TOTAL
TOTAL E&P PNG LIMITED

PAPUA LNG PROJECT

UPSTREAM ENVIRONMENTAL IMPACT STATEMENT

VOLUME 1: MAIN REPORT

Chapter 15: Impacts - Amenity and Climate Change

TOTAL E&P PNG LIMITED

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15. Impacts: Amenity and Climate Change

15.1 Air Quality

15.1.1 Context

15.1.1.1 Existing Air Quality

As identified in the Upstream Air Quality Baseline Report (Part 19 of Volume 2, summarized in Section 10.2 of this report), the Project area of influence (PAOI) is remote from existing industrial pollution sources, with minimal anthropogenic development. The ambient air quality across the PAOI is therefore assumed to be generally good and would be regarded as a 'non-degraded' airshed in relation to International Finance Corporation (IFC) assessment requirements. Baseline concentrations of gaseous pollutants (i.e., nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) and volatile organic compounds (VOCs)) would be negligible, and background levels of particulate matter (total suspended particulate matter (TSP), particulate matter with an aerodynamic diameter of 10 µm or less (PM_{10}) and particulate matter with an aerodynamic diameter of 2.5 µm or less ($PM_{2.5}$)) are expected to be low given the high rainfall, low wind speeds and dense vegetation in the area.

Similar to other air quality impact assessments performed in the region (e.g., PNG Biomass Project (SLR, 2017), Hidden Valley Gold Mine (RHA, 2004) and PNG LNG Project (upstream) (HAS, 2009)), background concentrations of particulate matter (TSP, PM_{10} and $PM_{2.5}$) have been estimated based on monitoring data from baseline monitoring programs for other projects, i.e., Wafi-Golpu Project, and with consideration given to the local land use and high rainfall in the onshore Project area. These levels are below the relevant international guidelines for particulate matter and are considered to be applicable across the onshore Project area. Baseline gaseous pollutant concentrations have been assumed to be negligible compared to international ambient air quality criteria.

Air emissions from the existing PNG LNG Facilities will influence air quality at the Caution Bay landfall approach. Air emissions from shipping, industrial and commercial activities in and around Port Moresby (14 km to the southeast) may also cause slight increases in background concentrations of both gaseous pollutants and particulate matter at the landfall compared to the onshore Project area. As air emissions associated with the Project activities proposed at the Caution Bay landfall approach will be limited to construction of the offshore export pipeline and air emissions during the operations phase of the pipeline will be negligible, further analysis of the baseline air quality at Caution Bay has not been undertaken.

15.1.1.2 Sensitive Receptors

15.1.1.2.1 Human Receptors

PRL-15 is situated in a remote location with just five small settlement or village areas located in the surrounding area. The CPF is situated approximately 1.7 km northeast of the Purari River and the proposed Logistics Base, and approximately 3 km west of the existing Herd Base. Poroi 1, approximately 4 km to the south, is the village closest to the proposed CPF and the associated operations accommodation camp. Mapaio Fish Camp is located approximately 8 km west of the CPF. A single residence is located approximately 5 km southwest on the southern bank of the Purari River adjacent to the Purari Airstrip. Other villages are located along the Purari River; however, these are all more than 8 km from the CPF. The wellpads are located in dense tropical rainforest far from any existing settlements.

The housing density increases at the coast near the southern end of the onshore export pipeline and the pipeline shore crossing construction area.

The locations of existing villages near proposed Project infrastructure are summarized in Table 15.1. In addition to these human receptors, potential adverse impacts of Project-related air emissions on the surrounding vegetation have also been considered.

Table 15.1 – Identified Sensitive Human Receptors

Village	Separation Distance
Receptors Located Near Major Project Infrastructure	
Subu 2	14.5 km northeast of ELK-10
Poroi 1	3.9 km south of the CPF 2.4 km east of the Purari Airstrip 2.6 km south-southeast of the Logistics Base 5 km south-southwest of Herd Base
Mapaio Fish Camp	7.9 km west-southwest of the CPF 5.6 km northwest of the Purari Airstrip 6.9 km west of the Logistics Base 11.5 km west of Herd Base
Purari Airstrip House	190 m northeast of the northern end of the existing airstrip 1.3 km northeast of the extension area at the southern end of the airstrip 85 m northeast of the proposed perimeter road at the north end of the airstrip 4.8 km southwest of the CPF 2.6 km southwest of the Logistics Base 7.4 km southwest of Herd Base
Receptors Located Within 5 km of the Onshore Export Pipeline Route and Associated Infrastructure	
Poroi 1	1.2 km from the export pipeline route 1.8 km from pipe yard 2
Evara	4.5 km from the export pipeline route 2.8 km from pipe yard 3
Aivai	1.8 km from the export pipeline route 260 m from pipe yard 4 700 m from the pipeline construction camp
Hepere	1.1 km from the export pipeline route
Kilavi	1.8 km from the export pipeline route
Ere	2.2 km from the export pipeline route
Muro Mission	3.5 km from the export pipeline route
Huruta	3.4 km from the export pipeline route
Arehava 2	1 km from the export pipeline route
Paevera	640 m from the export pipeline route
Houses on the coast: a) Mareke, Iuku, Hururu, Larihairu, Mirimurua, Kavava and Kaivukavu b) Marea, Harevavo, Miha Kavava, Lariau, Oru, Hiloi and Herekela	a) Located within 2 km east and west of the export pipeline route. The closest villages are Iuku and Mareke, approximately 460 m and 300 m from the pipeline route, respectively, with approximately 10 houses within 350 m. b) Located within 5 km east and west of the export pipeline route

Table 15.1 – Identified Sensitive Human Receptors (cont'd)

Village	Separation Distance
Villages Located on Banks of Rivers Proposed for Barge Access	
Lower Purari River Route	***Ivo River Route (alternative if Lower Purari River Route cannot be used)***
Poroi 1 Mapaio Fish Camp Kaevaria Evara Aivai Aumu Apiope	Poroi 1 Mapaio Fish Camp Mapaio Kairu'u Akoma

15.1.1.2.2 Ecological Receptors

Project infrastructure will be surrounded by terrestrial ecological systems as described in Chapter 7. While a preliminary assessment of some ecological impacts is provided in this chapter, Chapter 11 describes the potential impacts resulting from a reduction in air quality due to construction and operational activities.

15.1.2 Discipline-specific Impact Assessment Method

The air quality impact assessment has been performed using a combination of quantitative and qualitative assessment techniques, as detailed in Part 2 of Volume 3 and summarized below.

The emissions to air from CPF operations were estimated based on design data and process modeling information. An atmospheric dispersion modeling study was performed to simulate the dispersion of these emissions downwind of the CPF, considering the local topography and meteorology, to estimate maximum ground-level concentrations at nearby sensitive receptors and to assess compliance against international air quality guidelines and standards. The method used in the air dispersion modeling study is outlined in Section 15.1.2.1, and the air quality criteria used to assess compliance are summarized in Section 15.1.2.2. The estimated emissions (i.e., in-stack pollutant concentrations) have also been assessed for compliance with emission limit values in relevant international air quality guideline documents, as summarized in Section 15.1.2.3.

Activities with a lower potential for impacts on local air quality have been assessed qualitatively. To assess the potential for impacts from construction dust, the Institute of Air Quality Management (IAQM) Guidance on the Assessment of Dust from Demolition and Construction (Holman et al., 2014) has been used to provide a risk-based approach to assess the potential for these activities to cause any non-compliances with relevant air quality criteria (see Section 15.1.2.4). For other potential emission sources, e.g., air emissions associated with barging, a qualitative assessment of potential air quality impacts has been performed based on the nature and scale of activities proposed, and the distance to sensitive receptors.

15.1.2.1 Air Dispersion Modeling Method

Details of the meteorological modeling method and the air dispersion modeling method used to assess potential off-site impacts from the CPF operations phase are provided in Part 19 of Volume 2 and Part 2 of Volume 3, respectively. The meteorological modeling method used the Weather Research and Forecasting Model and the US EPA–approved CALMET meteorological model, followed by dispersion modeling using the US EPA–approved CALPUFF model. The Weather Research and Forecasting, and CALMET models were used to compile a one-year, hourly meteorological data file based on the 2015 calendar year, suitable for use in the CALPUFF model.

The modeling was performed using a 15 km by 15 km modeling domain, centered over the CPF site. Four discrete receptors were included in the model to represent the existing Herd Base site and the nearest identified sensitive receptor locations in the surrounding area: Poroi 1, Mapaio Fish Camp and the house near the Purari Airstrip.

The operational scenarios selected for modeling were chosen to represent normal operations at different stages in the life of the Project as follows:

- High pressure (HP)/incineration: HP mode without acid gas injection, and no additional compression of product gas, with transport of the gas to the PNG LNG Plant by gravity.
- MP/low pressure (LP) and acid gas injection: Acid gas injection into Elk reservoir with additional gas compression for transport, and thermal oxidizer on standby.

The stack and emission data used in the modeling for this scenario were based on a pre-FEED design option of using a sulfur recovery unit to remove 95% of the hydrogen sulfide (H_2S) from the acid gas prior to incineration in the thermal oxidizer which would then convert the remaining 5% of the H_2S to SO_2 before emission to the atmosphere. The design for this phase of operations now being considered is the acid gases first being incinerated using a thermal oxidizer to convert all of the H_2S to SO_2, with the exhaust gases then undergoing treatment with a caustic soda wash to remove SO_2 from the flue gas prior to discharge to the atmosphere; however, various concepts are being investigated further as indicated in Chapter 5, Project Options and Analysis.

A revised design may change the exhaust gas flowrate and stack conditions (e.g., temperature, moisture content and exit velocity) compared to the values used in the modeling. The implications of these changes on the modeling results presented for this scenario are discussed in Section 15.1.5.

The pollutants modeled included oxides of nitrogen (i.e., NO_X, to predict off-site NO_2 concentrations), SO_2, CO and VOCs (i.e., benzene, toluene, ethylbenzene and xylenes (BTEX)); and the total estimated site emissions for each scenario are summarized in Table 15.2 Background concentrations of these pollutants were assumed to be negligible given the absence of any significant combustion or industrial sources in the region surrounding the CPF (see Section 15.1.1.1).

Table 15.2 – Total Site Emissions Used in the Dispersion Modeling Study for the CPF

Scenario	Total Site Mass Emission Rate (kg/hr)			
	NO_X	SO_2	CO	VOC
HP/incineration	115.7	35.7	16.6	27.3
MP/LP and acid gas injection	169.2	6.4	43.7	70.4

15.1.2.2 Ambient Air Quality Guidelines

The Conservation and Environment Protection Authority's (CEPA's) Technical Guideline (Additional Information) for Air Discharges (DEC, 2004) sets out the information that should be provided as part of an application for an environment permit to discharge waste, where air emissions may be generated. This includes:

- Details of the source, nature, composition and rate of air emissions.
- Information on emissions control equipment and proposed methods to minimize air discharges (specific information for fabric filters, afterburners and wet scrubbers is requested).
- Maintenance procedures and contingency procedures to avoid air discharges from process failure and shut down.

- Stack emission details.
- Calculated ground-level concentrations of pollutants proposed to be discharged to air under normal and maximum operating conditions, and start up and shutdown conditions.
- An assessment of the impact of the proposal on the environment.

Part 2 of Volume 3 presents the above information on the operations phase air emission sources at the CPF, as relevant. Emissions control equipment, proposed methods to minimize air discharges, and procedures to avoid air discharges from process failures and shut downs are discussed in Section 15.1.4.

Papua New Guinea does not currently have any statutory ambient air quality standards, nor are any specified in DEC (2004). A review of relevant air quality criteria and guidelines set by other agencies was therefore performed as part of the Upstream Air Quality Baseline Report (Part 19 of Volume 2), including (in order of priority):

- General Environmental, Health and Safety Guidelines (IFC, 2007a).
- Air quality guidelines (WHO, 2000, 2005; EU, 2010).
- National air quality standards (US EPA, 2016, 2017).
- Effects screening levels for individual VOC compounds (TCEQ, 2018).

Table 15.3 summarizes the ambient air quality criteria identified for the Project based on this review. The most stringent criteria have been used where multiple guidelines are available from different agencies. The TCEQ effective screening levels have been used for individual VOCs where standards are not available from other agencies.

Table 15.3 – Ambient Air Quality Criteria Used in this Assessment

Pollutants	Averaging Period	Limit (µg/m^3)	Source
NO_2	1-hour	200	IFC (2007), WHO (2005), EU (2010)
	Annual	40	IFC (2007), WHO (2005), EU (2010)
SO_2	10-minute	500	IFC (2007), WHO (2005)
	1-hour	200	US EPA (2016)
	24-hour	20	IFC (2007), WHO (2005)
CO	1-hour	30,000	WHO (2000), EU (2010)
	8-hour	10,000	EU (2010)
Benzene	1-hour	170	TCEQ (2018)
	Annual	4.5	TCEQ (2018)
Toluene	1-hour	4,500	TCEQ (2018)
	Annual	1,200	TCEQ (2018)
Ethylbenzene	1-hour	26,000	TCEQ (2018)
	Annual	570	TCEQ (2018)
Xylenes	1-hour	2,200	TCEQ (2018)
	Annual	180	TCEQ (2018)
TSP*	24-hour	150	US EPA (2017)
	Annual	60	US EPA (2017)
PM_{10}	24-hour	50	WHO (2005)
	Annual	20	WHO (2005)
$PM_{2.5}$	24-hour	25	WHO (2005)
	Annual	10	WHO (2005)

* Replaced by PM_{10} standards in 1987, included here to assess nuisance effects.

The United Nations Economic Commission for Europe has identified 'critical levels' for various air pollutants to protect vegetation, with those for SO_2 listed in Table 15.4 (ICP, 2017). These European-based guidelines may have limited relevance to the types of vegetation and the growing conditions that exist in PRL-15 (i.e., warm temperatures and high rainfall), particularly given that SO_2 impacts on vegetation are exacerbated by cold temperatures (Ashmore et al., 2003); however, in the absence of local guidelines or data, they have been used to provide guidance on the potential for adverse impacts on vegetation due to SO_2 emissions from the Project.

Table 15.4 – Critical Levels for SO_2 by Vegetation Category

Vegetation Type	Critical SO_2 Level (µg/m^3)	Averaging Period
Cyanobacterial lichens	10	Annual mean
Forest ecosystems	20	Annual mean and half-year mean (Oct to Mar)
(Semi-) natural	20	Annual mean and half-year mean (Oct to Mar)
Agricultural crops	30	Annual mean and half-year mean (Oct to Mar)

15.1.2.3 Emission Limit Values

Papua New Guinea does not currently have any statutory stack emission limits, nor are any specified in DEC (2004). The in-stack pollutant concentrations reported in Part 2 of Volume 3 for the main emission sources at the CPF have therefore been compared to relevant emission limit values in the relevant IFC Environmental, Health and Safety guidelines (IFC, 2007a, 2008) and TOTAL's general specification covering environmental requirements for exploration and production activities (TOTAL, 2015). The relevant emission limit values are shown in Tables 15.5 and 15.6 for the IFC and TOTAL, respectively.

Table 15.5 – Relevant IFC Emission Limit Values

Relevant Sources	IFC Plant Category	Emission Limit Value	Source
Heating boilers (3 x 40 MW)	Gas boilers >50 MWth	240 mg/Nm^3 * NO_X *Dry, 3% O_2, 273 K, 101.3 kPa*	IFC (2008)
Power gas turbines (4 x 23 MW) Medium-pressure compressors (5 x 23 MW)	Turbine burning natural gas, 15 to 50 MWth	25 ppm # NO_X *Dry, 15% O_2*	IFC (2007a)

Notes: * Equivalent to 118 ppm. # Equivalent to 51 mg/Nm^3 at 273 K, 101.3 kPa.

Table 15.6 – Relevant TOTAL Emission Limit Values

Source	TOTAL Plant Category	Emission Limit Value	Source
Power gas turbines (4 x 23 MW) Medium-pressure compressors (5 x 23 MW)	Used for power generation or mechanical drive purposes (capacity unspecified)	37 ppm/75 mg/Nm^3 NO_X *Dry, 273 K, 101.3 kPa, 15% O_2*	TOTAL (2011)

15.1.2.4 Construction Dust Impact Assessment Method

Constructing the access roads, laydown areas, wellpads, the Purari Airstrip extension, quarries, CPF, Logistics Base and pipelines will generate fugitive dust emissions, which have the potential to cause elevated TSP concentrations and dust deposition rates near the works.

Due to the high rainfall and dense vegetation present in the onshore Project area, published fugitive dust (i.e., TSP) emission factors are unlikely to be representative of the dust emissions from construction activities in Papua New Guinea. In addition, dust emission modeling of construction projects is generally inappropriate, as emission rates can vary depending on a combination of the construction activity and prevailing meteorological conditions (e.g., rainfall and wind speed), which cannot be reliably predicted.

For this assessment, IAQM Guidance on the Assessment of Dust from Demolition and Construction (Holman et al., 2014) has been used to provide a qualitative approach to assessing the potential for these activities to cause non-compliances with relevant air quality criteria for particulate matter. The IAQM method has been developed for an urbanized environment and has limitations in its applicability to a remote undeveloped location, such as the onshore Project area; however, it is anticipated to provide a conservative assessment of the potential risks and is the method adopted in other PNG air quality impact assessments (e.g., construction phase assessments for the PNG Biomass Project and the Wafi-Golpu Project).

The IAQM method (Holman et al., 2014) uses a four-step process for assessing dust impacts from construction activities and is based on distance to the nearest sensitive receptor, whereby the sensitivity to dust deposition of, and human health and ecological impacts to, the identified sensitive receptors are determined. The risk of dust effects from activities is assessed by considering the sensitivity of the area, surrounding dust-generating activities, and the scale and nature of the works, which determines the potential dust emission magnitude. The required level of mitigation can then be identified based on the potential risk of off-site impacts.

The detailed assessment is presented in Part 2 of Volume 3 and takes into account:

- The specific sensitivities that identified sensitive receptors have to dust deposition and human health impacts.
- The proximity and number of those receptors.
- In the case of PM_{10}, the local background concentration.
- Other site-specific factors, such as whether natural shelters, e.g., trees, are present, to reduce the risk of wind-blown dust.

15.1.3 Identification of Potential Impacts

Proposed Project activities with the greatest potential for adverse off-site air quality impacts, i.e., decline in human health, amenity or vegetation condition, at the nearest sensitive receptors, have been assessed as part of this study. Potential human health, amenity or vegetation impacts include:

- Human health impacts, where:
  - Finer inhalable particulate matter (i.e., PM_{10} and $PM_{2.5}$), which is associated more with fuel combustion processes, are small enough to penetrate the thoracic region of the respiratory system. The health effects of inhalable particulate matter include the aggravation of asthma and other respiratory symptoms, and an increased incidence of cardiovascular and respiratory diseases and lung cancer.
  - Emissions of NOX, CO, and SO2 from the combustion of fuel gas and diesel can adversely impact human health by irritating the airways of the lungs, also aggravating asthma and other existing respiratory illnesses, and increasing the incidence of acute respiratory illness in children.
  - Chronic long-term exposure to elevated concentrations of VOCs, can adversely impact human health including cancer, central nervous system disorders, liver and kidney damage, reproductive disorders and birth defects. Many VOCs are also highly odorous and can adversely impact on amenity values due to odor nuisance.
- Amenity impacts: Nuisance impacts due to the larger-sized particles of fugitive dust settling rapidly, close to the source, and soiling of surfaces in and around properties.

- Vegetation impacts: Larger-sized particles of fugitive dust settling into leaves, blocking sunlight and disrupting photosynthesis, and acid rain (see Section 11.6.3.3), thereby damaging nearby vegetation.

Construction Phase

Earthworks and Fugitive Dust from Construction

- Construction of the CPF, Logistics Base and the Purari Airstrip extension: Clearing, earthworks and construction activities that have the potential to emit dust (i.e., TSP and PM_{10} predominantly, with small amounts of $PM_{2.5}$) from operation of vehicles, machinery and equipment movement will occur at these sites for an extended period. These emissions have been assessed for their potential to cause adverse human health, amenity and vegetation impacts.

  Construction of the onshore export pipeline and access roads, including the pipeline shore crossing at Orokolo Bay, which is close to coastal settlements: Clearing, earthworks and construction activities have the potential to emit dust (TSP and PM_{10} predominantly, with small amounts of $PM_{2.5}$) from operation of vehicles, machinery and equipment movement as activity progresses along the pipeline route and road alignments. These emissions have been assessed for their potential adverse human health, amenity and vegetation impacts.

River Transport

- Marine and river transport: Potential adverse human health impacts associated with exhaust emissions (e.g., NO_X, CO, SO_2, PM_{10} and $PM_{2.5}$, and VOCs) from fuel consumption have been assessed from the barges along the marine and river transport routes, focusing on the construction phase as a worst case, given that the barging frequency will be lower during the operations phase. As of 1 January 2020, TEP PNG will require vessels to burn fuel with a sulfur content of no more than 0.5%. This is consistent with TOTAL's commitment to meet the International Marine Organization's new regulation that comes into effect on that date for a 0.5% global sulfur cap for marine fuels

Road Use

- Road transport: Potential adverse human health impacts associated with engine emissions (e.g., NO_X, CO, SO_2, PM_{10} and $PM_{2.5}$, and VOCs) from fuel consumption during road use for the construction phase. This includes light and heavy vehicle movements between the main Project facilities (e.g., the CPF, the Logistics Base, Herd Base and the wellpads), and the transport and disposal of excess spoil.

Aircraft Transport

- Air transport: Potential adverse human health impacts associated with aircraft engine emissions (e.g., NO_X, CO, SO_2, PM_{10} and $PM_{2.5}$, and VOCs) from fuel consumption, with the construction phase as a worst case, given that the flight frequency will be lower during the operations phase.

Quarry Operations

- Quarry operations: Potential adverse human health, amenity and vegetation impacts associated with fugitive dust emissions and from blasting.

Waste Disposal

- Waste disposal: Potential adverse human health impacts associated with combustion emissions (e.g., NO_X, CO, SO_2, PM_{10} and $PM_{2.5}$, and VOCs, and traces of heavy metals, acid gases, dioxins and furans) from the proposed waste incinerator.

Operations Phase

- CPF operations: Air emissions from gas processing and fuel gas combustion at the CPF. The key pollutants requiring assessment due to potential adverse human health impacts are NO_X, CO, SO_2 and VOCs.
- CPF operations: Sulfur dioxide emissions from the acid gas removal unit. Potential adverse vegetation and fauna impacts from acid rain or acidification associated with SO_2 emissions from the CPF.

A number of embedded design controls address impacts to air quality:

- Project design is based on a risk-management approach, considering geotechnical constraints (e.g., flooding, landslides risks, geohazards) and anticipating and avoiding, or where avoidance is not possible, minimizing environmental and social impacts (e.g., avoiding sensitive features, and physical and economic displacement, priority ecosystem services, and minimizing the Project footprint, land clearing and disturbance, emissions and discharges) [ED013].
- The Project will design its plant to meet the applicable emission standards and relevant ambient air quality criteria beyond the proposed facility boundary [ED002].
- During the first years of production when it is not possible to dispose of acid gas by injection, a sulfur recovery unit will be installed and operated at the CPF to remove sulfur-containing compounds from the acid gas after it has passed through a thermal oxidizer [ED024].
- Once the Elk reservoir has been depleted, acid gas removed from the raw gas using the AGRU will be disposed of by injecting it into the reservoir [ED025].
- The sulfur recovery unit will remain on standby, ready to operate at short notice so that acid gas can be treated if acid gas injection is not possible [ED026].
- All vehicles (including vessels and aircraft) and machinery, plant and equipment will be regularly maintained to the manufacturer's specifications; defective items will be removed from service until they are repaired [ED019].
- Fixed or mobile equipment will be used and/or located in consideration of people and other sensitive receptors [ED030].
- Vessels will comply with applicable IMO requirements related to fuel to minimize related atmospheric emissions [ED001].
- The flares will be used only for safety flaring in alignment with the TOTAL no routine flaring policy [ED023].
- The Project will maintain a grievance mechanism that is legitimate, accessible, predictable, equitable, right-compatible, and transparent [ED033].

