Biodiversity Strategy

PNG LNG

Energy for the World. Opportunity for Papua New Guinea.

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BIODIVERSITY STRATEGY

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BIODIVERSITY STRATEGY

Executive Summary

This Biodiversity Strategy is an Esso Highlands Limited document, prepared with the participation of Coffey Environments Pty Ltd.

This Biodiversity Strategy outlines how the Papua New Guinea (PNG) Liquefied Natural Gas (LNG) Project (the Project) has and will continue to manage terrestrial biodiversity in its Upstream Project Area. The Project involves production of natural gas and associated liquids from new and existing wells in the Southern Highlands and Western provinces of PNG. The liquids will be separated and transported via the existing crude oil export pipeline to the Kumul Marine Terminal in the Gulf of Papua for export, while the dry gas will be transported in a buried pipe from the highlands to the Gulf of Papua, then undersea to an LNG Plant near Port Moresby where it will be liquefied and shipped to customers in Asia. The Project is operated by Esso Highlands Limited, an affiliate of the Exxon Mobil Corporation, on behalf of itself and co-venturers. It will be developed in six phases over a period of 16 years, with first LNG deliveries scheduled for 2014.

The Project is primarily located in the Kikori River basin alongside the existing Oil Search oil production operation at Kutubu and gas production operation at Hides. Approximately one-third of the new onshore pipelines in the Upstream Project Area will be co-located within existing pipeline corridors. The Upstream Project Area is known for high biodiversity values and is the site of the Kikori Integrated Conservation and Development Project (KICDP, now called the Kikori River Program), a World Wide Fund For Nature[1](WWF) conservation initiative supported initially by Chevron Asiatic Ltd and now by Oil Search Limited.

This Biodiversity Strategy draws extensively on the PNG LNG Project Environmental Impact Statement (EIS) and its Environmental and Social Management Plan (ESMP). These in turn relied on biodiversity impact and management analyses of field data collected by WWF in its KICDP operations and new surveys carried out by Esso Highlands Limited from 2005 to 2009. This Biodiversity Strategy is designed to align with PNG legislation, International Finance Corporation (IFC) Performance Standard 6 and ExxonMobil policy.

The preparation of this Biodiversity Strategy followed a process of first identifying high biodiversity values in the Upstream Project Area and then using the impact analysis in the EIS to identify the major potential risks to, or impacts on, these values. This then formed the basis for developing goals and objectives for the strategy, which then followed the generally accepted hierarchy of avoidance, mitigation and offsetting of residual impacts. Finally a Biodiversity Monitoring Plan is designed to gauge the success of the strategy.

Based on the surveys conducted over the past 15 years, biodiversity values are defined for the Upstream Project Area as a whole. These are: i) extensive intact forest, (ii) high floristic diversity, (iii) high faunal diversity, (iv) endemic species, (v) unique assemblages of species, (vi) species of conservation concern and (vii) biodiversity of importance to local communities for resource use and cultural and spiritual purposes.

The goal of this Biodiversity Strategy is to retain the biodiversity values of the Upstream Project Area on a regional scale for the long term. In order to achieve this goal, the following objectives have been defined: (i) to maintain the ecological intactness of the Upstream Project Area as a whole; (ii) to conserve the priority ecosystems; (iii) to protect focal habitats; and, (iv) to account for residual impacts. In order to achieve these objectives, avoidance, mitigation and monitoring of biodiversity values will take place at three levels: (i) the large scale, which is the entire Upstream Project Area; (ii) the medium scale, which is represented by particularly valuable areas called ‘priority ecosystems’; and, (iii) the small local-scale which are sensitive habitats referred to as ‘focal habitats’.

[1] WWF is known as World Wildlife Fund in North America.

Avoidance of impacts on values was carried out in the design phase of the Project and involved a consideration of several high-level routes both within and beyond the Kikori River basin and six alternative pipeline alignments within the Upstream Project Area. These routing analyses involved a 4-level approach: level 1 was to follow existing infrastructure corridors wherever possible; level 2 was managing safety, social and environmental constraints; level 3 was reducing interference with existing petroleum infrastructure and level 4 was cataloguing constraints for later micro-routing in preconstruction surveys. The priority ecosystems received particular design consideration and are discussed in detail. Avoidance of focal habitats is being achieved by preconstruction surveys for all proposed worksites.

Site-specific mitigation measures are contained in the ESMP, which includes 30 individual management plans. Relevant mitigation measures to the implementation of this Biodiversity Strategy are as follows: Ecological Management Plan; Weed, Plant Pathogen and Pest Management Plan; Induced Access Management Plan, Erosion and Sediment Control Management Plan; Reinstatement Management Plan; and Water Management Plan. In addition, the introduction and spread of alien species and diseases and enhanced access are managed under a project-wide Quarantine Plan, which is designed to reduce the probability of alien species entering into the country.

A Biodiversity Offset Delivery Plan will be developed following this Biodiversity Strategy. The plan requires consultation with stakeholders before particular projects or management systems are finalized. As consultation with stakeholders is yet to be undertaken, a final offset plan cannot be described at this point in the Biodiversity Strategy. Instead, this document presents the criteria that offset projects are required to meet, which need to be related to the identified values and residual impacts, and canvasses the management options for the Biodiversity Offset Delivery Plan. Biodiversity offsets undertaken by the Project will be tailored to PNG conditions where landholders are the dominant factor in conservation management.

Lastly, Esso Highlands limited is developing a Biodiversity Monitoring Plan to determine if the objectives of this Biodiversity Strategy have been met. It is complementary to the ESMP and will determine, in the longer term, whether the objectives of the Biodiversity Strategy have been met. While ESMP monitoring is construction-related, the Biodiversity Monitoring Plan will mostly be carried out during operations. Monitoring is aimed at the biodiversity values at the three scales. For each value at each scale, a set of targets is defined, each with an end-point. It is impractical to develop an individual monitoring system for each of the many high biodiversity values in the Upstream Project Area. Instead, a suite of five Programmed Monitoring Activities (PMAs) was conceived, each designed to gather information for indicators for many targets, so that a minimal number of data-gathering activities can inform the maximum number of targets. One of the PMAs involves remote sensing, three involve regular collection of field data and one involves regular compilation of data from elsewhere.

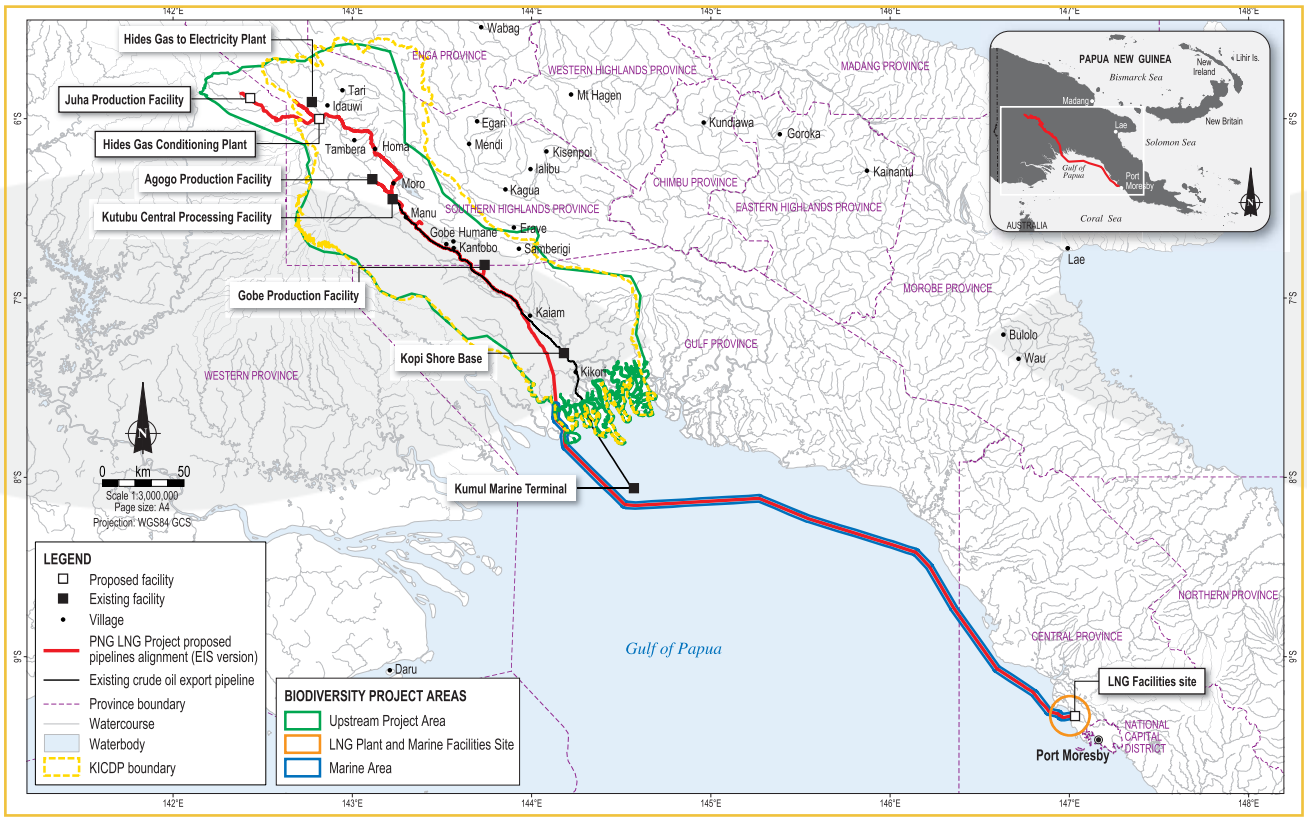
1.0 Introduction

The Papua New Guinea (PNG) Liquefied Natural Gas (LNG) Project (the Project) aims to commercialize the gas resources in the Hides, Angore and Juha fields and associated gas resources in the Kutubu, Agogo, Gobe and Moran fields in the Southern Highlands and Western provinces of PNG.

The Project will be operated by an affiliate of ExxonMobil Corporation, Esso Highlands Limited, in co-venture with parties including Oil Search Limited, Kroton No. 2 Limited, Santos Ltd, Nippon Oil Exploration Limited and Mineral Resources Development Company Limited (MRDC) on behalf of Project Area landowners.

The Project is an integrated phased development that includes gas production and processing facilities in the Southern Highlands and Western Provinces of PNG, liquefaction and storage facilities located northwest of Port Moresby on the Gulf of Papua and over 700 kilometers (450 miles) of pipelines connecting the facilities (Figure 1.1).

Figure 1.1: Project Areas



The investment for the initial phase of the Project, excluding shipping costs, is estimated at US$15 billion. Over the life of the Project, it is expected that over 9 trillion cubic feet of gas will be supplied to major LNG customers in Asia through long-term sales agreements, including Chinese Petroleum Corporation, Taiwan; Osaka Gas Company Limited; The Tokyo Electric Power Company Inc.; and Unipec Asia Company Limited, a subsidiary of China Petroleum and Chemical Corporation (Sinopec). The first LNG deliveries are scheduled to

begin in 2014, following a construction period of about four years.

Esso Highlands Limited recognizes that it is operating in a high biodiversity[2] country and that the Project Area itself has high biodiversity values. Moreover the ecosystems services within the Project Area are likely to be significant at several scales from local to international. Ecosystem services are the 'processes by which the environment produces resources that we often take for granted such as clean water, timber, and habitat for fisheries, and pollination of native and agricultural plants'[3]. Ecosystem services include (i) provisioning services, which are the products people obtain from ecosystems; (ii) regulating services, which are the benefits people obtain from the regulation of ecosystem processes; (iii) cultural services, which are the nonmaterial benefits people obtain from ecosystems; and, (iv) supporting services, which are the natural processes that maintain the other services. The range of services extends beyond the physical to psychological, cultural and spiritual support that nature provides humanity[4]. In a country like PNG where most inhabitants are subsistence cultivators who rely directly on the forest for their everyday needs ecosystem services are of particular relevance. Esso Highlands Limited recognizes the direct role of ecosystem services in meeting the subsistence, cultural and spiritual needs of the people of PNG and as such is committed to maintaining the ecological integrity of the Project Area[5].

Plate 1.1: The gecko *Cyrtodactylus*

Plate 1.2: Juvenile cassowary

Plate 1.3: *Melodinus forbesii* found on Hides Ridge

This Biodiversity Strategy document presents a multi-faceted approach to biodiversity management, which reflects good international industry practice.

The Project is generally described in terms of general areas, which include the Upstream, Marine and LNG Plant areas (see Figure 1.1) as discussed below.

The Biodiversity Strategy follows a 6-step process. **Step 1** involves the identification of biodiversity values and the major potential risks to such values. **Step 2** involves the development of goals and objectives for biodiversity management. **Steps 3**, **4 and 5** involve the formulation of measures to prevent, avoid, manage and mitigate identified risks and where this is not possible, identify need for offset. Offset planning is not completed at this stage and awaits final development following consultation with stakeholders. **Step 6** is the development of a Biodiversity Monitoring Plan (monitoring is also subject to further definition subject to field trials of methods). The process is further described in Chapters 5 to 10 of this Biodiversity

[2] For the purpose of the Biodiversity Strategy, the term 'biodiversity' (or biological diversity) is defined in Article 2 of the Convention on Biological Diversity as the 'variability among living organisms from all sources including, inter alia terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part: this includes diversity within species, between species and of ecosystems'. (http://www.cbd.int/convention/articles.shtml?a=cbd-02).

[3] www.esa.org/education_diversity/pdfDocs/ecosystemservices.pdf.

[4] For a detailed presentation of ecosystem services see the Millennium Ecosystem Assessment, 2005 (www.millenniumassessment.org and http://www.maweb.org/en/index.aspx and for a short introduction see, for example, Ecological Society of America, 1997).

[5] This document is not intended to provide an ecosystem services analysis.

Box 1.1: Biodiversity in Papua New Guinea

New Guinea is the world's second largest island. It has the third largest block of unbroken tropical rainforest in the world and the largest remaining tract of primary rainforest in the Asia–Pacific region[a]. New Guinea's rich biota includes between 5 and 10 percent of the world's plant and animal species on less than 1 percent of its land surface.

Pinnacle and tower karst countryside

Mountain cuscus

On a national basis, New Guinea ranks sixth in the world in terms of endemism[b] for mammals, birds and amphibians. In terms of species per 1,000 square kilometers, New Guinea ranks fifth for mammals, ninth for birds and second for amphibians. The high degree of floral endemism and the fact that many plant families are better represented in New Guinea than anywhere else indicates strong independent development of the biota of New Guinea over a long period of time and, in particular, that New Guinea has developed its own flora. Similarly there are high levels of endemism at both genus and species level in the mammals (Flannery, 1995; Bonaccorsco, 1998), the majority of which are obligate forest dwellers.

Few New Guinean mammals or birds have very small natural ranges and, amongst mammals at least, most of these narrow range species are on isolated ranges, e.g., the Tenkile (*Dendrolagus scottae*) in the Torricelli mountains, and those in the main cordillera are mostly inhabitants of subalpine habitats (e.g., the rodent Mallomys gunung). New Guinea has been the centre of diversity for the birds-of-paradise, bowerbirds, Australasian 'robins' (*Petroicidae*), cassowaries and owlet-nightjars, and is the only place in which berrypeckers, longbills and pitohuis are found (del Hoyo et al., 1999; 2007; 2008; Mack & Dumbacher, 2007). Of the more than 800 bird species recorded in New Guinea, some 330 are endemic (Coates, 1985; Beehler et al., 1986).

Papuan frogmouth

The tree frog *Litoria* cf. *arfakiana*

The herpetofauna of New Guinea consists of over 600 species recorded so far (Menzies, 2006; Allison, 2007) and expected to increase substantially, with up to 600 frog species expected (Gunther, 2006). This estimate is supported by recent taxonomic revisions of the fauna and exploration of remote regions that have discovered numerous new species, particularly of frogs (e.g., Richards, 2007) and the gecko genus *Cyrtodactylus* (e.g., Rösler et al., 2007; Oliver et al., 2008).

IUCN-listed species in Papua New Guinea

	IUCN status*						
Species Groups	**CR**	**EN**	**VU**	**NT**	**LR/cd**	**DD**	**Grand Total**
Mammals	11	18	12	12		46	99
Birds	1	1	34	47		15	98
Reptiles	2	3	4	1			10
Frogs	1		10	0		114	125
Fishes	6	2	30	35	0	43	116
Invertebrates	0	9	160	155	3	51	378
Plants	14	19	15	26	7	113	194
Grand Total	35	52	265	276	10	382	1,020

*CR: critically endangered, EN: endangered, VU: vulnerable, NT: near threatened, LR/cd: low risk/conservation dependent, DD: data deficient.

For probably all biological groups except birds, discovery of new species and major range extensions will continue as surveying continues; large areas of the island still remain unexplored biologically. Moreover, modern taxonomic research is uncovering many new species in existing collections. For example, studies of New Guinean 'moss-mice' collected since the last major revision of the 1950s has raised the diversity in this group from 6 to 15 species (Helgen & Helgen, 2009; Helgen et al., 2010), with more species still to name.

Over a thousand species from PNG are listed by IUCN. One third of these are data deficient reflecting the limited biological knowledge of New Guinea. The table shows the breakdown by species groups.

[a] http://www.thebiggive.org.uk/project.php?project_id=5217.

[b] Endemic species are those that are only found in a given region or location and nowhere else in the world.

2.0 The Project Area, History and Proposed Developments

2.1 OIL AND GAS DEVELOPMENT IN THE REGION

Oil was first discovered in PNG in 1911, but it was not until the 1980s that commercial reserves of oil and gas were found in Southern Highlands Province. Gas production began at Hides in 1991, followed by oil production at Kutubu (Kutubu Petroleum Development Project) in 1992. In 1995, Chevron Asiatic Ltd proposed the first gas project in PNG (the PNG Gas Project) to build on this established petroleum production infrastructure by commercializing gas from Kutubu, Gobe, Agogo and Moran and exporting the gas by pipeline to Australia. The PNG Gas Project underwent a series of feasibility, socio-economic and environmental investigations in the years that followed but went into abeyance in 2000. Shortly thereafter, Chevron sold its PNG petroleum interests.

Plate 2.1: Gobe Production Facility

By 2004, the PNG Gas Project's competitive position had improved and the project was revived, with Esso Highlands Limited as the operator. In late 2004, Esso Highlands Limited proceeded to front-end engineering design and an environmental assessment, which received an Approval-in-Principle from the PNG Government, but, for commercial reasons, the PNG Gas Project went into abeyance once again at the end of January 2007.

The studies conducted by Esso Highlands Limited for the PNG Gas Project encouraged licensees of the gas fields at Hides, Angore and Juha to enter into an agreement to evaluate production and export of LNG as an alternative to previous gas project proposals. The PNG Government-approved PNG LNG Project is the successful outcome of these latter collaborations.

2.2 KIKORI INTEGRATED CONSERVATION AND DEVELOPMENT PROJECT

In recognition of the high biodiversity in the area, the Kutubu Petroleum Development Project and the World Wide Fund For Nature (WWF) established a collaboration in 1994 aimed at facilitating conservation efforts in the Kikori River basin via an Integrated Conservation and Development Project (ICDP) whereby WWF works with local communities to foster conservation through sustainable development activities.

To achieve this, a Kikori ICDP (KICDP[6]) area was defined that encompassed the entire drainage of the Kikori River extending over 300 kilometers from the Southern Highlands to the coast and which includes the existing oil export project and both previous gas projects (see Figure 1.1). This area was defined on a catchment basis and in order to focus on conservation to counteract possible indirect impacts should in-migration occur[7]. The KICDP area is now known as a significant conservation management area, although not legally declared as such, and thus has major relevance to biodiversity conservation in New Guinea.

2.3 THE PROJECT AND PROJECT AREAS

The Project has been divided into three geographical segments – the Upstream Project Area, the Marine Project Area and the LNG Project Area (see Figure 1.1). The Project itself is to be undertaken in a series of development phases (Figure 2.1 and Table 2.1), with Phase I scheduled to commence operations in 2014 followed by additional developments in subsequent years. A detailed description of the Project is provided in Appendix 1 and the locations of major facilities are shown in Figure 2.2.

[6] Now termed the Kikori River Program.

[7] This was considered to be the most significant potential impact of the oil development.

Figure 2.1: Indicative project development schedule

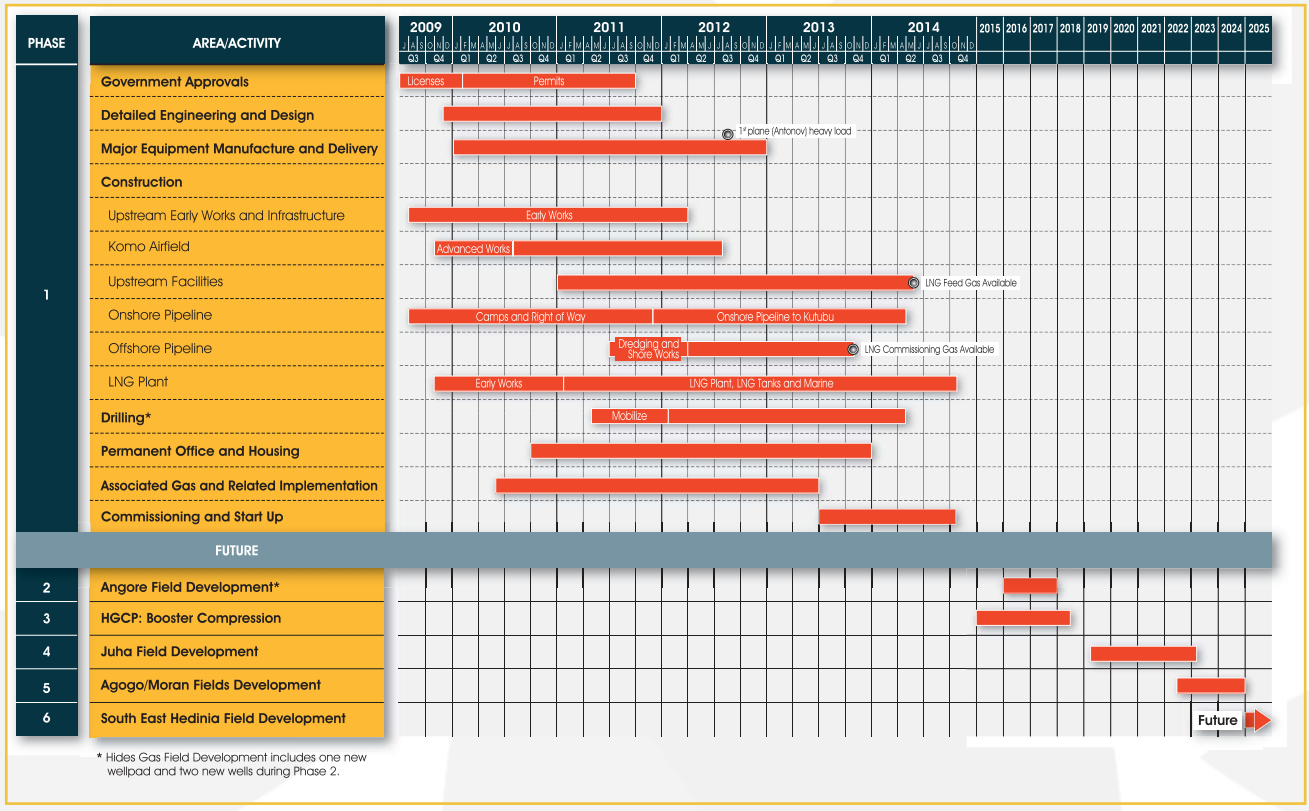


Figure 2.2: Project elements

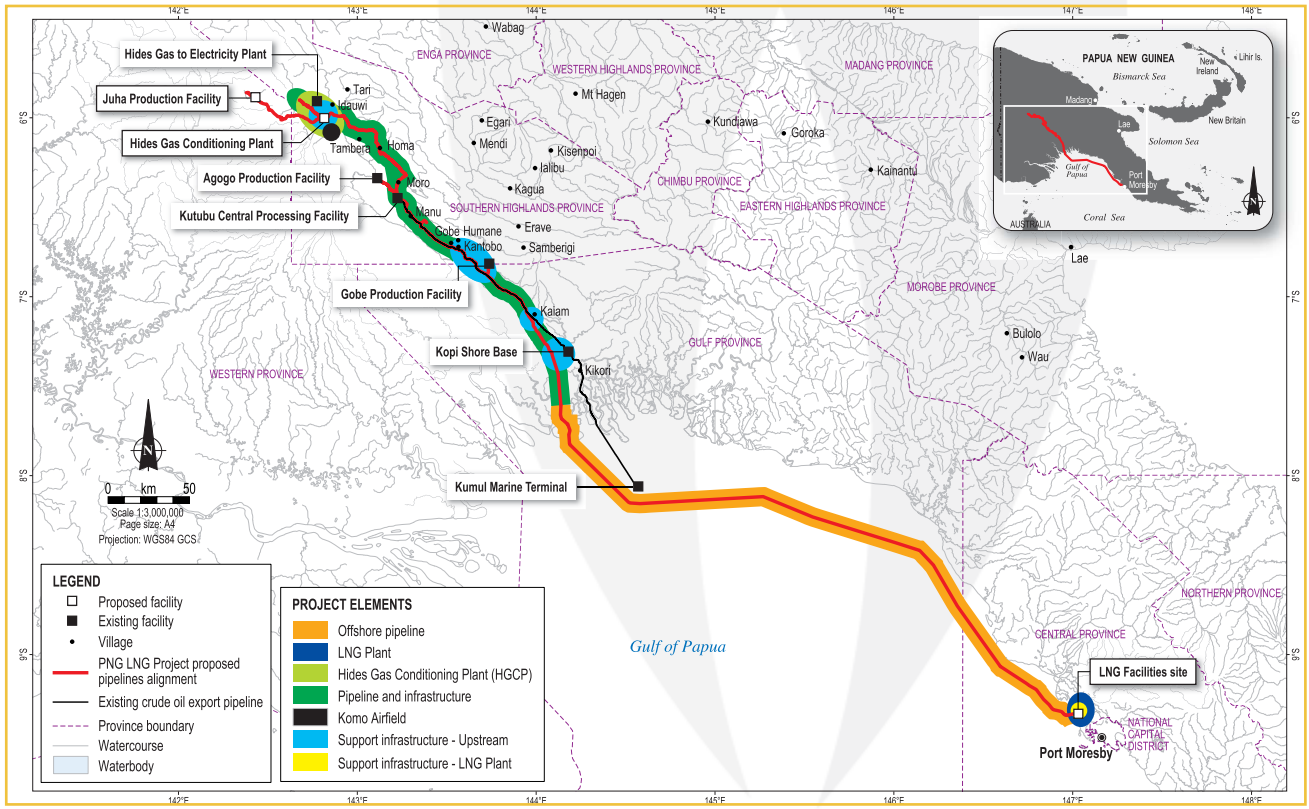


Table 2.1: Project components and phases

Phase	Proposed Facilities	Estimated Timing
Phase 1: Initial Development (and Drilling Campaign 1)	Hides Gas Field: Wellpads A, B, C, D, E and G	2014
	Hides Gathering System and Spineline	
	Hides-Hides Gas Conditioning Plant MEG Pipeline	
	Hides Gas Conditioning Plant	
	Hides Gas Conditioning Plant-Kutubu Condensate Pipeline	
	Kopi Scraper Station	
	Komo Airfield	
	LNG Project Gas Pipeline (Onshore/Offshore)	
	LNG Plant and facilities	
	Gobe Gas Pipeline	
	Kutubu Gas Pipeline	
	Hides Gas Field: Wellpad F and B2	
	Angore Gas Field Wellpads A and B	
	LNG Facilities site	
	Angore Gathering System and Spineline to Hides Gas Conditioning Plant	
	Angore-Hides Gas Conditioning Plant MEG Pipeline	

2.3.1 The Upstream Project Area

The PNG LNG Upstream Project Area encompasses the entire drainage of the Kikori River, and hence the KICDP area, and extends northwest into the drainage of the upper Strickland River in Western Province.

Limestone terrain, mostly extremely rugged polygonal and doline karst, karst plains and plateaus with karst corridors, dominates the Upstream Project Area, which ranges from sea level to 3,650 meters in altitude. The Kikori River itself flows through a karst plain overlain with alluvium.

There are extensive areas of volcanics in the north and northwest of the Upstream Project Area, with the beautiful cone of Mount Bosavi dominating the landscape to the west of the oil facilities at Kutubu. Southwest of the Hides gas field lies the blown-out crater of Mount Sisa, its lava flows responsible for the basalt soils of the agricultural lands around Komo. The Doma Peaks, northeast and outside the Upstream Project Area, is a region of remnant volcanic cones and domes, volcano-alluvial fans, and mudflows resulting from an eruption several hundred years ago. Alluviums are uncommon in the Upstream Project Area and are associated with the major river systems.

The Upstream Project Area consists of large expanses of undisturbed tropical forest with high biodiversity values relative to the Marine and LNG Plant areas. The upstream biodiversity is further discussed in Section 5.2.1.

The majority of the upstream facilities to be utilized by the Project will be new developments. Major new developments include gas production wells at Hides, Angore and Juha fields, gas production and processing facilities at Hides (Hides Gas Conditioning Plant) and Juha (Juha Production Facility) and an onshore gas pipeline (LNG Project Gas Pipeline) to transport processed gas from the Hides Gas Conditioning Plant approximately 292 kilometers overland through the Kikori River basin to the Omati River Landfall. Some existing oil production facilities will also be used to supply associated gas to the Project. These existing oil production facilities are not a part of the Project. However, upgrades to existing facilities undertaken and paid for by the Project in connection with the supply of associated gas will be part of the Project.

Plate 2.2: Crude oil export pipeline ROW and access road near the Iwa Range

Plate 2.3: Small rugged karst terrain south of Veiru Creek

Appendix 1 describes the developments that are planned for this area.

2.3.2 Marine Project Area

The Marine Project Area comprises the offshore section of the LNG Project Gas Pipeline that will run approximately 407 kilometers from the Omati River Landfall down river to the open sea, to the west and south of Kumul Marine Terminal and eastwards across the Gulf of Papua to Caution Bay approximately 20 kilometers northwest of Port Moresby. This route is the most direct from landfall to landfall in water deep enough to avoid undue effects from surface waves and which steers clear of the existing crude oil export pipeline and Kumul Marine Terminal infrastructure. It traverses two broad subsea environments: the muddy, organic-rich sediments 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.

