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

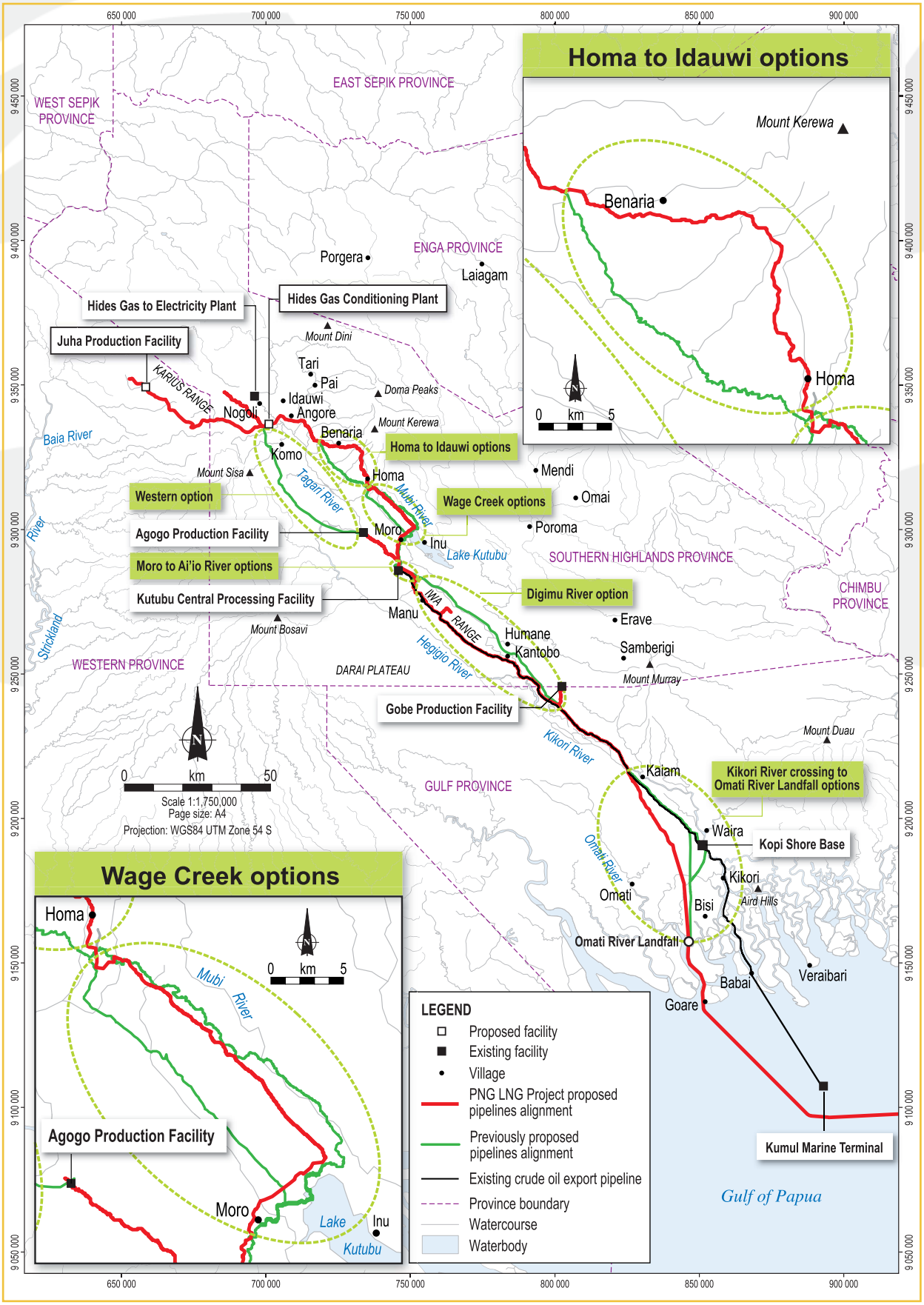


Table 7.1: Biodiversity-related design considerations and changes in priority ecosystems

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

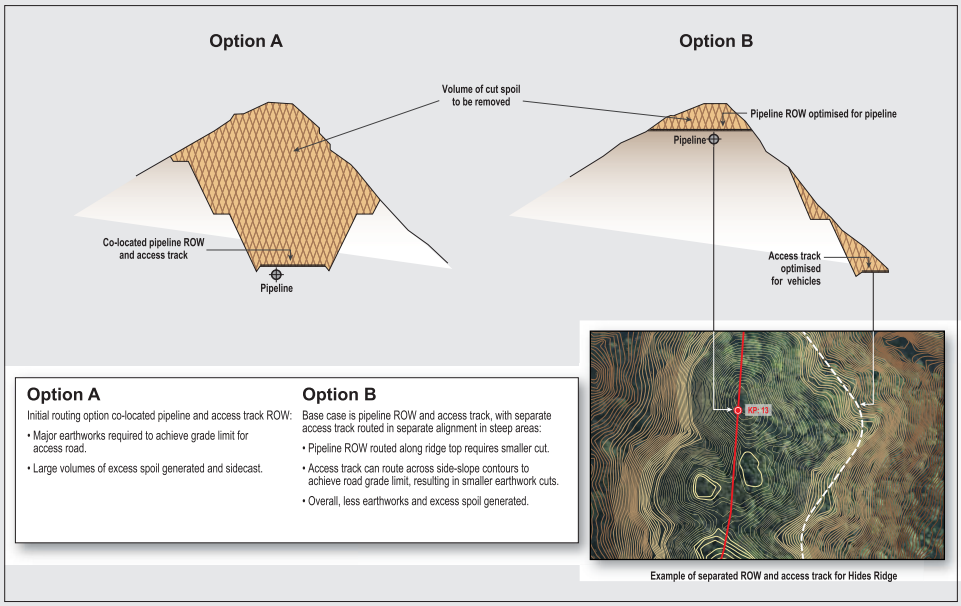
The conventional practice of co-locating the pipeline trench and construction access track requires a pipeline ROW 18 meters wide. This will generally reduce earthworks volumes in most types of terrain and, for much of Hides Ridge, could be achieved by routing along ridge tops. However, there are places 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.