acts as a spring the buoy being pulled below the surface as the force on the barge increases.

This is a relatively novel mooring system. It was selected to minimize the footprint of the mooring system. In very shallow waters often long chains are used to provide safe anchoring. Such a set-up in the Kavala Bay would have had a significant impact on fishing and other boat related traffic.

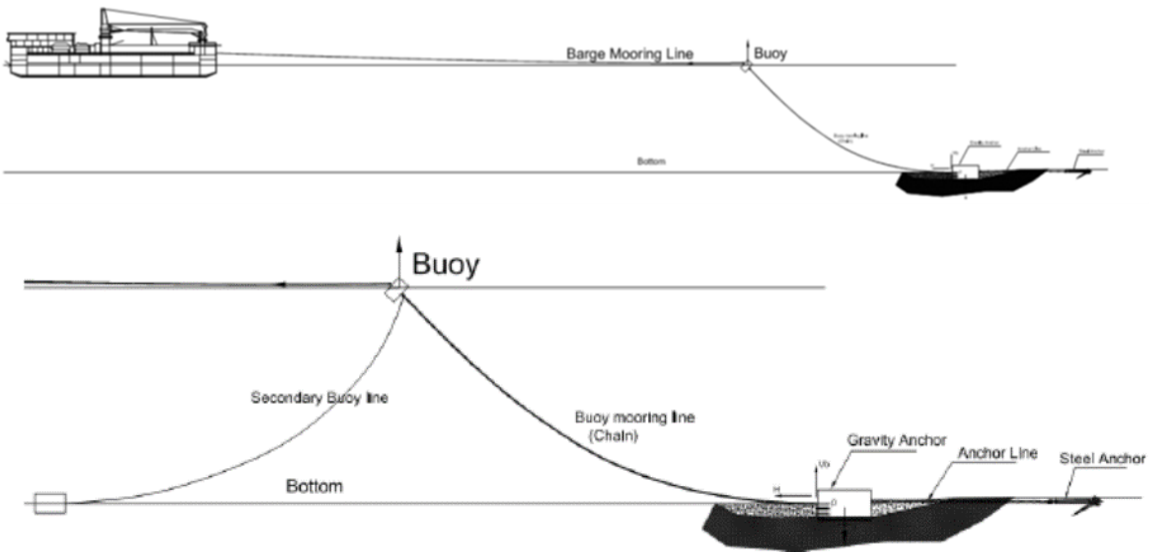


Figure 6-8: Mooring Line compositions

Mooring Spread: The figure below illustrates the overall layout of the mooring spread at Lamda and Omicron platforms. This mooring system could in principle be further reduced in size to six

(6) or four (4) lines if the radius of impact needed to be further reduced.

Main dimensions are:

- Wire rope length typically 100 m
- Chain length typically 100 m
- Trash zone around each gravity bloc of 60 m radius

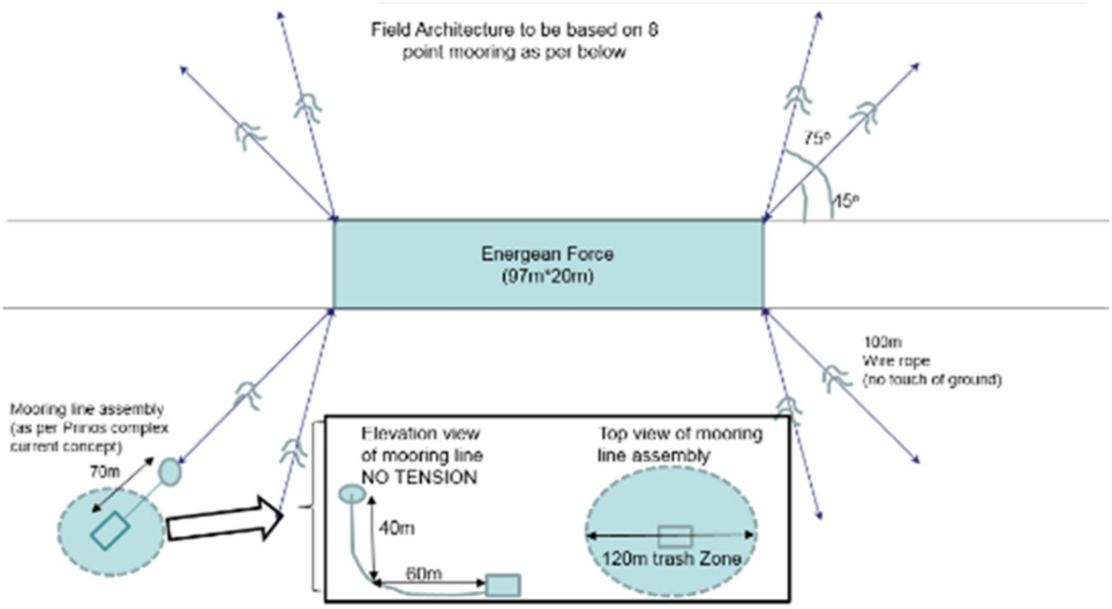


Figure 6-9: ‘Energean Force’ typical mooring spread

As well as limiting interference with fishing operations and other socio-economic activities a smaller impact area also facilitates the installation of necessary pipelines associated with the development.

6.2.4 Description of Activities by Phase

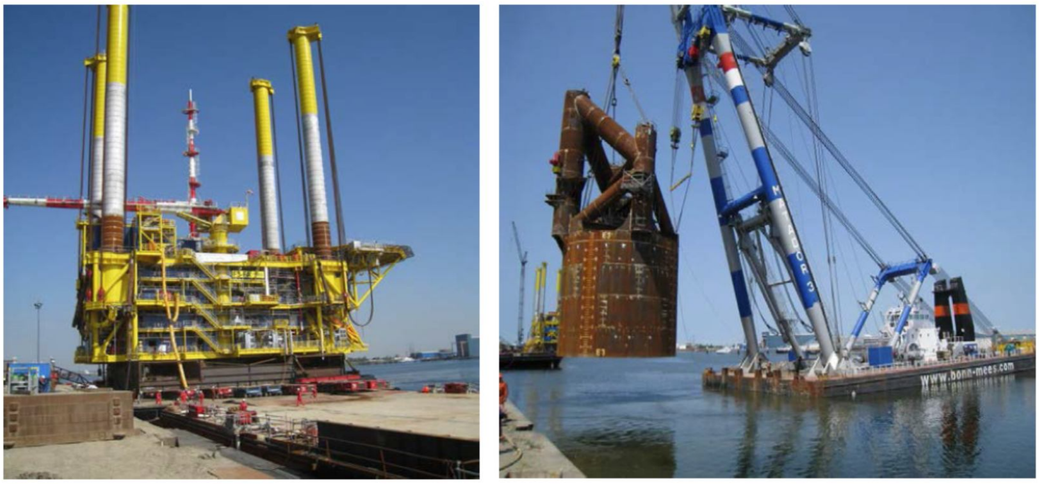
6.2.4.1 Construction Phase

6.2.4.1.1 SIP2 installation

The location of the new platforms has been selected based upon a review of the wells to be drilled from them in addition to the seabed conditions based upon the detailed geophysical survey completed September 2015. Well bottom-hole locations are determined based upon the constructed static and dynamic reservoir models. A top-hole location is then selected based upon a review of well trajectories and drilling cost/difficulty. This position is then fine-tuned based upon seabed conditions. In the case of Lamda the final platform location was moved 150 m to the southwest to avoid an area with a higher slope.

As mentioned previously, the Lamda SIP2 platform is designed to be self-installed without the assistance of specialist heavy lift vessels. The following steps are associated with the platform installation:

1. Transport of components and final assembly at a deep-water quay: The topsides and legs of the SIP2 are assembled adjacent to a quayside equipped with a water depth of minimum 8m. The assembly location could be the same as the fabrication location or a different site. It is possible for example for the topsides to be constructed in one location and then transported to the assembly location on the barge to be used during installation. Legs and suction anchors could be transported separately to this final assembly location or alternatively the assembly location could be where these sub structure elements were fabricated. The legs can be installed in the topside prior to load out onto the barge or after load out has occurred. The suction anchors will always be the final item to be added to the assembled platform.



F3FA loadout on barge *F3FA lifting suction piles underneath legs*

Photo 6-14: Platform loadout and suction can assembly examples

2. Transport to site: Once the topsides, legs and suction anchors have been assembled on the selected installation barge it is wet towed to the installation site by tugs. The assembled platform and installation barge are inherently stable due to the significant draft and the stability provided by the large buoyant suction anchors. Previous SIP2 platforms have been towed through significant storms in the North Sea on the way to the installation site. With a planned installation date of late April and a short tow through the relatively calm waters of the Aegean no transportation risk is envisaged. A minimum of three tugs will tow the assembled unit (topsides, legs, suction anchors, grillage and installation barge) from the final assembly location to the installation site.
3. Mooring at installation site: Energean intends to install the permanent mooring system for the Energean Force rig prior to the arrival of the assembled Lamda platform on the barge. This mooring system will be used to hold the installation barge at the selected

site prior to lowering the legs to the seabed. To ensure accurate positioning, the barge and support tugs will be equipped with DGPS positioning systems and real-time telemetry.

4. Leg-lowering: Once the assembled unit is moored at the installation location the legs are slowly lowered to the sea bed using temporarily installed strand jacks. No seabed preparation is required. It is noted that seabed surveys to identify exact seabed characteristics and obstructions will have been carried out prior to installation. The substructure will be designed to accommodate variations in seabed level. As the legs touch down on the seabed they will self-penetrate due to their weight.
5. Suction anchor installation: Temporarily installed suction pumps are used to draw water from the top of the suction anchors above the seabed. The suction anchors are pulled by the formation of a differential pressure, which allows the suction cans to penetrate progressively into the seabed to the required depth.
6. Topside jack-up: Once the suction anchors are installed the topsides is progressively raised up the legs using temporarily installed strand jackets. Sand that fills the annulus between the legs and sleeves during transportation is removed. Once the topside is at the correct elevation it is locked in place and the annulus filled with grout. This completes the installation sequence. The installation barge is pulled from between the legs as soon as the topsides are clear.

The platform installation modes are illustrated in next Figures.

