

## CHAPTER 7

### NEEDS OF COOPERATION

#### 7.1 Approach of Needs Assessment

The needs assessment of cooperation subject to the Survey has been done for the power generation requirement on the Port Moresby and Ramu grids and transmission and distribution requirements for the two grids among the following four components of the National and Provincial Ten Year Power Development Plan 2009-2018 (PNG Power Ltd., November 2009):

- 1) Generation requirement on the Port Moresby and Ramu grids
- 2) Transmission and distribution requirements for the above grids
- 3) Generation, transmission and distribution requirements in PPL centers outside the above grids
- 4) Rural electrification

The replacement of thermal based generation with renewable energy resources, wherever economically justified, is a major objective of PNG Power Ltd (PPL). Investigation of suitably sited rivers with potential for hydroelectric development has, therefore, remained as PPL's priorities. However, the ongoing financial constraints have adversely affected investigation, such as review of the feasibility studies done in 1970<sup>th</sup> and 1980<sup>th</sup> and new feasibility studies over the recent years. The deregulation and development of new generation system by the government as part of the corporatisation process of PPL is an incentive to invest to new hydropower projects with economic viability in line with the PNG renewable energy policy and hike of fossil oil prices over the recent years.

#### 7.2 Potential Projects for Cooperation

##### (1) List of Priority Project Candidates

The following priority projects identified in Chapter 4 will be potential projects for cooperation needs:

1. Port Moresby Grid
  - i. Inspection of Stability of Sirinumu Dam and Saddle Dams (water source of Rouna Hydropower Station)
  - ii. Naoro-Brown Hydro (60 MW) or Udava Hydro (58-145 MW)
  - iii. Lake Kosipe Hydro (30 MW)
  - iv. Rehabilitation of Rouna 1 Power Station (8MW)

2. Ramu Grid
  - i. Master Plan on Extension and Rehabilitation of Ramu Grid
    - a. Construction of 1 cct 132 kV transmission line (Sing Sing – Erap - Taraka), or construction of 2 cct 220 kV design transmission lines (start operation by 132 kV)
    - b. Extension and rehabilitation of other related transmissions and distribution systems
  - ii. Capacity strengthening of operation, maintenance & management
  - iii. Ramu 2 Hydro (60-240 MW)
3. Others
  - i. Wabo Hydropower (1,800 MW)

## **(2) Port Moresby Grid**

PPL requested to conduct inspection of the stability of the dam body due to increase of water leakages, the Sirinumu dam and its 7 saddle dams by the Japanese technology. The Sirinumu reservoir is the water source of the four Rouna hydropower stations and water supply to Port Moresby. The Survey Team has identified this issue considering the specific nature of social security though the team has not done any concrete inspection of these dams and thus, no basis to evaluate this problem (Refer to Section 4.2.2 (2)).

In line with the renewable energy policy of PNG Naoro-Brown Hydropower (60 MW) is evaluated as a promising priority hydropower project which will fulfill the power demand of Port Moresby projected to grow twice in five years. The priority order of Naoro-Brown and Udava (58-145 MW) which was evaluated by DPE as the first priority will be clarified by the feasibility study report which is scheduled to be completed by the end of 2010. Lake Kosipe Hydropower (30 MW) will follow Udava Hydropower (Refer to Section 4.2.1).

Rehabilitation of Rouna 1 Power Station, upgrading 2 units of 1 MW to one 8MW is a project having high investment efficiency, the yen credit will not be applicable to its small investment size, and PPL would be able to implement by own fund (Refer to Section 4.2.2 (1)).

## **(3) Ramu Grid**

PPL, ADB and the World Bank assessed as the Ramu 2 Hydropower as the first priority project to meet the growing power demand of the Ramu Grid. However, the present unstable power supply of the Ramu Grid represented by frequent and long power cut is mainly caused by its instability of the transmission and distribution systems instead of shortfall of the generating facilities. The sustainable and stable power supply of the Grid would not be achieved by the provision of new hydropower plants only unless reliability of the existing Ramu Grid is fundamentally improved by the extension and overall rehabilitation. There is also a risk that the invested capital to new hydropower development might not be recovered due to unstable power supply to the power users. PPL has understood the issue identified by the Survey Team as an urgent agenda.

Since there is no detailed study or concrete rehabilitation plan on this grid at present, the Survey Team proposed to execute a comprehensive master plan or an overall extension and rehabilitation plan composed of inspection, survey, plan, basic design and implementation schedule to find out a root –and- branch measures (Refer to Section 3.7.1). Significance of the capacity strengthening operation, maintenance and management of the Ramu and Port Moresby Grids is also delineated because unstable power supply in both Grids are partly due to insufficient operation and maintenance of the generating facilities and transmission and distribution facilities (Refer to Section 3.7.1).

Available economic evaluation indices are listed for the foregoing hydropower projects as a reference.

#### Outline Economic Evaluation Indices of Planned Hydropower Projects

Hydropower Project	Maximum Output	Capital Cost US\$ million	Financial Power Cost	EIRR
Re-installation of Rauna 1	8 MW			
Udava	145 MW	390	US\$ 0.069/kWh	14.3%
Lake Kosipe	30-55 MW	220 - 283		12.4%
Naoro-Brown	60 MW	240 – 320 (PGK 600- 800)		
Ramu 2	60 - 211 MW	339 (PGK 847) excluding transmission		
Wabo (to Hall Sound)	1,800 MW	1,020 (1976 price including transmission)	US\$ 0.0121/kWh	

Note: Combined Cycle US\$ 0.096/kWh; Diesel US\$ 0.197/kWh

(Source: The Papua New Guinea: Power Sector Development Plan, ADB, April 2009 (PSDP 2009) and the data compiled by JICA Survey Team)

#### (4) Others

Wabo Hydropower Project (1,800 MW) is not at the position of alternative hydropower projects to fulfill the future power demand of Port Moresby and Ramu Grids. The large scale hydropower resources developed at Wabo site targets on the demand of international energy consumptive industry as the natural gas development does not primarily aims to supply to the PNG domestic market demand. It would be subject to future issues if this clean energy is treated as export resources or to put it on the framework of the domestic economic development to create employment by attracting the international large scale energy consumptive industries to inside PNG.