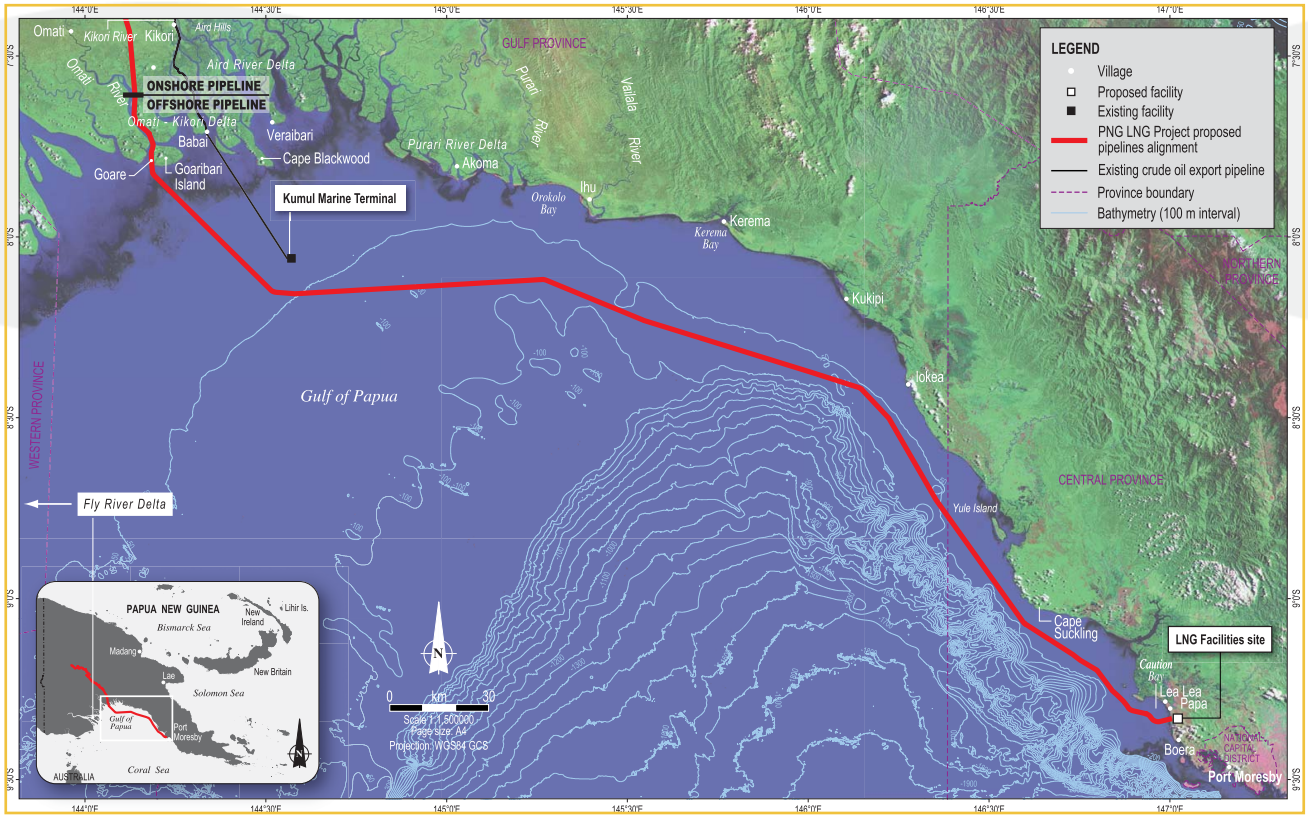
The Omati River is one of numerous highly turbid rivers that drain the mountainous highlands of central PNG and discharge sediment-laden waters into the Gulf of Papua. It forms a part of the Kikori–Purari deltaic system of low-lying mangrove and nypa swamp, a vast network of meandering tidal creeks and channels. The entire deltaic system is rich in fishery resources but the lower section of the Omati River where the offshore section of the LNG Project Gas Pipeline will be installed is around 2 kilometers wide, and the pipeline route is away from the banks and side creek habitats favored by these resources.

The majority of the offshore section of the LNG Project Gas Pipeline is far offshore (greater than 30 kilometers) and in waters greater than 70 meters depth. The route does not pass through marine reserves or critical habitats. It passes through the grounds of the Gulf of Papua prawn trawl fishery to the west of the Kumul Marine Terminal, a fishery that has operated since the early 1970s. Over its route eastwards, it gradually leaves the muddy bottom of the Gulf of Papua and traverses slightly firmer seabed to landfall in Caution Bay.

Caution Bay is a shallow coastal basin. The four main marine habitats along the nearshore marine environment of Caution Bay adjacent to the proposed nearshore marine components of the LNG Facilities are small areas of coral reef, seagrass and sandy seafloor (submerged and intertidal). The majority of nearshore coral reefs within Caution Bay are degraded, with low coral and fish abundance, and a veneer of sediment, dominated by sediment-tolerant corals. The degradation has most likely been caused by heavy fishing use and resuspension of sedimentation during periods of strong winds and waves, particularly during the season of the southeast trade winds. Discussions with local fishers indicated that dynamite was sometimes used for fishing. No fresh evidence of this was apparent during surveys, but the degraded condition of the reef does not justify particular consideration in this Biodiversity Strategy.

Figure 2.3 below sets out the routing of the offshore portion of the LNG Project Gas Pipeline and Appendix 1 describes the developments that are planned for this area.

Figure 2.3: Offshore LNG Project Gas Pipeline route



The offshore section of the LNG Project Gas Pipeline will be concrete-coated and self-bury in the seafloor for some of the route but installed in a trench in shallow water at both ends.

Six species of sea turtle occur within PNG waters, including the Gulf of Papua[8], but there are no known nesting beaches in the Gulf of Papua. Marine mammals recorded include the dugong. Whales are not often seen in the Gulf of Papua but several species of dolphins are present[9].

2.3.3 LNG Project Area

The LNG Facilities site on Caution Bay is located approximately 20 kilometers northwest of Port Moresby. Unlike the Upstream Project Area, which has large areas of intact habitat, this site has a long history of agricultural use and is mostly grazing land with only remnant terrestrial mangrove and woodland habitats. There is a complex of relatively intact coastal and subcoastal habitats on the Vaihua River to the southeast of the site. Some areas of supratidal mudflats occur to the landward side of the mangroves. These only receive tidal inundation during extreme spring high tides and are predominantly dry during the dry season. There are small areas of coral reef, mangrove and seagrass in the nearshore parts of Caution Bay adjacent to the proposed facilities.

Plate 2.4: Grassland and cleared terrain (central part of LNG Facilities site)

The offshore portion of the LNG Project Gas Pipeline will make landfall on the northern part of the site and the gas will then be processed, cooled, stored and loaded onto LNG carriers for export to the international market.

Appendix 1 describes the developments that are planned for this area.

[8] Species such as green, olive ridley and flatback turtles are known from incidental catches in prawn trawlers. However, the National Fisheries Authority now requires trawlers to be fitted with turtle exclusion devices.

[9] There are reports in the Kikori River of the rare and poorly known Irrawaddy dolphin (*Orcaella brevirostris*), a species inhabiting turbid waters within 5 kilometers of the coast in parts of southeast Asia and New Guinea and that can travel up large river systems. Its status is listed as vulnerable by the IUCN Red List of threatened species Version 2010.2. (www.iucnredlist.org, accessed in August, 2010).

3.0 Scope of Document

While the land and marine environments in which the Project will be developed are distinct and varied, it is the high biodiversity and largely undisturbed expanses of tropical forest of the Upstream Project Area that are the focus of this Biodiversity Strategy. This area contains the highest concentration of high value biodiversity attributes and is also where the bulk of potential biodiversity related impacts are predicted to occur (Coffey Natural Systems, 2009). The Biodiversity Strategy therefore applies to the Upstream Project Area only.

Nonetheless, the Project has also developed numerous mitigation measures, monitoring and management plans for the Marine Area and LNG Facilities sites and a list of these documents is presented in Appendix 3 of this document.

The Biodiversity Strategy is applicable to the construction and operations phases of the Project. Biodiversity management during decommissioning and abandonment will be addressed in due course as part of Esso Highlands Limited's Site Closure and Decommissioning Plan.

3.1 RELATED PROJECT DOCUMENTS

A number of environmental reports and documents have been produced to date for the Project. The key documents are outlined below.

3.1.1 Environmental Impact Statement

Esso Highlands Limited prepared the PNG LNG Project Environmental Impact Statement (EIS), which sought approval to construct and operate the Project, under s. 53 of the *Environment Act 2000* and under the direction of the Department of Environment and Conservation's (DEC) s. 50 Notice to Undertake an Environmental Impact Assessment dated 31 May 2007.

The EIS and its appendices encompass the entire Project Area (i.e., Upstream, Marine and LNG Facilities) and describe the Project, the environmental constraints and planning process and the impacts and mitigation measures. The EIS was submitted to the DEC, Port Moresby, in January 2009, and an environment permit was subsequently issued to Esso Highlands Limited on 9 September 2009.

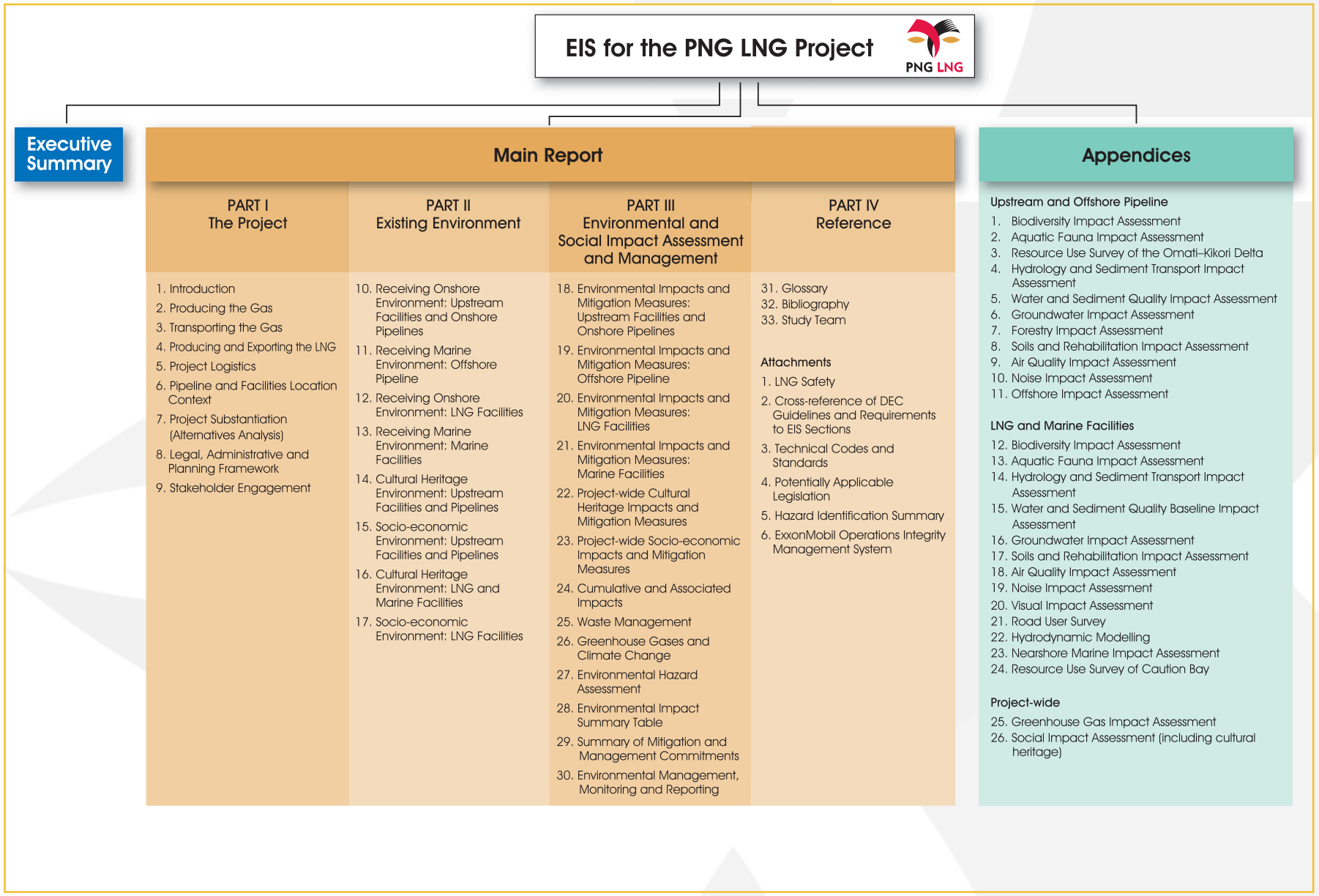
A number of suitably qualified, world-class specialist subconsultants were engaged as part of the EIS, particularly in the biodiversity and social fields, and the EIS draws upon their work. Approximately 120 technical consultants from some 30 specialist organizations, many with extensive biodiversity, social and cultural heritage knowledge and experience in PNG, contributed to the preparation of the EIS.

Figure 3.1 shows the content and structure of the EIS. The EIS appendices are listed in full in Appendix 2.

Plate 3.1: Kikori Project Community Awareness and Mitigation Roadshow presentation (November 2008)

Plate 3.2: Project Awareness and Environmental Inception Report Roadshow presentation to DEC and other government officials (November 2007)

Figure 3.1: Guide to the EIS



The EIS is currently available at http://www.pnglng.com/commitment/environment.htm.

Plate 3.3: Lea Lea Project Awareness and Environmental Inception Report Roadshow presentation (November 2007)

3.1.2 *Environmental and Social Management Plan*

Esso Highlands Limited developed an Environmental and Social Management Plan (ESMP) for the Project. The ESMP includes the mitigation commitments identified in the EIS and additional measures required to implement construction-related good industry practice, EIS approval conditions stipulated by the PNG Government and applicable International Finance Institution requirements. The ESMP:

- Scopes the current environmental and social aspects relevant to the Project.
- Provides an overview of the environmental and social risks associated with its construction.
- Outlines environmental and social management and mitigation actions and monitoring requirements.

The objectives of the ESMP are to:

- Describe specific measures required to implement construction-related management and mitigation commitments made in the EIS.
- Describe specific additional measures required to implement construction-related good industry practice, EIS approval conditions stipulated by the PNG Government and applicable International Finance Institution requirements.
- Outline the roles and responsibilities of the environmental and social management organization for the Project.
- Communicate environmental and social expectations throughout the PNG LNG Project organization.
- Establish the framework and minimum requirements for Contractors' ESMPs.

The ESMP is applicable to all phases of construction and drilling execution for the Project. However, as only execution of Phase 1 is sufficiently defined, the ESMP will be updated prior to each subsequent development phase. The ESMP is not applicable to operations; an Operations ESMP will be developed at least six months prior to commencement of production.

A series of discipline-specific environmental management plan and social management plan documents are included as appendices to the ESMP, and are listed in Appendix 3. As discussed in Chapter 8, some of the environmental management plan documents included in the ESMP constitute an integral part of the process established in this Biodiversity Strategy.

3.2 *INTENDED USERS AND AUDIENCE*

The Biodiversity Strategy is an Esso Highlands Limited document that aims to communicate the company's biodiversity management objectives and strategy internally to the Project Team and externally to direct and indirect stakeholders and interested parties. The Biodiversity Strategy shall be available to the public on the Project website (http://www/pnglng.com/).

3.3 DOCUMENT CONTROL

The Biodiversity Strategy is a controlled document stewarded by the PNG LNG Project Environmental and Regulatory (E&R) Department.

Changes requiring modifications to the Biodiversity Strategy will be incorporated in accordance with the process defined in Company's Management of Change Procedure.

Changes will be notified to relevant parties, including the Project Team, the Lender Group, the Independent Environmental and Social Consultant (IESC).

4.0 Legal and Other Requirements

4.1 LAWS AND REGULATIONS OF PAPUA NEW GUINEA

According to the Directives of the National Constitution of PNG (the Constitution), steps should be taken to give adequate protection to valued birds, animals, fish, insects, plants and trees. The Constitution also includes national goals and directives that outline the aspirations and principles for the development of the nation, the fourth of which states:

> We declare our Fourth Goal to be for Papua New Guinea's natural resources and environment to be conserved and used for the collective benefit of us all, and be replenished for the benefit of future generations.

The Constitution is supported by a legislative and policy framework that requires proposed developments to assess, reduce and manage residual social and environmental impacts such that they are as low as practicable.

Biodiversity relevant legislation includes:

- The PNG *Environment Act 2000*, which provides the administrative mechanism for environmental impact assessment and evaluation of activities regulating impacts on the environment through an approval and permitting system.
- The PNG *Fauna (Protection and Control) Act 1966*, which establishes procedures to declare fauna protected and establish sanctuaries, protected areas and Wildlife Management Areas.
- The PNG *National Parks Act 1984* and the *PNG Conservation Areas Act 1978*, which provide for the preservation of the environment and of the national cultural inheritance by conservation of sites and areas and their management. National parks are for 'public use and enjoyment' as well as conservation and can be developed as such, whereas conservation areas are primarily for conservation and alteration of land use within them is controlled under the Act.
- The PNG *International Trade (Fauna and Flora) Act 1979*, which promotes the sustainable use of fauna and flora and to implement the State's obligations as a party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).
- The PNG *Crocodile Trade (Protection) Act 1974*, which provides the mechanism for the management and control of crocodile exports and other related activities.
- The PNG *Fisheries Management Act 1998* under which the Minister of the National Fisheries Authority, in respect of fisheries waters, should seek to preserve biodiversity.

In addition to biodiversity-related objectives established in the Constitution and the Fisheries Management Act, PNG is party to many international conventions relevant to biodiversity.

As part of the State of PNG's Medium Term Development Strategy, the PNG National Biodiversity Strategy and Action Plan (NBSAP) (DEC, 2007) has recently been developed. The NBSAP is the 'roadmap to the sustainable use and management of the country's biological resources'. It is the vehicle for PNG to meet its obligations under the Convention on Biological Diversity and other multilateral agreements referenced in Box 4.1. The NBSAP promotes the following broad programs: policy, legislation and administration; financial and technical resources; benefit sharing; research and information on biodiversity; biodiversity conservation; measures of sustainability; education and public awareness; and monitoring, evaluation and adaptive management.

Plate 4.1: View of Lake Kutubu

Box 4.1: Relevant international conventions to which PNG is a party

- Convention on Biological Diversity (1992), which was ratified by PNG in 1993.
- Convention on Wetlands of International Importance Especially on Wildfowl Habitat (1971) (The Ramsar Convention).
- Convention on the Protection of Natural Resources and Environment of the South Pacific Region and related protocols (Noumea, 1986).
- Plant Protection Agreement for the Asia and Pacific Region (Rome, 1956) as amended.
- Convention Concerning the Protection of World Cultural Heritage and Natural Heritage (Paris, 1972).
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn, 1979) and incorporating the African-Eurasian Migratory Water Bird Agreement (1995) and the Agreement on the Conservation of Bats in Europe (1991).
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Washington, 1973).
- International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (Fund Convention), 1992.
- International Plant Protection Convention (Rome, 1952) with revised text and amendments for Southeast Asia and the Pacific region (Rome, 1956).
- International Tropical Timber Agreement (ITTA) (Geneva, 1994).

4.2 INTERNATIONAL FINANCE CORPORATION

International Finance Corporation (IFC) Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management applies specifically to biodiversity.

Key biodiversity requirements from Performance Standard 6 are contained in paragraphs 4 to 13 of the standard. These require an impact assessment on biodiversity to be an integral part of the social and environmental assessment process focusing on the major threats to biodiversity, which include habitat destruction and invasive alien species. Under Performance Standard 6, habitats are classified as either natural, modified, or critical habitats and all are recognized as able to support important biodiversity. In natural habitats, the ecological functions are essentially unmodified by humans and biological communities are formed largely by native species, whereas modified habitats have been altered by humans and, often, the introduction of alien species. Critical habitat are areas with high biodiversity value and can be either natural or modified habitat.

In modified habitat, care must be taken to limit further conversion or degradation and it is expected that opportunities to enhance habitat and protect and conserve biodiversity form part of operations. In natural habitat, a project cannot significantly convert or degrade[10] the habitat unless there are no technically and financially feasible alternatives, the overall benefits of the project outweigh the costs, including those to the environment and biodiversity, and conversion or degradation is appropriately mitigated in such a way as to achieve no net loss of biodiversity where feasible.

In critical habitat, no project activities can be implemented unless there are no measurable adverse impacts on the ability of the critical habitat to retain the values listed in Box 4.2, and there is no reduction in the populations of recognized critically endangered or endangered species.

[10] Significant conversion or degradation is (i) the elimination or severe diminution of the integrity of a habitat caused by a major, long-term change in land or water use or (ii) modification of a habitat that substantially reduces the habitat's ability to maintain viable population of its native species.

Box 4.2 Some criteria used to define critical habitat under International Finance Corporation Performance Standard 6

- Areas that meet the criteria of the IUCN protected areas classification.
- Habitat required for the survival of critically endangered or endangered species as defined by the IUCN Red List of threatened species or as defined in any national legislation.
- Areas having special significance for endemic or restricted-range species.
- Sites that are critical for the survival of migratory species.
- Areas supporting globally significant concentrations or numbers of individuals of congregatory species.
- Areas with unique assemblages of species or which are associated with key evolutionary processes or provide key ecosystem services.
- Areas having biodiversity of significant social, economic or cultural importance to local communities.

Should a project be located within a legally protected area, the project must also act consistently with the protected area management plans, consult with key stakeholders of the protected area and implement additional programs, as appropriate, to support the protected area.

Finally, Performance Standard 6 places emphasis on the importance of controlling invasive alien species.

4.3 EXXONMOBIL'S ENVIRONMENT POLICY

Esso Highlands Limited will plan and execute the ExxonMobil policy to conduct its business in a manner that is compatible with the balanced environmental and economic needs of the communities in which it operates. ExxonMobil Corporation and its affiliates are committed to continuous efforts to improve environmental performance throughout operations worldwide. Accordingly, it is Esso Highland's policy to:

- Comply with all applicable environmental laws and regulations and apply responsible standards where laws and regulations do not exist.
- Encourage concern and respect for the environment, emphasizing every employee's responsibility in environmental performance, and foster appropriate operating practices and training.
- Work with government and industry groups to foster timely development of effective environmental laws and regulations based on sound science and considering risks, costs, and benefits, including effects on energy and product supply.
- Manage its business with the goal of preventing incidents and to design, operate, and maintain facilities so that emissions and wastes are below harmful levels.
- Respond quickly and effectively to incidents resulting from its operations, in cooperation with industry organizations and authorized government agencies.
- Conduct and support research to improve understanding of the impact of its business on the environment, to improve methods of environmental protection, and to enhance its capability to make operations and products compatible with the environment.
- Communicate with the public on environmental matters and share its experience with others to facilitate improvements in industry performance.
- Undertake appropriate reviews and evaluations of its operations to measure progress and to foster compliance with this policy.

Esso Highlands Limited will plan and execute an environmentally responsible development consistent with the ExxonMobil initiative *Protect Tomorrow Today.*

Esso Highland's commitments promote biodiversity protection through efforts to limit impacts in sensitive areas and Esso Highland's environmental business planning efforts are designed to identify and steward environmental and biodiversity protection objectives and actions that are specific to each project and location. Mitigation actions include participating in initiatives that enhance the wildlife and habitat attributes of ExxonMobil's properties[11].

Plate 4.2: Goare Project Awareness and Environmental Inception Report Roadshow presentation (November 2007)

Esso Highland's Environmental Policy is supported by the co-venturers' environmental objective, which is to reduce the Project's impact on the environment and on affected communities (EIS Executive Summary).

[8] http://www.exxonmobil.com/Corporate/energy_biodiversity.aspx.

5.0 Identification of Biodiversity Values and Impacts

5.1 BIODIVERSITY STUDIES IN THE UPSTREAM PROJECT AREA

A comprehensive description of the biodiversity of the Upstream Project Area is provided in the EIS. Prior to the development of the Kutubu Petroleum Development Project, the Kikori River basin was one of the major biodiversity unknowns in PNG. In the 1970s, the southern karst was identified as one of the areas most in need of botanical exploration (Prance, 1977; Stevens, 1989; Johns, 1993) and the Kikori River basin and adjacent uplands was ranked among the 16 major terrestrial unknowns in PNG (Sekhran & Miller, 1994).

Plate 5.1: The Maruba River at Deviation Camp

Following the Kutubu Petroleum Development Project and the establishment of the KICDP, WWF carried out many biodiversity surveys in the Kikori River basin. Since 1995, they have amassed a large database from 70 sites over many expeditions within the area, which has resulted in 35 publications and reports. References to these surveys with details of their location, timing and biological focus are presented in Appendix 1 to the EIS. These data were available for a biodiversity analysis of the Upstream Project Area but areas north of the oil fields, including Hides, had not been biologically explored to any significant extent by WWF, and the inclusion of gas developments at Juha brought the Project out of the Kikori River drainage and into mostly uninhabited and previously biologically unexplored areas in the headwaters of the Strickland River drainage. Esso Highlands Limited therefore commissioned a further series of eight surveys, the Project surveys, specifically to enhance data in the northern part of the Upstream Project Area. These latter surveys were carried out independently of the WWF surveys by biodiversity scientists with extensive experience in PNG and with over 75 New Guinea expeditions between them[12].

The combined data from the WWF surveys and the Project surveys were analyzed to produce 10 independent assessments of the flora, mammals, birds, reptiles and amphibians of the Upstream Project Area and are included in Appendix 1 to the EIS.

5.2 IDENTIFICATION OF BIODIVERSITY VALUES

Based on the surveys conducted over the past 15 years, biodiversity values are defined for the Upstream Project Area as a whole. These biodiversity values form the basis of the avoidance, mitigation and monitoring measures described in this Biodiversity Strategy. The protection and conservation of these values will take place at three levels: (i) the large scale, which is the entire Upstream Project Area; (ii) the medium scale, which is represented by particularly valuable areas called 'priority ecosystems'; and, (iii) the small local-scale which are sensitive habitats referred to as 'focal habitats'. This section describes the biodiversity values in the Upstream Project Area as well as the three scales of management.

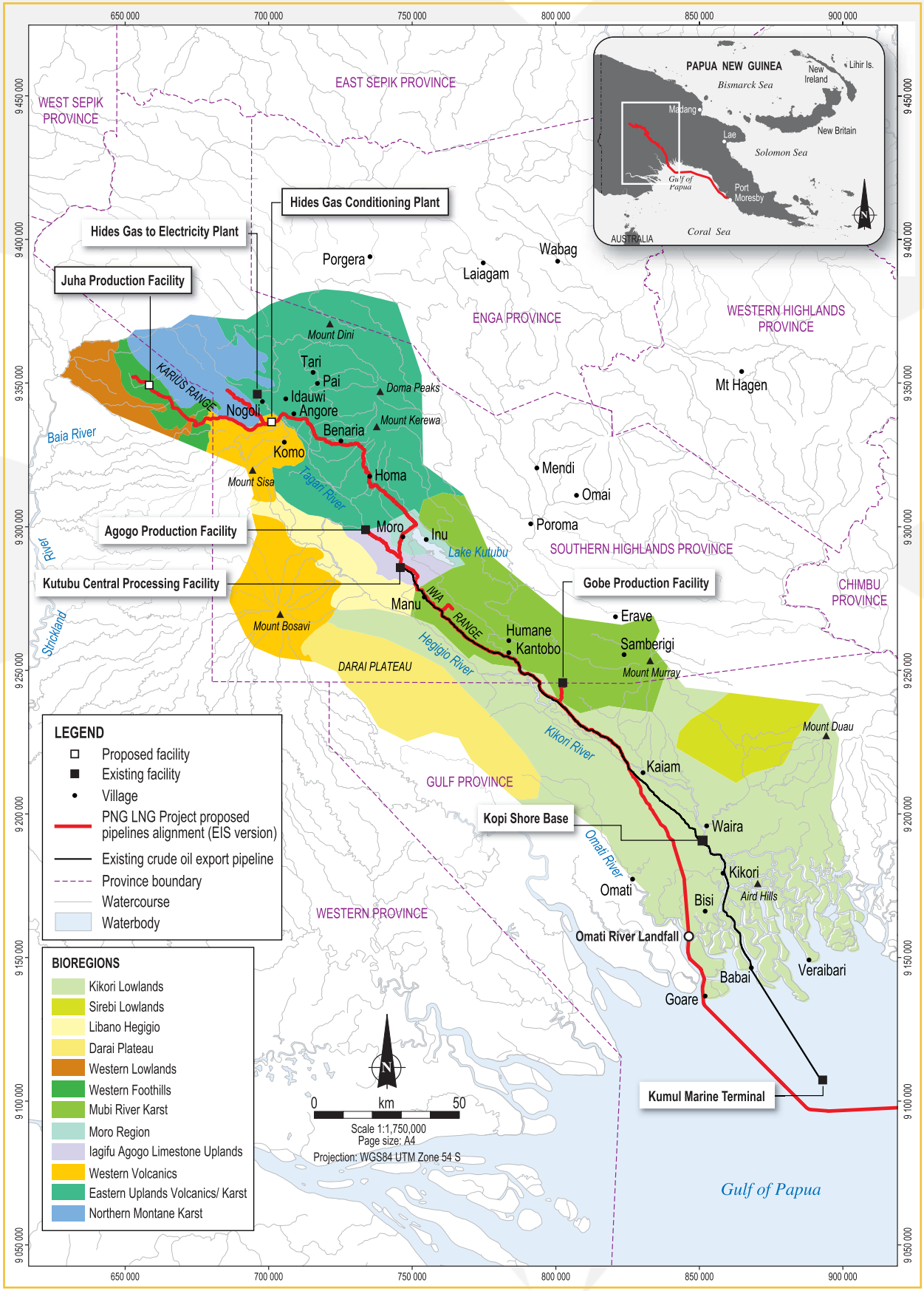
5.2.1 The Upstream Project Area as a Whole

The Upstream Project Area ranges from sea level to 3,368 meters altitude and covers the entire Kikori River basin and part of the upper Strickland River drainage. It encompasses diverse geologies, geomorphologies, soils and habitats and there is a great heterogeneity in biodiversity composition and ecology and hence a variable sensitivity to impacts. 'Bioregions' of the Upstream Project Area based on landscape, geology, climate and ecological communities are shown in Figure 5.1[13].

[12] The team spent a total of two and a half months in the field from helicopter-serviced survey camps in remote montane jungles. Three of the scientists were also key staff in the previous WWF biodiversity surveys.

[13] The bioregions have notional boundaries, with the centres of the bioregions having the core bioregion features, and bioregions blending into each other at the boundaries.

Figure 5.1: Bioregions of the Upstream Project Area



As described below, the biodiversity values of the Upstream Project Area are as follows: (i) extensive intact forest, (ii) high floristic diversity, (iii) high faunal diversity, (iv) endemic species, (v) unique assemblages of species, (vi) species of conservation concern and (vii) biodiversity of importance to local communities for resource use and cultural and spiritual purposes.

Plate 5.2: Epiphytes in lower montane small crowned forest with *Nothofagus*

5.2.1.1 Extensive Intact Forest

Virtually the entire Upstream Project Area is forested, with structure and floristics being influenced by altitude, climate, topography, soils, geology, degree of water logging and disturbance regime. Tree size, leaf size and crown size decrease with increasing altitude, although trunk sizes of individual trees can still be great in mid-altitude zones. Species diversity of

Box 5.1: Habitat dynamics

The dynamics of all the forests in the Upstream Project Area are determined by disturbance.

Gap Phase Dynamics – occurs where individual tree deaths produce small canopy gaps (1 hectare or less) and seedlings and saplings that have stayed quiescent in the shade of the understory are 'released' and grow up to fill the gap. There is an element of chance in which particular species fills the gap, and this is one mechanism that maintains the high diversity in tropical forests. Gaps form all the time and produce continuous low-level disturbance.

Old landslides, Baia River

The need for disturbance in tropical forests tends to make them resilient to human-induced disturbance, but the extent, type and duration of disturbance is critical. Short-term, small-scale disturbances can mimic natural gap phase or small-scale catastrophic dynamics. However, major changes to natural dynamics result in system collapse or forest conversion. This can be brought about by large-scale clearing, continuous small clearings fragmenting the forest, disturbances being too frequent, fire, weeds and/or disease gaining a foothold, or hydrology being altered. Human behavior promoting clearing and fire is the single biggest factor influencing forest loss in PNG (Rogers, 2005).