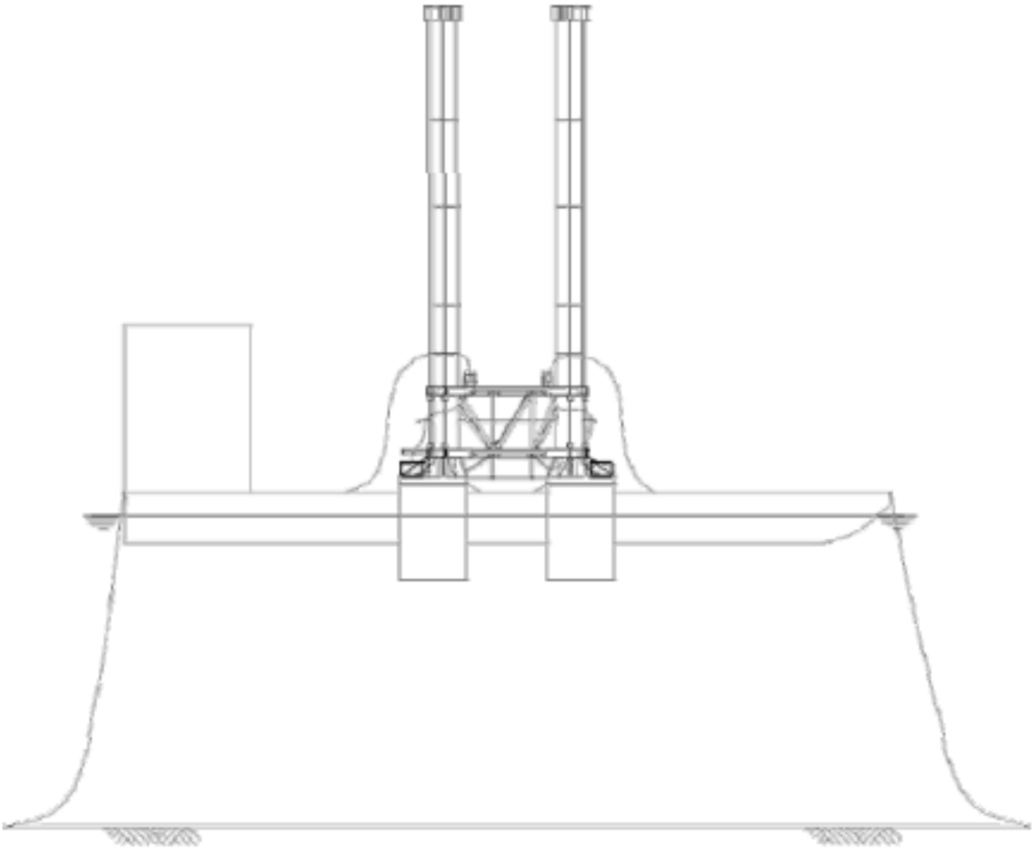


Figure 6-10: Barge in position attached to the pre-installed mooring lines

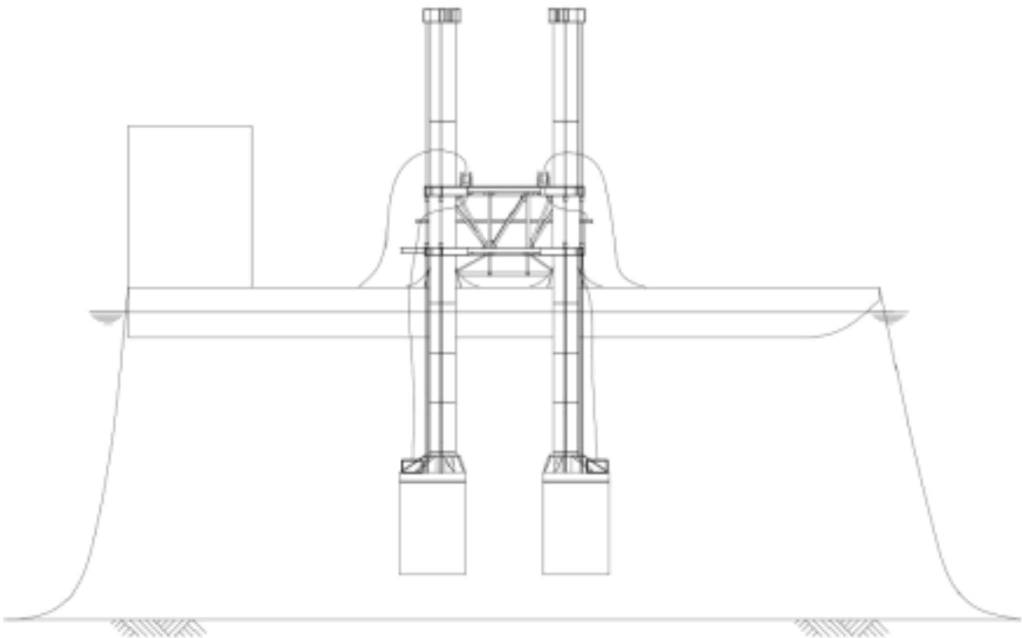


Figure 6-11: Legs lowering and suction can penetration

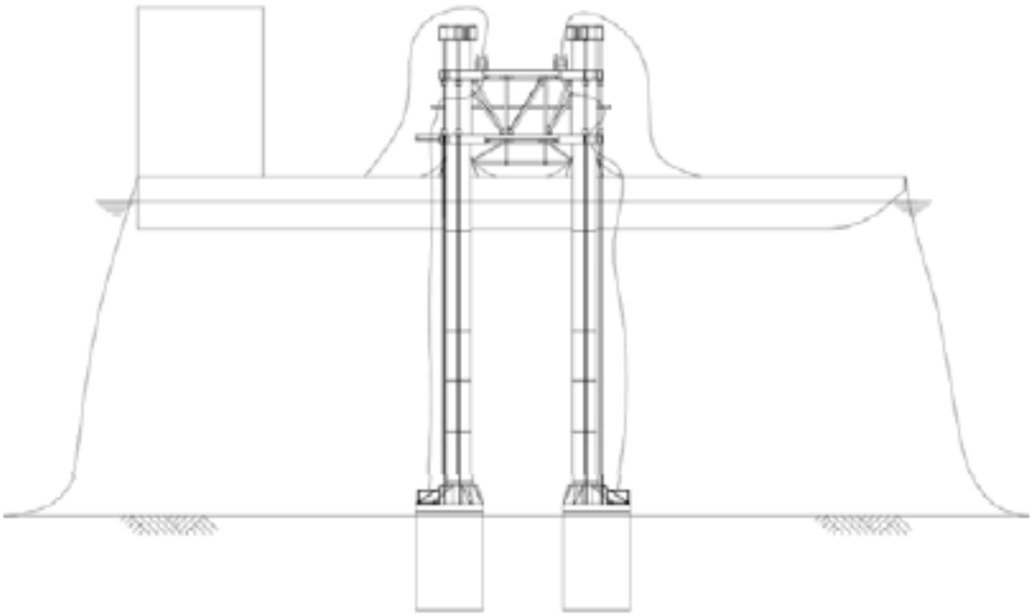


Figure 6-12: Jacking topside into final elevation and barge away

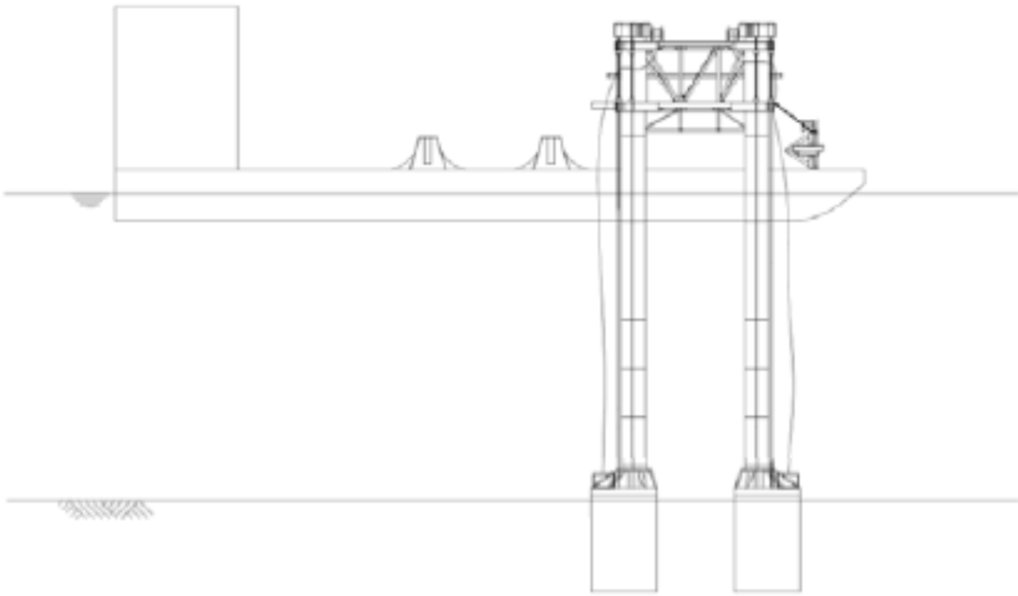
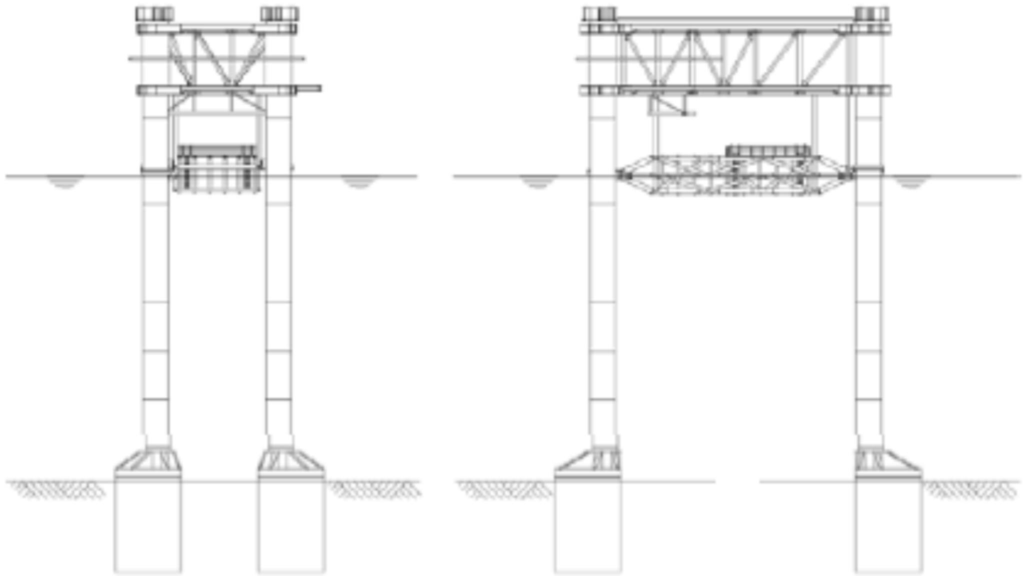


Figure 6-13: Final installed condition and boat landings installed in the raised position



6.2.4.1.2 Installation of the conductors

The Lamda and Omicron platforms will be each designed with fifteen (15) drilling slots. Each slot will be capable of accommodating a 30” riser through which a development well will be drilled. The SIP2 substructure does not include a riser support/guide structure partway between the topsides and seabed. The risers therefore have to be freestanding. This is the main reason why 30” conductors will be employed. The conductors will be driven into the seabed to the required depth by the ‘Energean Force’ rig once it is installed. It is probable that five (5) conductors will be installed prior to commencing the drilling of the first well.

6.2.4.1.3 Connection of pipelines and umbilical cables to the risers

The risers will be pre-installed in the southern two legs of the SIP2 platforms as previously described. The risers on Delta will be retrofitted. There are no existing spare risers on Delta. Riser clamps will be installed by divers onto the jacket bracing. The clamps will be fitted with hinges for ease of closing and a neoprene liner.

Pipelines and the umbilical cable will be installed by multiple single tows or a bundled tow from an onshore fabrication/stringing location. Final details of the towing and burial methodology of the pipelines will be developed as part of the detailed design.

Spool pieces will be used to connect the risers with the pipelines. Once the risers and pipeline ends are in place and fixed, the divers will perform metrology so that the final tie in spool pieces can be fabricated onshore and installed.

All tie-in connections within the pipelines will be made by means of suitable subsea mechanical connectors or welded. Suitable crossings details will be designed so that there is no interference on any existing pipelines or cables, where the spool or pipeline crosses an existing pipeline/cable or seabed obstruction. If required, subject to detailed design, protection concrete mattresses will be installed over the spools up to a defined distance from the platform, depending on the outcome of a dropped objects study.

6.2.4.1.4 Installation of topside equipment

All topsides equipment on the Lamda platform will be installed onshore in the construction yard. This will include the maintenance flare. Boat landings will be installed in parallel with the topsides using the same installation barge.

Brown field modifications on Delta will be designed so as to allow installation with the platform live. A short shutdown will be required to accommodate final tie-ins to the 1st stage separator inlet manifold. To avoid extended periods of "hot work", pipe sections, assemblies and spools will be pre-fabricated on shore and trial fitted before welding commences. For integrity purposes, pipe connections will normally be made by welding as opposed to by means of flanges.

Welding and NDT of field welds, and touch-up painting will be performed in accordance with approved procedures.

As the substructure and installation periods are expected to be short (2 to 3 days maximum) it is not intended to mobilise a dedicated offshore accommodation vessel. Required staff will be accommodated either on the 'Energean Force' barge or onshore. They will be transported to and from the installation barge by Energean's vessels. The total number of staff involved in the installation campaign should be less than 20.

Photo 6-15: Topsides fabricated at quayside

6.2.4.1.5 Installation of pipelines and umbilicals

6.2.4.1.5.1 Pipeline and umbilicals installation assessment

Pipelines and umbilical cables will be installed using the towed method. A preliminary assessment of the required towed length, routing updates and pipe strings fabrication yard capabilities has been completed assuming:

- Maximum wall thickness will be considered (as a conservative approach);

- Pipeline total length is 3.5 km;
- Buoyancy modules properties will be assumed;
- Line pipes towed empty;
- Hold back tension assumed as 5tonnes; and
- Line pipe grade will be considered as X60.

Pipelines will be fabricated onshore in +/- 1 km pipe sections. Individual sections will be pulled into the sea and connected to the next section by welding or by the use of mechanical connectors. The final 3 to 3.5 km pipeline will be towed to site with two tugs (one at each end) and lowered into the defined corridor. Studies to determine the merits of a bundled tow are being undertaken as part of detailed design. The installed pipeline will be connected to the risers with tie-in spools as described above.

Installation by S-lay has been also investigated. The S-Lay installation method is not problematic for the project pipelines. Vessel availability and cost are the only considerations that disqualify this alternative.

6.2.4.1.5.2 Pipelines and umbilical routes

The final pipeline routes between Lamda, Omicron and Delta, will be confirmed during detailed design. A detailed geophysical survey of the seabed between the three platform locations has been completed. This has demonstrated that there are no sea-bed or buried obstructions (man-made or natural) that need to be avoided. There is a natural "valley" between Lamda and Prinos Delta that has a width of almost 500 m and a depth of approximately 15 m. The pipeline route will be determined to give the shallowest possible angle into and out of this feature whilst minimizing overall length. Because the pipelines are being towed into position, it is important to orientate the platforms such that the risers and J-tubes/tie-in connections are in the correct positions (it is not possible to change direction when towing). The routes of the umbilicals between Delta and Omicron and Delta and Lamda were being designed to match the positions of the bottoms of the J-tubes (bell mouths).

