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14. CUMULATIVE IMPACT ASSESSMENT

This chapter presents the findings of the cumulative impact assessment completed for the Papua LNG Project – Downstream (the Project). A cumulative impact assessment aims to identify and assess where effects from individual projects or activities may overlap, interact, and accumulate and therefore result in a cumulative impact on environmental, social, and cultural value. The approach is described in Chapter 5 Overview of Impact Assessment Method, and shown in Figure 5.4. A cumulative impact on an environmental, social, or cultural value requires a credible project, and a spatial and temporal relationship to exist between that project or activities and the Project.

Under Papua New Guinean legislation (i.e., the *Environment Act 2000*), it is the proponent's responsibility to determine whether it is reasonable to assess cumulative impacts as part of an environmental and social impact assessment. International good practice, including International Finance Corporation (IFC) guidance, advocates that identifying and assessing cumulative impacts is essential to managing a project's potential impacts (IFC 2013).

This chapter is structured as follows:

- Section 14.1 describes the methods used to identify and assess the Project's cumulative impacts.
- Section 14.2 describes the scope of the assessment, including the mechanism of change, the identified environmental, social, and cultural values that may be affected by cumulative impacts, the assessments' spatial and temporal boundaries, and the identified credible projects.
- Section 14.3 assesses the Project's potential cumulative impacts structured around the identified mechanisms of change.

14.1 ASSESSMENT METHOD

The method for cumulative impact assessment outlined in this section is based on the approach within the International Finance Corporation's Good Practice Handbook on Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets (IFC 2013). The steps for assessing cumulative impacts comprise:

- Scoping the assessment to determine:
 - The mechanisms identified from project activities that may lead to cumulative impacts
 - The key environmental, social, and cultural values to be assessed
 - The spatial and temporal boundaries of the assessment
 - Credible projects that have the potential to contribute to cumulative impacts on the identified key values.
- Identifying the cumulative impacts on the key values and the significance of the cumulative impacts.
- Developing the management approaches and strategies where the Project could result in significant identified cumulative impacts to the extent that EMPNGA can influence them.

The assessment of potential cumulative impacts relating to the Project draws on the findings of the impact assessments carried out by technical specialists for relevant environmental, social and cultural values. The findings from the impact assessments are presented in Chapter 11 Environmental Impact Assessment: Onshore, Chapter 12 Environmental Impact Assessment: Marine, Chapter 13 Social and Cultural Impact Assessment, and in the specialist studies provided in Appendix A to L.

Publicly available information on other credible projects near the LNG Plant has also been reviewed to inform the cumulative impact assessment. For a project to be eligible for consideration in the cumulative impact

assessment, the valued environmental, social, and cultural heritage components need to have been described in a publicly available document (e.g., an environmental impact statement) to enable the contributions to a cumulative impact to be assessed. The cumulative impact assessment cannot assess speculative projects and for which there is no verified publicly available information relating to the project's design, construction, and operation.

14.2 SCOPE OF THE ASSESSMENT

The scoping phase of the cumulative impact assessment is discussed in this section. The spatial and temporal extents were determined by understanding the various mechanisms that may lead to impacts, their area of influence and the potentially impacted values. This step also includes identifying other credible projects, natural environmental stressors and human activities with the potential to contribute to cumulative impacts.

The mechanisms identified from Project activities that may lead to cumulative impacts include:

- **Physical disturbance:** Ground disturbance activities such as vegetation clearance, earthworks and construction will generate dust, sediment dispersion and noise, which may contribute to a cumulative impact on nearby sensitive receptors. Physical disturbance and vegetation clearance may also increase erosion and runoff into watercourses or waterbodies.
- **Air and noise emissions:** Emissions to air and noise generation may result in cumulative impacts if nearby projects also generate emissions.
- **Habitat loss:** The loss of habitat from various projects could cumulatively impact threatened species in the area, if present. Edge effects may also contribute to a cumulative impact on a particular habitat and species. Habitat loss can include removing areas of intact vegetation communities, decreasing the area of intact vegetation within the region, and loss or damage to local sites, i.e., important habitat features such as large trees, mangroves, seagrass beds or coral reefs.
- **Runoff and discharges to waterbodies:** Discharges to the environment, for example, discharge of brine or other wastewater through the retention pond outfall, may cumulatively impact water quality if other pollutants are also entering waterways or the marine environment.
- **Changes to coastal processes and sediment transport:** The construction of coastal structures can generate sedimentation. Coastal structures can influence currents and change patterns in sediment transport and deposition. Impacts may be cumulative if other credible projects also impact sedimentation patterns in the area of interest.
- **Shipping vessel movements and navigation lighting:** An increase in shipping vessel movements during operations, and associated navigation lighting for safety, may have cumulative impacts if other projects also increase shipping activity in Caution Bay and this part of the Gulf of Papua.
- **Traffic and transport:** Public road usage will be required to transport people and materials to and from the Project. Increases in traffic volumes may increase the risk of accidents and disturbance to roadside residents, businesses, and nearby communities. Lea Lea Road is the main public road that will experience increased traffic due to the Project. Motukea Port will be used to import freight during construction. Cumulative impacts may occur if the Project's induced traffic coincides with traffic generated by other projects.
- **Project economic benefits and Project-Induced In-Migration (PIIM):** Project economic opportunities and benefit streams can interact with those of other projects and generate economic stimulus and demand in the formal and informal economy. PIIM refers to the movement of people into an area in anticipation of a project's economic opportunities, such as employment, business development, and

compensation. PIIM is common in resource projects in Papua New Guinea and in some instances, has led to significant population growth (Keenan 2017; Bainton and Banks 2018).

These mechanisms could lead to cumulative impacts on environmental, social, or cultural values.