## 7.3 Support Policy of Other Donor Agencies

### 7.3.1 Aid Activities of ADB, World Bank, Government of Australia

#### (1) Activities of Asian Development Bank

Asian Development Bank dispatched a mission to PNG from April 5 to April 16, 2010. The purpose of the mission was (i) midterm review for project preparation TA 7113-PNG: Town Electrification Project, and (ii) design mission for proposed Japanese Fund for Poverty Reduction (JFPR) grant for “Improved Power Supply to Poor Communities”. The mission met with stakeholders and visited sites in West New Britain. A tripartite meeting was held between PPL, ADB and Consultants, and prepared Memorandum of Understanding (MOU)<sup>1</sup>. The mission also discussed about Country Strategy Program with IPBC, DNPM, PPL, Western Power Ltd, etc. The Survey Team had an opportunity to exchange information with Mr. Anthony Maxwell, ADB Energy Specialist.

The Scope of Work of the Town Electrification Project includes assessment of the six hydropower sites:

- Subproject 1. Gumini River Hydropower, Alatu Mine Bay Province
- Subproject 2. Kimadan River Hydropower, Kavieng, New Ireland Province
- Subproject 3. Divune River Hydropower, Popondeta, Oro Province
- Subproject 4. Ru Creek 2 Hydropower, Kimbe, West New Britain Province, or alternatively Kimbe-Bialla interconnection project
- Subproject 5. Ramazon River Hydropower, Buka, Autonomous Region of Bougainville (ABG)
- Subproject 6. Sowam River Hydropower, Wewak, East Sepik Province

Out of 6 small hydropower sites two sites were disqualified. The project cost of Sowam River Hydropower is too high, and available water is not sufficient for Ru Creek 2 Hydropower. Preliminary project assessments indicate a total of MFF (Multitranchise Financing Facility) of US\$ 100 million may be required with Tranche 1 for the initial 2 hydropower sites requiring US\$25-45 million. These small hydropower projects are located in the off grid areas outside the Port Moresby and Ramu grids.

Mr. Anthony Maxwell expressed ADB’s interest in co-financing to new hydropower projects such as Ramu 2 with JICA. He also indicated that the activities of the World Bank Energy Sector Mission in March 2010 included technical assistance to the possible development of the Wabo Power Project including the social and environmental studies.

In the TV meeting held between ADB PNG office and ADB Manila office on May 14, 2010 the Survey Team exchanged information about the findings by the Study with Mr. Charles T. Andre, PNG Country Director and Mr. Anthony Maxwell, Energy Specialist

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<sup>1</sup> PPTA 7113-PNG: Preparing the Town Electrification Project

ADB, Manila. Mr. C. Andre explained that the present ADB's priority of assistance to PNG is on the off grid small hydropower, though ADB is sounding a possibility of financing to large scale hydropower projects such as Ramu 2, Udava and Wabo. Both parties confirmed their close contact and information sharing on the PNG power sector.

## **(2) Activities of the World Bank**

The World Bank dispatched an Energy Sector Mission to PNG from March 29 to March 31, 2010. The Objectives of the mission were to follow up discussion on the possible IDA TA Project that was proposed during the energy sector mission in October 2009 and to assess the Sustainable Energy Financing Project (SEFP). The mission met with key Government representatives from the DNPM, Department of Treasury (DT), DPE, IPBC, PPL, PNGSDP and Western Power, and prepared draft Aide Memoire, March 29-31, 2010.

In the 3-year Country Assistance Strategy agreed between the Government of PNG and the World Bank covering the period through 2010, support is included for a new energy sector project. The mission discussed about the needs and priorities in the electricity sector as an input to defining the possible scope of proposed World Bank Energy Sector Projects, but the contents information was not obtained. The agenda covered hydropower development in PNG (from the very large scale to supply large new industrial projects, to medium scale to supply the Port Moresby and Lae grids, to smaller scale for supplying town or village isolated power systems), issue of access to electricity outside the main urban, assistance in developing the next hydropower project to meet the demand on the Port Moresby grid expected to increase to about 200 MW in 5 years, assistance in the areas of policy and strategy in the electricity sector with focus on rural and renewable energy, possible technical assistance to DPE (Renewable Energy Policy, Rural Electrification Policy, National Energy Policy), possible technical assistance to PPL (preparation of the next hydropower project for Port Moresby, assistance to improve key aspects of PPL efficiency, assistance in the early identification of subsequent hydropower projects), and technical assistance to the possible development of the large Purai hydropower project under consideration by PNGSDP (review of 1,800 MW Wabo Power Project including the social and environmental studies)<sup>2</sup>.

This broad agenda covers Ramu 2 Hydropower, Naoro-Brown Hydropower, Udava Hydropower and Wabo Hydropower, but the World Bank requires the Government of PNG to define these projects as national projects instead of independent private sector projects as precondition.

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<sup>2</sup> Refer to World Bank Energy Sector Mission, March 29-31, 2010, Aid Memoire, Draft

### **(3) Other Financing Agencies**

PPL expects loans from Chinese government and European Investment Bank (EIB) as options among donor agencies such as the World Bank, ADB and JICA. PPL finds advantage of EIB that it does not require guarantee by the PNG government though its interest rate is higher. PPL intends to extend the loan agreement with the Government of China for Ramu 2 Hydropower which expired at present<sup>3</sup>.

### **(4) Government of Australia**

The Government of Australia does not provide particular assistance to the energy sector in PNG at present according to Mr. Lawrence Duguman, Assistant Secretary-Bilateral Branch, Foreign Aid Division, Department of National Planning and Monitoring. The Australian aid program focuses on intervention on the governance of the Government. The subject areas are (i) institution and law, (ii) capacity development (proper management of funds, harmonize policy), and (iii) social aspects of governance, etc. The Government of New Zealand also provides assistance mainly to the same areas.