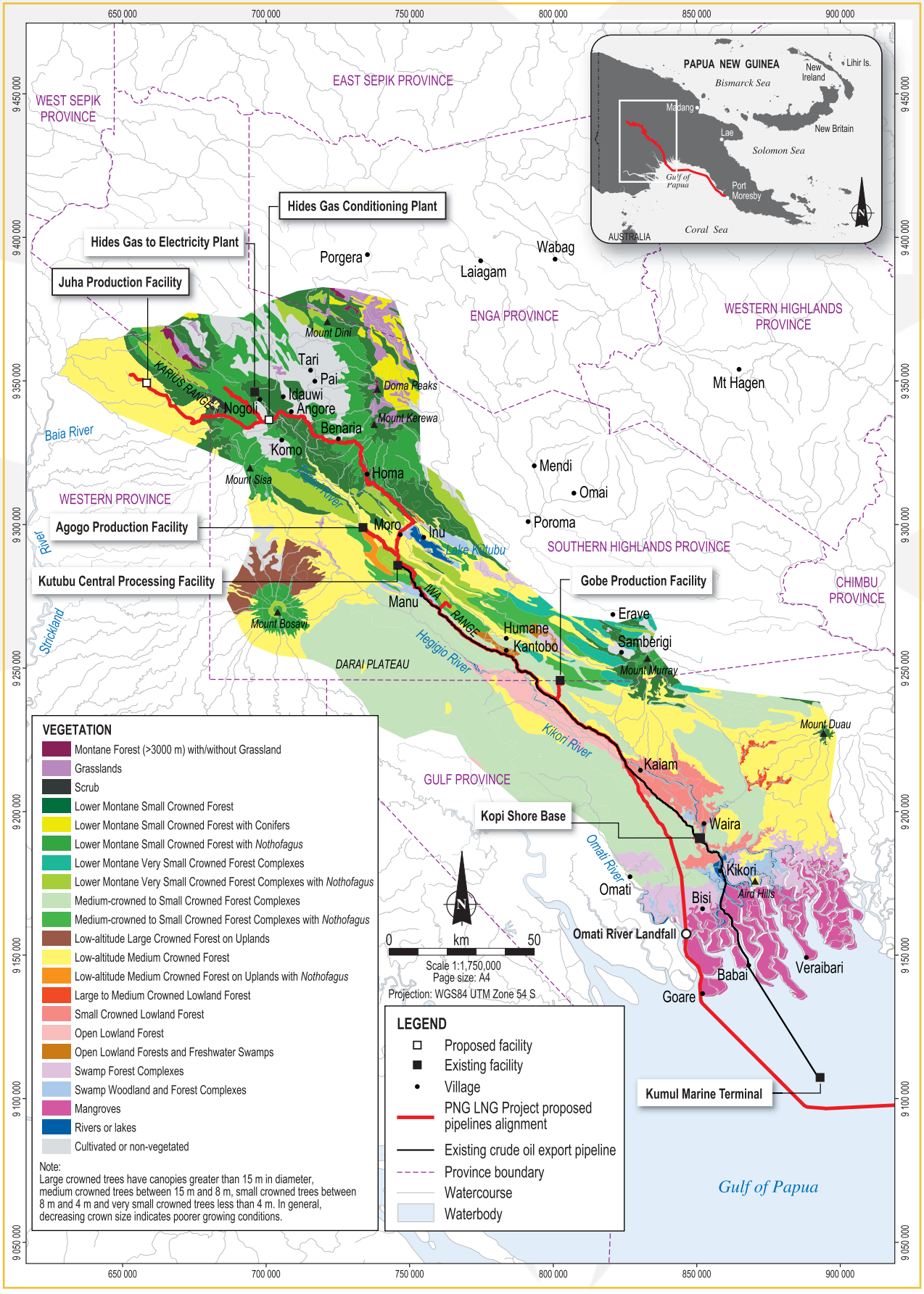
Catastrophic Dynamic Regimes – are common in PNG. When large disturbances, such as landslides, floods, fire, frost, drought or clearing, devastate large areas of forest, the area usually regenerates through successional processes. Where the disturbance has exposed large areas of mineral soil, species that can germinate in such conditions and thrive in full sun are favored over species that need more organic soils and cannot tolerate open conditions. The Baia River area and the Homa region are examples of unstable landscapes driving forest succession. Catastrophic disturbances, while a force for maintenance of some forests, can also produce ecosystem collapse and convert an area to some other habitat type, usually grasslands or scrublands. Rogers (2005) gives several examples of catastrophic events that have eliminated forest in certain locales.

Fire – is a potent force in rainforest dynamics and even the wettest tropical forests can burn during drought years. Swamp forests on peat are sensitive to fire. In most forests, fire and/or extensive clearing can allow grasses and other flammable species to invade. Such species will carry fire indefinitely if there are continuing sources of ignition (people, lightning), and permanent grassland can result. Large areas of the grasslands in the highlands were generated this way (Rogers, 2005).

Fire has had a considerable impact on PNG's forests, from the lowlands to the subalpine zone. The climatic conditions for severe fire occur about once each decade; however, there is no evidence to suggest that a single area of forest can survive repeated burns at this frequency. Although extensive areas of lowland forests may have originated from past catastrophic fires, such fires may occur once every 100 years or more. With increased population pressure across mainland New Guinea, the risk of repeated fires will increase as will the potential for conversion to permanent grasslands, as has occurred across large areas of the highlands.

Fire scar in *Nothofagus* forest near Benaria

Figure 5.2: Distributions of broad vegetation groups within the Upstream Project Area



trees tends to decrease with increases in altitude until the tree line is reached. While trees at all altitudes are generally festooned with epiphytes, the cooler, wetter and foggier climates of uplands favour epiphytes, ferns, certain conifers, cool-adapted, broad-leaved trees and mosses.

Seventy-five vegetation types or complexes are mapped by the PNG Forest Inventory Mapping System (FIMS) within the Upstream Project Area and have been grouped into 21 broad vegetation groups (BVGs) in the EIS (Figure 5.2 and Appendix 4).

Plate 5.3: *Begonia pseudobotrys*

5.2.1.2 High Floristic Diversity

Floristic diversity is high and some 6,000 to 12,000 species from over 150 families of plants may occur. Orchids may be the most speciose family with 342 species recorded in the vicinity of Kutubu alone. Epiphytes and ferns dominate in many areas and there may be more epiphyte and fern species in the Upstream Project Area than tree species. Epiphytes make up 75 percent of the floristic diversity in upland forests.

Plate 5.4: *Lithocarpus rufovillosus*

5.2.1.3 High Faunal Diversity

Using the combined data from the Project and the WWF surveys, there are 3,957 locality records of 702 species of terrestrial mammals, birds, reptiles and amphibians. One hundred thirty-two species of mammals were recorded and a further 28 bat species could occur; 46 (35 percent) of the recorded species are bats and 50 (38 percent) are rodents. After rodents and bats, the most speciose groups are the 11 species of possums, 8 species of macropods, the 6 cuscuses, and 7 marsupial carnivores.

Plate 5.5: *Ficus arfakensi*

The richest bioregions for mammals are the Western Volcanics and the Eastern Uplands Volcanics/Karst. They include the optimal altitudinal belt and have some areas of volcanic soils with more productive forest. The Northern Montane Karst is above the optimal mammal elevation belt and the fauna there is depauperate in rodents but has a high diversity of marsupials. In general, the number of species of arboreal marsupials increases with altitude but, by contrast, that of bats declines, particularity the flying foxes (Pteropodidae). While many non-volant mammals frequent the forest interior, data from the Project surveys showed fewer species of insectivorous bats use the interiors of rainforest than expected. Instead, forest edges, the edges of rivers and major clearings or open areas are primary habitats for insectivorous bats.

Plate 5.6: Rhododendron

Plate 5.7: *Nyctimene aello*

There are 402 known bird species in the Upstream Project Area and a further 131 species could occur. Parrots, pigeons, honeyeaters and birds-of-paradise are the largest families and between them account for over 28 percent of the total species in the Upstream Project Area. Both the lowlands and

mid-montane bioregions have higher species numbers than the higher montane areas, a well-known phenomenon in mountain avifauna. This mid-altitude region is an overlap zone where the ranges of montane and lowland species intersect.

Plate 5.8: Superb fruit dove

Migratory birds are concentrated in the coastal areas and wetlands in the Kikori Lowlands but the area does not appear to be significant for migratory waterbirds, as it lacks the open wetland habitats these species prefer.

There are 61 species of reptiles recorded so far and there is a distinct reduction of reptile diversity with increasing altitude since few species tolerate the cold, wet climates of the mountains. Most of the reptile species are small- to medium-sized skinks inhabiting forest or forest clearings and they are the only lizards found so far in the high montane karst areas. Crocodiles and freshwater turtles are restricted to the lowland rivers. Arguably, the most important reptile occurring in the Upstream Project Area is the New Guinea freshwater crocodile *Crocodylus novaeguineae* discovered by the Project surveys in the Western Lowlands bioregion in 2008. While the reptile fauna is depauperate, there are 13 new species at present only known from the Upstream Project Area. Like amphibians and plants, new species of reptiles are to be expected in well-conducted surveys of remote parts of New Guinea.

Plate 5.9: Green tree python *Morelia viridis* at Juha

Plate 5.10: The agamid *Hypsilurus modestus*

There are 107 species of frogs recorded so far and the tree frogs (Hylidae) and the Microhylidae dominate the fauna. The availability of standing water has dramatic effects on frog community composition. The Microhylidae have a reproductive strategy independent of free-standing water, laying their eggs in terrestrial environments humid enough for their embryos to develop, and have radiated extensively in the constantly moist, montane habitats. Because Hylidae need water, the Microhylidae can dominate in situations of high humidity with no standing or flowing water.

Altitude plays an important role in determining the distributions of most frogs because, at very high elevations, the temperatures are too cold for most species. Maximum frog diversity occurs in the low mountain zone between 500 and 1,500 meters above sea level. Those that live at high altitudes are specialized cloud forest species, e.g., most of the species of *Albericus.*

Plate 5.11: The tree frog *Litoria pronimia*

The fish fauna comprises 115 species. The PNG fish fauna is largely derived from marine fish that entered fresh water in recent geological times. With the exception of Lake Kutubu, the fish fauna has few specialist types that are restricted to a single food or habitat type, so most of the resident species are widely distributed. This overlap in diet and habitat requirements is an important mechanism for fish survival since floodplain habitats (e.g., swamps of the lower Kikori River floodplain) may dry out during severe El Niño-Southern Oscillation drought years. Altitude, habitat type and sediment regime appear to be the primary factors controlling the diversity and abundance of fish and other aquatic fauna in the rivers of the Upstream Project Area. At the highest altitudes, e.g., the Juha and Karius areas, only the fimbriated gudgeon *(Oxyeleotris fimbriata)* occurs. In lower altitude rivers and streams, the fish assemblages are generally more diverse.

Overall, the faunal communities are intact, reflecting the generally undisturbed nature and isolation of most of the KICDP area. Many rare species persist next to the Kutubu Petroleum Development Project facilities, a result of the small footprint of facilities and the strict environmental controls that have been maintained to date. Though overall diversity decreases at higher altitudes, faunal assemblages are most specialized and restricted in the high montane bioregions, i.e., the Western Volcanics and Northern Montane Karst bioregions and the proportion of primary-forest specialist birds, marsupials and specialist amphibians increases with altitude. The species-rich lowland regions tend to include many taxa that are widespread and adapted to disturbed habitats. The consensus of the scientists conducting the Project surveys was that it is unlikely that many faunal species will be found to be restricted to small, localized areas of the Upstream Project Area, although cavernicolous bats may roost or breed only in certain caves.

Plate 5.12: A new species of microhylid *Xenobatrachus sp.* from Juha South

5.2.1.4 New Species

The surveys in the Upstream Project Area have discovered numerous species new to science, a reflection of the poor biological documentation of the region prior to 1995. Five species of mammals, 11 of lizards and 50 of frogs new to science were discovered by the WWF surveys while the Project surveys added a further 3 lizards, at least 10 frogs and possibly 2 new bats. The Project surveys also found 31 plants new to science. Recent exploration on Mount Bosavi has added 16 new frogs and possibly 3 new mammals[14]. No bird species new to science have been recorded in the Upstream Project Area.

[14] http://www.guardian.co.uk/environment/2009/sep/07/discovery-species-papua-new-guinea.

5.2.1.5 Endemic Species

The Upstream Project Area is especially significant for endemic species. Seventy-five percent of the non-volant mammal species so far recorded from the Upstream Project Area are New Guinea endemics and there is a trend for increasing endemism with increasing altitude.

One hundred sixty-one species of birds in the Upstream Project Area are endemic to the island of New Guinea and a further 53 endemic to Melanesia. The Upstream Project Area lies entirely within two endemic bird areas (EBAs), the Central Papuan Mountains and the South Papuan Lowlands, that support a high concentration of what is termed 'restricted range species' (geographic ranges less than 50,000 square kilometers) found nowhere else (Stattersfield et al., 1998). The Central Papuan Mountains have the second highest number of restricted-range species of all EBAs in the Southeast Asian island region and includes nine endemic genera (BirdLife International, 2003). Eighteen restricted-range species of the Central Papuan Mountains have been recorded in the Upstream Project Area and a further 16 could occur there. All but five of them are high-mountain specialists. There are far fewer restricted-range species within the South Papuan Lowlands EBA but two have been recorded in the Upstream Project Area and two more could occur.

There are notable concentrations of nationally endemic birds in the Western Foothills, Western Volcanics and Northern Montane Karst bioregions.

Well over 90 percent of the amphibians and reptiles recorded from the Upstream Project Area are endemic to New Guinea (S. Richards, pers. com.) and many of the frogs and reptiles discovered on the WWF and Project surveys are known only from the Upstream Project Area so far. However, experience from these surveys indicates that it is too early to be able to say these species do not occur elsewhere. All of the Project surveys extend the ranges of species previously known only from one or two localities, e.g., successive EIS surveys extended the ranges into the Juha and/or Homa Deviation areas of six undescribed species known previously from only one locality each in the Upstream Project Area. The EIS surveys also extended the range of *Litoria* sp. nov. 14 (cf Ok Menga), previously only known from the Star Mountains, into the Upstream Project Area. Endemism is unlikely to be so localized in the Upstream Project Area that development of Project facilities and infrastructure would negatively impact any one species.

A total of 15 fish species are endemic to the Kikori River catchment, 12 of which occur in Lake Kutubu. This high level of lacustrine endemicity exceeds that of any other lake in the New Guinea–Australian region. Five of these endemics *(Hephaestus adamsoni, Mogurnda furva, M. spilota, M. variegata and M. vitta)* comprise up to 40 percent of the artisanal fishery and subsistence fish catches in the lake.

5.2.1.6 Unique Assemblages of Species

The Upstream Project Area contains notable assemblages of species. Among these is the high diversity of birds-of-paradise with at least half of the 40 living species and nearly two-thirds of the 31 species recorded in New Guinea and its satellite islands occurring in the Upstream Project Area. They are diverse in upland regions and many, such as the blue bird-of-paradise *(Paradisea rudolphi)*, have restricted distributions.

An important find in the Upstream Project Area is the greater melampitta *(Melampitta gigantea)*, one of New Guinea's most enigmatic birds, which is restricted to rugged limestone country where it roosts and nests below ground (the world's only passerine to do so).

The Upstream Project Area, in which one third of the New Guinea frog fauna has been recorded, has the most diverse assemblage of amphibians documented yet recorded for a catchment in New Guinea.

Lake Kutubu stands out as having a remarkable assemblage of fishes.

Table 5.1: Species in different IUCN red list categories and listed under the PNG legislation in the Upstream Project Area

IUCN Status	Protected under the *Fauna (Protection and Control) Act 1966*	Restricted in Trade under the *International Trade (Fauna and Flora) Act 1979*	Not Listed under PNG Legislation	Grand Total
Critically endangered			3	3
Endangered			4	4
Vulnerable	4	2	8	14
Near threatened	2	2	16	20
Data deficient			27	27
Not listed	24	26	27	77
Grand total	30	30	85	145

Table 5.2: IUCN critically endangered and endangered species in the Upstream Project Area

Common Name	Species Name	IUCN Status
Bulmer's fruit-bat (possible only)	*Aproteles bulmerae*	Critically endangered
Long-beaked echidna	*Zaglossus bartoni*	Critically endangered
Tree	*Halfordia papuana*	Critically endangered
Goodfellow's tree kangaroo	*Dendrolagus goodfellowi*	Endangered
Tree kangaroo*	*Dendrolagus notatus*	Endangered
Tree	*Bleasdalea papuana*	Endangered
Tree	*Flindersia pimenteliana*	Endangered

* In the EIS this species was recorded as *D. dorianus* and classed as vulnerable. Taxonomic changes have since split *D. notatus* from *D. dorianus*.

Box 5.2: Tree kangaroos

There are 14 species of tree kangaroos, twelve of which are endemic to New Guinea. These are the largest native land mammals in PNG and unique amongst kangaroos in that they are arboreal, although they come down to the ground frequently. They feed on leaves and fruits and tend to be solitary. They are heavily hunted and this has reduced populations of most species throughout New Guinea. Four of the New Guinea species are classified as vulnerable by the IUCN (2010), four as endangered and three as critically endangered.

Three species occur in the Upstream Project Area. The brightly colored Goodfellow's tree kangaroo, *Dendrolagus goodfellowi*, is a resident of montane forests of PNG and does not extend into West Papua, Indonesia. The subspecies most likely to occur in the Upstream Project Area is *D. goodfellowi buergersi*, which occurs along the central ranges, west to the Strickland River. It is very susceptible to hunting, and numbers have been heavily reduced by persecution and forest clearance.

Tree kangaroo *Dendrolagus notatus*

D. notatus was recently split from *D. dorianus* and occurs only in the central ranges of PNG. Its habitats and distribution are similar to the Goodfellow's tree kangaroo but generally occurs at higher elevations. It appears to exist at naturally low densities.

The lowland tree kangaroo, *D. spadix*, is classified by the IUCN as least concern. It is one of the least-known tree kangaroos and has a broad distribution in the south central lowlands of PNG centered on the Kikori River where there is little settlement. Hence, little is known of this species and the loss of habitat and hunting pressure it has experienced.

5.2.1.7 Species of Conservation Concern

One hundred forty-two[15] species of plants and animals are listed as of conservation concern by the IUCN (2010), under the PNG Fauna *(Protection and Control) Act 1966* or under the PNG *International Trade (Fauna and Flora)* Act 1979 (Table 5.1).

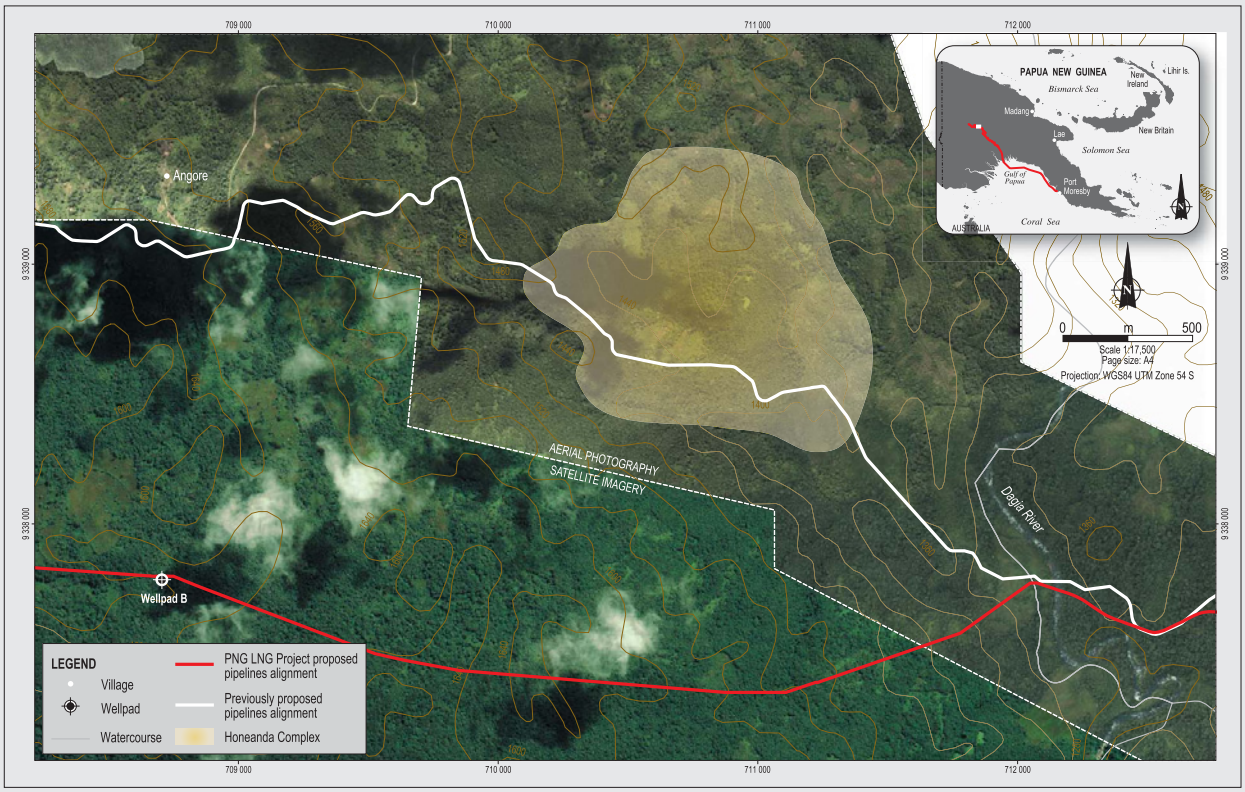
While the EIS considered impacts on listed species, the IFC Performance Standard 6 refers only to species classified by IUCN as Critically Endangered or Endangered in relation to critical habitat. These species are listed in Table 5.2 and are the biodiversity values of interest with respect to this Biodiversity Strategy.

Box 5.3: The Honeanda Complex

Another example of the link between biodiversity and the local communities is the complex of significant ritual sites on the Pagada ridgeline, including the Honeanda Complex, located in the vicinity of the onshore LNG Project Gas Pipeline route between Hides and Idauwi. This site complex represents the largest remaining series of hoop pine *(Araucaria cunninghamii)* groves in the region and possibly the largest single stand in New Guinea due to their anthropogenic nature and the fact that all other major ritual sites in the Tari region have been logged. Each grove marks the presence of one of the sites in this ritual site complex and it is a significant cultural heritage site in the Upstream Project Area. An early pipeline route option considered by the Project crossed this site; however, following consideration of the findings of cultural heritage surveys of the area and consultation with relevant clans representatives, Esso Highlands Limited realigned the onshore LNG Project Gas Pipeline ROW to avoid the Honeanda Complex and associated hoop pines. This realignment is shown in the figure below.

It is worth noting that, while the hoop pine, a species shared with Australia, has cultural significance, the New Guinea endemic congener klinki pine *(Araucaria hunsteinii)* has no cultural significance.

The Honeanda Complex



[15] Since release of the EIS, the IUCN Red List has been updated and while the species listed under the PNG *Fauna (Protection and Control) Act 1966* remain the same, the status of many species listed by IUCN has changed. This is the most recent figure.

5.2.1.8 Biodiversity of Importance to Local Communities for Resource Use and Cultural and Spiritual Purposes

Local communities in PNG are linked to the biodiversity values of the surrounding land through their reliance on subsistence-oriented production and a close physical and spiritual relationship to ancestral territories. Subsistence land use in the Upstream Project Area consists of shifting cultivation, hunting and gathering and sago production. Shifting cultivation occurs in all forest types but is restricted by terrain and soil quality. Hunting and gathering is not so constrained and the forest provides a vast array of natural resources to local people. Prey includes pigs, cassowaries, wallabies, bandicoots, megapodes, rats, frogs, possums, snakes, bats, crocodiles, turtles, lizards and birds. Particularly high-value items are birds-of-paradise and cassowaries and, in the lower parts of the Kikori River basin, pig-nosed turtles *(Carettochelys insculpta)*, listed under the IUCN Red List (IUCN, 2010) as vulnerable, but whose flesh and eggs are a significant food source for local communities.

Sago production occurs only in swamp forests and sago from a single palm is usually sufficient for a family for a month. Palm by-products are used for roofing and building.

In addition to relying on the land for subsistence-oriented production, there is a strong spiritual connection with the land, and culturally significant sites often include caves, sacred lakes, swamps and creeks, limestone outcrops, sacred groves, and plant harvest and hunting areas. For example, some sacred sites associated with water link the places of the living (such as villages) with the places of the dead through the journeys travelled by the spirits of dead family and clan members. Sacred sites may be located on land and in watercourses. Both landscapes and waterscapes were considered when recording cultural and spiritual places during the EIS and subsequent preconstruction surveys.

Plate 5.13: Unbroken low altitude medium crowned forest between Juha and Hides

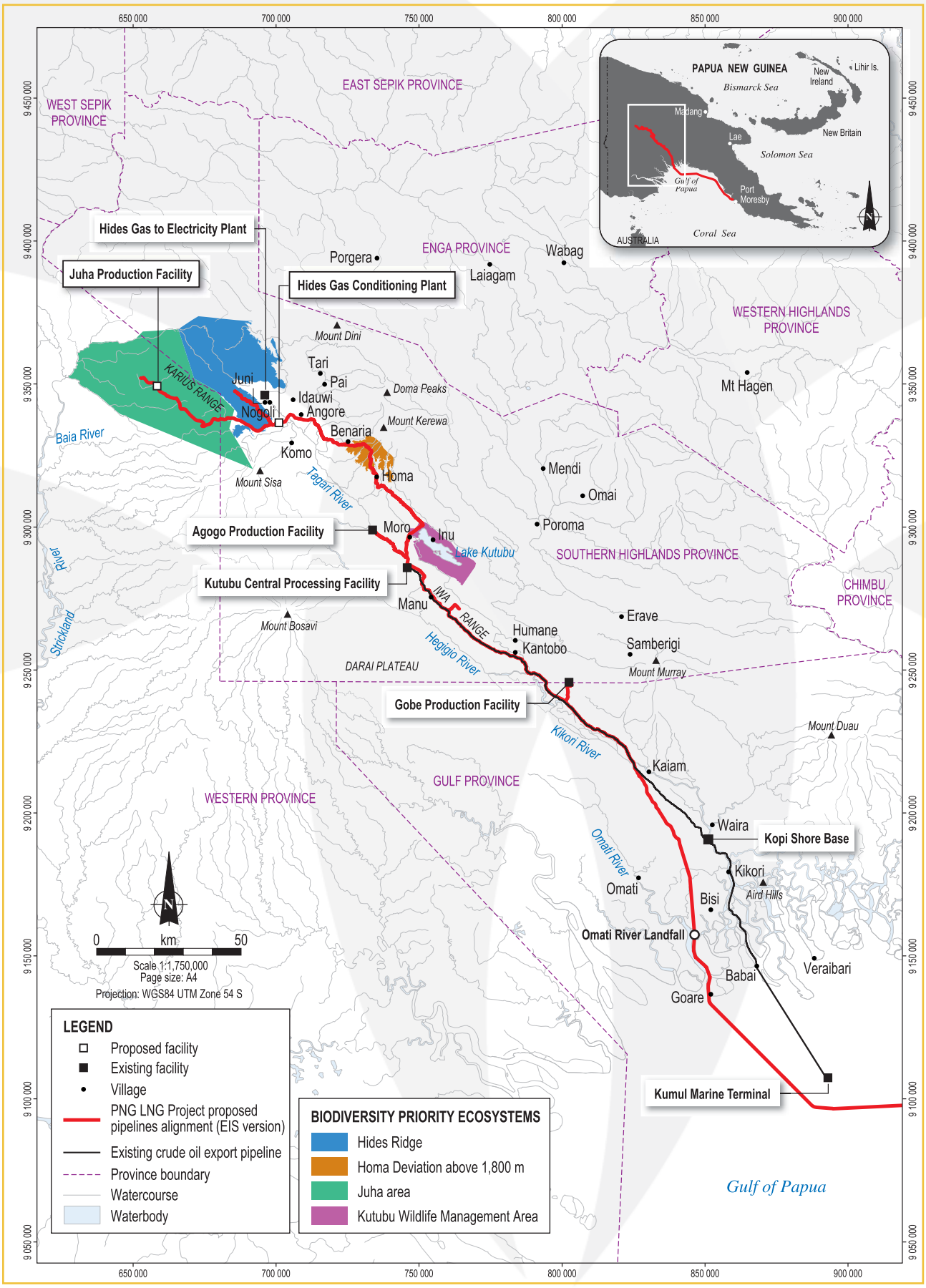
5.2.2 Priority Ecosystems

On the medium-scale, biodiversity management will focus on three 'priority ecosystems', which were identified as part of surveys, and have particularly high biodiversity values associated with them (Figure 5.3). These are the Juha area, Hides Ridge and the high-altitude forest above 1,800 meters on the Homa Deviation[16].
In addition Lake Kutubu qualifies as a priority ecosystem in its own right.

Plate 5.14: Forests at Juha

[16] These were termed 'Special Areas' in Appendix 1 to the EIS but grouped with focal habitats (next section) in the body of the EIS (Chapter 10) as 'noteworthy areas'.

Figure 5.3: Priority ecosystems within the Upstream Project Area



5.2.2.1 The Juha Area

Juha is a remote region where there has been little human influence on the vegetation and fauna and its ecological values are maintained by its difficulty of access. There are one or two small villages nearby but not within the area, and their impact has been minimal to undetectable. This area particularly supports the biodiversity values described in Section 5.2.1 due to the following attributes: (i) the remoteness of the region and the lack of human influence on the vegetation and fauna; (ii) the lack of weeds and other exotics in the area; (iii) the absence or the low populations of wild pigs; (iv) the absence of hunting. Among other biodiversity values that are specifically represented in this area, Juha contains notable concentrations of unique assemblages of frog species. The remoteness and mostly untouched condition of the forests warrant a management focus on access restrictions during construction and operations to prevent the indirect impacts of hunting, logging and induced settlement.

5.2.2.2 Hides Ridge

The high-altitude *Nothofagus* forest on karst above 1,800 meters shares with the higher regions of Mount Sisa and the forests on the Homa Deviation a montane fauna in a mostly undisturbed environment. The existing gas wells were drilled by rigs flown in by helicopter and the flow lines and helicopter pads have been constructed by hand and have had little material impact in this area so its ecological values are maintained by difficulty of access. The epiphytes and ferns developed on trees are the major component of plant biodiversity in this forest type. The forests on Hides Ridge are little disturbed, and only two exotic weeds were recorded, neither of which are invasive. Among other biodiversity values that are specifically represented in this area, Hides Ridge contains (i) unique assemblages of plants, including three remarkable calcium-depositing ferns that are likely restricted to these high-altitude karst areas; (ii) the potential for occurrence of caves of the Critically Endangered Bulmer's fruit-bat (*Aproteles bulmerae*); (iii) a high diversity of high-altitude birds-of-paradise and high concentration of restricted-range, endemic high-altitude birds; (iv) frogs that may have restricted-ranges.

This forest type is sensitive to fire and dieback, and the high altitude means slow growth rates and slow regeneration (Rogers, 2005); slow-growing individuals of *Nothofagus one* meter in diameter may be over 300 years old.

Dieback investigative surveys completed in the Upstream Project Area in June 2010 indicate dieback is present in the Hides Ridge area, more specifically, the pathogen *Phytophthora sp*. has been confirmed as causing the dieback. The *Nothofagus* forest in the Hides Ridge area has been historically affected by *Phytophthora sp*. but has been regenerating in recent times.

The Hides Ridge area warrants special erosion control and regeneration systems for construction, but controlling access to this area in the long term in order to eliminate indirect impacts of hunting and weed and pest invasion is the highest priority.

Plate 5.15: Hides Ridge lower montane small crowned forest with *Nothofagus*

Box 5.4: Bulmer's fruit-bat

This cave-dependent flying fox was originally described from subfossil material in an archaeological dig at 1,530 meters above sea level at the Kiowa rock shelter, 2 kilometers east of Chauve Government Station, Chimbu Province in layers dated between 10,000 and 11,000 years before present. Menzies (1977) described the species from 200 skulls that were 'kitchen waste' in a human occupation site in a small entrance to a large limestone cave complex. Living animals were subsequently discovered in 1975 at an altitude of 2,400 meters in Luplupwintem cave close to the main walking track between Tabubil, the Ok Tedi mine and Telefomin (Hyndman & Menzies, 1980).

In 1975, thousands of bats were present at Luplupwintem but, in 1977, only two bats were seen and local informants advised Hyndman and Menzies (1980) that several groups of hunters entered the cave and virtually eliminated the colony. The cave has a 100-meter drop at the entry, so hunters were keen enough to use ropes to get to their prey. A small number of bats were again resident in Luplupwintem in 1992 and 1993 (Flannery & Seri, 1993).