14.2.1 Key environmental, social and cultural values

Key environmental, social and cultural values were identified during the impact assessment process (chapters 11, 12 and 13) and were reviewed for relevance to the cumulative impact assessment. The key values considered for the cumulative impact assessment were those that were:

- Potentially subject to or exposed to a cumulative impact
- Determined to be sensitive to change
- Considered most significant to local communities.

The key values most at risk of cumulative impacts include:

- **Nearshore marine species and habitat (including mangroves):** Both threatened and non-threatened marine flora and fauna which may occur and the habitats in which they live.
- **Water quality:** The physical, chemical, and biological characteristics of water and the measure of its condition relative to the requirements for one or more biotic species or to any human need or purpose.
- **Road user safety:** The risk of traffic accidents and injuries due to traffic.
- **Community amenity:** Attributes and values that affect people's quality of life, such as noise and vibration, air quality and landscape or visual change. Specific features include residences and other buildings within the Project's area of influence.
- **Livelihoods:** Any means of securing life's necessities, including income from employment, business, farming, and tourism.
- **Community infrastructure and services:** The services and institutions that are critical to the lives, livelihood and development of a community (World Bank and Global Facility for Disaster Reduction and Recovery 2012), including but not limited to health and education facilities and services, local and regional government services, connective infrastructure such as roads and bridges, and water and sanitation structures and sources.

Understanding the potential impact mechanisms and values that may be impacted forms the basis for identifying and evaluating cumulative impacts that may arise from the Project and other credible projects.

The mechanisms that can lead to an impact on these key values are detailed in Table 14.1.

14.2.2 Spatial boundary

Spatial boundaries for the Project were determined based on an understanding of the construction and operation activities and the study areas from the following specialist studies:

- Air quality
- Noise and vibration
- Terrestrial biodiversity
- Nearshore marine, including ecological aspects, water and sediment quality
- Social.

The spatial boundaries relevant to the cumulative impact assessment are presented in Table 14.1.

Table 14.1 Spatial and temporal boundaries for relevant mechanisms

Pathway / mechanisms	Spatial boundary	Temporal boundary
Physical disturbance and air and noise emissions	Dust impacts will be localised and the potential for impacts on surrounding sensitive receptors is low given the commercial/industrial zoning of adjacent land and the disturbed nature of the area immediately surrounding the site. Noise and vibration will be localised to areas near infrastructure (including marine infrastructure) and roads. Additional infrastructure within the LNG Plant will be localised and result in increased light and noise. Ground disturbances during construction may disturb acid sulphate soils commonly associated with mangroves and low-lying coastal landforms. Approximately 100 ha of potential acid sulphate soils may be disturbed during construction. Black cracking clay soils inland from the swamp areas across most of the LNG Plant site may also be disturbed. Ground disturbances may also cause vegetation loss and possibly reduce recovery due to soil horizon mixing.	Dust, sediment dispersion, noise and vibration impacts will be temporary and transient throughout the construction period with negligible impact in the operational phase. Light and noise impacts from will continue through the operational phase. Ground disturbance impacts will be temporary and transient throughout the construction period. The disturbed soils will stabilise progressively and revegetate post-construction.
Habitat loss	Terrestrial habitat within the Project site is pre-disturbed and of low regional significance. Construction and operation of the additional facilities at the LNG Plant site are expected to present a low overall impact on local biodiversity values. Largely undisturbed habitat proposed for clearance at the LNG Plant site includes approximately 3 ha of mixed grassland, woodland scrub, mangroves and wetland/saltflat. The area of subsea benthic habitat predicted to be affected by the construction and operation of the CALM buoy is less than approximately 300 m² (main cause of effects occurring due to mooring installation and chain movement over time). An area of approximately 60 ha will be cleared for an additional laydown area outside the LNG plant fence.	Seabed disturbance will occur throughout the construction phase. Impacts on benthic habitat from the CALM buoy will persist during construction and operation. Additional vegetation clearance during operation is unlikely due to the permanent onshore facilities being located within the existing LNG Plant site boundary.
Runoff and discharges to waterbodies	Additional water discharges will occur from the retention pond into Caution Bay. This includes an increased volume of wastewater (including treated domestic wastewater and brine) and treated water from site activities.	Water discharges from the LNG Plant will occur throughout the construction and operational phases of the Project.

Pathway / mechanisms	Spatial boundary	Temporal boundary
Changes to coastal processes and sediment transport	Sediment dispersion impacts will be localised and low volume and are not expected to reach sensitive receptors beyond approximately 1 km from the source (i.e., CALM buoy marine infrastructure).	Potential changes to sediment transport and coastal processes may occur during construction and operations. Increased suspended sediment and sedimentation rates will be limited to the construction phase and possible maintenance events, including dredging.
Maritime vessel movements and navigation lighting	Vessel movements, primarily comprising LNG carriers and naphtha tankers, will increase from the current estimated 130 to 210 due to the Project. There is also a requirement for navigational lighting for the CALM buoy.	These impacts will primarily occur during operations, although there will be increased vessel movements and lighting during construction of the CALM buoy.
Public road use Import of freight via Motukea Port	Lea Lea Road is the main road that will experience Project-related traffic. Motukea Port will be the main entry point for large freight during construction.	Transport of people and materials to and from the site is expected to occur primarily in the morning and evening during the construction phase, with very few trips required for maintenance in the Project's operational phase. Import of freight will be predominantly during construction.
Influx of workers	The construction workforce is estimated to be around 5,000 to 7,000 personnel over the planned four-year construction period. The workforce will consist of Papua New Guinean and expatriate employees, contractors and support staff. Depending on the phase of construction, around 20% of the total workforce positions are estimated to be filled by Papua New Guineans, with the remaining filled by expatriate staff. Accommodation during construction is proposed to be provided in the form of construction camps for company and contractor personnel, catering for a bed capacity of between 4,000 to 6,000. The permanent operations workforce at the LNG Plant is expected to increase by approximately 50 full-time equivalent positions over current operational requirements with support staff to increase as well. Accommodation for staff and contractors during operations is proposed to be in the existing operation camp within the LNG Plant. The existing operation camp will not be expanded.	An influx of workers will occur primarily in the construction phase, with a reduced workforce for operations, similar to the current operational workforce.