6.2.4.1.5.3 Pipelines Towing Route

The towing route has been designed to avoid seabed obstructions. The part of the route that crosses the existing pipelines between Delta and the Sigma Plant was determined such, that they will be protected from the pipelines being towed, while ensuring that the pipelines being towed are likewise protected against damage.

6.2.4.1.5.4 Pipeline Corridors

The pipelines will be installed either in corridors, one at a time, about 20 m apart to accommodate slight variations in the pipeline tow and post-trenching operations or as a bundle. Thus, the maximum width of the corridors could be 100m. The width of the towing corridor will be about 20 m wide. The widths of the corridors will be verified during the design, also taking into consideration the vessels' course and station keeping capabilities.

6.2.4.1.5.5 Vessels

The spread required performing the work and services comprises the following vessels:

- Supply vessel 'Valiant Energy' (used for diving support and installation works);
- Supply vessel 'Epsilon';
- Supply vessel 'Skala Prinos';
- Crew tender 'Akra Prinos'

Photo 6-16: Supply vessel 'Valiant Energy'

Photo 6-17: Supply vessel 'Epsilon'

Photo 6-18: Supply vessel 'Skala Prinos'

Photo 6-19: Crew tender 'Akra Prinos'

The pipeline pulling forces will be relatively low and therefore it is intended to use the supply vessels as tugs. If the bollard pull of the vessels is not known, the company will perform bollard pull tests.

If a bundled installation is demonstrated to be attractive it will be required to mobilise suitable tugs to manage the installation. The existing Energean craft will not be capable of managing such a work scope.

6.2.4.1.5.6 Tie-In Method

The tie-in spools between the risers and the pipelines will be connected by means of flanges or mechanical connectors. The tie-ins will be made in the wet by divers. In the case that flanges are used, the divers will make use of hydraulic bolt tensioning system when tightening the nuts to the required torque.

6.2.4.1.5.7 Hydraulic Analysis and Pipeline Sizing

Hydraulic analysis has been performed to confirm the throughput of the pipelines (hydraulic profile) and their required internal diameter.

6.2.4.1.5.8 Flooding and Gauging

The pipelines will be flooded with filtered seawater by means of pigs fitted with polyurethane cups and gauge plates with a diameter equal to 95% of the pipeline internal diameter. When flooding is completed, the pipelines will be left in this condition for a period of twenty-four hours to allow the water to stabilise. Tests will be made to check for entrapped air.

6.2.4.1.5.9 Pressure and Tightness Testing

The hydrostatic test comprises two (2) phases:

1. a pressure test for a duration to be agreed with the certifying authority and
2. a tightness test to demonstrate that the system is water tight, lasting twenty-four hours.

The pipelines will be tested individually. Each pipeline will be system-tested between the tie-in with the wellhead manifold and the manifolding adjacent to the pig receiver.

6.2.4.1.5.10 De-Watering

De-watering of the gas line will be achieved by means of a combination of rigid pigs with polyurethane cups and foam pigs. The water injection line will not be dewatered. A small quantity of unfiltered seawater can be accommodated by the injection wells.
As only filtered seawater will be used to flood the pipelines, the floodwater will be dumped into the sea by means of a temporary dumping line. If the floodwater was treated with chemical additives (see below), the dumping will be co-ordinated with local authorities.

.

6.2.4.1.5.11 Drying (Gas Lift Pipelines)

The need for drying the gas lift pipelines to a specified dew point, using dry air, will be determined during the design phase.

6.2.4.1.5.12 Laid-Up Condition

The pipelines may be laid up with untreated test water for a period not exceeding thirty days. If the laid up period lasts longer than thirty days, chemical additives such as oxygen scavenger and biocides will be required to be added to the test water. To avoid the release of such chemicals into the sea during dewatering, the scheduling of the pre-commissioning work will be based on a laid up period of less than thirty days.

6.2.4.1.5.13 Preparation of Construction Right of Way (ROW)

The location of the pipeline fabrication site will be confirmed during detailed design. Two sites are currently under consideration. Neither site is owned by Energean. One is owned by the local port authority and one is a public space that would be temporarily used based upon permission from the requisite local authorities. Study work to define the size and facilities required are currently being progressed. An unused road adjacent to the Sigma plant or a location at the rear of the Fillipos Commercial port is being studied. Pipe racks, roller stations, welding and NDT stations, a field joint completion station, pipe-handling gear, winches and crawlers, etc. will be installed at the selected site.

Map 6-3: Indicative onshore construction site location

The pipeline will be made up in its entirety along the selected construction site. The pipe joints, already factory-fitted with the 3-layer PP coating and anodes, will be welded into strings with a length of about 1,000m (82 joints) each, using an external line-up clamp. Multiple welding stations, their number depending on the welding procedures (the number of passes) will be used. The welds will be examined by 100% x-ray at the NDT station downstream of the welding stations. Finally, the field joints will be completed by fitting a heat-shrink sleeve and a protective shield. When the four strings are thus completed, they will be connected together in the manner described above to form the entire pipeline with a total length of approximately 3,500m.

The first string, fitted with a pulling head, will be pulled off the construction ROW by a tug. The tug will pull the string far enough into the water for the end of the string to be positioned in the firing line where the second string will be mechanically connected to the first string. The tug will keep station at this position. This step will be repeated for the third and fourth strings.

The rear end of the pipeline will also be fitted with a pulling head. This pulling head will be secured to a hawser that is attached to a second, rear tug, which keeps the pipeline under a specified tension to prevent the pipeline from being subjected to compressive forces. The tension force will be monitored continually during the tow by means of a load cell. A support vessel will accompany the tow and correct the position of the pipelines as needed.

The pipeline will be towed into its respective pipeline corridor. The position of the pipeline relative to the seabed will be monitored by divers or ROV. The pulling heads will be placed into their target boxes, also monitored by divers. The ends of the pipeline will be temporarily fixed to the seabed by means of a concrete mattress, again placed with the assistance of divers. Divers will then proceed to remove the floatation bodies (de-ballasting the pipeline). The pipeline is now in its intended position within its respective corridor, resting on the seabed, filled with air.

Just prior to making the tie-ins with the risers, the divers will flood the pipeline. Since the air inside the pipeline is locked in at atmospheric pressure, water will ingress. The air cannot fully escape, however, and will be entrapped until it is driven out by the pigs during the testing activities. The pipeline must not be left in this condition for a period exceeding thirty days.

6.2.4.1.5.14 Installation of umbilicals

The umbilical cable will be installed from reels situated on board the Valiant or an equivalent vessel, which will be modified during the design phase to be able to fit the reeling equipment, including tensioner and chute.

A subsea electrical-chemical umbilical will be installed between each satellite platform and Delta. The umbilical will transfer power, instrument signals and chemicals (such as and corrosion inhibitors) from the Delta platform. The functional components of the umbilical shall be as follows:

- Electrical cables (Voltage level to be determined following a power system study).
- Fibre bundle 1 (containing 24 single mode optical fibres). The number of fibres is to be confirmed.
- Fibre bundle 2 (containing 24 single mode optical fibres)
- 7-off hose/tubes – designated as follows:
    - ⇨ 5x Chemical: supply from Delta of demulsifier, corrosion inhibitor, methanol, asphaltene and scale inhibitor. Batch type treatments during well intervention will be by temporary packages on Lamda.
    - ⇨ 2x Spare

The umbilical will be installed by the reel method. The umbilical will be reeled at the manufacturer’s plant, with towing heads fitted. One reel will be required for each umbilical. The reels will be transported to Fillipos Commercial port and fitted on board the installation vessel.

The vessel will set up at one of the platforms (the lay sequence will be determined later). The towline will be fed through the pre-fitted c.q. retrofitted J-tube with the use of a messenger wire and attached to the pulling head. The umbilical will then be pulled through the J-tube, monitored by a diver. When the pulling head sits in the hang-off clamp at the top of the J-tube, the vessel will lay away to the other platform.

The umbilical will be laid with a bow-out adjacent to the platform to allow sufficient slack (the length of the J-tube plus a few meters) for the pull through the J-tube. The umbilical will be pulled on board the platform in the manner described above.

In the case where the pipelines will be bundled (to be determined during detailed design) the umbilical reel could be set up at the stringing yard, and the umbilical pulled into the pipeline bundle, thus forming part of the bundle arrangement. In this case, the umbilical ends will be looped at both ends of the pipeline bundle ready to be attached to the respective platforms.

6.2.4.1.5.15 Burial of pipelines and umbilicals

The pipelines and umbilical will be buried to protect them against mechanical impact by falling objects and by trawl boards and chains or other fishing gear. The method of burial will be by jetting pressurized water in the area immediately around the pipeline and umbilical corridor to temporarily displace the sand, allowing the infrastructure to partially sink below the surrounding seabed level and then be buried by the settling sand. This method has been selected because it is less invasive than traditional trenching.

6.2.4.1.5.16 Diving support

It is intended to perform the underwater tie-ins "in the wet", requiring extensive intervention by divers. Diving support will be sought from local Contractors. If necessary the Energean supply vessels will be used to support diving operations; they will be fitted with sufficient portable decompression facilities. Procedures will be developed to minimize diving operations and to assure the safety of the divers employed.

6.2.4.1.6 Logistics

Energean will establish and maintain a project-specific logistics plan, covering the following requirements/activities, as a function of QA management:

- Stacking/packing/handling requirements for materials and equipment;
- Planning and scheduling shipments of heavy equipment and vessels from vendors' places of manufacture/fabrication to Energean (marshalling) yards/quay sides;
- Management of materials certificates, certificates of fitness, certificates of origin, and the like;
- Custody transfer of materials and equipment;

- Insurances for handling and transportation;
- Any importation and customs clearance for materials and equipment;
- Storage and maintenance of materials and equipment;
- Calculations for weights and centres of gravity;
- Authorities engineering for handling and transportation of heavy equipment and moving pipe strings over land.

The logistics plan serves to ensure that materials and equipment are delivered undamaged and on time at the Work Sites and in parallel the overland movement of equipment does not cause any damage or nuisance to local residents. The work will be performed by dedicated personnel.

6.2.4.1.7 Transportation and installation sea states

Transportation routes to the Gulf of Kavala will be determined once fabrication and assembly sites have been selected. Work completed to date has demonstrated the feasibility and cost effectiveness of fabricating the legs and suction cans in Greece. Potential fabrication sites for these components are close to deep-water port facilities at Athens, Volos and Thessaloniki. Whilst Energean intends to include Greek companies in the topsides construction tender it is possible that this more specialist piece of work will be awarded to a yard outside the country (in Italy, Turkey, Croatia etc.). An alternative would be to award to a local fabricator and use an experienced foreign company to help establish and manage the fabrication facility.

Even if all work is executed in Greece it is possible that the legs, suction anchors and topsides could be fabricated at different locations.

Preparation of the final assembly before installation will likely occur at the fabrication yard used for legs/suction anchors and/or topside whichever is closest to Kavala. For example if the topsides were fabricated in Volos and the legs in Athens, the legs would be transported to Volos by transportation/installation barge and then the assembled unit to Kavala. It is possible, but not likely that assembly could be undertaken at Fillipos port in Kavala minimizing the towing distance to site.

Map 6-4: Indicative transportation route to Platform Location from Athens

Each transport trip required shall be designed to withstand the loads caused by the most adverse environmental conditions expected for the area and season through which it will pass, taking into account any agreed mitigating measures.

For any relevant phase of transportation or marine operation, the design criteria will be defined, consisting of the design wave, design wind and if relevant, design current. It should be noted that the maximum wave and maximum wind may not occur in the same geographical area, in which case it will be necessary to check the extremes in each area, to establish governing load cases.

Transportation cases will be designed for 10 year monthly extremes for the area and season, on the basis of a 30-day exposure. For the motion analyses, sea states will include all relevant spectra up to and including the design wave height for the most severe areas of the proposed voyage route. A wave height smaller than the design wave height, at the natural period of roll and/or pitch of the tow, should also be checked if necessary. "Long crested" seas will be considered unless there is a justifiable basis for using "short crested" seas. Consideration should be given to the choice of spectrum, which should be applicable to the geographic area, and Hs of the design sea states.

The most probable maximum extreme (MPME) responses will be based on a 3-hour exposure period and shall be used for design. The range of periods associated with the extreme sea state will be calculated analytically in two different ways, with due consideration given to the influence of swell (General Guidelines for Marine Operations) or they will be taken from the available scatter diagrams. The design wind speed shall be the 1-minute mean velocity at a reference height of 10m above sea level. The 1-hour wind may also be needed in the calculation process. Therefore the transport sea state is a function of the route, season and hydrodynamic characteristics of the platform, barge and towing vessels.

Prior to the departure, a Marine Warranty surveyor will approve the seaworthiness of the marine transport barge.

