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3. ASSESSMENT OF PROJECT ALTERNATIVES

This chapter outlines the alternative development options that were proposed and continue to be assessed during the FEED phase of the Project. The alternative development options for the Project were assessed against primary constraints that would impact their implementation and feasibility.

Aspects considered while assessing the various Project options includes that which is discussed in further detail in social, cultural and environmental characterisation chapters 7 to 10 of this EIS and associated technical studies, and potential impacts discussed in chapters 11 to 14, as well as information of a commercially sensitive nature. These aspects broadly encompass:

- Economic constraints: construction and operational cost of each alternative.
- Physical constraints: location in relation to sensitivities and infrastructure, climatic conditions, and landscape constraints i.e., topographic and geotechnical constraints.
- Environmental constraints: environmental conditions and sensitivities, protected areas, endangered species.
- Social constraints: location, values, subsistence living, cultural heritage sites and significant areas.

Chapter 2 Project Description includes the preferred development concepts which will be further developed and determined as the Project progresses through FEED.

3.1 NOT PROCEEDING WITH THE PROJECT

The most straightforward alternative is to not proceed with the Project development. If the Project does not proceed, the environmental and social impacts described in chapters 11 to 13 of this EIS would not occur. However, there are also potential positive impacts associated with the Project that would not be realised in the event the Project does not proceed, including:

- Development of the Papua LNG Project – Upstream if the integrated LNG Plant is not available to process the gas associated with this project.
- Direct (equity, royalties and taxes) and indirect (infrastructure and business development grants, and community investments) payments to the State of Papua New Guinea, the provincial and local level governments and landowners.
- Improvements to subsistence livelihoods as increased income means disposable income can be allocated to more efficient gear purchases to improve catch per unit effort.
- Conservation of mangrove timber due to increased income allocation to houses made out of manufactured materials, resulting in reduced demand of natural materials.
- Businesses and industrial services receive the benefit of increased commerce, which in turn will allow for further investment and support employment opportunities.
- Employment and opportunities to up-skill associated with the construction and operation of the Project, which will improve technical capabilities in the area and help with employment opportunities post Project.
- Greater disposable incomes which could support local enterprises and attract future businesses.
- Improved and additional housing due to increased rates of personnel investments into housing.
- Improved accessibility to education for family members of workforce personnel due to benefit entitlements provided by the Project.

3.2 ALTERNATIVES CONSIDERED IN PROJECT PLANNING

This Project has matured through an assessment of alternatives for increasing the current capacity of the LNG Plant through commercialisation of gas supplied from the Elk and Antelope reservoirs being developed for the Papua LNG Project – Upstream. This Project has completed conceptual planning and pre-FEED and is currently conducting the FEED process to further develop the project design. The key alternative development options considered were marine facilities, onshore pipelines, logistics routes, LNG processing technology, equipment optimisation and water sources. The preferred Project alternatives have undergone various multi-criteria assessments including:

- Concept Challenge
- Materials Management Impact Assessment
- Independent Project Reviews
- Project Definition Readiness Index
- Environmental Aspects Assessment (EAA) – see Chapter 18 Environmental Monitoring, Management and Reporting
- Project Environmental Standards Review.

These assessments are intended to review and confirm the following:

- Adequacy of project definition
- Quality of project cost estimate, schedule, and execution strategy
- Optimum cost approach with regard to both facility scope and project execution
- Selection of the most suitable technology and identification of technology development needs.
- Project impacts to environmental and social aspects
- Project adherence to company environmental standards.

The assessments typically include the evaluation of various constraints and criteria related to feasibility, cost, schedule, logistics, regulatory and permitting considerations, and environmental impact. Given the small scope and brownfield nature of the Project, previously disturbed areas will be utilised, resulting in limited environmental impacts, particularly compared to development in a greenfield location. This feature, in conjunction with combining the offshore construction with the Upstream construction activities, will further reduce the overall environmental impact of the Project. Consequently, environmental impact aspects were not necessarily the leading criteria for preferred option selection.

3.2.1 Project location

The proposed location of the Project is driven by the location of existing infrastructure including the LNG Plant, pipeline and jetty.

The Project will be located primarily on existing LNG Plant lease areas, which will also allow for sharing of existing utilities where capacity will allow, such as power generation, service and instrument air, and hot oil system. The aim is to confine the Project footprint, as much as possible, to within the areas of the existing LNG Plant leases however, some aspects of the Project, such as the proposed Catenary Anchor Leg Mooring (CALM) buoy, are located outside the existing lease area.