The assessment's spatial boundary (area of influence) includes the area within which the Project and other credible projects could impact the key values identified. The area of influence differs depending on the value that is impacted and the pathway or mechanism that leads to the impact (for example, the Project's logistics route extends 16 km from Motukea Port to the LNG Plant). There is a potential for a cumulative impact if there is an overlap between the area of influence from the Project and the area of influence from other credible projects.

14.2.3 Temporal boundary

The temporal boundary of the assessment has been defined as between 2023 and 2056. This period encompasses the timeframe expected for the Project, including construction and commissioning between 2023 to 2028, an overlapping commissioning and start-up period from 2027 to 2028 and an operating period of up to 30 years (2026 to 2056). A project's construction and operation activities must overlap with the life of the Project for a cumulative impact to occur. The timing of projects determines their eligibility to be considered in this cumulative impact assessment. The temporal boundaries for each of the mechanisms for the Project are outlined in Table 14.1.

14.2.4 Credible projects

Credible projects are those that are:

- In operation and seeking approvals for expansion, for example, an existing power station that has lodged an application with the PNG Government to expand operation or increase production.
- Under construction or being commissioned, for example, a hydropower facility and associated transmission line.
- Approved and awaiting Final Investment Decision; for example, a project that has received approval from the Papua New Guinean Government and is awaiting the proponent's decision on whether to proceed with the investment or not.
- Approved and in detailed engineering design; for example, a project that has received approval from the Papua New Guinean Government and is currently in detailed design before construction begins.
- In an approvals process and likely to proceed if approval is obtained; for example, a project for which an Environmental Inception Report and/or Environmental Impact Statement (EIS) has been lodged with the Conservation and Environment Protection Authority (CEPA), and the company has established a presence in Papua New Guinea and expressed a desire to proceed with the project if approved.

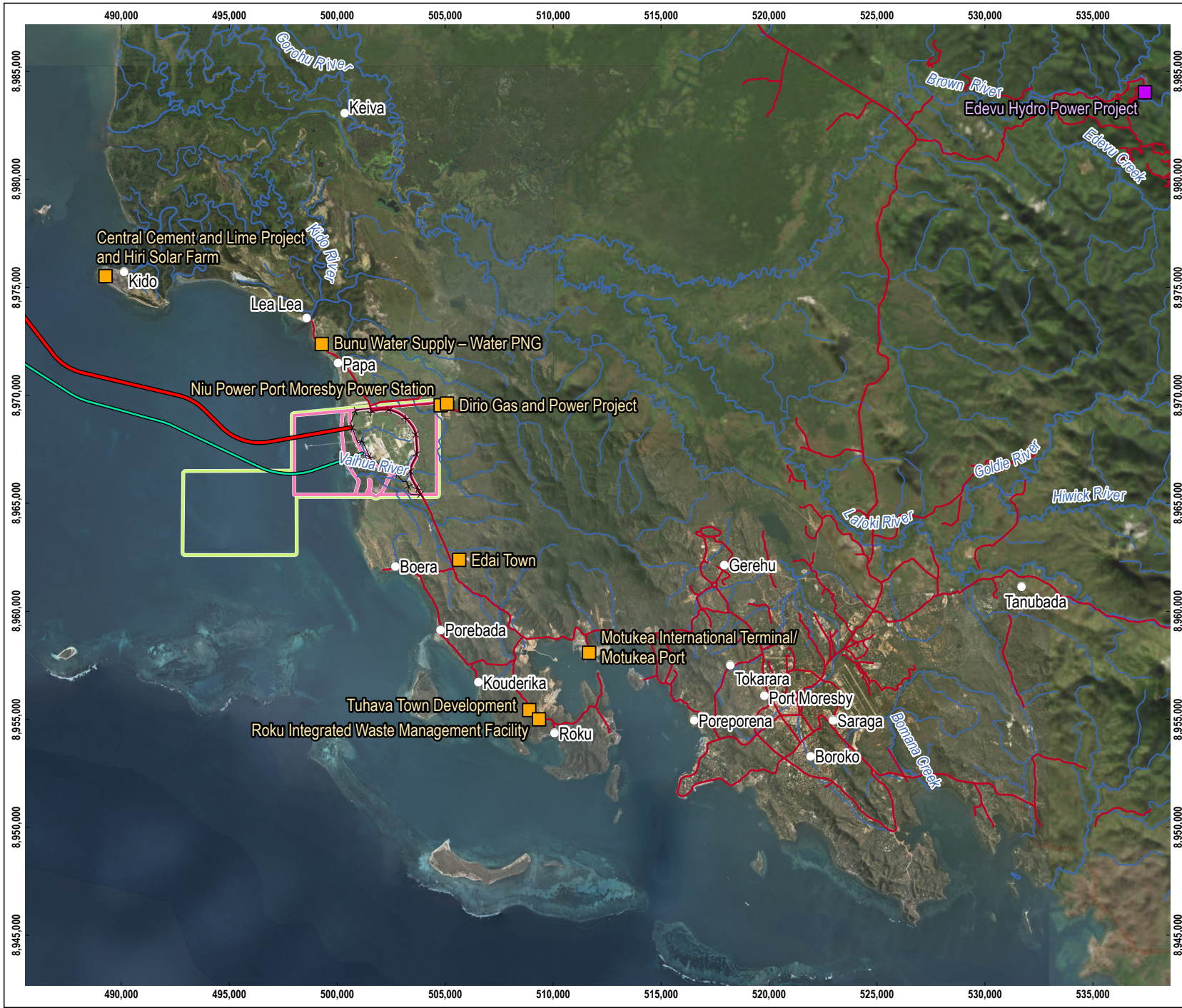
The Papua LNG Project – Upstream is being assessed under a separate EIS and is expected to be granted a separate Environment Permit to the Project, as the two components of the Papua LNG Project have different operators, geographical locations, and development timelines. The Papua New Guinea regulatory assessment of the Papua LNG Project – Upstream is in progress. The potential cumulative impacts of the Papua LNG Project's Upstream and Downstream activities within Caution Bay will be assessed in a separate Combined Impact Assessment to be submitted to CEPA by the Papua LNG Project – Upstream.