## **7.3.2 Needs of Cooperation among Donors**

PPL and DNPM envisage to set-up a round table for the power sector to share information among donors and the PNG agencies concerned, and to coordinate role of donors and the PNG agencies and allocation of aid programs. Arrangement of the first trial of the round table on May 13, 2010 was not materialized. DNPM will try to arrange a round table for the power sector inviting PPL and IPBC as execution organizations, DNPM and DPE as policy and regulation agencies of PNG Government, and ADB, JICA and the World Bank as financing and technical aid agencies. The Government of China and EIB are also candidates to the financing agencies.

If the envisaged round table is materialized the needs of cooperation among donors and role of respective donors would be clarified to some extent. It would be however necessary to watch the direction of ADB and the World Bank that have been forerunners in the power sector aid programs in PNG.

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<sup>3</sup> Information Memorandum, Ramu 2 Project K 1,100 Million, China Exim Bank Financing Facility

## Appendix-1: List of Persons Met

### Asian Development Bank

Mr. Anthony Maxwell	Energy Specialist, ADB(Manila)
Mr. Charles T. Andrews	Country Director, PNG Resident Mission
Mr. Mahfuz Ahmed	Principal Natural Resources Economist

### Japan International Cooperation

Mr. Kyoji MIZUTANI	Resident representative, Papua New Guinea Office
Mr. Takahira YOKOTA	Assistant Resident Representative, PNG Office
Mr. Shun NEZAKI	Assistant Resident Representative, PNG Office
Ms. Hikari MIYAHARA	Project Formulation Advisor, PNG Office
Mr. Masahiro ITO	Assistant Director, Pacific Division, Southeast Asia 1 and Pacific Department, Head Office, Tokyo
Mr. John KOL	Development Officer, PNG Office

### Embassy of Japan, Papua New Guinea

Mr. Hajime NISHIYAMA	Ambassador of Japan
Mr. Katsutoshi ITO	First Secretary
Mr. Takeshi FUJIMURA	First Secretary

### PNG Power Ltd.

<Head Office>

Mr. Tony Koiri	Chief Executive Officer
Mr. Lawrence Solomon	Deputy Chief Executive Officer
Mr. Togaro Asiba	Manager of Business Marketing & Sales
Mr. Edmond Pereira	Manager Revenue & Customer Services
Mr. Crusoe K. Dili	Team Leader – Civil Maintenance / Planning
Mr. Kone Bulina	Land Officer
Mr. Francis Uratun	Network Planning Engineer
Mr. Jones Pokarop	Substation Design Engineer
Mr. Titus Tsigese	Environmental Officer
Mr. Damien Sonny	Renewable Planning Engineer, Engineering Research & Planning
Mr. Steven Kerowa	Team Leader, Lands Community Relations
Mr. Wabing Mileng Stahl	Network Team Leader-Port Moresby, Network Management Division
Mr. Joseph S. Basse	manager Network Management
Mr. Ephraim Aurete Hau	Senior Electrical Engineer, Hydro Maint. Planning
Mrs. Lillian Sukot	Data & Statistic Coordinator, System Control Center
Mr. Peter Tukau	Revenue & Customer Services

<Lae Office>

Mr. Stanley Gogorea	Generation Team Leader - Lae, Operations Momase
Mr. Ronnie Kopi	Centre Manager - Vanimo, Assistant Manager – Electrical - Lae
Mr. Watson B. Naso	Regional Manager - Momase

<Milford>

Power Station Manager

<Rouna>

Mr. Joseph Buki	Power Station Manager
Mr. Kaiva Warina	Team Leader Operation
Mr. Pkil Sangara	Team Leader Electric
Mr. Eruesp Poyo	Team Leader Civil
Mr. Jim Aru	Team Leader Mechanical

<Yonki/Ram>

Mr. Andrew Magaiye	Center manager – Yonki/Gusap
Mr. Kamilus Wohuifia	Ramu Hydropower Station Manager
Mr. Awa Aporo	Regional Manager
Mr. Kenneth Rapudidi	Acting Network Team Leader
Mr. Andrew Magaire	Center Manager
<b>PNG Taiheiyo Cement Limited</b>	
Mr. Sunao SHIOMI	Former Managing Director
Mr. Makoto KAGAMIDA	Managing Director
Mr. Osamu MIZUI	Vice Factory Manager
<b>Western Power Ltd.</b>	
Mr. Tony Carbry	Chief Operating Officer / Company secretary
Mr. Ben Mehuwa	Project Development Manager
<b>PNG Energy Development Ltd.</b>	
Mr. Ken Baxter	Chairman
Mr. Ian J Bulmer	Chief Executive Officer / Director
Mr. Tony Carbry	Chief Financial Officer / Chief Operating Officer
Mr. Charles Niecewoudt	Director
<b>Origin Energy Ltd.</b>	
<b>Hydro Tasmania Consultant</b>	
Mr. David Wilson	Business Development Manager
Mr. Jayson Peterson	Hydrologist
Mr. Bruce Taylor	Geologist
<b>Mineral Resources Authority</b>	
Mr. Sonick Taguse	GIS Specialist, Information & Marketing Division
<b>Mapping Bureau</b>	
Mr. Sebastian Hani	Staff of Air Photo Division
<b>PGS Limited (PNG Geospatial Solution)</b>	
Mr. Raymond I. Bure	Director / Partner, GIS / Mapping Specialist
<b>Independent Public Business Corporation</b>	
Mr. Chris Burns	Chief Operating Officer
Mr. Parkop Kurua	Business Analyst
<b>Department of Public Enterprise</b>	
<b>Department of Petroleum &amp; Energy</b>	
Mr. Alan Lavi	Assistant Director Engineering Services, Policy and Planning Branch, Energy Division
Mr. Nelson Tai	Energy Planner, Policy and Planning Branch, Energy Division
<b>Department of National Planning &amp; Monitoring</b>	
Mr. Lawrence Duguman	Assistant Secretary-Bilateral Branch, Foreign Aid Division
Mr. Samuel Koney	Aid Policy and Coordination Directorate (APCD)
Mr. Michio SERIZAWA	Project Formulation Advisor (dispatched from JICA PNG)
<b>Department of Environment and Conservation</b>	



Mr. Dennis Iwawami, Senior Scientific Officer, Environment Protection Wing,  
Regulatory Services, Planning Branch,  
Mr. Rose Kualke Scingadar, Protected Areas Terrestrial Sustainable Environment  
Program Wing  
Ms. Grand Natetera, Manager GIS  
Ms. Adah Sauke, Senior GIS Officer, special Systems and Data(GIS)  
Branch, Information and Science Div.