The following identified potential air emissions are inherently addressed by the above embedded design controls or have been concluded to be negligible, with no significant potential for adverse off-site air quality impacts, and therefore have not been considered further in the assessment:

- Fuel combustion in construction equipment: NO_X, CO and SO_2 emissions from fuel combustion in construction vehicles, and other mobile and fixed equipment at construction sites and quarries will occur over relatively large areas and will rapidly disperse. They therefore do not have potential to give rise to any exceedances of the ambient concentrations off-site and would not adversely impact air quality at the nearest sensitive receptors.
- Emissions from wellpad and trunkline/flowline construction:
  - Dust from wellpad construction: ANT-10 is a new wellpad, but the ELK-10 and ANT-11 wellpads will be established on the existing Elk-1 and ANT-1 wellpads that were developed during the exploration and appraisal phases. Consequently, site preparation works will be of a smaller scale than if three new wellpads were required to be developed. The scale of the works is such that it is unlikely that dust would have an adverse impact beyond a hundred meters from the work area and there would be no impact at the nearest human receptors, which are much further away (14.5 km for ELK-10).
  - Dust emissions from trunkline/flowline construction: Clearing, earthworks and construction activities have the potential to emit dust (i.e., TSP and PM_{10} predominantly, with small amounts of $PM_{2.5}$) from operation of vehicles, machinery and equipment movement along the pipeline routes; however, approximately 77%, 35% and 68% of the Antelope trunkline, Elk flowline and water injection flowline follow existing tracks, respectively, reducing the land disturbance and hence earthworks required. Additionally, the area is surrounded by dense forest that would minimize dust dispersion.
  - Exhaust emissions from diesel-powered equipment, in particular, from diesel generators that will predominantly be used to power the drilling rig: A screening assessment of emissions from similar diesel generators proposed for the drilling operations at the PNG LNG Project operation indicated that the predicted downwind NO_2, CO, VOCs, PM_{10} and $PM_{2.5}$ concentrations were all below their respective assessment criteria (HAS, 2009). This screening assessment showed that, considering a release height of 7 m above ground, and an exit velocity of 20 m/s, air quality assessment criteria will not be exceeded.
  - On this basis, and given that the wellpads, trunkline and flowlines will be located more than 14 km from the nearest sensitive receptors, it is concluded that constructing the wellpads and trunkline/flowlines will not adversely impact air quality at the nearest sensitive receptors.
- Emissions from burning vegetation: Potential adverse human health effects or nuisance effects can occur due to particulates in smoke from open burning. Vegetation cleared for Project facilities will be used to stabilize earthworks and areas requiring rehabilitation. Small trees will be mulched. TEP PNG will avoid burning as far as practicable. By implementing these mitigation measures, TEP PNG does not expect emissions from burning vegetation to have any potential for impacts on air quality at the nearest sensitive receptors.
- Emissions from wellpad operations: Emissions from the wellpads during operations will consist predominantly of intermittent methane and VOC emissions associated with maintenance and inspection operations such as pig launching and retrieval. Dispersion

modeling undertaken for the Hides Gas Conditioning Plant study (URS, 2011) included emissions of VOCs from wellpads, and the results of this modeling did not predict any exceedances of relevant assessment criteria (URS, 2011). Given that the wellpads will be located more than 14 km from the nearest sensitive receptors, it is concluded that operations activities at the wellpads will not have the potential for impacts on air quality at the nearest sensitive receptors.

- Emissions from construction of the offshore export pipeline and pipeline landfall approach at Caution Bay: Emissions of NO_X, CO and SO_2 associated with fuel combustion in the vessels used during construction of the offshore export pipeline will occur over relatively large areas and will rapidly disperse. Except for works near the coastline, which will only occur for a limited duration, these emissions will occur at significant distances from any sensitive receptors. They therefore do not have the potential to adversely impact on air quality at the nearest sensitive receptors. Pipeline landfall approach construction activities at Caution Bay, covered by this assessment, are limited to works up to the PNG LNG lease boundary. These activities are expected to include some trenching and probably rock armoring; however, the works will be in the water and would not have any potential for significant air emissions.
- Fugitive VOC emissions from CPF operations: The fugitive nature of VOC emissions from the CPF means the quantification and characterization of these emissions for input into an air dispersion model is uncertain. In addition, dispersion modeling undertaken for the Hides Gas Conditioning Plant included estimated emissions of fugitive VOCs and concluded that they did not have the potential to exceed relevant screening-level assessment criteria at the nearest sensitive receptors (URS, 2011). The quantity and composition of non-methane fugitive VOC emissions from the CPF will differ to some extent from those estimated for the Hides Gas Conditioning Plant due to different gas compositions and different numbers of connectors and valves at the two plants; however, no adverse air quality impacts from these emissions would be anticipated on or off site. Given that flares will be used to combust any major gas releases from the facility in the event of upset operating conditions, VOC emissions from the CPF operations are not anticipated to have the potential for impacts on air quality at the nearest sensitive receptors and have not been considered further.
- Emissions from road, river and air transport activities during operations: The number of transport movements by barge, road and air during the Project's operations phase will be lower than during the construction phase; therefore, emissions to air from operations phase transport will be much lower than construction phase transport which will represent the worst case scenario in relation to emissions from transport activities for the Project.
- Other potential emissions: Emissions to air of VOCs from the storage and transfer of fuels, odor and dust from landfilling activities, odor from sewage treatment facilities and dust, VOCs and products of fuel combustion from workshops are expected to be minor due to the scale and nature of the activities, the small volumes or areas involved, and the distances to the nearest sensitive receptors and have not been considered further.
- Emissions associated with decommissioning activities have also not been considered further, given the uncertainty regarding the nature and scale of activities likely to be undertaken.

Emissions of CO_2 and other greenhouse gases are addressed separately in Section 15.2.

15.1.4 Proposed Mitigation and Management Measures

Table 15.7 describes proposed mitigation to be implemented to further reduce impacts to air quality.

Table 15.7 – Air Quality Mitigation Strategies and Management Plans

Potential Impact	Mitigation Strategy	Relevant Management Plans
Adverse human health, nuisance effects and vegetation effects due to fugitive dust from construction activities, quarry operations, and roads.	♦ Implement dust control, where required [EM041]. ♦ Actively or passively rehabilitating bare sites as soon as possible to promote a stable self-sustaining landscape, e.g., – Allow forest edges to naturally regenerate or create appropriate conditions to facilitate natural regeneration, e.g., rip the substrate, replace topsoil, apply mulch. – Rehabilitate Pandanus habitats, e.g., recreate mounds, re-instate the intertidal surface between Pandanus mounds. – Rip compact surfaces across the slope, as appropriate, to facilitate revegetation and minimize erosion. – Spread stockpiled topsoil, organic matter and cleared vegetation over the rehabilitation area to promote natural regeneration. – Use native vegetation to revegetate sites when active rehabilitation measures are required [EM029].	Air Emissions and GHG Management Plan
Adverse human health and nuisance effects due to fuel combustion emissions from operation of vehicles, machinery, fixed and mobile plant and equipment, and marine, river and air transport.	♦ Use low sulfur fuel, as far as practicable [EM042].	Air Emissions and GHG Management Plan
Adverse human health effects from combustion emissions of air pollutants associated with waste incineration.	♦ Waste incineration shall: – Use appropriately designed incinerators commensurate with proposed inventory. – Be considered for waste that will effectively combust. – Be operated within the required specification and by competent personnel [EM043].	Air Emissions and GHG Management Plan; Waste Management Plan
Adverse human health and vegetation effects from air emissions at the CPF.	No additional mitigations measures are proposed.	Air Emissions and GHG Management Plan
Community complaints associated with actual or perceived air quality effects from construction or operations.	No additional mitigations measures are proposed.	Air Emissions and GHG Management Plan; Stakeholder Engagement Plan

15.1.5 Residual Impact Assessment

The following section provides the assessment of residual impacts to air quality subject to the embedded design controls in Section 15.1.3 and the successful implementation of the mitigation and management measures in Section 15.1.4. A summary of the residual impact assessments is provided at the end of this section, including when and where (in which Project phase and location) these impacts are expected to occur.

15.1.5.1 Construction Phase

As outlined in Section 15.1.3, the construction phase activities identified as requiring assessment are:

- Earthworks and fugitive dust emissions from constructing the CPF, Logistics Base, terrestrial pipelines (including the shore crossing area at Orokolo Bay), access roads and Purari Airstrip extension.
- River transport.
- Road use including spoil disposal.
- Aircraft transport.
- Quarry operations.
- Waste disposal.

The potential air quality impacts associated with each of these activities are discussed in the following sections.

Earthworks and Fugitive Dust from Construction

The screening and assessment of dust emission magnitude was undertaken as per steps 1, 2a and 2b of the IAQM guidance, and is detailed in Part 2 of Volume 3. Based on the area sensitivities and dust emission magnitudes, the resulting risk of air quality impacts from fugitive dust has been derived for each construction activity using the impact matrix in Part 2 of Volume 3, the results of which are presented in Table 15.8. As per the IAQM guidance, the risk of air quality impacts assumes no mitigation is applied, to identify what level of control may be required to mitigate potential off-site impacts.

Based on the risk categories derived using the IAQM method, it is concluded that there is a ***Negligible*** or ***Low*** risk of human health or dust nuisance impacts associated with the earthworks and construction activities proposed as part of the Project, even if no dust mitigation measures were to be implemented. This is due to the separation distances between the worksites and the nearest inhabited areas (see Section 5.2.1 of Part 2 of Volume 3).

The risks of any potential ecological impacts are also concluded to be ***Low***, even if no dust mitigation measures were to be implemented, except for the pipeline and access road earthworks and for the Purari Airstrip extension earthworks and construction activities, which are indicated to have a medium risk of impacts. The implementation of dust controls during construction will reduce the risks of any off-site ecological impacts occurring to ***Low*** for all Project components; however, the above assessment indicates that particular care should be taken to reduce dust emissions during the pipeline and access road earthworks, and the Purari Airstrip extension earthworks and construction. Any residual impacts for the road and pipeline alignments would be highly localized to the area immediately adjacent to these activities and will move along as the works progress. For the airstrip, vegetation clearing will be maintained for safety reasons.

Table 15.8 – Assessment of Potential Fugitive Dust Impacts from Construction Prior to Mitigation

Value	Construction Activity	Sensitivity of the Area	Magnitude of Dust Emissions		Risk of Air Quality impacts	
			Earthworks	Construction	Earthworks	Construction
Dust soiling Human heath	CPF site	Low	Large	Large	Low	Low
	Logistics Base	Low	Large	Large	Low	Low
	Export pipeline route	Low	Medium	Small	Low	Negligible
	Export pipeline shore crossing site at Orokolo Bay	Low	Medium	Small	Low	Negligible
	Access roads	Low	Medium	-	Low	-
	Purari Airstrip extension	Low	Large	Medium	Low	Low
Ecology	CPF site	Low	Large	Large	Low	Low
	Logistics Base	Low	Large	Large	Low	Low
	Export pipeline route	Medium	Medium	Small	Medium	Low
	Export pipeline landfall site at Orokolo Bay	Low	Medium	Small	Low	Negligible
	Access roads	Medium	Medium	-	Medium	-
	Purari Airstrip extension	Medium	Large	Medium	Medium	Medium

Note: While pre-mitigation risk assessment is not generally applied in this EIS, an exception is made in this instance due to application of the IAQM method.

River Transport

Section 4.9.2.1 summarizes the anticipated frequency of barging movements during the Project's construction phase. Six barges per day are likely to pass villages along the river transport corridors during the first year of construction, accounting for up-river and down-river movements for each barge delivery. During the second year, this may increase to eight passes per day depending on timing of the weekly supply barges. The number of daily passes will progressively decrease over the remainder of the construction period.

Air emissions from the barge engines will occur near the center of the river while the barge is in transit, and each barge will be near each village for only a short time as it travels past. Given the low number of passes, the potential for these emissions to cause a decline in the health of local people is negligible.

The Logistics Base and Herd Base are located more than 2 km from the nearest village, which is Poroi 1 (see Table 15.1). Air emissions from the barges and cargo handling equipment have no potential to cause a decline in the health of local people at these distances. The family resident in the house at the Purari Airstrip will be near the unloading area for the barges delivering aggregate from Herd Base to the airstrip construction site during the second year of construction; however, these activities will only occur for four months. The number of daily vessel movements is minimal and air quality criteria in the surrounding area would not be exceeded.

Road Use

Once constructed, light and heavy vehicle movements on access roads between the CPF, Logistics Base, wellpads and Herd Base will emit wheel-generated dust and exhaust fumes.

These emissions will peak during the construction phase and will occur to a much lesser extent during the operations phase.

If the road surface is highly erodible, nuisance dust impacts may occur in the areas immediately adjacent to the road in dry conditions; however, given the high rainfall in the region which will act to suppress dust emissions, the potential for impacts due to construction traffic will be minimal.

As noted in Table 15.1, no human receptors are located within 350 m of the access roads associated with the Project. Poroi 1, the nearest sensitive receptor, is located more than 2 km from any Project road. At this distance, dust and exhaust fumes from vehicle movements have no potential to give rise to adverse health impacts.

Aircraft Transport

The number of aircraft movements from Port Moresby to Purari Airstrip during construction is anticipated to be between five to seven flights per day (ATR42, Twin Otter or Dash 8 type aircraft). The low flight frequency means that these activities are unlikely to exceed ambient air quality criteria at the nearest sensitive receptor (i.e., the house approximately 200 m northwest of the northern end of the runway), and they have not been considered further.

Quarry Operations

The quarries that the Project shall use are described in Section 4.8.4 and shown in Figure 4.11. All of these quarries are more than 4 km from the identified sensitive human receptors and would therefore not have any potential for adverse impacts on air quality at these distances.

Waste Disposal

A new high-temperature waste incinerator will be installed and operated at the general waste landfill site, approximately 245 m west of the operations accommodation camp, for the disposal of solid waste generated during the Project's construction, operations and decommissioning phases. This incinerator is likely to be a multi-chamber incinerator designed to destroy a wide variety of wet and dry waste materials. These types of incinerators are designed to maintain a secondary chamber operating temperature of not less than 1,000ºC with a secondary chamber gas retention time of not less than one second so that VOCs are destroyed and to meet international air emissions standards for dioxin and furan destruction.

The incinerator's size and the proposed waste volumes to be incinerated are unknown at this stage. Air dispersion modeling studies for waste incinerators for similar projects have shown that air pollutant concentrations at sensitive receptors at a separation distance of 150 m would be well below the relevant ambient air quality criteria. The Poroi 1 community is the closest sensitive receptor to the proposed incinerator and is more than 3.5 km away. The operations accommodation camp is also beyond this separation distance.

Waste management procedures will be implemented so that the appropriate waste streams are disposed of in the incinerator and that personnel are appropriately trained to operate the unit.

Based on the above, it is concluded that there is no risk of air quality impacts due to emissions from the incinerator, provided it is operated in accordance with the manufacturer's instructions.

15.1.5.2 Operations Phase

As outlined in Section 15.1.4, the only operations phase activity identified as requiring assessment is air emissions from the CPF. All other operational activities (i.e., barging, aircraft movements, vehicle movements, waste incineration) will have lower impacts in the operations

phase than in the construction phase. As no significant off-site impacts were identified for these activities during the construction phase, they have not been considered.

The results of the modeling undertaken in Part 2 of Volume 2 are presented in Tables 15.9 (HP/incineration) and 15.10 (MP/LP and acid gas injection). Results are presented for the three nearest sensitive human receptors identified near the CPF site and as predicted 'maximum off-site' concentrations. These maximum off-site concentrations have been extracted from the model output files based on the area proposed to be cleared as part of CPF construction (see facility boundary in Figure 15.1 and 15.2). They are therefore considered to be worst-case estimates of maximum off-site concentrations, as the boundary of an exclusion zone will be further away from the sources than assumed in the modeling.

Table 15.9 – Modeling Results – HP/Incineration

Pollutant	Averaging Period	Maximum Predicted Ground-level Concentrations* ($\mu g/m^3$)					Ambient Air Quality Criteria ($\mu g/m^3$)
		Poroi 1	Mapaio Fish Camp	Herd Base	Purari Airstrip House	Maximum Off-site	
NO_2	1-hour	44.7	13.6	27.3	22.8	109.6	**200**
	Annual	0.3	0.1	0.6	0.2	5.9	**40**
SO_2	10-minute	13.1	1.9	9.6	8.4	47.5	**500**
	1-hour	9.2	1.4	6.7	5.9	33.2	**200**
	24-hour	0.6	0.1	0.5	0.5	4.7	**20**
CO	1-hour	9.0	2.9	5.9	3.7	62.3	**30,000**
	8-hour	2.6	1.1	1.0	1.0	18.2	**10,000**
Benzene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**170**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**4.5**
Toluene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**4,500**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**1,200**
Xylene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**26,000**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**570**
Ethylbenzene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**2,200**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**180**

< = less than.
* Based on the following stack heights: 20 m for the power gas turbine and medium-pressure compressor stacks, 40 m for the heating boiler stacks and 50 m for the thermal oxidizer stack.

Table 15.10 – Modeling Results – MP/LP and Acid Gas Injection

Pollutant	Averaging Period	Maximum Predicted Ground-level Concentrations* (µg/m³)					Ambient Air Quality Criteria (µg/m³)
		Poroi 1	Mapaio Fish Camp	Herd Base	Purari Airstrip House	Maximum Off-site	
NO_2	1-hour	50.1	26.8	55.4	35.6	129.3	**200**
	Annual	0.6	0.1	1.0	0.3	15.5	**40**
SO_2	10-minute	4.7	1.5	3.4	2.7	33.8	**500**
	1-hour	3.3	1.0	2.4	1.9	23.6	**200**
	24-hour	0.4	0.1	0.2	0.2	3.4	**20**
CO	1-hour	11.9	6.9	16.2	8.7	123.7	**30,000**
	8-hour	3.7	2.9	3.2	2.5	57.9	**10,000**
Benzene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**170**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**4.5**
Toluene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**4,500**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**1,200**
Xylene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**26,000**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**570**
Ethylbenzene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**2,200**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**180**

< = less than.
* Based on the following stack heights: 20 m for the power gas turbine and medium-pressure compressor stacks, 40 m for the heating boiler stacks and 50 m for the thermal oxidizer stack.

Tables 15.8 and 15.9 show that for both operational scenarios assessed, the maximum ground-level NO_2, SO_2 and CO concentrations predicted at the sensitive receptors are well below the relevant ambient air quality criteria. Concentrations predicted at all off-site locations are also well below the relevant ambient air quality criteria. The maximum predicted ground-level VOC concentrations are negligible compared to the relative ambient air quality criteria. These results indicate the proposed CPF operations are expected to meet the applicable ambient air quality criteria under normal operating conditions.

Contour plots showing the maximum ground level concentrations predicted across the modeling domain are presented in Part 2 of Volume 3. As shown in Figures 15.1 and 15.2, the maximum predicted short-term (1-hour average) SO_2 and NO_2 contours when acid gas is being recovered and discharged (after treatment to minimize SO_2 in the exhaust gases). The maximum concentrations are well below the air quality criteria.

As discussed in Section 15.1.2, the stack and emission data used in the modeling for the HP/incineration scenario were based on a pre-FEED design option that is being revised.

The SO_2 emission rate and stack conditions may increase ground level concentrations from those predicted by the modeling; however, the maximum ground level SO_2 concentrations predicted by the modeling at the sensitive receptor locations were very low, at less than 5% of the relevant ambient air quality criteria, while the maximum off-site ground level SO_2 concentrations predicted by the modeling were less than 25% of the relevant ambient air quality criteria. Given this, while the predicted ground level concentrations for the revised base case may increase due to the changed stack parameters for the thermal oxidizer, they may not approach or exceed the associated criteria at the receptor locations.

MAXIMUM PREDICTED 1-HOUR AVERAGE NO_2 CONCENTRATIONS - YEARS 1 TO 4 NORMAL OPERATIONS

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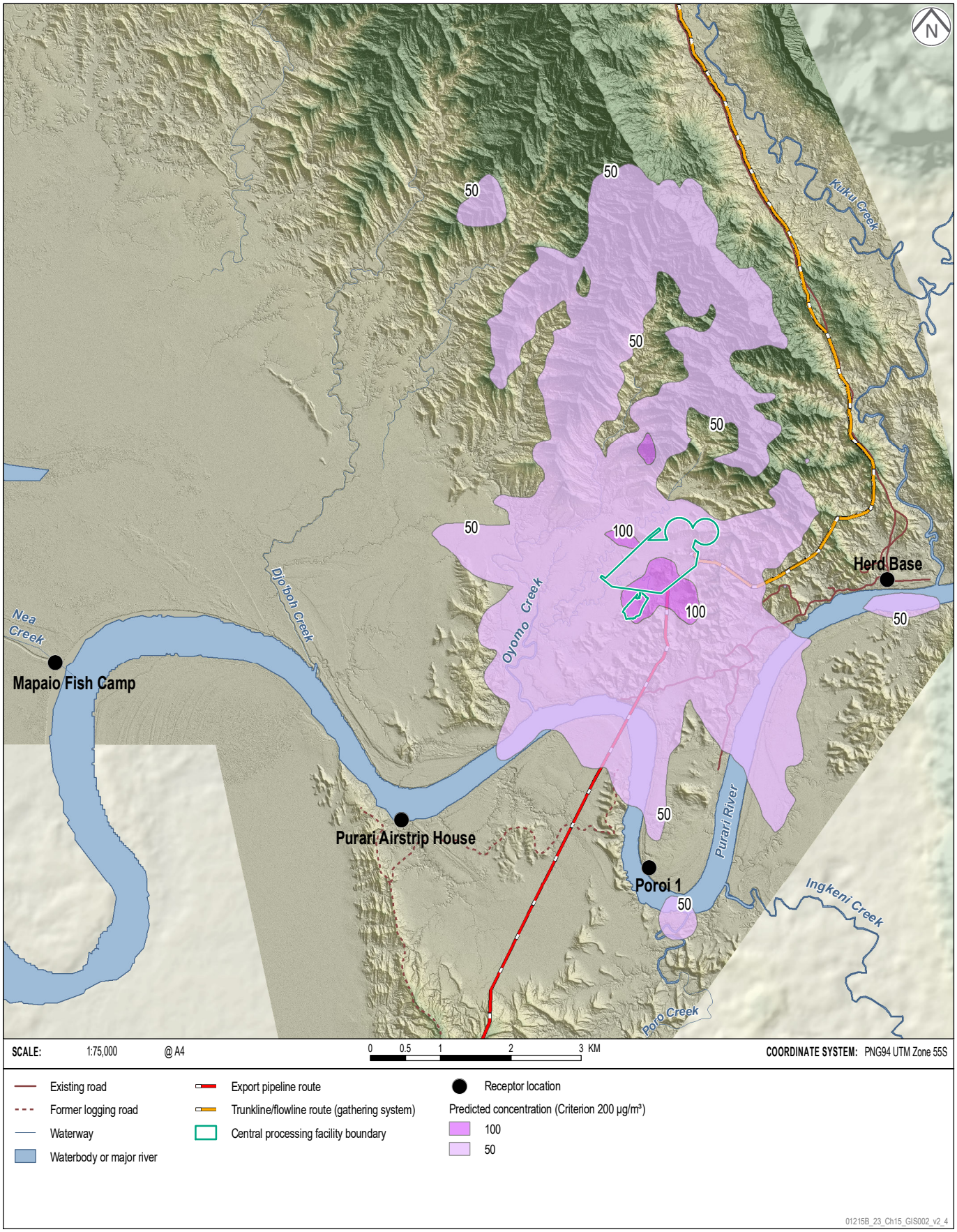
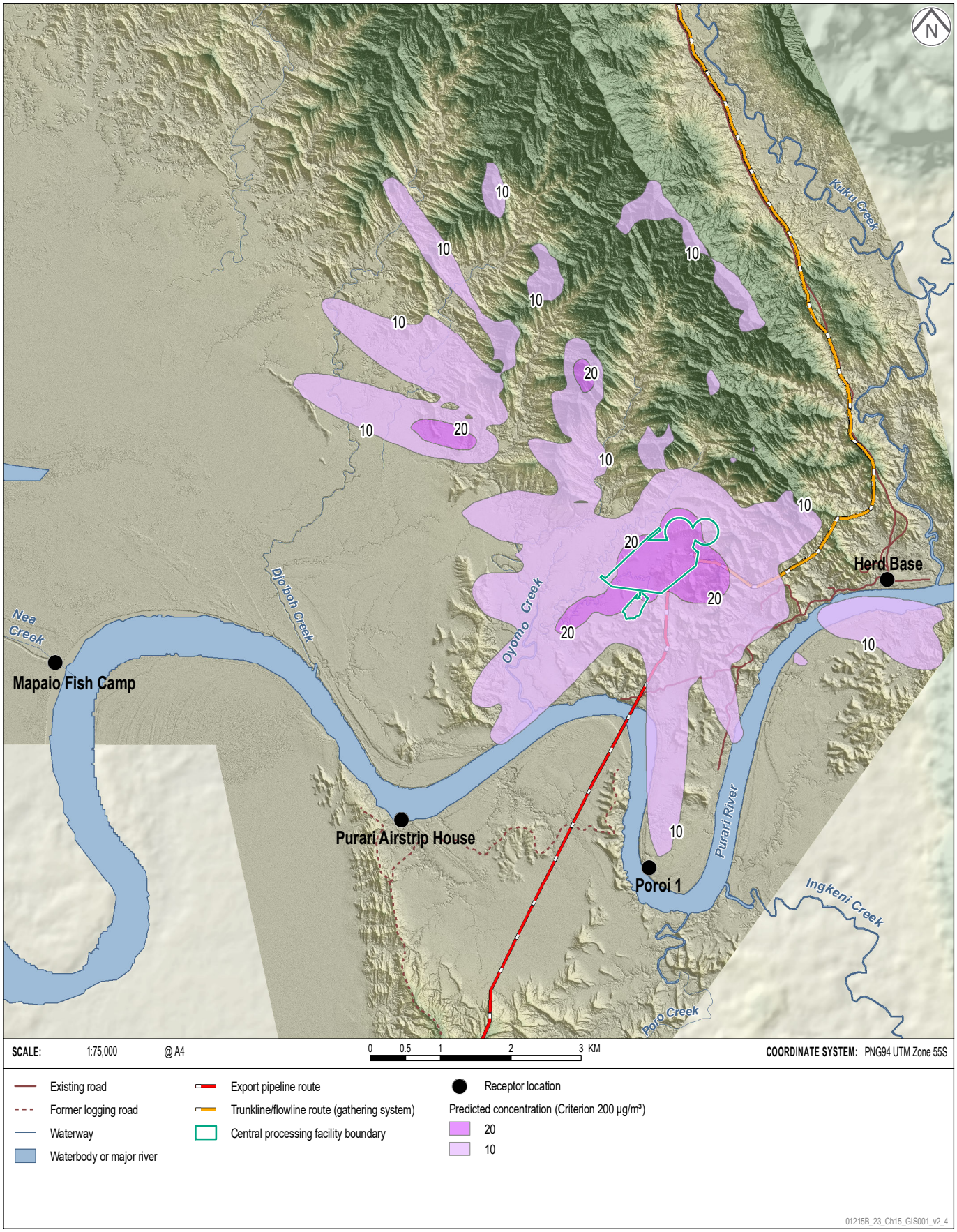
FIGURE 15.1



MAXIMUM PREDICTED 1-HOUR AVERAGE SO_2 CONCENTRATIONS - YEARS 1 TO 4 NORMAL OPERATIONS

Papua LNG Project | Environmental Impact Statement

FIGURE 15.2



A comparison of the in-stack pollutant concentrations used in the modeling study against the relevant emission limit values for each equipment type (see Section 15.1.2.3) shows:

- The proposed in-stack NO_X concentration of 50 ppm (dry gas basis, 15% O_2) for the power gas turbines:
  - Exceeds the IFC emission limit value of 25 ppm for turbines burning natural gas, 15 to 50 MW (IFC, 2007a).
  - Exceeds the GS EP ENV 001 emission limit value of 37 ppm for gas combustion used for power generation or mechanical drive purposes (TOTAL, 2011).
- The proposed in-stack NO_X concentration of 118 ppm (dry gas basis, 3% O_2) for the heating boilers complies with the IFC thermal power plants' emission limit value of 118 ppm for gas boilers >50 MWth (IFC, 2008).
- The proposed in-stack NO_X concentration of 50 ppm (dry gas basis, 15% O_2) for the medium-pressure compressors:
  - Exceeds the IFC emission limit value of 25 ppm for turbines burning natural gas, 15 to 50 MW (IFC, 2007a).
  - Exceeds the GS EP ENV 001 emission limit value of 37 ppm for gas combustion used for power generation or mechanical drive purposes (TOTAL, 2011).