A desktop search was undertaken to identify credible projects within a buffer encompassing an area of 25 km surrounding the LNG Plant with the potential to contribute to cumulative impacts. Table 14.2 lists the proposed projects and proposed expansions to existing projects found within the area that may contribute to cumulative impacts on the identified values, i.e., the credible projects for the purpose of this cumulative impact assessment. The table describes whether the projects fall within the assessment's spatial and temporal boundaries. The location of these projects in relation to the Project is shown in Figure 14.1. Information on the potential impacts of each project was reviewed where readily available. The information for the credible projects listed in Table 14.2 was gathered from environmental reports and public releases.

Table 14.2 Credible projects that may contribute to cumulative impacts

Project / operator	Project overview	Spatial relationship	Temporal relationship	Included in assessment?
NiuPower Port Moresby Power Station	Existing 58 MW grid-connected gas-fired power plant located near the LNG Plant. Has the capacity for staged expansion up to approximately 175 MW (NiuPower Limited Undated).	Opposite Dirio Power Station, 1.5 km east of the LNG Plant.	In operation, continued expansion is possible.	Yes – temporal and spatial relationship to the Project.
Dirio Gas and Power Project	The Dirio Gas and Power Project supplies 45 MW of power using gas from the PNG LNG Project. The produced electric energy is fed into the Port Moresby Grid.	Located opposite NiuPower Power Station, 1.9 km east of the LNG Plant.	In operation.	No – included in baseline due to being operational.
Edai Town	Mixed-use development that includes commercial, residential, and industrial zones. As at October 2022, Phase 2 has been completed, and there are 400 houses with a population of 1,500 people. The development is expected to house approximately 10,000 people at completion (Oxford Business Group, 2018).	Located along Lea Lea Road, 5 km south-east of the LNG Plant (3 km east of Boera).	In operation, continued expansion.	Yes – temporal and spatial relationship to the Project.
Central Cement and Lime Project and Hiri Solar Farm	Approved two phase raw lime (500 ktpa), quicklime/hydrated lime (400 ktpa), clinker and cement project, including a wharf and supporting infrastructure. A new road will connect the project to Port Moresby. A Special Economic Zone (SEZ) status has been granted for the project (Mayur Resources 2023).	Located in Kido – Lea Lea area, 10 km north-west of the LNG Plant.	Awaiting funding. A 20-year mining lease was awarded in August 2020. Hiri Solar Farm construction is expected to commence in 2024, with operation planned by 2026.	Yes – temporal and spatial relationship to the Project.
Bunu Water Supply – Water PNG	Proposed Papua New Guinea water supply project to service impacted villages (Papa / Lea Lea, including Metago) in Central Province from the LNG Plant (Water PNG Limited, 2023).	A proposed new water supply system to Papa-Lea Lea, Metago and nearby villages.	Project on hold.	Yes – potential temporal and spatial relationship to the Project.
Edevu Hydro Power Project	Large hydropower project expected to provide additional power (50 MW) to meet Port Moresby's power demands (PNG Power Ltd 2022).	Located along Brown River in Edevu, Central Province.	Under construction.	No – no spatial relationship to the Project.

Project / operator	Project overview	Spatial relationship	Temporal relationship	Included in assessment?
Roku Integrated Waste Management Facility	Integrated waste management, industrial services, environmental and renewable solutions (TWM Group, 2023).	Located at Roku, 12.5 km south-east of the LNG Plant.	Under construction (in stages).	Yes – temporal and spatial relationship to the Project
Tuhava Town Development	A pioneering project for Papua New Guinea that has resulted in the conversion of customary land into a State Lease for the purposes of private development. The project encompasses 4,000 residential dwelling capacity, social infrastructure, business park and commercial zone (Tuhava, Undated).	Adjacent to the Roku Integrated Waste Management Facility, 12.5 km south-east of the LNG Plant.	Under construction, first stage is proposed for 220 lots.	Yes – temporal and spatial relationship to the Project
Motukea International Terminal and Motukea Wharf/Port	The newest international seaport and trading gateway in Papua New Guinea. The only facility in Port Moresby that can accommodate international containers, Ro/Ro and break-bulk vessels, cater to vessels with drafts under 12.5 m and offer mobile cranes (non-ship geared).	Freight for the Project will be imported to Motukea Port. Located 30 km from LNG Plant by sea and 20 km by road.	In operation, continued expansion.	Yes – temporal and spatial relationship to the Project.



- LEGEND**
- Village
 - Location of credible project
 - Location of not credible project
 - Road
 - Watercourse
 - PNG LNG pipeline
 - Proposed Papua LNG pipelines route
 - LNG Plant security fence
 - PPFL2 boundary
 - APPFL boundary

SOURCE
 Project locations from Tetra Tech Coffey.
 Infrastructure, roads, watercourses and lease boundary from EMPNGA.
 Imagery from ArcGIS Online and Planet Labs.

 0 5 km
SCALE 1:250,000
 PAGE SIZE: A4
 PROJECTION: WGS 1984 UTM Zone 55S

EXXONMOBIL PNG ANTELOPE LIMITED
 PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 14.1
 Location of credible projects



14.3 CUMULATIVE IMPACT ASSESSMENT

This section presents the results of the cumulative impact assessment. The potential impacts are identified at a high level with a focus on those with the greatest potential to effect change in the condition of the key value. Impacts were assessed in relation to the values that they will affect.