**Department of Land and Physical planning**

Mr. Mr. Jacob Waifindo, Regional Manager,

**Papua New Guinea Forest Authority, National Forest Service**

Mr. Lyall Umbo, Project Manager, Resource Development Office  
Mr. Charles Pakuse A/Project Officer, Resource Development Office

**Department of Agriculture and Livestock**

Mr. Andy Agovava Asset Officer, Asset Office,

**National Statistic Office, Papua New guinea**

Mr. Ramat KIRAMU, Statistical Officer,

**National Research Institute**

Mr. Nalau Bingeding Research Fellow, Social & Environmental Studies  
Division.

## Purari River Wabo Hydropower Project

### 1. Project Features

- (1) Purari River is one of the largest rivers in the Papua New Guinea (PNG) that flows in the middle of the county to the south. The total length of the main stem is about 630 km, while the drainage area of the whole river basin is about 33,000 km<sup>2</sup>.
- (2) Wabo hydroelectric power station is planned at about 200 km from the river mouth the Purari River (Figure 1). The river basin is blessed with abundant annual rainfall of more than 8,000 mm. At the dam site of Wabo Hydropower Project, the basin catchment area is 26,300km<sup>2</sup>, having an average discharge of 2,500m<sup>3</sup>/s (Figure 2).
- (3) Wabo Hydropower Project is planned as a dam type development scheme with an installed capacity of 1,800 MW, which will generate 11,825 GWh per year.
- (4) Generated power at the Wabo Hydropower Project is transmitted with double-circuit 500 kV transmission line to the town of Hall Sound which is located about 300 km from the Wabo Project site.
- (5) Hall Sound is a natural harbour which has advantages for the development of a port. The area is scheduled to be developed as power consuming industry zones such as aluminium smelter. Hall Sound is also scheduled to be developed as an urban area.

### 2. Background

- (1) In 1956, New Guinea Resources Prospecting Company asked a British company, Halcrow to survey five rivers in Papua New Guinea for the power development to be used for aluminium smelting purpose. The survey result showed that the Purari River basin was the most prospective one. In 1959, Halcrow surveyed Wabo Project site by the request of Commonwealth Aluminium Corporation.
- (2) During the period from 1971 to 1973, Nippon Koei Co., Ltd. conducted hydropower potential study of the Purari River. Nippon Koei Co., Ltd. presented development schemes of six locations with total capacity of 6,000 MW. In the study, Nippon Koei Co., Ltd. recommended to conduct detailed survey of Wabo Project site.
- (3) The government of Papua New Guinea requested both governments of Japan and Australia to conduct a feasibility study (F/S) of Wabo Project. The Australian government asked SMEC to re-evaluate the report of Nippon Koei Co., Ltd. In the evaluation report of 1974, the Australian government confirmed that Wabo Project was prospective.
- (4) Industrial Bank of Japan, Limited conducted a study for industrial development. In 1975, the study team presented a concept of industrial complex back by the power generated by Wabo Project.
- (5) In 1975, an implementation of feasibility study (F/S) of Wabo Project was agreed among the three governments of PNG, Japan and Australia. The F/S was conducted from 1975 to 1977 by Nippon Koei Co., Ltd. and SMEC with assistance of Japan International Cooperation Agency (JICA). The F/S of Wabo Project included the development components of (i) hydropower, (ii) port, (iii) industry, and (iv) urban.
- (6) During the period from 1977 to 1979, an environmental study of Wabo Hydropower Project was conducted with a technical assistance of UNDP.

## Appendix-2 Wabo Project Features

- (7) In 1991, Mitsubishi Corporation asked Nippon Koei Co., Ltd. to re-evaluate the construction cost to re-estimate the unit power generation cost of Wabo Project. The re-evaluation works also included the idea of reducing the project size, and the stage wise development.
- (8) In 2008, Nippon Koei Co., Ltd. again conducted an overall review of construction costs and unit generation costs.

### 3. Plan of Hydropower Development Facilities

- (1) Major components of Wabo Hydropower Project are Main Dam, Saddle Dam, Power Generation Facilities, Spillway, and River Diversion Facilities. Figure 3 shows a general plan of the construction works, and Figure 4 shows the main dam site and related facilities.
- (2) Principal features of the facilities are as shown below (based on JICA F/S)

