2. PRODUCING THE GAS

2.1 Introduction

The resource base for the PNG LNG Project comprises a number of gas fields in the highlands of the Western and Southern Highlands provinces of Papua New Guinea (Figure 2.1). The development of this gas resource into a reliable supply for the proposed LNG Plant near Port Moresby requires wells, gathering systems and gas processing facilities at a number of locations:

- New gas wells or gas well recompletions, as well as new gathering systems, in four gas fields (Hides, Angore, Juha and South East Hedinia).
- New gas processing facilities, one at Hides and one at Juha, and modifications to the gas systems of existing oil processing facilities at Gobe, Kutubu and Agogo.

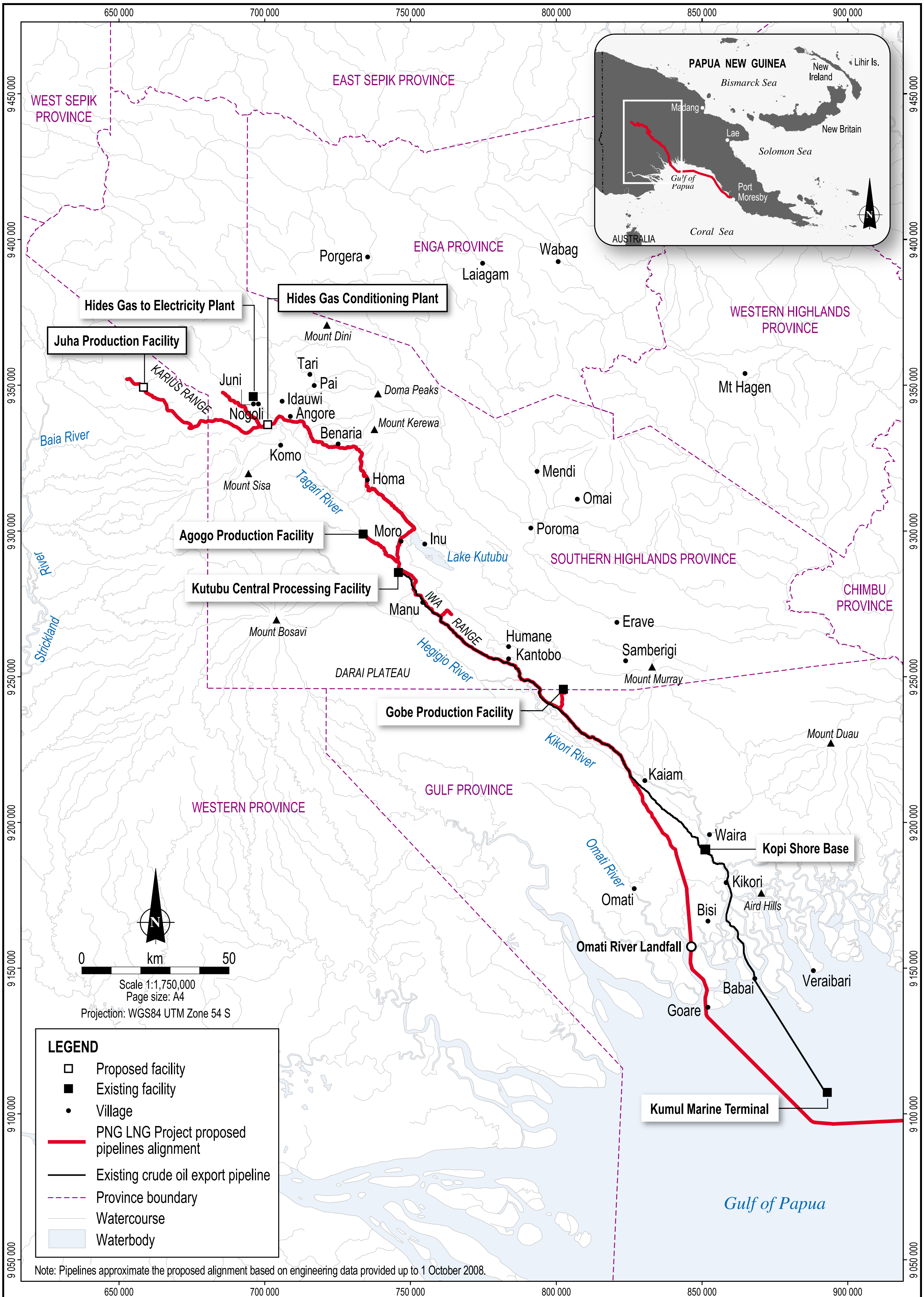
This chapter describes:

- The gas resource that will be developed and the wells and gathering systems proposed for each field (Section 2.2, Description of the Gas Resource).
- The proposed gas processing facilities and the modifications to be made at the existing oil processing facilities (Section 2.3, Description of the Gas Processing Facilities).
- How the construction activities at the facilities will be carried out (Sections 2.4, Common Construction Activities; 2.5, Drilling the Wells and Constructing the Gathering Systems and 2.6, Constructing the Processing Facilities).
- How the production facilities will operate and be operated and maintained (Section 2.7, Operating and Maintaining the Processing Facilities).
- Safety and security systems (Section 2.8, Safety and Security).
- The main environmental management issues (Section 2.9, Environmental Management).
- How the various facilities will be decommissioned at the end of the 30-year project life (Section 2.10, Decommissioning the Production Facilities).

ExxonMobil Engineering Practises System will serve as the basis for project design specifications. ExxonMobil guidelines and environmental standards will also be applied to the project as required. The project design specifications will be country specific to Papua New Guinea and will reference local codes and standards as appropriate. The project will be designed and installed in accordance with the project specifications in the following hierarchy:

- Regulatory requirements
- Project design specifications
- Standard industry and international standards.

In some cases, international codes and standards differ from PNG codes and standards. In these cases, the PNG codes and standards will be used, or an exception will need to be obtained from the relevant PNG regulatory body.



PNG LNG	Date: 26.09.2008 MXD: PNG_LNG_Project_GIS.mxd File Name: 1284_09_F02.01_GIS_HB	Esso Highlands Limited PNG LNG Project	**Locality map of upstream onshore components**	Figure No: 2.1

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The engineering design codes and standards applicable to the upstream project facilities and infrastructure including the associated gas facilities are provided as Attachment 3, Technical Codes and Standards, to this EIS.

Pipelines to transport processed gas and liquids are the other main upstream component of the project. They are described in Chapter 3, Transporting the Gas.

The infrastructure and logistical arrangements, such as roadways and construction camps, that are required to access and construct the wells, gathering systems and processing facilities are described in Chapter 5, Project Logistics.

The overall schedule for the project, including the elements described in this chapter, has been set out in Section 1.2.2, Project Development Schedule and Project Phases.

2.2 Description of the Gas Resource

The Papuan Fold Belt, in particular the area between the Darai Shelf edge and the Darai Plateau (i.e., the Kutubu Fold Belt) is an oil and gas province within Papua New Guinea. Past exploration and development have primarily focused on oil production. Significant undeveloped gas fields exist and further discoveries can be expected.

The project proposes to develop gas from the Hides, Angore, and Juha gas fields ('non-associated gas'), as well as from the Kutubu, Agogo, Gobe and Moran oil fields and the South East Hedinia gas field ('associated gas').

The following sections describe the geology (Section 2.2.1) and gas production forecast (Section 2.2.2) of these oil and gas fields.

2.2.1 Geology and Reservoirs

2.2.1.1 Regional Overview

The northwest–southeast trending Papuan Fold Belt forms a mountainous terrain covered by tropical forest. Topographic elevation exceeds 3,000 m (Mt Wilhelm is 4,509 m above sea level) with typical drilling locations at elevations between 1,500 m and 2,800 m above sea level. Local relief can be as high as 1,500 m.

The fold belt is the result of multiphase compressional tectonics combined of Miocene to recent age. Surface outcrops are dominated by Tertiary limestones (Darai Limestone), which form high-relief-karstified ridges. The main phase of crustal uplift commenced approximately four million years ago and has continued to the present day. Large surface anticlines associated with generally southwest-verging thrust faults form the main hydrocarbon traps. These traps are laterally confined by sealing tear faults which have steep forelimbs with 30° to 35° dipping backlimbs, and can have internal segmentation. Local detachment above the reservoir level may add to the tectonic complexity.

2.2.1.2 Stratigraphy

Late Jurassic to Tertiary rocks dominate the stratigraphic succession within the Papuan Fold Belt. Drilling has been confined to depths ranging from 2,000 m to 3,500 m below surface, which equates to the level of hydrocarbon reservoirs discovered to date. Older rocks have been penetrated in the foreland areas and are likely to exist beneath the fold belt. Figure 2.2 summarises the main stratigraphic units and hydrocarbon reservoir elements of the project area.

Late Jurassic marine siltstones and mudstones of the Koi-lange and Imburu formations are interpreted to be the source of reservoir hydrocarbons in the known reservoirs. Source rocks within the interval contain a variable mixture of terrestrial and algal organic material.

Late Jurassic to Early Cretaceous shallow marine sandstones represent the main reservoir units of the Toro, Digimu, and Iagifu sandstones. A thick sequence (generally greater than 1,000 m) of locally over-pressured marine shales and siltstones of the Ieru Formation provides the Toro Sandstone reservoir-sealing stratigraphic unit.

Rifting in the Coral Sea during the Upper Cretaceous led to the formation of a regional unconformity that represents the top of the Ieru Formation. Erosion on this angular unconformity has progressively removed material from the northwest to the southeast, with the youngest rocks preserved near Hides (Haito Member), and Jurassic reservoir units have been eroded near the present-day coastline.

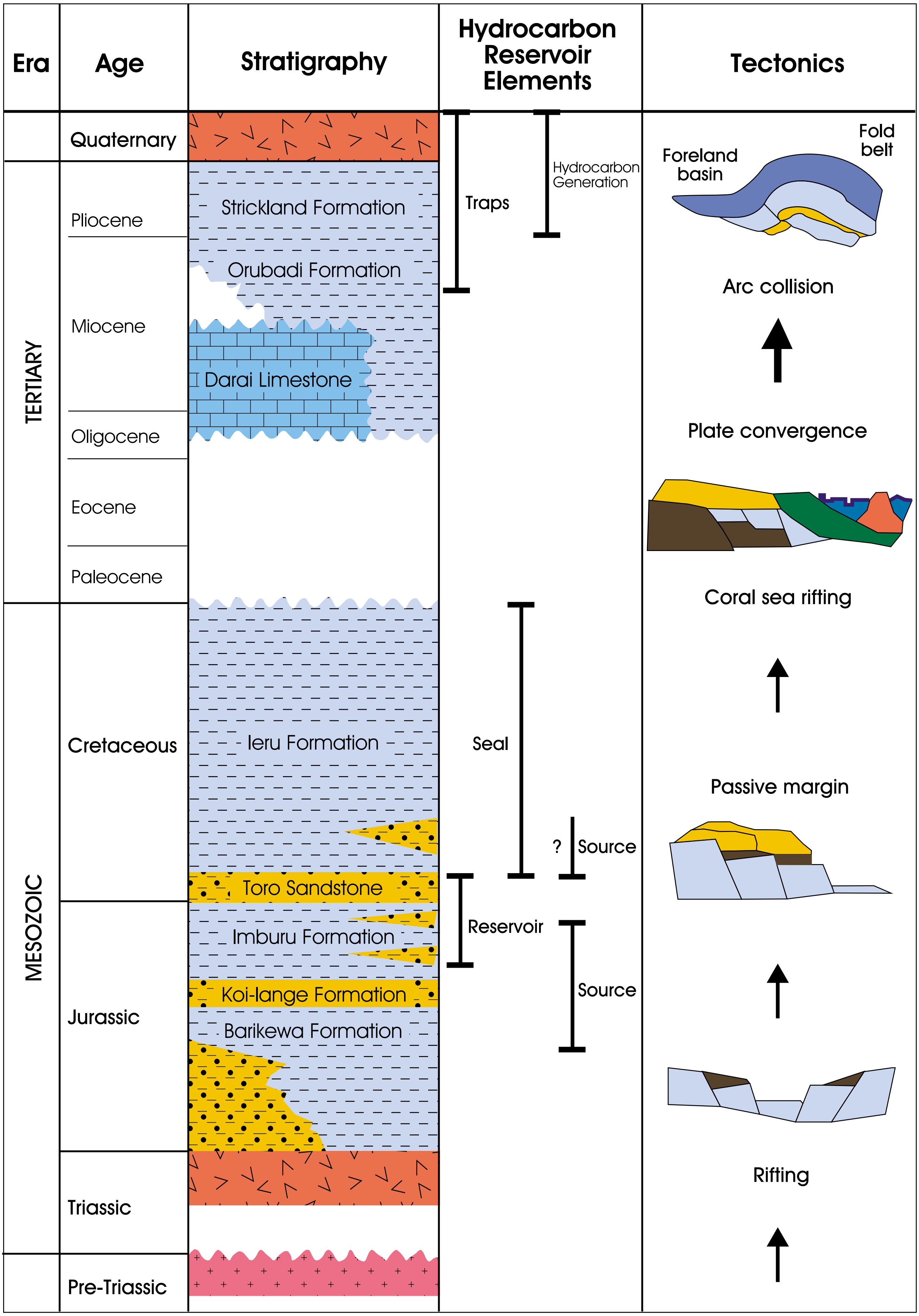
Deposition of the thick carbonate sequence of the Darai Limestone continued through most of the Miocene, followed by clastic deposition of offshore mudstones of the Upper Miocene to Pliocene Orubadi Formation. Plate collision during the Pliocene created the present-day fold and thrust belt with its associated hydrocarbon traps. In response to the uplift, local erosion and syn-tectonic deposition created the Strickland Formation, a sequence of volcaniclastic sandstones, conglomerates and siltstones. Basalts occurred simultaneously.

2.2.1.3 Reservoir Units

The Toro, Digimu, and Iagifu reservoirs are clean, shallow marine to estuarine quartzose sandstones deposited in a low-angle ramp setting. They range from Early Cretaceous to Late Jurassic age.

The Toro Sandstone is widespread, and internal units can be correlated throughout the area of the project fields (Juha to Gobe). Reservoir quality is usually good, although finer-grained rocks with lower permeability and porosity occur to the northwest of Hides, where intervening shales pinched out to form a common reservoir system approximately 140 m thick with the underlying Digimu Sandstone equivalents (Upper Imburu Sandstone). In the Kutubu area, the Toro Sandstone has an average thickness of approximately 110 m and excellent reservoir properties.

The Digimu Sandstone is well developed in the Kutubu and Moran area, where it is represented by a blocky estuarine sand approximately 30 m to 35 m thick with a sharp base and top. Towards the northwest of Hides, the stratigraphic unit thins and shows depositional environment changes to a more shoreline-dominated system. The sandstone pinches out adjacent to the Iagifu/Hedinia field and was not deposited southeast of this point.



PNG LNG	Job No: 1284 File Name: 1284_09_F02.02_HB	Esso Highlands Limited PNG LNG Project	**Schematic of regional geology and hydrocarbon reservoir elements**

Figure No: 2.2

The coarse-grained, blocky estuarine Iagifu Sandstone is the dominant reservoir at Gobe, where it occurs as a lower-quality upper unit and good-quality lower unit approximately 120 m thick in all.

Fields discovered to date typically have large hydrocarbon columns (in excess of 1,240 m at Hides) and can contain oil with a significant gas cap (Iagifu/Hedinia, part of the Kutubu fields), under-saturated gas (Hides), or saturated oil (Moran). Most fields contain both oil and gas.

2.2.2 Production Forecast

The inlet design gas flow rate for the proposed LNG Plant will be 1,133 kSm^3/hr. Table 2.1 shows the estimated per field stream-day contribution to this inlet requirement. Actual rates will vary over time (and the values shown make no allowance for fuel gas and flaring at the fields nor for end-of-field-life economic or operating constraints).

Table 2.1 Estimated stream-day gas quantities by field (kSm^3/hr)

Year	Hides	Angore	Juha	Kutubu	Gobe	Agogo/Moran	Total
1	27						27
2	454				51		505
3	1,084			74	51		1,210
4	1,079			80	51		1,210
5	1,073			86	51		1,210
6	1,007	59		92	51		1,208
7	1,007	59		92	51		1,208
8	772	236		151	51		1,210
9	739	236		163	51		1,188
10	564	295	118	163	51		1,191
11	360	295	295	195	51		1,195
12	371	255	295	195	45	35	1,195
13	480	184	258	195	30	47	1,194
14	599	117	208	195	27	47	1,193
15	657	103	165	195	24	47	1,191
16	697	91	132	195	2	71	1,188
17	730	80	106	195	0	77	1,188
18	760	72	85	194		77	1,187
19	780	65	71	177		94	1,187
20	799	59	59	175		94	1,186
21	819	54	51	168		94	1,186
22	808	50	44	165		94	1,161
23	713	47	39	151		94	1,044
24	631	44	34	60		124	893
25	558	41	32			124	755
26	496	39	30			124	688
27	441	37	26			124	628
28	393	34	21			124	572
29	350	32	21			124	527
30	314	31	20			124	489
31	280	30	18			124	451
32	250	27	19			124	420
33	224	26	18			124	392

Table 2.1 Estimated stream-day gas quantities by field (kSm^3/hr) (cont'd)

Year	Hides	Angore	Juha	Kutubu	Gobe	Agogo/Moran	Total
34	201	25	15			92	333
35	179	24	15			68	287
36	162	22	14			35	234
37	145	21	14			19	199
38	130	7	12			12	160
39	117					8	125
40	105		0			7	112

Condensate production will be a by-product of the project. The Hides Gas Conditioning Plant will separate condensate received from the gas fields and send it to the Kutubu Central Processing Facility by separate pipeline (the Hides–Kutubu Condensate Pipeline). The contributions to this condensate production by gas fields are shown in Table 2.2.