The projects identified in step 2 of this assessment were found to be within the Project's spatial and temporal boundaries for at least one aspect. No other planned projects or expansions to existing projects are known to exist within the Project's area of influence, and no anticipated cumulative impacts on environmental, socio-economic or cultural values are expected. Table 14.3 presents the values potentially impacted by the credible projects.

14.3.1 Physical disturbance

Potential cumulative impacts on land arise from multiple projects clearing vegetation to develop a resource, construct infrastructure or establish communities.

Most of the area within and adjacent to the LNG Plant site remains substantially modified due to frequent grassfires restricting the recovery of naturally occurring eucalypt woodland. Listed species were not observed, and their existence in such a disturbed area is improbable.

Physical disturbance is focused on construction footprints for the new and expanded onshore and marine facilities and access roads. The spatial boundary for impacts from ground disturbance from the Project does not overlap with the area of influence of other credible projects. Further, given the necessary safety exclusion zones around the LNG Plant's onshore and offshore infrastructure it is not possible for them to overlap in future. Negative cumulative impacts are not expected given the distance between the known projects.

Management measures outlined in the construction environmental and social management plan (ESMP) for the Project will limit the Project's contribution to negative cumulative impacts from physical disturbance activities. No additional measures are proposed.

14.3.2 Air and noise emissions

There are no villages within 1.5 km of the LNG Plant boundary. Four communities (Lea Lea, Papa, Boera and Porebada villages) are located within 8 km of the LNG Plant. Amenity contributes to the community and individual wellbeing.

The existing NiuPower, Dirio and Kanudi power stations emit combustion gasses containing air pollutants, the composition of which will depend on the fuel type used. The baseline conditions informing the impact assessment considered emissions from the NiuPower (both air quality and noise) and Dirio (air quality only) power stations for the Project and are presented in Section 11.5, Air quality and 11.6, Noise.

Other potential sources of air emissions in the area include domestic and agricultural activities carried out in the villages surrounding the LNG Plant, as well as traffic related emissions on from the roads that service them. These are outside ExxonMobil's ability to influence.

With implementation of good practice air quality management and measures included in the Project's Construction ESMP, impacts to air quality as a result of construction are expected to be localised and short-term.

Minor short-term exceedances of noise criteria are predicted during the construction period for the Project; however, with implementation of good industry practice noise management measures, it is expected that noise levels will be compliant with the noise criteria. During operations, no air quality impacts at sensitive receptors are predicted.

As a result, no air quality or noise cumulative impacts are predicted and no additional measures are proposed.

Table 14.3 Influence of credible projects on key environmental, social and cultural values

Project / operator	Spatial relationship	Temporal relationship	Potentially affected key environmental, social and cultural values						
			Threatened species and communities	Marine species and habitat	Water quality	Watercourse form and behaviour	Road user safety	Community amenity and wellbeing	Livelihoods
NiuPower Port Moresby Power Station	Opposite Dirio Power Station, 1.5 km east of the LNG Plant.	In operation, continued expansion is possible.	No	No	Yes	No	No	Yes	Yes
Edai Town	Located along Papa / Lea Lea Road, 5 km south-east of the LNG Plant (3 km east of Boera).	In operation, continued expansion.	Yes	No	Yes	Yes	Yes	Yes	Yes
Central Cement and Lime Project and Hiri Solar Farm	Located in Kido – Lea Lea area, 10 km north-west from the LNG Plant.	Awaiting funding. A 20-year mining lease was awarded in August 2020.	Yes	Yes	Yes	No	Yes	Yes	Yes
Bunu Water Supply – Water PNG	A proposed new water supply system to Papa-Lea Lea, Metago and nearby villages.	Project on hold.	Yes	No	No	No	No	Yes	Yes
Roku Integrated Waste Management Facility	Located at Roku, 12.5 km south-east of the LNG Plant.	Under construction (in stages).	No	No	Yes	No	No	Yes	Yes
Tuhava Satellite Town	Adjacent to the Roku Integrated Waste Management Facility, 12.5 km south-east of the LNG Plant.	Under construction, first stage is proposed for 220 lots.	No	No	Yes	No	No	Yes	Yes

Project / operator	Spatial relationship	Temporal relationship	Potentially affected key environmental, social and cultural values						
			Threatened species and communities	Marine species and habitat	Water quality	Watercourse form and behaviour	Road user safety	Community amenity and wellbeing	Livelihoods
Motukea International Terminal and Motukea Wharf/Port	Located along Napa Napa Road, 20 km from LNG Plant by road and 30 km by sea.	In operation, continued expansion or increased traffic / cargo volume is possible.	Yes	Yes	Yes	No	Yes	Yes	Yes

14.3.3 Habitat loss

14.3.3.1 Terrestrial

The Project's footprint will fall almost entirely on land already cleared for the LNG Plant site.

Terrestrial cumulative impacts may arise from the combined effect of vegetation and habitat disturbance as a result of two or more projects in proximity. This has the potential to reduce habitat connectivity and overall quality, and resources available for fauna, leading to competition between native and introduced species for resources. As described in Section 7.2, Terrestrial biodiversity, there is limited habitat value in the terrestrial environment of the LNG Plant.

The Project footprint is located mainly within previously degraded areas that are classified as grassland / open woodland and rocky grassland and are widespread vegetation types in the region. With the implementation of management measures that will be described in the Project's Construction ESMP, cumulative impacts on vegetation are expected to be negligible.

14.3.3.2 Marine

Cumulative impacts to marine habitats may occur due to the combined effect of habitat disturbances resulting from two or more projects, where the relevant areas of influence overlap.

The nearshore marine habitats affected by Project activities primarily include submerged soft sediment substrates in the location of the CALM buoy, in the southern portion of Caution Bay, approximately 7 km offshore. Marine habitat loss of submerged soft sediments due to the Project is expected to affect less than 0.01% of the overall proportion of this habitat in Caution Bay.