The species is likely to occur more widely as there are two other modern records; an animal shot in 1984 near Telefomin, Sandaun Province, and a recently hunted jawbone given to S. Hamilton in 1995 in the Eastern Highlands (Bonaccorso, 1998).

All that is know about the species' ecology is that it is probably frugivorous and inhabits large, deep, inaccessible caves. It probably commutes large distances to forage.

The Project surveys suggested an undiscovered colony could occur in large caves in the higher karst areas of the Upstream Project Area. This remains unconfirmed but the preconstruction surveys have been made aware of the species and the discovery of a large cave, even though there was no confirmation the species was present, resulted in precautionary redesign of Project components.

5.2.2.3 High-altitude Forest Above 1,800 Meters on the Homa Deviation

The area above 1,800 meters altitude between Homa and Hides has similar qualities to Hides Ridge. It is largely weed-free and has one of the highest mammal diversities in the Upstream Project Area. However, it differs from Hides Ridge in two fundamental ways: it is not a pure karst area and hence has generally better soils, and it is crossed by the walking trail from Homa to the settlement of Benaria. Regarding the biodiversity values, high-altitude forest contains excellent forest area and condition, high diversity of flora and high diversity of fauna. Construction through this area will require similar erosion control and regeneration management as for Hides Ridge.

5.2.2.4 Lake Kutubu Wildlife Management Area

The Lake Kutubu Wildlife Management Area (WMA) of 25,455 hectares is the only WMA that the Project footprint intersects. The high degree of fish endemism and the fact that the area is a WMA warrants special consideration of this area. Other than Lake Kutubu, there are four other government conservation areas in the Upstream Project Area[17], none of which are impacted by the Project. Box 5.5 provides a full description of the Lake Kutubu WMA.

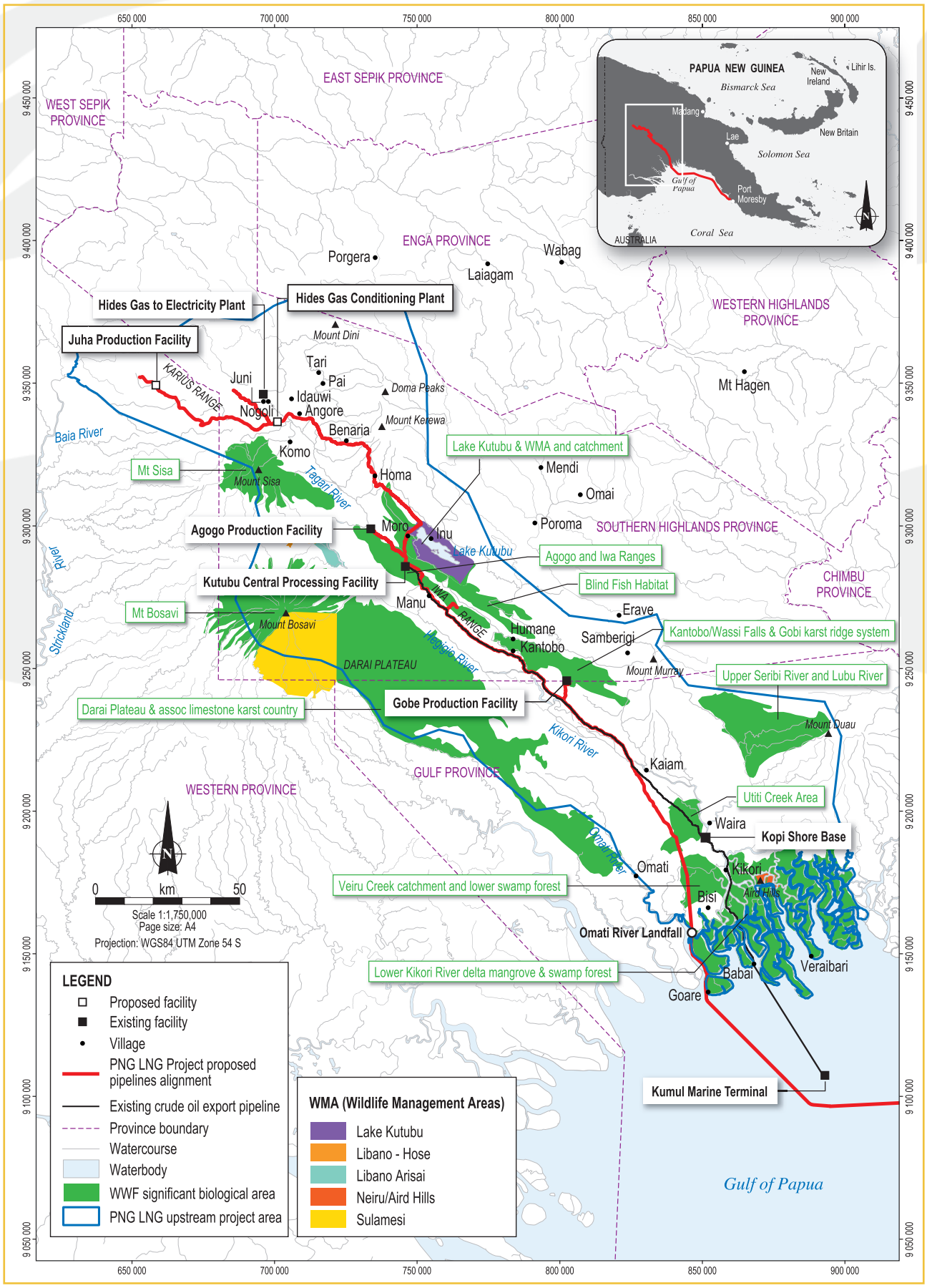
Eleven other areas of particular biodiversity significance in the southern section of the Upstream Project Area have been identified by WWF (Figure 5.4). As yet, none of these WWF significant biological areas have received official recognition as a reserve within PNG.

5.2.3 Focal Habitats

Biodiversity values are captured at the small or local scale in several habitat types and areas that require special focus for avoidance and mitigation measures. These are described below.

[17] Neiru/Aird Hills WMA of 3,963 hectares southeast of Kopi, Libano–Arisai WMA of 3,964 hectares on Libano Creek, Libano–Hose WMA of 7,736 hectares adjoining Libano–Arisai, and Sulamesi WMA of 86,451 hectares on Mount Bosavi.

Figure 5.4: Areas of biodiversity significance recognized by WWF



Box 5.5 Lake Kutubu

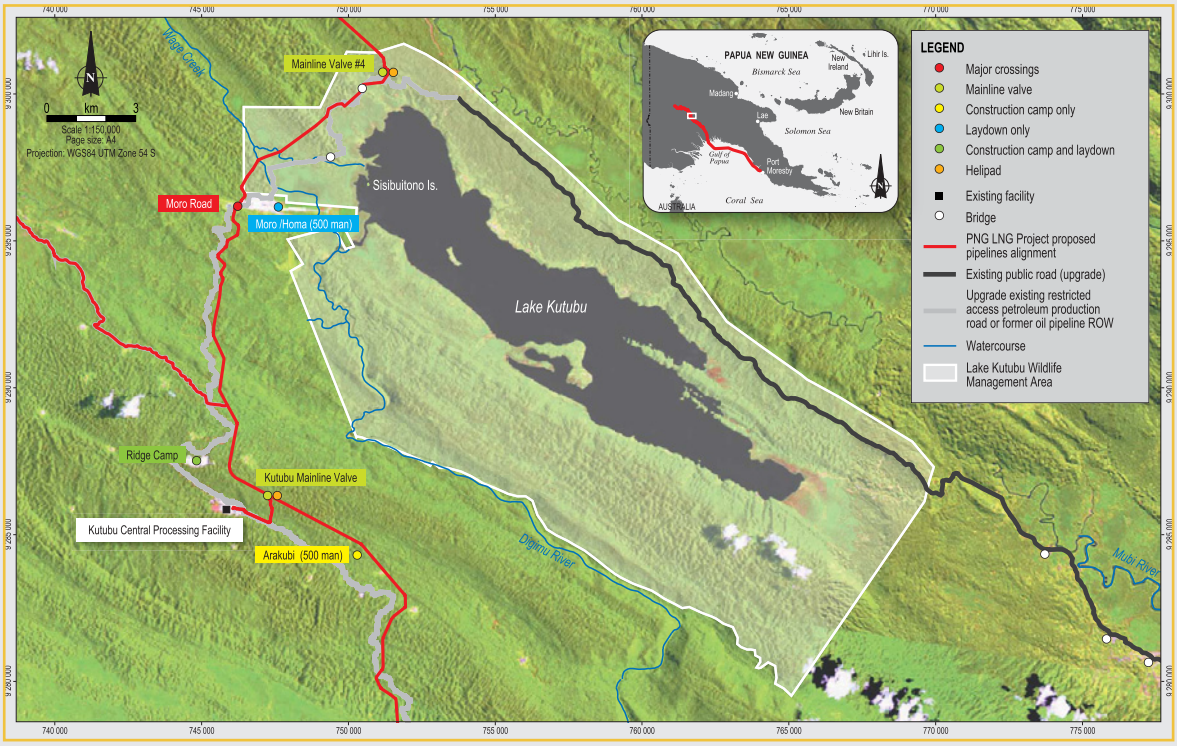
Lake Kutubu is the largest perched lake in PNG and is the second largest lake in PNG after Lake Murray in Western Province. It is one of the only large permanent lakes in the highlands region of the Upstream Project Area. At an elevation of 800 meters above sea level, the lake has a catchment area of 4,924 hectares, is about 19 kilometers long and 4 kilometers wide at its widest point, and has a maximum depth of about 70 meters (Osborne & Totome, 1992). It lies within karst terrain and was formed originally as a result of volcanic-derived debris and ash blocking the valley in which it now lies.

Twelve of the 18 species of fish in Lake Kutubu are endemic, the highest level of lacustrine endemicity of any lake in the New Guinea–Australian region. Five of these endemics comprise up to 40 percent of the artisanal fishery and subsistence fish catches in the lake (Enesar, 2005) and provide an important source of dietary protein for the local communities residing within the lake's catchment.

Lake Kutubu is included in the Lake Kutubu Wildlife Management Area (WMA) (see figure below), and is currently managed under the WMA arrangement. The boundary includes most of the lake's catchment and approximately 1,000 hectares of surrounding swamp forest. The lake was listed as a Ramsar wetland in 1998 and the Ramsar boundaries match those of the WMA.

Not only does the biodiversity of Lake Kutubu provide significant resources for local communities living around it, but the lake is also the locale for a number of traditional myths. Sisibuitono (see figure below), a myth site of major significance to the Lake Kutubu region, is a small grassy island at the northern end of Lake Kutubu that marks the location of the original mythical tree from which the waters of Lake Kutubu flowed.

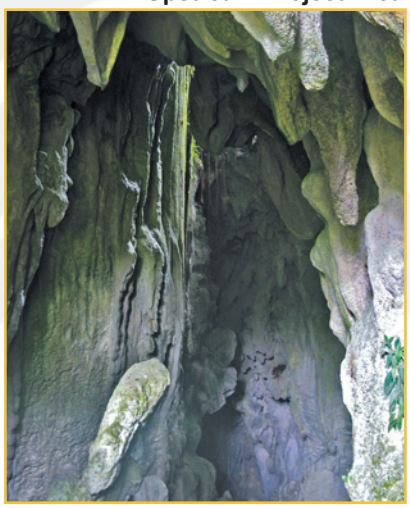
Lake Kutubu Wildlife Management Area



The northern end of Lake Kutubu

Subsistence catch of Kutubu tandans and fimbriate gudgeons from Lake Kutubu

Plate 5.16: Large cave in the Upstream Project Area



5.2.3.1 Caves

Caves are abundant in the karst of the Upstream Project Area, but only some are important for conservation of cave-dwelling bats as particular species require caves with specific conditions and architecture in which to roost and breed. Large caves in the uplands may support colonies of the extremely rare and critically endangered Bulmer's fruit-bat.

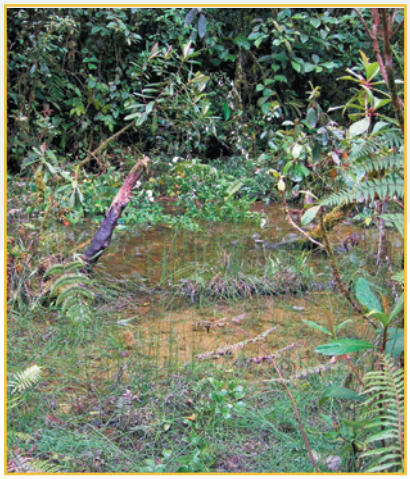
5.2.3.2 Sinkhole Swamps

Sinkhole swamps are microhabitats of ponds at the bottom of dolines or depressions in high-altitude karst on Hides Ridge, where falling leaf litter and other organic debris has impeded the drainage. These are the only habitats where tree frogs and other water-dependent frogs can breed in karst, which tends to have few flowing streams.

5.2.3.3 Upland Streams

Stream condition is important for maintaining populations of torrent-dwelling frogs and birds such as Salvadori's teal *(Salvadorina waigiuensis),* torrent-lark *(Grallina bruijni)* and torrent robin *(Monachella muelleriana).* The torrent-dwelling frogs, in particular, require fast-flowing, clear-water, rocky streams with intact riparian vegetation. Such vegetation can also be a specialized habitat for hydromyine rodents and, less commonly in these higher elevations, for birds.

Plate 5.17: Sinkhole swamp on Hides Ridge



5.2.3.4 Swamp Forest

Swamp forests support a range of specialist vertebrates, including the twelve-wired bird-of paradise *(Seleucidis melanoleuca)*, the New Guinea flightless rail *(Megacrex inepta)* and a range of freshwater turtles and crocodiles. The swamp forests are not always wet but are maintained by a drying and wetting regime. Drier conditions promote the growth of trees and a forest structure. Wetter conditions promote palms, particularly sago palms. Ponding converts them to freshwater swamps and, if there is seawater ingress, to mangroves. Dry conditions convert them to drier forest complexes, scrublands or grasslands. Swamp forests tend to be resilient to disturbance but the dependence of these forests on inundation and restricted drainage means that changes to hydrology may destroy them. Fire can eliminate these complexes if they are developed on peat substrates, which can readily burn when dried out.

Plate 5.18: Swamp forest complexes at Lake Kutubu

5.2.3.5 Stream Refuges in Unstable Landscapes

Areas of mature habitat on stable substrates (for example, stream heads or small plateaus) are disproportionately important as regional fauna refuges in otherwise unstable and landslide-prone areas around the Baia River on the pipelines route from Juha to Hides. Moreover, the dynamic hydrological conditions of major rivers in these unstable landscapes mean that the clearing, earthworks and sedimentation effects of Project construction activities add little damage to what occurs naturally. In these circumstances, it is appropriate to shift the emphasis of environmental management from its usual focus on river crossings to protecting the more stable backwater refuge areas in the general vicinity.

5.2.3.6 Lowland Rivers in Stable Landscapes

The lowland rivers in more stable landscapes provide the habitat for crocodiles and freshwater turtles. Within the Upstream Project Area, there does not appear to be a specialized bird fauna restricted to riverine forest (as there is in gallery forests in dry woodlands). However, some species are notably abundant, including kingfishers and shining flycatchers *(Myiagra alecto)*. In the lowlands, riverine forest supports a variety of large fruiting trees and there are consequently many pigeons and parrots. No species is restricted to this habitat, but many birds will take refuge in riverine forest during the drier parts of the year and at hot times of the day, particularly in the lowlands.

Plate 5.19: Pig-nosed turtle *(Carettochelys insculpta)*

5.2.3.7 Off-river Waterbodies

The discovery of breeding New Guinea freshwater crocodiles in a small, off-river waterbody alongside the Baia River during the Project surveys identifies this habitat type in unstable lowland landscapes as a management priority. Such habitats are created by localized damming of runoff by landslides and should therefore be reasonably simple to maintain through construction.

5.2.3.8 Habitats and Flora and Fauna of Cultural Significance

Culturally significant areas, habitats and species may occur throughout and surrounding settled areas in the Upstream Project Area. They may vary from a small swamp that harbors a spirit to a place where medicinal plants are harvested. As such sites are only known to locals and cannot be located by outsiders, local input is included in the preconstruction surveys.

5.3 RISK ANALYSIS AND IDENTIFYING POTENTIAL IMPACTS TO BIODIVERSITY VALUES

The EIS was prepared to assess potential impacts on a range of environmental and social parameters. Twenty-six independent studies carried out by environmental technical specialists, many with long experience in PNG and the Kikori River region, were conducted to assess the potential impacts of the Project and reported as appendices to the EIS and the results summarized in the main body of the EIS[18].

[18] Part III of the EIS presents the impact assessment for the Upstream Project Area. The results of the cultural heritage impact assessments and of the socio-economic impact assessments are given on a Project-wide basis in Chapters 22 and 23 of the EIS, respectively.

Box 5.6: New Guinea's long-beaked echidnas

There are four species of echidna; all occur in New Guinea and one is shared with Australia. The three species of long-beaked echidnas, Sir David's long-beaked echidna (*Zaglossus attenboroughi*), eastern long-beaked echidna (*Z. bartoni*) and western long-beaked echidna (*Z. bruijnii*), are endemic to PNG and all listed as critically endangered by the IUCN (2010). Together with the Australian platypus, they form the ancient monotremes.

Eastern long-beaked echidnas occur in the Upstream Project Area and are large, ant-eating, terrestrial, egg-laying mammals reaching to 0.75 meters in length and weighing up to 9 kilograms. While echidnas are mostly forest animals, if not persecuted, they can occur in grasslands and secondary forest areas. *Zaglossus* are specialised feeders of earthworms, which they detect with their keen sense of smell. Signs that an echidna may be present are the tubular holes that they make with their snouts when foraging.

Hunting has reduced populations of long-beaked echidnas in most populated regions of New Guinea and they have become extinct in several areas. If not persecuted, they can attain moderately abundant populations but this now tends to be localised to inaccessible rugged mountains.

The impact assessment for biodiversity relies on the biodiversity data collected during project surveys and on expert opinion on the dynamics of the habitats and species involved, as well as on the experience that had been gained with other hydrocarbon and resource projects. In such a diverse region as the Upstream Project Area, the knowledge of species biology and of habitat dynamics varies from reasonable to non-existent so impact assessments needed to be guided by a decision system that attempted to produce consistency across discipline assessments. The system had, as its core, the concept of significance of an impact, which in this case had the common English meaning of the word, not classical statistical significance.

For the EIS, significance was derived from two elements: the magnitude of change, including scale and duration of the impact; and the value or sensitivity to change of the receptor (species or habitats). The magnitude of impact was defined for three classes of effects: habitat impacts, population impacts, and other ecological effects that degrade habitat or reduce population viability e.g., barrier effects, fire, exotic species, contamination etc. Categories and definitions of magnitude are shown in Table A5.1 of Appendix 5. The value and/or sensitivity of the receptor related to biodiversity value is shown in Table A5.2 of Appendix 5. Significance was determined by a cross tabulation of impact magnitude and value of the receptor (see Table A5.3 of Appendix 5).

This approach is similar to Esso Highlands Limited's preferred risk-based assessment approach. Both methods utilize criteria concerning magnitude and susceptibility to determine the significance/risk of an impact and appropriate avoidance/mitigation measures to reduce the significance/risk of the identified impacts to acceptable levels.

The impact analysis identified many potential direct impacts on biodiversity: habitat loss, edge effects, barrier effects, physical damage and disturbance to caves, fauna falling in the pipe trench, erosion, movement of spoil and changes to hydrology, materials handling, disposal of hydrotest fluids, dust, loss of breeding and display grounds, noise, lights and other disturbance, Project traffic and other operations. Potential indirect impacts included fire, dieback, the introduction and spread of alien species and diseases, hunting, and enhanced access to the Project Area.

The significance of residual impacts after mitigation of all but seven potential impacts were low. The seven impacts whose residuals were moderate or major and therefore of most significance to biodiversity values were habitat loss in priority ecosystems, edge effects in high-altitude karst, barrier and erosion impacts in deep, steep cuttings in karst[19], and the indirect impacts of fire, the introduction and spread of alien species and diseases, and enhanced access. The latter two are arguably the most significant in that they have the potential for system-wide impacts in the Upstream Project Area forests. All seven residual impacts on the biodiversity values as defined in Section 5.2.1 formed the basis for offsetting and monitoring. Examples of impact analyses are given in Table A5.4 of Appendix 5 and a cross tabulation of the relevance of residual impacts to the biodiversity values are presented in Table A5.5 of Appendix 5.

[19] These barrier and edge effects were divided in the EIS analysis into: 'edge and barrier effects in high altitude karst', 'edge and barrier effects on arboreal species in high karst' and 'erosion, movement of spoil and change to hydrology on arboreal species in high karst'. The expression of these impacts in the Biodiversity Strategy is more useful.

6.0 Goals and Objectives

6.1 GOAL

The goal of this Biodiversity Strategy is to retain the biodiversity values of the Upstream Project Area on a regional scale for the long term. This goal is designed to be consistent with paragraph 10 of IFC's Performance Standard 6.

Box 6.1: IFC Performance Standard 6 paragraph 10 (critical habitat)

In areas of critical habitat, the client will not implement any project activities unless the following requirements are met:

- There are no measurable adverse impacts on the ability of the critical habitat to support the established population of species described in paragraph 9 or the functions of the critical habitat described in paragraph 9.
- There is no reduction in the population of any recognised critically endangered or endangered species and any lesser impacts are mitigated in accordance with paragraph 8.

6.2 OBJECTIVES

The Biodiversity Strategy is based on the premise that achieving this goal requires objectives at a regional, priority ecosystem and focal habitat scale as described in Chapter 5.

1. **To maintain the ecological intactness of the Upstream Project Area as a whole.** The long-term maintenance of biodiversity requires long-term functioning of the ecosystems in the Upstream Project Area. This objective can be realized by ensuring impacts capable of system-wide effects on function, i.e., invasion and spread of exotic weeds, pests and diseases, fire and uncontrolled access leading to wide-scale deforestation and defaunation, do not propagate into the Upstream Project Area as a whole.

2. **To conserve the priority ecosystems.** Some Project infrastructure will be built within these priority ecosystems and therefore it is necessary to demonstrate that these ecosystems do not degrade after construction. This has required changes to Project design, the development of special mitigation measures and will require ongoing management and control of access during operations.

3. **To protect focal habitats.** Focal habitats avoided or managed during construction need to be protected during operations to ensure that the risks of reducing a population of a critically endangered or endangered species are as low as possible.

4. **To account for residual impacts.** All projects have residual impacts and appropriately accounting for these by offsets is the final requirement to meet the goal of this Biodiversity Strategy.

Integral to achieving the goal and objectives of this Biodiversity Strategy is a management hierarchy of avoidance, mitigation, offset and monitoring, each of which is discussed in Chapters 7, 8, 9 and 10, respectively.

Plate 6.1: Stakeholder consultation at Benaria (October 2005)

7.0 Avoidance of Impacts on Biodiversity

7.1 PROCESS

Avoiding impacts on the biodiversity of the Upstream Project Area has been factored into Project feasibility, planning and design studies since its inception. In practice, this has meant considering avoidance measures at discrete phases of the Project and at discrete scales, the latter within the Upstream Project Area aligning with the three scales of biodiversity values discussed in Chapter 5.

Early feasibility investigations prior to the EIS assessed avoidance measures at the regional scale by contemplating the development of Project infrastructure on the north coast of PNG outside of the KICDP. For various technical and environmental reasons, this option was discarded (Box 7.1).

Box 7.1: Pipeline routing: Upstream Project Area versus other regions

A major planning decision early in the Project lifecycle was whether to locate the LNG Facilities site on the north or south coast of PNG. A north-coast option near Wewak would be closer to customers in Asia. However, constructing the LNG Project Gas Pipeline to the north coast would involve crossing the central cordillera of PNG whose northern slopes are largely biologically unexplored and undisturbed. Moreover, the extensive swamps and large rivers of the Sepik River floodplain would have to be crossed and disturbed. Most of this almost wholly greenfield pipeline alignment would cross country with no roads, little population and correspondingly large expanses of primary tropical forest of even higher value than that of the Kikori River basin.

A south coast option through the Kikori River basin, on the other hand, could take advantage of co-locating for much of its route in the existing disturbance corridor of the Kutubu crude oil export pipeline ROW. Here, the limestone-dominated terrain is inherently more stable, the risk of a seismic event is lower, and the environment and social setting are much better understood.

Esso Highlands Limited did not, therefore, proceed with the north coast option because the environmental (largely biodiversity) and constructability issues outweighed the commercial advantages of lower LNG shipping costs.

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

Once the Upstream Project Area had been chosen, limiting impacts on biodiversity values focused on (i) the large scale – the preferential siting of pipeline infrastructure and facilities in or near habitats that have already incurred some level of disturbance, (ii) the medium scale – limiting the Project footprint in priority ecosystems and (iii) the local scale – avoiding focal habitats.

7.2 AVOIDANCE MEASURES

7.2.1 Pipeline Routing – Options Within the Upstream Project Area

As part of the pipeline routing process, Esso Highlands Limited followed a hierarchical system of guidelines to inform the preferential siting of pipeline infrastructure giving due consideration to sometimes competing environmental, social and cultural, constructability and safety constraints (Box 7.2).

Significant alternate route options were analyzed in six pipeline route sections within the Upstream Project Area to meet the above guidelines (Appendix 6 and Figure 7.1):

- An eastern versus western route from the Hides Gas Conditioning Plant to Kutubu Central Processing Facility.
- Two routes from Idauwi to Homa.

Box 7.2: Routing guidelines for the upstream pipelines

Level 1. Follow existing infrastructure corridors (e.g., the Kutubu crude oil export pipeline, few existing roads and other infrastructure). If not possible then apply Level 2 guidelines.

Level 2. Route to best manage safety, social and environmental constraints.

- Route to optimize traversing landscapes of clearings, logged or degraded forest.
- In areas of undisturbed continuous forest, choose the shortest route to reduce habitat loss. The shortest route would then be modified, where practicable, according to the following safety, environmental and cultural criteria:

A Safety:
- The pipeline could be physically and safely built.
- The crossing of active faults is reduced.
- Avoid or reduce traversing terrain prone to landslides.

B Cultural:
- Passing through villages is either avoided or reduced.
- Passing through areas or sites of high cultural significance is either avoided or reduced.

C Environmental:
- Traversing a WMA or WWF noteworthy area for special protection measures is either avoided or minimized.
- Traversing swamplands or other areas prone to flooding is either avoided or reduced.
- Traversing terrain containing longitudinal or side slopes is either avoided or reduced.
- Crossing of large watercourses is either avoided or reduced.
- Traversing terrain where soils are stable and not prone to erosion is optimized.

Logging roads in Gulf Province

Level 3. In areas of existing petroleum production infrastructure, reduce interference with existing petroleum infrastructure.

Level 4. Environmental and social constraints too localized at the scale of mapping for the EIS were added to a catalogue of constraints to be identified for tactical micro-scale routing in preconstruction surveys.

- Three routes from Homa to Moro (Wage Creek).
- Two routes from Moro to the Ai'io River.
- Two routes between Manu and Gobe (Digimu River).
- Three routes from the Kikori River crossing to the Omati River Landfall.

In all cases, avoiding impacts on biodiversity by limiting losses of intact primary forest was a major consideration of the large-scale routing process.

7.2.2 Priority Ecosystems

The three priority ecosystems that will see development as part of Phase 1 of the Project, i.e., Hides Ridge, high-altitude forest above 1,800 meters on the Homa Deviation and the Lake Kutubu WMA, received particular design consideration to limit impacts in these areas. Table 7.1 and Box 7.3 summarize the design and management mitigation measures implemented by the Project to protect biodiversity values in these areas.

Figure 7.1: Alternative pipeline alignments

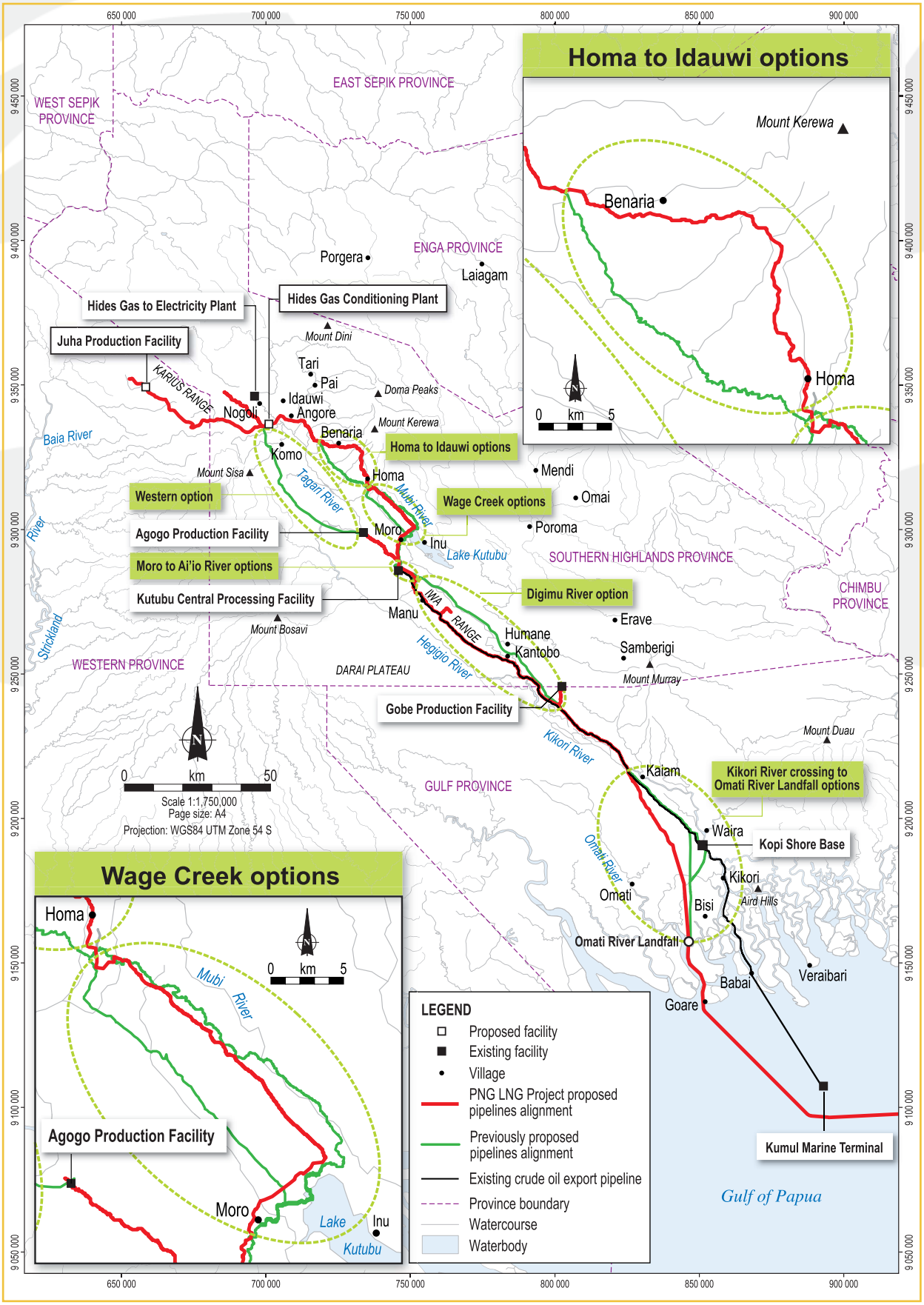


Table 7.1: Biodiversity-related design considerations and changes in priority ecosystems

Hides Ridge
Design options considered: • This area received much study with the primary aim of limiting disturbance to terrain and reducing loss of forest on the ridge. Keeping wellpad production and pipeline access facilities and infrastructure off the ridge by directional drilling from base of the ridge was analyzed but a range of physical factors, including the difficulty of controlling pressure in the gas bearing formations, the highly stressed nature of the rocks potentially fracturing shallow angle drill holes and limits to the density of drilling muds that can be used, conspired to force abandonment of the concept. • To limit the development footprint on the ridge, low-impact construction activities such as using similar helicopter-supported methods as were adopted to build the existing gathering system at Hides field were investigated. However, constructing the pipeline and drilling wells using only helicopter support was abandoned because of the limited cloud-free time on the ridge and because a ROW would still be needed for heavy machinery to lay the 22-inch pipe. • Manually building multiple above-ground flowlines with helicopter support using numerous small diameter pipes was canvassed as a means of delivering the gas from the wellheads to the Hides Gas Conditioning Plant. This option was abandoned as the environmental damage was likely to be greater because of the large work force that would need to be accommodated on the ridge and the necessary wide ROW needed to accommodate the many pipes, and on which no regeneration could be allowed.
Design features implemented: • Average pipeline ROW width reduced by ~ 50 percent i.e., 30 meters to 18 meters. • Construction track and ROW separated where possible to reduce size of cuttings. • High-level quarantine and access control.
Juha
The banks of the Baia River are particularly unstable and susceptible to erosion if disturbed. The proposed ROW will be located along the more stable northern areas of the Baia River valley, and special construction procedures will be taken into consideration for the crossing of the river to reduce the potential for landslip.
South of the Karius Range, the proposed pipelines ROW and access way cross karst terrain with small pools or swamps at the bottom of some sinkholes offering high-value conservation microhabitats. Design mitigation and management measures to limit erosion and sediment delivery to these habitats include: • Aligning the pipelines ROW to bypass potentially high-value conservation swamps and sinkholes less than 50 meters deep where practicable. • Locating the temporary Juha drilling camp within the footprint of the Juha Production Facility. • Optimizing construction to protect stream heads in the Baia River area and elsewhere above 1,800 meters to reduce erosion and sediment delivery to those watercourses.
High-level quarantine and access control over the life of the Project.
High-altitude forest above 1,800 meters on the Homa Deviation
Deviation around Homa to reduce crossing and disturbance to steep slopes, unstable volcanic soils and a landslide-prone terrain.
Construction track and ROW separated where possible to reduce size of cuttings.
High-level quarantine and access control.
Lake Kutubu
Lake Kutubu has been a focal point for management and protection for Esso Highlands Limited in the design and planning of Project pipeline routes and facilities. Design mitigation measures have been in areas as follows: • ROW Optimization. Reducing ground disturbance in the catchment of Lake Kutubu by reducing the LNG Project Gas Pipeline ROW footprint, in particular the crossing of watercourses draining into the lake thereby significantly reducing potential turbidity impacts to the waters of Lake Kutubu. • Liquids Loss Control. The Hides–Kutubu Condensate Pipeline that will share a common ROW with the onshore LNG Project Gas Pipeline between the Hides Gas Conditioning Plant and Kutubu will feature four mainline valves at approximately 20- to 25-kilometer intervals which will separate the pipeline into five segments and limit the volume of a potential spill from each segment to approximately 800 cubic meters. A check valve approximately 12 kilometers downstream of the last mainline valve will provide additional protection within the Lake Kutubu catchment. This valve will be buried; however, a security fence to restrict access will be installed as necessary. The volume between the last mainline valve and the check valve will be approximately 360 cubic meters. • Above-ground Fault Crossings. Project pipelines will cross major faults that could, if movement along the fault plane occurred, damage or even rupture the pipeline. There are seven potentially active faults (15 splays) along the pipeline route between Hides and Kopi. Two active faults, the Tibi Fault and Papua Fault, are crossed by the ROW at the north end of Lake Kutubu. • Pipelines will be designed to withstand earthquakes with a return frequency of 300 years, but with sufficient ductile strength to deform without rupturing under more severe shaking with a return frequency of 1,500 years. In order to reduce the risk of damage, in the vicinity of the fault, the pipeline will be constructed above ground and include an expansion loop sized to take into account predicted vertical movements of the fault.