Alternative locations for a separate LNG plant were considered by TotalEnergies and are discussed in Chapter 5 of the Papua LNG Project – Upstream EIS (Total E&P PNG Limited, 2019; Report No. 01215B_23_v5). Once TotalEnergies had selected Caution Bay as the facility location for the Papua LNG Project, utilising the existing LNG Plant location was the clear choice to reduce environmental impacts and leverage existing utilities, logistics, and social engagements.

3.2.2 Marine facilities

Two options were considered for the expansion of the existing marine facilities to accommodate the increased LNG and non-LNG liquids production rates and subsequent increase in the number of vessels. These were:

- Second berth: Construction of a new multiproduct berth to the north of the existing berth to export LNG and condensate, connected by a new trestle. The LNG cargos shipments would be split between the two berths. The existing naphtha cargos would remain at the existing berth and the condensate cargos would be handled at the new berth. Since the new berth would utilise the same LNG loading line as the existing berth, simultaneous loading of LNG at full rate on both berths would not be possible.
- CALM buoy: Installing a CALM buoy to export the non-LNG liquids (naphtha and condensate) to allow the existing multiproduct berth to become LNG only. Additional upgrades are also being considered to the existing berth to improve reliability and maintainability.

The CALM buoy option has been selected as the base case and is discussed in Chapter 2 Project Description. This option was selected primarily due to its lower front-end cost compared to the alternative berth. A high-level site selection screening analysis was conducted to evaluate the feasibility of six potential locations for the CALM buoy. The analysis included various considerations related to pipeline siting and crossing, mooring of the CALM buoy, navigational aspects, environmental and regulatory issues, and cost. Four locations were ruled out following assessment of technical, navigational, environmental, and cost feasibility considerations. Two locations were carried forward during pre-FEED for more detailed analysis and resulted in the base case location being selected for the CALM buoy as discussed in Chapter 2 Project Description. Surveys and assessments to determine which of the two CALM buoy locations was to be selected were conducted to address potential issues and included consideration of geohazards, ecological impacts, financial cost and constructability. The constructability of the associated export pipelines also influenced the site selection for the CALM buoy, and included considerations related to risks regarding existing operations and infrastructure. The various CALM buoy locations, including the selected option (option ‘E’) for the Project, are shown in Figure 3.1.

A similar screening analysis was conducted for the alternate navigational channel location (see Chapter 2 Project Description, Figure 2.1) for the LNG carriers. The requirement for rock armouring on the existing PNG LNG pipeline and associated safety and environmental risks, as well as navigation and environmental considerations (e.g., dredging) were considered. A base case location was selected for the alternate channel, primarily based on mitigation of environmental impacts due to dredging.

3.2.3 Papua LNG pipelines

Two new feed pipelines (referred to as the Papua LNG pipelines), one each for feed gas and field condensate, will be installed. The analysis and selection of the preferred pipeline route will be discussed in the Papua LNG – Upstream EIS addendum. ExxonMobil worked in conjunction with TotalEnergies to assess the options for the offshore pipelines leading up to the shore crossing and into the LNG Plant tie-in point, given this work will exist on the current PRL15 lease boundary.

3.2.4 Logistics route

Four alternative logistics route options were considered to transport cargo during the construction phase of the Project. The four alternatives were initially assessed in the EAA that was conducted prior to pre-FEED. The potential impacts of each alternative were shared with the Project team and were incorporated into a material offloading facility (MOF) study conducted during pre-FEED, which was designed to evaluate the technical feasibility and costs associated with each of the alternatives. The alternative options included:

- Shipping imported cargo to the Motukea Port and barging to a proposed MOF north of the existing LNG Plant jetty

- Shipping imported cargo directly to the proposed MOF
- Shipping imported cargo to the Motukea Port and trucking to the LNG Plant via the Lea Lea Road
- Shipping imported cargo to a proposed deep-water wharf north of Boera Village, which would have required construction of a new road to truck the cargo from the wharf to the LNG Plant.

The assessment of the various alternatives included consideration of the implications and impacts associated with potential disturbance areas and road widening activities on communities. The selected preferred option is to truck cargo from Motukea Port using the existing Lea Lea Road to minimise the disturbance of undeveloped areas that would be required for the construction of a MOF, wharf or new road. The existing Lea Lea Road may require some upgrades or minor expansions to accommodate modules or larger pieces of equipment, the extent of which will be further defined during FEED.

3.2.5 LNG processing technology

Two liquefaction processing technologies were evaluated, C3MR[1] and single mixed refrigerant (SMR).