No habitat loss within sensitive areas such as nearshore fringing coral reefs, mangroves and subcoastal wetlands/mudflats will occur due to the Project. Patch reef habitats are present nearby the likely areas of disturbance, though these are not anticipated to be affected directly and may be affected indirectly by temporary increases in suspended sediments. Species of conservation significance are expected to be present within the Project area at various times, though these species are not dependent on the habitats that are anticipated to be affected.

The Central Cement and Lime Project is likely to affect nearshore habitats along the northern coast of Caution Bay, near Kido. The nearshore marine habitats likely to be present in this area include nearshore fringing coral reefs, patch reefs and sandy and soft sediments. Significant marine habitat loss is not expected for the Central Cement and Lime Project, or other projects in the nearby area.

The combined percentages of habitat loss for both projects remain very small compared to the overall quantity of habitat available in Caution Bay and the immediate vicinity, and represent an even smaller proportion of their regional occurrence. Direct overlap of impacts resulting in detectable cumulative effects is not expected, in the context of the likely extent of impacts and the distance between the areas of impact.

Management measures outlined in Attachment 3 of this EIS will limit the Project's contribution to negative cumulative impacts from marine habitat loss. No additional measures are proposed.

14.3.4 Runoff and discharges to waterbodies

Cumulative impacts to the freshwater environment can potentially occur from the combined effect of disturbance of watercourses because of two or more projects in proximity. Such impacts can include aquatic ecosystem habitat loss or reduction in habitat quality due to removal or disturbance to riparian vegetation, changes to the natural hydrological regime, increased sediment transport resulting in increased sedimentation and suspended solids, and discharge of contaminants to watercourses. The LNG Plant is located primarily

within the North Vaihua River catchment, and in the Vaihua River and Karuka Creek catchments to a lesser degree, which discharge to the sea via Vaihua and the North Vaihua estuaries. Most of the rivers, creeks and tributaries within these catchments are intermittent or ephemeral, flowing only for short periods and following rainfall and are of low biological value.

In the year following construction, most of the disturbed areas and the formalised drainage system will have been revegetated or stabilised, such that further fine sediment delivery to watercourses will have been greatly attenuated.

Infrastructure related to the Project is not likely to impact surrounding surface water and groundwater. With appropriate mitigation measures in place for the Project, significant cumulative effects on the stability and behaviour of watercourses and water quality are unlikely.

Management measures outlined in the Construction ESMP will limit the Project's contribution to negative cumulative impacts from activities leading to runoff and discharges of sediment and pollutants to watercourses. No additional measures are proposed.

14.3.5 Changes to coastal processes and sediment transport

The marine habitats in Caution Bay are sensitive to physical disturbance, and changes to hydrological, water quality, and sediment transport and deposition. The marine habitats support species that are important on a regional level and provide food to local communities.

Coastal development activities can affect coastal processes and sediment transport and deposition in various ways, including altering foreshore alignments, current velocities, tidal plane elevations, littoral drift transport (causing down-drift erosion) and marine ecologies. Coastal development activities can also directly generate sedimentation and affect sediment transport and deposition processes (Nielson and Gordon 2015).

In the context of the Project, cumulative impacts related to the above aspects could arise if other credible projects have effects that overlap with those of the Project, mainly due to:

- The development of coastal infrastructure that may affect coastal processes.
- Construction (primarily) and other activities that generate suspended sediments.

Although it is unlikely, given the small magnitude of impacts associated with installation of the CALM buoy, potential changes to coastal processes and sediment transport and deposition could occur once the construction of the CALM buoy (and associated pipelines¹) is complete and during the Project's operational life. The installation of the CALM buoy will also temporarily increase suspended sediments and turbidity in areas where the seafloor is directly disturbed, and in subsequent sediment deposition areas. These effects will be localised and short lived, occurring in the order of hours to days, and likely not detectable beyond 1 to 2 km from the impact location, depending on ambient conditions.

The Central Cement and Lime Project is located approximately 14 km north-west from the LNG Plant. It is expected to involve the construction of a jetty, which will be located approximately 12 km north-west of the LNG Plant jetty and approximately 10 km north-northwest from the Project's CALM buoy. Jetty construction may result in effects related to coastal processes, and influence sediment generation, transport and deposition. However, data such as oceanographic and dispersion modelling is not available to determine the potential spatial extent of impacts of the activity. Based on the outcomes of related modelling for the construction of LNG Plant marine facilities (Coffey Natural Systems, 2009), and given the distance between the projects, it is unlikely that the effects associated with this aspect of the Central Cement and Lime Project would overlap with those of the Project, such that a detectable cumulative impact could be identified. Changes

¹ Pipeline construction is a component of the Papua LNG Project – Upstream. However, as the export pipelines will be operated as part of the Project, the operational aspect is referenced in this assessment.

to coastal processes and sediment transport and deposition are not expected for other projects in the nearby area, which are predominantly land based.

Issues related to suspended sediment and sedimentation rates from vessel activities are not considered significant issues, as LNG carriers will be propelled by tugs in the navigational access channel, and under-keel clearance is adequate to avoid significant propwash.

Management measures outlined in Attachment 3 of this EIS will limit the Project's contribution to negative cumulative impacts from activities leading to changes to coastal processes and sediment transport and deposition. No additional measures are proposed.

14.3.6 Shipping vessel movements and navigation lighting

Cumulative impacts associated with vessel traffic in Caution Bay may occur due to overlapping development projects in the area, resulting in a range of potential effects. The following effects are likely to occur:

- Increased marine traffic along main vessel navigational routes.
- Increased risk of adverse interactions between vessels and wildlife, primarily those related to direct physical impacts (collisions), increased noise and artificial navigational lighting.
- Increased potential for interactions between Project and non-project vessels.