While the NO_X emission concentrations proposed for the power gas turbines and the medium-pressure compressors exceed IFC and TOTAL emission limit values, the air dispersion modeling in Tables 15.8 and 15.9 shows that the stack heights used in the modeling for the CPF are sufficient to disperse these emissions to levels below the relevant ambient air quality criteria at all locations beyond the site boundary. No adverse off-site air quality impacts are therefore anticipated due to the emission concentrations.

In addition to human health impacts, air emissions from the CPF operations may adversely impact on the surrounding vegetation. The pollutant emitted from the CPF most likely to cause damage to vegetation is SO_2. At high concentrations, SO_2 can can produce acute injury in plants in the form of foliar necrosis even after relatively short duration exposure. Long-term exposure of plants to much lower concentrations of SO_2 can cause chronic injury, taking the form of reduced growth and yield, often with no clear visible symptoms or else with some degree of yellowing of the leaves. Different plant species and varieties, and even individuals of the same species may vary considerably in their sensitivity to SO_2.

The air dispersion modeling performed as part of this assessment predicted that maximum 24-hour average SO_2 concentrations beyond the site boundary would be less than 5 µg/m^3. It can be concluded that annual average off-site SO_2 concentrations will be far below the ICP (2017) guidelines for adverse impacts on vegetation and forest ecosystems of 20 µg/m^3. No adverse impacts on vegetation would therefore be anticipated due to SO_2 emissions from the CPF.

15.1.5.3 Summary of Predicted Impacts

A summary of the assessment of residual impacts related to air quality is provided in Table 15.11, including in which Project phase and location these impacts are expected to occur.

Table 15.11 – Summary of Compliance and Qualitative Assessment for Air Quality

Potential Impact	Location of Activity	Project Phase	Compliance Assessment
Adverse human health, nuisance or vegetation effects due to fugitive dust emissions from construction activities at the CPF.	PRL-15 (CPF)	Construction	The CPF is located more than 3.9 km from the nearest sensitive human receptor. Based on the assessment in Table 15.8, maximum ground-level suspended and deposited particulate levels would comply with relevant nuisance and health-based air quality criteria at this distance. Any impacts on vegetation from dust deposition will be limited to the immediate area and will be temporary in nature.
Adverse human health, nuisance or vegetation effects due to fugitive dust emissions from construction activities at the Logistics Base.	PRL-15 (Logistics Base)	Construction	The Logistics Base is located more than 2.6 km from the nearest sensitive human receptor. Based on the assessment in Table 15.8, maximum ground-level suspended and deposited particulate levels would comply with relevant nuisance and health-based air quality criteria at this distance. Any impacts on vegetation from dust deposition will be limited to the immediate area and will be temporary in nature.
Adverse human health, nuisance or vegetation effects due to fugitive dust emissions from construction of the export pipeline.	Onshore export pipeline	Construction	Aivai is the nearest sensitive human receptor to the pipeline construction activities (260 m away). Based on the number of receptors and the scale of the proposed activities, the risk of any adverse human health or nuisance impacts associated with fugitive dust emissions is concluded to be low even if no mitigation measures were implemented. Any impacts on vegetation from dust deposition will be limited to the immediate area and will be temporary in nature.
Adverse human health, nuisance or vegetation effects due to fugitive dust emissions from construction of the export pipeline shore crossing site at Orokolo Bay.	Export pipeline shore crossing Orokolo Bay	Construction	The nearest houses to the shore crossing construction activities are approximately 340 m away. Based on the number of receptors and the scale of the proposed activities, the risk of any adverse human health or nuisance impacts associated with fugitive dust emissions is concluded to be low even if no mitigation measures were implemented. Potential impacts on vegetation from dust deposition are concluded to be negligible.
Adverse human health, nuisance or vegetation effects due to fugitive dust emissions from construction of the access roads.	PRL-15 (access roads)	Construction	Access roads are located more than 2 km from the nearest sensitive human receptor. Based on the assessment in Table 15.8, maximum ground-level suspended and deposited particulate levels would comply with relevant nuisance and health-based air quality criteria at this distance. Any impacts on vegetation from dust deposition will be limited to the immediate area and will be temporary in nature.
Adverse human health, nuisance or vegetation effects due to fugitive dust emissions from construction of the Purari Airstrip extension.	Purari Airstrip	Construction	A single house is located approximately 85 m from the Purari Airstrip extension. Based on the number of receptors and the scale of the proposed activities, the risk of any adverse human health or nuisance impacts associated with fugitive dust emissions is concluded to be low. Any impacts on vegetation from dust deposition will be limited to the immediate area and will be temporary in nature.

Table 15.11 – Summary of Compliance and Qualitative Assessment for Air Quality (cont'd)

Potential Impact	Location of Activity	Project Phase	Compliance Assessment
Adverse human health and nuisance effects due to fuel combustion emissions from marine and river transport and during unloading.	Marine route and riverways	Construction, operations and decommissioning	The low frequency of barge movements means that there is no potential for air quality impacts at the villages on the banks of the rivers. The Logistics Base and Herd Base are located more than 2 km from the nearest sensitive human receptors, and air emissions from barges and cargo handling equipment are unlikely to adversely impact on air quality at these distances. Barging of aggregate from Herd Base to the airstrip construction site also would not potentially exceed air quality criteria at the Purari Airstrip House. There are no sensitive human receptors along the marine routes.
Adverse human health, nuisance or vegetation effects due to fuel combustion emissions or fugitive dust due to vehicles use on access roads.	PRL-15 and onshore export pipeline	Construction, operations and decommissioning	The nearest sensitive human receptor to Project access roads is located more than 2 km away in Poroi 1. At this distance vehicle movements would not adversely impact air quality. Any impacts on vegetation from wheel-generated dust will be limited to the immediate area adjacent to the road.
Adverse human health and nuisance effects due to fuel combustion emissions from air transport.	PRL-15 (Purari Airstrip)	Construction, operations and decommissioning	Emissions from the low frequency of flights (up to 5 per day) are unlikely to exceed ambient air quality criteria at the nearest sensitive human receptors (see assessment in Section 15.1.5).
Adverse human health and nuisance effects due to fuel combustion emissions and fugitive dust emissions from quarry operations.	PRL-15	Construction, operations and decommissioning	Project quarry sites are located more than 4 km from the nearest sensitive human receptors. Maximum ground-level suspended and deposited particulate levels will comply with relevant nuisance and health-based air quality criteria at this distance. Any impacts on vegetation from dust deposition will be limited to the immediate area.
Adverse human health effects from combustion emissions associated with waste incineration.	PRL-15	Construction, operations and decommissioning	The proposed incinerator at the general waste landfill site is located more than 3.5 km from the nearest sensitive human receptors. Based on the assessment in Section 15.1.5, maximum ground-level air pollutant concentrations associated with any waste incineration carried out at this site would comply with relevant air quality criteria at this distance.
Adverse human health and vegetation effects due to air emissions at the CPF.	PRL-15 (CPF)	Operations	Detailed air dispersion modeling studies for normal operations have demonstrated that maximum predicted off-site ground-level concentrations of NO_2, CO, SO_2, PM_{10} and $PM_{2.5}$, and VOCs (as BTEX) would comply with relevant health-based air quality criteria.
Adverse vegetation and fauna effects associated with SO_2 emissions from the CPF.	PRL-15 (CPF)	Operations	Annual average off-site SO_2 concentrations will be far below the ICP (2017) guideline for adverse impacts on vegetation and forest ecosystems of 20 µg/m^3. No adverse impacts on vegetation would therefore be anticipated due to SO_2 emissions from the CPF.

15.2 Greenhouse Gases and Climate Change

This section summarizes the findings of a greenhouse gas (GHG) assessment and climate change study undertaken for the Project, as detailed in Part 5 of Volume 3.

15.2.1 Context

The greenhouse effect is a naturally-occurring process that warms the Earth's surface and atmosphere. It is due to certain atmospheric gases, such as carbon dioxide (CO_2), water vapor and methane, influencing Earth's energy balance by absorbing longwave radiation emitted from the surface. The GHG concentration in the Earth's atmosphere controls the amount of heat energy added to the atmosphere by the greenhouse effect.

GHG emissions can result from natural or anthropogenic sources; however, there is strong consensus in the climate science research community that GHG emissions from human activities have become the primary driver for an observed enhancement of the natural greenhouse effect, i.e., climate change, following the industrial revolution. Accurate quantification of GHG emissions will aid the ongoing assessment of climate impacts, and the development of targeted and effective policies and strategies to reduce the impact of global climate warming.

The PNG Government released Papua New Guinea's First Biennial Update Report to the United Nations Framework on Climate Change (CCDA, 2018) in April 2019. This first Biennial Update Report (BUR1) presents an overview of PNG's national circumstances relevant to climate change and presents an inventory of anthropogenic GHG emissions by sources and removals by sinks for years 2000 through to 2015. It also presents information on identified mitigation actions and associated constraints and gaps, including information on the results achieved by PNG from reducing emissions from deforestation, forest degradation and enhancement of forest carbon stocks.

A summary of the PNG GHG emission inventory data presented in the BUR1 report for 2000 to 2015 is presented in Figure 15.3. It shows that the 'land use land-use change and forest' sector is one of the biggest sectors in the PNG GHG emission inventory, and historically acted as a sink. This sector has become an increasingly smaller sink over time due to a decrease in forest lands, and in 2011, 2013, 2014 and 2015 the land use land-use change and forest sector was a net source of GHG emissions. Figure 15.3 also shows that the estimated GHG emissions from the energy sector increased notably in 2014 and 2015, and the BUR1 report attributes this to the PNG LNG project's operations, and increased fugitive emissions associated with increasing natural gas production.

15.2.2 Discipline-specific Impact Assessment Method

The GHG assessment adopted a different approach to the impact assessment method described in Chapter 3.

The Project's GHG emissions will not have a direct impact on the local or regional environment that can be quantified or assessed. Instead they will contribute to PNG's national emissions and global anthropogenic GHG emissions, and will impact on the PNG government's ability to comply with its National Climate Compatible Development Management Policy (CCDA, 2014) and to meet its international obligations under the 2016 Paris Climate Change Agreement. The GHG assessment therefore assesses the Project's potential contribution to climate change by developing a GHG emissions inventory covering the life of the Project, including construction, operations and decommissioning. The significance of the Project's estimated annual emissions has then been assessed in relation to PNG's national GHG emission inventory.

Further information on the methods used in these studies is provided in the following sections.

ESTIMATED NATIONAL GHG EMISSIONS FOR PAPUA NEW GUINEA (2000 TO 2015)

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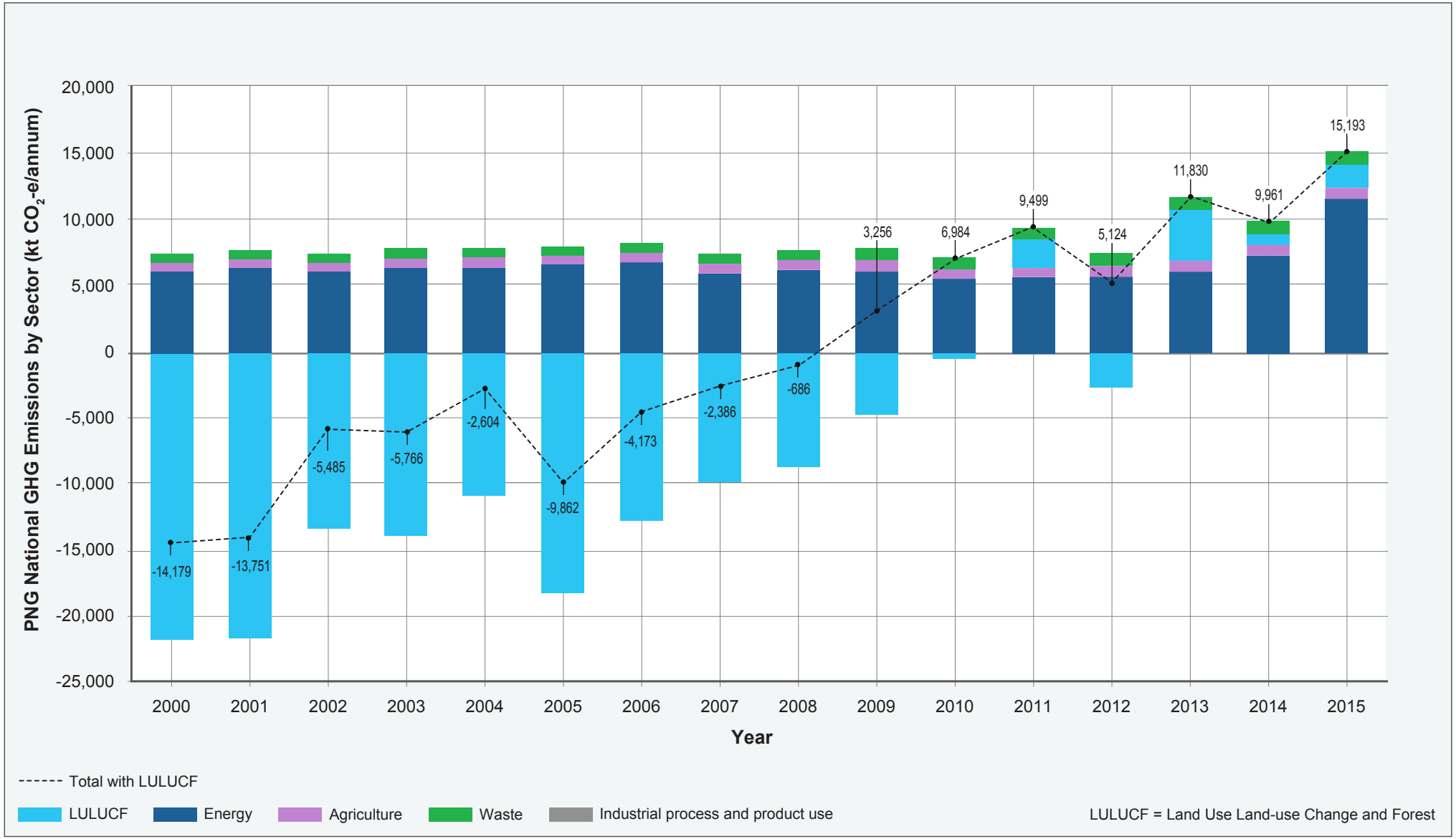
FIGURE 15.3



CCDA, 2018.

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Details of the emission estimation method used to compile the Project's GHG emissions inventory are provided in Part 5 of Volume 3. Calculation of GHG emissions from the Project was undertaken in a five-stage process:

- Definition of the Project boundary (geographical and operational).
- Identification of emission sources within the Project boundary.
- Identification of emission calculation methods for each source.
- Identification of activity data for each emission source.
- Calculation of GHG emissions.

GHG emissions are defined as Scope 1 'direct', and Scope 2 or Scope 3 'indirect' emissions, as follows (Part 5 of Volume 3):

- Scope 1 – emissions are produced from sources within the boundary of an organization and are due to the organization's activities.
- Scope 2 – emissions from the generation of purchased electricity consumed in owned or controlled equipment or operations. As the Project will not be sourcing any appreciable quantities of electricity (e.g., only for offices in Port Moresby), Scope 2 emissions have not been considered further.
- Scope 3 – emissions generated in the wider economy due to an organization's activities but are physically produced by the activities of another organization.

Downstream processing of the gas and condensate produced by the Project will be undertaken at new LNG facilities to be co-located within the existing LNG plant at Caution Bay. Nuigini LNG Operating Company will permit, construct and operate the additional gas processing trains and marine facilities following a separate EIS and approvals process. For this assessment, GHG emissions associated with downstream gas processing have been included in this assessment as a Scope 3 emission source and not as a Scope 1 emission source, as the downstream processing is beyond the scope of this EIS.

GHG emission factors allow the quantity of GHG emitted by a source to be calculated from the units of activity. Relevant GHG emission factors were sourced to compile the Project's GHG emission inventory using the following hierarchy:

- Intergovernmental Panel on Climate Change (IPCC) for National Greenhouse Gas Inventories (IPCC,2016).
- Australian National Greenhouse Accounts (NGA) Factors Workbook (DEE, 2018).
- Published industry guidelines for GHG emission inventory development.

Other IPCC publications have been used to compile the emission estimates including Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC, 2003). Annual GHG emission estimates, calculated by the TOTAL design team for fuel gas combustion, flaring venting/diffuse emissions at the CPF, were used and the relevant activity data required for the calculations (e.g., land clearance areas, fuel consumption rates and barging activity data) were compiled based on the Project description and in consultation with TOTAL.

15.2.3 Identification of Potential Impacts

Estimated Scope 1 (direct) and Scope 3 (indirect) GHG emissions have been calculated for each year of the Project life and are presented in Figure 15.4 (Scope 1 emissions only) and Figure 15.5 (Scope 1 and Scope 3 emissions). The estimated annual and life of Project emissions are summarized in Table 15.12, with further details provided in Part 3 of Volume 3.

A review of the emission estimates shows the:

- Main contributor to the estimated Scope 1 emissions for the construction phase is the loss of carbon stocks due to land clearing (70% of the total Scope 1 emissions for the five-year construction period). Figure 15.4 shows the emission inventory also accounts for the ongoing annual carbon losses during the operations and decommissioning phases, due to cleared vegetation not being available to assimilate any further CO_2. These estimates do not include the areas cleared for the pipelines; however, as they will be allowed to revegetate, albeit to a limited extent (i.e., vegetation will be cut to low levels and trees with extensive root systems will not be allowed to grow).
- Estimated Scope 1 emissions are highest during Years 2 to 5 of operations at 1,489 kt CO_2-e/annum[1], which is related to the discharging of acid gas (containing CO_2) from the thermal oxidizer. This reduces significantly after Year 5, when acid gas injection is assumed to begin.
- Maximum calculated annual emissions of combined Scope 1 and 3 GHG emission estimates associated with Project operations are still predicted to occur during Years 2 to 5 of operations (Figure15.5), due to the Scope 1 emissions associated with discharging acid gas from the thermal oxidizer.
- Indicative Scope 1 emission estimates compiled for the decommissioning phase are 25 kt CO_2-e per annum emitted for the assumed two-year decommissioning period. These emissions represent a minor component of the Project in its entirety (0.2% of the life of Project Scope 1 emissions).
- Major Scope 1 emission source over the Project operational lifetime is predicted to be the combustion of fuel gas at the CPF to drive the compressors, run the heating boiler and to generate power (61.8%).
- Most significant contributors to the estimated total Scope 1 and Scope 3 emissions over the Project operational lifetime come from downstream gas processing (25.4%) and product gas combustion by the end user (64.8%).

1 kt CO_2-e = kilotonnes of CO_2 equivalent.