Wabo Reservoir	Full Supply Level (FSL) Minimum Operation Level (MOL) Gross Storage Volume Effective Storage Volume Reservoir Area Catchment Area Annual Average Inflow	EL. 135 m EL. 110 m $16,600 \times 10^6 \text{ m}^3$ $6,490 \times 10^6 \text{ m}^3$ $290 \text{ km}^2$ $26,300 \text{ km}^2$ $79,000 \times 10^6 \text{ m}^3$
Main Dam	Type Dam Height Dam Volume	Central earth core fill embankment 160 m $15.9 \times 10^6 \text{ m}^3$
Saddle Dam(Including Emergency Spillway)	Number of Dams Type Maximum Height Total Dam Volume	5 locations Fill type dam of various kinds 75 m $7.8 \times 10^6 \text{ m}^3$
Spillway	Design Flood Design Outflow Type Chute Width	$22,600 \text{ m}^3/\text{s}$ $16,570 \text{ m}^3/\text{s}$ Chute Type, Ski Jump Type Dissipater 105 m
Intake, Penstock	Height of Intake Structure Penstock	56 m 8 m Diameter x 6 nos.
Power Station	Maximum Output of Generator Generator Output at MOL Number of Generator Rotation Speed Turbine Output  Firm Output  Annual Firm Energy Output (excl. Secondary Output)	360 MW 300 MW 6 (including one spare) 125 rpm $365 \text{ MW}$ (Net Head 98.0 m, Turbine Discharge $427 \text{ m}^3/\text{s}$ )  $1,350 \text{ MW}$ (Load Factor 90%, 5 nos. operation)  $11,825 \text{ GWh}$ (Generating End) $11,575 \text{ GWh}$ (Receiving End at Hall Sound)
Diversion	Number of Tunnel, length Inner Diameter	3 nos., 660 to 1,105 m 14.5 m

## Appendix-2 Wabo Project Features

### 4. Plan of Transmission Line

- (1) 500 kV double circuit transmission line with 300 km length is planned from Wabo Power Station to Hall Sound to transmit 1,800 MW of generated power. Transmission line route is as shown in Figure 1.
- (2) It is planned to install a switchyard for relaying the transmission lines. Two lines are carried on separate towers in the mountainous area from the power station to the switchyard. One line is installed in the rest of the route from the switchyard to Hall Sound.
- (3) Another switchyard will be constructed at the receiving end to step down 500 kV to 66 kV.

### 5. Construction Plan and Schedule

- (1) Construction material for the hydropower station facilities will be transported by sea and by the Purari River to Wabo hydropower project construction site. Transported construction material by sea is once unloaded in the transfer port to be constructed at Pai-a Inlet, and then transported by river along the Purari river up to the port of Wabo site. During the extreme dry period, a jetty will be constructed at Pawaira 1 to enable land transportation using the construction road for transmission lines.
- (2) For the transmission line construction, roads will be constructed along the transmission line route. In the coastal part, it is planned that public roads to be used for construction.
- (3) For the dam construction works, river flow of  $2,500\text{m}^3/\text{s}$  in average discharge will be diverted using three number of diversion tunnels by constructing cofferdams upstream and downstream. It is proposed to construct cofferdams by excavating riverbed with dredger, then mainly by dumping embankment material from both abutments.
- (4) Wabo project site is a high rainfall area without any clear dry period. The core material embankment works for the main dam will be limited to a single shift only.
- (5) 25 months will be required for the detailed design, selection of the contractors including contracting. During the period, preparatory works will be done for land acquisition, preparation of temporary equipment for construction, construction of workers' camp, jetty and dock, construction of road between Pawaia 1 and Wabo site, and procurement of dredging boat. The river will be diverted 30 months after the contract of main construction works, and the impounding works will start 62 months after the contract. The commencement of the power generation will be 68 months after the contract, which is 93 months (7 years and 9 months) after the commencement of design works.

## Appendix-2 Wabo Project Features

### 6. Construction Cost

- (1) Estimated construction cost for power generation and transmission facilities are 1,023 million US dollar (568 US dollar/kW) according to the JICA Feasibility Study Report in 1976.
- (2) A summary of the costs are as shown below:

Item	Cost (million US dollar)
1 Civil works	423.9
2 Power plant	155.3
3 Transmission line and terminal substation	198.8
4 Construction facilities	30.0
5 Land acquisition and resettlement (Wabo site only)	0.8
Sub-total	808.8
6 Engineering (10% of items 1 to 4)	80.8
7 PNG government Administration (5% of items 1 to 5)	40.4
Sub-total	930.0
8 Project contingency (10%)	93.0
Total	<u>1,023.0</u>

### 7. Power Cost

- (1) Result of analysis in 1976 F/S shows several estimates for power cost. The following table shows the power cost for different interest rates by project periods. In case the project period is 30 years, the power cost at Hall Sound receiving end will be 0.02 to 0.03 US dollar per kilo watt hour.

Interest Rate	Project Period		
	20 yrs	30 yrs	40 yrs
7%	25.6	19.1	17.8
8%	27.4	20.8	19.5
9%	29.4	22.7	21.4

- (Note) i Unit: ( $10^{-3}$ US\$/kWh)  
 ii Price Escalation: 8% per annum  
 iii Power cost at Hall Sound receiving end  
 iv Assuming that industrial power demand to be in full swing (1,735 MW) in five years  
 v Load Factor: 90%  
 vi Source: Purari River Wabo Power Project Feasibility Report (December 1977)

### 8. Port and Industrial Development

- (1) The proposed port development location at Hall Sound is a natural deep port sheltered from the prevailing waves. Little siltation is occurring and it is anticipated that only minor maintenance dredging would be required.