Large vessels currently utilise Caution Bay as part of existing PNG LNG Project operation. The existing LNG Plant berth currently manages an estimated 110 to 120 LNG carriers (based on 164,000 m³ LNG carriers) and 10 to 12 naphtha tankers at the berth annually. Local people also travel on coastal waters in Caution Bay for fishing and transport, primarily using small craft including banana boats and dugout canoes. Typically, these activities do not overlap due to large vessels operating further offshore in deeper water and local vessel movements taking place closer to shore. Marine exclusion zones are also established around the LNG Plant marine infrastructure, limiting interactions between PNG LNG Project and non-project vessels in these areas.

The Motukea International Terminal is located approximately 12 km from the Central Business District in Port Moresby. The Central Cement and Lime Project is planned to be developed around Kido, approximately 12 km to the north-west of the LNG Plant. Vessel traffic associated with these projects may overlap with that of the Project at various times, particularly during construction when vessel movements are at their peak, as well as during operations due to an overall increase in the number of vessel movements associated with the Project. The expansion of the LNG Plant under the Project will increase ship traffic, with up to 60 to 70 additional LNG carriers and 10 to 12 condensate cargos per year.

The main location where cumulative impacts may occur is likely to be around the Kido headland, where the Central Cement and Lime Project proposes to develop wharf infrastructure, (approximately 12 km from the LNG Plant jetty and 10 km from the proposed CALM buoy), and where Project vessels (e.g., LNG carriers and condensate tankers) may enter Caution Bay as they head toward the navigational channels to access the LNG Plant jetty berth and proposed CALM buoy.

Where navigational transit routes experience increased vessel traffic, a commensurate increase in anthropogenic noise and lighting will occur, primarily during the construction phase, though also during routine operations because of the increased number of vessel movements. These effects will be intermittent, only occurring when vessels are present.

The types of vessel-related Project activities are likely to be similar to existing activities and while the frequency of such activities will increase, the expected frequency of encounter and risks of causing physical injury to marine fauna that might be present (such as dugong, dolphins and turtles) will remain low, in terms of cumulative impacts. The cumulative effects of additional noise and lighting due to an increase in vessel movements associated with the construction, operation and maintenance of Project activities and other nearby developments (mainly those related to the Central Cement and Lime Project), may influence the

abundance, distribution, and behaviour of marine fauna. Fauna that rely heavily on sound to communicate, detect prey and/or navigate are likely to be most affected. The most likely effect will be localised displacement, due to marine fauna avoiding areas where vessel traffic is most concentrated.

Interactions between project and non-project vessels are not expected to increase in any substantial way, given the different marine areas used, and preference of all vessels to avoid interactions due to safety risks. Non-Project vessels will need to utilise alternative fishing areas or transit routes if construction activities overlap preferred fishing grounds or transit routes. During operations, cumulatively, there may be ongoing loss of access to livelihood locations through the growth of marine exclusion zones, safety zones, and navigation channels between the projects. As a result, the fishers will need to expend extra effort to circumnavigate these areas to get to their fishing grounds. With an effective community awareness program, it is expected that marine traffic using Caution Bay can avoid or bypass the Project for the duration of its activities with minor or minimal disruption to marine traffic movements. There will be an unavoidable impact on fishing grounds due to the safety requirements for the marine exclusion zones as described in Chapter 13 Social and Cultural Impact Assessment.

A marine fauna observation procedure will be implemented for all construction activities within Caution Bay, however it is not practicable for this to apply at all times during operations. There are no practical ways to reduce the noise characteristics from vessels. Management measures are outlined in Attachment 3 and Chapter 12 Environmental Impact Assessment: Marine will limit the Project's contribution to negative cumulative impacts from activities associated with vessel traffic. No additional measures are proposed.

14.3.7 Traffic and transport

The Project will require the transport of people and materials to the LNG Plant by air, sea and road. The logistics strategy for the Project aims to provide orderly movement of personnel into, out of and within Papua New Guinea, organise a transportation network across all modes of transport and ensure logistics infrastructure and support arrangements are in place to operate the Project.

Most construction material will be imported by ship via Motukea Port and trucked to site along the Lea Lea Road. An estimated 200,000 tonnes of cargo are expected to be imported through Motukea Port over the four-year construction period.

In addition, sections of the Lea Lea Road are expected to be upgraded to heavy haul specification and may require areas to be widened to accommodate heavy and/or overweight vehicles and transport of large modules required for the Project's construction.

The upgrade of Lea Lea Road and subsequent Project use of this road are expected to result in temporary and short delays across the construction phase, which will result in increased travel times for the other users. Although this generally will result in very limited changes to people's day to day lives for a short period of time, it is acknowledged that Lea Lea Road is the only connection between the study area and health services in Port Moresby, and the use of the road by emergency services is time sensitive, and travel delays may result in increased response times, if otherwise un-mitigated. The effect of these delays will be temporary and infrequent and are not expected to result in any material change to the community or commercial access to Port Moresby or services within the local area, following the implementation of measures detailed in the Project's construction ESMP. Consequently, the social and cultural impact assessment (Chapter 13) concluded that residual impacts to connectivity for general users were very low and low for sensitive users, such as emergency services and local government authorities.

However, there is potential for Project-related traffic generation on Lea Lea Road to occur at the same time as construction-generated traffic from the following projects identified in Table 14.2:

- The Central Cement and Lime Project, which has indicated that Lea Lea Road will be used by construction and operation traffic.

- The continued development of Edai Town, which connects with Lea Lea Road.

There is no publicly available information regarding the level of traffic generation for each of these projects. However, it is possible that the cumulative traffic generated by all three projects may result in noticeable if temporary delays for other road users. Following the implementation of the management measures detailed within the Project's construction ESMP, it is expected that the use of Lea Lea for sensitive users, such as local authorities and emergency services, will be maintained. To manage the potential for cumulative impacts, EMPNGA will require contractors to engage with identified project proponents when preparing traffic management plans to enable the passage of emergency vehicles during construction periods.