The installation of the SIP2 structure and associated topsides is relatively tolerant of sea state, however by planning for a date during April 2017 the chance of obtaining benign conditions will be maximized. In all cases, the weather restrictions imposed by the design and installation criteria will be adhered to.

Photo 6-20: Dry tow on transport barge to site

6.2.4.1.8 Personnel during construction / installation

Offshore project execution will take place in stages with the delta brownfield works starting early and the final well hook up ending the execution sequence.

A peak of up to 30 workers (10 of which will be based on nights) can be anticipated for a short period during platform installation. These numbers include contractors and representatives of the Energean project team. Most of the workers will be accommodated on the Energean Force or onshore. A breakdown of the main project execution stages and the associated personnel requirements for each is further presented below:

- Platform Installation: Duration 3d
    - ⇨ Workers are shuttled on 12hr on 12hr off using the KO ships for onshore/offshore transfers or Installation barge/Energean force.

  - Number of workers estimated at 20 dayshift, 10 night shifts.
  - Staff maybe accommodated on 'Energean Force' whilst it is at Alpha.
- Platform Commissioning & Well Hook Up: Duration ~15d per well
  - Provided by KO personnel exclusively, crew size of 5 people, dayshift only, working on normal work pattern during each well drilling phase
  - 'Energean Force' used for accommodation, as it will be at Lamda.
- Pipeline Installation: Duration 7d
  - Day and night shift by marine crew provided by Contractor.
  - Accommodation provided by 'Energean Force' off station during this period and located likely at Filipos.
  - Crew size ~ 8 dayshift, 8 night shift
- Pipeline Hook Up (Spools & Riser at Delta): Duration ~20d
  - Day and night shift
  - Installation Crew size ~ 7dayshift, 7 night shift
  - Diving Crew size ~ 8 dayshift, 8 night shift
  - Crew is fully contracted out to 2 main contractors: diving team and installation team.
  - Installation team rotating onshore for accommodation.
  - Diving team in chamber on contracted out barge.
  - No use of Energean Force.
- Delta Brownfield works: Duration ~120d
  - Staged execution with work packs broken in: Chemical area, piping, mezzanine and Riser
  - Work only in day shift with crew size of typically 10 people rotating with KO personnel and accommodated onshore or on Energean Force located on Alpha during most of this work.
  - Fabrication scope contracted out fully.

6.2.4.2 Operating Phase

6.2.4.2.1 Operation philosophy

The new installations are designed to function as Normally Unmanned Installations (NUIs), remotely operable under all weather conditions. The installations are designed with minimum facilities to safely control production from the satellite fields and to enable drilling and well interventions to take place as required. Oil production from the satellite platforms will be controlled and monitored from Delta CCR. A Local Instrumentation Room is available on the SIP but does not play the role of local control room. No local control room is provided on the satellite facilities.

All equipment includes instrumentation to manage its safety and provide security of operation. The facilities are designed to fail in a safe condition ('fail safe') if power or control functionality is interrupted. Satellite and total field production shall be measured and monitored from Prinos Delta. All necessary process and utility parameters shall be remotely available.

The platforms will be designed for Simultaneous Production and Drilling Operations and Simultaneous Production and Well Operations activities. During the primary drilling phase completed wells will be brought on stream whilst the 'Energean Force' drills new wells. Only when large components of the Drilling Equipment Set are finally lifted from the platform will a production shutdown be required. Well intervention operations can occur in parallel with production either during or after the primary drilling phase. In this case either the companies Light Work over Rig or Coiled Tubing Unit would be lifted onto the satellite.

Equipment on the satellites is divided into Oil Production, Water Injection, Gas Lift and Chemical Injection systems as well as a number of auxiliary systems. The operational philosophy applied to these systems is outlined below.

Oil Production:

A typical oil gathering system will be built. Individual Well Flow Lines for each well will be installed, with remotely operated chokes, chemical injection points upstream the choke and required manual isolation and check valves. Double block and bleed isolations will be provided to enable choke interventions with minimal production upset.

A Test Manifold will bring together all production wells and guide flow to a Multi-Phase Flow Meter (MPFM) and physical sampling cabin. Flow will then be directed back to the production manifold. Ability to route remotely each individual producer to the test header is required.

The Production Manifold has been designed to accommodate up to eight (8) production wells with gathered fluids discharged to the export pipeline. Chemical injection points are provided on the production header leading to the pipeline inlet. A second MPFM will be provided on the production header outlet in order to monitor gross flow exiting the platform.

A permanent Pig will be supplied on the multiphase export lines from each platform. A new pig receiver will be installed on the mezzanine deck of Prinos Delta. Pigging operations will be supported by use of gas provided by the gas lift system as purge gas. Installed pig launchers are designed for intelligent pig operations.

Water Injection:

Treated injection water will be supplied from the Prinos Delta platform. Injection water will be fully treated and dosed with necessary chemicals on the Delta platform. There is no envisaged need for further treatment or injection facilities on either Lamda or Omicron.

Water will be supplied to Lamda and Omicron through a dedicated high-pressure line. Water will reach Omicron via Lamda. The rated capacity of the seawater treatment and injection system on Delta is 45,000 bwpd. This is envisaged to be sufficient to accommodate forward needs of all envisaged satellites without any upgrades or modifications (current forecasted needs are estimated at 15,000 bwpd).

A Water Injection Manifold will feed up to seven (7) water injection wells. Water is routed from the water pipeline to the manifold and then distributed to each dedicated water injection well. Pressure is monitored at the manifold.

Each Water Injection Flowline is equipped with a flow transmitter, a controlled actuated flow control valve with flow rate control loop and a well head pressure transmitter to monitor flowing injection pressure at the well head. Space for installation of temporary pig traps has been allowed in the design (cleaning or inspection).

Gas Lift:

Gas lift will be supplied from Prinos Delta. Gas lift is sweet gas consisting mainly of methane (usually CH_4 is more than 75% mol) with an average molecular weight of 21.7 kg/kmol.

Gas lift will be supplied to Lamda and Omicron via a new 6" pipeline that flows over the Lamda platform. This pipeline will be fully rated for the closed in pressure of the Epsilon wells under initial conditions. Gas can be fed to up to eight (8) wells on each platform.

Each Gas Lift Flowline will be provided with an individual gas lift flow control valve. This will automatically control the flow of gas to individual wells based upon a set point entered by the control room operator on Prinos Delta. Flow and pressure measurements will be sent to the Prinos Delta control facility via the installed umbilical cable.

At this stage there is no plan to upgrade the gas lift compressors on Delta. The spare unit currently available will be used in parallel. Gas lift supply to Epsilon is expected to be used for a relatively short duration. Once water cuts and pressures have stabilized the intent would be to install ESP's in the Epsilon wells to better control draw down. Available gas lift could be then used at other potential satellites.

The gas lift system is also used to supply sweet gas to the platform for use in purging operations. A sweet gas supply to the maintenance flare system is available so that the flare can be purged and lit prior to draining operations taking place. Sweet gas connections will also be provided to each flowline to allow sour fluids to be partially evacuated to Delta before a shut down. A gas connection will also be provided to the inlet of the multiphase pipeline that can be used to avoid hydrates during planned shut downs of the line.

Chemical Injection System:

Prinos Delta will be used as the supplier of chemicals to the satellite platforms. Each platform will be connected to an expanded chemical injection system on Delta by a dedicated umbilical cable. New storage tanks and pumps will be required on Delta to enable it to serve the two envisaged satellites. This equipment will be located in an area previously occupied by gas compressors transferred to Kappa platform.

Utilities:

The new facilities require few utility systems. Utilities are either supplied from Delta (power, data) the mobile support vessels (fire water, breathing air) or avoided by design (instrument air). Systems installed are:

- A Closed Drains vessel with associated maintenance flare. No emergency flare system is required as all pipework is fully pressure rated and no relief valves are installed. This system is physically disconnected during normal operations and only lit and used during shutdown, start-up, pigging or well maintenance activities.
- An Open Drains system handles rainwater. An oily water separator together with a skim

pile and an oil-in-water analyser and automatic shut-off valve will prevent unintentional discharge of untreated fluids directly to sea.

- Dedicated HPU units with electrically driven pumps, will be installed on each SIP platform. Sufficient redundancy on the HPU pumps will be provided to accommodate the frequent demand of the control valves.
- A diesel driven crane rated to support well services operations. The crane will either be of pedestal type mounted on one of the platform legs or skiddable along the beams used to support the Energean Force. Options to use an electrical crane will be examined during detailed design.

When unmanned, the platform will have no firefighting capability. A dry deluge and ring main shall be provided to give coverage to the wellhead area and the muster area when the platform is manned. Water supply at this time will be from the companies support craft moored alongside.

Electrical power for the satellites will be provided from the Delta platform via the umbilical. There will be no electrical power generation on the SIPs. No stand-by generators will be installed. A UPS system will safely shut the facility down if there is failure of the power supply from Delta.

6.2.4.2.2 Simultaneous operations (SIMOPS)

The upper (drilling) deck has been designed to allow simultaneous drilling or well services and production operations. When lifting on or off the following items associated with the Energean Force DES the wells will be shut down:

- V-door side Master skid
- Draw works side master skid
- Mud package
- MCC
- Drill floor and
- Mast

6.2.4.2.3 Drainage systems

There are two types of drains on Lambda and Omicron platform: open drains and closed drains. More specifically:

- Open drains: these are atmospheric drains collecting the surface waste liquids and all their intakes (entry points) are permanently vented to atmosphere
- Closed drains: these are fully contained drains, hard piped from the equipment to be drained through all the facilities necessary before reprocessing or safe disposal to the environment

Water, which is not expected to contain any oil e.g. from container roofs, exterior wash-down, and laydown areas shall be collected and piped directly overboard below the lowest deck area. These drains need not be directed to the skim pile.

6.2.4.2.3.1 Open drains

Water entering the open drains system should normally not contain oil, but is treated as though it could. Sources of open drains are:

- Bunded areas beneath equipment in hydrocarbon service. These are intended to collect deluge water, washdown water, maintenance spillages, and possible leakage from equipment. Bunded areas are provided where drainage flowrate is significant or where deck plating is used for catching the spillage.
- Drip pans beneath smaller equipment items such as pumps and filters, in water service. These are intended to collect maintenance spillages. Some equipment items such as the chemical injection package, generators, pumps, etc. may be provided with built-in drip retention as part of the skid to contain any leaks or spills.
- Bunded area at the well service chemical storage area on the Production deck (Omicron only)
- Deck drains for contaminated deck areas. These are intended to collect washdown water, fire hose water and rain water.

There is not expected to be any grey water requirement on the satellites as all living quarters and accommodation will be on linked service vessels.

6.2.4.2.3.2 Closed drains

A closed system is installed to collect hazardous fluids from process pipework that has to be opened for maintenance purposes. This drained fluid is routed to a Closed Drains Drum where it is stored before return to the process via the multiphase export line. Pig launchers and receivers can also be drained to this vessel. All equipment to be drained will have been purged with sweet gas to minimize liquid inventories and H_2S levels. Operating procedures will ensure that only one item will be drained to the closed drains system at a time to avoid potential cross pressurisation of equipment.

Closed drains piping shall satisfy the following requirements:

- Closed drains headers are 150# rated irrespective of upstream process equipment or pipe rating
- Upstream system will be blinded during normal operation so as to avoid potential pressurisation of closed drains piping and drum due to mal-operation leading to gas blowby.
- Drain lines shall be self-draining to the closed drains drum i.e. sloped.

The Closed Drains Drum will be located at the lowest point on the platform (cellar deck) to achieve the desired piping slopes required for draining of liquid by gravity.

The gas outlet from the Closed Drains Drum will be connected to the maintenance flare. Thus any gaseous discharges or gas blow-by from process equipment will be flared/vented at the vent tip.

The Closed Drains Drum is designed to hold the full liquid inventory of the topside pipework.

Closed Drains Drum Pumps shall be used to transfer the accumulated liquids to the export line to Prinos Delta once the facility has resumed production.