Box 7.3: Design mitigation measures in priority ecosystems

Pipeline ROW Formation Earthworks on Hides Ridge

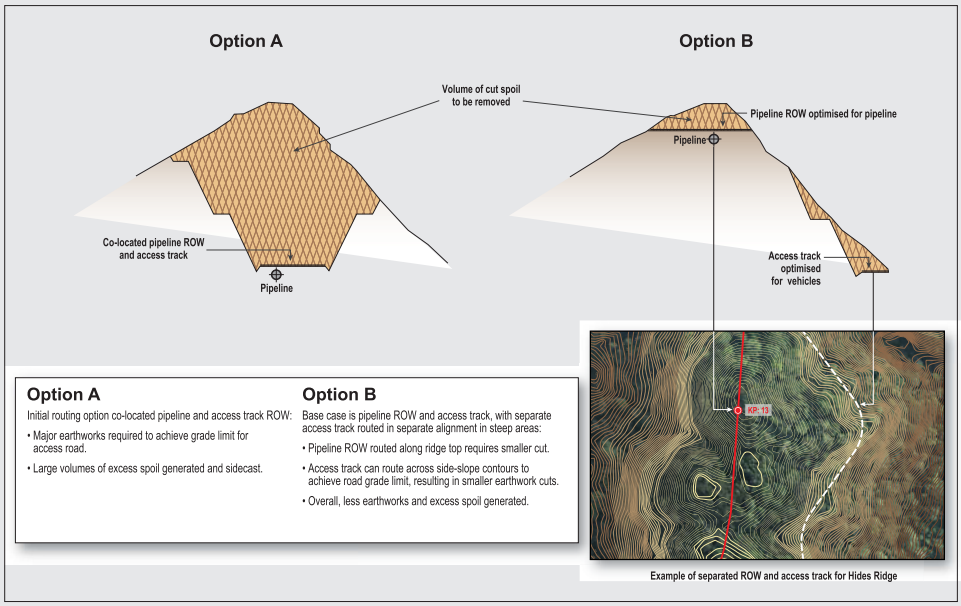
The conventional practice of co-locating the pipeline trench and construction access track requires a pipeline ROW 18 meters wide. This will generally reduce earthworks volumes in most types of terrain and, for much of Hides Ridge, could be achieved by routing along ridge tops. However, there are places where steep slopes on the long axis of Hides Ridge would require large cuts to meet the grade requirements of the access track. The alternative was therefore investigated of separating the pipeline ROW from the access track in separate benches. The stylized sections show that the volume of earthworks, and hence forest damage, reduces considerably if the access track and pipeline ROW can be separated in this way, and this approach has been adopted in Project design.

Hides Ridge very small crowned forest with *Nothofagus*

Between Homa and Idauwi—High-altitude Forest Above 1,800 Meters

This section of the onshore portion of the LNG Project Gas Pipeline ROW is constrained by lack of access roads, continuous forest cover and unstable soils. A previous proposed western alignment (Option A) to facilitate a future public road took the onshore portion of the LNG Project Gas Pipeline ROW through unstable volcanic soils on steep slopes, where major earthworks were needed with the attendant issues of unstable slopes, erosion, large footprint, tight working space, workforce and public safety and the disposal of cut spoil. A longer route (Option B) running east, then south was able to take advantage of more stable soils and ridge tops (see Figure 7.1). It involved more direct clearing of forest, but this was outweighed by the stability, safety and the other environmental advantages of much reduced earthwork volumes, less cutting spoil and lower fugitive sediment potential.

Reducing impacts on Hides Ridge



Example of separated ROW and access track for Hides Ridge

Wage Creek Pipeline ROW Optimization – Lake Kutubu Catchment

- The original onshore portion of the LNG Project Gas Pipeline ROW alignment (Option A) along the valley of Wage Creek to a point near Lake Kutubu was the shortest constructible route between Homa and Moro, but faced a number of environmental constraints. Wage Creek occupies a narrow and steep valley and flows directly into Lake Kutubu. Earthworks would increase sedimentation in Wage Creek and through its delta. As well, the route traversed previously undisturbed terrain and an area of ecologically significant swamp forest.
- Option B, subsequently proposed, followed an existing road and co-located the main upstream Project logistics route with the onshore portion of the LNG Project Gas Pipeline ROW. The pipeline ROW was longer by 12 kilometers but largely avoided the impacts of Option A.
- On further evaluation, a decision to use the 'ring road' between Moro Junction, Poroma, Tari, Idauwi and Hides as the main upstream Project logistics route rightly separated the discrete pipeline construction and logistics functions. Option C, as proposed between Homa and Moro, no longer has to meet the shallower slope angle required for road construction and therefore has been optimized to use steeper ground to shorten the route. Option C takes the onshore portion of the LNG Project Gas Pipeline away from swamp forests north of Lake Kutubu, maintaining a buffer width greater than1 kilometer between the pipeline ROW and the edge of the lake, onto the more stable limestone hills resulting in reduced clearing and disturbance impacts to the sensitive swamp forest of the lake (see Figure 7.1).

Box 7.4: Limestone

Limestone and karst, which tend to produce poor soils, comprise 79 percent of the Upstream Project Area. On the limestone plains of the lowlands and on some upland ridges, there is often a solid limestone pavement with little evidence of rock breakdown and little soil, with the forest in these areas supported by its own thin root mat covering the pavement. These forests are prone to wind throw that peels sections of forest off the pavement. Nutrient cycling on limestone pavements is highly internalized, with the bulk of the nutrients tied up in the forest itself. Regeneration of these areas appears to be very slow and require lichens and fine roots to form a mat in which larger plants and trees can germinate.

In areas of polygonal karst, in upland karst corridors and in the decomposing rock of the upper ridge slopes, tree roots can penetrate into the many fissures and weaknesses in the rock. Consequently, trees have bigger crowns and boles, producing better developed forests overall, similar to those on the richer valley alluvial soils. A feature of polygonal karst is the rarity of flowing steams; most surface water runs into the limestone through numerous fissures or into sinkholes. Underground rivers can also break out and form surface streams.

Most of the limestone landforms are well drained, and perched valleys with terra rossa clays occur in the uplands. However, the watertable in many parts of the lowlands is close to the surface and in areas of impeded drainage, dry forest gives way to palm- and pandanus-dominated swamp forest, swamps and wetlands. Close to the coast, swamp forests and swamps merge into mangroves.

While there is a specialized limestone flora, it is not restricted to the limestone of the Upstream Project Area.

Only some 21 percent of the Upstream Project Area is on volcanics and alluviums that provide high-quality growing conditions for plants. The soils on flat and rolling terrain are preferentially used for shifting cultivation, and the forest in these areas has been cleared or comprises a complex of secondary growth, old growth forest and regenerating areas.

A large waterfall has its source in this upwelling from karst at the Liddell River

Water ponding on karst on the Kutubu crude oil export pipeline ROW approaching the Mubi River valley

Darai Plateau showing polygonal karst countryside

7.2.3 Focal Habitats

Following the EIS process, Esso Highlands Limited committed to undertaking preconstruction surveys for all worksites, prior to the commencement of work. The objective of these surveys was to identify additional environmental and cultural heritage sensitivities that were impossible to map at the scale of assessment conducted during the EIS and to develop appropriate site-specific mitigation measures focused on avoiding local-scale focal habitats where possible. As of 30 June 2010, over 80 surveys have been conducted for ecology, weeds and cultural heritage and over 40 sites were surveyed for surface water quality.

As well as the focal habitats, the preconstruction surveys searched for the following sensitivities as required by the Project's environment permit:

- Recognized or pending protected areas, which include but are not limited to WMAs, conservation areas, Ramsar sites, provincial reserves, national reserves, sanctuaries and protected areas, and national parks.
- Any species protected under PNG legislation or listed in CITES appendices, or in the IUCN Red List as critically endangered, endangered, vulnerable or data deficient.

- Potential Bulmer's fruit-bat colonies.
- Bird-of-paradise and bowerbird display grounds or trees.
- Large individual trees (greater than 1 meter diameter at breast height).
- *Nothofagus* forest that will require special hygiene measures.
- Areas of *Nothofagus* dieback.
- Areas of infestations of priority weeds or pests that require management.
- High-risk areas for new weed and pest invasion.
- Cultural heritage (archaeological and oral tradition) sites.

8.0 Identification of Mitigation Measures and Development of Management Plans

8.1 MITIGATING IMPACTS THROUGH THE ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

The management and mitigation commitments contained in the EIS were taken forward during the development of the ESMP for the Project (see Section 3.1.2).

All environmental and social management and mitigation commitments made by Esso Highlands Limited are identified in the PNG LNG Project Environmental and Social Mitigations Register, which is used to track and document the implementation and status of each commitment. The register is updated as necessary to incorporate new commitments that arise as construction progresses. It includes site-specific mitigation and management measures resulting from preconstruction environmental and social surveys and other alternative and/or additional measures identified as Project execution progresses and lessons learned from field programs are documented.

Some key environmental impacts relating to biodiversity in the Upstream Project Area, as listed in Table A5.4 of Appendix 5, are addressed in the following Esso Highlands Limited environmental management plans:

- ESMP Appendix 1: Ecological Management Plan.
- ESMP Appendix 8: Weed, Plant Pathogen and Pest Management Plan.
- ESMP Appendix 9: Erosion and Sediment Control Management Plan.
- ESMP Appendix 11: Reinstatement Management Plan.
- ESMP Appendix 12: Induced Access Management Plan.
- ESMP Appendix 31: Quarantine Management Plan.

The scope of these plans and key management measures contained therein are discussed below.

Environmental preconstruction surveys will be undertaken both by Esso Highlands Limited and its contractors in order to further define environmental characteristics on a site specific basis, assess the associated potential environmental impacts to enable measures to prevent, reduce, mitigate, and otherwise manage and control such impacts.

8.1.1 Ecological Management Plan

The objectives of the Ecological Management Plan are to reduce the impacts on habitat and specific ecological aspects arising from construction activities. It addresses the impacts of habitat loss, edge effects in high-altitude karst, barrier and erosion impacts in high-altitude karst, and barrier and erosion impacts in high cuttings.

The focus of the Ecological Management Plan 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. It applies at all three scales of biodiversity values.

Environmental preconstruction surveys are undertaken prior to construction and the Ecological Management Plan requires these surveys of all Project worksites to identify not only focal habitats but also karst pinnacles that may contain bat colonies, bird-of-paradise and bowerbird display grounds or trees, large individual trees, *Pandanus* swamp forest, *Nothofagus* forest that will require special hygiene measures and IUCN-listed species.

The outcome of the surveys are defined GPS-registered constraints/sensitivities for avoidance, definition of further measures/methods to reduce and mitigate impacts on sensitive ecological features, such as seasonal constraints (breeding and lekking periods, migratory stop-over or pass-through periods, etc.) and identification of sections of access ways/infrastructure that require area or site-specific rehabilitation and revegetation intervention.

Please refer to the Ecological Management Plan for further details.

8.1.2 Weed, Plant Pathogen and Pest Management Plan

The objectives of the Weed, Plant Pathogen and Pest Management Plan are to prevent the introduction and spread of alien species and diseases in the Project Areas during construction works, identify and contain, suppress or manage significant weeds, plant pathogens and pests already in the Project Area to prevent spread by Project activities and implement measures to reduce the risk of spread of dieback in *Nothofagus* forests.

The scope of this plan includes measures to address (i) new weeds, plant pathogens or pests[20] imported into the Project Area from contaminated vehicles, machinery, equipment and/or freight and (ii) weeds, plant pathogens and pests spread by Project activities from existing infestation/dieback areas.

The plan requires preconstruction surveys to identify activities that present a high risk of spreading weeds and pests[21], construction areas that are high risk for new weed and pest invasion[22], particular weeds and pests for surveillance, control and management, including compilation of a list detailing priority weeds and pests[23] and common weeds, *Nothofagus* forest susceptible to fungal disease and associated dieback that will require special hygiene measures, areas of *Nothofagus* dieback and areas of infestations of priority weeds or pests that require management.

Control of priority weed species is required to prevent them becoming further established at Project worksites and to prevent the spread of priority weeds beyond their current distribution. Monitoring for the presence of weed species identified during preconstruction surveys shall be undertaken during construction and, when encountered, priority weeds species shall be appropriately controlled. Topsoil from Project worksites shall not be transported offsite nor stockpiled directly adjacent to natural drainage lines.

To facilitate the control of weeds, plant pathogens and pests, vehicle washdown facilities will be installed at strategic locations to prevent contamination of priority ecosystems.

8.1.3 Erosion and Sediment Control Management Plan

The objectives of the Erosion and Sediment Control Management Plan are to maintain stable landforms to reduce erosion and enhance reinstatement, maintain integrity of assets (through stable landforms) and reduce adverse impacts on stream water quality, and associated beneficial values, and in-stream sedimentation. It addresses the impacts of habitat loss, edge effects in high-altitude karst, barrier and erosion impacts in high-altitude karst, and barrier and erosion impacts in high cuttings.

The scope of the plan includes measures to address destabilized landforms and soil erosion potentially resulting in reduced water quality and/or reinstatement success, loss or degradation of topsoil from cleared areas, potentially resulting in reduced reinstatement success and runoff from cleared and disturbed areas causing increased suspended solids/turbidity and in-channel sedimentation, potentially resulting in reduced water quality with consequent reduction in availability of aquatic resources and suitability of water for drinking.

Project contractors are required to assess and establish erosion and sediment control requirements for each worksite (particularly in relation to site-preparation earthworks, road construction across watercourses, watercourse diversions, site drainage), detailing specific erosion and sediment controls to be implemented (e.g., diversion drains, sediment ponds and fabric silt curtains).

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[20] An exotic weed or pest is defined as an invasive (native or introduced) or introduced species that causes an adverse impact on the ecology and/or communities.

[21] High risk is defined as anything that a weed or pest can attach itself to, or be transported by.

[22] High risk is defined as an area that intersects a priority ecological area, i.e., Hides Ridge, or anywhere that has potentially uncontrolled access.

[23] Weeds and pests that have a high potential for significant adverse impacts if an incursion occurs or spread from an existing incursion occurs.

8.1.4 *Reinstatement Management Plan*

The objectives of the Reinstatement Management Plan are to establish stable landform conditions in areas disturbed as a result of construction activities and create ground conditions conducive to natural plant regeneration. It is another plan addressing the impacts of habitat loss, edge effects in high-altitude karst, barrier and erosion impacts in high-altitude karst, and barrier and erosion impacts in high cuttings.

No specific surveys are required for the plan as part of the environmental program; however, preconstruction pipeline engineering surveys will be undertaken, which will include the collection of data required to facilitate reinstatement planning.

Project contractors are required to develop site-specific reinstatement plans based on land systems or equivalent and address ground-preparation activities, interim and permanent soil erosion and sediment management issues, and approaches to revegetation (natural regeneration versus intervention). Project contractors are required to undertake site reinstatement promptly and progressively as works are staged, and as soon as possible after disturbance, taking into account the nature of subsequent Project activities that will be undertaken at the same sites and agreed end uses.

8.1.5 *Induced Access Management Plan*

This plan is entirely focused on managing the potential impact of induced access. Its objectives are to control access to new Project roads and reduce the occurrence of potentially damaging non-Project activities.

The planned approach for controlling access is an integrated management process that involves:

i) Use of natural terrain features and conditions to control access e.g., steep slopes, watercourses.

ii) When no longer required, removal of strategic Project infrastructure to control access.

iii) Installation of operational controls, e.g., security guards, physical barriers.

Additionally there are three specific measures for particular sections.

1. **Controlling Access for the Southern Access Route**[24]**:** the road from Gobe to Kantobo will be closed at the end of the construction phase to prevent induced access. A combination of natural terrain features and the removal of two culverts will prevent through access in the Southern Access Route.

2. **Kantobo Section:** the removal of culverts will occur at the end of the construction phase. Natural terrain and removal of culverts will prevent future passage of traffic.

3. **Gobe Section:** the removal of culverts will occur at the end of the construction phase.

8.1.6 *Quarantine Management Plan*

The Quarantine Management Plan has been developed to prevent the importation and spread of pest, plant pathogen or disease (invasive species) via Project personnel or cargo and ensure full compliance with all PNG laws and regulations.

[24] The Southern Access Route is a Project-developed logistics route between Kopi in the south and Hides in the north. It involves construction of new and repairs to existing sections of roads and bridges to allow transport of essential equipment and machinery to develop the facilities and infrastructure in the Upstream Project Area.

The objectives of this plan are to:

i) Prevent the importation and spread of pest, plant pathogen or disease (invasive species) via Project personnel or cargo.

ii) Ensure full compliance with all PNG laws and regulations.

iii) Facilitate expedient quarantine clearance of all freight imported into PNG for the Project.

iv) Implement effective quarantine control measures for the export of Project freight.

This plan is focused on prevention before either freight or personnel arrive in PNG. This is directly compatible with PNG Government policy, which, in view of the high quarantine risk associated with the import of goods such as new and used vehicles, plant and machinery, requires offshore cleaning and inspection before cargo is exported to PNG.

8.1.7 Fire Management

Prevention and response to fires (including wildfires) is addressed as part of the Project Safety Plan.

8.2 EXAMPLES OF MITIGATING IMPACTS ON VALUES

The majority of the mitigation and management commitments from the ESMP are applicable to the Upstream Project Area, priority ecosystems and the focal habitats. More specifically, 199 have been identified that apply to all three aspects. Appendix 3 includes the number of mitigation and management measures included in each ESMP appendix.

8.2.1 Upstream Project Area

There are 33 mitigation and management measures from the ESMP that are specific to the Upstream Project Area. Examples of these include:

- The standard pipelines' right-of-way (ROW) width for the Project is 30 meters. The pipeline ROW disturbance area should be limited to a 5-meter-wide buffer either side of the standard pipeline ROW, where practicable. Following construction, the ROW will be allowed to naturally regenerate except for a 15-meter-wide swathe to provide a gap in the canopy for aerial surveillance of the pipeline. If there is a requirement to exceed the ROW design width, the contractor shall seek approval through a formal procedure from Esso Highlands Limited.
- Design the modified and new wharfs at the Kopi Shore Base to take account of channel characteristics of the lower Kikori River that may affect the long-term stability of the river frontage.
- The construction and reinstatement of the pipeline ROW in the Omati River swamp area will be managed to maintain natural hydrologic flows and connectivity in the surrounding area. Monitoring of vegetation condition in the vicinity of the pipeline ROW will be conducted to assess the need for post-construction remedial works in this area.

8.2.2 Priority Ecosystems

There are 29 management and mitigation measures from the ESMP that directly relate to priority ecosystems. Those specifically related to Hides Ridge, for example, include:

- Prohibit transportation of live animals, plants or seeds to the Hides Ridge area.
- At Hides Ridge, hydrotest water sourced off the ridge will be discharged into the same watershed as its source to prevent cross-contamination with live organisms from another catchment.

- No quarries beyond cut to be established on the Hides Ridge where practicable.
- No construction camps are to be constructed on Hides Ridge beyond Hides Wellpad A[25] (with the exception of drilling camps).
- If a temporary drilling camp is necessary on Hides Ridge, there should be only one and it is to be located near Hides Wellpad D and to be used by successive drilling campaigns.
- The design criteria for the pipeline ROW width on Hides Ridge is 18 meters. During operations, the pipeline ROW will be allowed to regenerate except for a 10-meter-wide access road required for ongoing drilling and maintenance access to the wellpads on the ridge.
- Control access to Hides Ridge west of Hides Wellpad A and implement a permit system for vehicle access for the duration of construction.
- Dispose of drilling fluids, drilling cuttings and other drilling materials in an appropriate manner away from Hides Ridge.
- Dispose of wastes from pipeline ROWs and access ways construction activities (not spoil or timber) and camps (including the drilling camp) away from Hides Ridge.
- Identify areas requiring active revegetation on Hides Ridge and in areas between Idauwi and Homa, in particular unstable volcanic terrains.

8.2.3 Focal Habitats

There are 14 mitigation measures specific to focal habitats from the ESMP. The main focus of these management and mitigation measures is to avoid these particular habitat types, where possible. Examples of these measures include:

- Locate off-river waterbodies that might provide juvenile nursery habitat for New Guinea crocodiles and swamps in sinkholes less than 50 meters deep, and avoid destroying or avoid sidecasting into them.
- Implement appropriate avoidance measures for caves with bat colonies by prohibiting or controlling blasting within 100 meters of known colonies of cave bats.
- Reduce impacts on *Pandanus* swamp forest by designing access ways, pipeline ROWs, facility sites and supporting infrastructure to allow adequate surface flows.
- Conduct surveys along access ways, pipeline ROWs, facility sites and supporting infrastructure sites to identify sensitive features.

The main focus of the preconstruction surveys is to locate focal habitats (see Section 7.2.3). In instances where these habitats are found, the management and mitigation measures in the ESMP are refined and made specific to the survey site. Examples of site-specific mitigation measures include:

- The Ramsar-listed Lake Kutubu is located downstream of the Moro Parker Camp worksite. Control is required to prevent the release of pollutants to the Hamua Creek. Pursuant to Mitigation Measure M134 of Esso Highlands Limited's Water Management Plan, wastewater discharges shall be treated as necessary to comply with the wastewater discharge conditions prescribed in the Environment Permit. A contingency plan shall be developed to enable prompt preventive/remedial action in case discharge criteria may not be or are not met.
- Pursuant to Mitigation Measure A61 of Esso Highlands Limited's Weed, Plant Pathogen and Pest Management Plan, control is required to prevent *Lantana camara* and frangipani ginger becoming established at the Kobalu Camp worksite. Monitoring for the presence of these weed species shall be undertaken and, when encountered, be appropriately treated (i.e., via chemical application) or otherwise controlled.

[25] Wellpad A is the southernmost wellpad and located off the ridge in previously disturbed terrain.

9.0 Development of a Biodiversity Offset Delivery Plan

9.1 INTRODUCTION

Objective 4 of this Biodiversity Strategy (see Section 6.2) requires that residual impacts on biodiversity values be appropriately accounted for through an offset program of conservation/rehabilitation measures, guided by good industry practices. Planning and delivery of conservation/rehabilitation projects is not Esso Highlands Limited's core business nor does it have a right to make conservation decisions on lands it does not control. Fundamental to the Project's offset program, therefore, is the involvement of stakeholders who have the knowledge, experience, skill and rights to help determine what may be appropriate and effective offsets and how they may be delivered. At this early stage of Project development, this Strategy therefore presents an outline only of an offset program that is being contemplated for the Project so as not to close off structures and options that stakeholders may demonstrate are more appropriate.

Following stakeholder involvement, a detailed Biodiversity Offset Delivery Plan will be produced that will detail what, how and when offsets may be delivered.

9.2 INTERNATIONAL GUIDANCE AND REFERENCES

Biodiversity offset is subject to a variety of definitions that reflect differing interpretations of terms such as mitigation and compensation, and concepts such as no net loss, net benefit, the mitigation hierarchy of avoid, minimize, restore and offset impacts on biodiversity. The definition of biodiversity offsets adopted here is (BBOP, 2009a):

> conservation outcomes resulting from actions designed to compensate for significant residual diverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The goal....is to achieve no net loss and preferably a net gain of biodiversity.

Given that no net loss and preferably net gain is the aim of the offset program, there is a range of experience that can be drawn upon from other jurisdictions. Biodiversity offset frameworks already in place or being developed include:

- Australia:
  - Net Environmental Benefit (Western Australia).
  - Significant Environmental Benefit (South Australia).
  - Native Vegetation Framework (Victoria).
  - Biobanking Scheme (New South Wales).
  - Environmental Offsets Policy (Queensland).
- United States of America:
  - Habitat Evaluation Procedures.
  - US Wetlands Compensatory Mitigation.
- South Africa:
  - Western Cape Draft Provincial Guideline.
- New Zealand:
  - Risk Index Method and Averted Risk Formulae.
- European Union:
  - Resource Equivalency Methods for Assessing Environmental Damage.
- International:
  - Business and Biodiversity Offsets Program (BBOP).

Box 9.1 Principles for the Biodiversity Offset Delivery Plan

A review of practices implemented or being developed internationally has allowed the following principles to be developed for the Biodiversity Offset Delivery Plan.

1. A no net loss approach has been adopted, but it is recognized that the suite of example offset projects currently identified, if successful, could potentially provide some net gain and a range of conservation outcomes, well beyond the Upstream Project Area, with no added cost.
2. Prior to developing offsets, the Management Hierarchy of avoid and mitigate was followed.
3. A Biodiversity Offset Delivery Plan cannot replace irreplaceable or extremely vulnerable biodiversity components.
4. Local culture, safety and practicality limit potential offset projects. Offset projects that might clash with local cultural norms, are unsafe, or impractical to deliver will not be pursued.
5. The Biodiversity Offset Delivery Plan recognizes that the key residual impacts on biodiversity values requiring offsetting occur in a landscape that is not fragmented and is in a less-disturbed condition based on the scientific and local information available for the area.
6. Landholder engagement is key to the offset program's success. Any offset plan would require permission and most likely participation from landholders before it could proceed. The final arbiters of which offsets can go ahead on particular parcels of land are the landholders, rather than the Government of PNG or Esso Highlands Limited.
7. Initially, offset projects might need to comprise a range of measures that can be presented to landholders for consideration and may not be the final set of offset projects that are implemented.
8. The final agreed-upon offset projects would be made publicly available.

Most offset frameworks appear to have sought to reduce uncertainty for development projects and provide a scientific or engineering approach to offsets, which has in some instances resulted in complex systems but has provided consistency across all types of projects within each jurisdiction. These existing national and state frameworks have the advantage of being tailored to local environmental, legislative and social conditions.

BBOP has been used for guidance in developing the principles of the PNG LNG Project's Biodiversity Offset Delivery Plan.

9.3 DEVELOPING BIODIVERSITY OFFSETS IN THE PNG CONTEXT

The offset plan must take account of the uniqueness of PNG and the circumstances of the Project. It has to be recognized that:

1. Papua New Guinea has no system, formal or otherwise, guiding the development of an offset plan.
2. Programs developed in jurisdictions with fragmented and degraded landscapes elsewhere have limited relevance in extensively forested tropical landscapes such as those in PNG.
3. Acquiring or managing land as an offset is not a likely option because most land in PNG is subject to various forms of customary, and hence inalienable, tenure and there is little land solely controlled by government.
4. Landholders successfully practice subsistence shifting cultivation; hence, to acquire lands for a biodiversity offset project would likely affect landholders' livelihoods.
5. There are limited offset opportunities on government-controlled lands in the Upstream Project Area.
6. Non-forested lands that may warrant restoration are rare in the Upstream Project Area and are mostly restricted to roadsides. Non-forested land is part of the population's agricultural base and provides for part of their livelihoods. Thus, there is little potential for undertaking offset projects on this type of land.
7. Protected area establishment and management in PNG is difficult because most land is in customary tenure.

9.4 OFFSETTING RESIDUAL IMPACTS

Objective 4 of this strategy requires that residual impacts on biodiversity values be offset (see Table A5.4 of Appendix 5). Table 9.1 relates residual impacts to the three scales used to develop this Biodiversity Strategy. The residual impacts requiring offsetting such as indirect Project-associated impacts and edge and barrier effects, are mostly difficult or impossible to quantify and demonstrating that offsets are relevant to the residual impacts will be difficult. This will be an important element of consultation and it is likely some system of expert judgment will be required.

Table 9.1: Residual impacts associated with the Project ranked as moderate or higher

Impact	Description	Entire Upstream Project Area	Priority Ecosystems	Focal Habitats
Direct effects on fauna	Edge effects in high-altitude karst.		X	X
	Barrier and erosion impacts in high-altitude karst.		X	X
	Barrier and erosion impacts in high cuttings.		X	X
Overall habitat loss		X	X	
Indirect impacts	Fire.	X	X	X
	Introduction and spread of alien species and diseases.	X	X	X
	Enhanced access.	X	X	X

Esso Highlands Limited has approached this by challenge by adapting the Victorian Native Vegetation Framework (Parkes, Newell & Cheal, 2003; DNRE, 2002) as a guide in planning its residual impacts offset program. This method was selected because of its maturity.