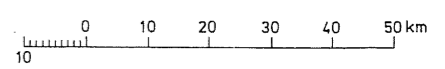
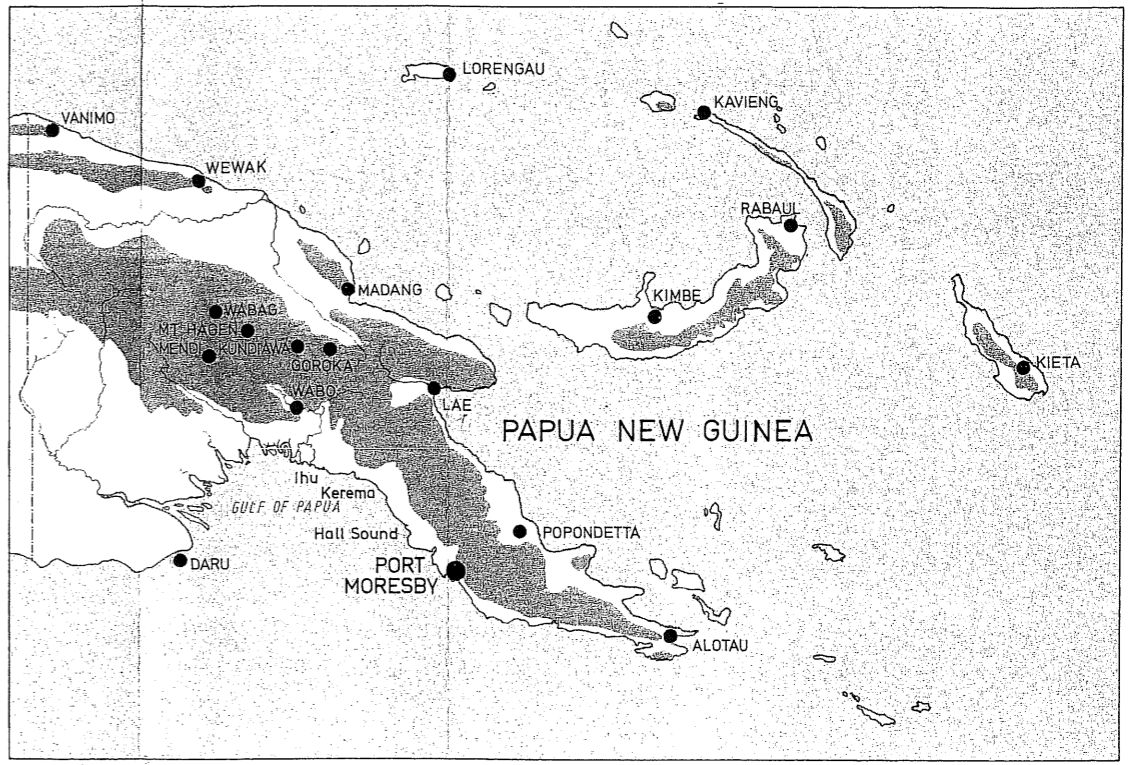
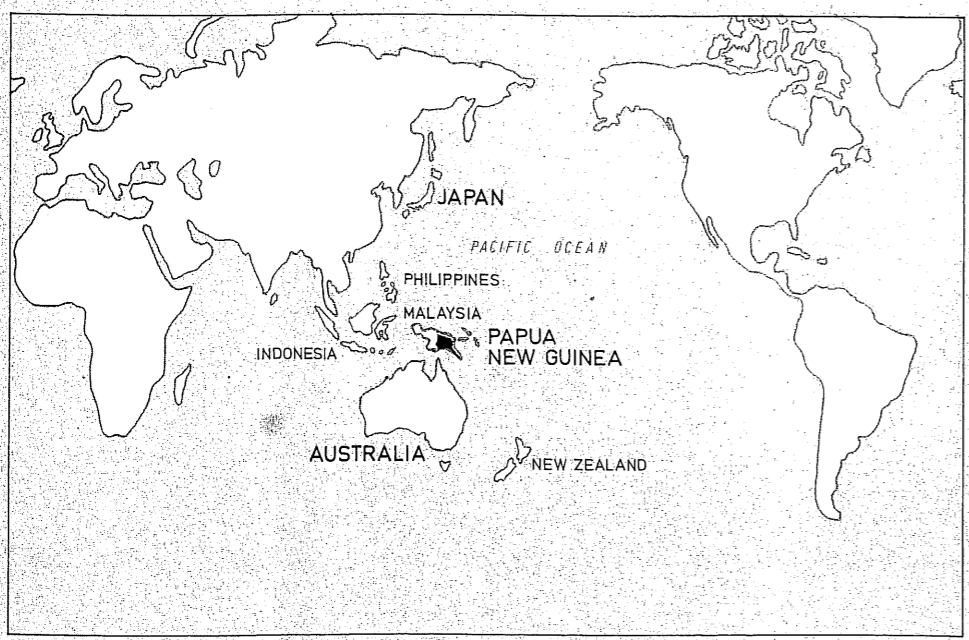
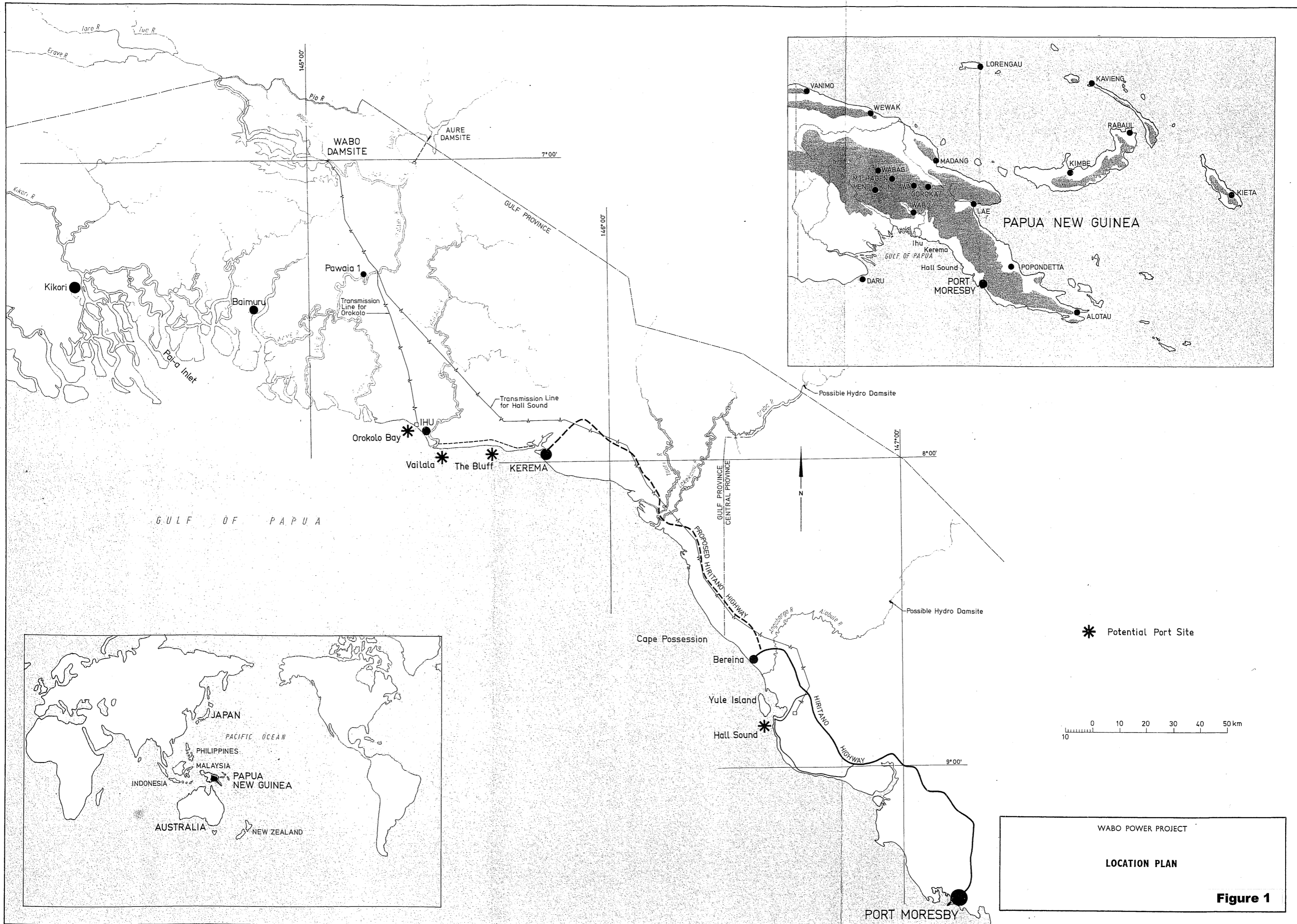
## Appendix-2 Wabo Project Features