6.2.4.2.3.3 Drains arrangements

The following typical drains arrangements will be applied:

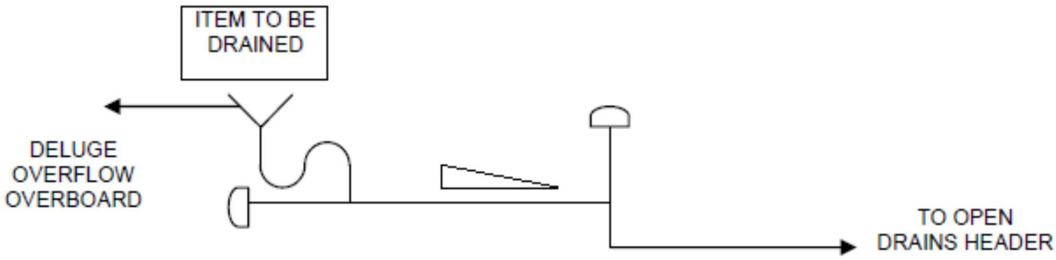


Diagram 6-1: Typical open drain arrangement

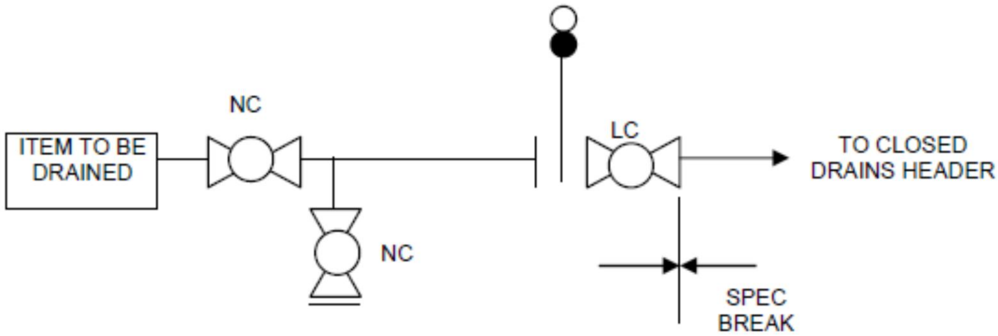


Diagram 6-2: Typical closed drain arrangement

6.2.4.2.4 Safety equipment

To ensure safety of the satellite installation, the following facilities are provided:

- Failsafe emergency shutdown of all process systems.
- Actuated riser ESD valves.
- Provision of a drilling rig interface that include TPS functionality and a link into the Rig's Fire, gas and emergency alarms system.
- A maintenance vent to allow managed (non-emergency) depressurization of the topsides. Ignition provided by means of flare guns after purging with sweet gas from gas lift system
- Cascade air system with external connection at boat landing locations and widow maker bridge area (drilling barge) for supply of pressurized air.
- Hard piped Firefighting ring main with external connection at boat landing locations and widow maker bridge area (drilling barge) for supply of water.
- Fire and gas detection system connected to ESD system.
- Fusible plugs over x-mas trees connected to ESD system.

6.2.4.2.5 Maintenance & inspection

The platform has been designed for minimal maintenance. A maintenance schedule will be developed as part of the detailed design when equipment vendors have been selected and routine maintenance activities defined. Operational visits to the satellites will occur at least once a month and non-shutdown maintenance activities will be scheduled to occur at the same time. Operational visits would be with a team of two production technicians from Delta. Discipline maintenance technicians could join them as required by the routine tasks to be undertaken. Breakdown maintenance activities will be undertaken during day light hours as and when required.

Shutdown maintenance campaigns will be undertaken every thirty (30) months (normally in conjunction with planned shutdowns of Delta and Sigma) with a support vessel, permanently stationed at the platform. Work shall be possible on a 24-hour basis if needed, although it is unlikely that this would be required.

As there are no relief valves installed on the platform and no process vessels shut-down maintenance requirements will be limited largely to electrical and instrument systems that are not spared. Where internal inspections to pipework or manifolds were required fluids are first pushed to the export pipeline with sweet gas and then drained to the closed drain system.

The Closed Drains Drum can be inspected with the platform live as it is physically isolated from the process at this time. It cannot be inspected during a shutdown as at this point it is in use.

Campaign maintenance and inspection manning level shall be limited to a minimum of two (2) persons (to allow the buddy system to be operated) to maximum 10 persons. The maximum personal is currently seen as follows:

- Operations (1- 2 pers.)
- Mechanical Maintenance (2 to 4 pers.)
- Crane operator (1 pers.)
- Instruments (1-2pers.)
- Electrical (1pers.)
- Safety Spvr (1pers.)

When the 'Energean Force' is attached to the platform maintenance of the power supply system shall be possible without interrupting production.

In addition to the normal maintenance and inspection events, the following operations will require sending people to the SIP platforms:

- Well interventions making use of the light workover rig or rigless interventions (water wash & squeeze jobs).
    - ⇨ Exact frequency will depend of the fluid behaviour (scale, salt/asphaltene deposit). Note that the frequency is reduced by design by allowing for downhole continuous injection. The maximum manning level is expected to be twelve (12) people and will be used for the design of the safety systems.
- Pigging operations foreseen only for the multiphase production pipeline. Exact

frequency will depend of the fluid behaviour (wax deposition, hydrate formation). Normal manning level of 2 people similar to routine maintenance and inspection visits.

- Other interventions such as instrumentation tuning, which should occur at low frequency. Normal manning level of 2-4 people similar to routine maintenance and inspection visits.

When staff is on board either of the satellite platforms a support vessel will remain on stand-by at the boat landing. This will be used for evacuation due to emergency, medical or weather. No safe refuge is available on the satellites and hence staff will not be left on location without a stand-by vessel present. During operations such as well services work where the platform will be manned for a number of days with 24-hour work, the standby vessel will be connected to the platform fire and breathing air systems effectively converting it to Temporarily Manned status. Short duration routine visits of up to six (6) people and duration less than six (6) hours will not require the stand-by boat to connect in this manner.

6.2.4.2.6 Production scenarios and profiles

Production forecasts based upon available dynamic simulation models and assumed number of wells has been prepared for P90, P50 and P10 profiles. These have been used to define production scenarios and hence allow equipment, pipework, pipelines, electrical systems etc. to be correctly sized. For each reserve scenario fluid rates at different periods of the fields' production life have been defined. This allows peak loadings to be determined and ensure turn down can also be accommodated. Data associated with the Epsilon field to be exploited via the Lamda platform is more mature than for the fields in the Prinos North Area. These include exploration and appraisal opportunities and hence the range of forecasts is somewhat greater.

As the intent is to "design once, build twice" the analysis performed for Lamda (Epsilon) has been used to size the Omicron facility also.

Table 6-10: Epsilon Production Scenarios

Base Case					
Epsilon field P50 production forecast	**Unit**	**Early Life (2017)**	**Transition (2020)**	**Mid-Life (2023)**	**Late - Life (2030)**
Max. reservoir fluid	kmol/hr (stdbpd)	585 (12,000)	519 (10,642)	209 (4,297)	96 (1,971)
Max formation water	kmol/hr (stdbpd)	1,945 (5,210)	781 (2,091)	2,268 (6,076)	3,874 (10,376)
Max gas lift	kmol/hr (Sm^3/hr)	105 (~2,500)	218 (5,200)	336 (8,000)	336 (8,000)
Flowing Tubing Head Pressure (FTHP)	barg (average of all producers)	42	29	21	21

Current production levels through the offshore Prinos complex and onshore Sigma processing plant range between 2,200 and 3,400 bopd. These rates are typical of those achieved since Energean took over operations. Peak rates of up to 4,000 bopd were achieved immediately following the drilling of ERD wells to Prinos North and Epsilon. Following the completion of the first Prinos infill well (PA-35A) by the 'Energean Force' rig in November 2015, production rates through the existing facilities will increase. Production from individual wells has been determined based upon Energean's history matched full-field dynamic reservoir model. Initial rates are a function of predicted net pay remaining in each in-fill location coupled with application of good oil field practice (i.e. avoid coning of water through over production and hence loss of ultimate recovery). Low to High forecasts have been prepared for each well. Forecasts for wells with potential at the A reservoir are more uncertain than forecasts for the B/C reservoirs. The reservoirs are more extensively developed and have seen more water injection to date.

The diagram below illustrates the mid case production profile for the overall Prinos Area Development project including wells to be drilled from Prinos Alpha, Lamda, Prinos Beta and Omicron.

As can be seen the 10 planned Prinos infill wells have the potential to increase the production rate to around 10,000 bopd (blue wedge). This increase gains from planned well services and work-over activities including stimulation, water shut-offs, gas lift installations and tubing replacements. It also includes gains from conversion of two closed in production wells to water injection. Production potential is significant because seven (7) of the wells are planned to be equipped with dual completions. Hence the current campaign is equivalent to 17 new wells.

Epsilon development drilling adds the brown production wedge and could increase production to around 14,000 bopd initially. As the Epsilon field contains significantly understaurated crude rates will drop rapidly as reservoir pressures fall. All initial wells will be completed as producers (including water injection wells). Towards the end of the Epsilon drilling campaign these wells will be converted and hence total Epsilon production will fall.

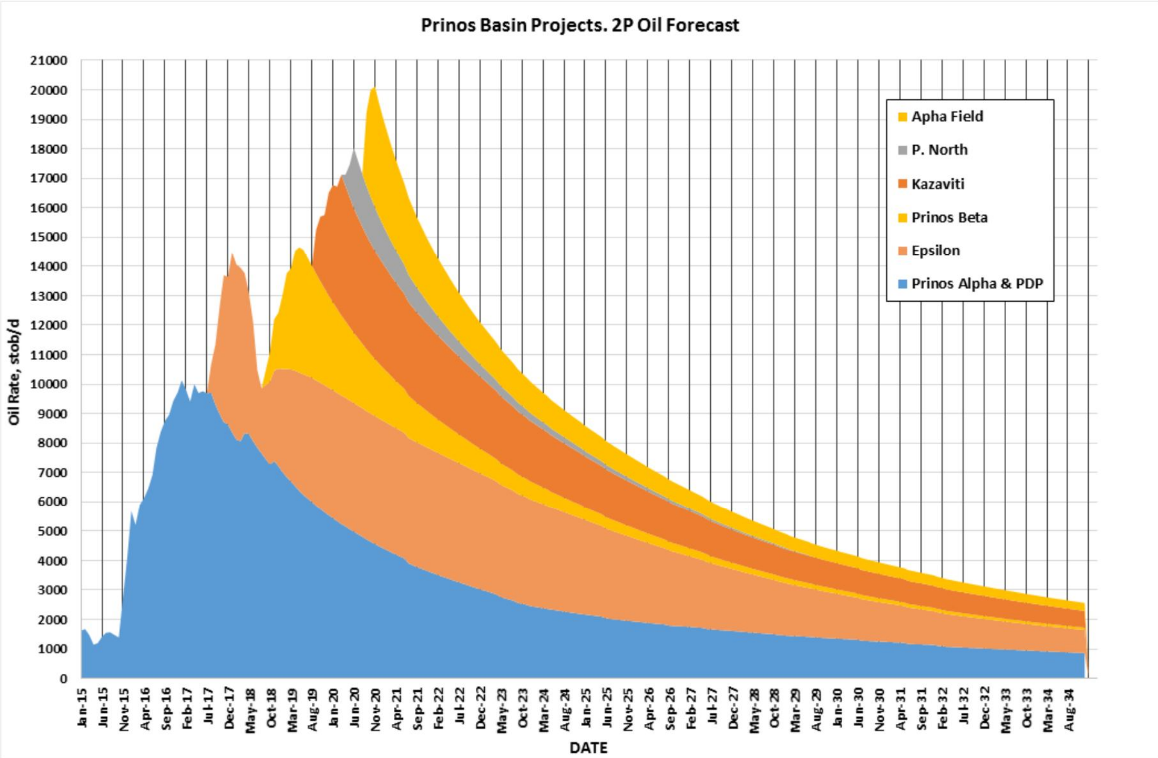


Diagram 6-3: Prinos basin, 2P oil forecasts

Planned wells on Prinos Beta have the potential to reverse this decline in the short term. As illustrated to achieve a long-term stable production above 12,000 bopd additional development activities will be required. Notional tranches of additional production for the discoveries and exploration prospects in the Prinos North Area are illustrated assuming the Omicron platform is installed in 2019 (two years after Lamda).

Currently no forecasts have been prepared for the remaining discoveries in the Prinos license area (Athos and Delta) as well as the heavy oil discoveries in the Nestos basin. Neither has incremental production associated with notional IOR and EOR projects. Implementation of these projects would be targeted to give production from 2021 onwards and hold oil production rates at the type of new plateau rate illustrated.

6.2.4.2.7 Structural stability

The platform is designed for the worse load cases applied when in drilling conditions. It is capable of withstanding the worst 1Y storm condition as well as the design seismic case while the rig is developing full drilling weights (Rig dead weight + worst case active weight: ~1,440T).

For the 100Y storm it is assumed that the rig operation would be suspended in advance of the 100Y storm and that only the dead weights of the rig would apply (Rig dead weight: ~1,020T).

A conservative fatigue assessment assuming a high percentage of time with the heavy rig on the platform over its design life has been made. The structure is designed to provide fatigue life in excess of twice the design life (i.e 40 years plus).

The platform is designed to withstand boat collision impact energy without collapsing. The boat sizes have been selected based on current boats part of company operations and third party fishing boats in close vicinity.

6.2.4.2.8 Drilling operations

6.2.4.2.8.1 Introduction

The existing wells on the Prinos Alpha and Beta platforms will remain operational during the described Prinos Area Development project except those, which have been selected as donor wells for the planned Prinos infill campaign. All existing wells will be managed under existing environmental permits.