Based on the generally accepted relationship between traffic volumes and accident frequency (Retallack and Ostendorf, 2020), an increase in traffic along Lea Lea Road will increase the potential incidence of traffic accidents and injuries along Lea Lea Road. However, the level of traffic generated by the Project will equate to an increase of the average daily traffic along Lea Lea Road of around 1% over current traffic volumes. The increase in traffic and therefore increased risk of traffic accidents and injury due to the Project is expected to primarily occur during the Project's construction period, and, as detailed above, may coincide with the use of Lea Lea Road by other projects. Measures are contained within the Project's construction ESMP to manage the potential for Project-related traffic accidents.

There is the potential for congestion at Motukea Port if the Central Cement and Lime Project occurs at the same time. However, proposed shipping movements will be integrated with current usage. Coordination of shipping movements (including berthing and loading and unloading requirements) is the key strategy for managing this cumulative impact, as successfully happened during the construction of the PNG LNG Project. This will involve projects communicating their needs to Papua New Guinea Ports Corporation Limited who will work with the project proponents to coordinate access to the port.

Management measures outlined in Attachment 3 of this EIS will limit the Project's contribution to negative cumulative impacts from project vehicles using public roads.

14.3.8 Project economic benefits and Project-induced in-migration

The Project will require a construction workforce of between 5,000 and 7,000 full-time equivalent positions over the planned four-year construction period. The permanent operations workforce at the LNG Plant is expected to increase by approximately 50 technician personnel over current numbers, with support staff to increase as well. Skilled and unskilled workers will be required to construct and operate the credible projects. The social and cultural impact assessment (Chapter 13 of this EIS) noted that the Project's workforce requirements have the potential to result in workforce draw from a range of related industries and may result in competition for employees during the Project's construction.

Should projects such as the Central Cement and Lime Project occur at the same time as the Project's construction phase, when workforce is highest, it is expected that the workforce demand and draw from other sectors will accumulate. However, given the short periods in which demand will peak, and the existing lack of formal employment opportunities in LNG Plant villages and the broader region (e.g., the Central Province and the National Capital District), it is expected that cumulative workforce draw would be temporary, and affect discrete portions of the community. No additional measures to manage potential cumulative impacts are proposed.

The Project's economic benefits that drive peaks in PIIM will peak during the Project's construction period. PIIM has been identified in the social and cultural impact assessment (Chapter 13) to contribute to, either directly or indirectly, the following impacts:

- A reduction in the availability of natural resources to support the livelihood of communities within the LNG Plant communities. The change in population due to anticipation of the Project's opportunities will likely be moderate-term and primarily focused on the Project's construction.

- A reduction in the ability to access and sustain an attachment to land due to population growth, which is a core component of cultural identity.
- A decrease in the perception of safety due to greater presence of strangers within a community, particularly for women.
- An increase in transactional sex and short-term relationships, presenting greater risks of single parenthood, particularly among women.
- An increase in mosquito-borne diseases, particularly where in-migrants originate from areas with greater incidence of mosquito-borne disease.
- A decrease in amenity from overcrowding, which may result in an increased incidence of respiratory diseases (tuberculosis, COVID-19, and other respiratory diseases).
- An increase in sanitation-related diseases through increased pressure on poorly functioning or non-existent sanitation infrastructure.
- An increase in demand on community infrastructure and services, resulting in the decreased capacity and efficacy of these services for the existing population.

As the Project's construction period may overlap with that of the Central Cement and Lime Project, the increase in economic activity and the perceived opportunity to engage with project benefits may act to increase in-migration to LNG Plant communities during this timeframe and exacerbate the impacts identified above. It is recognised that the LNG Plant communities may be subject to a 'honeypot' effect from the effect of multiple large-scale projects being developed in proximity to these communities, particularly given the existing input into infrastructure in these communities from ExxonMobil's community development program since the development of the PNG LNG Project.

Managing PIIM is challenging to achieve in practice, and despite the measures detailed within the Project-Induced In-migration Plan, which is a part of the Project's construction ESMP, a level of PIIM is still likely to occur. As detailed within the Project-Induced In-migration Plan:

- The Plan will be reviewed periodically so that measures remain effective in responding to the Project's contribution to cumulative impacts caused by in-migration.
- Engagement with stakeholders is vital in effectively managing PIIM. A key element to the management of PIIM will be supporting the establishment of a multi-stakeholder forum, in which ExxonMobil, district and provincial government representatives, civil society organisations and non-government organisations, amongst others, will be able to discuss PIIM and agree plans to manage it in a coordinated manner. It is expected that other project proponents will be invited to participate in these forums.

14.4 CUMULATIVE IMPACT MANAGEMENT STRATEGIES

EMPNGA will minimise the contribution of the Project to cumulative impacts by implementing management measures contained within the construction ESMP. Providers of goods and services to the Project will be required to meet safety, environmental and social performance standards, further limiting the potential contribution to cumulative impacts.

If similar approaches to management of impacts are implemented by the operators of the projects included in this assessment, where relevant, potential significant negative cumulative impacts will be further reduced.

Proposed strategies for management of cumulative impacts include:

- Implementing appropriate traffic management and community awareness programs to minimise cumulative impacts on local and regional traffic.

- Liaising with Papua New Guinea Ports Corporation to coordinate shipping movements between multiple projects.
- Managing, in consultation with relevant provincial and national government agencies, the effects of the influx of job-seekers and workers on communities.

Management strategies for mitigating the potential cumulative effect for each aspect will be developed as part of the Project mitigation strategies and programs in consultation with other project developers. This will provide an overarching framework to cater for changing conditions. The Central and National Capital District provincial governments will be encouraged to incorporate these management strategies into their development plans to manage increases in population and the economy while also managing impacts to the environment and people.