- C3MR would require installation of two LNG trains, consisting of gas treatment and liquefaction facilities, located east of the existing LNG Plant trains, capable of processing all the feed gas from the pipeline. C3MR would use direct gas turbine drive due to power requirements in the liquefaction section of the trains. The two new trains would utilise the spare capacity of the existing common infrastructure and utilities.
- SMR requires the installation of a common gas treatment facility and new liquefaction units in the same area to the east of the existing trains. The gas treatment facility is capable of processing all the feed gas, after which approximately one third is sent to the existing trains for liquefaction, while the remainder is liquefied in the new units. The liquefiers use electric motor drive. The SMR concept utilises spare capacity of the existing process trains, common infrastructure, and utilities.

The SMR processing technology was selected as the preferred option since it takes advantage of available processing capacity in the existing trains and offers the ability to utilise electric drive, which is compatible with more efficient power generation and enables connection of future renewable power sources.

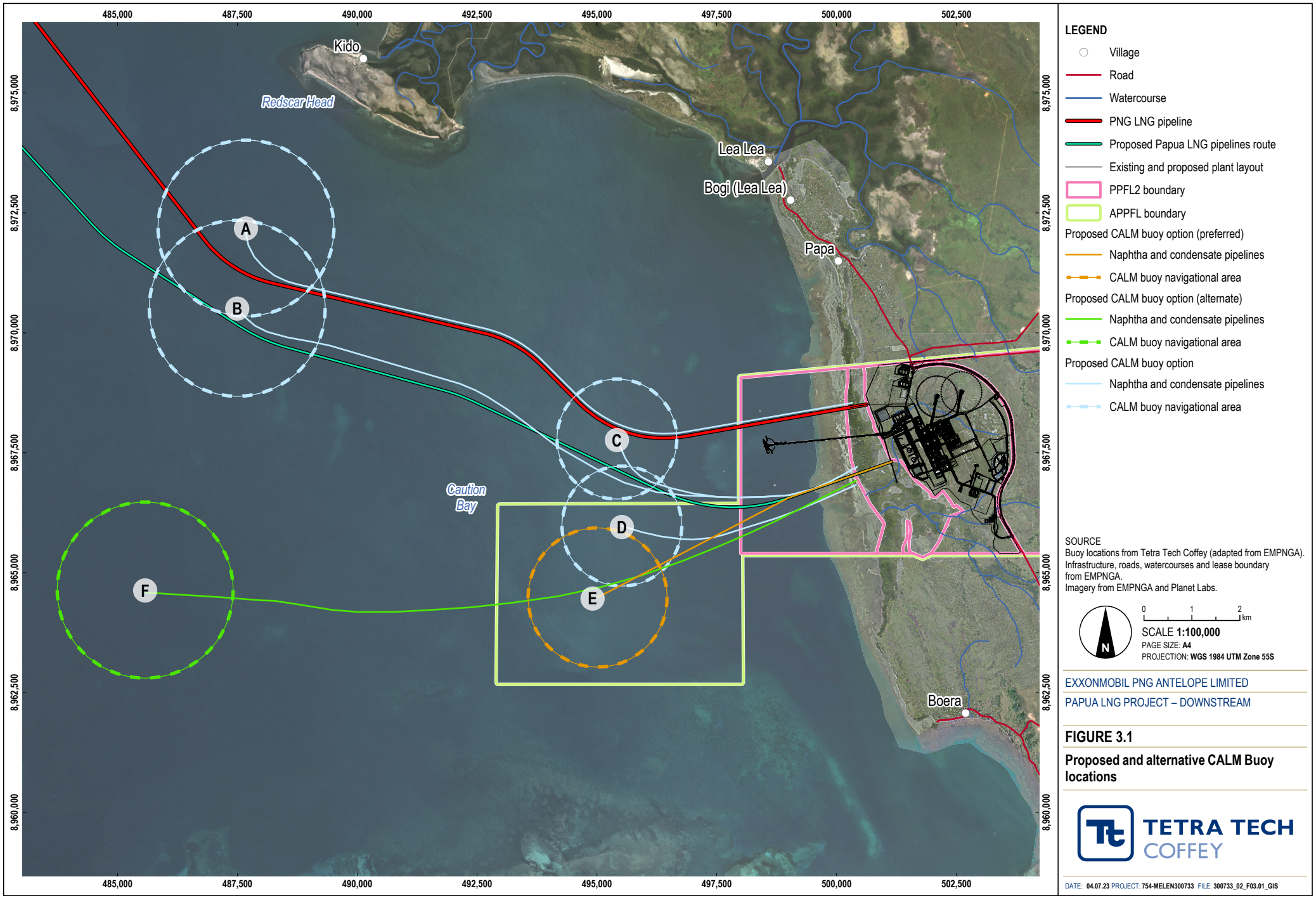
3.2.6 Power generation

Two types of power generation systems were evaluated for the Project:

- Conventional gas turbines which are currently used at the LNG Plant
- A new combined cycle power plant (CCPP), consisting of a combination of gas turbine generators, heat recovery stream generators (HRSGs) and steam turbine generators.