In this section the activities associated with the drilling of new wells and the sidetrack of existing wells is described in detail. All drilling activities will be undertaken by the Company's tender assisted rig, the 'Energean Force'. The 'Energean Force' mooring system has been described in earlier section. Further details are not given in this section.

Slim hole wells will not be employed. All new wells and side tracks will be constructed in the traditional manner using telescopic casings of decreasing size with depth. Casings will be cemented in place, the cement being located in the annulus between the casing and rock wall. Wells will be drilled with the aid of a Top Drive and steered with a combination of mud motors and rotary steerable tools depending on angle and inclination required. Cuttings will be circulated out of hole by pumping drilling mud down through the drill string, out through nozzles in the drill bit and then back up the well annulus. This drill mud will be oil based whilst drilling through the evaporitic cap rock section and water based in other sections including the reservoir. Mud weight is varied based upon knowledge of the pressure of the fluids in the strata to be penetrated. Chemicals such as barite are used to add weight. Mud weights can be reduced by passing the returned fluid through an installed centrifuge.

A detailed description of the planned drilling operations is provided in the following paragraphs.

6.2.4.2.8.2 Methodology of typical well drilling

Once the 'Energean Force' is connected to the platform drilling can commence. In the following sections the main elements of the drilling process are described:

- Drilling mud:
- Running of casing:
- Blow Out Prevention (BOP)
- Drilling, Cementing and Completion
- Management of losses

Throughout the drilling of the well it is necessary to use drilling mud, for the following reasons:

- Removes the rock cuttings from the bottom of the well and transfers them to the surface where they are examined to give information regarding the geology of the formation being drilled.

- Protects the walls of the well from subsidence (creates coating to the walls of the well preventing the diffusion and loss of drilling fluids during drilling).
- Cools and lubricates the drilling bit and the drilling column.
- Applies pressure (at or above hydrostatic as required) and therefore controls influx of fluids from the geologic strata being drilled into the well bore.

The drilling mud enters the well through the drill string and then returns to the rig floor area through the annulus formed between the walls of the well and the drill strings. At the rig floor area, the drilling mud passes through a sequence of processes that conditions mud so it can be re-circulated to the well. If present any significant volumes of gas are removed and safely vented. Rock cuttings are then removed in a number of "shale shakers" that are made up of vibrating mesh screens. Sand is removed in settling tanks before small gas bubbles are removed (if present) in a vacuum system. Conditioned mud is returned by gravity through flowlines to the storage tanks on the tender barge, before being pumped back to the rig floor with the high-pressure mud pumps.

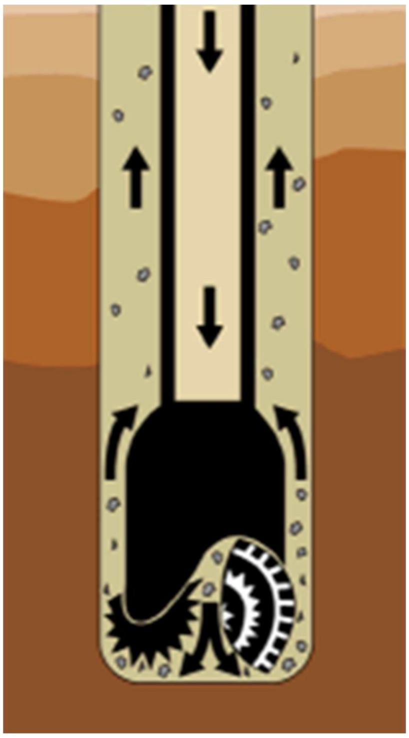


Figure 6-14: Schematic illustration of the movement of the drilling sludge through the drill strings of the drilling machine and the bit

Once a hole section of defined diameter has been drilled a pipe of slightly smaller diameter is lowered into it piece by piece. This casing provides stability to the walls of the drilled hole. This casing pipe is run to the bottom of the drilled section. Once in place cement is pumped through a special tool into the well bore and pushed up the annulus where it dries. The cement should completely fill the annulus between conductor and rock face. Once set a hole of smaller diameter is drilled to the bottom of the next section and the above process repeated. In this manner a telescopic, stable, well bore is constructed. The length of each section is defined in the drilling programme and is a function of the pressure gradient of formation fluids.

In a new well, as will be constructed on Lamda, the first piece of piping installed will be a conductor. This will have a diameter of 30”. This conductor pipe will be lowered to the seabed and then driven into the seabed a defined distance. The initial hole section will be drilled out of this conductor pipe.

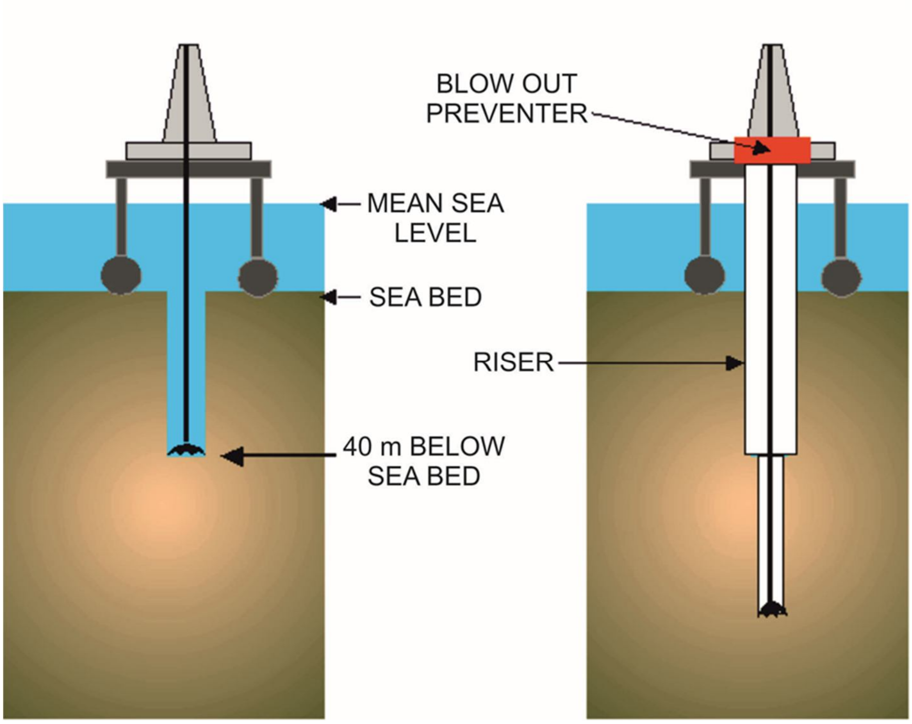
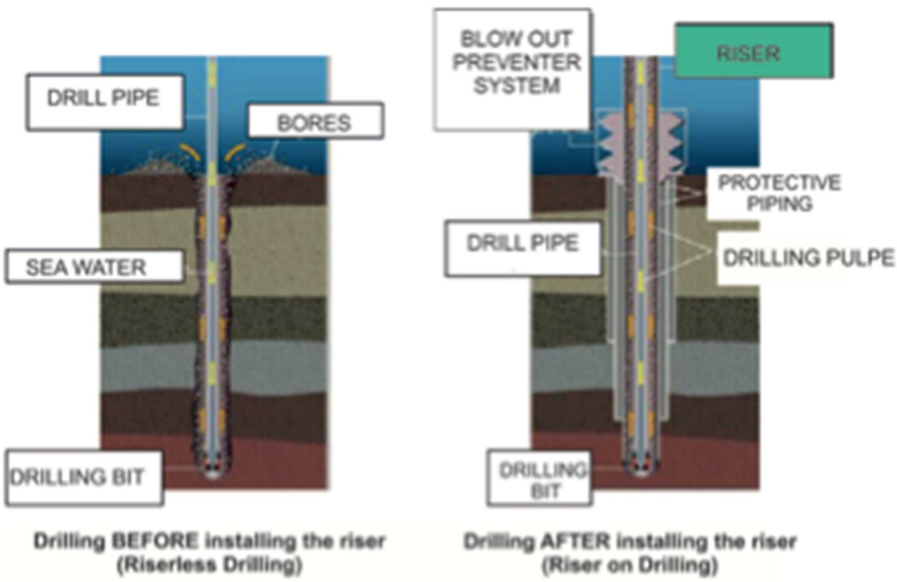


Figure 6-15: Drilling before and after the placement of the riser



Before drilling commences on either a new well or an old well that is to be sidetracked a Blow Out Preventor (BOP) is installed. The BOP is one of the main barriers that ensure that an inflow of fluid into the well whilst drilling cannot reach the drill floor. On a new well the BOP is installed once the surface conductor piping has been driven to the required depth. On an old well, the well is first killed, the Xmas tree removed and the BOP then attached to the wellhead.

Formation fluids can flow into a well bore whilst it is being drilled if the pressure in the formation is greater than the pressure exerted on the formation by the mud employed. The BOP consists of successive valves. When needed, these valves can be closed using a reservoir of hydraulic fluid stored on the drill floor in cylinders or accumulators. These cylinders are kept fully charged at all times. Loss of pressure automatically causes a closure of the BOP. When the valves close, the well is sealed hence preventing the fluids from the formation flowing to the surface. The sudden influx of reservoir fluids into a well bore is called a "kick". The fluids can be water or hydrocarbons.

Photo 6-21: Typical valves of BOP system and choke manifold valves system

Before the BOP can be re-opened, the fluids in the well bore are circulated out and the mud weight increased to prevent further influx from occurring. Increasing the mud weight increases the static head applied and eventually balances the formation pressure.

For proper and easy operation of this process, special outlet pipes are installed to the BOP. These pipes are positioned on the outer side of the riser and are connected with a remote-control valve system, called choke manifold.

Photo 6-22: Typical choke manifold

6.2.4.2.8.3 Typical drilling and tubing program

A typical program for a new well (Epsilon well drilled from Lamda) including the drilling process of each section until a final depth of **3.150m** is described below. The following paragraphs present a brief description of the stages of drilling, and the figure illustrates the tubing plan.

Driving of 30" diameter conductor to ~ 40m – 100 m

Initially, the **conductor pipe of the well** is set in place, which has a larger diameter than the pipes that will be positioned subsequently. The conductor will be embedded by using a hydraulic hammer. It is expected to be embedded to around 40m - 100m (depending on the subsoil) under the seabed. The conductor pipe will not be threaded, but they will be connected together when restrained.

Drilling of 26" diameter up to ~ 400 m

After setting in place and restraining the 30" conductor, a bit of 26" diameter will wash the conductor internally. Then, a wellbore of 26" will be drilled up to approximately 400 m. pure seawater, and when it is necessary for better washing, limited volumes of high viscosity pulp will be used. Before setting in place and cementing the **18-5/8" casing,** the well will be filled with bentonite mud.

Drilling of 16" diameter up to ~ 1.550 m

A wellbore will be drilled up to approximately 1.550 m with a bit of 16" diameter. Mud of high viscosity will be used regularly to keep the well washed. The wellbore will be purged by fresh high viscosity mud before logging and installation of the **casing 13-3/8"**. The casing will be cemented for 200 m above the bottom of the previous tube.

Drilling of 12-1/4" diameter up to ~ 2.350 m

A bit of 12-1/4" diameter will be used to drill a wellbore up to approximately 2.350 m. The final depth of this phase of the wellbore will be at the bottom of the lowest evaporate, just above the reservoir section. Before installing the **casing 9-5/8"** and cementing the wellbore, logging will be done and the well will be checked for inclination. The casing will be cemented with a single volume of cement designed to form a cementing column 200 m above the bottom of the previous casing 13-3/8" and cementing along the entire length of the open geological formation. For the Prinos wells that are to be sidetracked, this or the 8 ½" section would be the first to be drilled. The upper sections are inherited from the donor well. To make a sidetrack a whipstock is run into the donor well at the selected depth and a window milled through the casing. The new section is drilled from this window,

Drilling of 8-1/2" diameter up to ~ 3.150 m

A wellbore will be drilled up to approximately 3.150 m with a bit of 8-1/2". The previous drilling mud will be used. Currently it is expected that the Epsilon wells will be completed barefoot, i.e. no liner will be installed. This will allow production from a well bore to be maximised. The reservoir section in Epsilon is made up of consolidated sandstones and sand production is not expected to be an issue. In the Prinos wells a liner will be cemented over the full reservoir section and then perforated where oil pay is assessed as being present.