ESTIMATED ANNUAL SCOPE 1 GHG EMISSIONS FOR EACH YEAR OF PROJECT LIFE

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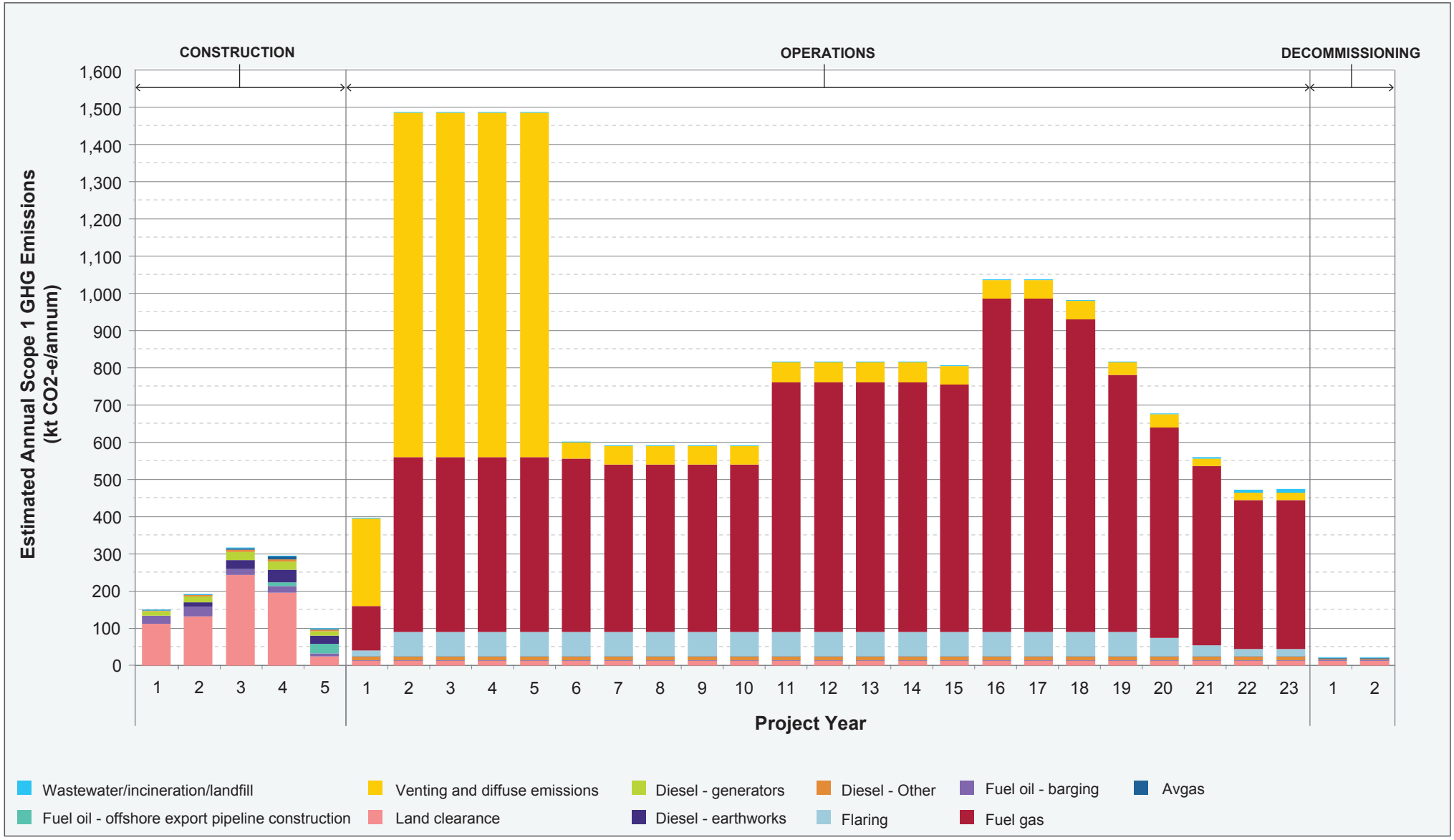
FIGURE 15.4



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ESTIMATED ANNUAL SCOPE 1 AND SCOPE 3 GHG EMISSIONS FOR EACH YEAR OF PROJECT LIFE

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FIGURE 15.5

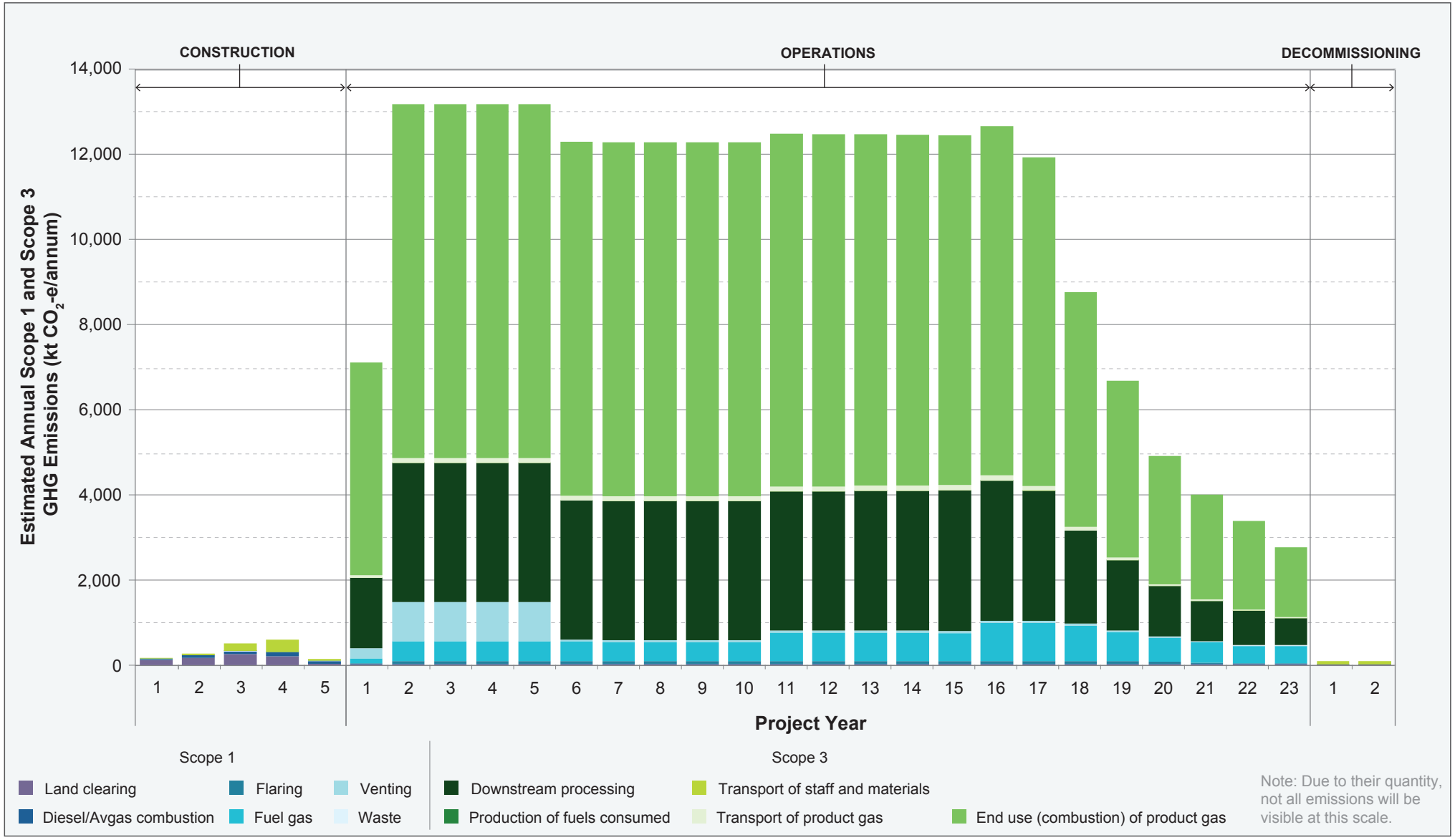

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Table 15.12 – Summary of Estimated Project GHG Emissions

Project Year	Estimated Annual GHG Emissions (kt CO_2-e)		
	Scope 1	**Scope 3**	**Total**
Construction Year 1	152	22	173
Construction Year 2	233	41	274
Construction Year 3	330	184	514
Construction Year 4	309	287	596
Construction Year 5	103	46	149
Operations Year 1 – high pressure phase, acid gas discharge from the thermal oxidizer (start-up year)	399	6,726	7,124
Operations Years 2 to 5 – high-pressure phase, acid gas discharge from the thermal oxidizer (average)	1,489	11,710	13,199
Operations Years 6 to 10 – high-pressure phase, acid gas injection (average)	597	11,710	12,306
Operations Years 11 to 15 – medium-pressure phase, acid gas injection (average)	818	11,667	12,485
Operations Years 16 to 23 – low-pressure phase, acid gas injection (average)	760	6,140	6,900
Decommissioning Year 1	25	68	93
Decommissioning Year 2	25	68	93
Total Life of Project GHG Emissions	**20,682**	**220,286**	**240,968**

Note: Rows may not add up exactly due to rounding. The emissions for the years of operation represent an average over the relevant period, hence the column totals do not add exactly to the total life of project emissions.

In summary, vegetation clearing; gas production, processing and transportation; and the operation of fixed and mobile equipment will generate GHG emissions (as estimated in Table 15.12) that have the potential to increase the greenhouse effect and climate change.

A number of embedded design controls address GHG emissions:

- Project design is based on a risk-management approach, considering geotechnical constraints (e.g., flooding, landslides risks, geohazards) and anticipating and avoiding, or where avoidance is not possible, minimizing environmental and social impacts (e.g., avoiding sensitive features, and physical and economic displacement, priority ecosystem services, and minimizing the Project footprint, land clearing and disturbance, emissions and discharges) [ED013].
- The flares will be used only for safety flaring in alignment with the TOTAL no routine flaring policy [ED023].
- Once the Elk reservoir has been depleted, acid gas removed from the raw gas using the AGRU will be disposed of by injecting it into the reservoir [ED025].
- The Project will generate its own electricity during the operation phase, which will minimize the use of diesel and related emissions [ED027].
- Waste-heat recovery units will be installed on the power gas turbines [ED028].
- Buildings will be insulated, where practicable [ED029].

15.2.4 Proposed Mitigation and Management Measures

Table 15.13 describes proposed mitigation to be implemented to further reduce impacts to GHG emissions for the Project. TEP PNG will monitor emerging issues and technology developments throughout the life of the Project and will consider adopting feasible technological solutions.

Table 15.13 – GHG Mitigation Strategies and Management Plans

Potential Impact	Mitigation Strategy	Relevant Management Plan(s)
Generation of GHG emissions contributing to an increase in the greenhouse effect and climate change.	♦ Implement standard practices to minimise fuel consumption, e.g., reduce speeds and idling times, maintain good road conditions, reduce site gradients, optimize vehicle tire pressure and maintain vehicles [EM044]. ♦ Implement fugitive emissions measurement controls [EM045].	Air Emissions and GHG Management Plan; Biodiversity Action Plan; Soil Management Plan

15.2.5 Residual Impact Assessment

The following section presents a comparison of the GHG emissions predicted for the Project to the PNG National emissions inventory and the GHG emissions intensity calculated for the Project to that reported internationally for similar projects.

The assessment is subject to the embedded design controls in Section 15.2.3 and the successful implementation of the mitigation and management measures in Section 15.2.4.

Project Contribution to PNG's National GHG Emissions Inventory

Emissions from the Project will be included in PNG's national GHG emissions inventory as part of the energy sector emissions.

The Project's estimated maximum annual Scope 1 GHG (i.e., during the acid gas discharge phase in operations years 2 to 5) are 1,487 kt CO_2-e. This represents an additional 9.8% increase in the total reported national PNG GHG emissions (including land use land-use change and forest) for 2015 of 15,193 kt CO_2-e. The contribution during other years of the Project life will be less, e.g., 3.9% during years 7 to 10.

Benchmarking Against Similar Projects

The international Association of Oil and Gas Producers (IOGP) has collected environmental data from its member companies annually since 1999. The objective is to allow member companies to compare their performance with other companies in the sector to facilitate improved and more efficient performance. The latest Environmental Performance Indicators – 2017 Data Report (IOGP, 2018) summarizes the GHG emissions (as CO_2-e) per thousand tonnes of hydrocarbon production from 2013 to 2017 (Figure 15.6). The Project's GHG emissions intensity (in tonnes GHG per thousand tonnes of hydrocarbon production) has been calculated based on the estimated total life of Project GHG emissions and the projected production volumes over the life of the Project. These calculations give a Scope 1 GHG emissions intensity (i.e., excluding downstream processing) of 155.4 tonnes GHG per thousand tonnes of hydrocarbon production. This emissions intensity value is 3% above the average value of 151 tonnes GHG per thousand tonnes of hydrocarbon production reported by the IOGP for 2017.

REPORTED GHG EMISSIONS INTENSITIES FOR IOGP MEMBER COMPANIES

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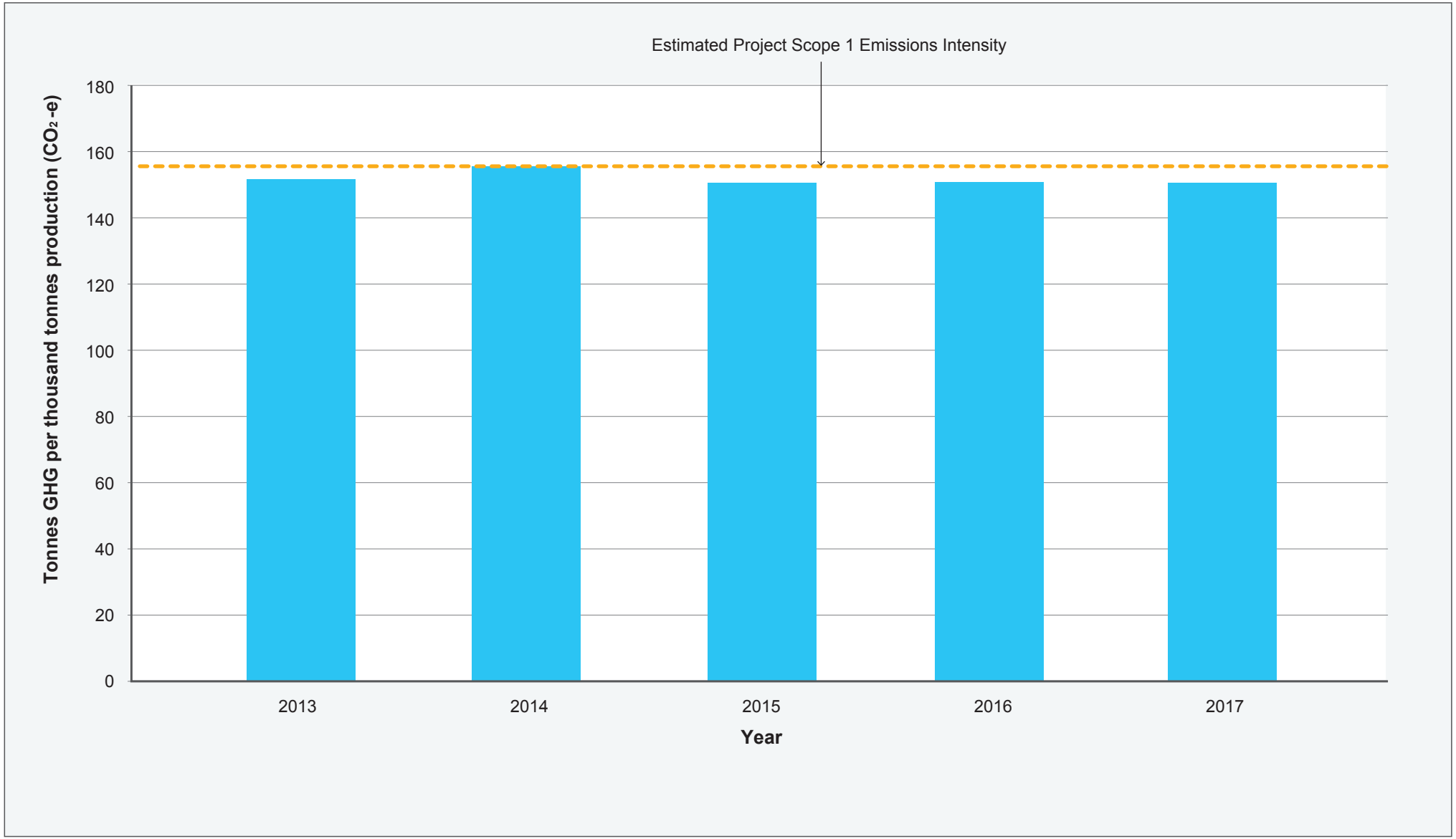
FIGURE 15.6



IOGP, 2018.

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15.3 Noise

15.3.1 Context

15.3.1.1 Existing Noise Environment

As identified in the Upstream Noise Baseline Report (Part 20 of Volume 2) and summarized in Section 10.3 of this report, the PAOI is remote from any existing industrial noise sources.

To quantify the existing ambient background noise, unattended noise monitoring was conducted at representative locations along the Project alignment including:

- The upstream wellpads.
- The closest villages (sensitive human receptors) near the CPF.
- Along the onshore export pipeline route.
- An existing village near the pipe shore crossing in the Orokolo Bay coastal area.

The monitoring was undertaken in November 2016 in general accordance with IFC monitoring requirements (see Part 20 of Volume 2).

Results indicate that existing noise levels in uninhabited forest areas can be very high during the night due to local insect noise. In these areas, the daytime background noise levels were typically between 42 and 46 dBA, L_{90}, increasing to a relatively continuous 56 dBA, L_{90} at night.

The measured background noise levels were significantly lower relative to uninhabited regions surrounded by thick forest due to land clearing around established villages. Nonetheless, insect noise still affected most village locations, but to a lower extent than forested areas, with the measured background noise levels typically between 35 and 44 dBA, L_{90} during the day and 38 dBA, L_{90} (at Hururu on the Orokolo Bay coast) and 41 dBA, L_{90} (at Mapaio Fish Camp) during the night.

Noise in villages was also influenced by intermittent noise associated with human habitation, such as voice/conversation noise, roosters crowing, dogs barking, intermittent use of line trimmers, diesel generators, motorboats (for locations along the river). These generally short-term activities had minimal effect on the resultant background L_{90} noise levels.

The area surrounding the house near the Purari Airstrip and the Purari River included noticeably more gardens and understory growth relative to the larger settlements and villages. The resulting background noise levels at this location were somewhat higher; i.e., an average noise level of 44 dBA, L_{90} during the day and 47 dBA, L_{90} at night.

The findings of the baseline noise monitoring are consistent with those SLR found during other surveys in similar regions of Papua New Guinea (SLR, 2009, 2010, 2012).

15.3.1.2 Sensitive Receptors

Sensitive human receptors are described in Section 15.1.1.2.1.

Sensitive ecological receptors are limited to terrestrial fauna as described in Chapter 7.

15.3.2 Discipline-specific Impact Assessment Method

The noise impact assessment has been performed using a combination of quantitative and semi-qualitative assessment techniques, as detailed in Part 3 of Volume 3 and summarized in the following sections.

Project noise emissions with a higher potential to adversely impact surrounding sensitive land uses were assessed quantitatively using a detailed three dimensional (3D) computer noise model. Components assessed quantitatively include the construction and continuous operation of the CPF, and where the onshore export pipeline construction is near existing villages on the Orokolo Bay coastline, particularly the shore crossing area.

Noise emissions from construction activities and CPF operations were predicted based on design information and specifications provided by TOTAL. SLR made conservative assumptions based on similar works previously undertaken where detailed information was unavailable. The 3D noise model incorporates the local topography and meteorological conditions to predict noise levels at nearby sensitive receptors. The method used in the noise modeling study is outlined in Section 15.3.2.1 while the noise criteria used to assess compliance are summarized in Section 5.3.2.3.

Noise emissions have been assessed by predicting buffer distances required to meet noise criteria for areas where noise impacts are likely to be short-term and/or are located a significant distance from any sensitive receptors. The prediction method used is described in Section 15.3.2.2.

15.3.2.1 Noise Modeling Method

Details of the meteorological environment and the modeling method used to assess potential noise impacts are provided in Part 3 of Volume 3. The noise modeling was undertaken using the CONservation of Clean Air and Water in Europe (CONCAWE) noise propagation algorithm as implemented in the SoundPLAN (V8.1) noise modeling package. CONCAWE (1981) provides a detailed description of a noise prediction model specially designed for large petrochemical complexes. The method incorporates the influence of wind effects and temperature inversions on noise propagation over large distances.

The scenarios selected for modeling were chosen to represent different stages in the life of the Project as identified in Table 15.14.

Table 15.14 – Summary of Scenarios Being Assessed by 3D Modeling

Project Component	Project Phase	Activities	Scenario/s Assessed
CPF	Construction	Vegetation clearance, earthworks and site preparation, pad preparation, civil works/building erection	Site preparation and civil works
	Operation	Gas turbines, compressors, pipework, pumps, flare	See note
Onshore export pipeline shore crossing	Construction	Earthworks (as per right of way)	Trenching

Note: Two conservative scenarios have been considered for the operational CPF:
1. All plant is operating 10 years after first gas (i.e., when the additional 5 x medium-pressure gas turbine compressors come online to achieve deeper depletion of the Antelope reservoir).
2. As above with emergency flaring at the 104-m high tower located approximately 400 m northeast of the main plant.

Noise levels have been calculated for both neutral (calm) and enhanced propagation (i.e., worst-case weather) conditions. The parameters used to assess the effects of enhanced meteorological conditions, such as temperature inversions and slight winds (from the source to receiver), are discussed in Part 3 of Volume 3. Topographical shielding, ground hardness and dense vegetation

are other factors (in addition to meteorological factors) that were considered when assessing noise propagation.

A detailed noise inventory was prepared of all major noise generating plant associated with the Project. The most significant noise producing equipment at the CPF will be:

- Gas turbine compressors (3 x 22.27 MW).
- Acid gas (AG) compressor (1 x 14.1 MW).
- C3 propane gas compressors (2 x 2.4 MW).
- Medium-pressure gas compressors (assume Solar Titan 250 gas turbine compressor set; 5 x 22.27 MW).
- Elevated low-pressure/high-pressure flare (one for startup/maintenance/emergency and upset conditions at 60 MMSCFD, except purge and pilot gases).

Other noise sources include fin fans, mono-ethylene glycol (MEG) injection pump/regeneration plant, pilot flare (for normal conditions), propane loop condenser and chiller, liquid and water transfer pumps, pipeline and booster compressor inter-stage and aftercoolers and inlet coolers.

15.3.2.2 Predicted Buffer Distance Assessment

Project activities with a lower potential for noise impact have been assessed using a semi-qualitative approach, as detailed in Part 3 of Volume 3. This was undertaken using the same CONCAWE prediction algorithm discussed in Section 15.3.2.1 to conservatively estimate noise emissions at a range of distances to determine the typical buffer distance required to meet the Project noise criteria.

The scenarios selected for the predicted buffer distance assessment are identified in Table 15.15 with a summary of the relevant Project components and key activities for each stage of the Project.

Table 15.15 – Summary of Scenarios Being Assessed Using Buffer Distance Method

Project Component	Project Phase	Activities	Assessed Scenario
Logistics Base	Construction and operation	Clear and grade activities, earthworks, general base operation (during the Project construction phase)	Clear and grade
Roads	Construction	Clear and grade activities, earthworks	Clear and grade
Export pipeline route	Construction	ROW clearing, stringing and bending, mainline welding, earthworks (trenching, lowering and backfilling)	Trenching
Accommodation camps (along the onshore export pipeline route)	Construction	Clear and grade, general operation of the camp (during the Project construction)	Clear and grade, and continuous operation of the facility
Purari Airstrip extension	Construction	Clear and grade activities, earthworks	Clear and grade
Purari Airstrip operations	Construction	Aircraft movements	Aircraft flyovers

The Australian Standard (AS 2021:2015) Acoustics–Aircraft Noise Intrusion–Building Siting and Construction was used to estimate the maximum noise from typical aircraft operations at the Purari Airstrip. Aircraft operations will continue at the runway after the CPF is completed;

however, during peak construction more aircraft will transport personnel and equipment to and from site.

15.3.2.3 Ambient Noise Guidelines

The CEPA Technical Guideline (Additional Information) for Noise Discharges (DEC, 2004) sets out the information that should be provided as part of an application for an environment permit to discharge waste. This includes:

- An outline of the proposal describing the nature and extent of activities.
- Site plans that also indicate the location of all external plant and equipment.
- Maps of the surrounding area to indicate the position of nearby receptors.
- Floor plans of internal plant of all major noise producing plant and details of existing or proposed mitigation measures (e.g., as enclosures, silencers or barriers).
- Sound power data for all significant plant and equipment.
- Plant operating hours, noting that background noise measurements should be taken over the proposed operating period with the results presented as hourly A-weighted L_{90} noise levels.

The above requirements provide a basis from which environmental noise from a facility can be predicted at the surrounding noise sensitive receptors and assessed. Part 3 of Volume 3 presents the above information for the Project's construction and operations phases, as relevant. Information on proposed methods to mitigate noise emissions are discussed in Section 15.3.4.

Papua New Guinea does not currently have any statutory ambient noise standards. A review of relevant noise criteria and guidelines set by other agencies was therefore undertaken as part of the Upstream Noise Baseline Report (Part 20 of Volume 2), including (in order of priority):

- Guidelines for Community Noise (WHO, 1999).
- General Environmental, Health and Safety (EHS) Guidelines (IFC, 2007b).
- TOTAL General Specification, Environmental requirements for project design and E&P activities, Section 5.9 Noise level (GS EP ENV 001).
- TOTAL General Specification, Safety rules for buildings. (GS EP SAF 221).
- Interim Construction Noise Guidelines (DECC, 2009), as construction noise is generally addressed separately from operational noise.

Noise from human activities associated with developments such as new infrastructure or industrial developments can affect fauna. The following literature was reviewed to determine appropriate noise criteria for fauna:

- Mackenzie Gas Project Effects of Noise on Wildlife (AMEC, 2005).
- Noise Disturbance along Highways: Kuranda Range Road Upgrade Project (Dawe and Goosem, 2008).
- Effects of aircraft noise and sonic booms on domestic animals and wildlife: a literature synthesis (Manci et al, 1998).
- Synthesis of Noise Effects on Wildlife Populations (US FHWA, 2004).

Table 15.16 summarizes the ambient noise criteria adopted for the impact assessment for the Project based on this review.

Table 15.16 – Project Noise Criteria

Activity/ Receptor	Noise Level Guidelines[1] One hour LAeq (dBA)		Comment
	Day/Evening 7.00 am - 10.00 pm	Night 10.00 pm - 7.00 am	
Construction noise[2, 3]/human	55 dBA Leq[2] (long-term target, i.e., impacting a receptor for longer than 1 month) 75 dBA Leq[4] (short-term target for all daytime works)	45 dBA Leq	As an overall long-term target, noise management levels equivalent to the general operational noise limits have been nominated. A higher limit of 75 dBA, Leq has also been nominated for short-term daytime construction works. Where noise exceeds this upper threshold the receiver is considered 'highly noise affected', and all feasible and reasonable noise management and mitigation measures should be considered to help reduce the impacts.
General operational noise[2]/human	55 dBA Leq[2]	44 dBA, Leq	The criteria is the lower of: Average night background level (L_{90}) + 3 dBA[3]. OR 45 dBA L_{eq}[2]. Background noise monitoring results at the closest villages/settlements to the CPF during the critical night period were typically between 41 and 47 dBA, L_{90}. The lower night-time noise criteria is 44 dBA, $L_{eq(1h)}$ based on the quietest noise level of 41 dBA.
Construction & general operational noise/fauna	65 dBA, Leq		Adverse impacts on fauna are highly unlikely at noise levels below 50 dBA, Leq and unlikely at noise levels below 65 dBA, Leq. Long-term adverse impacts on fauna are unlikely to arise from short duration, high noise events up to 90 dBA (Manci et al., 1998). These events may; however, cause a short-term startle response. Very high maximum noise levels up to 100 dBA (WHO, 2015) may cause hearing loss, or other long-term physiological effects. The hearing damage threshold is species and frequency dependent, and, as with humans, damage may be cumulative over time.

Note 1: Guidelines values are for noise levels measured out of doors.
Note 2: WHO, 1999 guideline noise level recommended during the day period to 'protect the majority of people from being seriously annoyed'.
Note 3: IFC, 2007b requirement to not 'result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site'.
Note 4: DECC, 2009 represents the 'point above which there may be a strong community reaction to noise'.

Total (2011) requires the evaluation of 'noise emissions at the facilities boundary limit'. As information on the proposed boundary of an exclusion zone for the CPF is currently unavailable, these emissions have been extracted from the model output files based on the area proposed to be cleared as part of the CPF construction. This approach will result in worst case estimates of maximum off-site emissions, given that the boundary will likely be further away from the sources than assumed in the modeling. Day/evening and night targets used for the assessment of off-site emissions are 55 dBA Leq and 45 dBA, Leq, respectively.

15.3.3 Identification of Potential Impacts

The Project activities with the greatest potential for adverse off-site noise impacts, i.e., human health, amenity and/or fauna effects have been assessed as part of this study. Potential human health, amenity or terrestrial fauna impacts include:

- Human health and amenity impacts: Perception of sound in day-to-day life is of importance for human wellbeing and amenity. Communication through speech, sounds from playing children, music, and natural ambient sounds in vegetation (e.g., birdsong, local wildlife, rustling water, wind in trees) are all examples of sounds considered essential for satisfaction in everyday human life. Excessive noise has the potential to impact health and wellbeing causing nuisance, interfering with normal speech communication, causing changes in behavior/upset daily work patterns, sleep disturbance/deprivation, and anxiety over sudden or unknown loud noises. These impacts can lead to stress and increased blood pressure, and other physical, physiological and psychological effects.
- Terrestrial fauna impacts: Impacts include physical damage to hearing organs, increased energy expenditure or physical injury while responding to noise, interference with normal activities, and impaired communication. Responses to noise disturbance cannot be generalized across species and depend on a variety of factors, e.g., noise level, frequency distribution, duration, number of events and variation over time. Individual responses to noise events will vary from a mild alert response (to relatively low noise events) to avoidance or the abandonment of otherwise suitable habitat. Generally, continuous noise (i.e., noise produced by generators is more readily tolerated by terrestrial fauna (particularly birds) than episodic noise disturbances, such as, haul trucks moving about the site, or low altitude helicopter flyovers).

Construction Phase

- Construction of the CPF: Clearing, earthworks and construction activities that have potential to emit noise from operation of vehicles, equipment and machinery for civil works, and erection of plant. This will initially involve site preparation and significant bulk earthworks to grade the site before the CPF modules are assembled. Noise emissions associated with these works have been assessed for their potential to impact the amenity of existing villages near the CPF and terrestrial fauna that inhabit surrounding vegetation.
- Construction of the Logistics Base, accommodation camps, and the Purari Airstrip extension: Clearing, earthworks and construction activities that have the potential to emit noise from operation of vehicles, equipment and machinery for civil works will occur at these sites for an extended period. These emissions have been assessed for their potential to cause amenity and fauna impacts.
- Accommodation camps: Noise emissions from 24 hr operation of equipment (i.e., air-conditioning units, refrigerated shipping containers, diesel power plant, water treatment plant) to run the camps during the construction phase have been assessed to determine potential amenity and fauna impacts.
- Construction of the onshore export pipeline and access roads, including the pipeline shore crossing at Orokolo Bay, which is near coastal settlements: Clearing, earthworks and construction activities have the potential to emit noise from operation of vehicles, machinery and equipment movement, as activity progresses along the pipeline route — for the excavating trench, stringing, bending, welding, lowering and backfilling sequence — and road alignments. These emissions have been assessed for their potential to cause amenity and fauna impacts.

- Air transport: Potential noise (amenity and fauna) impacts associated with aircraft take-off and landing movements at the Purari Airstrip, with the construction phase as a worst case, given that the frequency of flights will be lower during the operations phase.

Operations Phase

- CPF operations: Noise emissions from the 24 hr operation of gas processing equipment (e.g., gas turbines, compressors, pipework, pumps, and flaring when required) at the CPF have been assessed to determine the potential amenity and fauna noise impacts.

Decommissioning Phase

Noise emissions associated with the Project's decommissioning phase will depend on the type and scale of activities that are undertaken. The noise emissions will mostly be limited to demolition activities, and infrastructure removal and rehabilitation works. Generally, noise impacts associated with decommissioning works are likely to be less than those associated with the initial construction works (e.g., vegetation clearing, earthworks or pile driving).

A number of embedded design controls address impact to noise:

- Project design is based on a risk-management approach, considering geotechnical constraints (e.g., flooding, landslides risks, geohazards) and anticipating and avoiding, or where avoidance is not possible, minimizing environmental and social impacts (e.g., avoiding sensitive features, and physical and economic displacement, priority ecosystem services, and minimizing the Project footprint, land clearing and disturbance, emissions and discharges) [ED013].
- Minimise noise from machinery, plant and equipment, as far as practicable [ED031].
- The Project will design its plant and undertake activities to comply with the applicable noise criteria [ED032].
- All vehicles (including vessels and aircraft) and machinery, plant and equipment will be regularly maintained to the manufacturer's specifications; defective items will be removed from service until they are repaired [ED019].
- Fixed or mobile equipment will be used and/or located in consideration of people and other sensitive receptors [ED030].
- The Project will maintain a grievance mechanism that is legitimate, accessible, predictable, equitable, right-compatible, and transparent [ED033].

The following identified potential noise emissions are inherently addressed by the above embedded design controls or have been concluded to be negligible, with no significant potential for off-site noise impacts, and therefore have not been considered further in the assessment:

- Noise emissions from wellpad and trunklines/flowline construction:
  - Noise from wellpad construction: ANT-10 is a new wellpad, but the ELK10 and ANT-11 wellpads will be established on the existing Elk-1 and ANT-1 wellpads that were developed during the exploration and appraisal phases. Consequently, site preparation works will be of a smaller scale than if three new wellpads were required to be developed, reducing the land disturbance and hence earthworks required in a remote location.
  - Noise emissions from trunklines/flowline construction: Clearing, earthworks and construction activities have the potential to emit noise from operation of vehicles, machinery and equipment movement along the pipeline routes; however, approximately

77%, 35% and 68% of the Antelope trunklines, Elk flowlines and water injection flowline follow existing tracks, respectively, reducing the land disturbance and hence earthworks required.

– On this basis, and given that the wellpads, trunklines and flowlines will be located more than 14 km from the nearest sensitive receptors, it is concluded that construction noise for the wellpads and trunklines/flowlines will not impact the nearest sensitive human receptors. It is likely that fauna near the construction works could temporarily retreat further into the bush. As discussed widely in the literature (Dawe, G. and M. Goosem, 2008), many bird species become habituated to noise disturbances, particularly noise such as that associated with the operation of plant and equipment.

- Noise emissions from wellpad operations: Continuous noise from drilling operations will occur at each wellpad during the drilling campaign. The total drilling duration across the three wellpads (including mobilization and demobilization) is estimated to be 30 to 37 months, with an average of 70 days for the drilling of each well. Given the rugged and remote location of each wellpad, it is highly unlikely that there will be any in-migration to this area during this period. As the wellpads will be located more than 14 km from the nearest sensitive human receptors, it is concluded that activities at the wellpads will not impact the nearest sensitive human receptors. It is likely that fauna near the work area could temporarily retreat further into the bush during the drilling program. As discussed widely in the literature (Dawe, G. and M. Goosem, 2008), many bird species become habituated to noise disturbances, particularly continuous noise such as that associated with the operation of generators and drilling mud pumps, which are dominant throughout most of a drilling program.
- Noise emissions from construction of the offshore export pipeline and pipeline shore crossing at Caution Bay: Noise from construction vessels used for the offshore export pipeline will occur over relatively large areas and will rapidly disperse. Noise emissions from construction of the offshore export pipeline and pipeline shore crossing at Caution Bay are not considered by this assessment as the EIS is limited to works up to the PNG LNG project lease boundary
- Noise emissions from road and river transport activities during construction and operations: Potential noise impacts associated with trucks travelling along the Project roads will be limited to short-term pass-by events with noise levels reaching a maximum of around 80 dBA at a distance of 15 m from the source for a few seconds. While noise from barge diesel engines has the potential to be audible at some of the villages located along the river, e.g., Aumu, Evara, Kaevara, Poroi 1, any potential noise impacts will be limited to the time it takes for the barge to travel along the exposed section of river. Given the distance from Project roads (more than 2.5 km) and barge routes to any sensitive human receptors, any potential human health and amenity noise impacts associated with these sources will be minimal.
- Four condensate valve and two gas valve stations will be located along the onshore export pipeline. These stations include no major noise generating plant, with the electric actuator installed inside a building typically more than 350 m from any sensitive human receptor. As such, there will be minimal noise impacts associated with the valve stations.

- The proposed Herd Base Quarry C is approximately 2.5 km north northeast of the closest human sensitive receptor, which is in Poroi 1. While some blasting may be associated with removing material at the quarry, any potential noise and vibration impacts at existing sensitive human receptors would be well within acceptable limits given the distance to the closest sensitive receptor.[2] While infrequent blasting noise may cause fauna startle response, the noise and disturbance is momentary and as the disturbance is temporary the fauna are likely to resume normal behaviors within a short timeframe.
- Given the nature and typical offset distance from Project construction works to existing sensitive buildings, any transmitted ground vibration (e.g., due to rock breaking, piling works) would be well below typical damage-based vibration criteria. The levels are likely to also be below the threshold of human perception. Consequently, ground-borne vibration from Project construction or quarry activities has not been assessed any further.

15.3.4 Proposed Mitigation and Management Measures

Table 15.17 describes proposed mitigation and management measures to further reduce potential noise impacts.

Table 15.17 – Noise Mitigation and Management Measures

Potential Impact	Mitigation and Management Measures	Relevant Management Plans
Nuisance and disturbance, reduced amenity and fauna impacts, due to noise emissions from construction activities.	♦ Limit construction work, where practicable, to daytime hours [EM046]. ♦ The Project will prepare an updated stakeholder engagement plan for the Project's construction, operations and decommissioning phases, according to TOTAL's General Specifications and IFC PS1 and PS7. The updated stakeholder engagement plan will include the following key requirements: – Regular engagement with project affected communities on Project impacts, action plans and grievance mechanism. – Notification as early as possible to affected communities in advance of Project works, which describes the activities and how long they are expected to take. Particular focus is to be given to communities affected by project-induced in-migration. – A mechanism for enquiries and feedback. – Ongoing grievance and issues management [SEM002].	Noise and Vibration Management Plan
Nuisance and disturbance, reduced amenity and fauna impacts, due to noise emissions from drilling.	No additional mitigation measures proposed.	NA

2 Calculations were made using AS 2187.2-2006 and conservatively assumed a maximum instantaneous charge of 500 kg to determine potential air blast noise and vibration impacts at sensitive receptor locations. The predicted noise level of 60 dBLin is well within the target of 115 dBLin for 95% of all blasts. Similarly, vibration which was predicted at approximately 0.6 mm/s is well below the minimum 5 mm/s target for 95% of all blasts.500 kg to determine potential air blast noise and vibration impacts at sensitive receptor locations. The predicted noise level of 60 dBLin is well within the target of 115 dBLin for 95% of all blasts. Similarly, vibration which was predicted at approximately 0.6 mm/s is well below the minimum 5 mm/s target for 95% of all blasts.

Table 15.17 – Noise Mitigation and Management Measures (cont'd)

Potential Impact	Mitigation and Management Measures	Relevant Management Plans
Nuisance and disturbance, reduced amenity and fauna impacts, due to noise emissions from aircraft.	♦ The Project will prepare an updated stakeholder engagement plan for the Project's construction, operations and decommissioning phases, according to TOTAL's General Specifications and IFC PS1 and PS7. The updated stakeholder engagement plan will include the following key requirements: – Regular engagement with project affected communities on Project impacts, action plans and grievance mechanism. – Notification as early as possible to affected communities in advance of Project works, which describes the activities and how long they are expected to take. Particular focus is to be given to communities affected by project-induced in-migration. – A mechanism for enquiries and feedback. – Ongoing grievance and issues management [SEM002].	Noise and Vibration Management Plan

Note: NA = Not applicable.

15.3.5 Residual Impact Assessment

The following section provides the assessment of residual impacts to noise subject to the embedded design controls in Section 15.3.3 and the successful implementation of the mitigation and management measures in Section 15.3.4.

15.3.5.1 Construction Phase

As outlined in Section 15.3.3, the construction phase activities identified as requiring assessment are:

- Construction of the CPF.
- Construction of the Logistics Base, Accommodation Camps and Purari Airstrip.
- Construction of the onshore pipeline including the pipeline shore crossing at Orokolo Bay and access roads.
- Noise associated with using the Purari Airstrip.

The potential noise impacts associated with each of these activities are discussed in the following sections.

Construction of the CPF

The results of the predicted noise associated with construction of the CPF has been extracted from the noise model outputs provided in Part 3 of Volume 3.

The predicted noise levels during daytime construction works will range from 21 to 30 dBA, L_{eq} at the closest villages/settlements under enhanced propagation conditions. Given the significant margin of compliance with the long-term noise target of 55 dBA, L_{eq}, it is unlikely that there will be any adverse noise impacts while constructing the CPF.

Logistics Base, Accommodation Camps and the Purari Airstrip

Construction and Operation of the Logistics Base and Accommodation Camps

Site clearing, earthworks, construction/civil activities will create variable noise levels during the scheduled 'day' works required to build the Logistics Base on the north bank of the Purari River and the accommodation camps.

The closest accommodation camp with the potential to impact a sensitive human receptor is pipeline construction camp 2 approximately halfway along the export pipe route (near pipe yard 4) approximately 730 m east of Aivai village (see Figure 4.6). Noise will be associated with the construction and operation of this camp.

Table 1518 shows the predicted construction noise at a range of offset distances from the Logistics Base and accommodation camps, including at the closest sensitive human receptors, Aivai village and the Purari Airstrip House for the pipeline construction camp and the Logistics Base, respectively.

Table 15.18 – Predicted Construction Noise with Distance from the Logistics Base and Accommodation Camps

Weather Conditions	Predicted Noise Level with Distance (dBA, Leq)						
	50 m	100 m	250 m	500 m	730 m Aivai Village	2.7 km Purari Airstrip	4 km
Neutral	77	71	60	51	46	27	25
Enhanced	77	72	63	55	50	32	29

Note: The result is highlighted PINK where the predicted construction noise exceeds the short-term target of 75 dBA, $L_{eq(1h)}$. The result is highlighted ORANGE where the predicted noise level exceeds the long-term operational daytime noise target of 55 dBA, $L_{eq(1h)}$.

The predicted construction noise levels at Aivai village range from 46 dBA to 50 dBA, $L_{eq(1h)}$ which is below the nominated noise targets.

At the Purari Airstrip House approximately 2.7 km west southwest of the Logistics Base, the predicted noise level during the daytime construction works was between 27 and 32 dBA, L_{eq}, which is well below the nominated 55 dBA, $L_{eq(1h)}$ long-term noise target. Noise levels of this magnitude are likely to be inaudible at this receptor (Part 20 of Volume 2).

Once the Logistics Base and accommodation camps are operational, there will be noise emissions associated with normal camp operation (i.e., from air-conditioning units, refrigerated shipping containers, the diesel power plant and the water treatment plant) 24 hours/day, 7 days/week. The resulting noise emissions from the accommodation camps once operational have also been predicted and assessed against the long-term night time operational noise target of 45 dBA, $L_{eq(1h)}$ with the results shown in Table 15.19.

Table 15.19 – Predicted Operational Noise from Logistics Base and Accommodation Camps

Weather Conditions	Predicted Noise Level with Distance (dBA, Leq)						
	50 m	100 m	250 m	500 m	730 m Aivai Village	2.7 km Purari Village	4 km
Neutral	67	63	51	43	38	20	15
Enhanced	67	63	54	46	42	24	19

Note: The result is highlighted PINK where the predicted noise level exceeds the long-term operational daytime noise target of 55 dBA, $L_{eq(1h)}$. Potential night time noise levels in excess of 45 dBA, $L_{eq(1h)}$ have also been highlighted ORANGE, as the accommodation camps will operate 24 hours/day, 7 days/week.

The predicted continuous noise from normal operation of the Logistics Base and pipeline construction camp (near Aivai Village) are below the nominated operational criteria.

Purari Airstrip Construction

The Purari Airstrip House on the south bank of the Purari River is situated 190 m from the northwestern end of the existing Purari Airstrip, which extends to approximately 1.3 km to the southeast. The runway will be extended to accommodate larger aircraft for the Project which will also necessitate an upgrade to the airstrip facilities. Most of the construction works will extend the southeastern end of the runway; however, additional sealing/surfacing and terminal building works will be undertaken as part of the upgrade, the closest aspect of this being approximately 200 m from the Purari Airstrip House.

Table 15.20 provides predicted noise from the Purari Airstrip extension works for a range of different offset distances.

Table 15.20 – Predicted Construction Noise with Distance from the Purari Airstrip Extension

Weather Conditions.	Predicted Noise Level with Distance (dBA, Leq)						
	50 m	100 m	200 m Northwestern end of the Runway	400 m Existing Terminal Building	1 km	2 km	4 km
Neutral	74	68	59	50	37	26	14
Enhanced	74	70	63	55	42	32	20

Note: The result is highlighted ORANGE where the predicted noise level exceeds the long-term operational daytime noise target of 55 dBA, $L_{eq(1h)}$.

For works conducted at the northwestern end of the runway (i.e., within approximately 200 m of the house) the predicted noise levels were between 59 and 63 dBA, L_{eq}. While this is higher than the long-term daytime noise target of 55 dBA, L_{eq}, it is unlikely that the surfacing works in this area would last for more than a few days. Given the nature of the works program, and typical distance from the works, noise emissions at this dwelling are also likely to comply with the upper 75 dBA, L_{eq} short-term noise target. The new terminal buildings will be located no closer than the existing transit building/warehouse, which is located approximately 400 m southeast of the dwelling, therefore it is unlikely that the works would exceed the long-term noise target. Furthermore, the area of the runway extension will be sufficiently far away from the dwelling where noise emissions are predicted to meet noise targets.

Construction of the Onshore Export Pipeline Including the Pipeline Shore Crossing at Orokolo Bay and Access Roads

Access Road Construction

Earthworks associated with constructing the access roads will only occur for a limited duration in any given area, as they progress along the road alignment. Road works are limited to daytime hours, where practicable. The Project criteria for works taking more than one month is 55 dBA, $L_{eq(1h)}$.

Table 15.21 provides the predicted noise levels at a range of offset distances, including the three closest villages to the onshore export pipeline alignment along which the access roads will be built.

Table 15.21 – Predicted Construction Noise with Distance from Road Works

Weather Conditions	Predicted Noise Level with Distance (dBA, Leq)						
	50 m	100 m	250 m	500 m	1 km Hepere & Paevara Villages	2 km Kilavi Village	4 km
Neutral	72	66	54	45	35	25	13
Enhanced	72	67	58	50	41	31	19

Note: The result is highlighted ORANGE where the predicted noise level exceeds the long-term operational daytime noise target of 55 dBA, Leq(1h)..

The access roads are typically more than 1 km from any existing village except where the onshore export pipeline will cross the shore (see Table 15.23). The predicted noise from the associated daytime road construction works was from 35 dBA to 41 dBA, Leq depending on propagation conditions at Hepere and Paevara villages, which are both approximately 1 km from the onshore export pipeline right of way. Consequently, it is highly unlikely that these works will cause any adverse noise impacts.

Onshore Pipeline Construction

Similar to road construction, construction of the onshore export pipeline will only occur for a limited duration in any location, as the pipeline construction spread moves along the alignment. The predicted noise levels at a range of offset distances, including the closest three villages are shown in Table 15.22. The predicted noise levels shown at the offset distances provided in Table 15.22 are conservative in that that they assume all the plant and equipment is located at the closest point; whereas, the plant and equipment would be distributed across the pipeline spread.

Table 15.22 – Predicted Construction Noise with Distance from the Onshore Export Pipeline Construction

Weather Conditions	Predicted Noise Level with Distance (dBA, Leq)						
	50 m	100 m	250 m	500 m	1 km Hepere & Paevara Villages	2 km Kilavi Village	4 km
Neutral	78	71	59	51	41	30	18
Enhanced	78	73	64	55	46	36	23

Note: The result is highlighted PINK where the predicted construction noise exceeds the short-term target of 75 dBA, Leq(1h).. The result is highlighted ORANGE where the predicted noise level exceeds the long-term operational daytime noise target of 55 dBA, Leq(1h).

The maximum noise emissions from the daytime pipeline construction works were predicted to be 46 dBA, Leq at Hepere and Paevara villages, i.e., the closest villages. It is highly unlikely that noise from these works will cause any adverse noise impacts, as this is well below the nominated long-term construction noise target..

Noise from the onshore export pipeline construction works to villages along the coastline near the Orokolo Bay shore crossing was predicted using a detailed 3D noise model. The model assumed that as a conservative scenario, approximately 60 heavy vehicles would be operating across a 2-km work front (i.e., approximately one heavy vehicle every 30 m). Details regarding the assessed scenarios are provided in Part 3 of Volume 3.

Table 15.23 shows the predicted noise impacts to the closest villages along the coastline.

Table 15.23 – Predicted Noise from the Onshore Export Pipeline Construction Works at the Shore Crossing

Receptor	Predicted Noise at Village, dBA, Leq	
	Neutral Propagation	Enhanced Propagation
Iuku	44	48
Iuku East	47	50
Mareke	43	48
Mareke West	53	57

Note: The result is highlighted ORANGE. where the predicted noise level exceeds the long-term operational noise target of 55 dBA, $L_{eq(1h)}$.

The predicted construction noise levels at sensitive human receptors surrounding the onshore export pipeline route were predominantly below the long-term noise target of 55 dBA, $L_{eq(1h)}$, under both neutral and enhanced conditions. At Mareke West to the east of the onshore export pipeline right of way, there are three isolated properties where noise levels are predicted to exceed the long-term noise target by up to 2 dBA (i.e., 57 dBA, $L_{eq(1h)}$) under enhanced (i.e., worst case) propagation conditions. Under normal propagation conditions the predicted noise levels comply at all receptor locations. The predicted noise levels are well below that sufficient to cause a significant adverse reaction to construction noise, i.e., the short-term target of 75 dBA, $L_{eq(1h)}$, for which specific noise management/mitigation measures should be considered.

The maximum noise level predicted at Mareke West was 62 dBA associated with short-term tree felling/chainsaw works (with a sound power level of 121 dBA) at the closest point, approximately 250 m from the property. This would also comply with the short-term 75 dBA noise target. Similarly, the predicted noise levels were found to be 53 dBA to 56 dBA when a single grader is operating in this area.

Purari Airstrip

Up to approximately 5 to 7 flights per day are estimated to occur (using ATR42 or Twin Otter type aircraft) once the extension works are completed.

Australian Standard (AS 2021:2015) was used to predict maximum noise levels associated with aircraft using the runway based on the aircraft classification and the relative location of the receptor dwelling.

The maximum predicted external noise levels at the Purari Airstrip House were 73 dBA to 93 dBA, L_{max} during take-off and landing movements. Given the low frequency and typically short-term duration associated with each movement (e.g., typically less than a minute), it is unlikely that using the runway will cause any adverse noise impacts; however, open communications will be maintained with the family to identify any noise and amenity related concerns.

Fauna Impacts

Tables 15.18, 15.19, 15.20, 15.21 and 15.22 indicate that the zone of influence where adverse effects are possible (see Table 15.16) is limited to within approximately 100 to 200 m from the construction works.

During the initial site clearance and earthworks construction stages, when new noise sources are introduced, changes could be expected in the behavior of some fauna, particularly those individuals closest to the new noises.

Following the initial stages of construction, equilibrium is likely to be reached, involving:

- Likely changes in species composition near the Project, with less noise-tolerant species moving further away.
- Selection of more noise-tolerant individuals within the species' populations close to the Project.
- Habituation of some species and individuals to the noise impacts, as currently displayed by some species near existing operations.

Noise can have adverse effects on terrestrial fauna, with different species being sensitive to noise. Extremely high noise levels can cause hearing damage or other physiological effects, although fauna generally avoid exposure to such impacts wherever possible. At lower noise levels, terrestrial fauna will generally avoid anthropogenic noise sources and prefer to occupy areas more distant from noise sources.

Generally, terrestrial fauna will avoid areas where very high noise levels sufficient to cause injury or damage occur. Noise levels in excess of 100 dBA over extensive periods would be required to cause physical damage or injury (WHO, 2015). It is unlikely that any terrestrial fauna would remain in any area affected by these noise levels.

15.3.5.2 Operations Phase

CPF Impacts on Human Receptors

As outlined in Section 15.3.3, the only operations phase activity identified as requiring assessment is the CPF operations (gas processing) which includes significant noise generating plant.

Other noise sources associated with the Project's operational phase will either have minimal noise impacts compared with the constructions phase (such as the valve/condensate stations), or are sufficiently distant from any existing sensitive receptors.

The results of the modeling (refer to Part 3 of Volume 3) undertaken for years 10+ with additional compression are presented in Table 15.24. Both normal, and upset conditions when flaring occurs, have been modeled under neutral and enhanced propagation, and the results presented for the three closest sensitive receptors. Figure 15.7 shows contours for noise emissions from normal operations at the CPF under enhanced propagation conditions.

Table 15.24 – Predicted Operations Noise from the CPF (Years 10+), dBA, L_{eq}

Receptor	Normal Operations		Upset Conditions/Emergency Flaring	
	Neutral Propagation	Enhanced Propagation	Neutral Propagation	Enhanced Propagation
Poroi 1	27	32	38	40
Mapaio Fish Camp	22	26	29	33
Purari Airstrip House	29	34	38	41

Note: The operational daytime noise target is 55 dBA, $L_{eq(1h)}$. The night-time noise target is 44 dBA, $L_{eq(1h)}$.

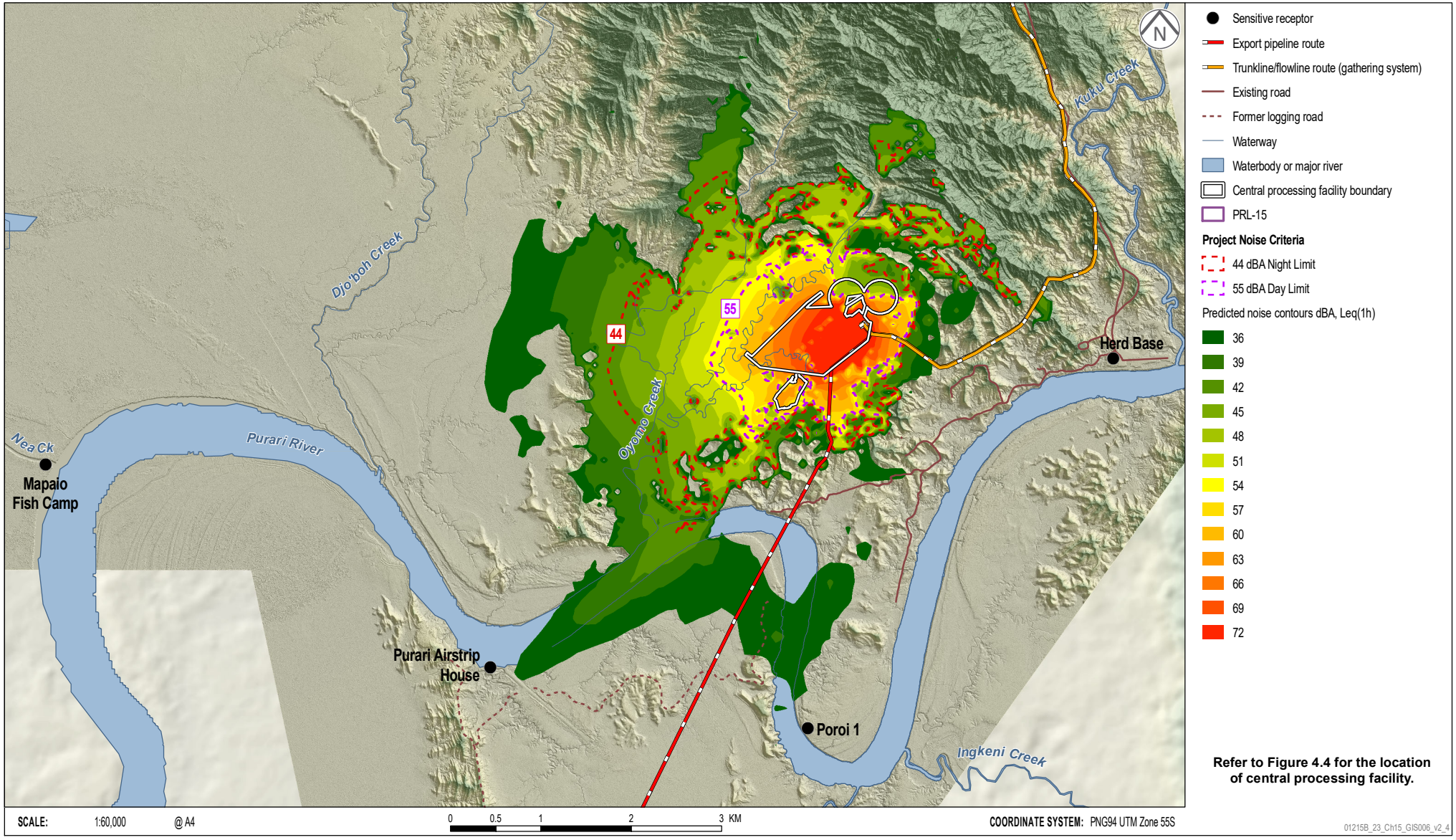
Operational Project noise targets will be met at all existing villages and the settlement near the CPF site. Emergency flaring may be required at times and, when required, an increase in the level of received noise is expected (i.e., 7 to 11 dBA); however, the predicted noise levels still comply with the most stringent 44 dBA, L_{eq} night-time noise target by a 3 dB margin.

Predicted maximum off-site noise levels at the southeast facility boundary near the medium-pressure compressors are up to 81 dBA, L_{eq} and the results on the western and southwestern facility boundary are approximately 60 to 69 dBA, L_{eq}. Consequently, the resultant noise

PREDICTED NOISE FROM THE CPF, NORMAL OPERATIONS AFTER 10 YEARS, UNDER ENHANCED PROPAGATION

Papua LNG Project | Environmental Impact Statement

FIGURE 15.7



emissions would exceed the nominated night time noise target by approximately 15 to 37 dBA if the vegetation clearance area was adopted as the CPF boundary.

An exclusion zone boundary would need to extend approximately 400 m and 1.4 km to the east/southeast and west/southwest, respectively, beyond this zone to meet the nominated night time noise target without further noise mitigation.

CPF, Impacts on Fauna Receptors

Under normal operating conditions the predicted noise levels at the PRL-15 oxbow wetlands were typically less than 30 dBA, L_{eq}, which is well below the existing ambient background noise environment and the nominated guideline noise target of 65 dBA, L_{eq} where fauna are unlikely to experience adverse impacts. Normal CPF operation will; therefore, not cause any adverse noise impacts to wildlife in the PRL-15 oxbow wetlands.

The predicted noise levels to forest immediately surrounding the CPF are predominantly below the nominated 65 dBA, L_{eq} noise target. The only area where noise from the plant could potentially impact local fauna extends approximately 250 to 350 m southeast of the medium-pressure compressors. This could cause some wildlife to relocate further away from the plant; however, as noted in Section 15.3.3, noise from continuous sources such as compressors is more readily tolerated by terrestrial fauna (particularly birds) than episodic noise disturbances, such as low altitude helicopter flyovers.

15.4 Landscape and Visual Amenity

15.4.1 Context

This assessment is based on the information gathered from the landscape and visual amenity baseline study, which involved a desktop study mapping and describing broad landscape character types (Part 21 of Volume 2). It focuses on PRL-15 and the Project components that are likely to cause the most significant landscape and visual impacts, which are the proposed CPF, Logistics Base and associated infrastructure, and Project components that are likely to be visible to more people, such as the export pipeline shore crossing at Orokolo Bay. Other Project components, including wellpads, flowlines and quarries are remote and accessible and visible only to Project personnel, and are therefore excluded from this assessment.

Steeply sloped mountainous terrain dominates the northern two thirds of PRL-15 (within which the wellpads are located). The southwestern portion of PRL-15 contains alluvial plains of the Purari River basin that are subject to frequent inundation from overbank river flows.

The proposed CPF, Logistics Base, river offloading facilities, camps, roads and bridges are in a hilly area adjacent to the Purari River alluvial plain, which is bounded to the south by the Purari River main channel. The Purari Airstrip is to the south of this channel.

After crossing the Purari River, the onshore export pipeline route traverses a varied landscape over 60 km, including a 3-km hilly area, then alluvial plains for 38 km, followed by steeper hills for 10 km, before a flat coastal area consisting of sand dunes and beach ridges. The topography is very low lying where the onshore export pipeline route intersects the coastal zone at Orokolo Bay. Beaches in this area are regularly interrupted by rivers, coastal lagoons and inlets.

The dominant anthropogenic activities in the Project area can be attributed to gas exploration and logging activities. As shown in Figures 7.19 and 7.20, logging roads are an existing feature of much of the Project area, particularly south of the Purari River, where riverside clearance also occurs to facilitate log landings and movement of machinery.

PRL-15 is predominantly unsettled, except for a small, subsistence-based village and a settlement along the Purari River to the west of Herd Base, i.e., Poroi 1 and Mapaio Fish Camp respectively. There is a single house near the Purari Airstrip on the Purari River bank. The export pipeline route is unsettled; however, settlements do occur near the route in the coastal area. Villages also occur intermittently along the river transport corridors.

Further characterization of the regional and PAOI landscape is provided in the baseline study (Part 21 of Volume 2).

15.4.2 Discipline-specific Impact Assessment Method

This assessment evaluates potential changes to visual amenity experienced by viewers at specific viewpoints, and to the broader landscape character, due to the Project. The assessment is founded upon:

- The Landscape Institute and Institute of Environmental Management and Assessment's Guidelines for Landscape and Visual Impact Assessment (LI and IEMA, 2013).
- TOTAL General Specification: Environmental Impact Assessment of E&P Activities (GS EP ENV 120).
- TOTAL General Specification, Sustainable Development: Social Impact Assessment (GS EP SDV 102).

The following sections describe the assessment method that has been adopted for this assessment.

15.4.2.1 Visual Impact Assessment

Approach

The baseline characterization study and this assessment have been informed by aerial photography, topographic surveys and GIS data, satellite imagery and LIDAR data, the Forest Inventory Mapping System (Hammermaster and Saunders, 1995), and photographs and physical observations collected by specialist teams during visits to the Project area.

A three-dimensional computer model, or viewshed analysis, was undertaken using elevation data from airborne LIDAR technology to derive an accurate digital elevation model of the topography surrounding the CPF, Logistics Base and Purari Airstrip extension. These models typically use only ground data points, removing existing non-Project structures and vegetation; however, as vegetation in the onshore Project area will have a considerable effect on reducing the visibility of the Project components and activities, this model incorporated an assumed average vegetation height to all non-cleared areas to account for existing vegetation.

The location, extent and height of key Project components were incorporated into the model for the CPF, Logistics Base and associated infrastructure in PRL-15. Assumptions incorporated into the model, which represents a conservative scenario in terms of its prediction of overall visibility, are listed below:

- Heights of the CPF low-pressure vent and high-pressure flare are 50 m and 104 m, respectively. These heights are measured from ground level and include the platform for each piece of infrastructure.
- Buildings at the Purari Airstrip are 4 m high.
- Buildings at the Logistics Base are 8 m high.
- Buildings at the CPF are 8 m high.

- Canopy cover in the onshore Project area is 60 to 80%, and canopy height varies considerably. The vegetation canopy height included in the viewshed analysis is 20 m, as a conservative value based on advice of the Project biodiversity specialists.
- Modeling from viewpoints has applied a viewer eye level of 1.5 m above the ground surface, within a 100 m buffer around Poroi 1, Mapaio Fish Camp, the Purari Airstrip House, and the PRL-15 oxbow wetlands.

The significance assessment method described in Chapter 3 was adopted to qualitatively assess the potential impact on visual amenity. This method considers the magnitude of impact on a receptor and the sensitivity of that receptor. Impact assessment criteria have been developed specifically for this assessment.

Visual sensitivity is a measure of how changes to the landscape or viewshed are viewed by receptors (or viewers – in this case primarily village residents) from representative viewpoints surrounding a development. While individuals will perceive change to their environment differently, visual sensitivity does not consider viewer opinion (i.e., whether the view is considered good or bad), but incorporates the viewer's likely expectations and experience (i.e., whether the view is what is expected considering the surrounding landscape and the activities being undertaken), the number of viewers to experience the view and the duration of the view.

Table 15.25 outlines ratings for sensitivity in relation to visual amenity.

Table 15.25 – Visual Amenity Sensitivity Criteria

Sensitivity	Description
Very High	♦ The viewpoint is a location where people's attention is focused on the landscape (e.g., a national park viewing platform). ♦ The viewpoint is visited daily and/or by more than 2,000 people per day from local, regional or international communities/visitors. ♦ Views are experienced for more than a day by local, regional or international communities/visitors. ♦ Very high-use subsistence and recreational areas, specific cultural sites and viewpoints of national significance.
High	♦ The viewpoint is a location where people's attention is often focused on the landscape. ♦ The viewpoint is visited weekly and/or by 1,000 - 2,000 people per day from local or regional communities. ♦ Views are experienced over several hours by local or regional communities. ♦ High-use subsistence and recreational areas, specific cultural sites and viewpoints of local significance.
Medium	♦ The viewpoint is a location where people's attention is occasionally focused on the landscape. ♦ The viewpoint is visited fortnightly and/or by 500 – 1,000 people per day from local communities. ♦ Views are experienced for 1 – 2 hours by local communities. ♦ Moderate-use subsistence and recreational areas that are used weekly by the local community for subsistence or travel.
Low	♦ The viewpoint is not a location where people's attention is focused on the landscape. ♦ The viewpoint is visited monthly and/or by less than 500 people per day from local communities. ♦ Views are experienced for less than 1 hour by local communities. ♦ Moderate-use subsistence or recreational areas that are used monthly by people from local communities for subsistence or travel.
Minimal	♦ Physically and/or visually inaccessible areas, or rarely accessed by local people. ♦ Areas with no permanent settlements.

The extent of modifications being made to the existing landscape, the distance of viewpoints from Project infrastructure and angle of view, the extent of screening and the permanency of change, are key factors in assessing the magnitude of a visual impact. The magnitude of visual impact of the Project was determined using the descriptors in Table 15.26

Table 15.26 – Visual Amenity Magnitude of Impacts Criteria

Magnitude	Description
Very High	♦ Landscape modification that is visually dominant in the immediate foreground of view (i.e., up to 0.5 km from the viewpoint) and/or occupies more than 45° of the field of vision. ♦ A permanent change to the visual landscape that takes place in weeks or months. ♦ Visual modification or intrusion, including buildings and facilities, that presents as an alien form to visual amenity, representing a fundamental change to the landscape character.
High	♦ Landscape modification that is clearly visible in the fore- to mid-ground of view (i.e., 0.5 to 1 km from the viewpoint), and/or occupies 30 to 45° of the field of vision. ♦ A permanent change to the visual landscape that takes place over 1 to 2 years. ♦ Visual modification or intrusion that presents as an alien form to visual amenity and is apparent due to dissimilarity to the existing landscape character.
Medium	♦ Landscape modification that is visible in the middle ground of view (i.e., 1 to 5 km from the viewpoint) and/or occupies 15 to 30° of the field of vision. ♦ A permanent change to the visual landscape that takes place in the long term over 3 or more years. ♦ Visual modification that leads to moderate change to visual amenity; it causes an apparent but not substantial change to the landscape character.
Low	♦ Landscape modification that is visible in the background of view (i.e., more than 5 km and less than 15 km from the viewpoint) and/or occupies 2.5 to 15° of the field of vision. ♦ A temporary change to the visual landscape that occurs over months to 2 years. ♦ Visual modification that leads to a minor change to visual amenity; it may be apparent but blends in with the existing view and will not cause a fundamental change to the landscape character, or other alien forms exist in the landscape.
Minimal	♦ Landscape modification that is barely perceptible in the distant background of view (i.e.,15 to 30 km from the viewpoint) and/or occupies up to 2.5° of the field of vision, ♦ A temporary change to the visual landscape that occurs over weeks to months. ♦ Change is imperceptible or barely detectable with respect to the existing landscape character (e.g., a road/clearing in an area containing other roads/clearings), and/or almost completely screened by intervening features.

The potential visual impact of the Project components was assessed by considering the visual sensitivity of a receptor from a specific viewpoint, and the magnitude of visual effect of the Project from each viewpoint using the matrix shown in Table 15.27.

Table 15.27 – Visual Amenity Significance of Assessment Matrix

Magnitude of Impact	Sensitivity				
	Very High	High	Medium	Low	Minimal
Very High	Extreme	Major	Major	Moderate	Moderate
High	Major	Major	Moderate	Moderate	Minor
Medium	Major	Moderate	Moderate	Minor	Minor
Low	Moderate	Moderate	Minor	Minor	Negligible
Minimal	Minor	Minor	Negligible	Negligible	Negligible

Viewpoints

There are limited viewpoints in the Project area that are likely to have significant visual divergence from the surrounding visual landscape due to the dense vegetative cover, remoteness, and topographical features. Viewpoints were selected to represent the range of views and receptors likely to be affected by the Project, and considered:

- Places of habitation and other areas of land use or transit from which Project components may be seen.
- The distance of viewpoints from Project areas and the angle of view.
- Whether viewpoints are permanent (e.g., villages) or transient (e.g., river traffic).

On this basis, viewpoints have been identified and a sensitivity assigned in Table 15.28.

Table 15.28 – Project Viewpoints Assessed

Location	Description
Places of habitation near the CPF, Logistics Base and Purari Airstrip.	♦ Poroi 1 and Mapaio Fish Camp are approximately 2.5 km to the southeast and 6.9 km to the west (respectively) of the Logistics Base on the Purari River (see Figure 4.4). ♦ The house near the Purari Airstrip is approximately 2.9 km southwest of the Logistics Base. ♦ **Low sensitivity** (less than 500 people per day; only used by people from local communities; views are temporary; high use for primary subsistence activities).
PRL-15 oxbow wetlands.	♦ The PRL-15 oxbow wetlands are approximately 8.5 km west of the CPF and 2.5 km north of Mapaio Fish Camp (see Figure 7.28). ♦ The wetlands are accessed by local communities year-round for subsistence collection of natural resources and for cultural reasons. ♦ **Minimal sensitivity** (area with no permanent settlement accessed rarely by people from local communities).
River transport corridors and river villages.	♦ Villages in the river transport corridors include Kaevaria, Evara, Aivai, Aumu and Apiope on the Purari River, and Mapaio, Kairu'u and Akoma on the Urika-Ivo River (see Figure 13.1). ♦ The village of Aivai on the west bank of the Purari River is approximately 1.8 km west of the onshore export pipeline route. A pipe yard and pipeline construction camp are proposed between the east bank of the river and the onshore export pipeline route (see Figure 4.6). ♦ The river transport corridors are used daily by both the community and commercial operators (see Sections 9.10 and 10.5). ♦ **Low sensitivity** (riverways have daily but often transient use mostly less than 500 people per day, predominantly from local communities; daily use for primary subsistence activities).
Coastal villages and land use areas near the export pipeline route.	♦ The closest villages to the onshore export pipeline route near the coast are Mareke and Iuku, the closest residences of which are 350 m from the proposed route (see Figure 13.1). ♦ In addition to residences, local inhabitants use the beach, walking tracks and vegetated areas near the pipeline route on a daily basis. ♦ **Medium sensitivity** (between 500 and 1,000 local people use the coastal area daily for primary subsistence activities, cultural activities, access, travel and recreation; views are typically experienced for 1 to 2 hours).

Lighting Impacts

The assessment also considered potential visual impacts at night. Direct lighting impacts were the key consideration and included all lights that have a line of sight exposure to locations beyond a Project site boundary that are not screened by topography or vegetation. Indirect light, which is defined as the contribution that Project lighting has to the 'glow' effect visible in a dark night sky, was not considered in this assessment due to substantial topographic features, and dense vegetation coverage which restrict views from places of habitation.

15.4.2.2 Landscape Character Assessment

Landscape character refers to the distinct, recognizable and consistent pattern of elements in the landscape that makes one landscape different from another. Part 21 of Volume 2 provides a detailed description of landscape character for the Project area.

The landscape character assessment considers the relative capacity of the landscape to accommodate changes of the type and scale due to the Project, through both the introduction of new features and the loss or modification of existing features. It sought to assess how Project-related changes may affect landscape character and its contribution to a 'sense of place' and was undertaken in the context of how Project infrastructure would impact on the broader regional setting, as seen from the air.

The sensitivity of a landscape considers the extent to which it can accept change of a particular nature and scale without adverse effects on its character. In this assessment it considers whether:

- It is protected by national designation and/or widely acknowledged for its quality and value.
- It has a distinctive character and low capacity to accommodate the nature and scale of change proposed.

Changes to landscape character were assessed in consideration of these factors and the Project description in Chapter 4.

15.4.3 Identification of Potential Impacts

15.4.3.1 Change to Visual Amenity

The construction and operations of Project facilities and infrastructure, some of which may be temporary in nature, may change, reduce or lose existing visual amenity or landscape character for viewers from representative viewpoints (i.e., Project receptors). Temporary construction areas include laydown areas associated with pipeline construction, camps, pipeline and material storage yards, workshops and material extraction sites. Operations phase footprints, which have a longer duration, include wellpads, the CPF, Logistics Base, pipeline right of ways, access roads, the upgraded Purari Airstrip, and ancillary and communication facilities.

During the Project's construction phase, the extent of changes to visual amenity will progressively increase as the Project footprint increases. As key elements in PRL-15, such as the CPF, most notably the vent and flare, Logistics Base and the Purari Airstrip extension, are progressively constructed, viewpoints from which Project components and activities may be seen by Project receptors will increase depending on the viewpoint (whether along the river, PRL-15 oxbow wetlands, the Purari Airstrip House, or as people move through the Project area). Project construction will change the landform and introduce new industrial elements into a remote and largely natural landscape. To some extent screening by elevated topography and dense, tall vegetation will ameliorate these landscape and visual amenity impacts.

While vegetation clearing and earthworks associated with the construction of the onshore export pipeline will change the landscape and visual amenity, few villages or transport routes are close enough to the corridor to be exposed to these impacts. The exception are communities close to the onshore export pipeline at Orokolo Bay who will experience reduced visual amenity during the approximately 6-month export pipeline construction period on the approach to and at the shore crossing. Vegetation in the pipeline right of way will be allowed to partially regenerate following rehabilitation works, which will reduce visual amenity impacts. Nonetheless, vegetation height will be permanently reduced along the pipeline route for ongoing pipeline integrity and to enable maintenance, which represents a longer-term change to landscape character.

During the 25-year Project operations phase, the extent of landscape change and visual impact will vary as construction progresses and screening provided by existing vegetation and vegetation regrowth. The most prominent change to landscape character and visual amenity will result from

the most visible key Project components, such as the vent and flare at the CPF, and the Logistics Base adjacent to the Purari River.

The following embedded design controls address impacts to visual amenity and landscape:

- Project design is based on a risk-management approach, considering geotechnical constraints (e.g., flooding, landslides risks, geohazards) and anticipating and avoiding, or where avoidance is not possible, minimizing environmental and social impacts (e.g., avoiding sensitive features, and physical and economic displacement, priority ecosystem services, and minimizing the Project footprint, land clearing and disturbance, emissions and discharges) [ED013].
- Waste will be managed to reduce, reuse and recycle/recover the waste where practicable. Waste management requirements (e.g., waste inventory, segregation, storage, disposal, tracking, recording) will be detailed during FEED [ED039].

15.4.3.2 Viewshed Analysis

A viewshed analysis was completed to identify the extent of potential visual impacts to sensitive receptors in the onshore Project area (see Section 15.4.5). The viewshed analysis outlines areas that are potentially visible from identified viewpoints described in Table 15.28.

CPF, Logistics Base and Purari Airstrip

Project components in PRL-15 that have the potential to be seen from the four identified viewpoints in Table 15.29 include the CPF flare, vent, and buildings, the buildings of the Logistics Base, and the buildings of the Purari Airstrip extension. Table 15.30 provides approximate distances between the viewpoints and these features, and Figure 15.8 shows the viewshed analysis undertaken for this area.

Table 15.29 – Distance of Viewpoints from Project Features

Viewpoint	Approximate Distance from Project Feature (km)		
	CPF	Logistics Base	Purari Airstrip*
Poroi 1	3.8	2.5	1.8
Mapaio Fish Camp	7.9	6.9	5.4
Purari Airstrip House	4.8	2.5	0.1**
PRL-15 oxbow wetlands	8.5	8.3	7.9

Note: * Measured to the closest boundary of the proposed upgrade. ** 85 m to the proposed perimeter road at the northern end of the airstrip.

The viewshed analysis indicates that the shorter of these Project components will theoretically be visible for 5 km or more, while the flare and vent (104 m and 50 m tall, respectively) could potentially be visible above the tree line for 10 km or more. In both cases, little of this area is inhabited, and the screening effects of existing tall, dense vegetation and topography will limit the visibility of these features considerably.

As shown in Figure 15.8 and summarized in Table 15.30, given their river valley locations and the screening effects of the local environment, viewers at Poroi 1 and Mapaio Fish Camp will not be able to see any Project features. The family house at the Purari Airstrip, day users at the PRL-15 oxbow wetlands or those on the Purari River transiting near the Logistics Base may be able to see some of the Project components in PRL-15.

CPF, LOGISTICS BASE AND PURARI AIRSTRIP VIEWSHED ANALYSIS

Papua LNG Project | Environmental Impact Statement

FIGURE 15.8

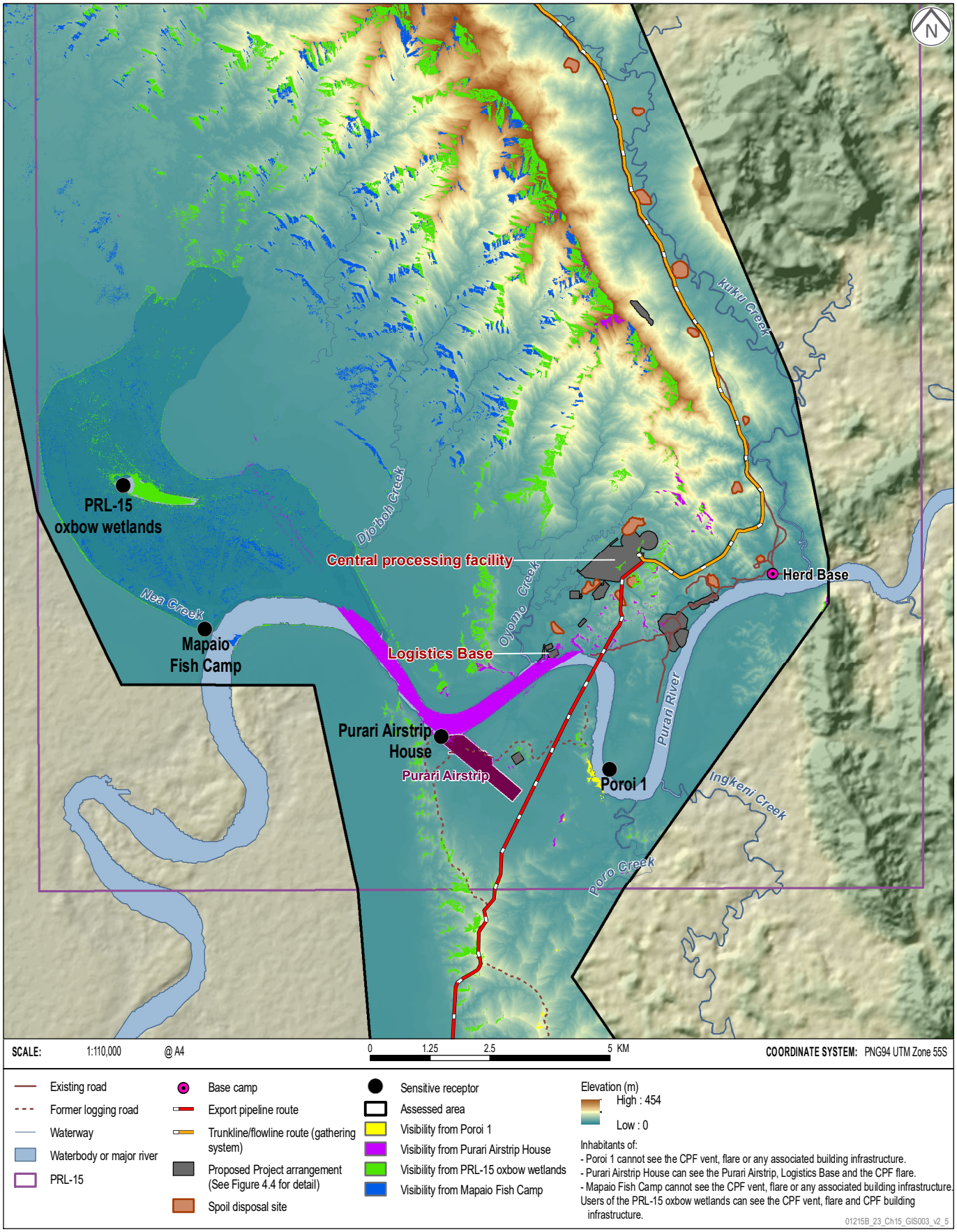


Table 15.30 – Visibility of Project Features from Viewpoints

Viewpoint	Ability to View Project Features				
	CPF Buildings	CPF Flare	CPF Vent	Logistics Base Buildings	Purari Airstrip Buildings
Poroi 1	No	No	No	No	No
Mapaio Fish Camp	No	No	No	No	No
Purari Airstrip House	No	Yes	No	Yes	Yes
PRL-15 oxbow wetlands	Yes	Yes	Yes	No	No

Note: Visibility from the viewpoints modeled consider an average 20 m vegetation height.

River Transport Corridors

The primary visual impact of the river transport corridors will relate to increased river traffic, rather than construction or operation of infrastructure, although users of the Purari River near the Logistic Base and the Purari Airstrip may notice Project construction and increased activity, and may catch distant views of the CPF flare. As noted in Table 15.28 viewpoints in the river transport corridors include villages on the banks of the Purari and Urika-Ivo rivers. Residents of these villages will view increased river traffic, primarily during the construction phase, both from their villages and while using the river and banks for travel and subsistence activities.

Onshore Export Pipeline Route

Changes to visual amenity during construction along the onshore export pipeline route will be due to temporary construction activities such as vegetation clearing, earthworks and the presence of machinery. Operations phase landscape changes will be a permanent, cleared corridor with short vegetation through logged forest, signage and valve stations.

The Aivai village residents may experience a temporary decline in visual amenity (in addition to river transport impacts) during the Project construction phase due to the proposed pipe yard and pipeline construction camp on the opposite side of the river to the village.

Most of the export pipeline route passes through uninhabited areas, with minimal potential for visual impacts associated with the pipeline right of way, until it reaches the more densely populated coastal area in Orokolo, where the pipeline route passes closer to communities. Here communities are likely to see a temporary decline in visual amenity associated with clearing of the right of way and access track, and the presence of construction vessels offshore.

15.4.3.3 Project Lighting Impacts

General Lighting

Permanent lighting is planned for facilities that are constantly crewed, such as the CPF. Throughout the Project construction and operations phases, night lighting will be required to illuminate work areas and associated infrastructure for safe operations. Night lighting will be located, as required, for safety and security.

Lighting requirements for the Project components are yet to be finalized. Night operations are not currently planned for the Purari Airstrip, and as such, any lighting will be restricted to security or safety lighting.

As the CPF buildings will not be seen from any villages, night lighting from the CPF is not expected to adversely affect any local inhabitants. The Logistics Base and Purari Airstrip may be visible from the Purari Airstrip House during both the night and the day, depending upon the final lighting design for these two facilities; however, as the airstrip will not be used for night flights and the Logistics Base is primarily a day use operational area, substantial night-lighting is not anticipated to be required and is not expected to adversely affect local inhabitants.

Gas Flare

Gas flaring from the CPF will be required occasionally during start-up, maintenance and upset conditions. The 104 m tall, high-pressure flare stack may be seen from the Purari Airstrip House. If flaring is required at night, the flare may reduce visual amenity at this location due to the brightness and apparent movement of the flame; however, upset condition flaring is rare and would not adversely affect residents of the Purari Airstrip House; therefore, flaring is not assessed further.

In addition to flaring, aircraft warning lights on the flare stack will be visible, though more so at night. Given the nature of these lights (i.e., height, directionality, purpose), these are not expected to adversely affect residents of the Purari Airstrip House and they are not assessed further.

15.4.3.4 Landscape Character

Changes to landscape character comprise the introduction of industrial elements into landscapes that contain few built structures of a similar nature, and that are generally characterized by dense vegetation and restricted access, based upon river transportation and a very limited network of existing roads and trails. In places, modifications to landform due to earthworks to develop these facilities (e.g., CPF, quarries) will also change landscape character.

15.4.3.5 Summary of Potential Impacts

The Project has the potential to cause the following potential impacts to landscape and visual amenity:

- Decline, loss of or change to existing visual amenity or landscape character, including illumination from night lighting for the Purari Airstrip House.
- Decline or change to existing visual amenity, landscape character or connectivity for people using the PRL-15 oxbow wetlands for fishing, hunting or cultural activities.
- Temporary decline or change to existing visual amenity along the river transport corridor due to increased barge traffic.
- Decline or change to existing visual amenity for river users near the Logistics Base and the Purari Airstrip.
- Temporary decline or change to existing visual amenity for people in Aivai, particularly during pipeline construction.
- Change in landscape connectivity and a temporary decline in visual amenity for some communities in Orokolo Bay.
- The introduction of new industrial elements into a predominantly natural landscape.

15.4.4 Proposed Mitigation and Management Measures

Table 15.31 describes proposed mitigation and management measures to further reduce adverse effects on landscape and visual amenity .

Table 15.31 – Landscape and Visual Amenity Mitigation Strategies and Management Plans

Potential Impact	Mitigation Strategy	Relevant Management Plan
Decline, loss of or change to existing visual amenity or landscape character, including illumination from night lighting for the Purari Airstrip House.	♦ Avoid directly lighting areas at night and minimise fixed night lighting for safe operations, e.g., direct lighting away from the Purari Airstrip House, and the surrounding forest [EM047].	Biodiversity Action Plan; Community Health, Safety and Security Plan
Decline, loss of or change to existing visual amenity, landscape character or connectivity for people using the PRL-15 oxbow wetlands for fishing, hunting or cultural activities.	No additional mitigation measures proposed.	NA
Decline, loss of or change to existing visual amenity due to increased barge traffic.	No additional mitigation measures proposed.	NA
Decline, loss of or change to existing visual amenity for river users near the Logistics Base and the Purari Airstrip.	♦ Actively or passively rehabilitating bare sites as soon as possible to promote a stable self-sustaining landscape, e.g., – Allow forest edges to naturally regenerate or create appropriate conditions to facilitate natural regeneration, e.g., rip the substrate, replace topsoil, apply mulch. – Rehabilitate Pandanus habitats, e.g., recreate mounds, re-instate the intertidal surface between Pandanus mounds. – Rip compact surfaces across the slope, as appropriate, to facilitate revegetation and minimize erosion. – Spread stockpiled topsoil, organic matter and cleared vegetation over the rehabilitation area to promote natural regeneration. – Use native vegetation to revegetate sites when active rehabilitation measures are required [EM029]. ♦ Where practicable, retain a vegetation buffer to screen infrastructure and facilities. [EM048].	Biodiversity Action Plan; Site Restoration and Rehabilitation Plan.
Decline, loss of or change to existing visual amenity for people in Aivai, particularly during pipeline construction.		
Change in landscape connectivity and in views for some communities in Orokolo Bay.		
Changes to landform and the introduction of new industrial elements into the landscape.		

Note: NA = Not applicable.

15.4.5 Residual Impact Assessment

The following sections provides the assessment of residual impacts to visual amenity and landscape subject to the embedded design controls in Section 15.4.3 and the successful implementation of the mitigation measures in Section 15.4.4.

15.4.5.1 Visual Amenity Assessment

CPF, Logistics Base and Purari Airstrip

Places of habitation near the CPF, Logistics Base and the Purari Airstrip have been assigned a ***Low*** sensitivity rating, as these viewpoints are not locations where the communities' attentions are focused on the landscape and they are visited/used by less than 500 people per day (Table 15.28). Purari Airstrip House residents are likely to see part of the flare stack (in the background of view, approximately 4.8 km distant), but not the vent or the CPF buildings, due to vegetation and terrain screening effects.

The flare will be a new and permanent feature for these residents; however, its presence in the background of view and in a very narrow field of vision, and the limiting of flaring during upset conditions to daylight hours where practicable, results in a ***Low*** magnitude rating, resulting in a residual impact significance assessment of ***Minor***.

Purari Airstrip House residents will also be able to see the Logistics Base in the middle ground of view, approximately 2.5 km along the river to the northeast, and the airstrip buildings in the foreground, approximately 60 m to the southeast. The Logistics Base will present as a permanent and new form to these residents, but its location in the middle ground of view and filling less than 10° of the field of vision, and the fact that Herb Base exists further upriver, will have an overall visual impact of ***Low*** magnitude, resulting in a residual significance assessment of ***Minor***.

Despite the airstrip buildings being a permanent change in the foreground view from this house, they will be low-lying and are part of an upgrade to the existing airstrip facility, as such blending in with existing features; therefore, the overall impact on visual amenity will be of ***Low*** magnitude, resulting in a residual impact significance assessment of ***Minor***.

Individuals using the PRL-15 oxbow wetlands may see part of the flare, vent, and CPF buildings, approximately 8.5 km in the distance. Viewers will not see buildings at the Logistics Base or the Purari Airstrip due to the screening effects of terrain. Although these features will be a permanent change to the visual landscape from this viewpoint, they will form a very narrow part of the field of vision, providing an overall visual impact magnitude rating of ***Low***. Given the ***Minimal*** sensitivity rating attributed to viewers at this viewpoint, this results in a residual impact significance assessment of ***Negligible***.

River Transport Corridors

Villages along the river transport corridors have been assigned a ***Low*** sensitivity rating as these viewpoints are not locations where the communities' attentions are focused on the landscape and they are predominantly visited/used by less than 500 people per day (see Table 15.28). While the visual impacts associated with increased barge movements (Section 15.4.3.2) may be in the immediate foreground of view for communities on or using the riverways, they will be short-term (i.e., the increase in barge traffic will be focused on the construction period) and transient (i.e., barges pass relatively quickly). Further, as there are already barges operating on the Purari River, the primary Project transport route, this change does not represent the introduction of a new feature to the landscape, only a small increase in barge frequency. For these reasons, the magnitude of additional barges being visible to communities along the Purari River is rated as ***Minimal*** magnitude, resulting in a residual impact significance assessment of ***Negligible***.

A sensitivity rating of ***Low*** was assigned to viewers on the river near the Logistics Base and the Purari Airstrip extension, as while this part of the river is used frequently as a primary transport method, it is used by few people (estimated at fewer than 100 per day based on nearby village and settlement sizes), from local communities, and views are temporary as people move past the infrastructure. The magnitude of any visual impact is rated as ***Medium***, as the proposed modifications will form a permanent change in the landscape, causing an apparent but insubstantial change to the landscape character, as it will be partially screened from view due to the riparian vegetation. Further, with the airstrip and Herd Base already being visible along this stretch of the river, the proposed changes will not represent a major divergence from the current landscape; therefore, the residual impact significance assessment of visual impacts on river users around, and approaching, the Logistics Base and the Purari Airstrip is assessed as ***Minor***.

Onshore Export Pipeline Route

Temporary landscape changes during construction of the export pipeline route will include vegetation clearing, earthworks and the presence of machinery, both onshore and offshore. Operations phase landscape changes will be a permanent, cleared corridor with short vegetation through logged forest, signage and valve stations.

Aivai village residents will experience a temporary decline in visual amenity, in addition to river transport impacts, during the Project construction phase due to the proposed pipe yard and pipeline construction camp on the opposite side of the river, towards the export pipeline right of way.

Most of the decline in visual amenity will be temporary, as the works and infrastructure will blend with the existing logging road, and measures to maintain riparian vegetation and allow regeneration will minimize the amount and length of time that buildings can be seen. This results in a ***Low*** magnitude rating for visual impact on Aivai village residents. Given the ***Low*** sensitivity rating assigned (see Table 15.28), the residual impact significance assessment is rated as ***Minor***.

While most of the pipeline route passes through uninhabited areas, there is the potential for a decline in visual amenity for coastal villagers, inhabitants of outlying residences and pedestrian traffic near the right of way. Coastal villages and land use areas near the export pipeline route have been assigned a ***Medium*** sensitivity rating as the area around the coast at Orokolo Bay is more densely populated and used more frequently for subsistence, cultural and recreational activities than elsewhere in the PAOI (see Table 15.28).

Landscape modification due to construction of the export pipeline shore crossing will not be visible from the nearby villages of Iuku or Mareke due to vegetation screening. Pedestrian traffic along the beach next to these villages may observe the construction activities in the immediate foreground, but these are likely to be visible only as they pass by, or are diverted around, or over, construction activity, or when the pipelay and other support vessels are active. Construction of the export pipeline shore crossing will also be visible to those gathering on the beach for social or recreational reasons. For residential, pedestrian and social/recreational viewers, most of the decline in visual amenity will be temporary (construction); although, the reduced vegetation height will be permanent over the pipeline ROW during operations, causing an apparent but insubstantial change to the landscape character. For these reasons, a ***Low*** magnitude rating is assigned, resulting in a residual impact assessment of ***Minor***.

Plates 4.8 and 4.9 highlight the decline in visual amenity that would be temporarily experienced by coastal communities close to the onshore export pipeline shore crossing.

15.4.5.2 Landscape Assessment

Several oil and gas industrial facilities exist at a regional or national scale in Papua New Guinea, such as the PNG LNG Facilities at Caution Bay or facilities and pipelines at Gobe and Lake Kutubu. No developments of a comparable scale or form to the Project occur in the provincial and local setting.

The introduction of new industrial elements into a landscape characterized by its forest cover, natural landforms and remoteness results in changes to landscape character through reduction in tree cover, modification of local landforms and potentially a reduction in sense of remoteness or perceived ‘untouched’ nature of the place. However, several intrinsic design and location factors combine to mitigate potential impacts to landscape character, such as changes to landform and increased sense of development, and include the:

- Presence of Herd Base near the CPF and Logistics Base that will contribute to visual integration of the Project in this area.
- CPF and associated infrastructure are not the first developments in the area, with oil and gas exploration facilities, and logging operations having been established in the area over the past decade.
- Pre-Project design, which maximizes the use of disturbed land; approximately 20% of the Project footprint in PRL-15 is on previously disturbed land, while most of the export pipeline route is on land previously degraded by commercial logging (see Section 4.10.7). The visual impact of Project pipelines, roads and vegetation clearing will be similar to that of existing logging roads and forest harvesting areas.
- Presence of dense vegetation, elevated topographical features near PRL-15 and the meandering Purari River will help to conceal Project facilities and infrastructure when viewed from the ground.
- Fast-growing vegetation, which will be allowed to regenerate around non-operational Project areas, and post-decommissioning, will help return the Project area to a near-natural condition.

Due to these factors, and the embedded design controls and mitigation measures proposed, changes to the broader landscape character are likely to represent minimal modification to landscape character in and around the Project area.

15.4.6 Summary of Residual Impacts to Landscape and Visual Amenity

A summary of the assessment of residual impacts related to landscape and visual amenity including the Project phase and location, and when and where impacts are expected to occur, is provided in Table 15.32. The table should be read in conjunction with the mitigation measures provided in Table 15.31. The residual visual impacts due to the Project were assessed as ***Minor*** or ***Negligible*** for all inland receptors, given the low sensitivity of receptors and the minimal to low magnitude of visual impacts.

Table 15.32 – Summary of Assessment of Residual Impact Significance Landscape and Visual Amenity

Key Sensitivity	Main Activity	Potential Impact	Location of Activity	Project Phase	Mitigation and Management	Residual Assessment	
						Sensitivity/ Magnitude	Significance
Purari Airstrip House	Gas flaring. Vegetation clearing. Earthworks. Construction works (Airstrip buildings, Logistics Base and flare).	Decline, loss of or change to existing visual amenity or landscape character. Illumination from night lighting, which may reduce visual amenity for residents in the Purari Airstrip House.	PRL-15	C, O, D	♦ EM047	Low/Low (flare) Low/Low (Logistics Base) Low/Low (airstrip)	Minor
PRL-15 oxbow wetlands	Vegetation clearing.	Decline, loss of or change to existing visual amenity, landscape character or connectivity.	PRL-15	C, O, D	None	Minimal/Low	Negligible
Villages in the river transport corridors	Logistics and transport (barging).	Decline, loss of or change to existing visual amenity.	River transport corridor	C, O, D	None	Low/Minimal	Negligible
Users of the Purari River around the Logistics Base and the Purari Airstrip	Vegetation clearing Construction works (Logistics Base and the Purari Airstrip).	Decline, loss of or change to existing visual amenity.	PRL-15	C, O, D	♦ EM029 ♦ EM048	Low/ Medium	Minor

Table 15.32 – Summary of Assessment of Residual Impact Significance for Landscape and Visual Amenity (cont'd)

Key Sensitivity	Main Activity	Potential Impact	Location of Activity	Project Phase	Mitigation and Management	Residual Assessment	
						Sensitivity/ Magnitude	Significance
Aivai village on the Purari River	Vegetation clearing. Earthworks. Onshore pipeline construction (including associated infrastructure).	Decline, loss of or change to existing visual amenity, particularly during pipeline construction.	Export pipeline corridor	C, O, D	♦ EM029 ♦ EM048	Low/Low	Minor
Coastal villages and associated land use areas	Vegetation clearing. Earthworks. Onshore pipeline construction (including associated infrastructure).	Change in specific landscape connectivity. Change in view for local community.	Export pipeline corridor			Medium/Low	Minor

C = Construction, O = Operation, D = Decommissioning and closure.

15.5 Commercial Traffic and Transport

15.5.1 Context

15.5.1.1 Coastal and River Shipping

No international shipping lanes traverse the Gulf of Papua near the offshore export pipeline corridor, although tankers arrive and depart from the PNG LNG Facilities in Caution Bay and from the Kumul Marine Terminal in the northern gulf. Shipping routes in the Gulf of Papua primarily center on commercial vessels sailing to and from Port Moresby and the inland river ports in Western and Gulf provinces. Typical vessels include cargo vessels, fuel tankers, bulk carriers, barges and tugs.

Existing traffic in the Project's river transport corridors (Route 6, Figure 10.7) includes barges from Port Moresby to Herd Base supplying TEP PNG's gas exploration activities in PRL-15 (approximately 190 return trips/year), and log barges to and from the Evara logging camp on the Purari River (approximately 24 return trips/year). TEP PNG also uses two small, high-speed barge-punts from Herd Base to transfer local personnel, goods and equipment to local locations up and down the Purari River and to neighboring villages.

At the Caution Bay terminus of the offshore export pipeline route, international LNG carriers, supported by four tugs and a pilot boat, serve the PNG LNG Facilities and complete approximately 200 trips/year to and from Port Moresby (Route 9, Figure 10.7). Supply and passenger ships from Port Moresby to Ihu (Route 7, Figure 10.7) also cross the offshore export pipeline route with an estimated 26 return trips/year.

Kiunga–Port Moresby (Route 2, Figure 10.7) is the busiest of other commercial shipping routes in the Gulf of Papua that may cross the offshore export pipeline route or Project shipping routes to/from Port Moresby, with 212 return trips/year. This is the key route for shallow-draft bulk carriers transshipping copper concentrate from the Ok Tedi mine to Port Moresby. It also serves Kiunga township and is used by cargo ships and barges for hydrocarbon exploration projects.

Other Gulf of Papua shipping routes include those between Port Moresby and Kikori/Kopi, Kumul Marine Terminal, and Baimuru and Daru townships. Timber industry shipping routes exist between Port Moresby and Bamu River tributaries, where there are timber processing facilities, and there are several logging shipping routes from other rivers west of the PAOI. The main overseas shipping lanes to and from Port Moresby are south, to the Australian east coast ports, and to the southwest, joining the Great North East Channel that leads to the Prince of Wales Channel through the Torres Strait and onwards to southeast Asia.

Further information on marine and river traffic and transport is presented in Chapter 10 and Part 22 of Volume 2. Figure 15.9 shows the shipping traffic operating in the Gulf of Papua during 2018.

15.5.1.2 Commercial Fishing Traffic

The Gulf of Papua Prawn Fishery currently operates eight trawlers, which are generally 24 to 30 m long, although smaller vessels occasionally trawl in more sheltered inshore waters. Trawling takes place 24-hours-per-day for approximately 250 days per year, between April and November.

The prawn fishing grounds extend seaward of the 3 nautical mile limit to approximately the 40 m depth contour, but trawlers typically operate in the 10 to 35 m depth range. Trawlers also access the 2 to 3 nautical mile zone based on joint venture agreements with local Gulf Province communities that have customary rights to these areas.

VESSEL TRAFFIC IN THE GULF OF PAPUA

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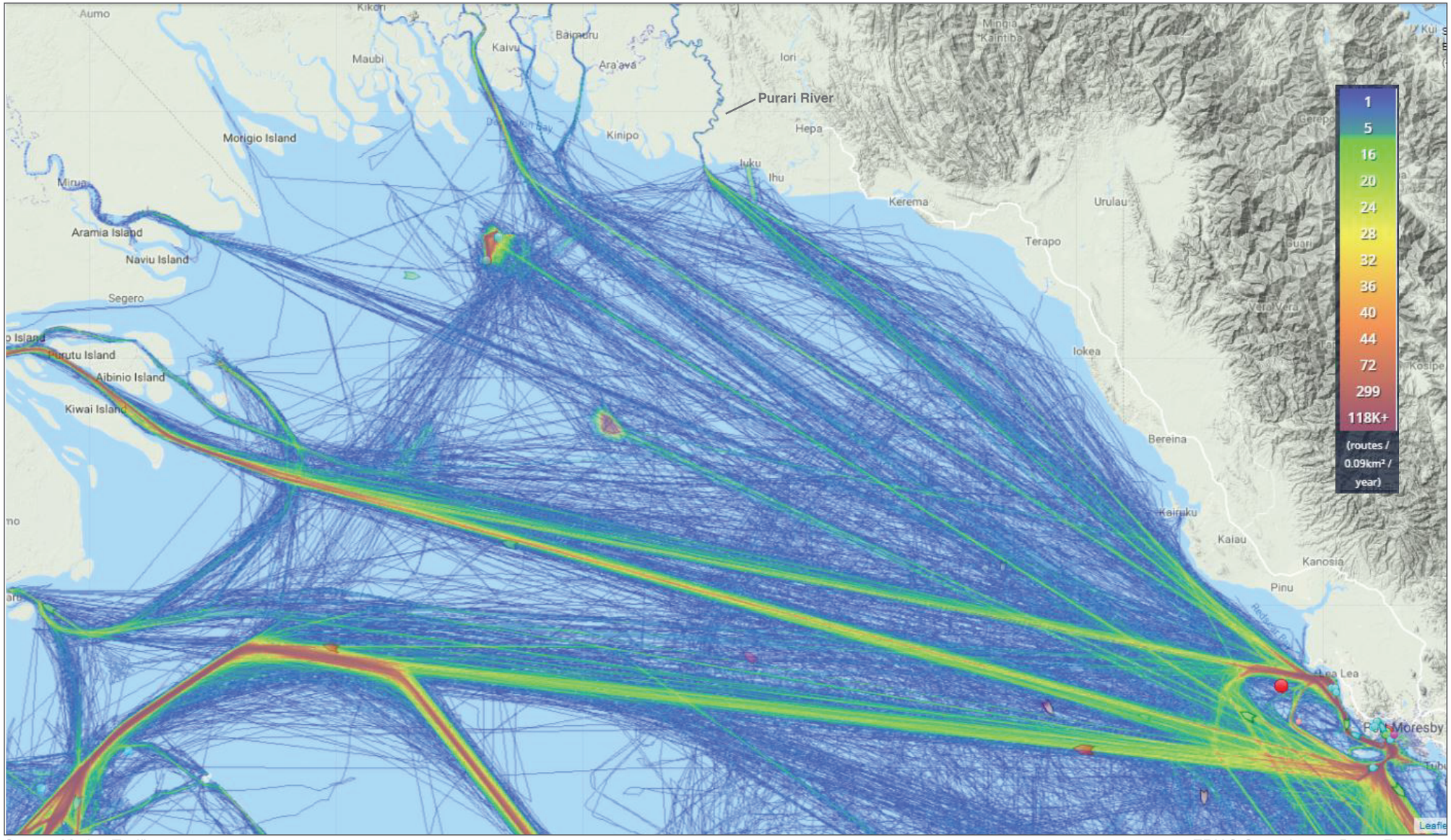
FIGURE 15.9



Source: Marine Traffic, 2018.

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Rock lobster and bêche-de-mer fisheries in Torres Strait are well outside of the PAOI, and export shipping from Daru is unlikely to traverse close to the offshore export pipeline route or Project shipping routes. A relatively small bêche-de-mer fishery also operates along the coast of the Gulf of Papua, from April to September.

Further information on commercial marine fisheries is presented in Chapter 8 and Part 13 of Volume 2.

15.5.1.3 Road and Air Transport

The main road in Gulf Province is the coastal Hiritano Highway, which extends approximately 300 km from Port Moresby to Kerema. Currently, the condition of this road is variable, being poor in some sections with extensive potholes or unsealed surface, but good near Port Moresby and Kerema.

Public roads are absent in the PAOI itself; only logging roads and minor local tracks are present. Project accessways will be constructed in PRL-15 and along the length of the onshore export pipeline route, as described in Section 4.8.3.

The Jacksons International Airport in Port Moresby is the largest airport in the country and the main entry/exit point by air. The closest airstrip to the Project is the Purari Airstrip, which is currently used by the Project. The airstrip will be upgraded for Project use.

15.5.2 Discipline-specific Impact Assessment Method

The significance assessment method described in Chapter 3 was adopted to qualitatively assess the potential impact on commercial traffic and transport from construction and operation of the Project. This method considers the magnitude of impact on a value and the sensitivity of that value. Impact assessment criteria have been developed specifically for this assessment.

Sensitivity considers the susceptibility of a value to change and its intrinsic importance considering factors such as the:

- Capacity to adapt to change without adverse effects on the value's inherent attributes, i.e., its resilience.
- Rarity or uniqueness of the resource or receptor.
- Importance to local businesses, economies and communities.

Table 15.33 defines the categories for assessment of sensitivity adopted in the commercial traffic and transport assessment.

Table 15.33 – Commercial Traffic and Transport Sensitivity of Receptor Criteria

Category	Description
High	♦ Route that facilitates connectivity between cities or regional centers. ♦ Route that supports more than 250 return tips per year. ♦ Value (i.e., efficiency, safety and amenity) has limited or no capacity for increased use. ♦ Value is unaffected by the impact prior to Project interaction. ♦ Value provides the sole source of income for local businesses. ♦ Many commercial operators depend on the value and cannot access nearby alternatives. ♦ Value cannot be relocated or replaced or is not a type common in the surrounding region.

Table 15.33 – Commercial Traffic and Transport Sensitivity of Receptor Criteria (cont'd)

Category	Description
Medium	♦ Route that facilitates connectivity between townships or villages. ♦ Route that supports 150 to 250 return tips per year. ♦ Value (i.e., efficiency, safety and amenity) has some capacity for increased use. ♦ Some sign of exposure to the impact is already evident for this value prior to Project interaction. ♦ Value upon which commercial operators are occasionally dependent.
Low	♦ Route that facilitates connectivity between other main transport connections. ♦ Route that supports less than 150 return tips per year. ♦ Value (i.e., efficiency, safety and amenity) has significant capacity for increased use. ♦ Value is already affected by the impact prior to Project interaction. ♦ Value upon which local people are rarely dependent for provision of food or income. ♦ Commercial operators can access nearby alternatives to the affected value. ♦ Value can be relocated or replaced or is a type common in the surrounding region.

Magnitude of impact is defined by the impact's severity, and spatial and temporal extents. Table 15.34 defines the categories adopted for assessment of the magnitude of Project impacts on commercial traffic and transport. Assessment of the magnitude of impact is undertaken assuming proposed mitigation measures, or existing operating procedures have been successfully implemented, i.e., provides a residual impact assessment.

Table 15.34 – Commercial Traffic and Transport Magnitude of Impact Criteria

Category	Description
Very High	♦ An impact that extends to a national level, lasting for more than 10 years, and prevents existing traffic using the route. ♦ Significant negative changes to economic activities or access causing major economic loss or business closure. ♦ Collision at sea causing the loss of life and property.
High	♦ An impact that extends to a regional level, lasting five to 10 years, and disrupts existing traffic using the route. ♦ Noticeable temporary negative changes to economic activities or access causing moderate economic loss. ♦ Collision at sea causing the loss of property.
Medium	♦ An impact that extends to a local level, lasting less than five years, and delays existing traffic using the route. ♦ Temporary, partial interruption to economic activities or access causing minor short-term economic loss. ♦ Incident resulting in a near miss.
Low	♦ An impact that is highly localized, predominantly contained in the PAOI, lasting less than five years. ♦ Minimal or no interruption to economic activities or access and commercial activities. ♦ Can be effectively mitigated through standard management controls.
Negligible	♦ No appreciable impact compared with baseline conditions. ♦ The impact is within a normal range of variation.

A matrix combining the magnitude of impact category with the sensitivity category determines the significance of the impact from the Project's activities. Table 15.35 presents the matrix used to establish the significance of Project impacts on commercial traffic and transport values.

Table 15.35 – Commercial Traffic and Transport Significance of Assessment Matrix

Magnitude of Impact	Sensitivity of Value		
	High	Medium	Low
Very High	Severe	Major	Moderate
High	Major	Moderate	Moderate
Medium	Moderate	Moderate	Minor
Low	Moderate	Minor	Minor
Negligible	Minor	Negligible	Negligible

15.5.3 Identification of Potential Impacts

15.5.3.1 Coastal and River Shipping

During construction, imported materials, fuel, chemicals, concrete, and equipment comprising CPF modules, pipes, and drilling equipment will be transported to the Project site for five years. Most of the imported materials will arrive through the Motukea Port or the Avenell Engineering Systems Ltd supply base near Port Moresby and be transported by sea and river to the Logistics Base. This will require up to four barges per day during the construction peak moving between Port Moresby and the Logistics Base or Herd Base on the Purari River and back again. An estimated 540 vessel movements per annum will be required during the peak Project construction period (Year 2). Barge movements during the operations phase may be three to five per month.

TEP PNG currently undertakes coastal and river shipping to support exploration activities and implements standard operating procedures in compliance with legislation and consistent safe shipping practices, including:

- Implementing normal maritime regulations to avoid interactions with commercial shipping vessels travelling through the Gulf of Papua.
- Maintaining regular communication with the PNG National Maritime Safety Authority (NMSA) and the National Fisheries Authority (NFA) to advise on offshore Project activities including planned vessel movements.
- Implementing appropriate and compliant (with NMSA regulations) navigation aids and equipment to enable monitoring of and communication with approaching vessels.

The following embedded design controls address the potential impacts identified below:

- Project design is based on a risk-management approach, considering geotechnical constraints (e.g., flooding, landslides risks, geohazards) and anticipating and avoiding, or where avoidance is not possible, minimizing environmental and social impacts (e.g., avoiding sensitive features, and physical and economic displacement, priority ecosystem services, and minimizing the Project footprint, land clearing and disturbance, emissions and discharges) [ED013].
- Liaise with NMSA to establish a safety exclusion zone around offshore export pipeline construction activities [ED042].
- Continue to work with relevant commercial operators to
  - Coordinate barge movements along the Purari River.
  - Notify them, as required, of in river Project activities and the associated hazards [ED043].
- Inform NFA and commercial fishing fleets who operate in the vicinity of the offshore export pipeline route of construction activities, including timing of construction activities and the safety exclusion zone [ED044].

- The Project will maintain a grievance mechanism that is legitimate, accessible, predictable, equitable, right-compatible, and transparent [ED033].

Coastal Shipping

Vessels supporting TEP PNG's Project development activities currently use the shipping route (Route 6) between Port Moresby and the Purari River mouth, which crosses few other routes identified in Figure 10.7. Other shipping routes operating in the PAOI, and that could intersect with Project barge movements, are Route 7; Port Moresby to Ihu, which operates an estimated 26 passenger vessels each year, and Route 9; Port Moresby to the PNG LNG Facilities, which operates an estimated 200 vessel movements each year, and which is centered around Caution Bay.

There will be a temporary increase in Project-related vessel movements along the coastline focused on the five-year Project construction period. During this period, barge traffic will be highest in Years 1 and 2, thereafter reducing as the main infrastructure components (e.g., the CPF and roads) are completed. The increase in coastal barge traffic associated with Project construction will increase the total number of vessels using the Gulf of Papua coastal shipping routes, which could potentially increase the rate of vessel collisions. However, given the low numbers of ship movements in these coastal routes (Figure 15.9) and the very low likelihood of incidents based on historical data (Butt et al., 2013), vessel collisions due to increased barge traffic is considered negligible and not assessed further.

Potential impacts of vessels on the marine environment (e.g., marine habitat, flora and fauna) are discussed in Chapter 12, and the effects of additional marine traffic associated with other projects in the Gulf of Papua are considered in Chapter 17.

River Shipping

TEP PNG barges made 190 return trips from Port Moresby to Herd Base to transfer local staff, goods and equipment in 2016. Log ships belonging to Frontier Holdings Limited, a subsidiary of Rimbunan Hijau (PNG) Limited, make approximately 24 return trips a year from Port Moresby to the Evara logging camp.

During the peak construction period, up to 10 barges may use the approximately 100 km of river at any one time, and up to 14 barge trips per day will ferry workers approximately 2.5 km between the Purari Airstrip on the southern shore and the Logistics Base on the northern shore of the Purari River. This has the potential to hinder logging barges moving through this river reach. The construction activities required for the offloading facilities at the Logistics Base landing may also hinder river traffic during this time.

Increased river barging also has the potential to disturb community access and amenity, and poses a risk of increased accidents with community members who travel the river in canoes, discussed in Chapter 13.

15.5.3.2 Commercial Fishing Traffic

Any interactions between the coastal zone bêche-de-mer fishery and Project activities are predicted to be spatially restricted to the nearshore approaches in Orokolo Bay, and the segment of the pipeline corridor that intersects with the coastal zone offshore of Cape Suckling. Due to the very low potential for interactions between Project activities and commercial fishers, based on a highly limited spatial and temporal overlap, the coastal zone bêche-de-mer fishery has been excluded from further assessment.

The Project intersects with the offshore area of the Gulf of Papua Prawn Fishery. There are three potential impacts to this fishery relating to commercial traffic and transport; increased interactions between Project barges and commercial fishing vessels, interactions between Project pipelaying vessels and commercial fishing vessels, and interactions between fishing equipment and the export pipeline once laid.

The marine Project transport route is mostly outside the 3 nautical mile zone, which is where most of the commercial prawn fishing activities take place (see Figure 8.26), and therefore there is some, albeit very limited potential for interactions between Project barges and commercial fishing vessels, potentially interfering with, causing collisions or excluding access to fishing grounds. However, given low numbers of vessels in the Gulf of Papua Prawn Fishery and the embedded design controls that minimize the likelihood of collisions, the potential for interactions between Project barges and fishing vessels is considered negligible and is not assessed further.

While the offshore export pipelines are being laid, an exclusion zone will be maintained around the pipelaying barge and supporting vessels. However due to the temporary and transient nature of this activity (i.e., pipelaying will take place over several weeks and the barges will be constantly moving along the length of the future pipeline), and the small areas of overlap with commercial fisheries (see Section 16.5.1.7), the potential for disruption to fishing activities as a result of pipelaying is considered negligible and is not assessed further.

The potential for fishing equipment to become entangled on the offshore export pipeline is very low, given; the fishing fleet is aware of the existing PNG LNG Project pipeline, which the Project pipeline will follow for much of its length; the NMSA has a standard procedure of adding pipelines to navigation charts; and the pipeline will be largely outside the primary areas of fishing effort (see Figure 8.26). For these reasons, and the pipeline design measures discussed in Chapters 4, the potential for fishing equipment to become entangled on the export pipeline has been excluded from further assessment.

15.5.3.3 Road and Air Transport

Road transport from beyond the PAOI is not viable, as no roads access the Project area from outside the province. A local road and access track network will be used to transport equipment from the Logistics Base to work sites in the PAOI, using roads constructed or upgraded for this purpose. There are no public roads in the PAOI and while some logging roads exist, the public use them as walking tracks only. Logging vehicles no longer use the logging roads south and east of the Purari River, as most of the timber resources have been exploited, and logging activities are moving north of the Purari River, beyond the Project area. All planned road movements are distant from current communities. For these reasons, the potential for the Project to impact road traffic has not been assessed further.

Project personnel will be transported to the Project area by air. Air traffic to the Purari Airstrip will increase by up to five to seven airplane landings per day during the construction period. This will increase noise associated with planes larger than those currently using the airstrip, and more frequent take offs and landings, which may have noise implications for local communities; these are considered in Section 15.3.

The construction workforce may also increase the demand for seats on international flights to and from Port Moresby's international airport. This is discussed further as a potential cumulative impact in Chapter 17.

TEP PNG, Rimbunan Hijau (PNG) Limited and the occasional commercial airline charter flight currently use the Purari Airstrip. No regular, scheduled commercial flights use the airstrip. TEP PNG is currently negotiating an access agreement to use the airstrip, and access for other

operators currently using the airstrip is expected to continue throughout construction and operations phases; therefore, the potential for the Project to impact on users of the airstrip is not assessed further.

15.5.3.4 Summary of Potential Impacts

The Project has the potential to interact with river traffic on the Purari River, potentially causing the following impact:

- Temporary delay of logging barges using the Purari River resulting from ferrying and/or barge offloading facilities during construction.

15.5.4 Proposed Mitigation and Management Measures

All potential impacts associated with commercial traffic and transport are managed through existing procedures and embedded design controls. No additional mitigation measures are required.

15.5.5 Residual Impact Assessment

The following section provides the assessment of residual impacts to commercial traffic and transport subject to the embedded design controls in Section 15.5.3.

The sensitivity of the Purari River as a transport route is rated as ***Medium***, as it is the primary route that connects towns and villages along the river transport corridor, with no roads available for alternate use. The Purari River is already used by TEP PNG and accounts for most vessel movements, with only one other known regular user; Rimbunan Hijau (PNG) Limited.

While the increase in barge traffic on the river is predicted to more than double during the construction period, a magnitude rating of ***Low*** is assigned to the potential for Project barges to disrupt logging vessels during the construction phase, as any delays or disruptions experienced by other river users would be highly localized, and temporary, and can be effectively managed through standard operating procedures and embedded design controls (Section 15.5.3.1). This results in a residual impact assessment rating of ***Minor***.

15.5.6 Summary of Residual Impact Assessment for Commercial Traffic and Transport

The following section provides the assessment of residual impacts related to commercial traffic and transport subject to the embedded design controls in Section 15.5.3. A summary of the residual impact assessments is provided in Table 15.36, including when and where (in which Project phase and location) these impacts are expected to occur.

Table 15.36 – Summary of Assessment of Residual Impact Significance for Commercial Traffic and Transport

Key Sensitivity	Main Activity	Potential Impact	Location of Activity	Project Phase	Mitigation and Management	Residual Assessment	
						Sensitivity/ Magnitude	Significance
Commercial vessels on the Purari River	Logistics and transport (barging along waterways)	Temporary disruption or delay of logging barges using the Purari River.	River transport corridor	C	None.	Medium/Low	Minor

C = Construction.

15.6 References

AMEC Americas Limited, July 2005. Mackenzie Gas Project Effects of Noise on Wildlife prepared for Imperial Oil Resources Ventures Limited.

Ashmore, M., Emberson, L. & Murray, F. 2003. Air Pollution Impacts on Crops and Forests: A Global Assessment. Imperial College Press. UK.

Australian Standard (AS 2021:2015). Acoustics - Aircraft Noise Intrusion – Building Siting and Construction. Sydney NSW.

BoM, CSIRO. 2014. Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Melbourne, Australia: Pacific Climate Change Science Program. Report prepared by the Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation, Canberra, ACT.

Butt, N., Johnson, D., Pike, K,. Pryce-Roberts, N., and Vigar, N. 2013. 15 Years of Shipping Accidents: a review for WWF. A WWW publication accessed 26 November 2019 at http://awsassets.panda.org/downloads/15_years_of_shipping_accidents_a_review_for_wwf_.pdf. Project Report. WWF. Unpublished.

CCDA. 2014. National Climate Compatible Development Management Policy. Report prepared by Climate Change and Development Aurthority, Port Moresby.

CCDA. 2018. Papua New Guinea's First Biennial Update Report to the United Nations Framework Convention on Climate Change. Report prepared by Climate Change and Development Authority, Port Moresby.

CONCAWE, 1981. The propagation of noise from petroleum and petrochemical complexes to neighbouring communities. The Conservation of Clean Air and Water in Europe (CONCAWE), The Hague, Netherlands.

Dawe, G. and M. Goosem,2008. Noise Disturbance along Highways: Kuranda Range Road Upgrade Project. Report to the Marine and Tropical Sciences Research Facility. Reef and Rainforest Research Centre Limited, Cairns (157pp.).

DEC, 2004. Technical Guideline (Additional Information) – Noise Discharges. DEC Publication: IB-Env/03/2004, Port Moresby, PNG.

DEC. 2004. Technical Guideline (Additional information) – Air Discharges. DEC Publication: IB-ENV/02/2004. PNG Department of Environment and Conservation, Environmental Division. Port Moresby, Papua New Guinea.

DECC, 2009. Interim Construction Noise Guidelines (ICNG). New South Wales (NSW), Department of Environment and Climate Change (DECC), Sydney, Australia.

DEE. 2018. National Greenhouse Accounts Factors. Report prepared by Department of the Environment and Energy, Canberra, ACT.

EU. 2010. European Commission Air Quality Standards. A WWW publication accessed on 18 February 2019 at http://ec.europa.eu/environment/air/quality/standards.htm. European Union. Brussels, Belgium.

Hammermaster, E. T. and Saunders, J. C. 1995. Forest Resources and Vegetation Mapping of Papua New Guinea. Papua New Guinea Resource Information Service Publication 4. Commonwealth Scientific and Industrial Research Organisation and Australian Agency for International Development, Canberra, ACT.

HAS. 2009. Air Quality Assessment – Papua New Guinea Liquefied Natural gas Project (Upstream). Holmes Air Science. Sydney.

Holman, C., Barrowcliffe, R., Birkenshaw, D., Dalton, H., Gray, G., Hawker, G., Brett, P., Laxen, D., Marner, B., Marsh, D., Prismall, F., Pullen, J., Stoaling, M., Storey, C., Vining, L., Walker, D. 2014. IAQM Guidance on the assessment of dust from demolition and construction. Version 1.1. A WWW publication accessed March 2019 at www.iaqm.co.uk/text/guidance/construction-dust-2014.pdf. Institute of Air Quality Management. London, UK.

ICEM. 2011. Climate Change Adaptation and Mitigation (CAM) Methodology Brief. A WWW publication accessed on 21 May 2019 at Retrieved from http://www.icem.com.au/documents/climatechange/cam/CAM%20brief.pdf. International Centre for Environmental Management. Hanoi, Vietnam.

ICP. 2017. Chapter III – Mapping Critical Levels for Vegetation. Manual on methodologies and criteria for modelling and mapping critical loads and levels and air pollution effects, risks and trends. International Cooperative Programme on Effects of Air Pollution on Natural vegetation and Crops. Bangor, UK.

IFC. 2007a. General Environmental, Health, and Safety Guidelines, Section 1.1 - Environmental - Air Emissions and Ambient Air Quality. International Finance Corporation, World Bank Group. Washington, D.C.

IFC. 2007b. Environmental, Health, and Safety (EHS) Guidelines – General EHS Guidelines: Environmental – Noise Management, Section 1.7 Noise. International Finance Corporation (IFC), World Bank Group.

IFC. 2008. Environmental, Health, and Safety (EHS) Guidelines for Thermal Power Plants. International Finance Corporation, World Bank Group. Washington, D.C.

IOGP. 2018. Environmental Performance Indicators - 2017 Data. International Association of Oil and Gas Producers, London, UK.

IPCC. 2003. IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG-LULUCF). Report Prepared by Intergovernmental Panel on Climate Change, Kanagawa, Japan.

IPCC. 2006. IPCC Guidelines for National Greenhouse Gas Inventories, Volumes 1 to 5. Report prepared by Intergovernmental Panel on Climate Change, Kanagawa, Japan.

LI and IEMA. 2013. Guidelines for Landscape and Visual Impact Assessment. Edition 3. The Landscape Institute and Institute of Environmental Management and Assessment. London, UK.

Manci, K.M., D.N. Gladwin, R. Villella, and M.G. Cavendish, 1988. Effects of aircraft noise and sonic booms on domestic animals and wildlife: a literature synthesis. U.S. Fish and Wildlife Service. National Ecology Research Center, Ft. Collins, CO. NERC-88/29. 88 pp.

Marine Traffic. 2018. Live Vessel Chart. A WWW publication accessed October 2018 at: https://www.marinetraffic.com.

SLR, 2009. 40-1530-R2R2 PNG LNG Project – Upstream Environmental Noise Impact Assessment prepared for Coffey Natural Systems.

SLR, 2010. 40-1530-R6R0 PNG LNG Project – Semi-Permanent Facility Baseline Noise Monitoring for Coffey Natural Systems.

SLR, 2012. 640.10029-R1D1 Hidden Valley Project – Environmental Noise Impact Assessment, and Noise Management Plan for Morobe Mining Joint Venture.

TCEQ. 2018. Effects Screening Levels. A WWW publication accessed on 5 March 2019 at https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=report.main. Texas Commission on Environmental Quality. Houston, Texas.

TOTAL. 2011. General Specification – Environment – Environmental requirements for project design and E&P activities. Total E&P PNG Limited. Port Moresby.

URS. 2011. Air Quality Impact Analysis for the PNG LNG Project – Upstream Analysis. Report prepared for ESSO Highlands Ltd by URS Corporation. Texas, Houston.

US Department of Transportation Federal Highway Administration (US FHA), September 2004. Synthesis of Noise Effects on Wildlife Populations. Publication No. FHWA-HEP-06-016

US EPA. 2016. US EPA National Ambient Air Quality Standards, 2016. A WWW publication accessed on 5 March 2019 at https://www.epa.gov/criteria-air-pollutants/naaqs-table. United States Environmental Protection Agency, Washington, D.C.

US EPA. 2017. Table of Historical Particulate Matter (PM) National Ambient Air Quality Standards (NAAQS). A WWW publication accessed on 14 February 2017 at https://www.epa.gov/pm-pollution/table-historical-particulate-matter-pm-national-ambient-air-quality-standards-naaqs. United States Environmental Protection Agency, Washington, D.C.

WHO, 1999. Guidelines for Community Noise. World Health Organization (WHO), Geneva.

WHO. 2000. Air Quality Guidelines for Europe. 2nd Edition. WHO Regional Publications, European Series, No. 91. World Health Organization. Copenhagen, Denmark.

WHO. 2005. Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide – Global Update 2005. World Health Organization. Copenhagen, Denmark.

World Health Organization (WHO, 2015). Make Listening Safe. Retrieved from https://www.who.int/pbd/deafness/activities/MLS_Brochure_English_lowres_for_web.pdf. *Geneva, Switzerland.*