The CCPP was selected as the preferred option due to energy efficiency and lower greenhouse gas emissions intensity for the energy produced. Relative to the existing gas turbine generators operating at the LNG Plant, this Project option has a lower relative energy demand to generate comparable amounts of power, resulting from the steam generation process instead of use of fuel gas. The decision to use the CCPP relates to the adoption of eLNG[2] trains for the Project, that in turn require less energy to process gas, increase gas availability for LNG production, and reduce processing and production costs.

[1] Propane precooled mixed refrigerant process used to liquify natural gas.
[2] eLNG refers to electric liquefied natural gas, and is the term used to refer to the new eLNG trains that will be powered by the new Combined Cycle Power Plant (CCPP).



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LEGEND

- Village
- Road
- Watercourse
- PNG LNG pipeline
- Proposed Papua LNG pipelines route
- Existing and proposed plant layout
- PPFL2 boundary
- APPFL boundary

Proposed CALM buoy option (preferred)

- Naphtha and condensate pipelines
- CALM buoy navigational area

Proposed CALM buoy option (alternate)

- Naphtha and condensate pipelines
- CALM buoy navigational area

Proposed CALM buoy option

- Naphtha and condensate pipelines
- CALM buoy navigational area

SOURCE
Buoy locations from Tetra Tech Coffey (adapted from EMPNGA).
Infrastructure, roads, watercourses and lease boundary from EMPNGA.
Imagery from EMPNGA and Planet Labs.

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PROJECTION: **WGS 1984 UTM Zone 55S**

EXXONMOBIL PNG ANTELOPE LIMITED

PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 3.1

Proposed and alternative CALM Buoy locations

TETRA TECH COFFEY

DATE: **04.07.23** PROJECT: **754-MELEN300733** FILE: **300733_02_F03.01_GIS**

3.2.7 Equipment optimisation

This section explains the equipment optimisation options assessed by ExxonMobil to incorporate into the design.

3.2.7.1 Flare characteristics

Five flare options were considered for the SMR processing technology:

- Individual pressure control without high integrity pressure protection system (HIPPS) to dry gas flare
- Individual pressure control without HIPPS to wet gas flare
- Individual pressure control plus HIPPS to dry gas flare
- Individual pressure control plus HIPPS to wet gas flare
- Common pressure control without HIPPS.

The use of HIPPS or a fully rated pressure safety valve flare system sized for full open of all active pressure letdown station control valves to provide overpressure protection in the inlet of the Papua LNG Plant are being evaluated as the primary options for pressure control. The individual pressure control plus HIPPS to wet gas flare is considered the preferred option and is being evaluated during FEED.

3.2.7.2 Management of gas contaminants

The majority of gas contaminants are removed in the upstream facilities, leaving only very low (ppm-level) concentrations of water, mercaptans, carbon dioxide and hydrogen sulphide, and trace amounts of mercury at the LNG Plant inlet. Removal upstream allows contaminants to be reinjected, which is impractical at the LNG Plant due to lack of well infrastructure.

Of the contaminants remaining at the LNG Plant inlet, any mercury is captured by adsorbent bed. Hydrogen sulphide and mercaptans from the gas are concentrated in the gas dehydration system and eventually burned in the fuel gas stream. Dissolved mercaptans in the water from the dehydration system is sent to a thermal oxidiser for incineration to minimise offsite odours. Alternatives will continue to be assessed during FEED.

3.2.8 Water supply

Three water supply options were initially considered for the Project:

- Desalination
- Groundwater
- Trucking water into the LNG Plant.

Due to the water requirements for the Project, a new water desalination package has been determined to be the most feasible option and is considered the base case. Further studies will be performed during FEED to validate this decision. The use of a desalination plant, as opposed to trucking of water will reduce the strain on resources and infrastructure in the surrounding communities.

The water demands on the existing water treatment and distribution system are being evaluated during FEED to determine if additional packages, such as potable water and firewater systems, are required to support the needs of the Project and future operations.