Table 6-11: Drilling and Tubing Plan

Section	Final depth (from the seabed) (m)	Section's length (m)	Well's diameter (inches)	Casing diameter (inches)
I	40 m	400 m	36''	30''
	400 m		26''	20''
II	1,550 m	1,150 m	16''	13 3/8''
III	2,350 m	800 m	12 1/4''	9 5/8''
IV	3,150 m	800 m	8 1/2''	7''

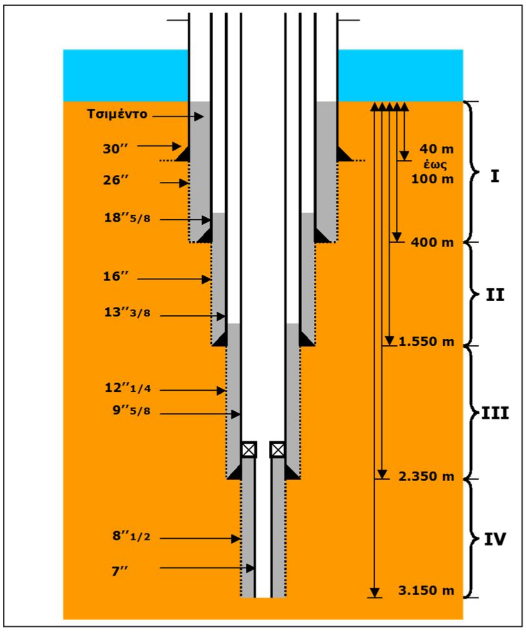


Figure 6-16: Schematic illustration of tubing plan

6.2.4.2.8.4 *Typical drilling mud plan*

Whilst drilling the 26'' diameter section down to a depth of 400m, a seawater gel will be used as the drilling fluid. Cuttings from this section will be deposited at the seabed. This is unavoidable, as until the first casing string is installed a riser to recover the cuttings cannot be installed. The gel used is selected to be fully biodegradable with no negative impacts on the local environment. Below this depth drilling fluids are returned to surface where the cuttings are removed and the mud is conditioned as described above. Dried cuttings are shipped to shore for disposal.

The total volume of drilling mud as well as the added ingredients (with concentration) is presented in the following table.

Table 6-12: Drilling Sludge Plan per Drilling Section

Section	Well's diameter (inches)	Estimated volume of drilling mud (m^3)	Mud system
I	26	140	Sea Water + Gel for the cleaning of the well Products: Bentonite (M-I Gel)
II	16	210	M-I Gel / Polymer (Sea water) Products: Bentonite (M-I Gel), POLYPAC UL, CMC-HV
III	12 Ό	180	Saturated Salt (KCl, NaCl) / KLA CURE / POLYMER Products: Saturated salt, POLYPAC UL, POLYDRILL, KLA-Cure, Barite
IV	8 ½	110	FLO-PRO / POTASSIUM FORMATE Products: K-Formate Brine, Flo-Vis, Flo-Trol, Safe Scav HS, Sized Calcium Carbonate
Total		640	

In the following paragraphs the products that are used for the preparation of the drilling mud are described.

- **BENTONITE:** Is a clayey mineral, which is used to increase the specific weight of the drilling mud and to compensate the hydrostatic pressure. It is used with pre-hydration at initial concentrations of 40 - 70 kg/m^3. Bentonite is a mineral and is not considered hazardous to the environment.
- **POLYPAC UL:** Polypac UL Consists of polyanionic cellulose and is a high quality water-soluble polymer that is designed to control the loss of fluids. It is an additive of a very small quantity ("Ultra Low" additive), so causes zero to minimum reduction of liquidity. Usual concentration is 5 - 15 kg/m^3. The POLYPAC UL is biodegradable.
- **CMC HV:** CMC HV is sodium carboxymethyl cellulose of high viscosity, which is designed to control the losses of the drilling mud into the walls of the borehole and

control the liquidity of the water base mud. It is resistant to bacteria and has a wide tolerance in chemical reactions of the mud. The CMC HV is biodegradable.

- **POLYDRILL:** Polydrill is a polymer for water base mud, which controls the fluid loss and the rheology of the mud and is particularly effective at high temperatures, as well as in fluids with high content of electrolytes. Polydrill reduces fluid loss by reducing or blocking the pore diameter. This polymer has significant water-binding capacity, minimizing the loss of fluids.
- **KLA-CURE:** KLA-CURE is a hydration suppressor and consists of a water-soluble environmentally acceptable organic mixture, which is designed to reduce the swelling and dispersion of reactive clay formations. KLA-CURE can be used in systems of fresh or seawater with low or high solids content. Usually the concentration is 11.4 – 22.8 kg / m^3 depending on the diameter of the hole and the length of the drilling section.
- **BARITE:** Barite is used to increase the specific weight of the drilling mud and compensates the hydrostatic pressure. Barite is a mineral and is not considered hazardous to the environment.
- **FLO-VIS:** FLO-VIS is a biopolymer (clarified xanthan gum biopolymer) of high quality, which is able to improve the drill mud rheological characteristics. Not considered as hazardous to the environment.
- **FLO-TROL:** FLO-TROL is a highly modified starch derivative used for fluid loss control and viscosity. Not considered as hazardous to the environment.
- **SAFE SCAN HS:** SAFE-SCAN HS reacts with the hydrogen sulphide and remains soluble even after the chemical reaction therewith. It is based on an organic chemical instead of the commonly use of mixtures of zinc or iron.
- **SIZED CALCIUM CARBONATE:** Sized Calcium Carbonate is produced in different granule sizes that can be used as an increasing factor of the specific weight of the drilling sludge, and to reduce the inflow of fluid formations at the drilling slurry. It is a mineral and is not considered hazardous to the environment.

Table 6-13: Concentration of materials for the preparation of the drilling mud per well section

Section		I	II	III	IV
Bentonite (M-I GEL)	kg/m^3	70,000	50,000	20,000	
Caustic soda	kg/m^3		0,500	2,000	
Soda ash	kg/m^3	1,000	0,500	1,000	
Polypac UL	kg/m^3		4,000	14,000	3,000
CMC HV	kg/m^3		2,000		
Polydrill	kg/m^3			3,000	
Lube 167	ltr/ m^3			20,000	
NaCl	kg/m^3			280,000	
KCl	kg/m^3			80,000	

Section		I	II	III	IV
KLA Cure	kg/m³			15,000	
Barite	kg/m³			680,000	
Defoamex	kg/m³			1,500	
K+-Formate	ltr/ m³				833,000
Flovis	kg/m³				4,000
Flotrol	kg/m³				15,000
Safescav HS	ltr/ m³				5,000
Magnesiumoxide	kg/m³				4,000
Sized $CaCO_3$	kg/m³				70,000

Table 6-14: Estimated quantities of materials for the preparation of the drilling mud per well section

Section		I	II	III	IV
Bentonite (M-I GEL)	kg	40.000	42.000	12.000	
Caustic soda	kg		425	1.250	
Soda ash	kg	575	425	625	
Polypac UL	kg		3.350	8.675	800
CMC HV	kg		1.675		
Polydrill	kg			1.850	
LUBE 167	ltr			12.400	
NaCl	kg			173.650	
KCl	kg			50.000	
KLA Cure	ltr			9.200	
Barite	kg			421.500	
Defoamex	ltr			1.000	
K+-Formate	m³				225
Flovis	kg				1.075
Flotrol	kg				4.050
Safescav HS	kg				1.400
Magnesiumoxide	kg				1.075
Sized $CaCO_3$	kg				18.900

6.2.4.2.8.5 Mitigation of drilling fluid losses

Loss of circulation is defined as the loss of drilling fluids from the well into the surrounding geological formations during drilling. In this case, the bore of the well may not remain filled with drilling material even if the pumps turn off, resulting in reduction of the hydrostatic pressure in the well and therefore the pressure that is applied on the hydrocarbon formation decreases. In this case drilling is out of control. To regain the control of drilling, and in particular pressure control of hydrocarbons formation, the losses must be stopped.

There are several techniques that are applied in case of fluid loss, depending on the severity of the occasion (for more details see next section). The used products seal the drillings and pores of permeable formations, in order to avoid drilling fluid losses during drilling and tubing. These products react with the drilling mud at the bottom of the well, creating a mass, which allows re-drilling and therefore regaining control of the well.

6.2.4.2.8.6 Well control

The planning of a well is made in such a way as to maintain the density of the drilling fluids, so that they apply a static pressure at the rock formations, greater than the formation pressure but not so high that mud losses occur. After research, appropriate depths are selected for the position (depths) of the conductor strings, described above, in order to contain loose rock formations, thereby allowing increases in the pressure of the drilling liquids, as required to exceed the pressure of the rock formations.

In cases where a well kick occurs then the BOP system will be used. In the layers above the evaporitic top seal formation pressures greater than hydrostatic (i.e. the pressure that would be exerted by a column of fresh water) are unlikely to be exceeded. Since the water-based drilling fluids have a greater density than water, there is a very low probability of sudden inflow of fluids of the formation into the well, under normal operating conditions. Nevertheless, the Wellbore Control Plan will be applied, which specifies all the necessary preventive actions, as well as the treatment means, according to Best Practice Guide for Drilling Program. Once drilling through the evaporitic section and the underlying hydrocarbon charged sections pressures in excess of hydrostatic will be encountered as the Epsilon field remains at virgin pressures (which are in excess of the hydrostatic pressure at an equivalent depth). Management of mud weights is therefore very critical in these deeper horizons.

In the Prinos wells the reservoirs penetrated have been significantly depleted over the last 35 years and pressures are now less than hydrostatic. Drilling mud weights therefore are reduced once the cap rock has been penetrated. High-pressure zones remain within the cap rock and hence when drilling this section high mud weights are required. Oil based mud is employed whilst drilling through the evaporates to prevent swelling of embedded clays and hence stuck pipe incidents.

6.2.4.2.8.7 Crew

The normal crew of the Energean Force tender assisted barge is 72 split into two shifts of 12 hours each. All staff is accommodated offshore in an accommodation unit that currently can hold 100 people. Staff travels to and from the rig by boat from Kavala. Whilst drilling is ongoing contractor staff supplement the rig crew. The number of such staff varies considerably and is a function of the activities being undertaken. Typical contractor staff includes directional drillers, mud engineers, geologists, cementing engineers, solids handling crew, etc.

The rig is supported by a fleet of vessels and support ships that are also owned by Energean. These vessels also support ongoing production operations at the rest of the Delta complex, transfer staff to Kappa and will in future transfer staff to and from Lamda. Approximately 25 people work on these vessels.

The crew that will work during drilling is described below:

- Drilling rig crew 15-20
- Maintenance crew 15-18
- Barge crew 8-10
- Catering crew 5-8
- Work floor area crew 10-15
- Drilling supervision 3-5
- Service staff 4 – 15

The above staff is included in the overall personnel presented earlier.

6.2.4.2.9 Personnel estimate

Energean already employees a number of technical and administrative people to carry out its day to day operations as presented earlier. Those are supported by the contractors' personnel and the personnel on board the drilling rig 'Energean Force' as also presented earlier. The future plans for installing the future platforms Lamda and Omicron ensures the viability of the operations as they are today and continued employment of existing staff. It is not expected that the new projects will increase staffing numbers due to the small size of the new installations.

6.2.4.3 Abandonment Phase

6.2.4.3.1 Abandonment of drilling wells

As mentioned earlier, wells can be abandoned permanently or temporarily.

More specifically:

- Temporary abandonment of drilling wells: the borehole of the well will be protected against any damage. A common practice is the use of a well grout with a proper marking, for easily locating the well in the future. The structures and grout used for temporary abandonment will be monitored for the avoidance of any pollution risks (i.e. by leakages). The seabed disturbance will be minimum and no drilling fluids will be dispersed through the borehole.
- Permanent abandonment of drilling wells: the same procedures and pollution prevention measures will be applied, as in the temporary abandonment of the drilling wells. Furthermore, a well grout in the hydrocarbon zone will be installed, for the prevention of the non-hydrocarbon zone.

6.2.4.3.2 Decommissioning of platforms

Before platform removal, the wells will be abandoned as described above and the process systems will shut down and cleaned.

Generally, the decommissioning of the existing installations is divided in the following discrete modules:

- **Hook-down:** prior to removal of the facilities, a hook-down team will sever all necessary topside-jacket connections and install the necessary padeyes to the topsides. These operations can be done by local resources.
- **Dispersal of drill cuttings:** Accumulated drilling cuts on the piles of the Alpha and Beta drilling platforms will be removed. The cuttings will be removed from around the jacket to prevent their presence hindering jacket removal operations. The dispersal activities will be performed by divers deployed from the platform dispersing the piles using water jetting nozzles. The divers once mobilized to disperse the drill cuttings will, also, disconnect the pipelines from the base of the risers.
- **Removal:** The lift vessel will then be mobilized to site to remove the platforms. Topsides and bridges will be removed first to gain access to the pipe internals. Charges will be run down the inside of the piles and detonated. Once the piles have been cut, the lifting vessel can lift and load the jackets on barges.
- **Disposal:** Following the removal of the platforms it is assumed that either onshore deconstruction or recycling of the material or deep-water disposal will be the preferred disposal route (note: this alternative disposal option is discussed as detailed below).