- (2) At Hall Sound, large areas of firm, well drained land exist, which when levelled, are appropriate for industrial development accessible to a port site. Climate of Hall Sound is similar to that of Port Moresby with rather small amount of annual rainfall of 1,200 mm.
- (3) According to the study carried out by the Purari Industrial Survey Mission, the scale of industrial development adopted would be as follows:

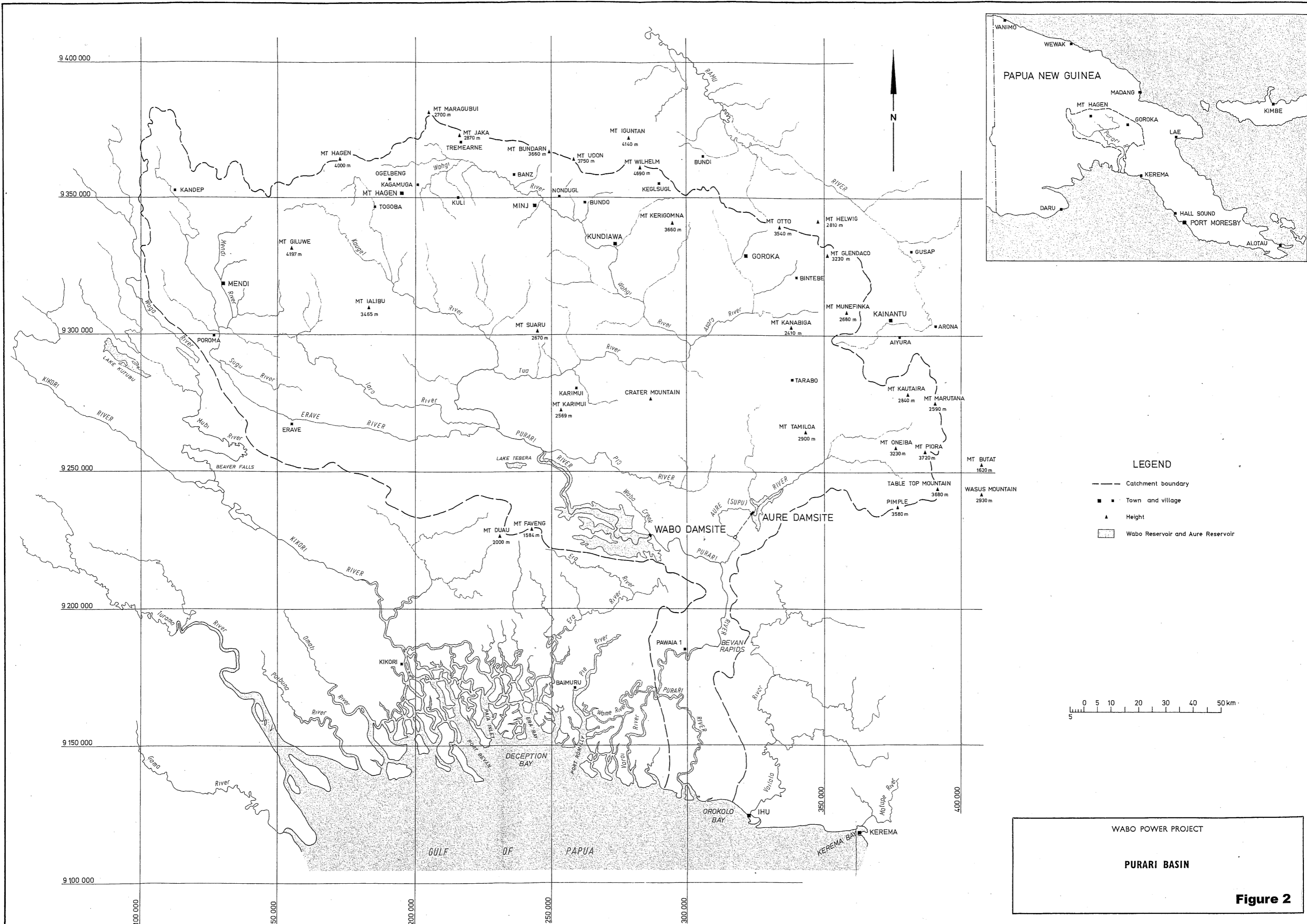
Industry	Production (10 <sup>3</sup> ton/year)	Peak Power Requirements (MW)	Plant Site Area (ha)
Aluminum Smelting	580	1,000	150
Ferroalloys (except ferronickel)	384	271	52
Ferronickel	150	105	65
Integrated Steel Mill	100	29	17
Electrolytic Caustic Soda, Ethylene Dichloride	540	120	25
Copper Refining	100	11	35
Zinc Refining	90	45	42
Silicon Carbide	32	32	60
Liquefied Natural Gas	2,140	110	50
Chemical Fertilizer	550	12	20
Total	4,666	1,735	516