The Victorian Native Vegetation Framework calculates a quantitative offset debt based on the formal calculation of 'habitat hectares' that a development will clear. This is a function of the size of the area cleared, its condition, landscape context, and defined conservation value. In the State of Victoria, this debt is then repaid by acquiring and managing other lands that meet the same quantitative value of the debt, or by some agreed conservation program. This requires an analysis of the potential offset actions that are available in the form of lands that can be reclaimed and/or acquired for conservation purposes equivalent to the debt. In this system, the emphasis is on acquiring conservation lands and the proportion of the debt that can be met by revegetation schemes is restricted.

It is not possible for the Project to follow this system completely because, as indicated above, most lands in PNG are under the control of landholders and, therefore, obtaining conservation lands is extraordinarily difficult. Instead, the framework was used in order to calculate a habitat hectare debt based on the area to be cleared by the Project. Then, instead of using this figure to determine the area of habitat to be secured for an offset, it was used as a surrogate to estimate an approximate amount to invest in offset activities. Rules for developing offsets were then developed and it is at this stage that consultation with stakeholders will take place to determine the suite of offset projects that will be implemented.

There were sufficient data available from the EIS studies to calculate a habitat hectare debt with a slightly modified set of algorithms (Appendix 7). The initial calculation was a debt of 6,586 habitat hectares[26]. However, all but 15 meters of the ROW will be allowed to regenerate and so this means that, after 30 years,

[26] This was based on estimates of forest loss in the EIS plus allowances for Komo Airfield. An assessment of as-built losses after construction may require the calculations to be revisited.

enough land will have regenerated to reduce this debt to 3,633 habitat hectares. Estimates were then made of how much it might cost to reforest this amount of bare land[27], which provided a base case for deciding how much to invest in offsets[28]. It needs to be remembered that this estimate of offset debt included multipliers and so resources would be committed above and beyond that which would be required to simply purchase or replant the actual area of habitat lost.

Given that land purchases for conservation initiatives will be unlikely to form the bulk, if any, of the offset projects, it is considered that the best approach is to choose offsets that are most suited to the specific circumstances and stand the optimal chance of long term success in securing additional conservation outcomes (BBOP, 2009b).

9.5 CHOOSING OFFSET PROJECTS

In developing offset projects with stakeholders, there needs to be an awareness of the following:

- It is difficult to quantify what effect a particular offset project will have on the Project's residual environmental impacts on biodiversity values, and expert judgment will be a key component in the rationale for offset selection.
- No offset project has a 100 percent chance of success.
- There is likely to be a time lag between investment in an offset and achieving the full effect of the conservation benefits of an offset.
- Restricting offsets to be carried out in the Upstream Project Area may be suboptimal, and better outcomes may be achieved elsewhere. This is particularly the case for Critically Endangered and Endangered species.
- Offset projects involving culturally important biodiversity need to be included in considerations of offset projects if there are project residual impacts on these values.
- Ultimately the Government of PNG and landholders will be the final arbiters of what offsets may proceed.

A minimum set of preliminary criteria for the selection of biodiversity offset projects have been developed as follows:

1. The proposed project must address residual impacts on biodiversity values as identified in this Biodiversity Strategy to the extent practicable given the in-country challenges (see Table 9.1 and Appendix 5, Table A5.5).
2. Ideally, the proposed project is carried out in the Upstream Project Area but may be carried out elsewhere or may be carried out nationally.
3. If not carried out in the Upstream Project Area, the project should target the same biodiversity values as are impacted by the project in the Upstream Project Area.
4. For species-based conservation projects, the proposed project must target threatened species of biodiversity listed in the EIS and in priority order of Critically Endangered, and Endangered as listed in this Strategy.
5. Projects targeting Critically Endangered and Endangered species are best carried out where the best outcomes can be generated.
6. Projects involving managing indirect impacts, e.g., exotic species management, will be favored if they have a national or regional benefit beyond the Upstream Project Area.
7. If the proposed project has a research component, it must be an obvious requirement for the offset to be implemented and must be subject to external peer review.

[27] This was based on costs of employing, for example, a PNG forestry, environmental and/or landowner company, not the costs for using foreign-based consultant companies.

[28] This figure will not be made public as it may compromise discussions with stakeholders.

8. Biodiversity survey components of offsets must be within the Upstream Project Area and focused on the new species discovered in the Upstream Project Area and/or on the Critically Endangered or Endangered species.

9. The potential must exist that landowners, and/or other relevant national stakeholders, will be in favour of the offset.

10. Every project is required to have measures of success and a monitoring program built in and budgeted for and is required to supply results of monitoring annually.

11. Preference will be given to projects that have socioeconomic benefits.

In addition, the following may be considered:

- Will the project have a positive social benefit?
- Will the project have a positive climate benefit?
- Is there technical and management capacity to implement the offset?
- Is there a management system capable of delivering the project?
- Is there a track record of delivering conservation outcomes?
- Can the project be managed for the long-term in coordination with the Government of PNG and relevant stakeholders?
- Does the project take account of PNG's national biodiversity conservation priorities, as provided in the National Biodiversity Strategy and Action Plan (NBSAP)?

9.6 MANAGEMENT

There are a variety of ways offset projects may be developed and delivered by the Project:

A. Development

- Projects can be designed internally.
- Suitable existing projects can be investigated.
- Projects can be suggested by others.
- A system can be set up for submissions of projects on a competitive basis.

B. Delivery Options

- Esso Highlands Limited contracts and manages projects individually.
- Esso Highlands Limited invests in the support and/or expansion of existing conservation projects that meet the criteria.
- Funds tied to specific projects are invested in conservation trust or endowment funds managed by others.
- Trust or endowment funds are set up and run by a board with Esso Highlands Limited as a board member.
- Esso Highlands Limited contracts out the offset program to a third party.

Prior to stakeholder consultation all the above remain options.

Table 9.2 outlines the steps required to finalize the Biodiversity Offset Delivery Plan.

Table 9.2: Steps required to finalize the Biodiversity Offset Delivery Plan

Step	Timing
Establish Biodiversity Working Group & Charter	H2 2010
Stakeholder Communication & Consultation[1]	H1 2011
Finalize process for review and approval of Biodiversity Offset Projects	H2 2011
Review and approval of proposed Biodiversity Offset Projects	H2 2011 – H2 2012
Finalize and commence execution of Biodiversity Offset Delivery Plan	H2 2012

[1] Stakeholders will include as a minimum national and international NGOs and research institutions, government departments and possibly industry. There is an extensive and long-running stakeholder consultation process covering government agencies, local communities and national NGOs run by PNG LNG Project Public Affairs and SELCA. The Biodiversity Offset Delivery Plan will capitalize upon the mechanisms already in place and consultation with stakeholders will be through this group.

10.0 Development of a Biodiversity Monitoring Plan

10.1 INTRODUCTION

Esso Highlands Limited will develop a Biodiversity Monitoring Plan to monitor the success of this Biodiversity Strategy. Monitoring Activities will be started during the later stages of construction and will be in addition to monitoring of environmental performance of the Project during construction that will be carried out under the ESMP.

The ESMP dictates monitoring requirements for Esso Highlands Limited and contractors and is the primary mechanism by which environmental performance of the Project will be monitored during construction. The core environmental monitoring under the ESMP focuses on ensuring mitigation measures are carried out and specified environmental standards are adhered to. The ESMP monitoring activities most relevant to biodiversity are concentrated in the Ecological Management Plan, the Water Management Plan, the Weed, Plant Pathogen and Pest Management Plan, the Erosion and Sediment Control Management Plan, the Reinstatement Management Plan, and the Induced Access Management Plan.

The Biodiversity Strategy Monitoring Plan is complementary to the biodiversity related monitoring activities documented in the ESMP and will determine, in the longer term, whether the objectives of the Biodiversity Strategy have been met. While monitoring under the ESMP is for construction, the Biodiversity Monitoring Plan will mostly be carried out during operations.

10.2 GOAL

The overall goal of the Strategy Biodiversity Monitoring Plan is to determine if the objectives of the Strategy have been met:

1. Maintain the ecological intactness of the Upstream Project Area.
2. Conserve the priority ecosystems.
3. Protect focal habitats.
4. Account for residual impacts.

If degree of success of objectives 1 to 4 (see Chapter 6) are to be usefully related to the Project's activities, it will be necessary to add a fifth objective:

5. Determine the extent to which the project design parameters were followed and mitigation measures duly implemented.

10.3 APPROACH

Monitoring is aimed at the three scales. For each value at each scale, a set of targets is defined, each with an end-point. The end points are based on predictions of the EIS assessment process.

It is impractical to develop an individual monitoring system for each of the many high biodiversity values in the Upstream Project Area. Instead a suite of five Programmed Monitoring Activities (PMAs) was conceived each designed to gather information for indicators for many targets, so that the least number of data-gathering activities can inform the maximum number of targets. One of the PMAs involves remote sensing, three involve regular collection of field data and one involves regular compilation of data from elsewhere. The PMAs are as follows and their relevance to the values and impacts presented in Table 10.1.

Table 10.1: Relationship of PMAs to impacts and values

	PMA 1 (Remote Sensing)	PMA 2 (ROW Aerial Reconnaissance)	PMA 3 (Regeneration Surveys)	PMA 4 (Access Monitoring)	PMA 5 (Results of Offset Programs)
RESIDUAL IMPACTS					
Habitat loss	X	X	X		
Edge effects in high-altitude karst		X	X		
Barrier and erosion impacts in high-altitude karst		X	X		
Barrier and erosion impacts in high cuttings		X	X		
Fire	X				
Introduction and spread of alien species and diseases		X	X		
Enhanced access	X	X		X	
VALUES					
Upstream Project Area					
Extensive intact forest	X	X	X		
High floristic diversity			X		
High faunal diversity			X (avifauna only)		
New species			X (avifauna only)		
Endemic species			X (avifauna only)		
Unique assemblages of species			X (avifauna only)		
Species of conservation concern			X (avifauna only)		
Biodiversity of importance to local communities for resource use and cultural and spiritual purposes			X (some birds and some flora of cultural value)		
Priority Ecosystems					
The Juha area	X	X	X		
Hides Ridge	X	X	X		
High-altitude forest above 1,800 meters on the Homa Deviation	X	X,	X		
Lake Kutubu Wildlife Management Area	X				X
Focal Habitats					
Caves		X			
Sinkhole swamps		X			
Upland streams		X			
Swamp forest		X	X		
Stream refuges in unstable landscapes		X			
Lowland rivers in stable landscapes		X			
Off-river waterbodies		X			
Habitats and flora and fauna of cultural significance		X			

PMA 1 Remote Sensing of Indirect Impacts – involves the use of remote sensing to determine to what extent the Project has facilitated or increased major or moderate indirect impacts and degradation within the Upstream Project Area. This PMA will also allow estimation of final forest losses after construction. The data gathered is generally status at a particular time but change analysis will be used to monitor forest loss and gain and thus provide some insight into forest cover dynamics.

PMA 2 Aerial ROW Surveys – gathers data on the condition of the whole ROW and Project roads, by regular aerial inspection. It is this PMA that will be used to regularly check focal habitats along the ROW and act as an early warning system for invasion and spread of alien species and diseases.

PMA 3 Regeneration Surveys – gathers data on the progression of successions and faunal communities upstream using permanent plots stratified by substrate, location and treatments and scored using a benchmarking system. This PMA is not to be confused with the monitoring to be undertaken as part of the Reinstatement Management Plan under the ESMP during construction under which vegetation cover will be measured quarterly (field operation). This PMA aims at assessing regeneration performance, a part of ecosystem function measure.

PMA 4 Road Record Assessment – monitors the use of Project roads and infrastructure in order to demonstrate that during operations their use remains restricted to Project activities only. It will be carried out by regular compilation of road use records from the Induced Access Management Plan.

PMA 5 Efficacy of Offset Projects – assesses the efficacy of the Biodiversity Offset Delivery Plan. It is realized by regular compilation, review and evaluation of monitoring results required by every offset project.

Details of the PMAs are presented in Appendix 8 and the targets and end points are given in Appendix 9.

Indicators are being developed simultaneously with the development of each PMA and will be refined as data from field monitoring trials becomes available. Some example indicators are presented in Appendix 9 but these are notional only and will be developed as field techniques are tested.

The monitoring will be designed to be practical and be able to be carried out by Operations staff. It will provide high-level information to detect major changes. It will be designed to avoid some of the mistakes commonly made by theoretical designs of monitoring, which ambitiously aim for monitoring to cover too much and provide definitive answers to what are fundamentally research questions while overlooking functionality and common sense.

10.4 ADAPTIVE MONITORING

Monitoring activities should adapt to changing circumstances and results of the monitoring itself. The key to effective adaptation of monitoring is to keep track of the changes that are made, and decide what kind of changes will allow continuity of effectiveness of the monitoring program and are permissible. Table 10.2 below provides a general guide to the Project's adaptive monitoring approach related to the Biodiversity Strategy.

Table 10.2: Suggested adaptation "rules" for the Biodiversity Strategy's monitoring program (not exhaustive)

Activity	Permissible
Adding indicators.	Permissible.
Removing an indicator.	Permissible only when the indicator's usefulness has ended.
Replacing an indicator with another.	Would generally not be permitted unless the link with the previous indicator is real and acceptable to management.
Changing timing of sampling in a PMA.	Could be permissible depending on reasons.
Adding a PMA.	Permissible.
Deleting a PMA.	Permissible once the consequences were understood and accepted.
Changing a data gathering method in a PMA.	Not permitted if it results in discontinuity of data by seriously changing the bias of the method.
Changing a particular designed spatial pattern of samples.	Generally not permitted. Depending upon the reason for the patterning, a case might be made for changing it. This would need investigating before changes are made.
Changing the number of samples for an indicator.	Would be undesirable but probably permissible since it would only change the confidence interval for an estimate.

10.5 NEXT STEPS

Remote sensing (PMA 1) will begin in 2011 but field monitoring for PMA 2 and PMA 3 will generally commence towards the end of the Project construction phase when most potential direct impacts have occurred. Starting the latter too early is likely to be inefficient as there remains strong likelihood of plots (PMA 3) established too early being compromised by construction and sections of the ROW may need to be revisited during construction for emergency works and/or reinstatement (PMA 2). Target milestones for development of the monitoring plan are as follows:

Development of indicators:

Indicators complete	Q2 2011

Develop and test procedures for PMAs:

PMA 1 complete	Q2 2011
PMA 2 complete	Q2 2011
PMA 3 complete	Q4 2011
PMA 4 complete	Q4 2012
PMA 5 complete	Methodology complete

Design monitoring management system:

System complete and ready for contracting	Q4 2012

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11.2 PERSONAL COMMUNICATION

Richards, S. Verbal communication to F. Crome. 1 July 2010.

12.0 Abbreviations

BBOP	Business and Biodiversity Offset Program.
BVG	Broad Vegetation Group.
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora.
DEC	Department of Environment and Conservation.
EBA	Endemic Bird Area.
EIS	Environmental Impact Statement.
ESMP	Environmental and Social Management Plan.
FIMS	Forest Inventory Mapping System.
ICDP	Integrated Conservation and Development Project.
IESC	Independent Environmental and Social Consultant.
IFC	International Finance Corporation.
IUCN	International Union for the Conservation of Nature.
KICDP	Kikori Integrated Conservation and Development Project.
LNG	Liquefied Natural Gas.
MRDC	Mineral Resources Development Company Limited.
NBSAP	National Biodiversity Strategy and Action Plan.
PMA	Programmed Monitoring Activities.
PNG	Papua New Guinea.
ROW	Right of Way.
SELCA	Socio-Economic, Land and Community Affairs.
WMA	Wildlife Management Area.
WWF	World Wide Fund For Nature.

Appendix 1 – Project Developments

1. Upstream Project Area

1.1 NEW UPSTREAM PROJECT FACILITIES

The new upstream facilities will include wellpad facilities at Hides, Angore and Juha; the Hides Gas Conditioning Plant; the Juha Production Facility and associated upstream infrastructure, and are designed to optimize development of the primary gas fields with proven technologies and demonstrated design concepts.

1.1.1 Development Drilling

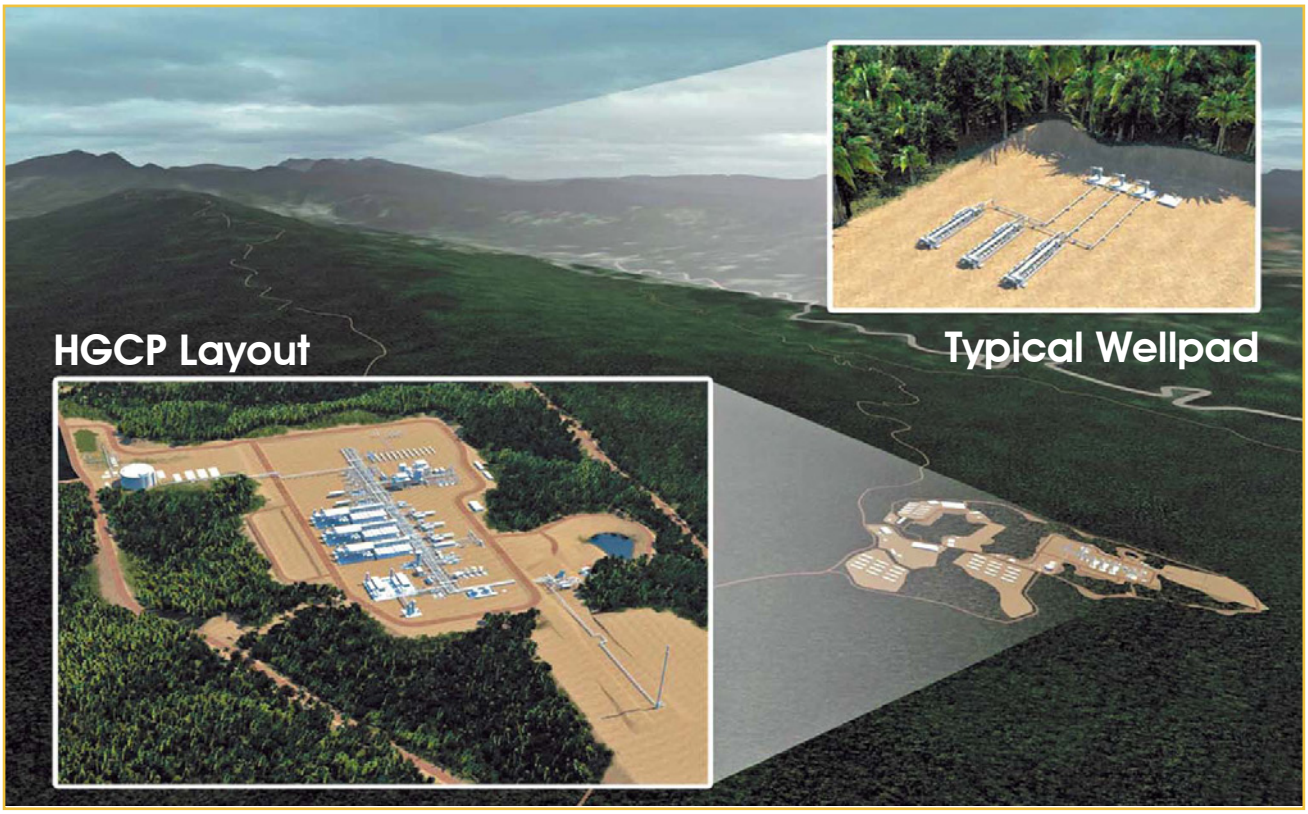
The drilling activity associated with the Project comprises a total of 14 new wells in the Hides (eight wells), Angore (two wells), and Juha (four wells) fields and re-completing two existing Hides Wells (Hides 1 and 4). Drilling activities will occur in a phased approach, with the Hides and Angore activities occurring under a combined Phases 1 and 2 Drilling Campaign, and the Juha activities under a subsequent Phase 3 Drilling Campaign.

Six of the eight Hides development wells comprising the Phases 1 and 2 Drilling Campaign are planned to be drilled directionally. The wellpads (some with multiple drills) will be customized for each location to provide a surface that allows safe and efficient drilling, workover and production operations while reducing the footprint and the amount of vegetation clearance required.

1.1.2 Hides Gas Conditioning Plant

The Hides Gas Conditioning Plant (Figure A1.1) will be located in the Southern Highlands Province at the southeast end of Hides Ridge near the village of Laite (1.5 kilometers from the existing Hides A Wellpad). The plant will include the processing facility, rotator housing community and industrial park.

Figure A1.1: Artist's impression of Hides Gas Conditioning Plant and typical wellpads



The Hides Gas Conditioning Plant will process gas and liquids from the Hides field and will be designed to stabilize condensate and gas. Process systems include slug handling, gas and liquid inlet separation, dewpoint conditioning, compression, produced water injection, condensate stabilization and condensate transfer system. The facility includes a number of supporting utility systems. A housing community will be developed, geographically separated from but within a shared security zone of the processing facility. An industrial park will be a separate security area adjacent to the processing facility and will provide the facilities necessary to support ongoing operations and maintenance. It will include a warehouse, chemical and hazardous materials storage shelter, outdoor storage yard, and maintenance workshop.

Monoethylene glycol (MEG) will be used to prevent the formation of hydrates in the well production tubing and in the surface wellstream collection pipelines. The MEG will be regenerated by removal of trapped water at the Hides Gas Conditioning Plant and recirculated to injection points as required.

Over time, as reservoir pressure in the gas field naturally declines, additional booster compression will need to be installed during Phase 3 of the Project to maintain production volumes. After the Juha Field is developed, its wellstream products will be transported to the Hides Gas Conditioning Plant after being separated into natural gas and liquids at the Juha Production Facility.

1.1.3 Juha Production Facility

The wellstream products from the Juha gathering system will be transported to the Juha Production Facility for gas and liquids separation prior to transportation to the Hides Gas Conditioning Plant for further liquid stabilization and gas treating/compression.

The Juha Production Facility will be installed approximately 60 kilometers northwest of the Hides Gas Conditioning Plant during Phase 4 of the Project and will provide 295 thousand standard cubic meters per hour (250 thousand standard cubic feet per day) separator gas to the Hides Gas Conditioning Plant inlet.

Other process systems and utilities at the Juha Production Facility will include power generation, MEG storage, a diesel system, open and closed drainage, a flare system and a water system.

1.1.4 Komo Airfield

A new government-certified international airfield is to be constructed at Komo in the Hides area, approximately 10 kilometers southeast of the Hides Gas Conditioning Plant. The Komo Airfield is required as part of the Project in order to enable the delivery of large, heavy and bulky plant and equipment to the Hides Gas Conditioning Plant in a timely, efficient and dependable manner. The airport is to be situated east of the existing Komo airstrip. It is designed for use by Dash 8 aircrafts and Antonov AN 124-100 aircraft with capability for heavy lift. The new Komo Airfield will comprise a 3,400-meter-long runway, navigation and landing aids, aircraft parking aprons, taxiway to runway, two helicopter pads, meteorological station, terminal building, hangar, freight and equipment storage area, fuel depot, fire station, boundary and security fencing, internal and external access roads, powerhouse/airfield lighting equipment room, entrance guard house and pump house.

1.1.5 Early Works Upstream Project Infrastructure

A program of infrastructure upgrades will be undertaken in advance of main construction activities in the Gulf Province and Southern Highlands Province. This program includes civil works at and in the areas of Hides and Kutubu and the upgrade or new construction of roads and bridges along two main logistics routes. The scope of this work, referred to as Upstream Infrastructure, is summarized below:

- Construction of approximately 30 kilometers of new road and upgrade of approximately 280 kilometers of existing road to enable vehicular access to upstream facilities and materials supply points.

- Upgrade or replacement of 20 to 30 bridges and construction of up to five new bridges to allow connection of existing and new roads.
- Construction of a new wharf at Kopi to serve as an Upstream Project Area supply point for the onshore portion of the LNG Project Gas Pipeline and oversized equipment needed for construction of Project facilities.
- Establishment of telecommunications to enable communication between facilities.
- Establishment of permanent waste disposal sites, including incinerators and landfill sites.
- Construction of the Hides Industrial Park to support ongoing operation and maintenance of the Hides Gas Conditioning Plant.
- Creation of contractor construction camps along the length of the onshore portion of the LNG Project Gas Pipeline and permanent operator camps at or near the Hides Gas Conditioning Plant and Juha Production Facility to house both operations staff and contractor personnel.
- Installation of new helipads at several locations for emergency medical evacuations.

Reliable transport routes are required during construction and operation of the Project. These logistical transportation corridors will comprise a combination of existing public roads, restricted access roadways and new Project roads. Key considerations in determining the routing of the Project roadways include environmental, social and safety issues, construction logistics, construction risks, earthworks and reducing pipeline length.

1.1.6 Onshore Pipelines

An extensive pipeline network will be constructed to transport gas from the individual wellpad facilities to the Hides Gas Conditioning Plant and on to the LNG Facilities site, and liquids from the Hides Gas Conditioning Plant to the Kutubu Central Processing Facility. The pipeline facilities will consist of an onshore pipeline network and an offshore pipeline (discussed below) with the interface between the two sections being located at the landfall of the offshore portion of the LNG Project Gas Pipeline at the Omati River. Approximately one-third of the onshore portion of the LNG Project Gas Pipeline will be constructed along the existing crude oil export pipeline corridor.

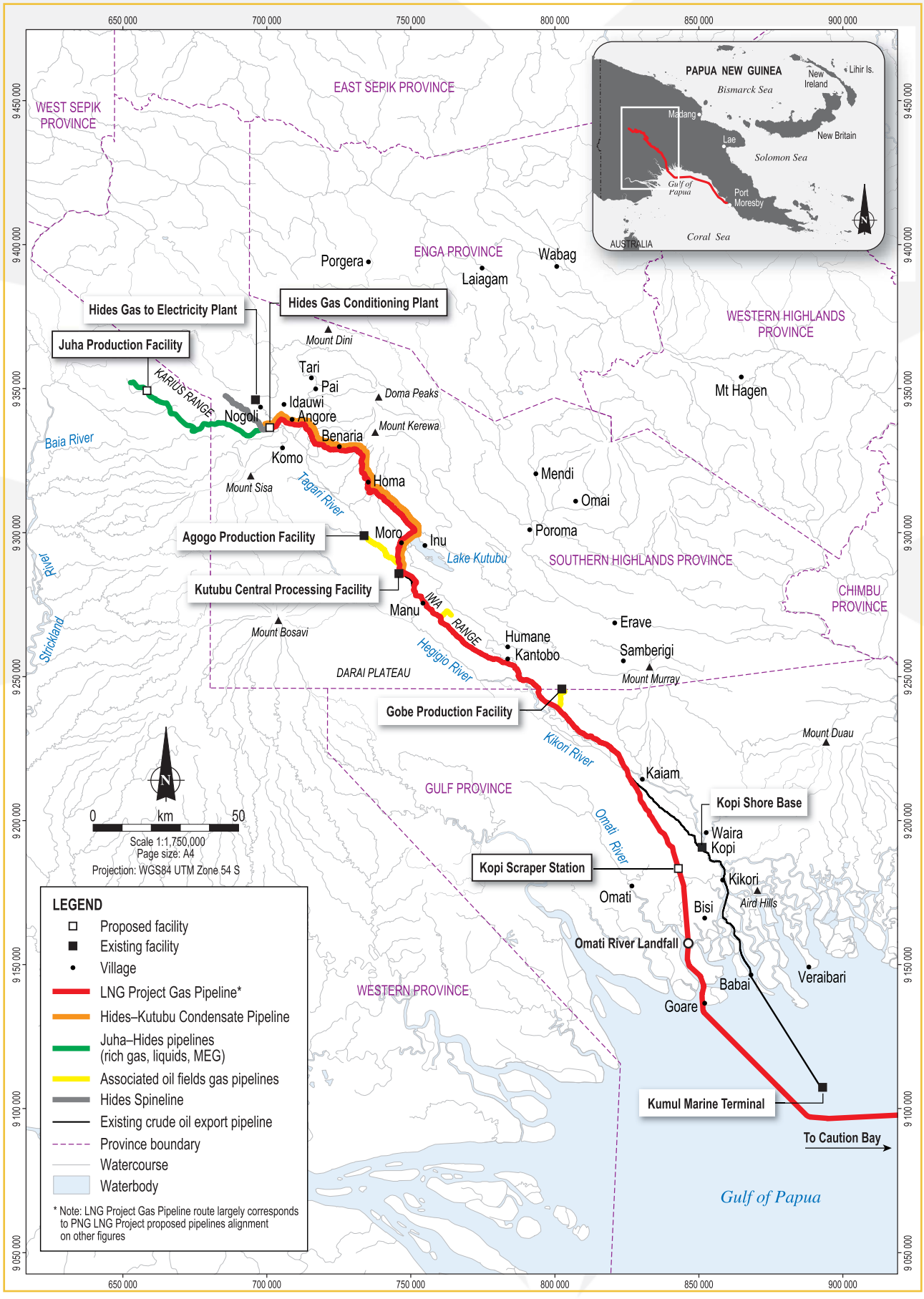
The onshore portion of the Project pipeline network will consist of:

- Approximately 284 kilometers of a 34-inch diameter gas pipeline – the onshore portion of the LNG Project Gas Pipeline – starting from the Hides Gas Conditioning Plant to landfall at the Omati River.
- Approximately 104 kilometers of an 8-inch diameter condensate pipeline running from the Hides Gas Conditioning Plant to the Kutubu Central Processing Facility.
- Approximately 266 kilometers of pipeline gathering systems for transportation of wellstream products from the Hides field and Angore field wellpad facilities to the Hides Gas Conditioning Plant, from the Juha field wellpad facilities to the Juha Production Facility and gas and liquids separated at the Juha Production Facility to the Hides Gas Conditioning Plant.
- Approximately 31 kilometers of 10-inch to 12-inch diameter associated gas tie-in from the existing oil fields.

Figure A1.2 sets out the route of the onshore portion of the Project pipeline network from the Hides Gas Conditioning Plant to the Omati River and the associated gas tie-ins.

The onshore pipeline system includes facilities such as pig launchers and receivers, main line valve stations, check valve stations and cathodic protection sites.

Figure A1.2: Upstream Project pipelines



1.2 UPGRADE OF EXISTING UPSTREAM PROJECT FACILITIES

The existing non-Project upstream facilities that will be utilized for the Project include the Kutubu Central Processing Facility, the Agogo Production Facility, the Gobe Production Facility, and the associated gas field wellpad facilities and the Kutubu crude oil export system. Several upgrades to these facilities will be required to enable integration with the Project and to extend the life of these existing facilities beyond their original design life to be consistent with the Project design life. These include upgrades to the field processing facilities to bring the associated gas within required specifications for transportation to and liquefaction at the LNG Facilities site.

1.2.1 Kutubu Central Processing Facility

The Kutubu Central Processing Facility will receive condensate extracted at the newly constructed Hides Gas Conditioning Plant and blend it with stabilized crude. The blended product will be pumped from storage tanks through the existing 260-kilometers-long, 20-inch-diameter crude oil export pipeline to the existing Kumul Marine Terminal in the Gulf of Papua.

Plate A1.1: Kutubu Central Processing Facility

The Kutubu Central Processing Facility was installed between 1990 and 1992 as part of the Oil Search-operated Kutubu Oil Project and has been producing oil for export since 1992.

As part of the development of the Project, new installations will be put in place to integrate the existing production facilities at the Kutubu Central Processing Facility with Project infrastructure. These include installation of gas metering, two enhanced dehydration and regeneration packages, battery limit valving, piping to the Project's gas metering station and modifications to the tank farm isolation and emergency shutdown systems to enhance the capacity to reliably import condensate from the Hides Gas Conditioning Plant. Modifications will also be made to the gas re-injection system.

Plate A1.2 : Agogo Production Facility

1.2.2 Agogo and Gobe Production Facilities

The Agogo Production Facility is located approximately 20 kilometers from the Kutubu Central Processing Facility and is connected by road. The Gobe Production Facility is located approximately 90 kilometers southeast of the Kutubu Central Processing Facility.

New developments required for the supply of associated gas from these facilities will consist of installation of gas metering, new valving to allow isolation, additional piping and enhanced gas dehydration and regeneration packages.

2. Marine Project Area

The offshore portion of the LNG Project Gas Pipeline length will be approximately 407 kilometers from the Omati River onshore/offshore pipeline tie-in to the LNG Facilities site onshore/offshore tie-in. The Omati River Landfall section of the pipeline will start at an onshore tie-in location approximately 200 meters onshore from the river bank. This section of pipeline will be pulled ashore from a Shallow Water Lay Barge (SWLB) through a prepared trench to the tie-in location with the onshore pipeline. The shallow water section of the offshore portion of the LNG Project Gas Pipeline includes areas of pipe lay in water depths less than 10 meters lowest astronomical tide. From the tie-in location with the onshore portion of the LNG Project Gas Pipeline at the Omati River Landfall, the pipeline will run from the landfall for 24 kilometers until it reaches the open sea at the mouth of the Omati River.

The offshore section of the LNG Project Gas Pipeline will start at a location beyond the mouth of the Omati River, in the Gulf of Papua. The pipeline will be laid on the seabed by lay barge through the Gulf of Papua until it reaches the landfall at the LNG Facilities site. The onshore tie-in point at the LNG Facilities site is located at approximately +1 meter highest astronomical tide. The shore approach zone is approximately 1.3 kilometers in length. The pipeline will be pulled ashore through a prepared trench to the tie-in location.

Offshore pipeline construction activities include pipelaying, pipeline protection and stabilization, and pre-commissioning activities (i.e., cleaning, hydrotesting and dewatering). The offshore portion of the LNG Project Gas Pipeline will include a concrete weight coat to ensure that the pipeline is stable on the seabed under design environmental conditions. Additionally, the weight coating provides protection against natural and or third-party impact. Due to the prevalence of soft deltaic sediments in the Gulf of Papua, the pipeline is expected to embed in these sediments for most of its length.

The offshore portion of the LNG Project Gas Pipeline will be buried for protection against impacts from vessels and anchors in the Omati River (and for some distance beyond the river mouth to a water depth of between 5 and 10 meters) and seaward from the landfall in Caution Bay to a water depth of 15 meters. In addition, the pipeline will be trenched and buried for the shipping channel crossing offshore from the LNG Facilities site.

3. LNG Project Area

The LNG Facilities site will be located at Caution Bay approximately 20 kilometers northwest of Port Moresby. The plant will receive and process gas into approximately 6.3 million tonnes per annum of LNG. An impression of the LNG Facilities site layout is provided in Figure A1.3.

A program of early works will be undertaken at the LNG Facilities site and environs. The scope of this work, is summarized below:

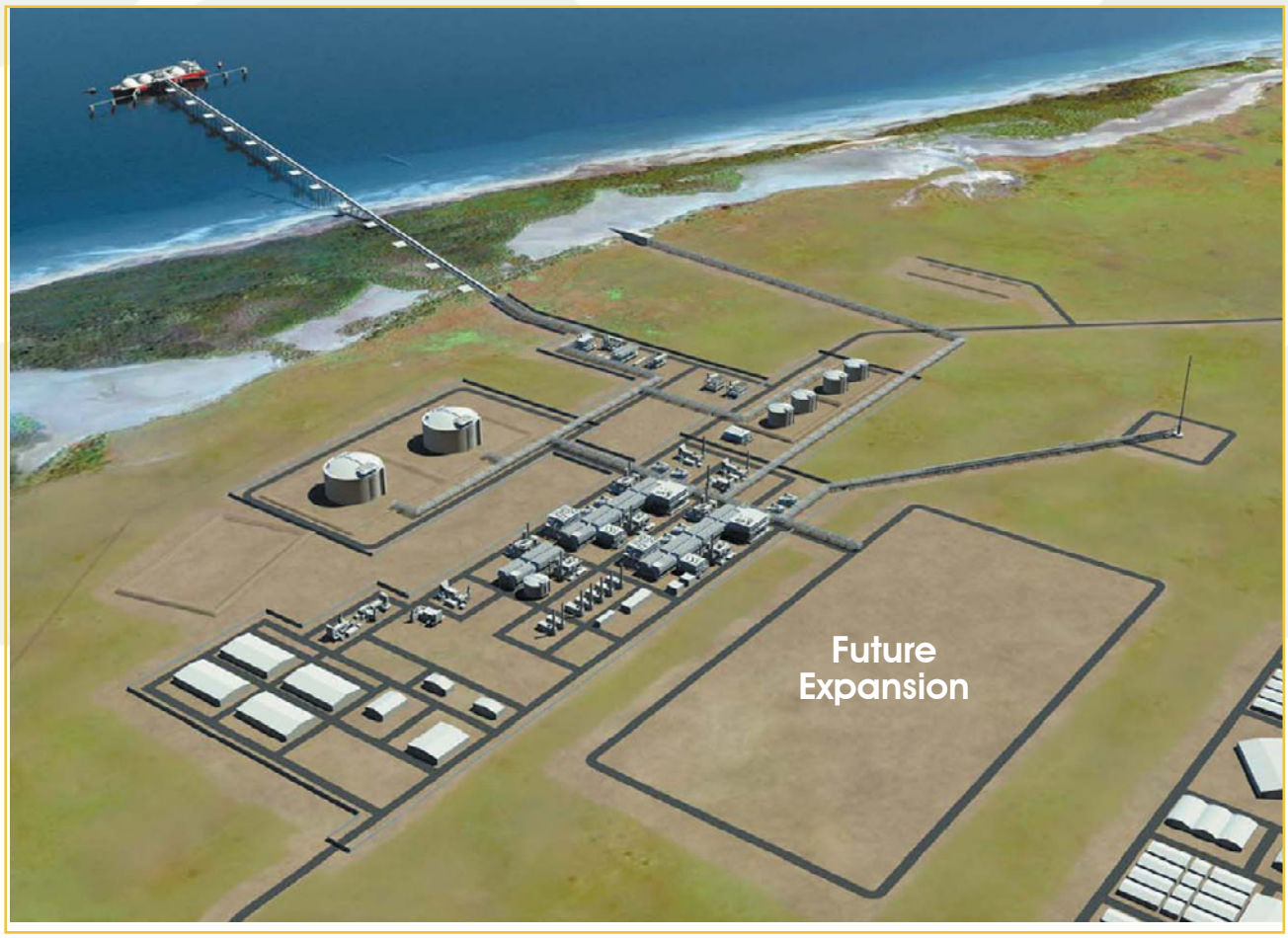
- Upgrade of the existing public road from Motukea Island to LNG Facilities site.
- New bypass road (rerouting of existing public road, which transects LNG Facilities site).
- LNG Facilities site security fence.
- A 7,500-person temporary construction camp.
- Desalination facilities to provide water to the site during construction and operations.

The LNG Plant's processing facilities include inlet gas receiving, acid gas removal unit, dehydration, mercury removal, refrigeration, liquefaction and condensate fractionation. Major utilities include power generation, hot oil, air and nitrogen systems. Major offsite systems at the LNG Facilities site include LNG storage (2 x 160,000 cubic meters) tanks, condensate storage (2 x 8,500 cubic meters) tanks, firewater system, flare systems, fresh water system and effluent handling.

The LNG Facilities site's marine facilities design will accommodate the loading of LNG carriers in the size range of 125,000 cubic meters to 220,000 cubic meters and condensate tankers of 7,000 dead weight tonne. The marine facilities include LNG export berth, condensate export berth, tug landing area and materials offloading facility with permanent tug mooring berths.

A permanent operator personnel camp will also be installed within the boundary of the LNG Facilities site.

Figure A1.3: Impression of proposed LNG Facilities site layout



Appendix 2 – Environmental Impact Statement Documents

This appendix outlines the specialist appendix reports that have been prepared for the EIS.

1. Upstream and Offshore Pipeline

- Biodiversity Impact Assessment. Appendix 1 to the EIS.
- Aquatic Fauna Impact Assessment. Appendix 2 to the EIS.
- Resource Use Survey of the Omati–Kikori Delta. Appendix 3 to the EIS.
- Hydrology and Sediment Transport Impact Assessment. Appendix 4 to the EIS.
- Water and Sediment Quality Impact Assessment. Appendix 5 to the EIS.
- Groundwater Impact Assessment. Appendix 6 to the EIS.
- Forestry Impact Assessment. Appendix 7 to the EIS.
- Soils and Rehabilitation Impact Assessment. Appendix 8 to the EIS.
- Air Quality Impact Assessment. Appendix 9 to the EIS.
- Noise Impact Assessment. Appendix 10 to the EIS.
- Offshore Impact Assessment. Appendix 11 to the EIS.

2. LNG and Marine Facilities

- Biodiversity Impact Assessment. Appendix 12 to the EIS.
- Aquatic Fauna Impact Assessment. Appendix 13 to the EIS.
- Hydrology and Sediment Transport Impact Assessment. Appendix 14 to the EIS.
- Water and Sediment Quality Baseline Impact Assessment. Appendix 15 to the EIS.
- Groundwater Impact Assessment. Appendix 16 to the EIS.
- Soils and Rehabilitation Impact Assessment. Appendix 17 to the EIS.
- Air Quality Impact Assessment. Appendix 18 to the EIS.
- Noise Impact Assessment. Appendix 19 to the EIS.
- Visual Impact Assessment. Appendix 20 to the EIS.
- Road User Survey. Appendix 21 to the EIS.
- Hydrodynamic Modeling. Appendix 22 to the EIS.
- Nearshore Marine Impact Assessment. Appendix 23 to the EIS.
- Resource Use Survey of Caution Bay. Appendix 24 to the EIS.
- Greenhouse Impact Assessment. Appendix 25 to the EIS. This is a Project-wide study.
- Social Impact Assessment (including Cultural Heritage). Appendix 26 to the EIS. This is a Project-wide study.
- LNG Facilities Onshore Preconstruction Summary Report. This report includes information on terrestrial ecology, aquatic ecology, weeds, hydrology, groundwater and cultural heritage.

Appendix 3 – Environmental and Social Management Plan Appendices

The following are the appendices to the Environmental and Social Management Plan. Those with more of an environmental focus number the management and mitigation measures included as well as the associated objectives.

- **Appendix 1:** Ecological Management Plan. One hundred eighty-six management and mitigation measures included. Objective is to:
  - Reduce impacts on habitat and specific ecological aspects and species arising from construction activities.
- **Appendix 2:** Air Emissions Management Plan. Fourteen management and mitigation measures included. Objectives are to:
  - Reduce the impact of Project activities on ambient air quality.
  - Optimize equipment to reduce greenhouse gases.
- **Appendix 3:** Noise and Vibration Management Plan. Fourteen management and mitigation measures included plus three in common with the Air Emissions Management Plan and two with the Ecological Management Plan. Objective is to:
  - Reduce noise and vibration impacts from Project activities to local residents and specific fauna habitat, including marine fauna and bats.
- **Appendix 4:** Waste Management Plan. Twenty-five management and mitigation measures included. Objectives are to:
  - Contain, transport, handle and dispose of solid and liquid wastes arising from Project construction activities in such a manner as to avoid impacts to human health and the environment.
  - Dispose of wastes at facilities approved by Esso Highlands Limited, for which disposal (with or without prior treatment) is the only practicable option.
- **Appendix 5**: Water Management Plan. Twenty-three management and mitigation measures included plus three in common with the Waste Management Plan. Objectives are to:
  - Reduce the impact on water quality (and associated beneficial values) from construction activities.
  - Reduce the impact on existing surface water flow regimes and groundwater aquifers (and associated beneficial values) arising from construction activities.
- **Appendix 6:** Spill Prevention and Response Plan. Twenty-five management and mitigation measures included. Objectives are to:
  - Prevent spills.
  - In the event of a spill, reduce environmental and social impact.
- **Appendix 7:** Hazardous Materials Management Plan. Twenty-seven management and mitigation measures included plus one in common with the Water Management Plan and six with the Spill Prevention and Response Plan. Objectives are to:
  - Avoid the use of chemicals and hazardous materials subject to international bans or phase-outs.
  - Prevent uncontrolled release of hazardous materials during transportation, handling, storage and use.

- **Appendix 8:** Weed, Plant Pathogen and Pest Management Plan. Seventy-six management and mitigation measures included and one in common with each of the Ecological Management, Noise and Vibration Management, Spill Prevention and Response and Water Management Plans. Objectives are to:
  - Prevent exotic weeds, plant pathogens and pests from entering, spreading or becoming established in the Project Areas during construction works.
  - Identify and contain, suppress or manage significant weeds, plant pathogens and pests already in the Project Area to prevent spread by Project activities.
  - Implement measures to reduce the risk of spread of dieback in *Nothofagus* forests.
- **Appendix 9:** Erosion and Sediment Control Management Plan. Eighty-three management and mitigation measures included plus one in common with the Air Emissions Management Plan and five with the Ecological Management Plan. Objectives are to:
  - Maintain stable landforms to reduce erosion and enhance reinstatement.
  - Maintain integrity of assets (through stable landforms).
  - Reduce adverse impacts on stream water quality, and associated beneficial values, and in-stream sedimentation.
- **Appendix 10:** Raw Materials Management Plan. Seven management and mitigation measures included plus twelve in common with the Erosion and Sediment Control Management Plan and one with the Ecological Management Plan. Objectives are to:
  - Extract aggregate from Esso Highlands Limited-approved locations and manage according to the relevant, individual management plans.
  - Maximize use of cleared timber and purchase additional timber supplies from known and approved sources.
- **Appendix 11:** Reinstatement Management Plan. Fifteen management and mitigation measures included. Objectives are to:
  - Establish stable landform conditions in areas disturbed as a result of construction activities.
  - Create ground conditions conducive to natural plant regeneration.
- **Appendix 12:** Induced Access Management Plan. Three management and mitigation measures included. Objective is to:
  - Control access to new Project roads and reduce the occurrence of potentially damaging non-Project activities (i.e., via improved access).
- **Appendix 13:** Cultural Heritage Management Plan. One hundred eight management and mitigation measures included plus one in common with the Induced Access Management Plan. Objectives are to:
  - Avoid known cultural heritage sites (including both archaeological sites and oral tradition sites) where necessary and practicable.
  - Where avoidance is not possible, manage cultural heritage sites in consultation with the PNG Government and landowners.
- **Appendix 14:** Hydrotest Management Plan. Eighteen management and mitigation measures included. Objective is to:
  - Reduce environmental impacts related to hydrotest water abstraction and discharge.

- **Appendix 15:** Acid Sulfate Soils Management Plan. One management and mitigation measure included. Objectives are to:
  - Provide measures to avoid or minimize the disturbance of acid sulfate soils and to contain, mitigate and minimize the impacts of disturbed acid sulfate soils.
  - Protect the local environment from adverse impacts arising from the disturbance of actual acid sulfate soils and potential acid sulfate soils.
- **Appendix 16:** Dredge Management Plan. Three management and mitigation measures included. Objectives are to:
  - Reduce impacts of dredging on the marine life and water quality.
  - Reduce sediment (turbid plume) mobilization during dredging and placement of dredge material.
- **Appendix 17:** Community Health and Safety Plan.
- **Appendix 18:** Community Impacts Management Plan.
- **Appendix 19:** Labor and Worker Conditions Management Plan.
- **Appendix 20:** Camp Management Plan.
- **Appendix 21:** Procurement and Supply Management Plan.
- **Appendix 22:** Community Engagement Plan.
- **Appendix 23:** Community Infrastructure Management Plan.
- **Appendix 24:** Community Health, Safety and Security Management Plan.
- **Appendix 25:** Community Support Strategy.
- **Appendix 26:** Resettlement Framework Document.
- **Appendix 27:** Stakeholder Engagement Plan.
- **Appendix 28:** Environmental Monitoring Plan.
- **Appendix 29:** Social Monitoring Plan.
- **Appendix 30:** Environmental Performance Indicators and Statutory Reporting and Notification Requirements.
- **Appendix 31:** Quarantine Management Plan.

Appendix 4 – Vegetation in the Upstream Project Area

Montane Forest (greater than 3,000 meters) with/without Grassland – is very small crowned mossy forest ('elfin' forest) and alpine grassland complexes. It is low, 5 to 15 meters high with thin, crooked stems and lacks emergents. It only occurs in the far north of the Upstream Project Area and no Project infrastructure is planned in this vegetation.

Grasslands – within the Upstream Project Area are mostly alpine grasslands above the tree line in the north and no Project infrastructure is planned in this vegetation.

Rocky Scrub – occurs on the extreme slopes of the Karius Range. No Project infrastructure is planned in this vegetation.

Lower Montane Small Crowned Forest – occurs above 1,000 meters altitude. It has an even to undulating canopy 20 to 30 meters high and is very dense to almost closed. *Nothofagus* is absent or very rare but, in the vicinity of Idauwi and Nogoli, the forests on the ranges have many emergent *Araucaria*. Ferns and epiphytes are common. Trees tend to be thin, and oaks *(Castanopis and Lithocarpus)* are common, dominating in some areas. While somewhat less diverse in tree species composition than other forests, it can have high diversity of smaller plants and epiphytes. At lower elevations in the river valleys, clearing for gardens has heavily disturbed the forest. Areas of this vegetation occur frequently at the eastern end of the pipeline corridor between the Juha Production Facility and the Hides Gas Conditioning Plant and for a long length of the onshore portion of the LNG Project Gas Pipeline between the Hides Gas Conditioning Plant and Lake Kutubu at elevations of approximately 1,200 meters altitude and above.

Lower Montane Small Crowned Forest with Conifers – only occurs in the high far northeast of the Upstream Project Area. Emergent conifers include the genera *Dacrydium, Libocedrus and Phyllocladus.* No Project infrastructure is planned in this vegetation.

Lower Montane Small Crowned Forest with *Nothofagus* – has a closed, even to slightly undulating canopy 20 to 30 meters high and is dominated by *Nothofagus pullei* and *N. rubra.* This is a classical mossy forest. *Nothofagus* is concentrated along ridgelines and subcrests. In the drainage channel subcatchments, the canopies are usually lower and the mixed communities typical of Papuasian habitats become more apparent. Small patches of seral growth are scattered through the forest as a result of natural canopy-opening mechanisms (e.g., wind throws and tree senescence and death). Generally, the dynamics of *Nothofagus* communities tend to be site-specific; however, the forests on Hides Ridge and the Homa Deviation are clearly being maintained by a classic process of patch dynamics and spatial rotation of forest units in different stages of maturation. In the Homa Deviation area, fire has influenced this vegetation. As in most other places that this vegetation group occurs, on Hides Ridge it contains large numbers of epiphytic ferns and orchids, which may represent up to 75 percent of the local plant diversity.

Large areas occur on the Doma Peaks, Mount Sisa, Hides Ridge and between the Benaria and Kondari rivers. The eastern end of the pipeline corridor between the Juha Production Facility and the Hides Gas Conditioning Plant traverses this vegetation and the onshore portion of the LNG Project Gas Pipeline crosses large expanses of this forest above 1,600 meters between the Benaria and Kondari rivers and sporadically at higher elevations between the Kondari River and Lake Kutubu.

Lower Montane Very Small Crowned Forest Complexes – occurs on the central eastern boundary of the Upstream Project Area northeast of Gobe. No Project infrastructure is planned within this vegetation.

Lower Montane Very Small Crowned Forest Complexes with *Nothofagus* – is concentrated in the uplands surrounding the Kutubu Central Processing Facility. The forest has a dense, evenly textured, dark-toned canopy 5 to 15 meters high. Around Kutubu, *Nothofagus* dominates in areas such as along ridges but is far less obvious than in the higher regions to the north. There are fewer ferns but more vines in this vegetation. The onshore portion of the LNG Project Gas Pipeline traverses this forest type either side of the Kutubu Central Processing Facility, as does the South East Hedinia Spineline.

Medium Crowned to Small Crowned Forest Complexes – covers large areas of the southern and central parts of the Upstream Project Area. It has a canopy 25 to 30 meters high with 60 to 80 percent closure, the smaller crowned forest having thinner trees and a more even canopy with no emergents, while the medium crowned forest has emergents up to 40 meters high. The smaller crowned forest tends to develop on the more difficult pavement sites. The Gobe Gas Pipeline and South East Hedinia Spineline encounter this forest type as does the onshore portion of the LNG Project Gas Pipeline between Wassi Falls and the Mubi River and between the Kikori River crossing and the Omati River Landfall.

Medium Crowned to Small Crowned Forest Complexes with *Nothofagus* – occurs in the central eastern part of the Upstream Project Area. It has a canopy 25 to 30 meters high with 60 to 80 percent closure and is a mixture of medium crowned forest and small crowned forest. The latter tends to have a more even canopy with no emergents; the former has emergents up to 40 meters high. There is an abundance of a range of *Nothofagus* species. The South East Hedinia Spineline crosses some of this forest type and the onshore portion of the LNG Project Gas Pipeline crosses large areas between the Kutubu Central Processing Facility and the Ai'io River.

Low Altitude Large Crowned Forest – occurs on the slopes of Mount Bosavi. It has an uneven canopy 30 to 35 meters high and 80 percent closure with emergents to 40 meters. No Project infrastructure is planned within this vegetation.

Low Altitude Medium Crowned Forest – occurs widely in the Upstream Project Area. The canopy is 25 to 30 meters high with 60 to 80 percent closure with emergents up to 40 meters high. Species composition varies widely according to altitude and substrate. In the Juha area, it has many upland forest features and plants other than trees may dominate the flora. Project infrastructure mostly encounters this vegetation at Juha and along the Juha–Hides Rich Gas Pipeline and again sporadically between Lake Kutubu and the Gobe turnoff where it merges into open lowland forest on the edge of the karst pavements.

Low Altitude Small Crowned Forest with *Nothofagus* – has a fairly even canopy approximately 30 meters high with emergents up to 35 meters high. Tree crowns average between 8 and 15 meters in diameter, orchids and figs are very common, ferns are moderately common, and palms and pandanus are sparse. Conifers such as *Papuacedrus* spp. and *Phyllacladus* spp. can be abundant, and oaks (*Castanopis* and possibly *Lithocarpus)* are common. A single area occurs east of the Kutubu Central Processing Facility and the proposed Agogo Gas Pipeline traverses part of this.

Large to Medium Crowned Lowland Forest – occurs in small areas in or near the Sirebi Bioregion on alluvial fans. It is tall with a canopy 30 to 35 meters high and emergents exceed 50 meters. Structurally it is the best-developed forest in the Upstream Project Area. No Project infrastructure is planned within this vegetation.

Small Crowned Lowland Forest – has a canopy 25 to 30 meters high composed of dense small crowns with no emergents, and the canopy is often dominated by single species such as *Intsia* sp. and dipterocarps. This type of forest often occurs on very poor or badly drained substrates, such as limestone pavements. It will be crossed by the onshore portion of the LNG Project Gas Pipeline between the Gobe turnoff and the Omati River Landfall.

Open Lowland Forest – consists of small and medium crowned trees with large crowned emergents up to 40 meters high. The canopy profile is very uneven with many large gaps produced probably by frequent tree falls on the limestone pavements. A variety of palms occur, and climbing rattans are common. In low-lying areas, sago palm (*Metroxylon sagu*) stands develop, and where they have the opportunity, broad-leaved trees can reach great sizes (greater than 1 meter diameter at breast height). The onshore portion of the LNG Project Gas Pipeline encounters this forest type near Gobe and, while the Forest Inventory Management System does not map it as such, the forest at Baia River is also of this type.

Open Lowland Forests and Freshwater Swamps – is a complex of open forest and mixed swamp forest. The onshore portion of the LNG Project Gas Pipeline crosses this forest type several times either side of the Gobe turnoff.

Swamp Forest Complexes – occurs patchily but widely in the Upstream Project Area wherever impeded drainage allows its development. The trees can be large (greater than 1 meter diameter at breast height) and up to 30 meters tall. Lianas are common, and epiphytes abundant. *Selaginella* is common on the forest floor. A feature of this area is the abundance of palms. In frequently inundated areas, sago palms can form almost pure stands. In areas where karstification has produced some relief within these basins or plains, sago palms dominate in the small hollows or dolines, while the raised ridges of limestone support medium crowned or small crowned forest. Where inundation is less frequent, other palms, such as *Arenga* sp. and *Galubia* sp., are dominant. There are large areas behind the mangrove of the Kikori River mouth and scattered patches towards the centre of the Upstream Project Area. The onshore portion of the LNG Project Gas Pipeline traverses large areas approaching the Omati River Landfall.

Swamp Woodland and Forest Complexes – occurs around the north of Lake Kutubu, near Kantobo and behind the Kikori River mangroves. Swamp woodland is a dense layer of sago palms with scattered broad-leafed trees and an understorey of sedges, ferns, reeds and/or grass. Swamp forest has an irregular open canopy of medium to very small crowned trees 20 to 30 meters high and an understorey of sago palms visible in gaps in the canopy. Sago and tree density varies, giving this type of forest a very patchy appearance. The onshore portion of the LNG Project Gas Pipeline crosses this forest type to the north of Lake Kutubu and in the Ai'io River valley.

Mangroves – are extensive in the Kikori River delta. The onshore portion of the LNG Project Gas Pipeline does not cross mangrove vegetation except for a fringe of *Nypa* palms at the landfall.

Appendix 5 – Determining Magnitude of Residual Impacts

These tables are reproduced from Appendix 1 to the EIS.

Table A5.1 Magnitude of impact categories used in assessment

Magnitude of Impact	Habitat	Other Ecological Effects (Barrier Effects, Contamination, Exotics, etc.)	Populations
Very high	Large impact on substrates and habitats that will be permanent and reduce ecosystem survival and health over large areas within the Upstream Project Area or a local region possibly even leading to system collapse. Recovery, if possible, is likely to take more than 25 years or never.	Impact may be widespread effecting greater than 10 percent of Project Area or local region, perhaps even up to a national scale.	Populations will be lost from impact site and losses may cause local extinctions in a Special Area or within the entire Project Area or local region.
High	Substrates will be lost and replacement or treatment may be difficult or impossible. If replaced there is a strong possibility that succession may not lead to original habitats and there is a reasonable chance of long-term reduction in site capacity to support original habitat. Loss and/or degradation of habitat extends more than 1 kilometer beyond impact site. Habitat regeneration, if allowed, will be slowed and good tree cover in forest may take up to 25 years after substrate treatment or replacement. Loss of habitat may affect up to 10 percent of the habitat's range within the Upstream Project Area or within any one Special Area.	Impact is regional affecting up to 10 percent of Project Area or local region.	Impacts will involve local loss of population for at least 25 years or recolonisation may never occur. Any losses of local population likely to seriously reduce chances of species persisting in a Special Area and/or would significantly reduce likelihood of species persisting in the Upstream Project Area or local region. No national impacts.
Medium	Substrates will be lost and replacement or treatment may be necessary to initiate successions. However there is unlikely to be any long-term reduction in site capacity to support original habitat. Loss of and/or degradation of habitat extend up to 500 meters beyond impact site. Habitat regeneration will be slowed and good tree cover in forest may take up to 12 years after substrate treatment.	Detectable up to 10 kilometers from impact site.	Impacts will involve local loss of population for up to seven years or recolonisation may never occur. However loss of the local population highly unlikely to affect persistence of the species within the Upstream Project Area or local region.
Low	Substrates may be disturbed or lost but habitat can readily develop on remaining substrate with slowing of successions by only one to three years at most. Generally only a short-term (one to three years) reduction in site capacity to support original habitat. Impacts restricted to immediately around impact site. Habitat regeneration capable of starting within one to three years and successions likely to proceed normally to good tree cover in forest within five years after start of succession.	Effects immediate surrounds from impact and detectable up to 2 kilometers from impact site.	Impacts likely to involve loss of a portion of the local population that will reduce the chances of long-term survival in remaining habitat around the Project component and species may be temporarily lost. Recolonisation will be rapid and occur within three years after development of successions to the stage of canopy closure.
Negligible	Deleterious impacts unlikely to be detectable on habitats.	Not detectable.	Species populations may lose a few individuals or home ranges may retract but there is unlikely to be any long term lowering of the viability of local populations, i.e., those around the Project component site. Changes only detectable by intensive population monitoring pre and post impact.

Table A5.2 Biodiversity value and/or sensitivity of receptor

Value Category	Sites and/or Habitats	Species
Category 1 (very high value)	An internationally designated site. A Special Area within the Upstream Project Area. A designated national protected area, e.g., Wildlife Management Area. An area with an unusually high concentration of very high and high value species. Site supports 20 percent or more of a national population of any species.	A population of internationally important species in IUCN category critically endangered.
Category 2 (high value)	A sustainable area of priority habitat identified by WWF. Habitat of peculiar sensitivity that is hard to restore or regenerate (focal habitat). Site supports up to 20 percent of national population of any species.	A population of internationally important species in IUCN categories endangered or vulnerable.
Category 3 (moderate value)	A local reserve. A high diversity area with a moderate concentration of very high and high species. Site supports up to 10 percent of national population of any species.	A population of a species in IUCN category near threatened and/or classified as P under PNG legislation.
Category 4 (minor value)	Sites that enrich the local area. A low to moderate diversity area with a low concentration of very high and high species.	A population of a species that is either classified by IUCN as data deficient and/or as R under PNG legislation.
Category 5 (least value)	Lower ecological value.	A population of a species that is classified by IUCN as of least concern or is unclassified and is not listed under PNG legislation.

Table A5.3 Significance matrix

	Value				
Magnitude of Impact	**Category 1**	**Category 2**	**Category 3**	**Category 4**	**Category 5**
Very high	Major	Major	Major	Low	Minimal
High	Major	Moderate	Moderate	Low	Minimal
Medium	Moderate	Moderate	Low	Low	Minimal
Low	Moderate	Low	Low	Low	Minimal
Negligible	Minimal	Minimal	Minimal	Minimal	Minimal
Positive	Positive	Positive	Positive	Positive	Positive

Table A5.4 Examples of impact analysis from the EIS

Value	Potential Impactor	Value of Receptor	Magnitude Before Mitigation	Impact Without Mitigation	Magnitude After Mitigation	Residual Impact	Notes*
Upstream Project Area							
Flora	Edge effects	1	Low	Moderate	Minimal	Minimal	Experience with the oil project indicates that below about 1,800 meters above sea level edge effects from previous pipeline construction are temporary and that the forest edge rapidly seals. Taking care that construction does not excessively damage trees remaining along the edge will reduce or eliminate the potential for further erosion of the edge. The magnitude of the impact of edge effects on flora before mitigation is therefore estimated to be low but negligible after mitigation. Considering the vegetation and flora of the Project Area as a Category 1 conservation asset, the overall significance of the residual impact after mitigation of edge effects on flora is predicted to be minimal.
Vegetation, flora and fauna	Fire	1	High	Major	Low	Moderate	The length of the Project footprint means that propagation of fire from points along the ROW has the potential to promote widespread ecosystem degradation over large areas of the Project Area and KICDP area should wildfire start and spread. In some circumstances, the ROW could act as a firebreak and break the spread of fires from elsewhere in PNG travelling east west or vice versa. This could be a positive impact. The magnitude of the potential impact of fire before mitigation is estimated to be high but low after. Considering the Project Area as a Category 1 conservation asset, the overall significance of the residual impact of fire on biodiversity is predicted to be moderate.
Species of conservation concern - *Bleasdalea papuana* (IUCN endangered tree)	Habitat loss	1	Minimal	Moderate	Minimal	Minimal	"The tree is a presumed Gondwanic relict supposedly restricted to a small number of localities in northern New Guinea (Smith & Haas 1975). The survey collection is the first from the Papuan side. The discovery of *Bleasdalea* on the Kutubu karst represents a biogeographically significant record". The species was located on an abandoned village site at the top of a ridge near Benaria camp. Considering its capacity to grow in disturbed and previously cleared areas, the significance of even unmitigated direct impacts are likely to be minimal. Accidental introduction of an exotic weed could impact on this species but mitigations through quarantine plans could reduce the likelihood of the introduction of such a weed to low levels. The significance of other residual indirect impacts after mitigation are likely to be minimal.
Priority Ecosystems							
Juha area all values	All direct impacts	1	Medium	Moderate	Negligible	Minimal	The direct impacts discussed above are unlikely to operate more severely in the isolated Juha area than elsewhere in the Project Area, except for the fact that the habitats, flora and faunal populations are even less disturbed. Unmitigated, the magnitude of the direct impacts in this area could be medium and considering that this area is a Category 1 conservation asset, the overall significance of the impact without mitigation would be moderate. Once mitigated, however, the impact magnitude could be reduced to negligible and the significance of the residual impact to minimal.
Juha area all values	Induced access	1	Very high	Major	Low	Low	However the major potential impact of the Project will be through reducing the isolation of the area and the protection it engenders which will allow indirect impacts to possibly manifest i.e., wildfire, pests, weeds and diseases, hunting, and increased access. These indirect impacts have the potential to destroy the area's biodiversity and ecological characteristics. If unmitigated the severity of indirect impacts could be very high and the significance of the impact major. The keys to reducing residual impacts in this area to acceptable levels are the plans related to quarantine and access control and control of the Projects workforce. If these are effectively implemented the magnitude of indirect impacts could be reduced to low or negligible and the significance of the residual impacts after mitigation to low or minimal.
Focal Habitats							
Upland streams	Erosion	2	High	Moderate	Low	Low	Protection of the heads of upland streams is meant to protect their amphibian communities. The potential magnitude of impacts could be high but if stream heads above 1,800 meters can be kept free of silt then this could be reduced to low. Upland streams are a Category 2 conservation asset so the significance of residual direct impacts after mitigation is likely to be low.

*Taken verbatim from Appendix 1 to EIS.

Table A5.5 Relevance of residual impacts to biodiversity values

	Direct Effects				Indirect Effects		
Values	**Habitat Loss***	**Edge Effects in High-altitude Karst**	**Barrier and Erosion Effects in High-altitude Karst**	**Barrier and Erosion Effects in High Cuttings**	**Fire**	**Introduction and Spread of Alien Species and Diseases**	**Enhanced Access**
Upstream Project Area							
Extensive intact forest					X	X	X
High floristic diversity		X			X	X	X
High faunal diversity		X	X	X	X	X	X
New species		X	X	X	X	X	X
Endemic species		X	X	X	X	X	X
Unique assemblages of species		X	X	X	X	X	X
Species of conservation concern		X	X	X	X	X	X
Biodiversity of importance to local communities for resource use and cultural and spiritual purposes	X	X	X	X	X	X	X
Priority Ecosystems							
The Juha area	X				X	X	X
Hides Ridge	X	X	X	X	X	X	X
High-altitude forest above 1,800 meters on the Homa Deviation	X	X	X	X	X	X	X
Lake Kutubu Wildlife Management Area	X				X	X	X
Focal Habitats							
Caves	X					X	X
Sinkhole swamps	X		X	X	X	X	X
Upland streams	X			X	X	X	X
Swamp forest	X				X	X	X
Stream refuges in unstable landscapes	X				X	X	X
Lowland rivers in stable landscapes	X				X	X	X
Off-river waterbodies	X				X	X	X
Habitats and flora and fauna of cultural significance	X	X	X	X	X	X	X

*Residual impacts of habitat loss on the Upstream Project Area was determined to be negligible in the EIS; however, it becomes more significant at finer scales.

Appendix 6 – Route Choices

1 PNG LNG Project Pipeline Routes – Broad Scale

The Project's principal pipeline routes have been divided into four sections; Juha Production Facility to Hides Gas Conditioning Plant, Hides Gas Conditioning Plant to Kutubu Central Processing Facility, Kutubu Central Processing Facility to Omati River Landfall, and Omati River Landfall to the LNG Facilities site.

1.1 SECTION A: JUHA PRODUCTION FACILITY TO HIDES GAS CONDITIONING PLANT

There is no option to deliver gas from Juha to Hides Gas Conditioning Plant except through largely uninhabited and undisturbed primary tropical forest. In other words, the Juha–Hides Rich Gas Pipeline and Juha–Hides Liquids Pipeline will break new ground wherever they are located. The route alignment, therefore, is the shortest that can be constructed safely and avoids unstable terrain. This broadly equates to the lowest level of forest clearance and ground disturbance.

1.2 SECTION B: HIDES GAS FIELD TO KUTUBU CENTRAL PROCESSING FACILITY

The LNG Project Gas Pipeline starts at Hides, together with the Hides–Kutubu Condensate Pipeline. Within the vicinity of this pipeline route section is the Agogo Gas Pipeline, which will generally parallel the existing crude oil export pipeline ROW from Agogo to the Kutubu Central Processing Facility.

1.2.1 Eastern or Western Routes

Options for this section involved first a high-level choice between routes east and west of the Tagari and Hegigio rivers.

The western option was some 40 kilometers shorter over an area of more stable ground and easier construction. However, this advantage would be offset by taking the pipeline some distance from the Angore gas field, by having to cross land undisturbed for all but the first few kilometers south of Hides, and by the logistical and practical issues of crossing the large highland Hegigio River as it exists at the Hegigio Gorge.

The eastern option and its features are largely the inverse of the western route. Much of the route has been lightly disturbed by human activity and there are roads at either end. It avoids a major crossing of the Hegigio River and it is more conveniently located in relation to Angore and existing roads. These factors outweigh the distance and terrain advantages of the western route and the eastern route has been selected on this basis.

1.2.2 Options with the Eastern Route

The eastern route will be able to take advantage of the roads and human disturbance at either end. However, alternatives were identified between Homa and Idauwi and again at Wage Creek, north of Lake Kutubu, which offered optimizations.

1.3 SECTION C: KUTUBU CENTRAL PROCESSING FACILITY TO OMATI RIVER MOUTH

While generally following the ROW easement of the existing crude oil export pipeline, the presence of this pipeline in the Kikori River raised safety and operability constraints for what would otherwise have been the most direct way out to sea. Therefore, the next-best landfall, through the delta of the Omati River to the west, was chosen.

The route basically follows the crude oil export pipeline route but significant options were considered and adopted in two important sections: Moro to the Ai'io River, and Kikori River Crossing to Omati River Landfall. A third option to align the pipeline between the Kutubu Central Processing Facility and the Mubi River along the valley of the Digimu River crosses undisturbed country and was rejected to follow existing infrastructure.

1.4 SECTION D: OMATI RIVER LANDFALL TO LNG FACILITIES SITE LANDFALL

From the Omati River Landfall to the Caution Bay Landfall at the LNG Facilities site, the LNG Project Gas Pipeline base case runs 407 kilometers past existing oil export facilities and across two broad subsea environments: the sediments of the Gulf of Papua prograding offshore from the deltas of the Kikori and Purari rivers; and the reefs and coral sand lagoons approaching landfall at Caution Bay.

The alternative for this section is to take the pipeline overland to Port Moresby. This would entail an almost entirely greenfield route, with environmental impacts, land access issues, a number of large river crossings and constraints imposed by special features, such as caves and archaeological sites. The preferred option by sea avoids these issues.

Appendix 7 – Calculation of Offset Debt

The system used for terrestrial habitats was a modification of the Victorian Native Vegetation Framework[1]. The procedure to calculate the offset requirement was as follows.

1. Determine the Broad Vegetation Group (BVG) (see Appendix 4) to be cleared.

2. Determine the quality of the vegetation being cleared. In the Victorian system, this is done by comparing the structure of the vegetation on the site to be cleared with a benchmark set of values of what top quality habitat should look like and further judged on landscape ecology principles as to how the site fits in the landscape. The scores are then normalized to generate a score between 1 and 0 with 1 being pristine habitat in a non-fragmented landscape and 0 being a site bare of vegetation.

   The scoring system for habitat quality used here was based on the vegetation condition classes defined in Table A7.1 (extracted from the Appendix 1 to the EIS). A score was attributed to each habitat condition type based upon the assumption that condition A1 (old growth forest with no disturbance) was the optimum condition and attracted the maximum score of 1. At the other end of the scale, road and facility surfaces do not support biodiversity so are given a score of 0.

3. Determine the area lost in each BVG multiplied by condition class category.

4. Apply multipliers according to the biodiversity value of the habitat being cleared. The highest multiplier as defined by the Victorian Native Vegetation Framework is X2. Considering that the forests in the Upstream Project Area support many rare and threatened species, and that the forests constitute a significant area of the world's intact rainforest, a multiplier of X2 was applied to all scores. In addition a further multiplier of X2 was applied if the cleared area was in a priority ecosystem or in a WWF significant biodiversity area. The multipliers were applied cumulatively. Table A7.2 gives examples of the calculations.

Tables A7.3 and A7.4 present the habitat hectare debt for the Upstream Project Area according to vegetation type and bioregion.

Table A7.1 Habitat condition categories

Condition in EIS	Description	Score for Habitat Hectare Analysis
A1	Old growth forest in non-fragmented landscapes.	1
A2	Reduction in biodiversity value due to small-scale local use near settlements, larger mammals reduced, some medium sized trees cut.	0.8
C	Loss of many medium sized trees and diminution of populations of harvested wildlife.	0.7
D	Forest with many pioneer and secondary species, low populations of forest interior specialists but good populations of generalist species. Poorer structure than other condition classes.	0.5
E	Cleared areas and gardens still have biodiversity value with populations of many species of vertebrates.	0.1
L	Logged forest with severe reduction of commercial trees, disrupted populations of canopy species and forest interior specialists.	0.25
V	River surface - no vegetation.	0
O	Existing oil pipeline ROW – no vegetation.	0
R	Road surface - no vegetation.	0
F	Facility surface - no vegetation.	0

[1] DNRE. 2002. Victoria's native vegetation management: A framework for action. Department of Natural Resources and Environment, Victoria.

Table A7.2 Examples of offset debt calculations

Segment	Bioregion	Broad Vegetation Group	Condition	Area (Hectare)	Habitat Hectare Score	Priority Ecosystem	If Yes, Then X2	In a WWF Area?	If Yes, Then X2	Final Habitat Hectare Score
Juha wells to the Baia River catchment	Western Foothills	Low altitude medium crowned forest	A1	2.70	5.41	Juha	10.82	No	10.82	10.82
Kondari River to Lake Kutubu	Eastern Uplands Volcanics/ Karst	Lower montane small crowned forest	D	3.50	3.50	No	3.50	No	3.50	3.50
Kutubu to Moro	Moro Region	Swamp woodland and forest complexes	R	2.89	0.00	Lake Kutubu	0.00	Yes	0.00	0.00
Ai'io River valley	Mubi River Karst	Medium crowned to small crowned forest complexes	E	0.15	0.01	No	0.01	No	0.01	0.01

Table A7.3 Habitat-hectare debts in various vegetation types

Broad Vegetation Group	Habitat Hectare Debt	Percent
Cultivated or non-vegetated	14	0.2
Low altitude medium crowned forest	1,708	25.9
Low altitude small crowned forest with *Nothofagus*	15	0.2
Lower montane small crowned forest	1,406	21.3
Lower montane small crowned forest with *Nothofagus*	1,243	18.9
Lower montane very small crowned forest complexes with *Nothofagus*	507	7.7
Mangroves	7	0.1
Medium crowned to small crowned forest complexes	922	14.0
Medium crowned to small crowned forest complexes with *Nothofagus*	250	3.8
Open lowland forest	119	1.8
Open lowland forests and freshwater swamps	24	0.4
Small crowned lowland forest	107	1.6
Swamp forest complexes	215	3.3
Swamp woodland and forest complexes	49	0.7
Grand total	**6,586**	**100**

Table A7.4 Habitat-hectare debts in various bioregions

Bioregion	Habitat Hectare Debt	Percent
Eastern Uplands Volcanics/Karst	1,463	22.2
Iagafu Agogo Limestone Uplands	868	13.2
Kikori Lowlands	995	15.1
Moro Region	258	3.9
Mubi River Karst	1,154	17.5
Northern Montane Karst	532	8.1
Western Volcanics	592	9.0
Western Foothills	684	10.4
Western Lowlands	40	0.6
Grand total	**6,586**	**100**

Appendix 8 – Details of Programmed Monitoring Activities (PMAS)

1. PMA 1 Remote Sensing of Indirect Impacts

1.1 AIM

This PMA uses remote sensed imagery analysis to determine to what extent the project has facilitated or increased the occurrence of anthropogenic habitat loss and degradation within the Upstream Project Area. The PMA will also allow estimation of final forest losses after construction.

1.2 METHODS

Various remote sensing techniques are used to:

1. Detect and map changes to forest cover in the Upstream Project Area.
2. Determine which of these are the result of natural processes such as landslides and changes to river morphology and which are the result of anthropogenic processes.
3. Distinguish between anthropogenic processes:
   - Road building.
   - Logging.
   - Development of broad scale agriculture such as oil palms, fish farms and other crops.
   - Broad scale shifting cultivation.
   - Permanent settlement.
   - Other human activities resulting in habitat loss and degradation.
4. Detect and map fires.
5. Determine the geographic source of anthropogenic activities and which have emanated from project infrastructure.

1.3 ADAPTATION

Locations and resolution of imagery may be adapted depending upon results of previous analysis. However, continuity is required so changes must a) be additional to, not instead of, previous imagery acquisition system, and/or b) allow legitimate year-to-year comparisons of the same areas.

1.4 PROPOSED FREQUENCY

Every two years starting in 2011.

2 PMA 2 Aerial ROW Surveys

2.1 AIM

This PMA gathers data on the condition of the whole ROW and Project roads, as well as checking for local indirect impacts by regular aerial inspection and the status of focal habitats located adjacent to the ROW or roads.

2.2 METHODS

Aerial reconnaissance and if possible, videography of the ROW, Project roads and facilities at low level will be carried out by helicopter. On each occasion, the ROW and the nearby focal habitats will be checked for condition. The following aspects of condition will be recorded:

- Measures of ingrowths of regeneration.
- Areas of the ROW not regenerating.
- Areas of erosion not rehabilitating.
- Focal habitats still intact.
- Weed infestation.
- Signs of human intrusion.
- Status of focal habitats identified and mapped during the preconstruction surveys next to the ROW, roads and facilities.

Ground checks will be undertaken as necessary during the flyovers.

2.3 ADAPTATION

This PMA would be adaptive in that, if monitoring indicated remedial action, e.g., weed eradication, was necessary, the monitoring team would carry out the action and adjust monitoring accordingly. However, continuity is required so alterations to the monitoring regime must a) be additional to, not instead of, previous monitoring, and/or b) allow continuity of comparisons of the same areas.

2.4 PROPOSED FREQUENCY

Twice annually starting a year before the start of operations.

3 PMA 3 Regeneration Surveys

3.1 AIM

This PMA gathers data on the progression of successions and faunal communities and the condition of forest adjacent to the ROW and roads and facilities. This PMA is not to be confused with the monitoring to be undertaken as part of the Reinstatement Management Plan under the ESMP during construction under which vegetation cover will be measured quarterly.

3.2 METHODS

1. Regeneration will be monitored using permanent plots stratified by substrate, location and treatments (left to regenerate naturally or assisted regeneration) and scored using a benchmarking system.
2. Forest condition next to the ROW and roads will be monitored to determine if the forest is degrading or maintaining its condition (edge effects).

3.3 BENCHMARKING

Following clearing, succession is predicted to progress to the original forest in structure and species composition. Under natural circumstances, species composition is unpredictable since tree recruitment has a strong stochastic basis driven by dispersal dynamics, seedling competition, sweepstakes establishment in

gaps, and density dependent seed mortality. High, small-scale variability in species composition is a salient characteristic of tropical forests. Were a monitored site to develop an identical species composition to the original, it would be considered that regeneration was successful. However, if it regenerated to a completely different suite of species found in surrounding primary forest, then it would also be considered a success. Thus, knowledge of the exact previous composition is not critical to judging success of regeneration, only whether the regeneration is within the limits found in intact examples of that particular forest type.

A similar argument can be made for structure, which also varies locally but, in this case, it is possible to make finer judgments as to the progression of succession. A regenerating site may have good representation of saplings of 'primary' forest trees but the site's structure as measured by, for example, canopy cover, height, size class distribution of trees, leaf litter development, diversity of life forms and plant functional types, etc., may indicate a retarded succession that will not develop well.

The argument is the same for fauna. A change in community composition is to be expected but would not be considered as evidence of failure because such variability across the forest landscape is to be expected.

Thus, instead of a control–impact/before–after approach, the monitoring system proposed for the Project uses a benchmark approach. Sites will be compared against benchmark values for intact habitat types (see, for example, Parkes et al., 2003)

3.4 FREQUENCY OF SAMPLING, NUMBER OF SAMPLES AND FIELD ROUTINE

The frequency of sampling for PMA 3 is best determined by the expected rate of change of the variables being measured. In the case of the regeneration of forest habitats and build-up of faunal communities, it is useful to consider that there will be an initial rapid colonization of pioneer and secondary plant species, followed by colonization of fauna characteristic of open and secondary areas (generalist forest species according to Appendix 1 to the EIS). Subsequently, there will be gradual maturation of the succession with an increase in frequency of primary forest species then the colonization of adaptable then primary forest fauna species. There is probably a continuum in species dependence on old growth, but this has not been a very active research topic. It should be noted that some primary forest fauna species might not colonize for a couple of decades.

Frequent sampling may be necessary to estimate the speed of succession but the major interest of monitoring is to determine whether progress towards mature forest and faunal communities is occurring. A longer period between samples is preferable as this will enable more resources to be placed in increasing sample size on each sampling occasion.

To monitor if forest is degrading next to the ROW or roads, the plot will be extended into the intact forest and that will be scored against mature forest benchmark. No deviation from benchmark is expected if edge effects ameliorate rapidly.

The number of plots will depend upon final Project layout and accessibility. The level of replication would depend upon final Project layout and logistics. Ideally, several plots would be assessed from each helicopter landing point. The suggested number of sample sites and stratification is shown in Table A8.1. In order to conveniently monitor both regeneration and forest condition next to the ROW, a plot design involving a long plot extending from the ROW or road centerline into the forest will be considered.

Fauna may also be monitored, logistics allowing, at the same sites or a subset of the permanent plots. Methods would be:

1. Birds:

a. Twenty species counts.

b. Species tally walking between plots.

2. Mammals:
    a. Spotlight transects 1 kilometre long for nocturnal mammals.
    b. Species observations walking between plots.

Fauna results are likely to be expressed as abundance of guild types, e.g., frugivores, carnivores.

3.5 PROPOSED FREQUENCY

Years 1 (2 years before start of operations), 2, 4, 7 and every three years thereafter.

Table A8.1 Cross tabulation showing occurrence of substrate, location and treatment combinations and number of replicates for monitoring regeneration using permanent plots

	Substrate								
	Limestone Pavement		Limestone Rubble		Volcanics		Sedimentaries and Alluviums		
Location	**Natural**	**Rehabilitated**	**Natural**	**Rehabilitated**	**Natural**	**Rehabilitated**	**Natural**	**Rehabilitated**	**Totals**
Juha Special Area (Juha Production Facility to Wai Asia River)*			3	2					5
Juha Special Area (Wai Asia River to Karius Range)*							3	3	6
Hides Ridge Special Area (end of pipeline to Wellpad A)			3	3					6
Hides Gas Conditioning Plant to Benaria					3				3
Homa Deviation Special Area (Benaria to Homa)					3	3			6
Kutubu (Tibi Creek to Moro)			2	2			2		6
Moro to Heartbreak Hill			3	3			3		9
Heartbreak Hill to landfall	3	3	3				3	3	15
Totals	3	3	14	10	6	3	11	6	56

* Not to be commenced until Juha section of project is constructed.

4. PMA 4 Road Record Assessment

4.1 AIM

To monitor the use of project roads and infrastructure in order to demonstrate that during construction and operations their use remains restricted to Project activities only.

4.2 METHODS

Compile records being collected under the Induced Access Management Plan of the ESMP during construction.

4.3 PROPOSED FREQUENCY

Six monthly, starting in 2012.

5 PMA 5 Efficacy of Offset Projects

5.1 AIM

To assess the overall efficacy of the Biodiversity Offset Delivery Plan.

5.2 METHODS

Each biodiversity offset project will be designed with its own performance indicators and monitoring plan. Requirements will be included for monitoring results to be integrated with the overall monitoring database utilized for the Biodiversity Monitoring Plan. Performance of each biodiversity offset project will be included in reporting of the Biodiversity Monitoring Plan and the results compiled to provide an overall assessment of the efficacy of the delivery plan.

5.3 PROPOSED FREQUENCY

Yearly.

6 Reference

Parkes, D., Newell, G. and Cheal, D. 2003. Assessing the quality of native vegetation: The 'habitat-hectares' approach. *Ecological Management and Restoration* 4:29–38.

Appendix 9 – Biodiversity Monitoring Targets and Endpoints

Proposed targets and endpoints for the PMAs are provided in Tables A9.1 to A9.3 below.

Table A9.1 Monitoring of values of the Upstream Project Area as a whole

Value	Biodiversity Targets to be Monitored	Biodiversity Goal	Possible Indicator				
			PMA 1	PMA 2	PMA 3	PMA 4	PMA 5
Extensive intact forest	Forest in Project Area	No losses beyond prediction in EIS associated with the Project	Forest cover (hectare)				
	Cleared vegetation allowed to regenerate on stable non-limestone sites	Will regenerate in life of Project with successions the same as on cleared areas outside project footprint	Forest cover on that substrate on the ROW	Forest cover on that substrate on the ROW from videography	Deviation of regeneration plots from benchmark		
	Cleared vegetation allowed to regenerate on very erosive volcanic sites.	Will regenerate after reinstatement works with successions the same as those on landslides in vicinity	Forest cover on that substrate on the ROW	Forest cover on that substrate on the ROW from videography	Deviation of regeneration plots from benchmark		
	Cleared vegetation allowed to regenerate on limestone rubble or pavement elsewhere.	Rubble: will regenerate after reinstatement works with successions quicker than those on cleared areas outside project footprint but still slowly	Forest cover on that substrate on the ROW.	Forest cover on that substrate on the ROW from videography	Deviation of regeneration plots from benchmark		
	Cleared vegetation allowed to regenerate on limestone rubble off Hides Ridge	Pavements where not ripped: regeneration will not progress noticeably in project life	Forest cover on that substrate on the ROW.	Forest cover on that substrate on the ROW from videography	Deviation of regeneration plots from benchmark		
	Cleared vegetation allowed to regenerate on limestone rubble off Hides Ridge	Pavements where ripped: regeneration will progress normally	Forest cover on that substrate on the ROW.	Forest cover on that substrate on the ROW from videography	Deviation of regeneration plots from benchmark		
	All habitat next to ROW, roads and facilities	Forest will not degrade below benchmarks	Forest cover within 100 meters of edge of ROW, roads and facilities		Deviation of forest plots from benchmark		
	Weeds	No new species of weeds associated with infrastructure		Number and area of weed infestations in flyovers	Cover of weeds on regeneration plots		
		No expansion of weed areas associated with infrastructure		Identity of weeds in infestations located during survey	Identity of weeds in regeneration plots		
	Dieback	No expansion of dieback associated with infrastructure		Area of dieback detected associated with infrastructure	Dieback evidence from forest plots		
	Fire	No fires associated with infrastructure	No fire scars in change imagery	No evidence of fires generated from infrastructure	No plots burnt		
	Human incursion	No human incursion—not associated with Project or landowners	None evident	None evident			None evident

Table A9.1 Monitoring of values of the Upstream Project Area as a whole (cont'd)

Value	Biodiversity Targets to be Monitored	Biodiversity Goal	Possible Indicator				
			PMA 1	PMA 2	PMA 3	PMA 4	PMA 5
High floristic diversity	Flora	No diminution of species numbers below those recorded for the EIS					
High faunal diversity	Fauna	No diminution of species numbers below those recorded for the EIS					
New species	New species	No diminution of species numbers below those recorded for the EIS					
Endemic species	Endemic species	No diminution of species numbers below those recorded for the EIS					
Unique assemblages of species	Unique assemblages of species	No diminution of species numbers below those recorded for the EIS					
Species of conservation concern	Species of conservation concern	No diminution of species numbers below those recorded for the EIS					
Biodiversity of importance to local communities for resource use and cultural and spiritual purposes	Biodiversity of importance to local communities for resource use and cultural and spiritual purposes	No diminution of species numbers below those recorded for the EIS					

Table A9.2 Monitoring of priority ecosystems

Value*	Biodiversity Targets to be Monitored	Biodiversity Goal	PMA 1	PMA 2	PMA 3	PMA 4	PMA 5
Juha Area							
The remoteness of the region and the lack of human influence on the vegetation and fauna.	Forest in Juha area	No losses beyond prediction in EIS associated with the Project	Forest cover (hectare)				
	All habitat next to ROW, roads and facilities	Forest will not degrade below benchmarks	Forest cover within 100 meters of edge of ROW, roads and facilities				
	Cleared vegetation allowed to regenerate	Will regenerate in life of project with successions the same as on cleared areas outside project footprint.	Forest cover on that substrate on the ROW	Forest cover on that substrate on the ROW from videography	Deviation of regeneration plots from benchmark		
	Human incursion	No human incursion—not associated with Project or landowners	None evident	None evident			None evident
The lack of weeds and other exotics in the area.	Weeds	No weeds invading					
	Weeds	No new species of weeds associated with Project infrastructure		Number and area of weed infestations in flyovers on Hides Ridge	Cover of weeds on regeneration plots		
	Weeds	No expansion of weed areas associated with infrastructure		Identity of weeds in infestations located during survey	Identity of weeds in regeneration plots		
	Dieback	No expansion of dieback associated with infrastructure		Area of dieback detected associated with infrastructure	Dieback evidence from forest plots		
	Fire	No fires associated with infrastructure	No fire scars in change imagery	No evidence of fires generated from infrastructure	No plots burnt		
Hides Ridge							
The forest is in good condition and only two exotic weeds were recorded, neither an ecological problem.	Area of forest on Hides Ridge	No losses beyond prediction in EIS associated with the Project	Forest cover (hectare)				
	Human incursion	No human incursion—not associated with Project or landowners	None evident	None evident			None evident

Table A9.2 Monitoring of priority ecosystems (cont'd)

Value*	Biodiversity Targets to be Monitored	Biodiversity Goal	PMA 1	PMA 2	PMA 3	PMA 4	PMA 5
Hides Ridge (cont'd)							
	Cleared vegetation on limestone rubble on Hides Ridge	Will regenerate after reinstatement works with successions quicker than those on cleared areas outside project footprint but still slowly.	Forest cover on that substrate on the ROW	Forest cover on that substrate on the ROW from videography	Deviation of regeneration plots from benchmark		
	Cleared vegetation on limestone rubble on Hides Ridge	Where not reinstated regeneration will be the same as cleared areas outside project footprint.	Forest cover on that substrate on the ROW	Forest cover on that substrate on the ROW from videography	Deviation of regeneration plots from benchmark		
	Forest edges next to ROW, roads and facilities	All habitat next to ROW, roads and facilities	Forest will not degrade below benchmarks	Forest cover within 100 meters of edge of ROW, roads and facilities	Deviation of forest plots from benchmarks		
	Weeds	No new species of weeds associated with infrastructure		Number and area of weed infestations in flyovers on Hides Ridge	Cover of weeds on regeneration plots		
	Weeds	No expansion of weed areas associated with infrastructure		Identity of weeds in infestations located during survey	Identity of weeds in regeneration plots		
	Dieback	No expansion of dieback associated with infrastructure		Area of dieback detected associated with infrastructure	Dieback evidence from forest plots		
	Fire	No fires associated with infrastructure	No fire scars in change imagery	No evidence of fires generated from infrastructure	Deviation of forest plots from benchmarks		
	Edge effects in high-altitude karst.	No evidence of edge effects expanding	No retreat of forest away from ROW and road edges	No loss of canopy evident from flyovers	Deviation of forest plots from benchmarks		
	Barrier and erosion effects in high-altitude karst.	Species susceptible to barrier effects still present either side of ROW		No evidence of further erosion from flyovers	Deviation of forest plots from benchmarks		
	Barrier and erosion effects in high cuttings.	Species susceptible to barrier effects still present either side of ROW		No evidence of further erosion from flyovers	Deviation of forest plots from benchmarks		
High-altitude Forest above 1,800 Meters on the Homa Deviation							
Forest area and condition	Area of forest above 1,800 meters	No losses beyond prediction in EIS associated with the Project	Forest cover (hectare)				

Table A9.2 Monitoring of priority ecosystems (cont'd)

Value*	Biodiversity Targets to be Monitored	Biodiversity Goal	PMA 1	PMA 2	PMA 3	PMA 4	PMA 5
High-altitude Forest above 1,800 Meters on the Homa Deviation (cont'd)							
	Forest edges next to ROW, roads and facilities	All habitat next to ROW, roads and facilities	Forest will not degrade below benchmarks	Forest cover within 100 meters of edge of ROW, roads and facilities	Deviation of forest plots from benchmarks		
	Weeds	No new species of weeds associated with infrastructure		Number and area of weed infestations in flyovers	Cover of weeds on regeneration plots		
		No expansion of weed areas associated with infrastructure		Identity of weeds in infestations located during survey	Identity of weeds in regeneration plots		
	Dieback	No expansion of dieback associated with infrastructure		Area of dieback detected associated with infrastructure	Dieback evidence from forest plots		
	Fire	No fires associated with infrastructure	No fire scars in change imagery	No evidence of fires generated from infrastructure	Deviation of forest plots from benchmarks		
	Barrier and erosion effects in high cuttings.	Species susceptible to barrier effects still present either side of ROW		No evidence of further erosion from flyovers	Deviation of forest plots from benchmarks		
Lake Kutubu Wildlife Management Area							
Forest area and condition	Area of forest	Forest cover same as at end of construction	Forest cover (ha)				
	Forest edges next to ROW, roads and facilities	All habitat next to ROW, roads and facilities	Forest will not degrade below benchmarks	Forest cover within 100 meters of edge of ROW, roads and facilities	Deviation of forest plots from benchmarks		
	Weeds	No new species of weeds associated with infrastructure		Number and area of weed infestations in flyovers on ROW within WMA	Cover of weeds on regeneration plots		
	Weeds	No expansion of weed areas associated with infrastructure		Identity of weeds in infestations located during survey	Identity of weeds in regeneration plots		New species of weeds recorded by offset projects
	Dieback	No expansion of dieback associated with infrastructure		Area of dieback detected associated with infrastructure	Dieback evidence from forest plots		
	Fire	No fires associated with infrastructure	No fire scars in change imagery	No evidence of fires generated from infrastructure	Deviation of forest plots from benchmarks		
Fish fauna	Fish	Endemic species still present					Records from offset projects

*These are values as listed in the EIS.

Table A9.3 Monitoring of focal habitats

Focal Habitat	Biodiversity Goal	PMA 1	PMA 2	PMA 3	PMA 4	PMA 5
Caves next to ROW and facilities	No evidence of cave disturbance		Percent of caves next to ROW showing signs of disturbance			
Sinkhole swamps next to ROW and facilities	Swamps still vegetated and filled with water		Area of open water and aquatic vegetation in sinkhole swamps next to ROW (from videography or visual scoring)			
Lowland river crossings	Regenerating normally	Area of bare ground at each crossing	Percent of crossings at benchmark values for regeneration (from videography or visual scoring)			
Swamp forest	Regenerating normally	Area of open ground on ROW where it crosses swamp forest	Percent of open ground on ROW where it crosses swamp forest (from videography or visual scoring)	Deviation of regeneration plots from benchmark		
Upland streams next to ROW and facilities	Regenerating normally	Area of open ground on ROW where it crosses upland streams	Percent of crossings at benchmark values for regeneration (from videography or visual scoring)			
Stream refuges in unstable landscapes	Still intact	Baia River only - Designed later	Baia River only - Designed later	Baia River only - Designed later		
Off river water bodies	Still intact	Baia River only - Designed later	Baia River only - Designed later	Baia River only - Designed later		
Pandanus swamp forest next to ROW and facilities	Not disturbed	Area of pandanus swamp forest	Area of pandanus swamp forest next to ROW remaining undisturbed (from videography or visual scoring)			

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