The new platforms (Lamda and Omicron) employ a design that enables them to be removed and reused at an alternate location using the reverse of the installation procedure. This reduces the cost of abandonment activities significantly and clearly allows for fuller recycling if re-use can be achieved.

More specifically:

The baseline abandonment operation for the existing facilities is to remove the platforms and load them on barges for towing to shore for offloading and dismantlement. It is assumed that all hook down activities have been completed prior to mobilising the crane vessel to site and that all drill cuttings have been dispersed from around the base of the drilling platform jacket.

Typically, the removal operations will involve a crane vessel positioning itself adjacent to the platforms and removing the bridges, topsides and jackets in a pre-determined sequence and placing them on a pre-prepared cargo barges for transport to a suitable final destination. In calculating the size of and number of barges, the dimensions of the platforms are required.

Activities will be scheduled to minimize the crane vessel time on location. Therefore it is proposed to remove bridges and topsides first to allow the DSV/workboat to run explosive charges internally down the piles and perform pile-cutting activities simultaneously to other topside removal operations. Explosive cutting tools are envisaged for pile cutting however other options such as diamonds wire and abrasive waterjet techniques could also be used.

More specifically, the SIP may be decommissioned in two main parts: topsides and hull. The SIP hull can be removed/relocated/decommissioned by deballasting the ballast tanks and reversing the suction operation. The SIP may be relocated to another similar location by towing in the upright position. A small water depth variation is allowed for the SIP relocation. The hull will have towing pad eyes with a capacity sufficient for vertical tow. The topsides must be independently removed/relocated/decommissioned in a separately operation.

An alternative decommissioning solution is the disposal of the platforms in deep-water. The exact deep-water disposal technique applied will be a result of extensive environmental, legal, social and technical studies.

This deep-water disposal solution had been examined in the past (1998) for the existing offshore facilities. A crane-vessel, a special launch barge and explosive cutting tools will be used.

Proposed sites for the disposal are:

- 100 m depth at distance of 10 km S/SW of Kappa platform
- 200 m depth at distance of 15 km S/SW of Kappa platform
- 500 m depth at distance of 30 km S/SW of Kappa platform

All hook-down activities have to be completed prior to mobilizing the crane-vessels to site. The procedures of drilling wells and drilling cuts are the same with the ones described in the basic decommissioning solution.

In other shallow water oil and gas provinces platform jackets are employed to create artificial reefs to aid the local fishing industry. Once removed jackets are laid horizontally on the seabed in an agreed location. They are covered by wire or rope meshing to give a structure to encourage marine growth. Topsides would not be abandoned in this manner due to the potential for remaining oil contamination.

6.2.4.3.3 Decommissioning of pipelines

All pipelines (i.e. existing and new pipelines) will be flushed with seawater to remove all hydrocarbons. A portion of this water will be discharged into the existing water treatment facilities at the Delta platform and treated to remove contaminates (as verified by monitoring) prior to discharge to the sea. The other portion of the pipeline wash water will be sent through the line for discharge via the Sigma plant. This waste water will be disposed of onshore through an authorized waste disposal/treatment site as managed under the WMP.

6.2.4.3.3.1 Reinstatement of site

Due to the fact that all infrastructures are located offshore, the only reinstatement activities are the prevention measures for elimination of pollution risk and for the minimization of seabed, as described in previous paragraphs.

6.2.5 Emissions and Material Use

6.2.5.1 Construction Phase

6.2.5.1.1 Raw Material Usage

Due to the nature of activities and the short duration of construction, minimal raw material usage will occur during construction. This will consist mainly of the typical materials used for vessel operation (e.g. fuel) and those associated with the presence of a workforce (e.g. water, food).

6.2.5.1.2 Noise emissions

During the construction phase of a typical upstream project noise emissions are associated with two main elements; namely a) the number and size of the vessels employed and the overall duration they are at site and b) the installation of piles to hold the jacket structure to the sea bed. A typical execution strategy involves a heavy lift barge to place the jacket in position, tugs to hold transportation vessel in placed, a piling spread, a floating accommodation unit to house the large number of staff required plus vessels to bring supplies and remove waste to shore. A typical construction activity can last 6 to 8 weeks.

Energean has selected a design concept that minimises the time required to install the new facilities and avoids the use of heavy lift equipment, piling spreads and temporary living quarters. The expected installation time is just 3 days and marine requirements limited to 2 tugs and a dumb cargo barge. The quantity of noise from this spread is expected to be less than 1% of that associated with a typical installation. The tugs to be employed re based in the Kavala area and hence contribute sub-sea and airborne noise to the area currently.

Energean has also selected to use suction piles instead of driven piles to hold the structure in place. When driving piles noise levels in excess of 180 dB are created sub-sea. These can cause permanent damage to mammals within 2 to 10m distance and impact their normal behavioural patterns up to 200m away. The use of suction piles avoids these significant noise emissions. The only item installed subsea that emits noise will be the suction pumps that extract water from the piles. These will operate for around 12 hours. They emit noise at a level of about 40 dB, similar to an idling car. These levels will have no impact on the environment.

Surface noise will also be limited by the fact that no heavy lifting gear is required and hence no diesel engines. The topside structure is lifted into position using hydraulic jacks.

6.2.5.1.3 Emissions to air

Emissions to air during the construction phase are due to the flue gasses associated with the marine spread employed. As described for noise emissions the selection of a Self Installing Platform helps ensure that air emissions are brought to a level significantly lower than a typical platform installation.

6.2.5.1.4 Wastes

No significant waste streams are expected in the construction phase. The platform topsides will be fully constructed onshore and hence there will be little need for mechanical operations following platform installation other than the mating of pipelines and risers subsea.

There will be no offshore accommodation in the field and hence no human related waste streams to deal with.

6.2.5.2 Operating Phase

6.2.5.2.1 Raw material usage

6.2.5.2.1.1 Use of chemicals

The offshore processing on the Prinos complex that takes place in platform Delta consists basically of:

- 3- Phase (oil, gas and water) production separation
- Well production testing
- Crude dehydration
- Crude oil transfer to shore, with high pressure pump via 8'' submarine pipeline
- Gas dehydration (BASF)
- Treatment of waste water for disposal (de oiling and stripping)
- Sea water injection

For the above processes, the following chemicals are used on Delta platform:

Table 6-15: Chemicals currently used on existing facilities

Chemical	MSDS
Demulsifier	EC-2173A
Scale inhibitor	EC-6156A and EC-6187A
Corrosion inhibitor	EC-1175A and EC-1185A
Antifouling	EC-6201A and EC-6388A
Oxygen scavenger	EC-6213A
Cationic polyelectrolyte	EC-6176A
Triethylene glycol	BASF
Methanol	
Citric acid	

For each stage a different chemical is used:

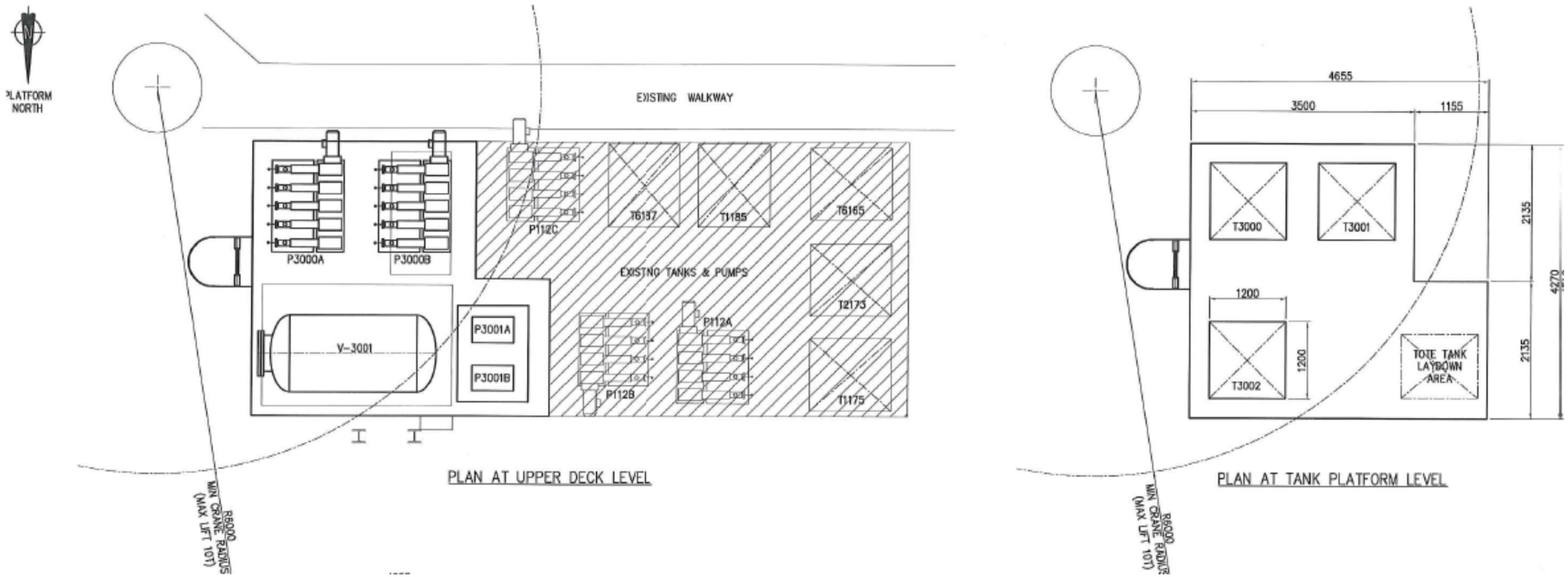
- Demulsifier (EC-2173A): A demulsifier is required to prevent the formation of emulsions within the overall production system
- Scale inhibitor (EC-6156A and EC-6187A): This chemical is required in order to prevent scaling, due to the high salinity of formation of water.
- Corrosion inhibitor (EC-1175A and EC-1185A): For prevention of corrosion, inside the offshore flowlines and pipeline, two types of corrosion inhibitors are used.

- Antifouling (EC-6201A and EC-6388A): Antifouling agents are used for the protection of equipment from algae and bacteria growth.
- Oxygen Scavenger (EC-6213A): Oxygen is removed from the seawater, by the use of oxygen scavenger, for protection of corrosion by the growth of certain bacteria.
- Cationic polyelectrolyte (EC-6176A): This polyelectrolyte is used for flocculation of salts etc.
- Triethylene glycol (BASF): Triethylene glycol is used in order to remove the water from the sour gas and prevent corrosion of the 12” sour gas pipeline.
- Methanol: Methanol is to be used as the hydrate inhibitor.
- Citric acid: This type of acid is used for scaling cleaning

Moreover, Prinos Delta will supply chemicals to the new satellite platforms maximizing the use of the umbilical and minimizing the need to send operators to the platforms. The chemical injection area of Delta platform will be upgraded to accommodate new chemical injection equipment.

The relevant layout plan is presented in the below.

Chemicals will be injected with the wells and platform in flowing status. No chemical injection is required with the wells closed in thus limiting maximum pressures required to inject at Lamda platform. Subsequently, Omicron platform will be installed south of the Prinos North field. The two platforms will be essentially identical.



Drawing 6-1: Accommodation of chemicals

The chemicals that will be used are presented in the following table below.

Table 6-16: Chemicals currently used on existing facilities

Chemical	MSDS
Corrosion inhibitor	EC-1175A
Demulsifier	EC-2173A
Asphaltene	EC-3019A
Hydrate inhibitor (methanol)	
Scale inhibitor	EC-6187A

More specifically:

- The current Prinos Delta corrosion protection scheme will be adopted for use on the new platforms. The current scheme has proven that the use of carbon steel pipework with suitable corrosion inhibitor injection is acceptable. Corrosion inhibitor will be injected continuously at a point upstream of the relevant well choke valve.
- Demulsifier will be injected continuously at the inlet to the export pipeline on both satellites. Demulsifier is required to prevent the formation of emulsions within the overall production system. An additional demulsifier injection point will be installed at the test manifold
- Asphaltene precipitation problems are expected in the Epsilon wells and potentially on wells drilled from Omicron. Asphaltene precipitation is to be mitigated via continuous down hole injection by means of a deep set Chemical Injection Valve (typically 3/8" control line) which will be installed with the injection point set as low as possible along the tubing so as to maximize the effect of the asphaltene inhibitor. The preferred Chemical Injection Valve location is below the production-tubing packer.
- A hydrate inhibitor is required for discontinuous use during start-up and planned shutdowns to prevent hydrate formation in the flowlines and multi-phase pipeline. Methanol is to be used as the hydrate inhibitor. Currently the design assumes a separate Methanol injection system.
- Scale inhibitor is expected on wells with high formation water production, mainly anticipated on Omicron wells, where higher aquifer support is anticipated. Injection is done down hole using the same control line as the asphaltene inhibitor injection. Note that Asphaltene and scale inhibitor will not be injected at the same time.

The injection system scheme between Delta and Lamda / Omicron is provided in the following diagram: