

PNG LNG Project

Environmental Impact Statement

Volume 1 Executive Summary

January 2009



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Esso Highlands Limited

PNG LNG Project

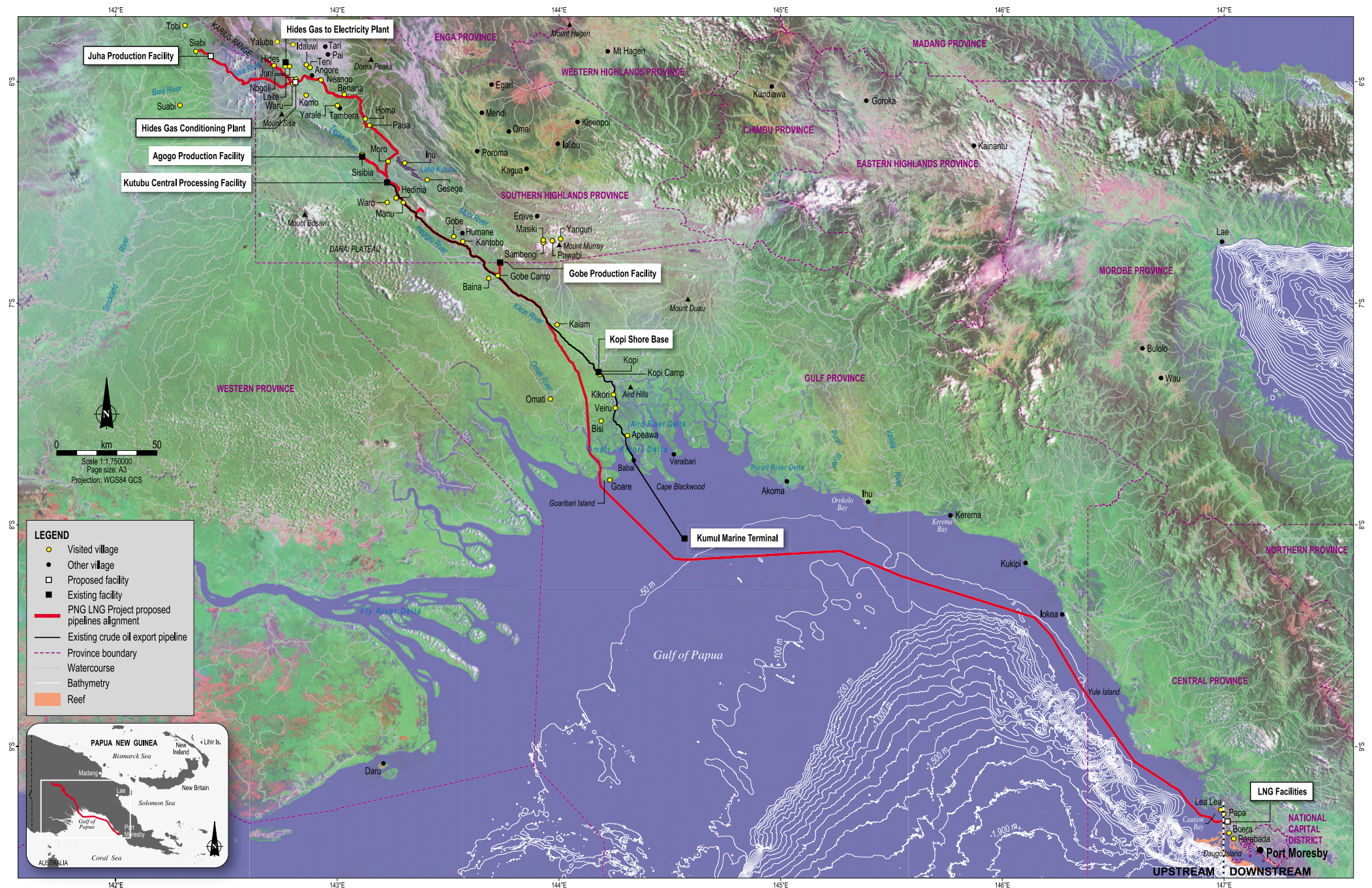
Environmental Impact Statement

Executive Summary



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Note: Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

Figure 1.1 Locality map of proposed project facilities and pipelines

GUIDE TO THE EIS

The Papua New Guinea Liquefied Natural Gas Project Environmental Impact Statement (PNG LNG Project EIS) consists of nine volumes. Volume 1, the Executive Summary, is available in English, Tok Pisin and Motu. Volumes 2 to 9 are available in English only.

A table of contents, including lists of figures, tables, plates, attachments and appendices, can be found at the beginning of Volumes 2 and 3; and each volume of appendices begins with a list of all the appendices.

Volume 1	Executive Summary	Provides an overview of the project impact assessment process and stakeholder consultation for non-technical readers.
Volume 2	EIS Main Report (Parts I and II)	<p>Part I – The Project: Information on the history of the project, its participants, its substantiation, and the guiding legislation; the proposed project elements and the related construction, operations and decommissioning activities; and stakeholder consultation.</p> <p>Part II – Existing Environment: Information on the characteristics of the existing environmental and social conditions of the onshore and marine environments potentially impacted by the project.</p>
Volume 3	EIS Main Report (Parts III and IV)	<p>Part III – Environmental and Social Impact Assessment and Management: Assessment of potential impacts, means of mitigation and management, and predicted residual impacts, as well as discussion of cumulative and associated impacts, project waste management, greenhouse gases, and a hazard and risk consequence assessment. Summary of proposed mitigation and management measures, description of environmental management plans, and ongoing environmental monitoring and reporting.</p> <p>Part IV – Reference: The glossary (which defines technical terms and abbreviations used in the EIS), the bibliography and the study team chapters, as well as the attachments to the EIS.</p>
Volume 4	Appendix 1	Specialist studies.
Volume 5	Appendices 2 to 11	
Volume 6	Appendices 12 to 16	
Volume 7	Appendices 17 to 25	
Volume 8	Appendix 26 (Part 1)	
Volume 9	Appendix 26 (Part 2)	

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1. INTRODUCTION

1.1 Proponent and Project Objectives

Esso Highlands Limited (Esso) proposes to develop the Papua New Guinea Liquefied Natural Gas Project (PNG LNG Project) in a co-venture with other participants (Table 1.1).

Esso (as project operator) will produce and condition gas from new and existing petroleum fields in the Southern Highlands and Western provinces of Papua New Guinea (Figure 1.1), send the conditioned gas by pipeline across Gulf Province and the Gulf of Papua to a 6.3-Mtpa LNG Plant in Central Province, liquefy the gas, and load it onto LNG carriers for export. The project will also produce condensate for export.

The commercial objective of the project is to develop the gas resources from gas fields at Hides, Angore, Juha and South East Hedinia and from the associated gas produced from the Kutubu, Gobe, Agogo and Moran oil fields. For the co-venturers, who are also current oil producers, the project will not only realise the value of the gas, but also enhance oil recovery from their declining oil fields. The PNG LNG Project co-venturers chose to commercialise their gas resources by producing and exporting LNG for the following principal reasons:

- LNG has become tradeable on world markets, and new projects are less reliant on rigid take-or-pay contracts with individual customers.
- Gas transported by pipeline faces the limits of how far gas can be economically piped, and pipeline-transported gas from Papua New Guinea to eastern Australia, the closest market, faces new competition from domestic coal seam methane.

Table 1.1 Co-venturers of the PNG LNG Project and their interest in the PNG LNG Project

Co-venturer	Interest in the PNG LNG Project
Exxon Mobil Corporation (Esso Highlands Limited as operator)	32.9%
Oil Search Limited	28.7%
Santos Ltd	13.7%
AGL Energy Limited*	3.6%
Nippon Oil Exploration Limited	1.7%
PNG state and landowners**	19.4%

*AGL announced on 30 October 2008 that it had executed sale and purchase agreements with an undisclosed international oil and gas company for all its oil and gas exploration and production interests in Papua New Guinea, including its 3.6% interest in the PNG LNG Project.

**The PNG state and landowners consist of the Minerals Resources Development Company (MRDC) with a 2.78% interest in the project, Eda Oil Limited (0.24% interest), and a wholly owned subsidiary of Independent Public Business Corporation of Papua New Guinea (IPBC, 16.39% interest).

- Long-term world demand forecasts for LNG are strong.

The social, cultural and economic objective is to deliver a project that has the potential to benefit local and wider communities at minimal impact on the environment, by:

- Recognising local amenity, values and culture of those people directly affected by the project.
- Managing environmental and social impacts.
- Contributing to the state's economy and human wellbeing.

For national and provincial governments and local landowners, the project will greatly prolong the benefits that they currently realise from the country's oil and gas industry.

Esso intends to reduce impacts on the environment and on affected communities by planning, building and operating the project according to industry good practice, applicable government requirements, realistic community expectations of environmental performance, and international environmental standards.

These objectives are underpinned by the principles and values of the operator and the co-venturers. They are also framed and moderated by the laws and governmental processes of the Independent State of Papua New Guinea in accordance with the customs and priorities of the country.

1.2 Introduction to LNG

Liquefied natural gas (LNG) is an extremely cold, non-toxic, non-corrosive substance that is transferred and stored at atmospheric pressure.

The market for LNG is based on the fact that some customers for natural gas are too far from the gas resource for producers to supply the gas by pipeline. Cooling natural gas to -161°C liquefies it, which reduces its volume by a factor of 600. This reduced volume makes LNG an economical method of transporting large volumes of natural gas over long distances by ocean-going carriers.

Commercial LNG has been produced for more than 65 years and has been safely delivered across the oceans for nearly 50 years. The safety record

of LNG compares well with refineries and other petrochemical plants: only five fatal LNG-specific incidents have occurred at onshore facilities since 1944. None of these facilities was owned or operated by Esso or its sister companies within Exxon Mobil Corporation (ExxonMobil). No fatalities have occurred in connection with shipping of LNG.

1.3 Investment, Revenues and Employment

The project will require a direct capital investment of some K36 billion, is projected to double PNG's gross domestic product to an average of K18.2 billion annually, and will have average recurrent project expenditure of up to K680 million per year. Over the 30-year operational life of the project, gross taxation revenue to the national government is estimated to total K67 billion. Royalty payments are estimated to amount to K5.3 billion and are expected to accrue approximately one-third to provincial governments and approximately one-tenth to local-level governments, with the balance (amounting to more than half the total) going to landowners.

Part of these revenues will comprise tax credits (of nearly K0.5 billion to be spent by Esso on public infrastructure) or will be held in a trust specifically set up to invest in social infrastructure and on behalf of future generations (more than K4 billion).

Construction employment will peak at 12,500 full-time equivalent employees in April 2012. Operations employment

will average 850. PNG Nationals will be a significant proportion of the construction workforce and, in due course, a majority of the operations workforce, as training and experience take effect.

These projections are based on a number of financial assumptions and their implied positive social impacts rest on the view that benefits allocation and distribution processes will be equitable, transparent and accountable.

1.4 No-Project Option

The no-project option foregoes the project's benefits and avoids its impacts. However, it also loses the opportunity to capitalise on synergies with existing petroleum industry infrastructure and human capital. Oil production in Papua New Guinea has some life ahead of it; but, other things being equal, it will become more difficult and expensive to develop the gas fields after oil production has ended.

1.5 The Environmental Impact Statement

This report is the executive summary of the environmental impact statement (EIS) for the PNG LNG Project. Esso has prepared the EIS under s. 53 of the *Environment Act 2000* and under the direction of the Department of Environment and Conservation's (DEC) Section 50 Notice to Undertake an Environmental Impact Assessment, dated 31 May 2007.

The EIS seeks approval for Esso to construct and operate the PNG LNG Project.

Prior to the oil and gas discoveries of the mid 1980s, the PNG LNG Project area was one of the least scientifically understood areas on the island of New Guinea.

The Kutubu Petroleum Development Project (1992, Plate 1.1) and subsequent studies for new petroleum projects has brought a rapid expansion of scientific and social knowledge (Plate 1.2).

Also better understood are the effects of the past 25 years of petroleum exploration and production on the natural and social environments. The developments assessed by this EIS are similar to what has taken place to date and provide the basis for the impact predictions and mitigation measures that Esso proposes for the PNG LNG Project.

Impacts on biodiversity and the people of the project area are the PNG LNG Project's two main issues addressed by this EIS. The accumulated data and information on these subjects especially are voluminous. The impact assessment has therefore been carried out within the appendices, with the results summarised in the EIS itself.

This EIS and its appendices describe the project, the environmental constraints and planning process to date and the impacts and mitigation measures. This analysis is intended to enable the overall environmental and social credentials of the project to be judged and, if the project is to be approved, for conditions to be set.



Plate 1.1 Kutubu Central Processing Facility



Plate 1.2 The South Karius biodiversity field survey camp

The mitigation measures proposed by the EIS for the natural and social environments are based on the project as it is currently defined, and on industry experience generally and in the upstream project area. As the project advances to the next stage of engineering design and construction planning, the mitigation measures will be defined in sufficient detail to be contractually binding on the teams that Esso will engage to build the project.

2. THE PROJECT

2.1 Project Description

The PNG LNG Project will add to existing production fields and facilities developed in Southern Highlands Province in the 1990s. Parts of the project will be built adjacent to or within the footprint of the existing oil production and transport facilities and infrastructure located between Kutubu and Kopi.

The natural gas to feed the LNG Plant will be produced from gas fields at Hides, Angore and Juha (via the Hides Gas Conditioning Plant and the Juha Production Facility), from a gas field at South East Hedinia and from the existing oil fields (via the existing facilities at Kutubu, Agogo and Gobe). The natural gas will be conditioned and then transported by pipeline to the Gulf of Papua and then offshore to the LNG Plant some 20 km northwest of Port Moresby at Caution Bay. Here, the gas will be liquefied and exported by LNG carriers to international customers. The project will also produce a light crude oil (condensate) at Hides and at the LNG Plant. The former will be transported via pipeline to storage tanks at Kutubu and then exported via the existing crude oil pipeline to the Kumul Marine Terminal; the latter will be stored in tanks at the LNG Plant and then exported via condensate carriers.

Figure 2.1 shows the new facilities to be constructed as part of the project and the existing facilities that are part of the oil operations.

Declining reservoir pressures in the gas fields brought on early in the project (e.g., Hides, Kutubu, and Gobe) will

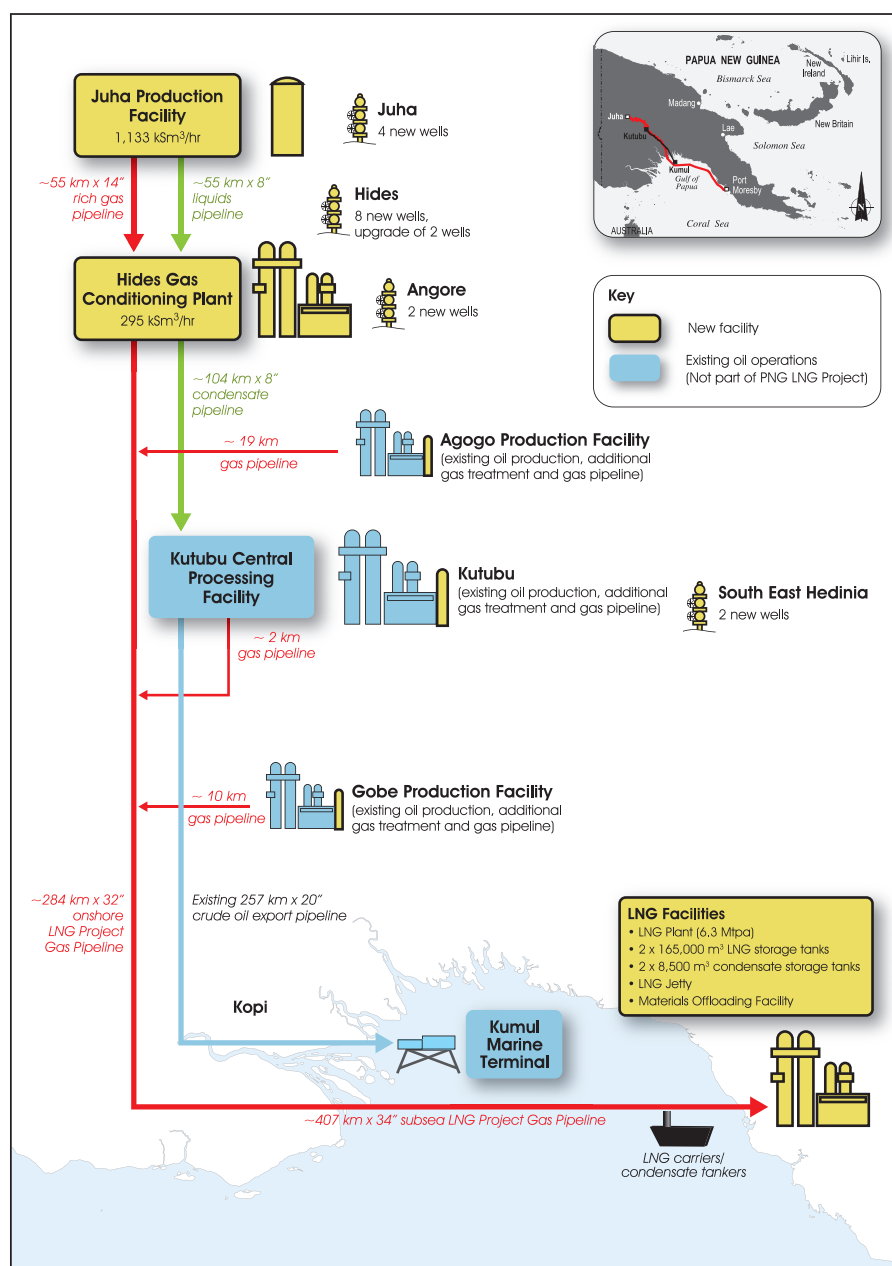


Figure 2.1 Project overview: new and existing facilities and pipelines

require the development of additional wells, gas fields, processing and compression, in order to maintain gas production and quality. The five phases of development are as follows.

Phase 1: Initial Development (2014)

- Field production: three wellpads, six wells, two existing-well recompletions at the Hides gas field.
- Gathering system to bring the gas from the Hides gas field to the Hides Gas Conditioning Plant.
- Hides Gas Conditioning Plant to separate the gas and condensate

and condition the gas as feed for the LNG Plant.

- LNG Facilities: onshore LNG Plant and other onshore and marine facilities and infrastructure (Figure 2.2).
- LNG Project Gas Pipeline onshore and offshore sections from Hides to the LNG Plant.
- Hides–Kutubu Condensate Pipeline from Hides to the crude oil storage tanks at Kutubu Central Processing Facility.
- Scraper station southwest of Kopi.



Figure 2.2 Proposed LNG Facilities site layout

- Gas processing modifications to the Kutubu Central Processing Facility and the Gobe Production Facility.
- Kutubu and Gobe gas pipelines to connect the new gas treatment equipment to the LNG Project Gas Pipeline.

Phase 2: Additional Drilling (2017–2018)

- One wellpad and two new wells at the Hides gas field.
- Two wellpads and two wells at the Angore gas field.
- Gathering system at the Angore field and flowlines to the Hides Gas Conditioning Plant.

Phase 3: Hides Gas Conditioning Plant Booster Compression (2019 nominal)

- Additional booster compression at the Hides Gas Conditioning Plant to maintain gas production volumes.

Phase 4: Juha Gas Field Development (2021–2022)

- Field production: three wellpads and four wells at the Juha gas field.
- Gathering system and flowlines to the Juha Production Facility.
- Separation of gas and liquids: Juha Production Facility to separate gas and liquids.
- Pipelines to the Hides Gas Conditioning Plant.

Phase 5: Associated Gas Developments (2024)

- Gas processing modifications to the Agogo Production Facility to process the gas from the Agogo and Moran gas fields.
- One new wellpad and two wells at the South East Hedinia gas field.
- Gathering system to bring gas from the South East Hedinia gas field to the Kutubu Central Processing Facility.

2.2 Project Development Schedule and Operational Life

A decision to proceed to development by the PNG Government and the

co-venturers in late 2009 would allow the first delivery of LNG to customers in 2013–4, after the first-phase construction period of around four years. The project has a nominal operational life of approximately 30 years.

2.3 Project Logistics

The project construction logistics strategy aims to spread the influx of cargo for the PNG LNG Project between Port Moresby and Lae, as follows (Figure 2.3):

- Overland from Lae to Hides or Moro via the Highlands Highway to Poroma and then via the ring road to Hides or Moro ('Northern Logistics Route').
- By barge from Port Moresby to Kopi Shore Base and then overland from Kopi to Hides via the ring road ('Southern Logistics Route').
- Either overland or by barge from Port Moresby to the LNG Facilities site.
- By air from Port Moresby to Komo Airfield and then by road to Hides.

Public roads that will be upgraded and new public roads, project roads and access tracks that will be constructed are shown in Table 2.1 (and Figure 2.3 for the upstream project area).

Also required will be the following: camps to support drilling, pipelaying and plant construction; laydown areas and fuel depots; vehicle washdown stations (weed and pathogen hygiene); quarries; equipment maintenance facilities; offices; traffic management systems; and environmental and safety safeguards.

3. UPSTREAM ONSHORE PROJECT SETTING, FACILITIES AND IMPACTS

3.1 Upstream Onshore Setting

The environment, in which the upstream onshore components of PNG LNG Project is located, ranges from the northwest–southeast trending ridges

and ravines, karst and incised volcanic landforms of the higher elevations of the Papuan Fold Belt (Figure 3.1) to the Kikori Basin lowlands and delta landforms of the Gulf of Papua (Figure 3.2).

The project area lies mainly within the catchment of the Kikori River system, with Juha to the west in the drainage of the Baia River, a tributary of the Strickland River (see Figure 1.1). Karst landforms predominate as limestone plains, corridor plateaux and polygonal (cockpit) karst, with the volcanic cones and fans of Mt Sisa, Mt Kerewa and Mt Bosavi and fluvial plains, fans and swamps of the Kikori River valley and in upland areas of impeded drainage. This diverse landscape supports twelve bioregions (see Section 3.3), and all but the relatively flat and productive volcanic landforms around Komo remain almost entirely under forest.

Floristic diversity is high, with between 6,000 and 12,000 species of plants present and few weeds.

The fauna is likewise diverse, and endemism is high. The 89 species of non-flying mammals are dominated by rodents (50 species), followed by possums (11; Plate 3.1), macropods (8), cuscuses (6; Plate 3.2) and marsupial carnivores (7). There are 47 species of bats (Plate 3.3), 407 species of birds, 61 species of reptiles and 107 species of amphibians.

Mean annual rainfall varies across the project area, from 2,500 mm at Tari to 4,500 mm at Kutubu and 5,700 mm at Kikori, with relatively low runoff and high infiltration through the karst landforms and thence into aquifers and underground rivers. Smaller rivers through volcanic terrain and the numerous larger rivers carry high sediment loads during higher flows, and there are some areas of impeded drainage, with swamps.

Remoteness, soil infertility and endemic malaria have kept human populations at low densities, and so there has been limited hunting and forest clearing pressure over most of the project area to date.

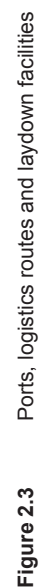


Figure 2.3

Table 2.1 Upgraded public roads and new public roads, project roads and access tracks

Type of Road	Section or Road Involved	Length	Access
Upgraded public roads	Highlands Hwy: Lae–Poroma turnoff Moro–Idauwi via Poroma Poroma–Mendi Hides Gas Conditioning Plant–Juha turnoff Hides Gas Conditioning Plant turnoff–Komo Kopi–Samberigi turnoff Lea Lea Road: Port Moresby–LNG Facilities site	25 km ^Δ 236 km 25 km 2 km 17 km 77 km 22 km	Current and future public access
New public road	Lea Lea Road site bypass road Idauwi–Hides Gas Conditioning Plant	8.3 km 21 km	Future public access
Project roads (upgrades of existing oil project controlled-access roads)	Samberigi Turnoff–Moro upgrade* Gobe Airfield to Gobe Production Facility upgrade Agogo–Moro–Kutubu road	116 km 10 km 17 km	No current or future public access
New project roads	Juha turnoff–Juha Production Facility Idauwi–Dagia River Kutubu Central Production Facility access	57 km 6 km <1 km	No future public access
New wellpad access tracks	Dagia River–Angore Juha turnoff to Hides wellpads Juha Production Facility –wellpads South East Hedinia access	11 km 21 km 8 km 4 km	

^Δ25 km to be upgraded of 604 km total distance.

*Includes 10-km section of new project road between Mubi River and Kantobo.

Species listed under PNG's Fauna (Protection and Control) Act and on the International Union for the Conservation of Nature's Red List in, or likely to be in, the upstream project area include 8 trees, 22 non-flying mammals, 27 bats, 70 birds, 11 reptiles and 5 amphibians. Many of the listed and restricted fauna species are generally under hunting pressure across their range in Papua New Guinea, with critically endangered species comprising several mammals and one plant. No bioregion and no particular part of the project area

traversed by the project pipelines has a concentration of listed species.

Industrial development to date in the Kikori River basin area has involved the oil and gas industry and large-scale selective commercial logging near the coast. With localised exceptions around the main petroleum production facilities at Kutubu and Hides, the historic pattern of sparse population has generally persisted since petroleum production began in 1990 (Plate 3.4).

The PNG LNG Project will broaden to a limited extent the development footprint at the extremities of the existing oil and gas infrastructure and extend the life of the industry in the region by several decades.

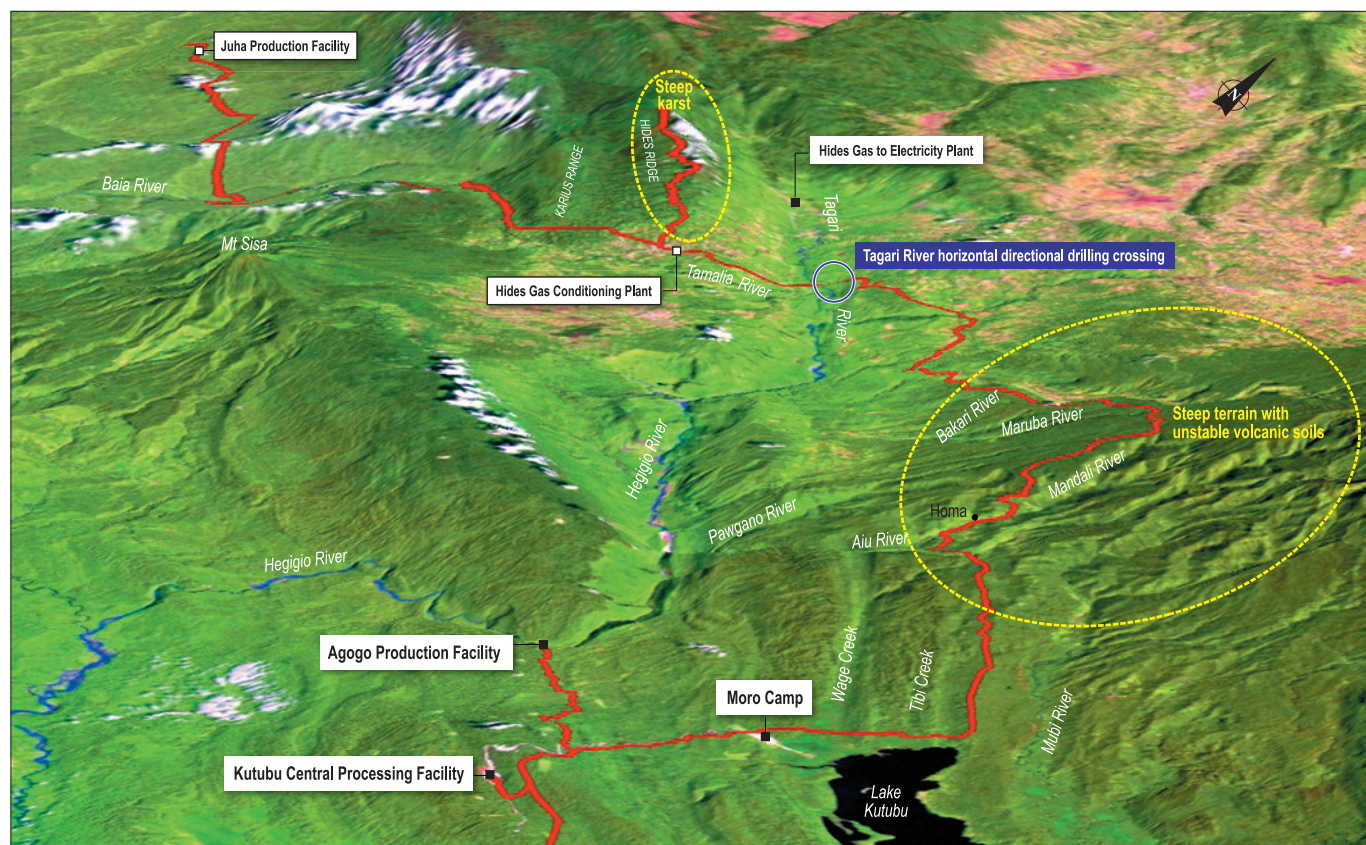
In general, the conservation values of the project area are high; and numerous local-scale landform features, such as sinkholes, pinnacles, towers, caves, springs and waterfalls, are to be found (Plate 3.5). However, these values and features are not



Plate 3.1 Plush-coated ringtail

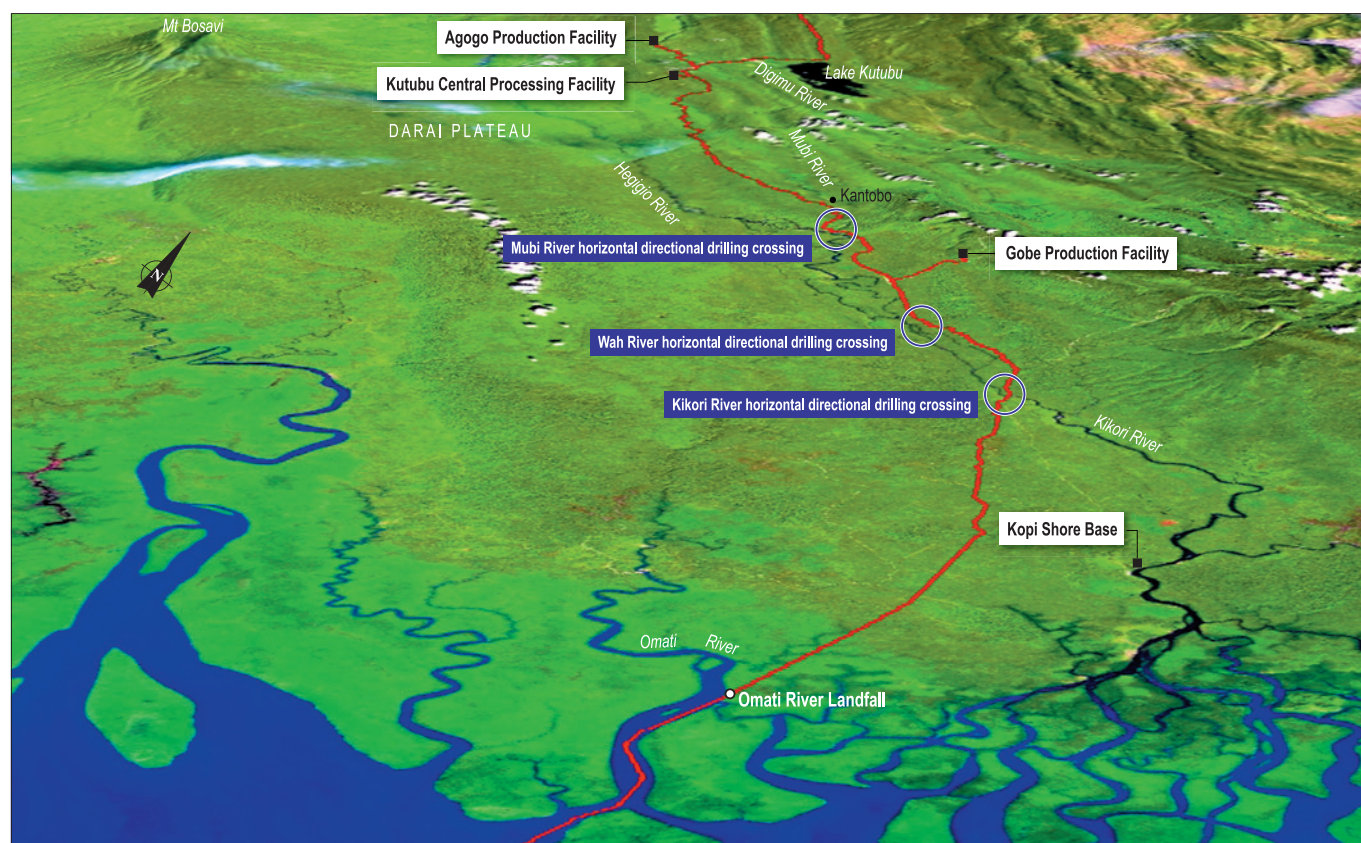


Plate 3.2 Mountain cuscus



Note: Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

Figure 3.1 Digital elevation model: Juha and Hides to Kutubu



Note: Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

Figure 3.2 Digital elevation model: Kutubu to landfall

uniformly exposed to potential impacts from the project. Accordingly, ten noteworthy areas have been identified for which priorities for management and the application of appropriate mitigation measures have been defined. These areas are:

- Low-altitude forest around Juha – remote, inaccessible, sparsely populated and virtually undisturbed, with sixteen species of plants and frogs new to science, generally high biodiversity and a refuge for birds and mammals under pressure elsewhere in their range.
- The lower montane forest with *Nothofagus* on the karst of Hides Ridge – largely undisturbed, with high biodiversity, sixteen plants new to science, rare birds, bats and mammals and three of the five listed frog species. Existing, small-scale gas production wells and flowlines have had little impact on the conservation status of this area.
- High-altitude forest above 1,800 m – volcanic geology but otherwise similar to Hides in biodiversity values, conservation status and management priorities.
- Caves – abundant in the upstream project area but of note because only a few suit the particular habitat requirements of bats.
- Sinkhole swamps – reasonably widespread but locally important as breeding habitat for tree-frogs and other water-dependent frogs in karst, where flowing water is uncommon (Plates 3.6 and 3.7).



Plate 3.3 Near-threatened greater tube-nosed bat (*Nystimene aello*)

- Upland streams – habitat for torrent-dwelling frogs and birds and some rodents.
- Swamp forest – specialist vertebrate habitat (birds, turtles, crocodiles).
- Stable areas in landslide and erosion-prone areas (notably Baia River), such as stream heads and small plateaux – fauna refuges.
- Lowland rivers in stable landscapes – crocodiles, turtles and bird refuges during dry periods.
- Off-river water bodies in unstable landscapes (for example stream damming by landslides) – crocodile breeding habitat (Plate 3.8).

Also of note is the Lake Kutubu Wildlife Management Area – habitat for endemic fish and Ramsar-listed wetland of international significance (Plate 3.9).

These areas will be subject to general and specific mitigation measures.

3.2 Upstream Onshore Facilities and Travelogue

The route of the pipeline right of ways (ROW) has been chosen on the basis of the criteria set out in Table 3.1.

The routing process is ongoing, with final design still to be done to avoid localised special features and constraints. This will be based on ground survey. The routes as they stand now are described below.

Juha to Hides Gas Conditioning Plant (55 km)

Uninhabited and undisturbed forest covers two-thirds of the 55 km from Juha to Hides Gas Conditioning Plant. The ROW alignment, therefore, is the shortest, that can be constructed safely and that avoids steep and unstable terrain. This broadly equates to the lowest level of earthworks and hence of forest clearance and ground disturbance.

From the Juha gas field (950 m ASL), the spines run over a rugged karst plateau (Plate 3.10) to the Juha Production Facility and thence southeast into unstable ground either



Plate 3.4 Kantobo village on the Mubi River



Plate 3.5 Pinnacle and tower karst



Plate 3.6 Sinkhole swamp



Plate 3.7 Tree frog eggs on leaf where tadpoles will hatch and drop into a sinkhole swamp below



Plate 3.8 New Guinea freshwater crocodile (*Crocodylus novaeguineae*) at Baia River



Plate 3.9 Existing road from Moro to Homa running through karst and swampy terrain past the northwest end of Lake Kutubu

Table 3.1 Pipeline route selection criteria

<p>Route Selection</p> <ul style="list-style-type: none"> • Reducing pipeline length • Locating the ROW • Close to existing infrastructure • Parallel to, or using, existing linear disturbances • Away from existing habitation • Facility siting <p>Watercourse Crossings</p> <ul style="list-style-type: none"> • Reducing number, complexity and width of crossings <p>Geotechnical</p> <ul style="list-style-type: none"> • Avoiding steep, unstable longitudinal slopes • Avoiding landslide areas • Minimising side slopes • Minimising active fault crossings • Avoid sinkholes in karst terrain • Minimising exposure to liquefied soils 	<p>Environmental</p> <ul style="list-style-type: none"> • Land use plans • Avoiding site-specific critical wildlife habitat and important cultural or archaeological sites • Socio-economic implications <p>Construction</p> <ul style="list-style-type: none"> • Reducing length of steep, longitudinal and side hill slopes • Reducing pipeline length through wet areas • Reducing required grading • Consider access – shoo-fly roads, main road, etc. • Minimise difficult ground conditions • Reduce number of water crossings • Providing adequate workspace • Sinkhole risk • Slope stability
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side of the Baia River at 380 m ASL. From the river crossing, the ROW climbs through landslide-prone terrain (Plate 3.11) to the swamplands between Karius Range and Mt Sisa (see Plate 1.2) across more settled country up past the southern end of Hides Ridge and down to the Hides Gas Conditioning Plant near Laite at 1,250 m ASL.

Hides Gas Field and Spine **(24 km)**

The ROW along Hides Ridge (see Figure 3.1) runs over rugged polygonal karst at elevations between 1,800 m and 2,800 m. It links the production wells to the spine running 24 km to the Hides Gas Conditioning Plant.

There are currently two existing gas production wells and their flowlines and two undeveloped exploration wells on Hides Ridge, but the area is otherwise

little disturbed. Frequent cloud cover makes for a consistently moist climate, and the trees on the ridge are festooned with epiphytes (Plate 3.12). The biodiversity on Hides Ridge is notable. Similar habitat is to be found on adjacent mountains and ranges to the southwest and northwest.

From Hides Ridge, the spine will descend through cleared and settled country to join the ROW from Juha and thence to the Hides Gas Conditioning Plant (Plate 3.13).

Hides to Moro (88 km)

The ROW from the Hides Gas Conditioning Plant to Moro runs 88 km initially through rolling and heavily gardened country, up steeply rising volcanic terrain through mostly forest with scattered gardens between the Tagari and Dagia rivers and into progressively less disturbed forest and

regrowth forest along the old Tari road. The ROW makes a trenched crossing of the Benaria River (Plate 3.14), then runs around the headwaters of the Bakari and Maruba rivers via the village of Homa to the Kondari River. From here, the ROW generally follows the existing road from Homa to Moro, with fine-scale route design required to skirt cultural heritage sites between Homa and Paua villages. The ROW runs eastwards down the valley of the Mubi River across settled and cultivated medium-crowned to small-crowned forest complexes, before turning south through swamp to the north of Lake Kutubu generally along the existing road to Moro (see Plate 3.9).

Much of this area is partly cleared and settled, but the forested, steep, incised volcanic terrain between the Maruba (Plate 3.15) and Kondari rivers will require major earthworks, with



Plate 3.10 Unbroken low-altitude, medium-crowned forest on the route from Juha to the Hides Gas Conditioning Plant



Plate 3.11 Old landslides, Baia River



Plate 3.12 Hides Ridge very small-crowned forest with *Nothofagus*



Plate 3.13 Area between the road and the Tagari River proposed for the Hides Gas Conditioning Plant

attendant issues of forest clearing, spoil management and the impact of construction-generated sediment on watercourses. The geology reverts to limestone and gentler terrain along the existing road from Homa to Moro (see Plate 3.9).

Moro to Omati River Landfall (196 km)

The ROW will bypass the Kutubu Central Processing Facility and run for 196 km generally adjacent to the easement of the existing Kutubu Crude Oil Export Pipeline past Gobe to cross the Kikori River north of Kaiaam (see Figure 3.2), before deviating south through logged terrain west of Kopi directly to landfall.

From Kutubu, the ROW will initially step down over successive ridges through lowland hill forest to the Ai'io River, before continuing over flatter karst terrain through swamp forest and woodland and finally descending the last escarpment to the confluence of the Mubi and Kikori rivers. At this location, the construction access way will deviate to the west between a point west of Kantobo and the Mubi River (in order to maintain a trafficable grade), while the pipeline ROW will stay within a steep section of the existing crude oil export pipeline easement.

From the Mubi River, the rejoined ROW and access way will follow the existing crude oil export pipeline ROW



Plate 3.14 Possible site of the Benaria River crossing

along the floodplain of the Kikori River through lowland hill forest on limestone pavement and karst featuring some caves and pinnacles. The management focus in this section will be the protection of bat caves. Some 6 km west-northwest of Kaiaam, the ROW crosses the Kikori River before parting from the crude oil export pipeline ROW and running through logged small-crowned, lowland forests of the Kikori River floodplain before threading a path through a low range of polygonal karst clothed in forest complexes, with patches of swamp forest in low-lying areas. From here, the ROW again crosses previously logged forest

either side of Veiru Creek through progressively swamplier terrain on delta sediments to the *Nypa*-fringed landfall on the Omati River (Plate 3.16).

Kopi Support Base

The existing Kopi Support Base and wharf will be extended and upgraded by the PNG LNG Project. These works will also need to negotiate archaeological and cultural sites.

3.3 Upstream Onshore Issues, Proposed Mitigation and Management Measures and Residual Impacts

Issues for Upstream Facilities Planning, Design and Management

The size of the upstream project area, its remoteness, its low human population density and the localised impacts of the oil and gas industry (Plate 3.17) make its biodiversity of almost uniformly high quality and value.

Reducing potential impacts on biodiversity has been a project priority. Moreover, within this overall high-value project area are places that are either of particular conservation note or particularly susceptible to impact. Places which are both (such as Hides Ridge and bat caves) or which are not susceptible but have formal conservation status (such as Lake Kutubu) are priorities for mitigation.



Plate 3.15 The Maruba River near Homa

Managing earthworks has been a major focus of environmental management. The steep, high-rainfall environments are typically dynamic and are dominated by erosional processes (see Plate 3.11). Earthworks in these areas inevitably create fugitive sediment that for practical purposes cannot be contained. The vegetation is adapted to this environment and will generally recolonise disturbed areas and this has been the experience of earthworks for previous petroleum developments. Mitigation has therefore focused on the few situations where this does not happen readily.

By contrast low-relief environments are typically stable and dominated by sedimentary processes. Earthworks in these areas are typically more straightforward except where impeded drainage creates poor ground conditions for construction. Fugitive sediment potential is low, by virtue of both the small volumes of material disturbed and the flat or subdued terrain.

Managing stream water quality and aquatic ecology is closely linked to earthworks design and management. The lower-order rivers tend to be turbid, but can be reasonably clear during low flows. The high-order streams, on the other hand, are generally of low turbidity, except during floods and (infrequently) if there is a landslide in the catchment. Thus protection from



Plate 3.16 Omati River Landfall

fugitive sediment is focused on these higher order, smaller streams.

The implications of this are as follows:

- Direct impacts of construction – mainly clearing and fugitive sediment – should be broadly similar to natural environmental perturbations and are typically of short duration.
- The terrestrial and aquatic flora and fauna are adapted to natural perturbations of the environment and would therefore be expected to survive the direct impacts of project-induced impacts, provided they do not exceed – in nature, intensity or

duration – what occurs naturally. (The co-existence of the biodiversity around Lake Kutubu with more than 25 years of petroleum exploration and production is a case in point.)

- At the same time, all environments will be vulnerable to any impact that persists, which for the PNG LNG Project means any impacting process that the project might introduce but which survives beyond the period of direct disturbance. These are the ‘indirect impacts’: susceptibility to fire, weeds and plant pathogens, and feral pests.
- Within these broad observations are quite specific exceptions. Caves are common, but not so caves able to be colonised by bats. Such caves are therefore regionally important, and their dependent populations are vulnerable to the loss of what could be the roosting or breeding habitat of an entire colony. Lekking areas for birds-of-paradise are similarly important.
- Mitigation focus is twofold: to protect particularly susceptible features from direct impacts; and to pay due attention to preventing indirect impact processes that could survive the period of direct impacts.

The noise and air quality environments of the upstream project area reflect the low level of development. The project will not be a superimposition on



Plate 3.17 Mubi River valve station and existing Kutubu Crude Oil Export Pipeline ROW

pre-existing industrial impacts and so the issue of cumulative impacts does not arise except at existing petroleum production operations.

Specific mitigation measures and impacts are discussed below.

Biodiversity Conservation

The direct biodiversity impacts of the construction and presence of PNG LNG Project facilities will be felt primarily as limited and localised habitat loss due to clearing and edge and barrier effects (Plate 3.18). Table 3.2 shows the directly affected proportion of each of the 12 bioregions of the upstream onshore area (Figure 3.3) and suggests that none will be put at conservation risk directly by clearing.

However, it is the potential indirect impacts that are the most significant. Invasion by weeds or exotic pest fauna, the spread of dieback, over-hunting and facilitating the spread of logging and deforestation can be insidious over time and are by definition not necessarily under the control of the project operator. Nor are they contained within the direct impact footprint, but can spread some distance beyond, and exert a multiplier effect on, what might have begun as a small and localised direct effect. Indirect impacts require both preventative mitigation and monitoring and management attention over the life of the project, notably:

- Adherence to the general petroleum industry practice in the project area of no uncontrolled public vehicle access to project roads (Plate 3.19, see also Table 2.1 and Figure 3.4).
- Quarantine and construction worker and mobile plant hygiene. The absence of weeds and pathogens in the project area to date has been fortuitous. The intention is to systematically reduce this risk during the period of highest risk, which is during construction.
- Fire control.
- Monitoring and remedial action where necessary.

Of the notable habitat areas, Hides Ridge stands out as the most sensitive, by virtue of its rugged karst terrain,

Table 3.2 Estimated habitat losses (ha) from the 12 bioregions

	Kikori Lowlands	Seribi Lowlands	Libano-Hegigio	Darai Plateau	Western Lowlands	Western Foothills	Mubi River Karst	Moro Region	Iagafu-Agogo Limestone Uplands	Western Volcanics	Eastern Upland Volcanics/Karst	Northern Montane Karst	Total
Area of vegetation in bioregion	773,405	97,077	80,234	178,520	50,616	41,381	283,689	23,973	33,617	178,471	415,791	108,322	2,265,096
Primary tropical forest	176	0	0	0	20	208	110	52	125	60	193	111	1,056
Primary tropical forest but with some disturbance	55	0	0	0	0	0	34	68	183	11	51	22	424
Late secondary or heavily disturbed primary tropical forest	53	0	0	0	0	29	61	2	2	7	112	22	288
Other*	414	0	0	0	0	2	232	13	20	151	192	19	1,042
Grand Total	698	0	0	0	21	238	437	135	331	230	548	175	2,811
% of vegetation lost from bioregion	0.0903%	0%	0%	0%	0.0406%	0.5763%	0.1539%	0.5638%	0.9841%	0.1286%	0.1317%	0.1611%	0.1241%

* Includes pioneer/early secondary, gardens, secondary complexes, logged forest and existing facility areas. Also includes river surfaces.

high biodiversity and the slow rates of plant growth potential characteristic of high altitude. Mitigations will focus on reducing construction footprints and damage to the forest edge, managing materials handling, controlling the workforce and, above all, quarantine, plant and pathogen hygiene, fire management and access control. Direct potential impacts on swamps in shallow (and hence most susceptible to sediment impacts) dolines and sinkholes (less than 50 m vertical depth) are predicted to be highest in Hides Ridge, where it is likely some 40 shallow sinkholes lie within 100 m of the ROW for the Hides spinline. These comprise between 5% and 9% of the sinkholes in the 50-km² area surrounding the Hides Spine, with extensive similar habitat on the adjacent Karius Range and in the high country to the northwest of Hides.

Overall, the magnitude of impacts on Hides has been assessed after mitigation as low. However, a significance rating for these impacts of moderate reinforces the management priority that this area warrants.

Of the other noteworthy areas or features in the project area, the swamp forest habitat will not be adversely affected provided appropriate drainage is maintained; measures to this effect are proposed to be adopted. Bat caves and other local-scale habitats will be a



Plate 3.18 Example of pipespread stringing and welding pipe

priority for the biodiversity and social surveys, on which the fine-scale ROW route design will be in part based. Measures to limit clearing and fugitive sediment have been adopted in the alignment of the ROW and in its design. Completed watercourse crossings will be reclaimed and ROW formations will be allowed to substantially regrow once construction has been completed, with provision for active rehabilitation where warranted. The main mitigation measure against indirect effects will be controls against fire, weeds, pathogens during construction and the closure of project roads to public access.

The EIS has assessed the ability of the PNG LNG Project infrastructure to assist future logging. Even if access were to be granted (which it will not be), project roads would offer no more than a very small proportion of the overall requirements for a logging concession.

The project will cross the Kutubu Wildlife Management Area, one of the five formal conservation areas in the project area. The ROW from Hides to Kutubu runs generally along an existing road through moderate terrain and specific mitigation measures are to be applied in this area (see Plate 3.9).

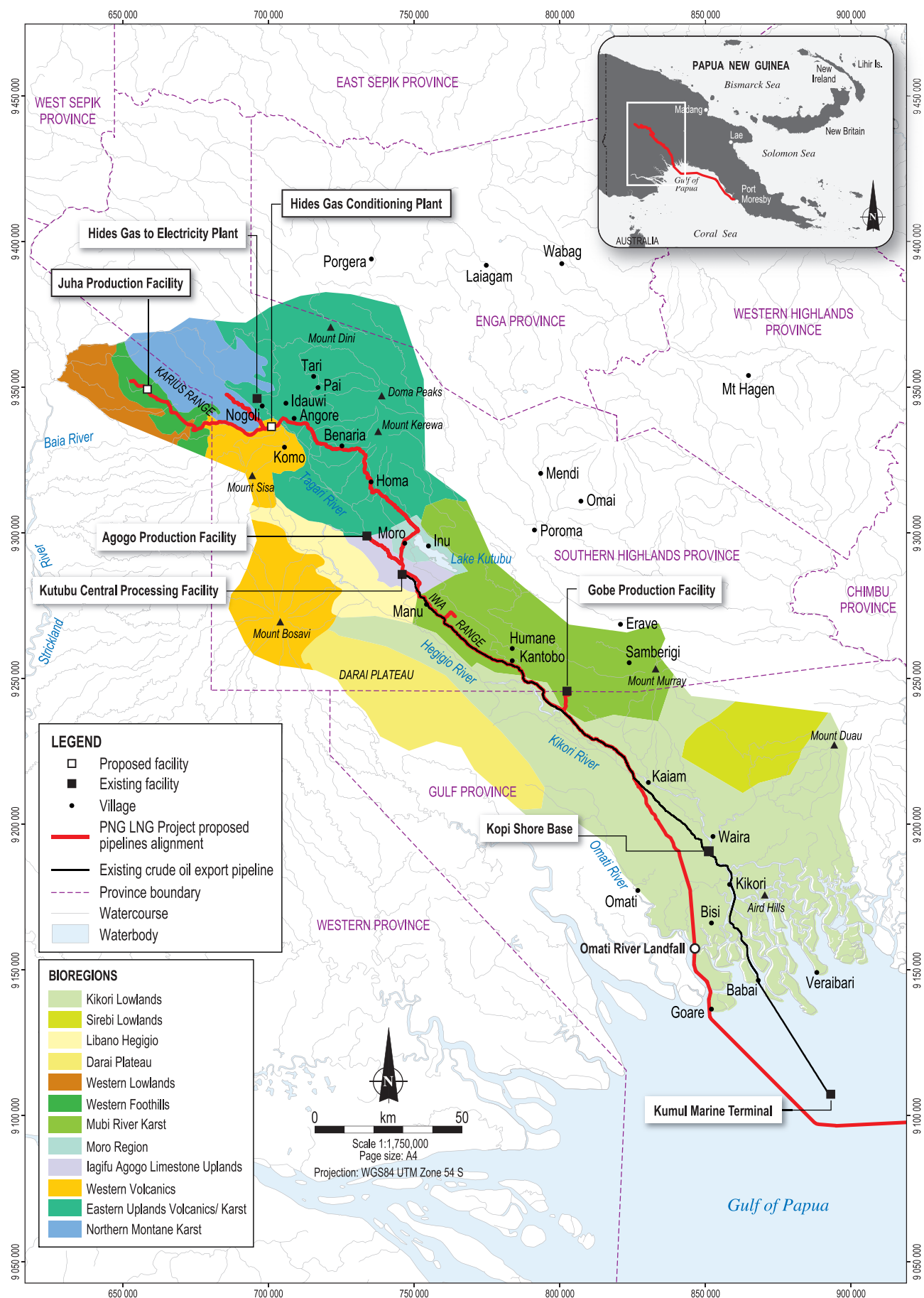
The experience of the existing petroleum developments in the Kikori River basin has shown direct impacts to have been restricted to very close proximity of facilities. Moreover, natural revegetation of reclaimed earthworks is rapid, and so the direct impacts of the project on flora and fauna should be similarly limited and localised (see Plate 3.17). Overall, the EIS has found that the mitigation measures proposed to address potential direct and, especially, indirect impacts on biodiversity should maintain general conservation values and the conservation of individual species of the project area.

Aquatic Environment

Discharges to the aquatic environment, such as sewage effluent, foam returns lost from drilling through cavernous



Plate 3.19 Existing controlled-access petroleum road near the Kutubu Central Production Facility



Note: Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

Figure 3.3 Bioregions of the upstream project area

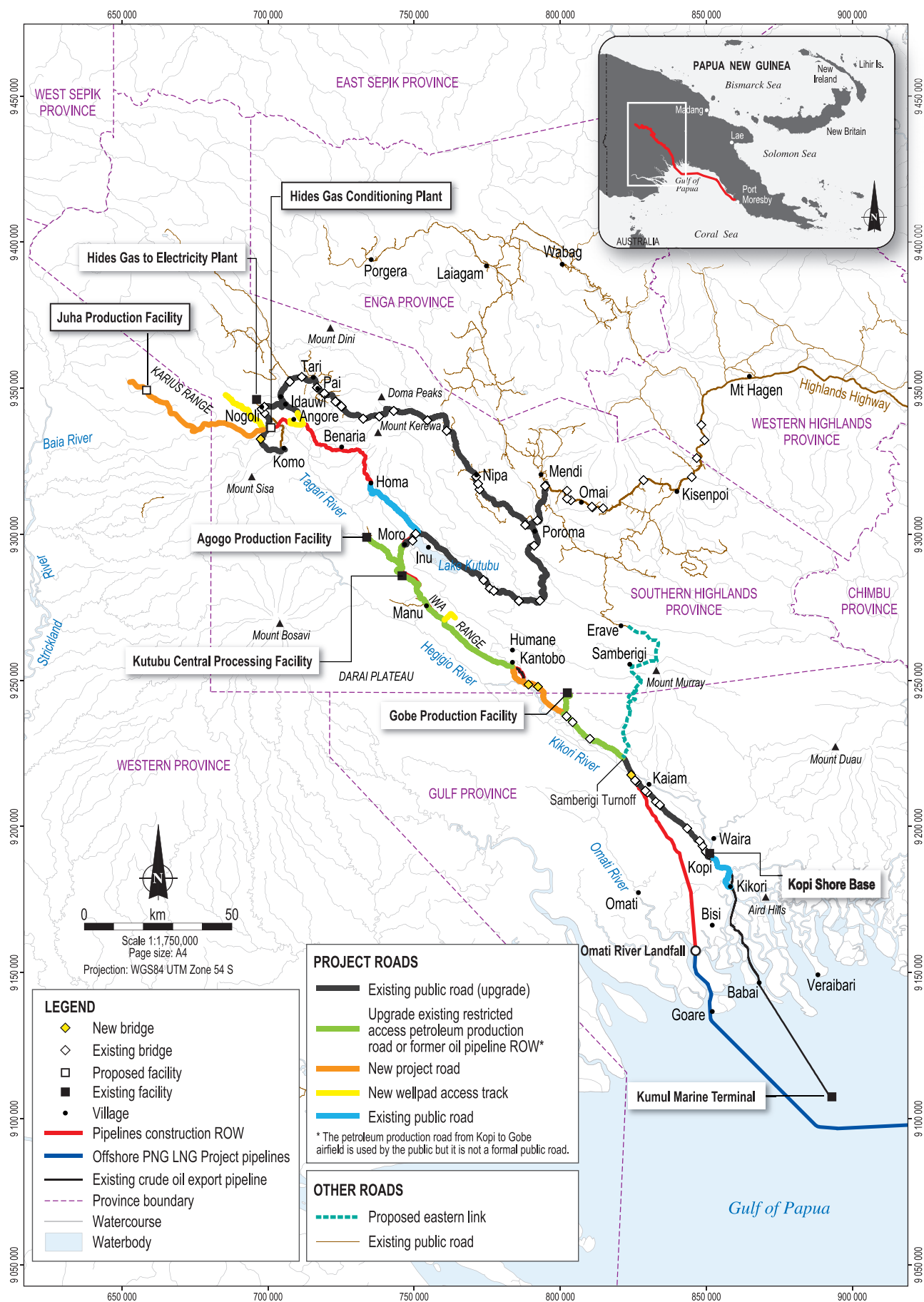


Figure 3.4 Roads, access tracks and bridges (upstream)

limestone and pipeline integrity hydrotest water will be managed to meet environment (waste discharge) permit conditions under PNG's *Environment Act 2000*, and will be monitored for compliance during construction and operations. The main release to the aquatic environment will be fugitive sediment from construction earthworks. For most of the project area (including the catchment of Lake Kutubu), moderate or swampy terrain and, in the steeper areas, limestone, mean that most eroded material will settle close to the area of direct disturbance. The exception will be seen in the 14-km-long section of the pipelines ROW between Homa and Idauwi across the unstable, volcanic soils of the steep upper catchment of the Mandali River (one of the upland streams supporting torrent-dwelling fauna). Here, the sedimentation and turbidity effects of construction earthworks on the aquatic ecosystem of watercourses will be minor in the short term (less than one year) at site scale (within 2 km). The Mandali River is one of a number of similar tributaries of the Hegigio River draining the dissected, steep and sparsely inhabited volcanic footslopes of Mt Kerewa.

The evidence of similar previous works is that natural revegetation is rapid once construction ends (Plates 3.20 and 3.21), and fugitive sediment stops.

Post-construction monitoring will be required to confirm these predictions and reveal if and where remedial work is required to assist the natural revegetation. Specific attention will be paid to Hides Ridge, the valley of the Mandali River and along sections of the existing Moro–Homa public road through the catchment of Lake Kutubu. Remedial work will include active revegetation in areas of ongoing instability and erosion. Impacts on the onshore aquatic environment are predicted to be minimal from the medium term (after one year).

Air Quality

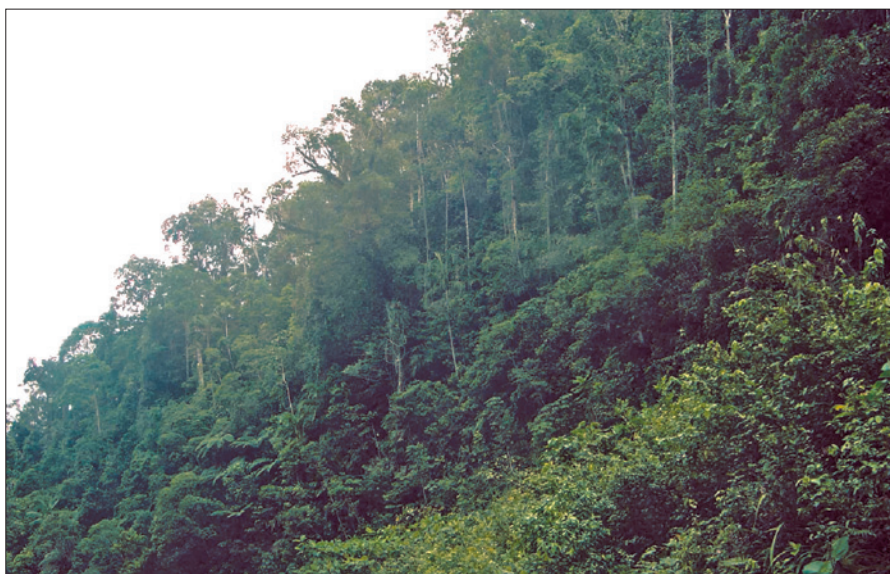
Papua New Guinea has no formal air quality standards, and the project has used assessment criteria based on the guidelines of international authorities.



(1991)



(1998)



(2005)

Plate 3.20 Regeneration of Kutubu to Kopi access way with a sidecast cut on ridge descending into Ai'io River



(1991)



(1998)



(2005)

Plate 3.21 Regeneration of the crude oil export pipeline construction ROW approaching Mubi valve station

The main airborne emissions during construction will be vehicle exhausts. Roads will dust when the weather is dry and will be watered.

The Hides Gas Conditioning Plant will be fuelled by natural gas and emissions of particulate matter, CO and SO₂ will therefore be low. The main air quality indicator will be nitrogen oxides (NO_x). Esso's adoption of low-NO_x burners has substantially reduced gross emissions, and dispersion modelling indicates that air quality targets for NO_x can be readily met at the outer plant perimeter.

The upgrades at the existing processing facilities at Kutubu, Gobe and Agogo required to supply associated gas mainly involve enhanced dehydration and the redirection to the LNG Project Gas Pipeline of gas currently being re-injected into oil reservoirs. The gas compression is already in place and there are no other significant increases in air emissions involved.

Noise

Papua New Guinea has no formal environmental noise standards. The project has therefore proposed targets based on the guidelines of international authorities, in order to maintain living amenity in areas of project activity.

During pipelaying, the peak noise would be unlikely to exceed guidelines beyond distances of 500 m during the day and 1,600 m at night. For dwellings within these zones, however, the periods of exposure will be short (the spreads move at between 300 m and 750 m per day) and work will generally only be carried out during the day.

Drilling will take place around the clock. The most sensitive receptors will come into play at the end of the program, by which time the exact noise signature of the rig will be known and the mitigation and compensation measures able to be defined.

The main noise sources during operations will be the compressors, generators, flares and pressure let-down valves at the Hides Gas Conditioning Plant. Guideline noise values will be met at the nearest sensitive receptors.

4. UPSTREAM OFFSHORE PROJECT SETTING, FACILITIES AND IMPACTS

4.1 Upstream Offshore Setting

The offshore section of the LNG Project Gas Pipeline avoids the terrain, environmental and social issues of an overland pipeline to Port Moresby (see Figure 1.1). It runs 407 km past existing oil export facilities and across two broad subsea environments: the muddy sediments and dead trees of the Gulf of Papua prograding offshore from the deltas of the Kikori and Purari rivers; and the reefs and coral sand lagoons to the east and approaching landfall at the LNG Facilities site on Caution Bay.

The offshore section of the pipeline has taken the most direct route that was able to avoid the oil export infrastructure and unstable areas close to the continental shelf edge (see Figure 1.1).

The offshore section of the Kutubu Crude Oil Export Pipeline runs to the Kumul Marine Terminal 35 km south of Cape Blackwood. The LNG Project Gas Pipeline runs parallel to, but to the west of, the oil pipeline until it can turn east safely to seaward of the platform and tanker anchorage at Kumul.

The pipeline enters Caution Bay through a gap in the barrier reef, crossing the deeper lagoon seabed of terrigenous, silt and clay sediments and avoiding scattered coral bommies closer to shore. The approach to landfall crosses a narrow fringing reef and a band of seagrass, with mangrove and saltflats landward of the shoreline.

4.2 Upstream Offshore Issues, Proposed Mitigation and Management Measures and Residual Impacts

Route selection to avoid coral reefs and conflicts with existing oil export infrastructure has been the principal mitigation adopted for the offshore section of the LNG Project Gas

Pipeline. The seabed sediments to be crossed are extensive and physical disturbance during pipelaying will be localised and transitory. The pipelay spread will add underwater noise and stray light in a similar manner as shipping generally. In the long term, the pipe will lie passively on the seabed. It will be routinely monitored and excessive spanning rectified where necessary. Tropical rock lobsters on breeding migration from Torres Strait across the Gulf of Papua to reefs around Yule Island will need to cross the pipeline and based on previous trials, are not expected to have any difficulty doing so, especially as self-burial will see the pipeline largely or wholly in the seabed for most of its length. The pipeline route does not affect the coastal reefs around Yule Island, where the lobsters spawn on completion of their migration, and where local divers operate a seasonal artisanal fishery. The pipeline crosses the main prawn ground at right angles and runs for most of its length to seaward. The pipeline is designed to withstand trawling but if any prawn trawl gear does become snagged on the pipeline and lost, the owners will be compensated under normal international procedures.

5. LNG FACILITIES SITE PROJECT SETTING, FACILITIES AND IMPACTS

5.1 LNG Facilities Site Setting

From the Caution Bay Landfall (see Figure 1.1), the ROW travels southeast through grassland/open woodland habitat before terminating at the inlet facilities of the LNG Plant (see Figure 2.2). There is a concentration of archaeological sites immediately north of the ROW alignment.

The LNG Facilities site is situated on the coast approximately 20 km northwest of Port Moresby between the coastal settlements of Boera and Papa (see Figure 1.1). The site consists of highly modified savanna and grassland habitats (Plate 5.1). Much of the site was cleared early in the twentieth

century for agriculture and original, intact vegetation is largely restricted to mangroves, areas of melaleuca woodland and the saltflats that persist along the coast and the Vaihua River (Plate 5.2). The mangroves are widest (approximately 600 m) along the Vaihua River and narrow to a break with a small beach just north of the northern section of the security fence. Other remnant vegetation includes areas of gallery forest that persist along the Vaihua River between the mangroves and existing Lea Lea Road and isolated pandanus and low trees on shallow drainage lines running into the Vaihua River.

Like the offshore pipeline approach, the jetty runs at right angles through strips of fringing reef, seagrass and mangrove. The jetty and the access channel for the LNG carriers does not intercept any coral bommies.

5.2 LNG Facilities Site Issues, Proposed Mitigation and Management Measures and Residual Impacts

The LNG Facilities site is relatively flat and for the most part disturbed (Plate 5.3). The mangrove fringe, the estuary of the Vaihua River and concentrations of archaeological sites are the principal natural and cultural conservation assets of the site and the facilities have been arranged to minimise disturbance to the former and avoid intruding on the latter two features altogether. Construction will occur within the site security fence, which encloses some 700 ha, and bulk earthworks, responsible for most of the disturbance, will be limited to about half this area.

Construction works areas will be subject to standard environmental management measures to maintain drainage, control fugitive sediment and test for and if necessary deal with acid sulfate soils.

Construction and operation of the LNG Facilities are expected to present a low overall threat to local biodiversity values if the appropriate mitigation and management procedures are adopted.



Plate 5.1 Grassland with streamside open woodland



Plate 5.2 Mangroves and subtidal wetland/saltflats around the Vaihua River

These procedures are now standard industry practice: quarantine, weed and plant pathogen hygiene, maintenance of critical hydrological processes, minimising vegetation clearance, erosion and sediment control, and prohibitions of burning and poaching.

The listed species of plants and animals, which could or do occur on the site, appear unlikely to be adversely affected by the construction and operation of the PNG LNG Project: the project's footprint will fall almost entirely on land cleared (and since abandoned) for cattle grazing, the loss of the least disturbed habitats is a small proportion of their local occurrence and a very small proportion of their regional occurrence and, on the positive side, some existing threatening process (such as hunting and burning) will be eliminated within the security fence of the LNG Facilities site. The greater risk arises from indirect impacts of squatting and associated poaching (see 'Social Impacts' in Section 6.4.2).

Offshore, the original plan for a long causeway for the Materials Offloading Facility was shown to affect the current and sediment regime of the Vaihua River estuary and has been modified accordingly. The tradeoff—a major increase in dredging, with a short-term water quality and sediment impact but none of the long-term effects of the causeway—has been selected on environmental grounds.

Discharges to the marine environment of Caution Bay, such as pipeline integrity hydrotest water (once-off)

and ongoing treated sewage effluent and brine from desalination water will be treated and controlled to meet environment (waste discharge) permit conditions and will be monitored for compliance. Modelling of the fate of discharged brine, even under conservative assumptions indicates rapid and localised dispersion to harmless levels.

The perimeter security fence around the site establishes a land exclusion zone according to safety criteria. Air quality and noise standards are readily met at the nearest villages.

Figure 5.1 shows the visual effect of the LNG Facilities as a localised industrial landscape viewed from the three nearest vantage points (Figure 6.1).

6. SOCIAL SETTING AND IMPACTS

6.1 Upstream Onshore Social Setting

6.1.1 Population, Land Use and Social Organisation

The upstream PNG LNG Project area occupies one of the most remote and least accessible parts of Papua New Guinea. The region supports a generally sparse local population, which operates a mainly subsistence economy based on sago palm cultivation, slash-and-burn agriculture, and hunting, gathering and fishing. At the same time, however, most of the people of the project area have first-hand acquaintance with the petroleum



Plate 5.3 Mangrove wood harvesting in Vaihua Estuary



Figure 5.1 LNG Facilities photo simulations

industry, including field production, processing and pipelines.

The project area has a diverse sociocultural character, with numerous tribal and language groupings. Social organisation is mainly based on patrilineal descent, which determines all of the important relationships of people to people, people to land, and people to their spiritual beliefs.

Apart from land already taken up for gardens around Hides and Komo, the project area has a very low potential for broad-acre commercial agriculture, and none has developed.

For the proponents of new projects, the most important feature of PNG society is the primacy of small clan groups and their customary ownership and control of land.

6.1.2 Infrastructure and Services

Roads link the Hides and Kutubu areas to the populated parts of Southern Highlands Province and there is a new public road from Kikori to Kopi to Samberigi and thence to Southern

Highlands via Erave, which is nearing completion. Otherwise, roads are for practical purposes absent.

The health status of the population is poor and public health facilities generally inadequate or non-existent unless directly supported by the existing petroleum producers and resources.

The public education system is likewise under-staffed and under-resourced, with literacy averaging 55% for males and 40% for females and very low levels of tertiary qualification (less than 1%).

The direct contribution of the existing petroleum producers to health and education is relatively high, with clinics treating more than 10,000 community outpatients per year and sponsorship support for tertiary students.

6.1.3 Economics and Government

The principal sources of cash income in the upstream project area are wages and royalties from the existing petroleum developments and, to a

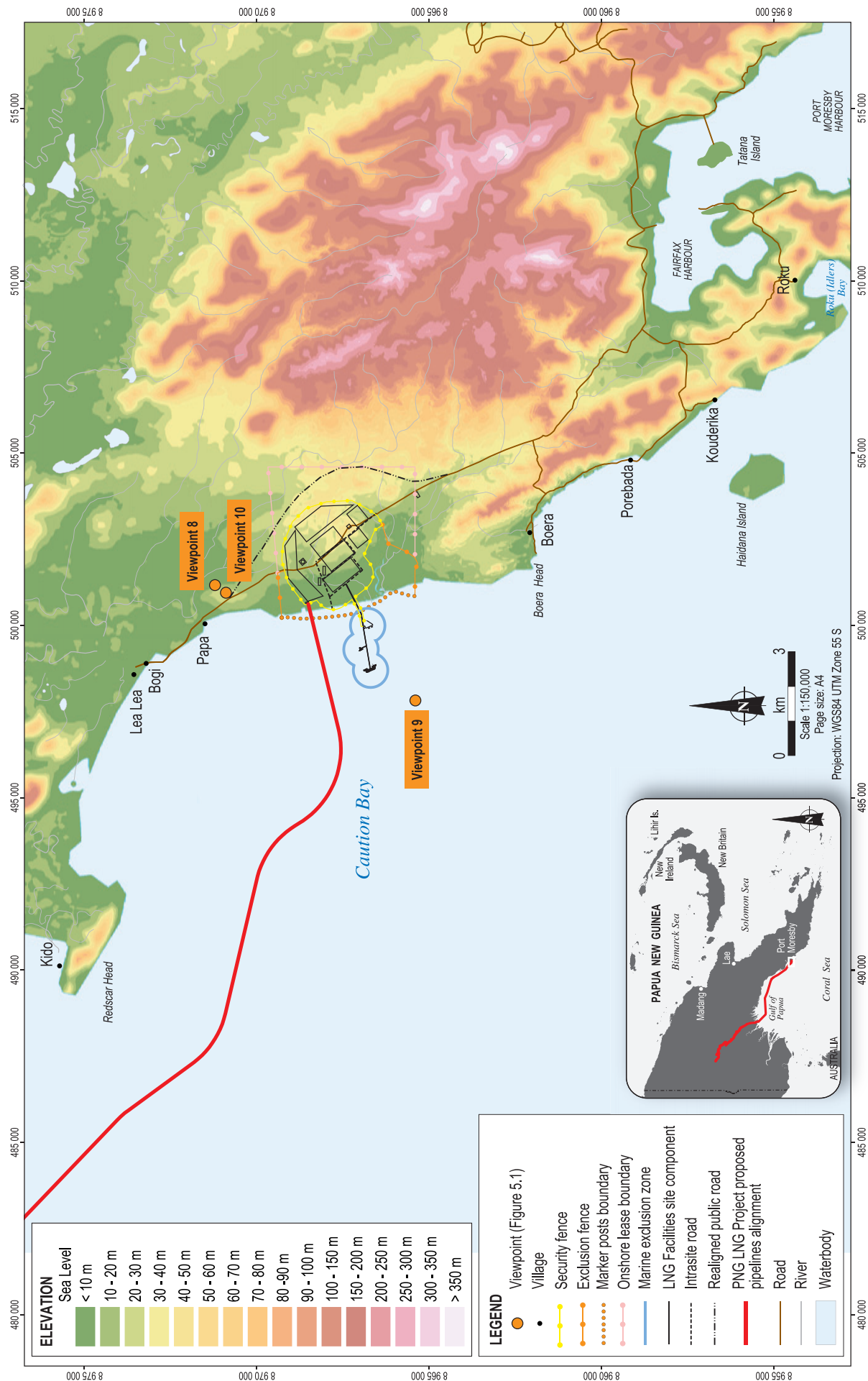
lesser extent, from commercial logging in the Gulf lowlands.

The PNG LNG Project will increase the quantum of benefits and extend their geographic scope and term. As far as all those who own land are concerned, the amount, destination and use of project revenue streams is the PNG LNG Project's single biggest socio-economic issue.

The state-managed negotiation of project benefits between the different levels of government and landholders is mandated by legislation and codified in a formal and structured process. This provides for the negotiation of agreements to share resource project benefits between the various levels of government and landowners and for a process by which the state will manage their distribution.

6.1.4 Attitudes to the Project

The presence of oil and gas production operations over the past 18 years does not appear to have led the affected people to reconsider their long-standing support for the presence and



Note: Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

Figure 6.1 LNG Facilities area roads, villages and viewpoints

expansion of the petroleum industry. Most project-area landowners believe that the project will improve their lives, with Table 6.1 showing support for the project to be greater than 95%, an increase over the already high levels of more than 80% that were recorded as part of the Social Impact Assessment for the 2005 PNG Gas Project.

6.2 Downstream Social Setting

The LNG Facilities site and the four nearest main villages of Lea Lea, Porebada, Boera and Papa (see Figure 5.2) are located within the Hiri Rural Local-level Government area, which has a population of approximately 20,000 at an average density of approximately 10 persons/km².

6.2.1 Population, Land Use and Social Organisation

The people of the four villages are of two different linguistic and cultural origins (Koita und Motu), but co-exist. The social structure reflects patrilineal descent groups and both ascribed and achieved leadership. Historic pressures of migration and warfare have seen individual groups within communities (called *idahu*) merge, incorporate outsiders and split, with increasing emphasis on the land-owning aspect of the *idahu*. Village populations are: Lea Lea – 1,798 in 212 households;



Plate 6.1 Fresh catch of tuna in Boera village

Table 6.1 Attitudes to and opinions of the project

Support for the project:	
• PNG Gas Project 2005*	83%
• PNG LNG Project 2007 – greenfields	95%
• PNG LNG Project 2007 – brownfields	97%
Belief that project would improve respondents' lives:	
• PNG Gas Project 2005 – brownfields	48%
• PNG LNG Project greenfields 2007 – Komo	100%
• PNG LNG Project greenfields 2007 – Juha	75%
• PNG LNG Project greenfields 2007 – LNG Facilities site	78%

*PNG Gas Project was an earlier proposal to commercialise some PNG LNG Project gas fields.

Porebada – 4,510 in 479 households; Boera – 1,310 in 155 households; and Papa – 959 in 114 households.

6.2.2 Economics and Government

The people of the Caution Bay villages of Lea Lea, Papa, Boera and Porebada are heavily dependent on the sea. The principal subsistence and economic activity is fishing, with the surplus catch sold into markets in Port Moresby (Plate 6.1). Agriculture is based on yam, banana and cassava, but soils are poor. Men hunt for deer and wallaby. Villagers operate trade stores along roads, but the incomes are small and erratic.

The PNG Government intends to create the Konebada Petroleum Park to facilitate petroleum developments

based on the commercialisation of PNG's natural gas. Specific plans and arrangements on the ground are yet to be announced.

The villages are represented by 4 of the 18 ward councillors of the Hiri Rural Local-level Government, which has an overall development budget of K100,000. Much of the daily governance of the villages involves the local church, and church tithes (*bobo*) often take precedence over school fees.

6.2.3 Infrastructure and Services

The lack of a reliable, convenient and safe water supply and poor sanitation are the principal infrastructure issues for all four villages. There are aid posts at Papa and Boera and a hospital in Port Moresby. However, health services suffer from the same shortcomings as for the upstream project area and an under-diagnosis of HIV/AIDS and TB is likely.

There are elementary and primary schools in all four villages and a high school in Porebada, but parents favour boys' education over girls'.

The area is well served by roads. Daily traffic averages 500 vehicles at Baruni Junction and approximately 140 vehicle journeys through the Konebada Petroleum Park turnoff, mostly utilities or trucks.

A police station has recently been built at the junction of the road to Caution Bay and the Napa Napa turnoff.

6.2.4 Attitudes to the Project

The attitudes to the project of the people in the vicinity of the LNG Facilities site area have been summarised in Table 6.1, with 'support for the project' nominally at 95% and 'belief that the project would improve respondents lives' at 78%. Improved water supply and better business opportunities were the main answers to the question 'what communal benefits would you like to see from the PNG LNG Project?'.

6.3 Project-wide Social Issues

The most important aspect of the social context of the PNG LNG Project is the local people's ability to adapt their cultural, political and economic situations to introduced industries, institutions and infrastructure. This hybrid culture confronts the values of developed nations (such as gender equity and financial transparency) with the indigenous political reality of secrecy, politico-jural decision-making by men and respect for leadership based on inheritance or 'big-man' status—all of which reflect the political decentralisation and grass-roots empowerment of PNG society.

The higher level challenges that the project faces to bring about the betterment of the host society are as follows:

- The factionalised multi-ethnic composition of the project area.
- The need for modern concepts of 'contract' and other business conventions to engage fluid customary notions of 'agreement'.
- The delivery of government services.
- Prudent investment and financial management.

There are moreover, recurring complaints by landowners about the representation of their interests in equitable and accountable entities and about the process of benefits distribution. On the other hand, workable arrangements require landowners to look beyond narrow,

customary allegiances and rivalries and this change of perspective has not been easy to make.

The EIS notes that the processes of funding and service management will need to change, if the best is to be made of the opportunities that this project brings. There is ample evidence, from women especially, that local people are impatient for current practices to change.

The PNG LNG Project will continue the process of social change in the project area and access to services and commercial opportunities. On the other hand, there will be a number of law and order, public health and social challenges that government will need to address.

In the longer term lie questions of economic dependency and options for sustainable business and services in the future.

6.4 Proposed Mitigation and Management Measures and Residual Impacts

6.4.1 Mitigation Measures

The State has the responsibility for managing the main social and economic issues related to the PNG LNG Project, especially the vehicles for local participation, governance and equity and effectiveness of benefit and service distribution processes.

The planning of these arrangements has been underway for some time and is the subject of renewed rounds of explanatory presentations and consultations in the villages and towns of the project area carried out by government agencies with the assistance of project personnel.

Social impacts in the project area within the control of the PNG LNG Project to mitigate directly lie in the following areas: employment; contributing to health, education and agricultural initiatives (especially those targeted at women); avoiding cultural property and spiritual places; payment of legislatively required compensation in a fair and transparent manner; and consulting with local communities.

Notwithstanding the respective, separate responsibilities of the PNG LNG Project, on the one hand, and the national and provincial governments and landowners, on the other, it is one function of a social impact assessment forming part of an EIS to inform the overall process of managing a project's socio-economic impacts and opportunities. The EIS has therefore set out a full schedule of mitigation measures for the attention severally of the respective parties. Those measures that apply to Esso are commitments, and cover areas such as employment, training and localisation, business development, local content and compensation. The measures that apply to other parties are for them to consider and act accordingly. The topics addressed by the mitigation measures provided for the information of other parties include:

- Representation, equity and transparency in the distribution of project benefits to landowners.
- Government revenue management.
- Government infrastructure planning and service delivery.
- Partnerships for economic diversification projects.
- Conservation and investment of capital wealth.
- Local business development structures and management.
- The status of women and programs.
- Health and welfare information.
- Consistency in benefits management between existing and new projects.
- Law and order.
- Long-term (post-project) economic sustainability.

In all cases, the mitigation measures are intended to address past difficulties of and between the principal stakeholders in oil and gas projects and, especially, to make the most of the opportunities that this new project offers.

6.4.2 Residual Impacts

Revenue

The PNG LNG Project will provide revenue to the project area over a 30-year operational life, as follows:

- Provincial government benefits of K7.4 billion: K490 million from tax credit expenditure, K1.6 billion from royalties and the largest portion, K5.3 million, from development levies.
- The future net dividend income projected to be generated from an notional equity shareholding of the order of 19% held by national and provincial governments and project area landowners, which could total in the order of K37 billion.
- The development levies estimated at K5.3 billion, which will be a considerable boost to the budgets of the Southern Highlands, Gulf, Western and possibly Central provincial governments and their local-level governments, at a rate of approximately K150 million to K225 million a year.
- Tax credits totalling almost K490 million, commencing in 2013 at K12 million per year and gradually rising to K18 million by 2030 and continuing at this level throughout production.
- Contracts awarded to local landowner companies. Estimates of quantum are hard to make, but will be considerable for a project of this scale.
- Personal income to adults (i.e., over 16 years of age) project landowners. Based on the assumptions given above about royalty and equity splits, each individual might receive several thousand kina per annum for the life of the project.

The general arrangement of benefits streams is expected to be as set out in Table 6.2.

On the other hand, if there were to be no PNG LNG Project, the petroleum industry in Papua New Guinea would continue to provide a smaller, but still substantial, flow of income. Projected

government receipts in the period 2008 to 2022 have been estimated to be up to K6 billion (with PNG LNG Project it would be K43 billion).

Social Impacts

Predictions of the PNG LNG Project's social impacts are tempered by the fact that the most important factors will be determined by the actions of other stakeholders in PNG's system of government and social organisation. In general terms, however, the project will continue to provide infrastructure, service, wealth, training and employment opportunities, all of which align well with the development priorities expressed by local people.

In so doing, it will add impetus and longevity to processes of change already in train after nearly two decades of oil and gas production: new forms of representation have arisen; access to non-traditional economic, political and jural institutions has increased; and commercial business developments with shareholding constituencies, democratic decision-making and monetary responsibilities have been created.

On the downside will be the corollaries of industrialisation and modernity, with higher rates of crime, prostitution, and sexually transmitted diseases

(including HIV/AIDS) to be expected. Social conflicts between migrants from Southern Highlands Province seeking economic opportunity and existing populations have been a source of concern in Kopi and Kikori, although new wealth here will be small compared to around the production fields in Southern Highlands itself. On the other hand, people living around Caution Bay have similar concerns but, in their case, with some justification. The LNG Facilities area will attract a range of visitors, including the squatters and rascals that are already an endemic part of Port Moresby society, and government control of illegal settlements and the maintenance of law and order will be a priority for both the project as well and for the local people.

Land and Resource Use Impacts

The broad social and economic impacts of the project centre on change in the balance between subsistence and cash in the local economies of the project area. However, this is a gradual process, and existing subsistence and artisanal activities will remain integral to daily life for some time to come.

As far as land-use and resources are concerned, the project engenders little conflict with existing patterns of settlement and cultivation. The most settled part of the upstream

Table 6.2 Expected PNG stakeholder benefit streams

National Government	Provincial/Local-level Governments
<ul style="list-style-type: none"> • Petroleum income tax • Salary/wages tax • Stamp duty/import duties • Equity dividends • Business withholding tax • Company taxation 	<ul style="list-style-type: none"> • Special support grants • Infrastructure grants • Royalties • Equity dividends • Memorandum of agreement grants • Development levies
Landowners – cash	Landowners – non cash
<ul style="list-style-type: none"> • National wages and training • Landowner company contracts • Community assistance projects • Business development seed capital grants • Memorandum of agreement grants • Scholarships/donations • Future generation trusts • Community infrastructure/services trust • Employment 	<ul style="list-style-type: none"> • Royalties • Land compensation • Land rentals • Equity dividends • Local business company dividends

project area, the site of the Hides Gas Conditioning Plant, will require approximately 20 houses to be relocated, with some dwellings and gardens also affected for wellpads at Angore and Hides.

At the LNG Facilities site, however, the exclusion zone around the causeway and jetty will be a restriction on fishing in Caution Bay and gathering in the mangrove fringe. This loss of income, access and amenity will be subject to compensation and options for access to and between mangroves and reefs are to be discussed further with the people concerned.

Traffic and Road Safety

The construction phase of the project will bring major increases in traffic to the Highlands Highway and the upgraded road from Port Moresby to Caution Bay. The maintenance of traffic flows and safety are a project planning and management priority. Once construction is complete, the upgraded roads will remain as improved public assets.

Disadvantaged or Vulnerable Groups

The ethnic groups in this category are probably limited to the small populations of Onabasalu and Febi living between Hides and Juha. These people have expressed the strongest desire of any project area community for social and economic development and the strongest support for the PNG LNG Project. Indeed many now speak Huli and have already moved to the Southern Highlands mainstream. In other words, the process of change has been underway under their own initiative.

As far as the project is concerned, the primacy of land ownership means that every project area landowner affected by the project has an as-of-right entitlement to project benefits. At the same time, opportunistic outsiders will work to capture these benefits for themselves, and measures have been recommended to alert all landowners to these risks.

The status of women has been a recurring issue across all ethnic groups. In pre-contact times, there was little challenge to the social order, in which women were tied to domestic roles, while men monopolised the politico-legal realm of social action. However, women no longer accept the status quo, and modern development projects (which bring their own employment policies, an emphasis on education and specific support for women's groups) would appear to be a factor (along with churches and other NGOs) promoting this change. They face, however, resistance from male-dominated landowner groups (to whom project benefits have traditionally been paid) and the failure of local level government, in theory women's main avenue to formal political influence at the local level. The outlook, therefore, is of continuing but slow change.

Long-term Economic Sustainability

The Future Generations Trust is the principal vehicle for the conservation of capital wealth created by resource projects in Papua New Guinea. Resource industries contribute to the Trust, and the benefits are payable as cash or non-cash to its beneficiaries (provincial governments, landowners and other entitled parties). The longevity of the PNG LNG Project makes it difficult to speculate on how this wealth may be deployed post-closure but, at K4.4 billion over the project life, the quantum is considerable. The accumulation of capital is a precondition of local investment and ownership of resource development, and the Trust will keep this option open for the future.

7. CULTURAL HERITAGE

The cultural heritage of the project area takes the form of archaeological and historic sites and places of cultural significance to people.

These sites are numerous – a reflection of the intimate relationship with landscape and environment of people living a mainly subsistence life in dispersed rural settlements.

In the upstream project area are sites with discrete locations (such as caves, burials, sacred stone sites, settlement sites and sacrifice sites) and sites comprising broader landscape features (such as sacred lakes, swamps and creeks, spirit sites, limestone outcrops, sacred groves, and plant harvest and hunting areas).

Strategic re-routing has already moved the current ROW alignment away from ritual site complexes between Hides and Moro and away from the numerous rock shelters, old villages, shell middens and caves around Kopi. Most identified sites are at no risk from the future pipeline ROW, but it will be an objective of the detailed route design to avoid the remainder that are in the corridor of the ROW or that may yet be identified.

The cultural heritage of the downstream project area includes old villages, burial, sacred and story sites and scatters of artifacts. There are also the particular artefacts and important places of the *hiri* trade, in which clay pots were manufactured in the area around Port Moresby and carried by *lagatoi* to trade with villages along the Gulf of Papua (Plate 7.1). Post-European contact heritage sites include World War II equipment (Plate 7.2) and crashed aircraft, and churches and other places associated with Christian missionaries.

In both upstream and downstream areas, the project has been able to avoid the most important of the known cultural heritage sites and will avoid by detailed planning and design many of the remainder. Those that cannot be avoided and items discovered during routine preconstruction clearance surveys or earthworks will be recorded or salvaged according to statutory requirements and in consultation with the landowners and the PNG National Museum and Art Gallery.

8. STAKEHOLDER CONSULTATION

The PNG LNG Project has numerous and diverse stakeholders. It is in the project's interests that these individuals and entities understand the project and its implications for them and their interests, and so Esso has devoted corresponding attention to both briefings on progress and understanding and addressing issues.

Departmental briefings at National Government level have typically been held monthly, with additional meetings to deal with specific technical or administrative issues. Provincial and local level governments have been briefed on major project developments.

As is normal practice in Papua New Guinea, particular attention has been paid to the people of the project area. There have since 1998 been some 6,700 household surveys conducted – a population coverage of approximately 40%. For the PNG LNG Project



Plate 7.1 Lagatoi on Port Moresby Harbour

Photo: Biama Kanasa Collection, University of PNG

Land and Community Affairs team, who are responsible for coordinating all community-related field activities, such as engineering and EIS studies.

local organisations and faith-based groups.

Esso maintains a record of all consultations and views expressed. Of the latter, the most frequent have been support for the project, on the one hand, and complaints about the administration, equity and efficiency of the benefits distribution processes of existing projects, on the other. Specific issues have included: future access to bush resources, fisheries and clean water; impacts on coastal processes; the safety of petroleum production facilities; air quality; introduction of pests and diseases; training and education; the life of the local economy after the project's nominal 30-year-life; in-migration by outsiders; social change; and law and order.

A number of these issues are material to the mitigation measures proposed, while others are subject of mitigation by design. In all cases, these matters will be addressed in future stakeholder briefings.



Plate 7.2 2008 Boera battery: gun pit number 2

specifically, two roadshows have been conducted for the villages shown in Figure 1.1: at the scoping stage of the EIS (in November 2007, Plates 8.1 and 8.2) and on the development proposal and of the environmental mitigation measures proposed to be included as EIS commitments (in November and December 2008).

These specific engagements sit within a routine process of community briefings carried out by the PNG LNG Project's

In due course, the Department of Environment and Consultation will conduct its own roadshow, in order to canvass community opinion on the project. The response of the local people to this information will inform the government's assessment of the EIS and conditions.

A variety of non-governmental organisations have been included in the project's publication consultation program, including international and

9. CUMULATIVE AND ASSOCIATED IMPACTS

If the restrictions on public access to oil and gas project roads continue, as they have since 1992, then the potential cumulative impacts associated



Plate 8.1 Papa Project Awareness and Environmental Inception Roadshow presentation (November 2007)



Plate 8.2 Idauwi Project Awareness and Environmental Inception Roadshow presentation (November 2007)

with the PNG LNG Project are likely to comprise population growth at the existing oil settlements in the highlands part of the project area (Moro and Hides area) and Komo, with additional land under cultivation and small-scale logging by villagers to supply sawn timber to local customers. This view is reasonably well grounded in what has actually happened since the oil and gas industry began operations, with sporadic settlement along the existing public road network and almost none beyond it.

The project area, defined as the basin of the Kikori River and an envelope around Juha, comprises some 2.7 M ha. Some 5% (132,000 ha) has been cleared, more than 97% of which has been for settlement and cultivation around Komo and Nogoli and mostly pre-dating the arrival of the oil and gas industry. The balance involves mainly logging, followed by oil and gas production and other infrastructure. It is difficult to predict what clearing might be over the 30-year project life, but an estimate has been made of a further 15,000 ha, mainly cultivation (52%), followed by logging (36%) and the PNG LNG Project itself as assessed by this EIS (12%).

The population in the highlands part of the project area (around Hides in particular) is expected to grow by perhaps 10,000 people, driven by wages and PNG LNG Project benefits generally.

Growth in the 'lowlands' will be substantially less at perhaps a few thousand or so mainly around Kopi and Kikori, driven by project benefits and the new near-completed government road linking Mendi and Kikori via Kagua, Erave and Samberigi (see Figure 1.1).

Mass migration has not occurred previously. New drivers are not evident and none is expected.

Downstream, the PNG LNG Project will, by mere fact of doubling the gross domestic product of the country, have a widespread impact through every sector and every level of the economy of Papua New Guinea. At the site scale, the LNG facilities area will attract squatters, with flow-on impacts on the natural environment, cultural and historic sites, the people of the project area and the project workforce. The PNG Government took action to move squatters on in Port Moresby and Moro in 2008 and will be expected to take similar action at the LNG Facilities site if necessary.

Associated impacts have been defined as those arising outside the project area from the activities of other parties, for example creating value-adding gas-fuelled industries within Papua New Guinea. A number of such developments are being explored by others, with encouragement from the State.

10. GREENHOUSE GAS

The PNG LNG Project is expected to generate greenhouse gas emissions to a maximum of 3.1 Mt CO₂-e per annum. Over the 30-year life of the project, total emissions are estimated at 77 Mt CO₂-e. The low level of CO₂ in the feed gas and the chosen technology mean that the greenhouse gas emissions overall for the project compare favourably with similar LNG operations around the world.

The project will add to Papua New Guinea's total emissions. However, in a global context, the production and export of LNG from this project will represent a reduction in global greenhouse gas emissions compared to the case where customers were to meet their energy requirements by coal, fuel oil or diesel.

11. WASTE

Project waste management will rely on new project facilities or existing co-venturer waste management areas as, in general, there are no suitable waste management facilities available at any of the various localities of the PNG LNG Project. Waste that cannot be recycled or reused will typically be incinerated.

12. HAZARDS

Major hazards are defined as scenarios or incidents resulting from the project that may cause adverse,

off-site impacts in terms of acute or chronic human health issues, injuries or fatalities or major impacts on the natural environment. These are essentially unplanned events, to be anticipated as possibilities, for which either preventative action or reactive responses or both are required. The project's environmental hazard and risk management systems will be based on PNG and international standards and guidelines, as well as internal ExxonMobil standards, philosophies and specifications. Assessments undertaken to date have identified hazardous scenarios, potential receptors and mitigation measures, and this analysis will be progressively refined as the project proceeds through detailed design.

13. MANAGEMENT AND MONITORING

The proposed mitigation measures for the natural environment appear as 223 specific commitments in the EIS. Esso will implement the measures progressively during the project's preconstruction, construction and operations phases as a series of specific, inter-related management plans within the framework of an environmental management system. The natural environmental management plans will include the following topics:

- Ecology, natural habitat and biodiversity.
- Air emissions and greenhouse gas.

- Noise.
- Waste.
- Water and sediment.
- Reclamation.
- Hazardous materials.
- Spill response.
- Dredging.
- Fire.

A total of 51 mitigation measures have been recommended by the social impact assessment to apply to the management of social issues. Some of these are measures beyond Esso's control. They are for the consideration by government and landowners and apply to the issues of benefits sharing and distribution, social services and infrastructure, squatting, and law and order.

In addition, 39 mitigation measures have been recommended by the cultural heritage impact assessment to apply to the management of cultural heritage issues.

Those to be implemented by Esso are presented as commitments that will be addressed by specific management plans covering the following topics:

- Cultural heritage.
- Induced access, resettlement and compensation.
- Employment and training.
- National content.

- Consultation and disclosure.
- Security management.
- Community and workforce health and safety.

Esso will advance its management plans in step with the next stage of engineering design and construction planning, so that the management measures can be defined in sufficient detail to be binding on the contractors that Esso will engage to build the project. Provision will also be made for incident investigation, training, detailed scopes of work, organisational structure for the project's social, security, environment and safety team; staffing, budgets and lines of authority and accountability; reporting procedures; compliance cross-referencing against conditions and standards; quality assurance and control; and baseline monitoring programs to validate the predictions of this EIS.

Where necessary and prior to construction, the existing environmental characterisation data of this EIS will be supplemented with further studies of existing conditions, in order to establish a baseline against which both the implementation of mitigation measures and the EIS's predictions of project-related impacts can be validated by monitoring. The baseline monitoring program will in broad terms cover the scopes of the management plans, but will also address matters arising from the review of the EIS that become a condition of project approval.

Notes

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