Table 2.2 Estimated stream-day condensate quantities by field (kSm^3/d)

Year	Hides	Angore	Juha	Total	Year	Hides	Angore	Juha	Total
1	0.03			0.03	21	1.26	0.05	0.19	1.49
2	1.84			1.84	22	1.18	0.05	0.17	1.40
3	4.18			4.18	23	0.99	0.05	0.14	1.18
4	3.70			3.70	24	0.84	0.05	0.13	1.02
5	3.51			3.51	25	0.72	0.03	0.11	0.86
6	3.10	0.11		3.21	26	0.62	0.03	0.11	0.76
7	2.91	0.11		3.02	27	0.52	0.03	0.10	0.65
8	2.08	0.45		2.53	28	0.46	0.03	0.08	0.57
9	1.96	0.41		2.37	29	0.41	0.03	0.08	0.52
10	1.42	0.46	1.07	2.94	30	0.35	0.03	0.06	0.45
11	0.87	0.38	2.19	3.45	31	0.32	0.03	0.06	0.41
12	0.87	0.30	1.67	2.85	32	0.27	0.02	0.06	0.35
13	1.10	0.22	1.21	2.53	33	0.25	0.02	0.05	0.32
14	1.32	0.13	0.86	2.31	34	0.22	0.02	0.05	0.29
15	1.38	0.11	0.65	2.15	35	0.19	0.02	0.05	0.25
16	1.40	0.10	0.49	1.99	36	0.17	0.02	0.05	0.24
17	1.40	0.08	0.40	1.88	37	0.16	0.02	0.05	0.22
18	1.38	0.08	0.33	1.80	38	0.14	0.02	0.03	0.19
19	1.35	0.06	0.27	1.69	39	0.13		0.03	0.16
20	1.30	0.06	0.22	1.59	40	0.11		0.0	0.11

Table 2.3 summarises projected total resource contribution by field to the gas and condensate volumes.

Table 2.3 Total resource contribution by field over 30 years and over 40 years

Field	Original Gas in Place (Gcf)*	30-Year Recovery			40-Year Recovery		
		Wet Gas (Gcf)	Field Liquids (Mbbls)	Gas RF** (% Original Gas in Place)	Wet Gas (Gcf)	Field Liquids (Mbbls)	Gas RF (% Original Gas in Place)
Hides	7,796	5,687	96	73%	6,237	100	80%
Angore	1,068	759	7	71%	812	8	76%
Juha	924	614	23	66%	653	24	71%
Kutubu	1,295	974	0	75%	974	0	75%
Agogo/Moran	1,083	506	0	47%	686	0	63%
Gobe	267	183	0	69%	183	0	69%
Project Total	**12,433**	**8,723**	**126**	**70%**	**9,545**	**132**	**77%**

*Gcf = billion cubic feet; 1 Gcf is equivalent to 0.0283 billion cubic metres (Gm^3). **RF = recovery factor.

2.2.3 Fields, Wells and Gathering Systems

Field production requires wells and a gathering system of flowlines and spinelines to collect production from individual wells and send it for processing. This section describes these facilities.

2.2.3.1 Fields

Hides Gas Field

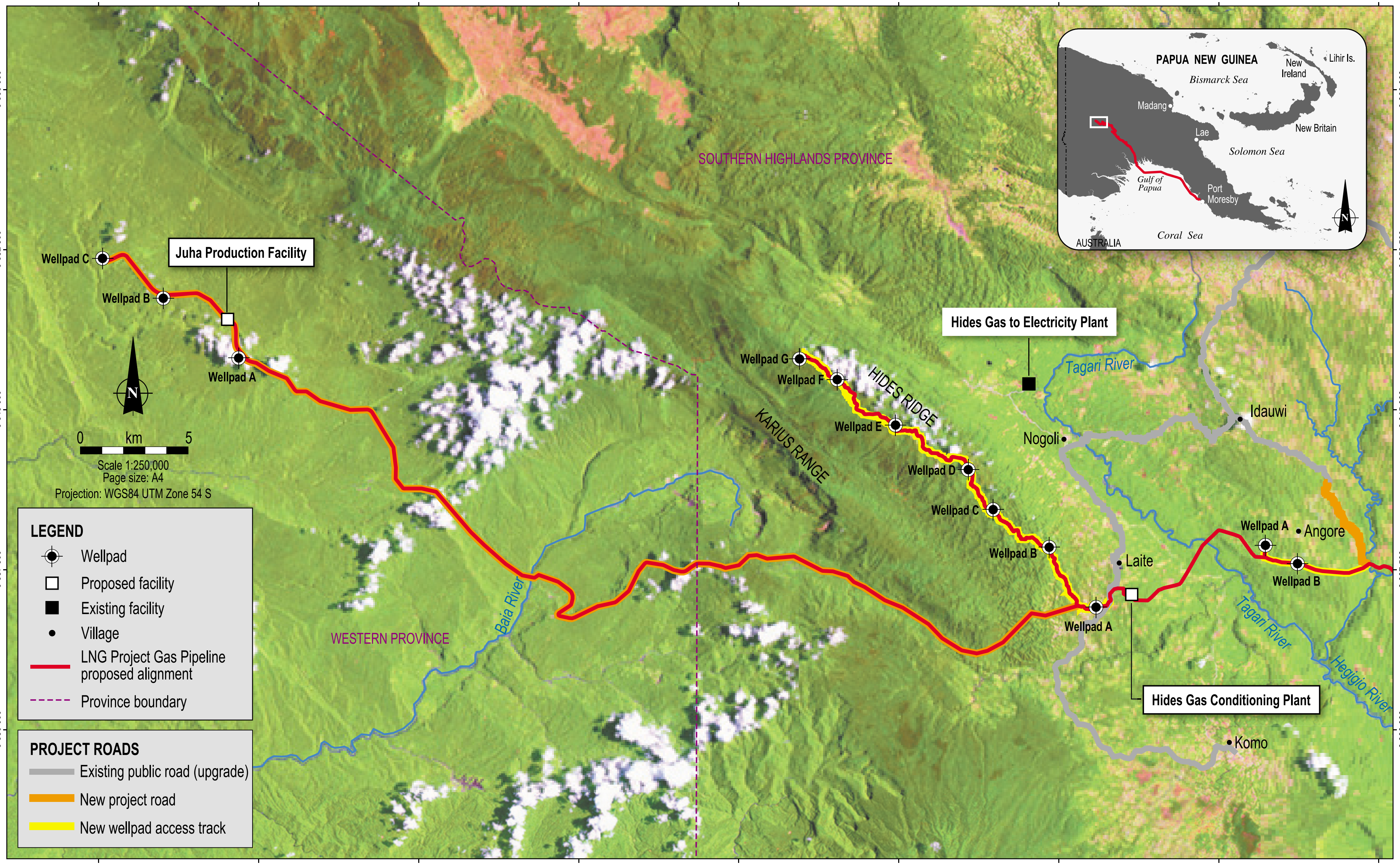
The large gas accumulation of Hides lies approximately 75 km northwest of the Kutubu Central Processing Facility (Figures 2.3 and 2.4) and is the cornerstone gas supply for the LNG Plant. Sufficient production capacity will be developed at Hides to meet total inlet requirements from first gas (Phase 1). Additional wells (in Phase 2) and compression (in Phase 3) will maintain the ability of Hides to contribute to the full capacity requirements of the LNG Plant.

Angore Gas Field

The Angore anticline is a northwest-to-southeast trending topographic feature 10 km east of the Hides anticline. Angore's proximity to the Hides Gas Conditioning Plant (see Figure 2.3) and its low unit development cost make it attractive as an early development to supplement total gas production capacity as the Hides reserves deplete.

Juha Gas Field

The Juha gas field (see Figure 2.3) is trapped in a faulted anticline that is part of the leading edge thrust fault of the Papuan Fold Belt about 35 km northwest of the Hides gas field. Juha has been scheduled for the fourth phase of development because it incurs the relatively high development costs of the Juha Production Facility and two pipelines from the Juha Production Facility to the Hides Gas Conditioning Plant, and requires time for further resource definition and development optimisation.



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

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PNG LNG Project

Juha, Hides and Angore fields locality map

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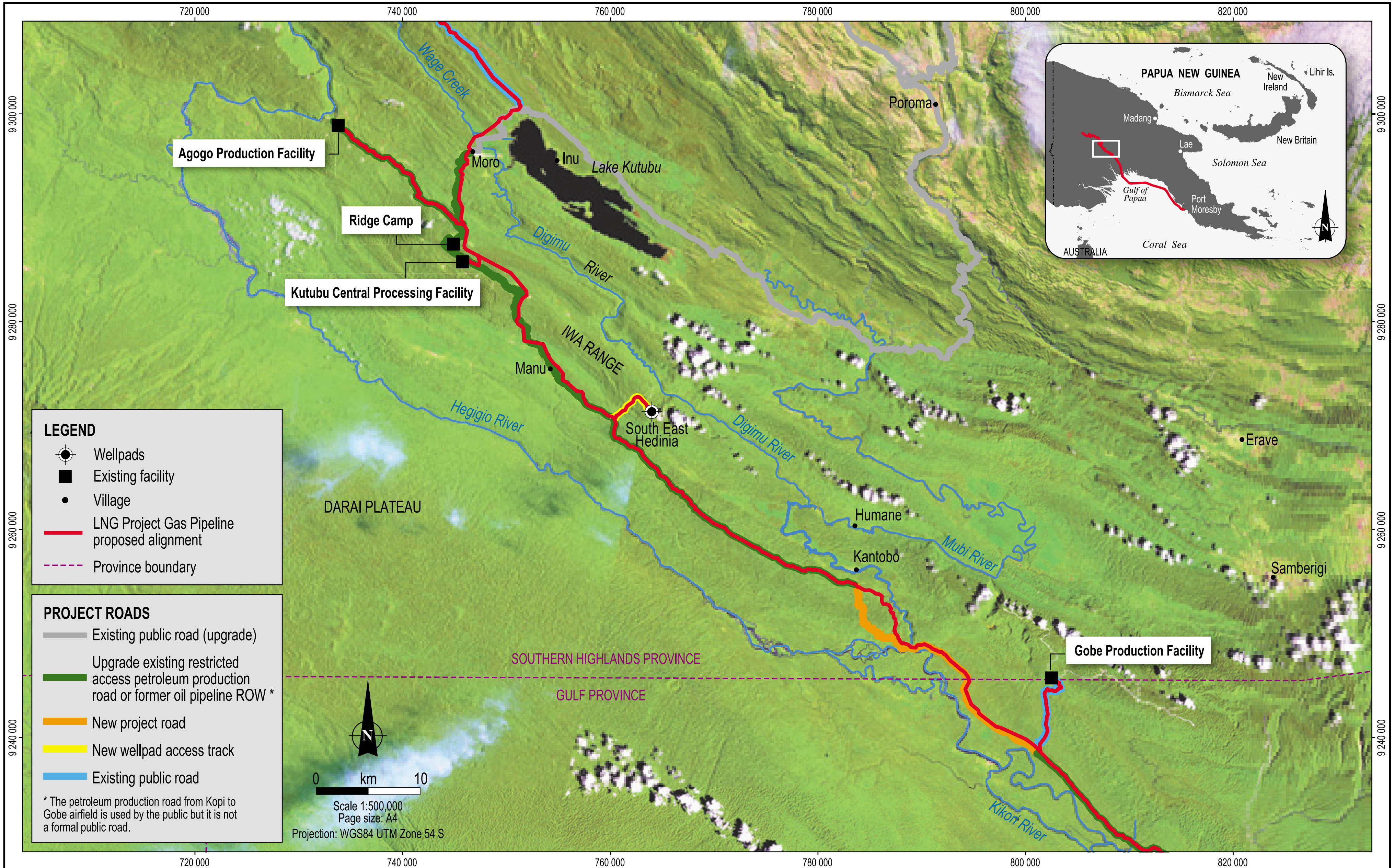

Note:
Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

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PNG LNG Project

Agogo Production Facility, Kutubu Central Processing Facility, Gobe Production Facility and South East Hedinia gas field locality map

Figure No: 2.4

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South East Hedinia Field

The South East Hedinia gas field (Figure 2.4) is located on a mountain ridge approximately 30 km southeast of the Kutubu Central Processing Facility. It has a large gas cap above the oil accumulation. The South East Hedinia gas reserves are a potential future resource for Phase 5 of the PNG LNG Project; but new wells are required, and feasibility will need to be confirmed in due course.

Other Associated Oil Project Fields

The other associated oil project fields (located in the vicinity of the Kutubu Central Processing Facility, Gobe Production Facility and Agogo Production Facility; see Figure 2.4) will not require new wells or gathering systems. The existing operator will continue production and, as the oil reservoirs deplete, the flow of associated gas will progressively grow to supplement production from the Hides, Angore and Juha fields.

There are currently no plans to increase gas production capacity in the existing associated oil project fields. However, the gas-to-oil ratios will increase over time as oil volumes decrease. As is the case for the non-associated gas fields, well production will typically (and subject to other reservoir management requirements) be prioritised to maximise liquids for a given amount of gas produced.

2.2.3.2 Wells and Wellpads

The bottomhole target of a well is designed to optimise production from a specific part of a field and to combine with other wells to efficiently develop the field as a whole. For each well, it is the bottomhole location and geological target (which are determined by the analysis of geoscientific datasets) and also the surface topography that determines the location of the wellpad, from which the well is drilled. In some cases, two or more wells can be drilled from a common pad to access different reservoir targets. At Hides, three of the wellpads will be able to support multiple wells in this way, with corresponding cost, operability and environmental advantages.

Section 7.10.1, Hides Gas Field Development, discusses the feasibility of alternative wellpad locations by which to develop the Hides Gas Field.

Hides Wells and Wellpads

The development of the Hides gas field involves two campaigns:

- First drilling campaign (Phase 1): Three new wellpads (B, C and G), six new wells and workovers of the existing wells at wellpads A and E.
- Second drilling campaign (Phase 2): One new wellpad (F) and two new wells.

Ultimately, there will be ten gas production wells on seven wellpads at Hides (Table 2.4).

Table 2.4 Wellpads and wells proposed for the PNG LNG Project

Project Phase	Field	Wellpads	Wells
Phase 1 (Drilling Campaign 1)	Hides	A (existing)	Hides 4 (existing), A1 and A2
		B	B1
		C	C1
		D (existing)	D1
		E (existing)	Hides 1 (existing)
		G	G1
Phase 2 (Drilling Campaign 2)	Hides	F	F1
		B	B2
	Angore	A	A1
		B	B1
Phase 4 (Drilling Campaign 3)	Juha	A	A1 and A2
		B	B1
		C	C1
Phase 5 (Drilling Campaign 4)	South East Hedinia	A (existing)	A1
		B	B1

Note: The existing Hides 2 wellpad and well are not part of the current proposal. The well provides gas to the existing Hides Gas to Electricity Plant, part of the Porgera Gas to Electricity Project.

Reservoir performance during the life of the project may indicate the need to add or relocate wells, in which case approvals will be sought from the appropriate government agencies in accordance with the approval process in place at that time.

The new and workover Hides wells and associated gathering system will be designed to deliver approximately 1,200 kSm^3/hr of raw gas to the Hides Gas Conditioning Plant. The existing Hides 2 well will continue to provide 18 kSm^3/hr to the Hides Gas to Electricity Plant, part of the Porgera Gas to Electricity Project. Potential for future tie-in of the Hides 2 well to the Hides gathering system (see Section 2.2.3.3, Gathering Systems) will be provided by a new takeoff at Hides Wellpad E from the Hides spineline.

The initial six new production wells will each have a capacity of 295 kSm^3/hr. Workovers on the two existing wells (Hides 1 and Hides 4) will increase their gas production capacity to the range of 71 to 94 kSm^3/hr per well. The expected total developed capacity at the completion of the first drilling campaign will therefore exceed 1,935 kSm^3/hr. (The developed capacity exceeds the design inlet flow rate at the LNG Plant to avoid operating the wells at capacity.)

The two new production wells to be drilled in Phase 2 and the booster compression to be installed at the Hides Gas Conditioning Plant in Phase 3 will offset declining reservoir pressure. Further compression and production optimisations will be investigated for development late in the life of the field.

Angore Wells and Wellpads

The Angore gas field requires the construction of two new wellpads and the drilling of two new production wells (see Figure 2.3). The field will be developed in conjunction with the second Hides drilling campaign (see Table 2.4), so as to share mobilisation and demobilisation costs.

The Angore wells and associated gathering system will be designed to deliver a stream-day rate of 295 kSm^3/hr of raw gas for delivery to the Hides Gas Conditioning Plant. Each of the two wells will be capable of producing approximately 149 kSm^3/hr.

Juha Wells and Wellpads

The Juha gas field will be developed during Phase 4 and requires the construction of three new wellpads and the drilling of four new wells (see Figure 2.3 and Table 2.4).

The Juha wells and associated gathering system will be designed to deliver a stream-day rate of 295 kSm^3/hr of raw gas for delivery to the Hides Gas Conditioning Plant. Each of the four wells will produce average stream-day rates in the range of 71 to 83 kSm^3/hr.

South East Hedinia Wells and Wellpads

The South East Hedinia field currently contains one wellpad and five exploration and appraisal wells. If feasible, development to supply gas to the PNG LNG Project would involve the construction of one new wellpad and the drilling of two production wells, one on each wellpad (see Table 2.4) during Phase 5.

2.2.3.3 Gathering Systems

Gathering systems collect the raw gas from individual wells and transport it to a processing facility. Flowlines from the individual wells are used to connect the wellhead to the spineline. These flowlines start above-ground at the wellhead and run for a short distance within the fenced area of the wellpad, where they connect with the spineline underground. This small above-ground section of the flowline contains most of the valving and instrumentation required to operate the wells. Spinelines will transport well fluids from the wellheads or flowlines to the Hides Gas Conditioning Plant, the Juha Production Facility or the Kutubu Central Processing Facility.

Hides Gathering System

Overview. The existing gathering system at the Hides gas field consists of individual flowlines from the Hides 1 and Hides 2 wells to the existing Hides Gas to Electricity Plant (see Figure 2.3 and Plate 2.1).

The Hides Gas to Electricity Plant has been processing gas since 1991 to fuel the Porgera Power Plant, which provides electricity for the Porgera Mine. The gas plant also has the capacity to distill condensate into diesel, naphtha and residue.

The new Hides gathering system will consist of a series of flowlines, a spineline, and a mono-ethylene glycol (MEG) line. The spineline and MEG line will run parallel to each other in the same ROW from the Hides Gas Conditioning Plant (see Section 2.3.1, Hides Gas Conditioning Plant) to Wellpad E for 17 km. At this point, the spineline will terminate, but the MEG line will continue a further 7 km in a trench from Wellpad G to the manifold at Wellpad E. The manifold system will be located upstream of the spineline pig launcher on Wellpad E and will have tie-ins for flowlines from wellpads E, F (Phase 2) and G. The spineline pig receiver will be located at the Hides Gas Conditioning Plant. (Pig launchers and receivers are described in Section 3.3.6.1, Scraper Station.)

Plate 2.1
Hides Gas to Electricity Plant (background) and
Porgera Power Plant (foreground)

Plate 2.2
Gobe Production Facility

Plate 2.3
Kutubu Central Processing Facility

Wellpad E will also provide the plot space and tie-ins for the Wellpad G and Phase 2 Wellpad F flowline pig receivers. When the spineline requires pressure relief, the gas will generally be sent to the flare system at the Hides Gas Conditioning Plant. However, Wellpad E will be equipped with a full-flow relief valve and knock-out drum that can be used if the spineline flow is obstructed and relief via the flare system is not possible. In addition, Wellpad E will be designed to vent gas from the Hides Spineline through the wellpad vent system. The other wells will have wellhead relief valves, but these valves are to protect the wellhead flowlines, not to relieve gas due to spineline flow obstructions.

The spineline and MEG line will all be buried, with a minimum depth of cover per AS 2885.1 of 750 mm**.** The flowlines will start at each wellpad and run to the spineline. The field safety system will be designed for appropriate wellhead shut-in pressure and to meet peak pressures anticipated in the gathering system.

A freshwater line will run above ground to provide water from local streams for drilling over the life of the project.

Well utilities will include control telemetry, MEG and corrosion inhibitor injection equipment, and an open-air drain sump and drainage treatment separator. Each flowline will have facilities for flow, temperature and pressure monitoring, sand detection, and corrosion probes and coupons. Power and communications for the well utilities will be supplied from the Hides Gas Conditioning Plant via a power and fibre-optic communications cable, which will be buried in the same ROW as the spineline and MEG line.

Design. The wells and gathering system will be designed to assure consistent and safe delivery of well production to the Hides Gas Conditioning Plant without flow instabilities, restrictions or blockages. The gathering system design life will be 30 years.

Pipe strength and wall thickness will be designed to meet all codes and standards for the design case. External corrosion coating for the spinelines and MEG line will be provided by three-layer polyethylene, with joint coating of applied urethane or urethane epoxy and a mechanical protection coating.

Table 2.5 summarises the Hides gathering system.

Table 2.5 Hides gathering system design data

Parameter	Description			
	Spineline	Flowlines from Recompleted Wells	Flowlines from New Wells	MEG Line
Length (approximate)	17 km	1 km	10 km	24 km
Nominal diameter	DN 550 (22")	DN 150 (6")	DN 250 (10") / DN 300 (12")	DN 50 (2")
Maximum flowrate (capacity)	1,208 kSm^3/h	94 kSm^3/h	295 kSm^3/h	194 m^3/day

Spineline Route and Crossings. The Hides Spineline will run in a southeasterly direction down the Hides Ridge from Wellpad E to Wellpad A and then to the Hides Gas Conditioning Plant at Laite (see Figure 2.3 and Section 6.4.2, Hides Gas Field to Hides Gas Conditioning Plant). The standard ROW construction width for the combined spineline and access track will be 18 m. For approximately 10 km of its length along the steeper part of the ridge, the spineline ROW will be constructed on the ridge and the access track will be constructed parallel to the ROW on the side of the ridge to reduce the amount of sidecasting required (see Section 7.10.1.3, ROW Formation Earthworks on Hides Ridge). The access track will be on average 7 m wide but can be up to 10 m wide to account for the presence or not of drains, additional space at bends, and passing bays.

The section of spineline ROW separate from the access track in the steeper terrain will be allowed to fully regenerate after construction. The vegetation will be kept low over the pipeline section of the ROW to allow access to cathodic protection test points three to four times a year. Similarly the 18-m-wide combined spineline and access track ROW will be allowed to fully regenerate after construction except for the access track. During operations the access track will be kept open to support ongoing well operations and successive drilling campaigns, and a security gate will be constructed at Wellpad A to control access to the ridge. This access track will be made impassable when the gas field is decommissioned[1]. Areas requiring active vegetation on Hides Ridges after construction works will be identified during detailed design (see discussion of landform and soil issues in Section 18.2, Landform and Soils.

There will be no major pipeline water crossings on the Hides Spineline and MEG line. There will be one minor water crossing (less than 10 m wide with a water depth less than 1 m).

Angore Gathering System

Overview*.* The Angore gathering system will consist of a main spineline to Wellpad B and a branch spineline connected to the main spineline to tie in Wellpad A (to transport gas from the wells to the Hides Gas Conditioning Plant) and a MEG line from the plant to the wells (see Figure 2.3). The spinelines and MEG line will run buried in the same trench to a minimum depth of cover per AS 2885.1 of 750 mm.

Pig launchers will be located at wellpads A and B and a pig receiver at the Hides Gas Conditioning Plant. The MEG line will not require pigging. Each wellhead will be equipped with a full-flow relief valve and knock-out drum that can be used if the spineline flow is obstructed and relief via the flare system is not possible.

Well utilities will be as for the Hides gathering system (see 'Overview' under 'Hides Gathering System' in Section 2.2.3.3, Gathering Systems), and power and communications will be supplied from the Hides Gas Conditioning Plant via a power and fibre-optic communications cable buried in the same ROW as the spinelines and MEG line.

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[1] The management of access and activities on Hides Ridge involves customary land. All such measures will require the understanding and agreement of the customary landowners.

Design. The wells and gathering system will be designed to assure consistent and safe delivery of well production to the Hides Gas Conditioning Plant without flow instabilities, restrictions or blockages. The gathering system design life will be 30 years.

Pipe strength and wall thickness will be designed to meet all codes and standards for the design case. External corrosion coating for the spinelines and MEG line will be provided by three-layer polyethylene. Joint coating will be provided by applied urethane or urethane epoxy and a mechanical protection coating.

Table 2.6 summarises the Angore gathering system.

Table 2.6 Angore gathering system design data

Parameter	Description		
	Angore Spineline A	Angore Spineline B	Angore MEG Line
Length (approximate)	0.5 km	10 km	10.5 km
Nominal diameter	DN 300 (12")		DN 50 (2")
Maximum flowrate (capacity)	295 kSm^3/h		28 m^3/day

Spineline Route and Crossings. Angore Spineline B will begin at Wellpad B, then parallel the ROW for the LNG Project Gas Pipeline and the Hides–Kutubu Condensate Pipeline to the Hides Gas Conditioning Plant (see Figure 2.3 and Section 6.4.3, Hides to Moro). Angore Spineline A will begin at Wellpad A and then join with Spineline B as it parallels the existing ROW. The Angore MEG line will parallel the two spinelines.

There is one major (wider than 10 m) watercourse crossing (of the Tagari River) along this ROW, and it will be constructed using horizontal directional drilling (see Section 3.4.4.5, Horizontal Directional Drilling).

Juha Gathering System

Overview. The Juha gathering system will comprise the Juha A, B and C spinelines, which will transport gas from the wells to the Juha Production Facility, and three MEG lines, which will transport MEG from the production facility to the wells. The spinelines and MEG lines will all be buried, with a minimum depth of cover per AS 2885.1 of 750 mm in the same ROW.

Pigging for Spineline A will comprise a launcher at the wellpad and a receiver at the Juha Production Facility. The pigging facilities for spinelines B and C will be combined, with a launcher at Wellpad C and a receiver at the Juha Production Facility end of Spineline B. No launcher or receiver will be provided at Wellpad B, only a tie-in from the well to the spineline. The MEG line will not require pigging.

Well utilities will include control telemetry, MEG and corrosion inhibitor injection equipment, and an open-air drain sump. Each well will have facilities for flow, temperature and pressure monitoring, sand detection and corrosion probes and coupons. In most scenarios that require pressure relief of the spineline, the gas will be sent to the flare system at the Juha Production Facility. However, each wellhead will be equipped with a full-flow relief valve and knock-out drum that can be used if the spineline flow is obstructed and relief via the flare system is not possible.

Power and communications will be supplied from the Juha Production Facility via a power and fibre-optic communications cable buried in the same ROW as the spinelines and MEG lines.

Design. The wells and gathering system will be designed to assure consistent and safe delivery of well production to the Juha Production Facility without flow instabilities, restrictions or blockages. The gathering system design life will be 30 years.

Pipe strength and wall thickness will be designed to meet all codes and standards for the design case. External corrosion coating will be provided by three-layer polyethylene. Joint coating will be provided by applied urethane or urethane epoxy and a mechanical protection coating.

Table 2.7 summarises the Juha gathering system.

Table 2.7 Juha gathering system design data

Parameter	Description			
	Juha Spineline A	Juha Spineline B	Juha Spineline C	Juha MEG lines
Length (approximate)	2 km	3 km	4 km	9 km
Nominal diameter	DN 250 (10")	DN 300 (12")	DN 250 (10")	DN 50 (2")
Maximum flowrate (capacity)	236 kSm^3/h (200 Mscf/d)	236 kSm^3/h (200 Mscf/d)	118 kSm^3/h (100 Mscf/d)	78 m^3/d (490 bbl/d)

Spineline Route and Crossings. The route for the spinelines (see Figure 2.3 and Section 6.4.1, Juha Gas Field to Hides Gas Conditioning Plant) was selected to provide the shortest distance avoiding significant side slopes.

There will be one open-cut major (wider than 10 m) and 14 open-cut minor (less than 10 m wide) watercourse crossings.

South East Hedinia Gathering System

The South East Hedinia gathering system (scheduled for construction in Phase 5) will follow the design principles of the prior phases of development but will need to be studied in detail to confirm commercial feasibility. A future arrangement might consist of flowlines from each wellpad connected to a 31-km long spineline to the Kutubu Central Processing Facility. The spineline would have a midline valve station and pigging facilities. The first 4 km of the spineline would require a new ROW along the side of a ridge between the gas field and the existing crude oil export pipeline ROW. The remainder of the spineline would follow the existing crude oil export pipeline ROW to the Kutubu Central Processing Facility. This gas field development will be planned and executed based on the standards and the technologies that exist at the time of development and will be documented in an environmental management plan or similar as required by the conditions of approval.

2.3 Description of the Gas Processing Facilities

New gas processing facilities and modifications to existing oil and gas processing facilities will be required to support the PNG LNG Project. The design life of the facilities will be 30 years but proper maintenance and gas reserves could extend the operating life of the project for much longer.

The Hides Gas Conditioning Plant (see Section 2.3.1, Hides Gas Conditioning Plant) will treat the gas ready for final processing at the LNG Plant and send condensate to the existing Kutubu Central Processing Facility. The Juha Production Facility (see Section 2.3.2, Juha Production Facility) will separate the raw product from the Juha wells into gas and liquids for further processing at Hides. The existing oil processing facilities (see Sections 2.3.3, Gobe Production Facility to 2.3.5, Agogo Production Facility) will require additional facilities to condition the existing associated gas, which is currently being reinjected into the oil reservoir formations. The new gas from the South East Hedinia field will be processed at the Kutubu Central Processing Facility.

2.3.1 Hides Gas Conditioning Plant

The Hides Gas Conditioning Plant will be developed in Phase 1, with booster compression added in Phase 3.

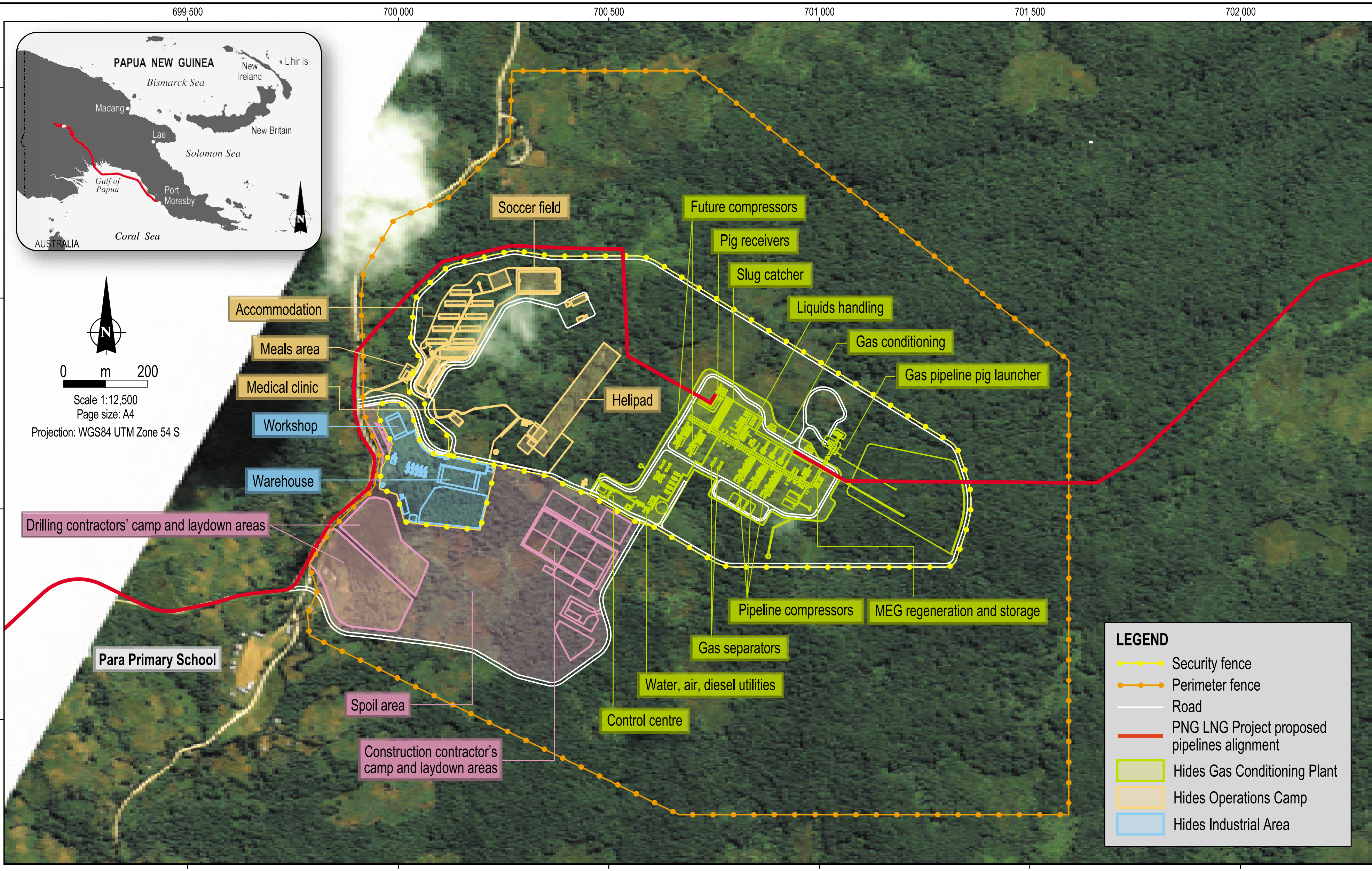
2.3.1.1 Proposed Site and General Description

The Hides Gas Conditioning Plant and associated facilities will be constructed at the southeast base of Hides Ridge approximately 2 km north-northeast of the village of Laite in Southern Highlands Province (see Figure 2.3).

The overall Hides site (including the plant, industrial area and operations camp) will occupy approximately 250 ha. The site will be enclosed by a simple wire perimeter fence. Within this area, 100 ha will be within a security fence: about 65 ha will be cleared and occupied, and the remainder will be safety zones. The area between the security fence and the perimeter fence will serve as a noise and air quality buffer between the plant and neighbours. Noise levels from the Hides Gas Conditioning Plant at the perimeter fence are expected to be approximately 45 dBA under neutral atmospheric conditions at night, which conforms to international standards for protection of amenity to surrounding receptors. The impact assessment of potential noise impacts from the facility is provided in Section 19.8, Noise; and air quality impacts are provided in Section 18.8, Air Quality.

The proposed layout of the new facilities (Figure 2.5) reflects:

- The placement of ignition sources (for example, fired heaters and incinerators, gas turbines and flare) upwind of potential flammable releases.
- The direction of noise and emissions to air away from the local population and from accommodation and recreational facilities at the operations camp.
- An open access area for future booster compression construction.
- Noise shielding by the local topography.
- Site drainage away from ignition sources.
- Shared power generation and water storage for process facilities and camp.



Note: Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.	PNG LNG	Date: 16.01.2009 MXD: PNG_LNG_Project_GIS.mxd File Name: 1284_09_F02.05_GIS_HB	Esso Highlands Limited PNG LNG Project	Indicative layout of the Hides Gas Conditioning Plant, Hides Industrial Area, operations camp, construction camp and laydown areas	Figure No: 2.5

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2.3.1.2 Plant Description

The Hides Gas Conditioning Plant will be capable of producing an LNG Plant feed gas with a water and hydrocarbon dewpoint at or below 5°C and a condensate meeting a Reid vapour pressure specification of 9.3 under normal operating conditions.

The plant will receive full wellstream fluids (hydrocarbon gas and liquids and water of condensation mixed with MEG and corrosion inhibitor) from the Hides and Angore fields. From Phase 4, the plant will also receive gas and liquids separated at the Juha Production Facility. MEG, which will be used as the primary mitigation for hydrate formation within the flowlines and spinelines, will be regenerated at the plant and pumped to the injection points via the Hides and Angore MEG lines. Regenerated MEG will also be transported from Hides to storage tanks at the Juha Production Facility via the Hides–Juha MEG Pipeline; it will then be pumped from those tanks to the injection points in the Juha field via the Juha MEG line.

The plant includes:

- Separation, slug handling, dehydration, gas conditioning and compression.
- Liquids stabilisation into a condensate product that can be mixed with the crude oil being exported from the existing Kutubu Central Processing Facility.
- Services and utilities. The services and utilities for the Hides Gas Conditioning Plant include:
  - Fuel gas system to provide fuel for plant.
  - Power generation and electrical systems.
  - Plant telecommunications.
  - Firewater system.
  - Utility and potable water systems.
  - Diesel storage and distribution system.
  - Hot oil system.
  - Utility and instrument air system.
  - Chemical injection systems.
  - MEG regeneration and storage system.
  - MEG vent gas incinerator.
  - Flare system.
  - Open and closed drain systems.

2.3.1.3 Hides Control Centre

The Hides Control Centre will include the Hides central control room, an office, a telecommunications equipment room, a control equipment room, a tea room, a permitting office, a storage room for personal protective equipment, a cleaning store and, female and male toilets. The building, which will normally be occupied by people, will therefore be located more than 150 m from the hydrocarbon process area (excluding the fuel gas coalescer for the generators).

2.3.1.4 Hides Industrial Area

An industrial park adjacent to the Hides Gas Conditioning Plant will provide operational and maintenance support, with parking for shuttle buses operating between the processing facility, the industrial park and airstrips and for light vehicles. Utilities, which will be provided as part of the overall Hides Gas Conditioning Plant site services, will include power, fuel gas, potable water, and fire water supply and distribution; sewage collection and treatment; and information technology and telecommunications. Instrument and utility air will be provided as stand-alone systems.

The Hides Industrial Area facilities and buildings are anticipated to include:

- Warehouse and office, with climate controlled storage.
- Maintenance and vehicle shops.
- Outdoor storage and laydown area.
- Laboratory.
- Chemical and hazardous materials storage shelter.
- Training classroom and outdoor fire-fighting training facility with fire equipment building.
- Ablutions.
- Fuel storage and distribution area and diesel refueling station.
- Waste management area.
- High-temperature industrial incinerator.
- Offices and workstations in workshops.
- Car park.

2.3.1.5 Hides Operations Camp

Hides Operations Camp. The Hides permanent operations camp will accommodate 260 operations personnel and contractors (see Figure 2.5) and will include the following facilities and buildings:

- Field operations administrative office.
- Accommodation and ablution units.
- Indoor catering and recreational facilities.
- Sports and recreational facilities.
- Other camp facilities, including a camp reception area and office, guard house, vehicle parking, camp maintenance workshop, and community affairs office.
- Camp utilities, including main power supply (from the Hides Gas Conditioning Plant), back-up power supply (from the Hides Gas Conditioning Plant), power distribution, potable water treatment (from the Hides Gas Conditioning Plant) and distribution, sewage treatment, and information technology and telecommunications.

2.3.1.6 Hides Gas Conditioning Plant – Further Developments

Initially, the Hides and Angore reservoir pressures will provide sufficient inlet pressure at the Hides Gas Conditioning Plant. As reservoir pressures decrease, booster compression will be required at the inlet of the plant in Phase 3. The plot space and tie-ins for the future booster compression will be incorporated into the design for Phase 1. The booster compression system will be installed upstream of the dewpoint control units. It will consist of two centrifugal compressors driven by gas turbines with dry, low-NO_x combustion systems.

The tie-in for the Phase 2 Angore Spineline will be valved and blind-flanged. The tie-ins for the Phase 4 rich-gas and liquids pipelines from Juha will be blind-flanged only.

2.3.2 Juha Production Facility

The Juha Production Facility (see Figure 2.3) will be developed in Phase 4 of the project.

2.3.2.1 Proposed Site

The Juha Production Facility will be sited on about 100 ha enclosed by a perimeter fence. Within that area, the plant will be enclosed by a security fence around approximately 50 ha. Figure 2.6 shows an indicative site layout, which is based on preliminary topographical data. Final details of site location, size, layout, and fencing will be developed during detailed engineering design in Phase 4 (over 10 years from now; see Figure 1.3).

This facility and gas field development will be planned and executed based on the standards and the technologies that exist at the time of development and will be documented in an environmental management plan or similar as required by the conditions of approval.

2.3.2.2 Plant Description

The Juha Production Facility will receive and separate well products from the Juha field into gas and liquids. It will provide 295 kSm^3/hr of rich gas to the Hides Gas Conditioning Plant inlet and also produce a partially stabilised liquids stream. The separated rich gas and liquids will flow through the Juha–Hides Rich Gas Pipeline and the Juha–Hides Liquids Pipeline to the Hides Gas Conditioning Plant.

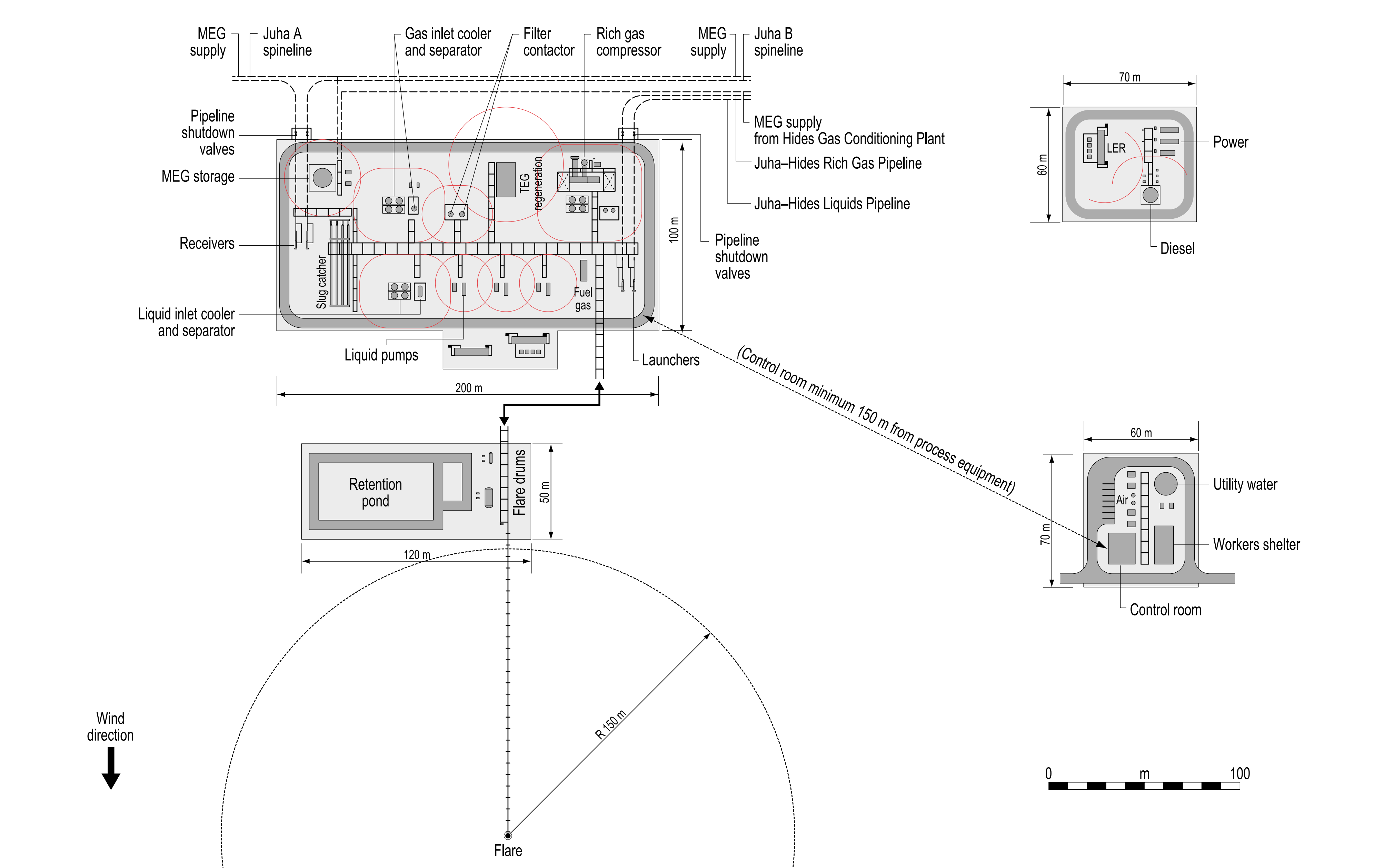
MEG will be used as the primary mitigation for hydrate formation at the Juha Gas Production Facility. Lean MEG will be regenerated at the Hides Gas Conditioning Plant and sent via the Hides–Juha MEG Pipeline to the lean MEG storage at the Juha Production Facility. Tri-ethylene glycol (TEG) will be used to dry the gas to the 112 mg/Sm^3 water specification required to mitigate corrosion in the compression system and the Juha–Hides Rich Gas Pipeline. Vapour from the TEG regeneration system will be condensed and sent to the Hides Gas Conditioning Plant via the Juha–Hides Liquids Pipeline. The condensed vapour, which may contain benzene, toluene, ethylbenzene, and xylene (BTEX), will eventually be disposed of through the MEG vent gas by thermal destruction or industry best practice.

The Juha Production Facility will normally be unstaffed, aside from security personnel.

The Juha processing facilities will comprise:

- Inlet facilities and separation.
- Gas dehydration and TEG regeneration.
- Gas compression and transport.
- Liquids transport system.

The utilities system at the Juha Production Facility will include:



Note: This is an indicative layout and will change with project developments.

PNG LNG	Job No: 1284 File Name: 1284_09_F02.06_HB	Esso Highlands Limited PNG LNG Project	Indicative layout of the Juha Production Facility

Figure No: 2.6

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- Fuel gas system.
- Power generation.
- Diesel system.
- Utility water system.
- Open and closed drain systems.
- Air, fire and chemical systems.
- Metering.

2.3.2.3 Juha Operations Camp

A 20-person operations camp will be constructed at Juha Production Facility to accommodate visiting operations personnel and contractors who need to stay overnight. The camp will normally be occupied only by security personnel. Facilities and buildings will include accommodation units, cold food storage, kitchen, mess, laundry and ablutions, TV room, guard house, clinic, office and stores.

2.3.3 Gobe Production Facility

The existing Gobe Production Facility processes reservoir fluids from the Gobe Main and South East Gobe oil fields to produce stabilised crude oil for export. The fields went into production in 1998 and are located approximately 90 km southeast of Kutubu (see Figure 2.4 and Plate 2.2). No new wells are currently planned to be drilled in these fields for the PNG LNG Project.

2.3.3.1 Existing Process Description

The existing processing facilities consist of liquid and gas systems. The liquid systems stabilise crude oil for export. The gas systems dehydrate and compress the associated gas and reinject it into the producing formation. Produced water is also reinjected.

2.3.3.2 Existing Utilities

The existing utilities at the Gobe Production Facility include compressed air, fuel gas, electrical power, high- and low-pressure flares, slop oil and oily water drains and treatment, steam, water supply and chemical injection.

2.3.3.3 Proposed Modifications

The gas produced by the Gobe Production Facility does not meet the required moisture content limit for the LNG Project Gas Pipeline of 112 mg/Sm^3, which requires a design specification of 80 mg/Sm^3. The design specification of the existing TEG dehydration system at Gobe is 192 mg/Sm^3, and the current performance is around 432 mg/Sm^3, so an upgrade of dehydration at Gobe is required.

The base case involves the enhanced glycol concentration process (DRIZO process), which regenerates the glycol by solvent stripping (instead of conventional gas stripping). The solvent required for the DRIZO process is usually obtained from the BTEX present in the natural gas itself and the method has the advantages of cost, performance and compatibility with existing processing facilities. However, the alternative of silica gel dehydration will be retained for further investigation during FEED and detailed design.

Access to the associated gas of the Gobe field will require the following additions and modifications at the Gobe Production Facility:

- An enhanced glycol dehydration package adjacent to the existing TEG regeneration unit with interconnecting piping and instrument and electrical cabling.
- LNG Project gas metering station.
- Gas metering at appropriate locations for allocation and balance monitoring.
- A new gas pipeline (Gobe Gas Pipeline) to tie in to the LNG Project Gas Pipeline, with pig launcher and receiver (see Section 3.3.5.2, Pipeline Routes and Crossings).
- Battery limit valving on the Gobe Gas Pipeline (at the custody boundary between the Gobe Petroleum Development Project and the PNG LNG Project) to allow isolation in the event of an upset.
- Piping from the discharge manifold of the existing reinjection gas line to the new LNG Project gas metering station and to take the gas metering signals to the Gobe Production Facility distributed control system.
- A gas reinjection control system to divert excess compression capacity to the existing reinjection wells.
- Integration of the control and shutdown system.

The modifications described above are not expected to exceed the spare capacity of the existing utilities.

Tie-in capability for the Gobe Gas Pipeline will be installed in the LNG Project Gas Pipeline during Phase 1. If the project co-venturers make the decision to proceed, the modifications at Gobe and the construction and connection of the Gobe Gas Pipeline will need to occur in Phase 1.

2.3.4 Kutubu Central Processing Facility

The Kutubu Central Processing Facility (Plate 2.3), located about 90 km northwest of the Gobe Production Facility (see Figure 2.4), has been producing oil for export since 1992 as part of the Kutubu Petroleum Development Project. Oil from the Kutubu, Iagifu, and Hedinia fields flows to the Kutubu Central Processing Facility. The facility also receives liquids from the Moran and Agogo fields via the Agogo Production Facility (see Section 2.3.5, Agogo Production Facility).

The Kutubu oil fields complex comprises approximately 50 existing wells in total, including producing and shut-in oil wells, gas injection wells, and a produced water injection well. No new wells associated with the PNG LNG Project are currently planned to be drilled in the existing Kutubu fields. However, two new gas wells will be drilled at the South East Hedinia field (see Figure 2.4) and processed via the new facilities at the Kutubu Central Processing Facility described in Section 2.3.4.3, Proposed Modifications.

The Kutubu Central Processing Facility stabilises crude oil and provides crude oil storage, pumping and metering facilities for the existing crude oil export pipeline.

Associated gas is currently being produced with the oil from the existing producing wells. Some of this gas is used for gas lift, which involves the injection of a recirculated gas stream into wells to assist in reducing static pressure in the well tube, thus allowing the flow of liquids to increase. Most of the gas is currently being reinjected into a number of injection wells, with flaring where permitted. The gas from the Kutubu Central Processing Facility that is currently being reinjected or flared will be directed instead to new facilities for processing once this facility becomes operational. Some of this gas may still be directed to the existing gas-lift or gas reinjection system.

2.3.4.1 Process Description

The existing processing facilities consist of liquid and gas systems. The liquid systems comprise:

- Three-phase separation for oil, gas and water.
- Oil stabilisation in three trains.
- Crude oil storage in six tanks.
- Export crude pumping.
- Produced water treatment and reinjection.

The gas systems contain the following components:

- Stabiliser overheads compression to approximately 1,400 kPag.
- First-stage gas compression in three trains to approximately 3,600 kPag.
- Dehydration via conventional TEG units in two trains.
- Second-stage gas compression in three trains to approximately 7,500 kPag.
- Third-stage gas compression in three trains to approximately 14,600 kPag.
- Gas reinjection and gas lift facilities.

2.3.4.2 Existing Utilities

The existing utilities at the Kutubu Central Processing Facility include compressed air, fuel gas, electrical power, high- and low-pressure flares, slop oil and oily water drains, water supply and treatment, diesel fuel and chemical injection.

2.3.4.3 Proposed Modifications

Like Gobe (see Section 2.3.3.3, Proposed Modifications), the gas produced by the Kutubu Central Processing Facility does not meet required moisture content limit for the LNG Project Gas Pipeline of 112 mg/Sm^3, which requires a design specification of 80 mg/Sm^3. The design specification of the existing TEG dehydration unit at Kutubu is 192 mg/Sm^3, and the current performance is around 352 mg/Sm^3, so dehydration at Kutubu needs to be upgraded.

As for Gobe, the base case involves the DRIZO process, but with the alternative of silica gel dehydration retained for further investigation during FEED and detailed design.

Assuming that the DRIZO process option is selected, the following will be required at the Kutubu Central Processing Facility:

- Two enhanced glycol dehydration packages (one for each TEG unit) adjacent to the existing TEG regeneration units, with interconnecting piping and instrument and electrical cabling.

- Replacement of the two existing trayed glycol contactors with two new columns of the same dimensions but with structured packing to improve gas-glycol contact.

Other upgrades and additions include:

- Oil balance metering in the combined crude oil rundown to storage.
- A condensate line from the battery limit tying in to the combined crude oil rundown, which will receive incoming condensate from the Hides Gas Conditioning Plant.
- LNG Project gas metering.
- The new Kutubu Gas Pipeline to connect the facility to the LNG Project Gas Pipeline, with pig launcher and receiver (see Section 3.3.5, Associated Oil Field Gas Pipelines).
- Gas metering at appropriate locations for allocation and balance monitoring.
- Battery limit valving on the new Kutubu Gas Pipeline and the new incoming Hides–Kutubu Condensate Pipeline to allow isolation in the event of an incident.
- Piping from the discharge manifold of the existing third-stage compressors to the new LNG Project gas metering station and to take the metering signals to the Kutubu Central Processing Facility distributed control system.
- A gas reinjection control system to divert excess compression capacity to the existing reinjection wells.
- New instrumentation on both TEG contactors to enable column performance to be verified.
- Integration of the control and shutdown system.

The modifications described above will place minimal additional demand on the existing utilities. It is likely that the total demand will not exceed the spare capacity of the existing utilities, and hence they will not need to be upgraded.

A tie-in capability for the Kutubu Gas Pipeline will be installed in the LNG Project Gas Pipeline during Phase 1. If the co-venturers decide to proceed, the modifications at Kutubu and the construction and connection of the Kutubu Gas Pipeline are expected to occur in Phase 1.

2.3.5 Agogo Production Facility

The Agogo Production Facility (see Figure 2.4 and Plate 2.4) was developed in 1992 as a satellite facility to the Kutubu Central Processing Facility, which is 23 km southeast. It initially processed production from the Agogo field and was subsequently modified and expanded to process production from the Moran field.

Plate 2.4
Agogo Production Facility

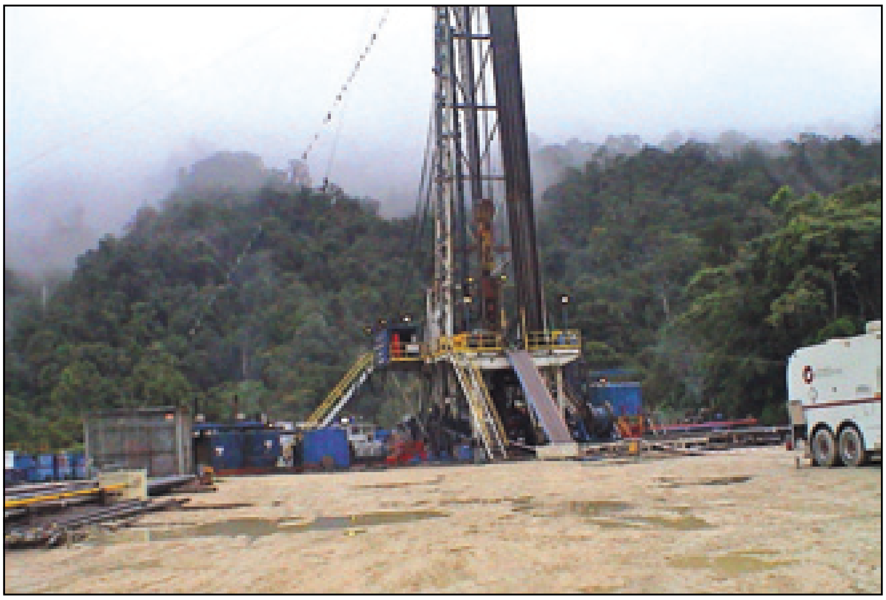


Plate 2.5
Typical drill site (at Kutubu)

The Agogo Production Facility separates oil and water (from gas) from the Agogo and Moran fields for further processing at the Kutubu Central Production Facility. The separated gas is used for gas lift and reinjection. No new wells associated with the PNG LNG Project are currently planned at the Agogo or Moran fields.

2.3.5.1 Process Description

The existing processing facilities consist of liquid and gas systems. The liquid systems contain the following components:

- Three-phase separation facilities for oil, gas and water.
- Oil test stations for the measurement of oil and water.
- Liquids surge vessel.
- Liquids pumping facilities for export to the Kutubu Central Processing Facility.

The gas systems contain the following components:

- Dehydration via conventional TEG units in three trains.
- Low-pressure first-stage gas compression in three trains to about 9,300 kPag.
- Low-pressure second-stage gas compression in three trains to about 17,400 kPag.
- Agogo reinjection and gas lift facilities.
- High-pressure first-stage gas compression in a single train to about 28,500 kPag.
- High-pressure second-stage gas compression in a single train to about 40,000 kPag.
- Moran field gas reinjection facilities.

2.3.5.2 Existing Utilities

The existing utilities at the Agogo Production Facility include compressed air, fuel gas, electrical power, high- and low-pressure flares, slop oil and oily water drains and treatment, water supply and treatment, diesel fuel and chemical injection.

2.3.5.3 Proposed Modifications

Like Gobe (see Section 2.3.3.3, Proposed Modifications) and Kutubu (see Section 2.3.4.3, Proposed Modifications), the gas produced by the Agogo Production Facility does not meet required moisture content for the LNG Project Gas Pipeline. The design capability of the existing TEG unit at Agogo is 152 mg/Sm^3 and the current performance ranges between 144 and 640 mg/Sm^3. The PNG LNG Plant limit of 112 mg/Sm^3 requires a design specification of 80 mg/Sm^3 and so an upgrade of dehydration at Agogo is required.

Assuming that the DRIZO process option is selected, the following work will be required at the Agogo Production Facility:

- Replace the three existing TEG dehydration units with one glycol contactor, one TEG dehydration unit and an enhanced glycol dehydration package.

- Move the existing air system to a safe area to accommodate the new equipment.

- Connect the existing Moran slug catcher as per its original design and install gas blowdown valves.

- Install a new LNG Project gas metering station.

- Construct the Agogo Gas Pipeline to connect the facility to the LNG Project Gas Pipeline.
- Install a pig launcher and receiver on the Agogo Gas Pipeline.
- Install gas metering at appropriate locations for allocation and balance metering.
- Install battery limit valves on the Agogo Gas Pipeline to provide isolation in the event of an incident.
- Install piping from the discharge manifold of the third-stage compressors of the existing Agogo gas system to the LNG Project gas metering station and in order to take the metering signals to the Agogo Production Facility distributed control system.
- Install a gas reinjection control system to divert excess compression capacity to the existing reinjection wells.
- Relocate the air system to a safe location within the battery limits to provide space for the installation of the new dehydration equipment.
- After 2024, reconfigure gas compression to allow the inlet pressure of the Agogo Gas Pipeline to be reduced from 3,400 kPag to 1,400 kPag (which will extend the life of the field).
- Integrate the control and shutdown system.

The modifications described above are not expected to exceed the spare capacity of the existing utilities.

A future tie-in capability for the Agogo Gas Pipeline will be installed in the LNG Project Gas Pipeline during Phase 1. If the co-venturers make the decision to proceed, the modifications at Agogo and the construction and connection of the Agogo Gas Pipeline are expected to occur in Phase 5.

2.4 Common Construction Activities

The following activities will occur at all sites where construction of new or upgraded facilities, infrastructure or drilling of wells will occur:

- Preconstruction survey.
- Surveying.
- Archaeological clearance.
- Erosion control.
- Equipment mobilisation.
- Vegetation clearing.
- Grading and foundation excavation.
- Site clean-up and rehabilitation.

2.4.1 Preconstruction Survey

All sites proposed for development of project facilities and infrastructure will be subject to a preconstruction survey by environmental and social specialists (or both if required), in association with project engineers and surveyors. The purpose of the preconstruction survey will be to establish no-go zones at facility sites and along the routes of pipelines, access tracks and roadways. These surveys will be conducted during the detailed design stage of project planning (see Figure 1.3) as it is only then that sufficient information on final proposed siting and alignment will be available to allow this level of tactical mapping to take place.

The environmental preconstruction surveys will focus on identifying and mapping for avoidance (where practicable) sensitive biodiversity features, such as caves with bat colonies, bird-of-paradise lekking trees, sinkhole swamps, and large trees providing habitat for arboreal species and epiphytes. In addition, the survey will focus on identifying those areas in the upstream project area that may be difficult to regenerate following construction disturbance.

The social preconstruction surveys will focus on establishing the precise boundaries of sensitive social features at the local scale for avoidance and protection ahead of project construction work. Sensitive social features include archaeological sites, such as ossuaries, as well as ritual and food resource areas of importance to landowners.

All preconstruction surveys will be conducted on foot, and the information from the surveys will be recorded in the project's geographic information system (GIS) for use in preparing detailed site-scale plans. On the basis of these plans, biodiversity and social constraints identified for avoidance during the preconstruction surveys will be marked on the ground during the follow-on site surveying activities described in Section 2.4.2, Surveying, below.

2.4.2 Surveying

All sites proposed for infrastructure construction will be surveyed and pegged to confirm that they avoid, to the extent practicable, significant cultural and biodiversity areas and to reconcile other construction constraints encountered. The extent of site clearing and incidental site disturbance will be minimised by the demarcation of areas that require clearing for infrastructure construction and by confining traffic to designated access ways and laydown areas.

2.4.3 Archaeological Clearance

All areas that will be disturbed by the project will undergo a site archaeological clearance survey, as well as selective subsurface salvage and recording of artefact material where required. The archaeological clearance survey and any salvage work will be conducted under permit obtained from and in consultation with the PNG National Museum and Art Gallery and with local landowners. Remaining artefacts not salvaged will be allowed to be destroyed under permit from the PNG National Museum and Art Gallery and other departments as required (see Chapter 22, Project-wide Cultural Heritage Impacts and Mitigation Measures for further details).

2.4.4 Erosion Control

A surface-water drainage system will be constructed for all facility and non-linear infrastructure. The objective will be to reduce the potential for soil loss and degradation both on and off construction areas and to limit soil erosion and discharge of sediment-laden water to local drainage lines and watercourses. The surface-water drainage system will divert clean surface-water runoff away from areas to be disturbed and will collect sediment-laden water from disturbed areas in sediment traps, sediment retention ponds or similar structures prior to discharge. Controlled release of water from sediment retention ponds will be in accordance with the requirements of the relevant environment (waste discharge) permit. Along access ways and pipeline and spineline ROWs, erosion control structures will be installed as required near streams and rivers.

The design and construction of the surface water drainage systems will be provided in the requirements of the project's water management plan that will contain associated plans dealing with erosion and sediment control management, water quality management, waste water management, surface water and storm water management, and water course construction management. The preparation of these management plans will be guided by the project's commitment to specific management measures to protect water resources as summarised in Chapter 29, Summary of Mitigation and Management Commitments. The water management plan will be prepared under the project's environmental management plan framework that is described in Chapter 30, Environmental Management, Monitoring and Reporting.

The potential impacts of soil erosion resulting from project construction activities are assessed and the proposed erosion mitigation and management measures are described in more detail in Sections 18.2, Landform and Soils; 18.4, Water Resources and Hydrology; 18.5, Water Quality; and 18.6, Aquatic Ecology. The environmental management system, under which the water management plan will be developed, is described in Chapter 30, Environmental Management, Monitoring and Reporting.

2.4.5 Equipment Mobilisation

Construction equipment will initially be mobilised from Kopi Shore Base or the port at Lae to the construction sites (see Chapter 5, Project Logistics). It will then be moved to successive areas as the need arises.

2.4.6 Vegetation Clearing

After survey pegs are placed, the site will be cleared to the designed width. This will involve:

- Clearing of vegetation and grubbing of stumps. Vegetation that will be cut and not grubbed will be cut close to the ground without striking the earth, where practicable.
- Stockpiling of woody vegetation not used for construction purposes in piles at the edge of the site or along the side of access ways.
- Where practicable, merchantable timber cleared will be utilised during construction. Where practicable, landowners will be given unwanted merchantable timber for use in construction or as firewood.
- Cut vegetation will be pushed to the sides of the cleared areas, and some may be used for soil stabilisation or rehabilitation works.

The mitigation and management measures for vegetation clearing are described in Section 18.2, Landform and Soils.

2.4.7 Grading and Foundation Excavation

Sites will be graded and excavated to the designed level and slope to provide a base for the infrastructure. These activities will be undertaken using front-end loaders, backhoes, bulldozers, motor graders, hydraulic excavators, rollers, and dump trucks. Water trucks, water sprays or dust suppressants will be used as necessary to manage dust. Areas will be trimmed to final grade and compacted.

During grading of the non-linear infrastructure sites, and where practicable for linear infrastructure, topsoil (i.e., the top layer of fertile soil, including all plant matter that has not been cleared) will be progressively stripped and either used immediately in site fill and rehabilitation works or stockpiled separately for subsequent use in rehabilitation works on the site. Topsoil will be respread over the final surfaces of areas designated for active rehabilitation and landscaping to support regrowth (see Section 18.2, Landform and Soils).

Excavated cut spoil material will be used for fill where suitable. Surplus spoil will be deposited in designated spoil areas at facilities sites where practicable and used for noise and air quality bunds and for landscaping as required**.** For linear infrastructure in steep terrain, excess spoil will be sidecast. Discussion of routing and other design measures to reduce the amount of sidecast material is given in Section 7.10.1.3, ROW Earthworks on Hides Ridge and Section 7.10.2, Spoil Management.

2.4.8 Site Clean-up and Rehabilitation

Following construction, all sites will be cleaned up and rehabilitated where required. Site clean-up activities will feature:

- Removal and disposal of all restricted waste materials from site and documenting the process in accordance with local laws and the project waste management plan (see Chapter 25, Waste Management).
- Removal of surplus material and scrap (unless otherwise identified for retention) for recycling in accordance with the project waste management plan (see Chapter 25, Waste Management).
- Removal of any temporary buildings from site.
- Removal of all construction equipment, along with all equipment owned, leased, and rented by contractors.
- Undertaking environmental remediation involving all or any of the following:
  - Site cleanup. The site will be cleaned of all residual debris. Pits for septic systems will be emptied, neutralised with lime and covered with dirt and compacted.
  - Soil remediation and rehabilitation. If soil is found to be contaminated by hydrocarbons, it will be managed in accordance with the project's soil contamination plan (see Chapter 30, Environmental Management, Monitoring and Reporting).
  - Revegetation. Where soil has been compacted by project activities and in areas identified for specific reclamation, the surface will be ripped to assist in the re-establishment of the original soil characteristics. After ripping, any topsoil saved during grading will be spread; and any stockpiled vegetation will be spread to reduce the risk of erosion and to promote natural revegetation. Areas will be allowed to naturally revegetate except where active revegetation has been specifically identified during preconstruction surveys and detailed design as being required (e.g., on limestone pavement areas) and at areas at facilities identified for landscaping.

2.4.9 Construction Environmental Safeguards

Standard industry practice will be implemented to reduce environmental effects during construction. The main measures are described below. A summary of the mitigation and managements measure adopted by the project, including those relevant to facilities construction, is given in Chapter 29, Summary of Mitigation and Management Commitments. Chapter 30, Environmental Management, Monitoring and Reporting, describes the project's environmental management plan framework that will give effect to the project's commitments.

The main construction environmental safeguards include:

- Sediment Control and Management. The proposed management strategy for sediment control, including such measures as use of fabric silt fences downstream of flow paths and channels to intercept sediment generated during construction, is given in Chapter 18, Environmental Impacts and Mitigation Measures: Upstream Facilities and Onshore Pipelines, including for soil contamination in Section 18.2, Landform and Soils.
- Management of Chemicals and Fuel Storage: The proposed approach to managing chemical and fuel storage, particularly in relation to protection of soil and water resources, is described in Section 18.2, Landform and Soils, and Section 18.5, Water Quality.
- Management of Biodiversity. The proposed management and mitigation measures to minimise impacts on flora and fauna from habitat loss from clearing and ground disturbance, traffic collision, noise, light and other potential disturbance is described in Section 18.7, Biodiversity.
- Management of Other Construction Wastes: The proposed management strategy for waste is described in Chapter 25, Waste Management.
- Management of Hazard and Risk: The proposed approach to managing safety, security and emergency response is described in Chapter 27, Environmental Hazard Assessment.
- Management of Emissions: The proposed management and mitigation measures for air and noise emissions, including dust control, are described in Sections 18.8, Air Quality and 18.9, Noise, respectively.

2.5 Drilling the Wells and Constructing the Gathering Systems

The PNG LNG Project proposes to drill 16 new wells in the Hides (eight wells), Angore (two wells), Juha (four wells), and South East Hedinia (two wells) fields. The drilling will be undertaken in four drilling campaigns (see Table 2.4).

2.5.1 Preparation of Wellpads

Wellpads provide a level formation on which drilling and associated activities can be safely conducted. The three existing wellpads (A, D and E) at Hides will require additional clearing. For example:

- Wellpad A will be extended to its maximum boundaries to accommodate a laydown area and pioneer camp.
- Wellpad D may require an extra 4 ha cleared for a drilling field camp.

- Wellpad E will be extended to accommodate the pig launcher for the spineline, the pig receivers for flowlines F and G, the manifold for the E, F, and G flowlines, the full flow relief and vent discussed in Section 2.2.3.3, Gathering Systems, and a new telecommunications tower.

Clearing and earthworks for new wellpads will depend on the local relief, with locations chosen to minimise cost and hence also disturbance. The estimated area to be cleared for the four new wellpads will be between 6 and 10 ha each. Figure 2.7 shows a typical drill rig site layout while Figure 2.8 shows typical layouts for single- and double-well sites, respectively. An operating rig at Kutubu is shown in Plate 2.5.

Wellpads will be prepared before the drill rig arrives and will involve:

- Completion of an access track to site.
- Clearing and site preparation of each wellpad. A portion of the pad may be boarded for stability. Trees felled during the clearing of the drill site are a potential source for the rig boards.
- Erection of a gated security fence with controlled access.
- Provision of water supplies for drilling.

Site surveying, clearance and erosion control activities described in Section 2.4, Common Construction Activities, will be undertaken as appropriate.

2.5.1.1 Drilling Camps

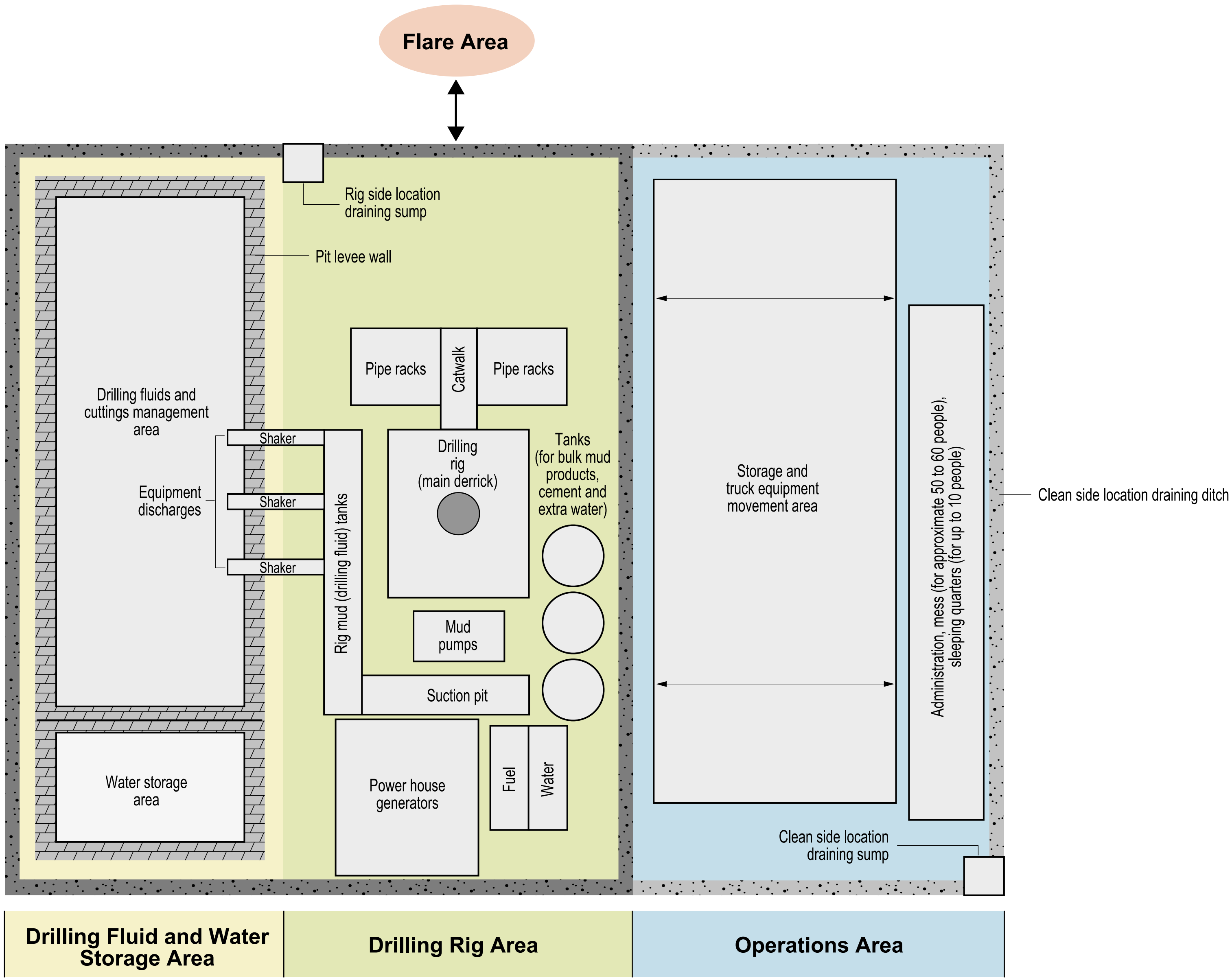
For the drilling of the wells associated with the project, drilling will require two types of temporary camps to be established: drilling field camps and base camps. In addition, up to 10 people will live ‘on the rig' in a small camp located on the wellpad that will move from one wellpad to the next as the rig moves between sites.

Drilling field camps will accommodate approximately 100 personnel and occupy approximately 85 m by 45 m (approximately 0.38 ha); they must be sited in close proximity to the drilling rig. Base camps will accommodate approximately 120 personnel and will occupy a slightly larger area. The actual dimensions of the camp types will depend on the final camp design.

A base camp (and laydown area) for the first three drilling phases will be set up within the Hides Gas Conditioning Plant footprint (see Figure 2.5) and will serve as the support base for drilling operations at Hides, Angore and Juha.

The drilling field camp for the Hides gas field will be set up near Wellpad D (Hides 3 location) and will remain there for the duration of the drilling operations associated with Phase 1 and potentially for Phase 2. The drilling field camp for the Juha gas field will be set up within the footprint of the Juha Production Facility due to its distance from the Hides area.

The base and drilling field camps will consist of portable accommodation units, food storage and preparation areas, a dining hall, recreational facilities, offices, and a laundry. Power for each camp will be supplied by a portable diesel generator sized to meet the required demands. The water source for the camps will most likely be the same water source that will be used for



PNG LNG	Job No: 1284	Esso Highlands Limited	Typical drilling rig site layout	Figure No: 2.7
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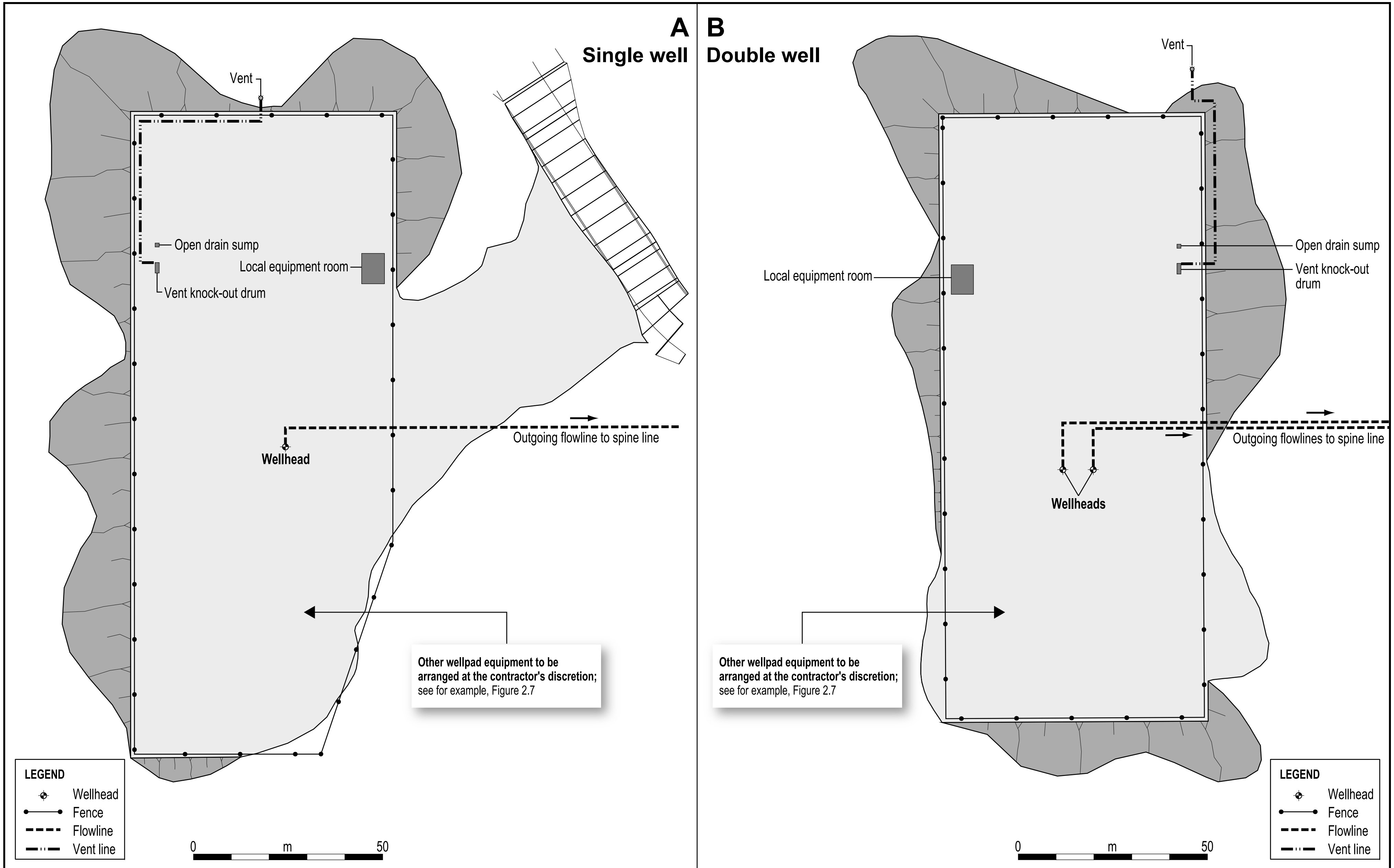

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Typical site layouts for a single and double well

Figure No: 2.8

supplying water for the drilling operations. Potable water may be bottled or trucked in, eliminating the need for a water treatment plant at the remote Hides location.

The 'on the rig' camps will include sleeping accommodations (for up to 10 people), shower, sewer facilities, power, and communications. Each wellpad will also include facilities at which the drilling crews can eat, as well as washrooms for their use. The mess quarters will accommodate all rig personnel (i.e., approximately 50 to 60 people). Waste-water discharges from the drilling camp facilities will be in accordance with the relevant environment (waste discharge) permit.

2.5.2 Water Supply

A freshwater line will run above ground adjacent to the access track to provide locally sourced water to the drilling campaign up to Wellpad D. Branch lines will be run along the road from Wellpad D to the other well sites. Water for the second (Phase 2) drilling campaign at Hides will most likely be supplied using the same water source and distribution system. The drilling water supply pipelines will be designed to last for 10 years and will be removed when the Phase 2 drilling campaign is complete.

The water may be sourced from a suitable freshwater location between Hides and Karius ridges or alternatively from groundwater bores located at the Hides Gas Conditioning Plant (see Section 2.7.1.2, Operations of Plant Utilities). Abstraction of water for drilling will be in accordance with the relevant environmental (water abstraction) permit issued by the DEC.

Water for the Angore, Juha and South East Hedinia drilling programs will be supplied from the closest reliable water source using the same method.

2.5.3 Equipment

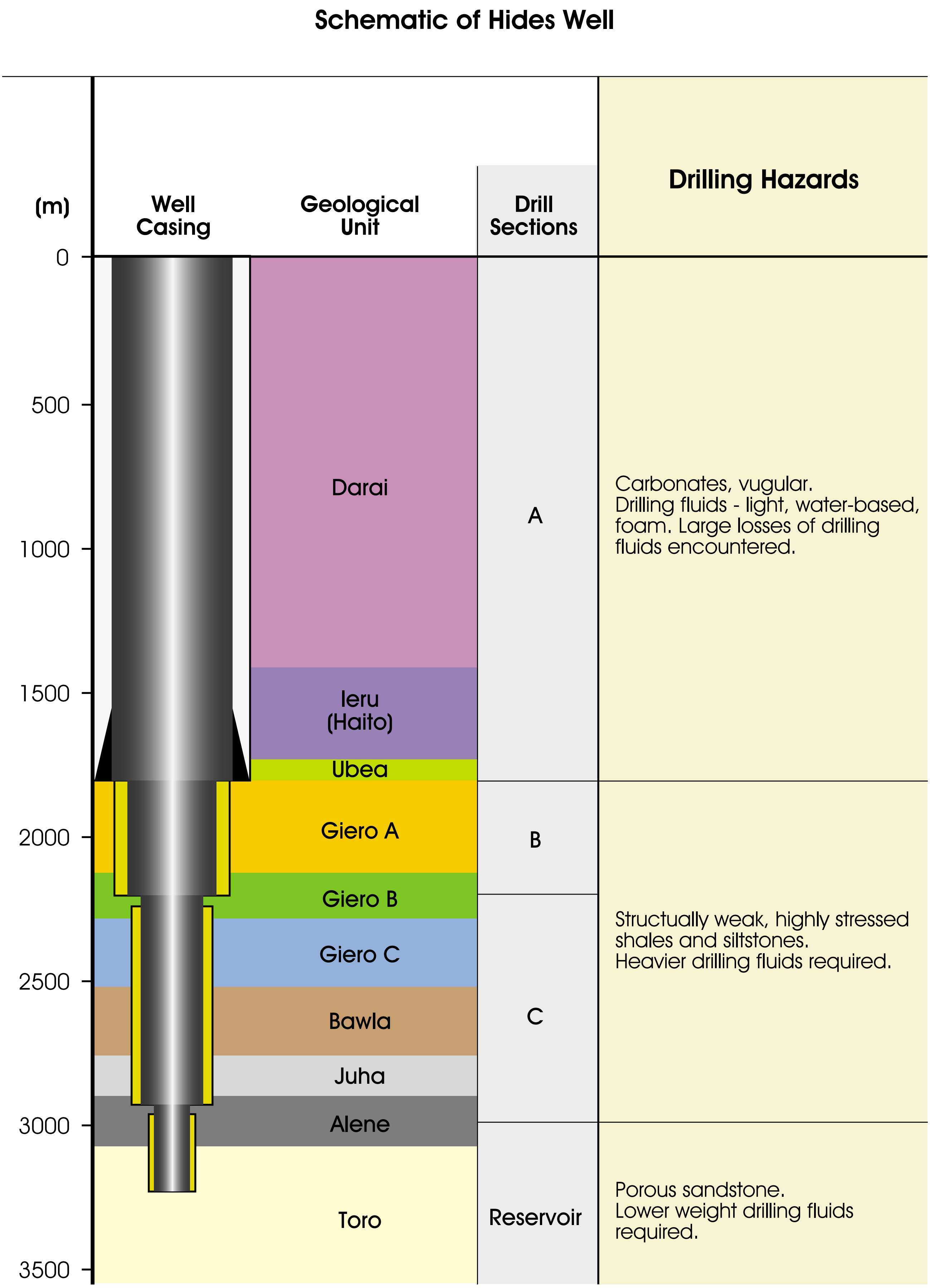
The drilling rig site will accommodate a main derrick and substructure; power supply system (generators); flare area; drilling fluids and cuttings management area (which will also cater for equipment discharges); water storage areas; fuel storage; drilling pipe racks; suction pit; circulatory system (pumps, drilling fluid tanks and shale shakers); tanks for bulk mud products, cement and extra water; storage and truck equipment movement area; well control system (blow-out preventer); well monitoring system; and administration; mess and sleeping quarters (see Figure 2.7). Water-based or foam drilling fluids – rather than oil-based drilling fluids – will be used to drill the wells.

Rig equipment and materials will be moved by road.

Assessment of potential impacts on soil from drilling activities is provided in Section 18.2, Landform and Soils.

2.5.4 Drilling Method for New Wells

The Papua New Guinea drilling industry has acquired a substantial body of experience from numerous wells at mountainous locations of the fold belt over the past three decades. Figure 2.9 is a schematic of a typical well design for Hides. At Hides, drilling will typically involve the following steps:



PNG LNG	Job No: 1284	Esso Highlands Limited	Schematic for well design at Hides	Figure No: 2.9
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- From the surface, a conductor hole is initially drilled through the Darai Limestone with low-density fluids, such as air and foam, or drilled with water and without returns to surface. This geological unit is vugular and prone to severe losses of drilling fluids. Casing is then cemented in the hole, with the wellhead A section welded to the casing and the diverter installed above the A section.
- A surface hole is then drilled through the Darai Limestone to the setting depth into the Ubea Formation below. The casing is then run and cemented in place, and the wellhead B section and blowout preventer installed. The surface casing covers the Darai Limestone and the weak, permeable Haito/Upper Ubea formations, which cannot tolerate the heavier drilling fluids that are required to control downhole pressures and maintain wellbore stability lower in the well.
- A bit-and-hole opener is needed to drill the intermediate hole into the structurally weak and highly stressed siltstones and shales of the Giero B Formation. Drilling requires an inhibitive water-based drilling fluid and careful fluid management, so as to control increasing overpressure and prevent collapse into the wellbore.
- The production hole is then drilled to the top of the Toro Sandstone reservoir. The production casing is run and cemented in place to isolate the overpressured and unstable sections above. The wellhead C section is then installed.
- The reservoir section is then drilled to total depth, with a lower-weight drilling fluid designed to protect the porous reservoir from damage. A production liner is run, cemented in place and perforated.
- The tubing is then lowered into place and the tubing hanger and Christmas tree are installed.
- Deviated wells are drilled vertically to the kick-off point below the depth of the surface casing. (The kick-off point is the depth at which the well begins to be drilled directionally.) From the kick-off point, the well angle is built at approximately 3° per 30 m towards the target formation.

Approximately 2,000 to 3,000 kSm^3/d (70 to 100 Mscf/d) of gas will be flowed from the well during well testing and clean-up, and this gas will most likely be produced into the main production line instead of being flared on location. The well is then ready for production.

(Assessment of potential impacts on groundwater from drilling fluid losses is provided in Section 18.3, Groundwater.)

2.5.5 Recompletion of Hides 1 and Hides 4

Well recompletion involves redrilling a well to establish a new producing zone. More specifically, the goal of recompleting two of the three existing Hides wells is to replace and increase the size of the tubing strings to increase well productivity. This work will be done using either the drilling rig or a rig specifically designed to perform this type of work.

2.5.6 Disposal of Cuttings

Due to the environmental sensitivities on the Hides Ridge, the drill cuttings will be dried on-site and then transported to the Hides Gas Conditioning Plant site for burial in an engineer-designed, lined pit. Cuttings from Angore will also be disposed of at this location. The Juha and South East Hedinia drill cuttings will be similarly disposed of in an engineer-designed pit close to each location. The drill cuttings will not be disposed of in the project landfill sites that form part of the project waste management areas discussed in Chapter 25, Waste Management.

Other alternatives, such as deep injection into another well, for the disposal of cuttings will be evaluated during FEED and detailed design to determine if this technique is feasible.

Disposal of all other solid waste and drilling fluids at the drilling pad site will be in accordance with the relevant environmental (waste discharge) permit issued by the DEC and the project's waste management plan (see Chapter 25, Waste Management).

2.5.7 Gathering Systems

The gathering system flowlines will be constructed as follows:

- The route will be cleared and grubbed and a bench established.
- Concrete footings for the flowlines will be constructed.
- The sections of pipe will be trucked and laid out along the route, welded and coated and then placed onto the footings and secured.

The gathering system spinelines will be constructed in a similar manner to the onshore pipelines, as described in Section 3.4, Constructing the Onshore Pipelines.

2.6 Constructing the Processing Facilities

2.6.1 Site Preparation at the Hides Gas Conditioning Plant

The early works activities associated with the Hides Gas Conditioning Plant include:

- Site boundary fencing.
- Bulk earthworks for the plant site.
- Vehicle washdown facility.
- Diesel fuel storage and refuelling station (construction use only).
- Waste management (sorting) area.
- Water supply headworks (construction use only).
- Modification to the existing landfill facility in the Hides area (see ‘Landfill at Hides’ in Section 25.4.1, Waste Management Area Infrastructure: Upstream).
- Development of a quarry, including crushing and screening plant, in the Hides area.
- Pioneer camp facilities (50 beds; see Section 5.2.4.1, Accommodation Facilities).

In addition, a training facility will be constructed at Juni (see Figure 2.1) to support community-based employment training designed to service up to 100 trainees and approximately 25 trainers and support staff, including accommodation for up to 90 persons, four classrooms, a canteen facility and a clinic. The site preparatory and construction activities described in Section 2.4, Common Construction Activities, will apply to this site. Relevant building approvals will also be obtained.

Site preparation will involve constructing platforms on which the infrastructure can be erected and constructing internal site access ways. Standard earthmoving machinery will be used to prepare the sites for the non-linear infrastructure.

Figure 2.10 shows the layout of the Hides Gas Conditioning Plant site during early construction earthworks, including the areas of ground that will be cut and filled, the perimeter road, spoil area, and erosion and sediment control structures. Cut and fill quantities during bulk earthwork activities at the site are estimated at 1.413 million m^3 and 1.387 million m^3 respectively, resulting in an estimated excess of fill over cut of 26,000 m^3. However, if specific rock materials required for fill are not available in sufficient quantities on site, approximately 500,000 m^3 is expected to be available from clearing and grading of the Hides Spineline ROW or from a quarry developed near the plant area.

Because the plant site will be located on a ridge, earthworks will disturb ground in or near the headwaters of numerous streams that drain either north into the Tagari River or south into the Tamalia River, a tributary of the Tagari. Three sediment retention ponds are proposed at the site; sediment retention ponds (A and B) will be constructed on headwater streams of tributaries of the Tagari River, and one sediment retention pond (C) on a headwater stream of a tributary of the Tamalia River (see Figure 2.10). Additional sediment retention ponds may be constructed on other headwater streams crossed by the perimeter road if required and this will be determined during detailed design. Overflow control for the ponds will be via culverts with discharge to existing steams via stepped gabion spillways.

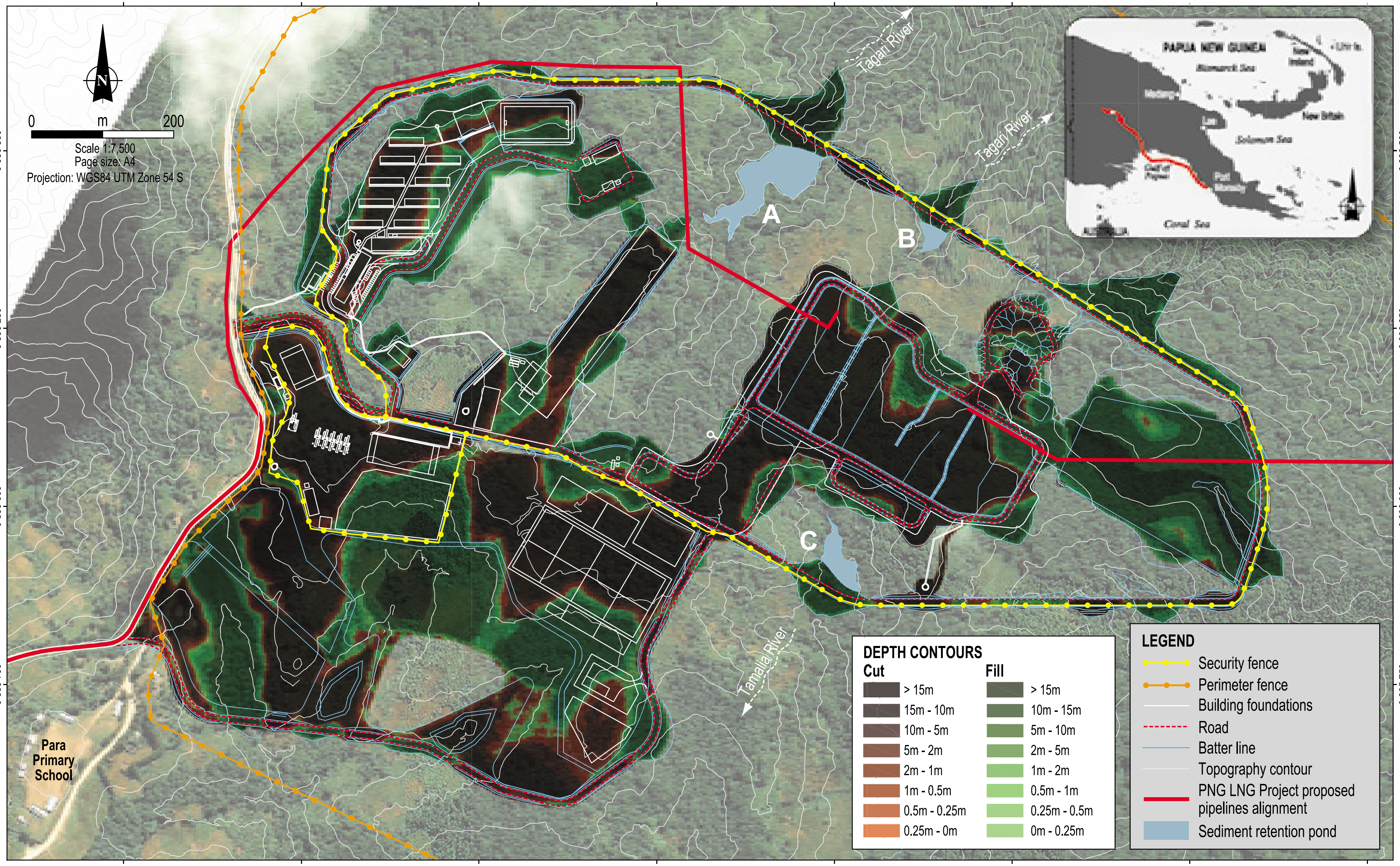
The sediment retention ponds will be designed to accommodate the high rainfall at the site and to provide sufficient residence time for sediment particles to settle. Preliminary design of the sediment retention ponds have been based on a one-in-two storm event. The settling volume is equal to 6 hours of the average flow, and the storage volume is equal to one half of the settling volume. The size of each sediment settlement pond is a function of the size of the catchment draining to that pond and will be designed to provide sufficient volume for sediment settling prior to the overflow discharging from the site.

The sediment retention ponds will be inspected after major rain events and excavated or cleared regularly to maintain storage volumes at optimal capacity. Material removed from the sediment retention ponds is not expected to be contaminated and can be used on site as required, or taken to the project spoil area(s). Sediment control and mitigation measures will be detailed in the project's erosion and sediment control plan, which will form part of the construction environmental management plan (see Chapter 30, Environmental Management, Monitoring and Reporting).

The sediment retention ponds will be maintained during construction and into operations until such time as disturbed areas revegetate. Further into operations, the ponds will be maintained as required as part of the site operations sediment control plan, which will form part of the operations environmental management plan (see Chapter 30, Environmental Management, Monitoring and Reporting).

2.6.2 Construction of the Hides Gas Conditioning Plant

The indicative layout of the Hides Gas Conditioning Plant, Hides Industrial Area, and Hides operations camp is shown in Figure 2.5.



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

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Hides Gas Conditioning Plant construction earthworks areas and sediment retention ponds

Figure No: 2.10

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Construction of the facility will be by conventional 'stick- built' methods with elements of skid-mounted equipment and potentially modularised pipe rack structures.

The sequence of constructing the Hides Gas Conditioning Plant will be based on the construction contractor's construction execution plan. A possible construction execution plan could include elements of:

- **Steel, pipe and electrical installation.** Following the foundation works, structural steel and piping installation will take place, including platework and welding. Crawler-mounted cranes will be used for steel and pipe installation in the early stages of construction. Electrical installation will occur in parallel with piping. Structural steel and piping will be prefabricated.
- **Equipment setting.** Larger, long-lead equipment items arriving throughout the construction phase will require setting into position before being integrated into the plant. Once in position, those items needing installation will be lifted into place before being set in the correct position and bolted to the foundations.
- **Welding and radiography.** The equipment will be welded together under welding shelters. Crews will perform tie-in welds; weld inspection and repair; and weld coating application, inspection and repair. Welds will be radiographed and faults repaired before the weld is coated. Ultrasonic testing may also be employed.
- **Electrical and instrumentation installation.** Electrical wiring and instrumentation will be installed once equipment has been set and welded into position.
- **Insulation and application of coating materials.** Major vessels that are not insulated prior to delivery will be insulated in the horizontal position at the appropriate laydown area before lifting**.** Insulation of piping will follow hydrotesting, along with touch-up painting and fireproofing.

Major equipment will be transported to site as described in Chapter 5, Project Logistics. Personnel will be mobilised by air via existing airstrips using a combination of fixed-wing aircraft and helicopters.

During construction, a 250-tonne crane is the most likely method for installing the heaviest and most distant lifts while smaller cranes will also be used throughout construction to move all other materials and equipment.

2.6.3 Construction of the Juha Production Facility

The sequence of activities involved in the construction of the Juha Production Facility is likely to be similar to that described for the Hides Gas Conditioning Plant in Section 2.6.2, Construction of the Hides Gas Conditioning Plant. Detail planning of the Juha Production Facility will not take place until Phase 4 and will benefit from the presence of infrastructure and logistical support established during Phase 1 of the project.

2.6.4 Construction of the Associated Facilities

The Kutubu Central Processing Facility and Gobe Processing Facility associated facility developments will be constructed in Phase 1, and the Agogo Production Facility associated facilities developments in Phase 5 (see Figure 1.3). Construction of the associated facilities will be within existing facility boundaries and with minimal disturbance. Site preparatory and construction works will be in line with those activities described in Section 2.4, Common Construction Activities.

2.7 Operating and Maintaining the Processing Facilities

2.7.1 Operating and Maintaining the Hides Gas Conditioning Plant

2.7.1.1 Gas Processing

The plant will receive full wellstream fluids (hydrocarbon gas and liquids and water of condensation mixed with MEG and corrosion inhibitor) from the Hides and Angore fields. From Phase 4, the plant will also receive gas and liquids previously separated at the Juha Production Facility. MEG will be the primary measure to prevent hydrate formation in flowlines and spinelines. It will be regenerated at the plant and pumped to the injection points via the Hides, Angore and Juha MEG lines.

Figure 2.11 provides a simplified process flow diagram of the Hides Gas Conditioning Plant.

Inlet Facilities

The inlet facilities will comprise a pig receiver for the Hides and Angore spinelines and Juha liquids and gas pipelines and a single, finger-type slug catcher for the three lines carrying gas.

The slug catcher will separate the gas and liquids from the three incoming gas pipelines. The gas will be sent to the gas inlet separators, and the liquids will be mingled with the liquids entering the plant from the Juha–Hides Liquids Pipeline (see ‘Liquids Handling’ below for more information on the course of the liquids streams).

Gas Separation, Conditioning and Compression

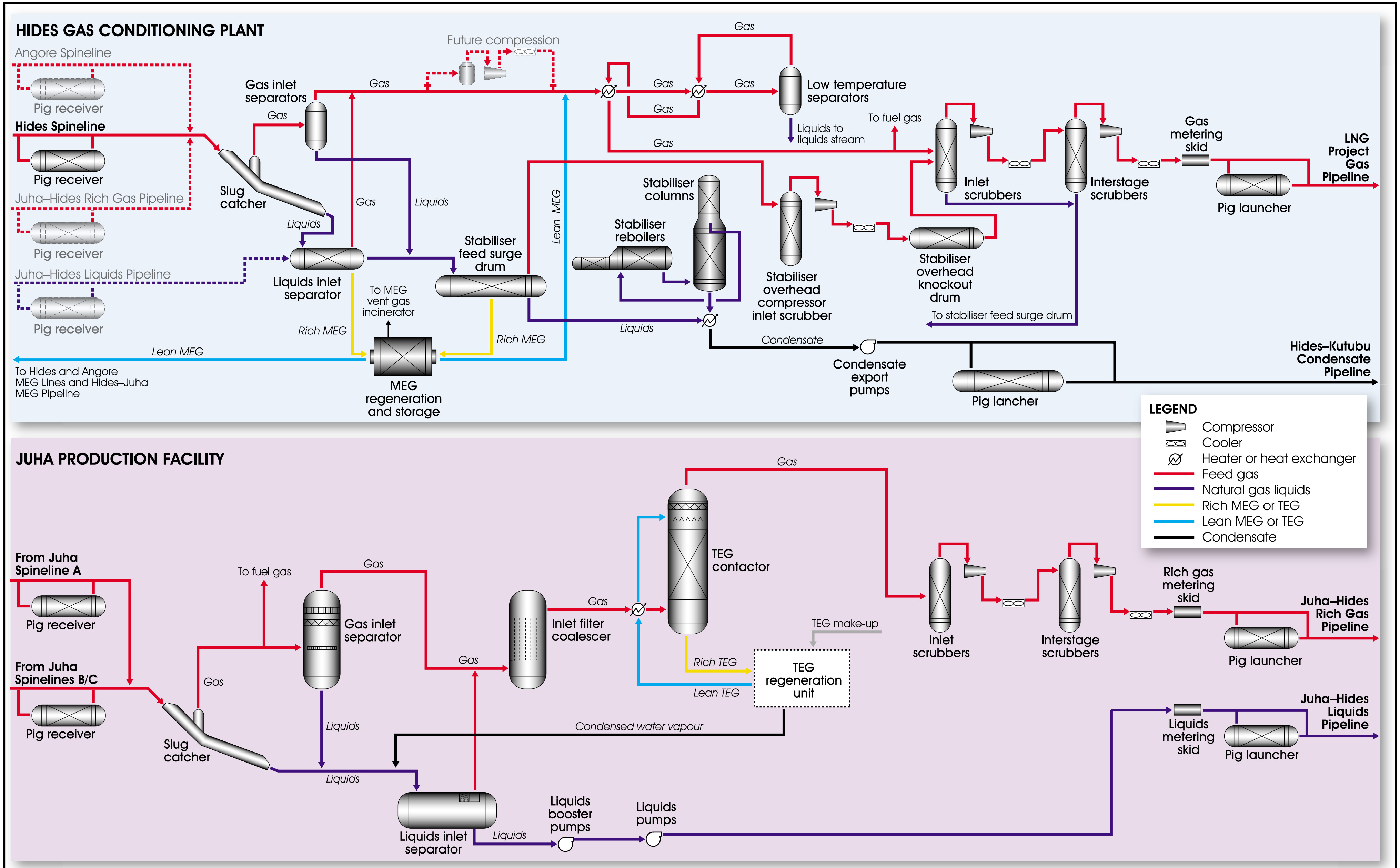
Primary Separation. Three gas inlet separators will further separate the gas from liquids. The separated gas will be sent to the dewpoint conditioning units, and the separated liquids will join the liquids stream via the stabiliser feed surge drum.

Gas Dewpoint Conditioning Unit. Three gas dewpoint conditioning units will use pressure reduction and the resultant cooling that naturally occurs from pressure reduction to condition the gas to the required pipeline hydrocarbon and water dewpoint of less than 5°C.

Gas from the dewpoint control units will be sent to the gas pipeline compressor inlet scrubbers in the compression section, with an offtake to the fuel gas system. Liquids from the low-temperature separators in the gas dewpoint control units will be sent to the stabiliser overhead compressor exchanger (see ‘Liquids Handling’ below).

Pipeline Compression. Three pipeline compression systems will compress the gas and further separate liquids from the gas. The gas turbines will be provided with dry, low-NO_x burners and will include waste heat recovery units for the hot oil system.

Gas from the compressors will be sent via a gas metering skid and the pig launcher to the LNG Project Gas Pipeline. Liquids from the scrubbers will be sent to the stabiliser feed surge drum



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Job No: 1284	Esso Highlands Limited	Simplified process flow diagram for Hides Gas Conditioning Plant and Juha Production Facility	Figure No: 2.11
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(see ‘Liquids Handling’ below). Gas will also be used in the fuel gas system (see ‘Fuel Gas System’ below in Section 2.7.1.2, Operation of Plant Utilities) via an outlet before the pig launcher.

Liquids Handling

Liquids from the slug catcher and from the Juha–Hides Liquids Pipeline will be sent to two liquids inlet separators, which will separate gas and MEG from the condensate. The gas will then be sent to the dewpoint conditioning unit (see ‘Gas Separation, Conditioning and Compression’ above), the MEG will be sent to the MEG flash drum in the MEG regeneration and storage package (see ‘MEG Regeneration and Storage’ below in Section 2.7.1.2, Operation of Plant Utilities below), and the liquids will be sent to the stabiliser feed surge drum.

The stabiliser feed surge drum will be a three-phase separator that will collect all the liquids produced in various areas of the process and further separate gas and MEG. Gas from the feed surge drum and the stabilisation trains will be fed to overhead compressors, which will have a control valve to flare (see ‘Flare System’ below). The liquids from the feed surge drum will be split between two stabilisation trains capable of producing condensate at a flowrate of 230 m^3/hr.

The combined flow from the condensate stabilisation trains will be sent to the Hides–Kutubu Condensate Pipeline via the condensate shipping pumps, one in each train. Off-specification liquids will be recycled to the slug catcher.

2.7.1.2 Operation of Plant Utilities

Fuel Gas System

Two fuel gas conditioning skids will provide high-pressure fuel gas (at approximately 3,500 kPaG) to the gas turbines and low-pressure fuel gas and low-pressure fuel gas (at approximately 800 kPaG) to the incinerator, hot oil heater, flare purges and pilots, and other blanket gas requirements.

The outlets of the dewpoint conditioning units will provide the normal supply of fuel gas to the fuel gas conditioning skids. Fuel gas for startup heat will be provided from the slug catcher or the LNG Project Gas Pipeline. Backup fuel gas for the turbines will be provided via an outlet from the LNG Project Gas Pipeline.

Power Generation and Electrical Systems

The power system objective is to provide a generation and distribution system that is stable under all normal operating conditions.

Main Power Generation. The main power generation system will supply the entire Hides site, including wellpads, process area, camp, and industrial area. Electrical power will be generated at 6.6 kV, 50 Hz.

The system will be based on an approximate total load of approximately 11 MW, which includes 20% growth in electrical load, contingency loading and provision for future booster compression requirements (Table 2.8). There will be three Solar Mars 100 generators. Only two generators run at a time to produce the required 11 MW.

Table 2.8 Hides area electrical load summary

Load	MW
Hides Gas Conditioning Plant	6.8
Hides Industrial Area/camps*	1.5
Base load total	8.3
Growth (20%)	1.7
Future loads and contingency	1.0
Design load total	11.0

* The maximum Hides operations camp electrical load has been based on 500 people, which includes operations turnaround staff. The normal Hides operations camp load will be approximately 200 people.

The power system gas turbine generators will be dual-fuel (gas and diesel). The gas turbines will be fitted with dry, low-NO_x burners.

Essential Power Generation. A 690-V essential bus will be fed from the main power system and a diesel essential generator.

Electrical Distribution. A 6.6-kV switchboard will distribute power to the Hides Gas Conditioning Plant, the Hides and Angore wellpads, the Hides Industrial Area and the Hides operations camp.

Uninterruptible Power Supply. Three-phase, alternating-current, 400-V, uninterruptible power supply units will provide the battery backup for the emergency lighting systems, integrated control and safety system, Hides Gas Conditioning Plant instrumentation requirements, wellpad instrumentation requirements and communications equipment.

Cables. High- and medium-voltage cabling and low-voltage cabling for motors will be buried. Other low-voltage and instrument cabling will be buried between local equipment rooms and process areas to the first distribution box or junction box. Individual runs within the process area for instruments and lighting may be located above ground. Cabling will be steel wire armored unless it is part of an intrinsically safe circuit.

Hazardous Areas. Hazardous areas will be assigned in accordance with Papua New Guinea Oil and Gas Regulation, Part IV – Electrical Installations, Section 63 – Wiring Rules.

Plant Telecommunications

The Hides Gas Conditioning Plant will be connected to the telecommunications backbone via a high-speed, fibre-optic link from the Hides control centre to the Hides Tower and VSAT backbone node. This inside-plant fibre-optic cable will carry all voice, data, and control communications within the Hides Gas Conditioning Plant site.

Firewater System

The firewater system will consist of a firewater tank, a jockey pump, two firewater pumps (one diesel and one electrical), ring main and monitors. Turbine enclosures will be provided with water mist systems. Electrical enclosures will be provided with FM200 waterless fire suppression systems. The operation of the firewater system is described further in Section 2.8.4, Fire-Detection and Firewater Systems.

Utility and Potable Water Systems

The utility and potable water systems will provide treated bore water to the Hides Gas Conditioning Plant, Hides Industrial Area and camp areas. Groundwater will be extracted from bores located within the Hides Gas Conditioning Plant site. A minimum of two bores will be required to provide estimated operations flow volumes of 20 m^3/hr for utility and potable water supply of 12 m^3/hr. Firewater will be stored in a tank on site and be available to provide 1,115 m^3/hr in a single event if required.

Further hydrological investigation studies will be conducted during FEED and detailed design to identify potential groundwater sources at the Hides Gas Conditioning Plant for supply in construction, drilling and eventually operations activities.

Abstraction of groundwater for project activities will be in accordance with the conditions of the relevant environment (water abstraction) permit issued by the DEC. Assessment of potential impacts on groundwater is provided in Section 18.3, Groundwater.

Diesel System

Diesel is not required for the plant process during normal operation and will be trucked to site. Diesel will be stored in a storage tank to supply the essential generator, the diesel firewater pump, and mobile equipment. The system will also back up the main power generation system when fuel gas is not available. The diesel storage tank will be sufficient to provide backup power for at least five days.

Hot Oil System

A hot-oil circuit will provide heat for re-boilers and other equipment. Three waste heat removal units (one of which will be a spare) on the exhaust of the pipeline compressor gas turbines will be the main source of heat for the thermal-fluid–based hot oil system.

Utility and Instrument Air System

Two air compressor packages will provide utility and instrument air at pressures of 800 kPaG and 700 kPaG, respectively.

Chemical Injection Systems

A corrosion inhibitor skid, an oxygen scavenging and biocide injection package, and a generic chemical injection package will be provided. The corrosion inhibitor will be injected into the MEG, which will become the carrier. The oxygen scavenger and biocide will be injected into the pump suction of the slop oil tank pumps (see ‘Open Drain System’ and ‘Closed Drain System’ below) to prevent corrosion in the presence of air.

MEG Regeneration and Storage

The water/MEG mixture from the incoming fluids will be recovered from the slug catcher and inlet separators for glycol recovery. The regeneration process will remove water from the MEG, recondense the water for separate treatment and disposal (see ‘Open Drain System’ and ‘Closed Drain System’ below), and then send the regenerated glycol to the Hides Gas Conditioning Plant storage tanks for re-use.

MEG Vent Gas Incinerator

MEG regeneration will produce a vent gas of water vapour and a small amount of hydrocarbons (less than 1%), including BTEX. The BTEX in the vent gas will be disposed of by thermal destruction or industry best practice prior to atmospheric discharge. In the event of a MEG vent gas disposal system being down, the vent gas will be sent to the atmosphere.

Flare System

The high pressure and low pressure flare systems will be sized for initial operations and future demand. Flaring will only occur during start-up, emergencies, and upset conditions. Facilities will be designed and operated in accordance with ExxonMobil's internal standards to avoid the routine flaring and venting of associated gas and CO_2 from natural gas production. The high-pressure and low-pressure flare systems dispose of hydrocarbon fluids from pressure safety valves and blowdown valves during process upsets.

The high-pressure flare system will be sized to handle all relief and blowdown streams greater than 1,000 kPaG. The liquids from the high-pressure flare knock-out drums will be pumped to the stabiliser feed surge drum.

The low-pressure flare header will discharge into the closed drain and low-pressure flare drum. The liquids from this drum will be pumped to the slop oil tank (see 'Open Drain System' and 'Closed Drain System' below).

A common elevated stack, tip assembly, and ignition system will be used by both flare systems. The high-pressure tip will be designed for smokeless flaring over the maximum range of operational conditions. Both high-pressure and low-pressure flare headers will be continuously purged with low-pressure fuel gas.

Estimated emissions from the flare system have been included in the air quality impact assessment that is provided in Section 18.8, Air Quality.

Open and Closed Drain Systems

A system of open and closed drains, connecting to appropriate retention ponds will be provided to separate uncontaminated from potentially contaminated surface water. Open drains will direct surface water to stormwater retention ponds, and closed pipe drains will direct any potentially contaminated flows to retention ponds provided with oil/water separators and treatment systems as appropriate.

Open Drain System

The open drain system will comprise an open drain to collect all liquids from rain, wash down, spillage, and fire water from all sealed (bunded) areas in the plant. Each sealed area will have a water-sealed pit to prevent the migration of flammable vapours from one area to another. The open drains will flow to the open drain sump.

Retention in the open drain sump and then in a corrugated-plate interceptor pack will separate oil and grease from the water. The oil will be pumped to the slop oil tank. The water will be sent to the retention pond for final polishing.

The retention pond will collect the water from the open drain sump and provide sufficient residence time for sediment to settle and for the residual hydrocarbons to separate. Water discharged from the retention pond will not exceed 10 mg/L oil and grease and will be discharged off-lease in accordance with requirements of the relevant environment (waste discharge) permit. A sump with a pump at the retention pond will return the collected hydrocarbon back to the open drain sump. A surface water and stormwater management plan will be prepared as part of the operations environmental management plan.

The open drain system will be designed to accommodate the greater of a six-hour, one-in-ten-year storm or a firewater deluge.

The stormwater system will divert rainwater from the non-bunded areas of the Hides Gas Conditioning Plant site and discharge this water to existing waterways. Stormwater drains away from the Hides Gas Conditioning Plant site will be designed to drain the sediment retention ponds described in Section 2.6.1, Site Preparation at the Hides Gas Conditioning Plant above.

Closed Drain System

The closed drain system will collect hydrocarbon fluids when processing systems are manually drained and direct them to the closed drain and low-pressure flare drum. The collected liquids will be pumped to the slop oil tank.

The slop oil tank will collect liquids from the closed drain and open drain sump, as well as used lube oils from rotating equipment. The slop oil tank pump will send the liquids via a filter to the liquids inlet separators at the plant where it will be recycled for processing by reinjection into the condensate.

Automatic drains and dumps from process vessels that cannot be routed back into the process will have independent lines to the closed drain and low-pressure flare drum.

2.7.1.3 Process Control

The Hides Gas Conditioning Plant and the Juha Production Facility, as well as all the project pipelines, gathering systems and wells, will be monitored and controlled 24 hours per day from both the Hides Gas Conditioning Plant control centre and the LNG Plant control room under the project's supervisory control and data acquisition system.

The design of the integrated control and safety system will provide for the monitoring, control, and protection for PNG LNG Project facilities. Pressure, temperature, level, flow-rate and position instrumentation and control systems will be monitored and process and safety control systems will provide sufficient surveillance to safely shut down the process in the event of a major failure.

2.7.1.4 Maintenance

Planned maintenance shutdowns (turnarounds) will be scheduled and coordinated to achieve a combined field (upstream gas field and gas processing infrastructure) and LNG Plant availability of 94%.

Piping, valving, and equipment will be designed so that sections of the plant can be isolated for maintenance work. Vents and drains will allow for safe and effective depressurising, draining, and purging of equipment. Where possible, common equipment will be considered across upstream and LNG Facilities (e.g., gas turbines, valves, instrumentation, etc.) to minimise spares holdings and personnel competency requirements.

Plant data and equipment performance monitoring systems will collect and plot data, monitor critical rotating equipment, and process data so that it can be accessed locally and remotely for troubleshooting and predictive maintenance.

Over time, naturally occurring radioactive material (NORM) can form a scale on gas processing equipment, which then must be removed for disposal. This will be dealt with as described in Table 25.2 in Chapter 25, Waste Management.

2.7.1.5 Staffing

The Hides Gas Conditioning Plant will be continuously staffed 24 hours per day, 7 days per week, with staff working a 12-hour shift (i.e., there will be two shifts per day). Staffing levels will be reduced at night to what is required for safe operations and emergency response. Maintenance personnel will work one 12-hour shift, with a call-out service after hours.

It is anticipated that all permanent upstream personnel will work a 28 days-on/28 days-off rotational cycle, with all personnel living and remaining onsite in the Hides operations camp during their rotation.

Operational personnel will be transported by fixed-wing aircraft from Jacksons International Airport to Komo Airfield, then by mini-bus from Komo to the Hides Gas Conditioning Plant. Komo is approximately 10 km from the Hides Gas Conditioning Plant, so no accommodation facilities will be constructed at Komo airfield. There will, however, be processing, passenger and cargo transfer facilities. Cargo will be transported by Dash-8 and other suitable aircraft.

Expatriate specialists will provide an experienced core team to conduct initial operations, coupled with trained new- and experienced-hire PNG nationals. The number of expatriates on staff is expected to steadily decline over time as PNG nationals acquire competency and experience and in accordance with training and localisation plans approved by the PNG Government.

A number of project (construction) team members will stay on after commissioning, in order to transfer knowledge to the operations personnel until the new facilities are operating reliably.

Section 1.2.6, Project Staffing, summarises project workforce numbers for the whole project during construction and operations.

2.7.2 Operating and Maintaining the Juha Production Facility

2.7.2.1 Processing

Figure 2.11 provides a simplified process flow diagram of the Juha Production Facility, which will be controlled from the Hides Gas Conditioning Plant and operate in a similar manner (see Section 2.7.1.1, Gas Processing).

2.7.2.2 Staffing and Maintenance

A full-time security team will be located at the Juha Production Facility. Maintenance staff and operations staff will attend the facility as required to perform operations surveillance and maintenance activities.

A 20-person Operations Camp at the Juha Production Facility will provide accommodation. offices, meals area and a small medical clinic.

Maintenance activities at Juha will be similar to those at Hides (see Section 2.7.1.4, Maintenance).

2.7.3 Operating and Maintaining the Wells and Gathering Systems

Routine inspections and maintenance will be carried out on the gathering system and wells. Later in their life, some wells are expected to require the following interventions:

- Water shut-offs to restrict inflow into the wellbore and eliminate produced water in the wellstream.
- Well stimulation to restore the permeability and yield of the wellbore.
- Mechanical repair of surface or down-hole equipment.

A vacuum truck will empty the sump tanks at the wellpad locations and transport the contents to the Hides Gas Processing Facility for treatment.

Process control will be automated as much as practicable. All the wells will be capable of being remotely started up and shut down under the Hides control centre.

2.7.4 Operating and Maintaining the Camps

Camps will be maintained and operated to meet safety, hygiene, public amenity, hazardous materials, environmental and pollution control requirements.

Solid and liquid waste will be managed as part of the waste management plan (see Chapter 25, Waste Management).

2.8 Safety and Security

2.8.1 General

Production facilities and pipelines will incorporate integrated control and safety systems to operate the facility safely and reliably. This system maximises the use of automation to the extent economically justified and minimises local manual control and the need for operator intervention.

Speed limits will be set for the project’s road networks and around the facilities.

Specific aspects of safety and security are described below for site layout, site security, fire detection and fire fighting, gas detection, plant emergency shutdown systems and alarms, and pipeline leak detection.

2.8.2 Site Layout

Project design philosophies, standards and codes for site layouts of the processing facilities at Hides and Juha are intended to provide for inherently safe loss prevention separations and setbacks and optimal use of space for:

- Normal operation and maintenance.
- Separation of plant and support (administration) areas.
- Emergency response actions.
- Evacuation.

2.8.3 Site Security

A security company owned and operated by local landowners will provide 24-hour entry and exit controls for the processing plants and for the in-field access tracks and will patrol aircraft at the Komo Airfield and warehouses at night. The Hides Gas Conditioning Plant will provide radio and telephone monitoring 24-hours per day.

Table 2.9 summarises the security measures for the upstream components of the project.

Table 2.9 Security design basis summary

Site	Manned security	Guardhouse	Visitor Processing	Security Command Centre	Electronic Access Control	Security Fence	Turnstiles	Vehicle Barriers	Internal Security Barriers	Security Lighting	Key Control Program	Electronic Surveillance	Electronic Intrusion Detection
Hides Gas Conditioning Plant	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Hides Operations Camp	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Hides Waste Management Landfill	✓	✓				✓			✓		✓		
Hides Gas Conditioning Plant Industrial Area	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Komo Airport	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	
Hides Wellpads*						✓			✓		✓		✓
Angore Wellpads						✓			✓		✓		✓
Remote Telecommunication Sites						✓			✓		✓		✓
Pipeline Valve Stations (Including Kopi Scraper Station)						✓			✓		✓		✓

*A guardhouse will be located at Hides Wellpad A to control access to the access track.

2.8.4 Fire-Detection and Firewater Systems

The Hides Gas Conditioning Plant and the Juha Production Facility will have the fire-detection and fire-suppression systems dictated by hazard evaluation and the philosophies, codes and standards set out in Chapter 27, Environmental Hazard Assessment. The strategy objective for the facilities is to reduce the potential for accidents to occur in the first place by an inherently safe design and mode of operation: layout, separation, segregation, isolation and blowdown, and prevention of ignition.

Hazard evaluations then identify the need for mitigation measures, including fire and gas detection systems and active/passive fire protection systems, such as flame, smoke and heat detectors and fusible plug loops.

The firewater system for the Hides Gas Conditioning Plant is described in Section 2.7.1.2, Operation of Plant Utilities. The Juha Production Facility will rely on inherent safety, and the facility layout and equipment spacing will be specified accordingly. Turbine enclosures will be provided with water mist systems. Electrical enclosures will be provided with fire suppression systems.

Well sites will include fire detectors at the wellheads and fire-detection equipment in the wellpad local equipment rooms.

These facilities will be supported by the fire-fighting training facility at the Hides Gas Conditioning Plant (see Section 2.3.1, Hides Gas Conditioning Plant).

2.8.5 Gas Detection

The Hides Gas Conditioning Plant, the Juha Production Facility, and all wellheads will have the gas detection systems dictated by hazard assessment (see Chapter 27, Environmental Hazard Assessment). Gas detection systems may include point, line-of-sight and ultrasonic detectors and will be monitored continuously.

2.8.6 Plant Emergency Shutdown Systems and Alarms

2.8.6.1 Emergency Shutdown Systems

Facility shutdowns will provide protection of personnel, environment, and equipment by initiating the safe shutdown of plant and/or process equipment during an event that may include hazards. The shutdown system for each facility will be a self-contained stand-alone system.

The Hides Gas Conditioning Plant, the Juha Production Facility, and all wellheads will have process and emergency shutdown systems activated either automatically or manually.

Automatic systems include:

- Centrally controlled, computer-based systems.
- Local controllers.

Manual systems include:

- Manual call points activated by operators.
- Manual emergency shutdown pushbuttons.

All pipelines will be protected from overpressure by multiple automated safety protection systems at each inlet to a pipeline. The valves stations along the pipeline route are remotely activated by operator intervention from either the LNG Plant control room or Hides Gas Conditioning Plant control centre.

The Hides Gas Conditioning Plant, Juha Production Facility and wellheads will have fire- and gas-detection systems (see Sections 2.8.4, Fire-Detection and Firewater Systems, and 2.8.5, Gas

Detection). The executive actions for a confirmed fire or confirmed gas leak will depend on whether the site is manned (Hides Gas Conditioning Plant) or unmanned (Juha Production Facility and wellheads), as follows:

- A confirmed fire at the Hides Gas Conditioning Plant will cause a facility shutdown.
- A confirmed gas leak at the Hides Gas Conditioning Plant will cause a facility shutdown.
- A confirmed fire at the Juha Production Facility will cause a facility shutdown and blowdown.
- A confirmed gas leak at the Juha Production Facility will cause a facility shutdown and blowdown after a defined time delay.
- A fire at a wellhead will cause a well shutdown.
- Gas detection at a wellhead will cause an alarm only (see Section 2.8.6.2, Alarm Management System).

Confirmed fire or gas detection means that at least two detectors in an associated area detect either a fire or gas leak.

A cause-and-effect matrix will be prepared to ensure that all inputs to, outputs from and actions by the shutdown system are formally recorded, evaluated and implemented.

2.8.6.2 Alarm Management System

The alarm management system considers the facility to be in one of three operations modes:

- Normal.
- Abnormal.
- Shutdown/startup (including out-of service, and out for maintenance).

During the abnormal mode, alarms and alerts are used as notification, and during normal mode, messages and indications are provided.

For potentially hazardous process excursions, there will be at least one level of pre-alarm prior to shutdown of the system or initiation of the response system.

2.8.7 Gathering System Safety Shutdown Valves

Safety shutdown valves on the gathering system flowlines and spinelines will be activated by:

- Low pressure in the event of flowline or spineline failure or mainline failure.
- High pressure in the event of a downstream shut-in or blockage.
- Operator intervention based on abnormal pressures or flow rates.

2.9 Environmental Management

Upstream facilities will be in operation for 24 hours a day for 30 years or more; and a hazard and operability study will be undertaken to identify, define and manage operational, social, environmental and other risks. A series of activity-specific environmental management and protection measures will be developed, and performance will be monitored against targets.

The primary upstream environmental management issues for facilities developments are:

- Wastewater/stormwater discharges and water abstraction (see Sections 18.3, Groundwater, 18.4 Water Resources and Hydrology, and 18.5, Water Quality).
- Air emissions (gas turbines, back-up generators, flares) (see Section 18.8, Air Quality and Chapter 26, Greenhouse Gases and Climate Change).
- Noise emissions (see Section 18.9, Noise).
- Solid and restricted waste disposal (see Chapter 25, Waste Management).
- Safety and hazards (see Chapter 27, Environmental Hazard Assessment).

In relation to drilling activities, clearing of vegetation for wellpads, spinelines and access ways has been included in discussions and assessments in Section 18.7, Biodiversity. Issues related to abstraction of freshwater and discharge of drilling wastewaters are discussed in Section 18.5, Water Quality. Disposal of drill mud and cuttings is discussed in Section 25.4, Waste Management Areas. Air quality and noise emissions are assessed in Sections 18.8, Air Quality, and 18.9, Noise, respectively.

2.10 Decommissioning the Production Facilities

Individual items of equipment may be decommissioned when they have no further foreseeable use, and each production facility as a whole will be decommissioned when its operation is no longer economically viable. Reuse and recycling alternatives will be considered where feasible, for example:

- Removal for use by another operator.
- Removal for sale to a third party.
- Rerouting hydrocarbons to a future development.
- Access to the plant and equipment by new production fields.

If none of the above options are feasible, the facilities (or parts thereof) and associated infrastructure will be decommissioned. Larger equipment may require a life-cycle analysis of the energy, safety, resource and environmental implications of recovery and recycling alternatives.

The overall aim is to leave project land and any equipment and infrastructure that remains in a condition that allows it to be transferred with minimal residual liabilities or risk to public safety and the environment. For example, land would be returned to the landowner.

The nominal life of the proposed facilities is approximately 30 years and so it is reasonable to expect that the decommissioning procedures and regulatory requirements of the day will reflect advances in technology, new information, different monetary and other values for land and materials and the PNG Government's decision on whether and if so how to exercise its rights to take over or transfer facilities and licences. Commitments to specific procedures now cannot anticipate future circumstances. For present purposes, therefore, the PNG LNG Project undertakes to follow the regulatory requirements and good industry practice at the time of decommissioning.

Project decommissioning, when it ultimately occurs, is expected to entail the following:

- Dismantling above-ground facilities, including production equipment, wells, flowlines, compressor stations and scraper stations.
- Removal of dismantled equipment.
- Site clearance, cleanup and rehabilitation.

The hydrocarbon product to be processed will be predominantly gaseous, therefore soil contamination is not expected to be an issue. However, a soil contamination survey will be conducted to determine if there has been any inadvertent contamination (e.g., diesel fuel). If any contamination is discovered, a soil remediation program will be instigated, consistent with good industry practice environmental management as it stands at the time of decommissioning.

Closure plans will be prepared for each facility before decommissioning work starts and will be documented in the project's environmental management plan (see Chapter 30, Environmental Management, Monitoring and Reporting).