### 9. Environmental Impacts

- (1) To assess the environmental impacts of Wabo project, it is necessary to review the contents of EIA report prepared by UNDP in 1979.
- (2) Expected environmental impacts will be as follows:
- Impacts on inundation of 29,000 ha natural forest and affects to ecology. Possibility of disappearance of endangered/new species.
  - Disappearance of primary forest caused by construction of transmission line construction road and analysis of its impact on ecology
  - Impacts on river and river mouth due to decrease of sediment supply to the downstream area of the dam, especially on erosion of delta, seawater intrusion, and possibility of adverse affects on mangrove.
  - Impacts on fish species in delta and residents living on fishing by decrease of nutrient supplied to the downstream area of the dam.
  - Resettlement of two villages with indigenous people due to inundation.
  - Resettlement of population in Hall Sound (1,800 people, according to JICA F/S in 1976) due to the port, industrial and urban development. It is expected that 900 people would be directly affected and one village would need to move.
  - Air pollution, water contamination from wastewater from factories due to industrial and urban development.

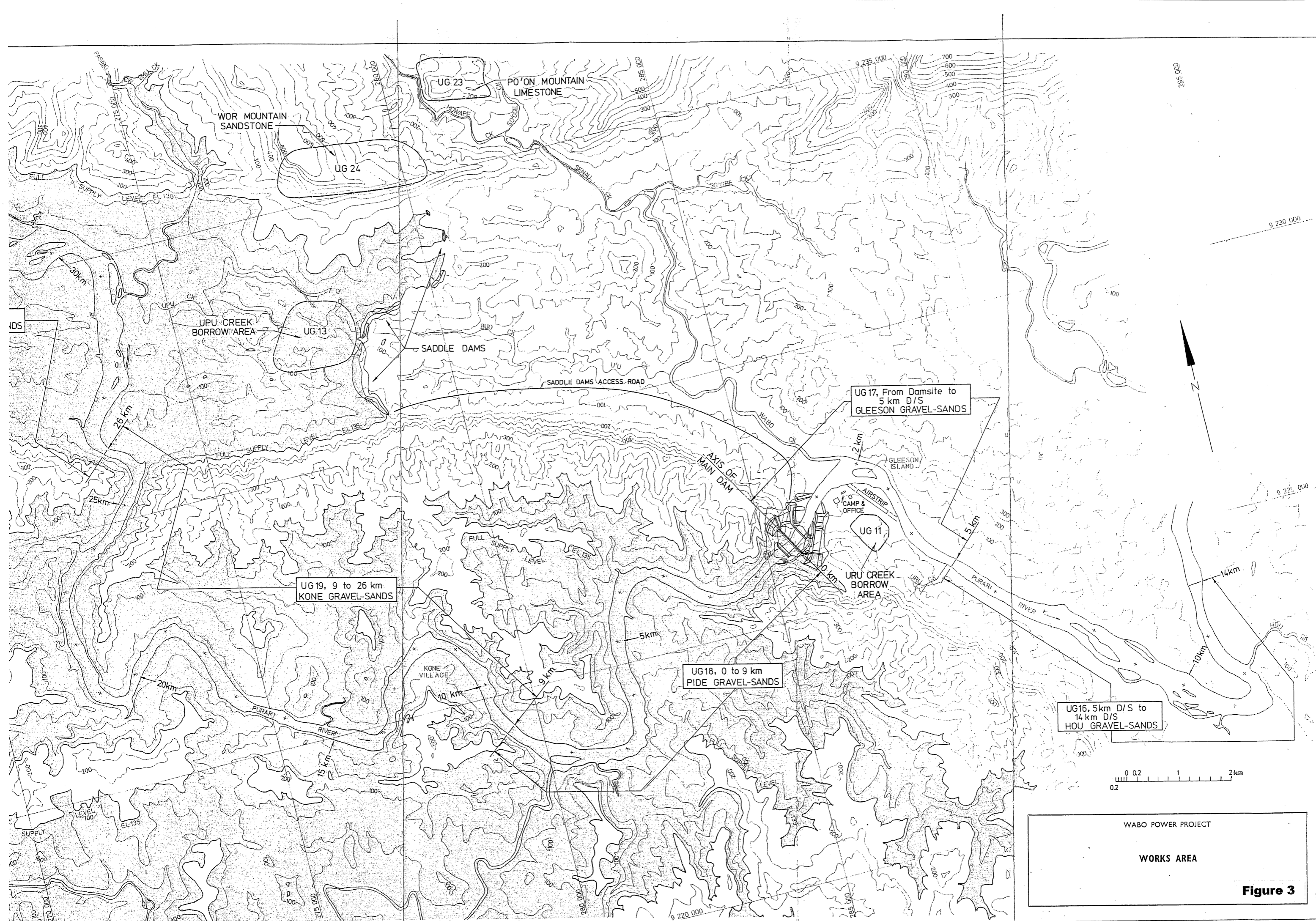


\* Potential Port Site



WABO POWER PROJECT  
**PURARI BASIN**  
**Figure 2**





WOR MOUNTAIN SANDSTONE

PO'ON MOUNTAIN LIMESTONE

UPU CREEK BORROW AREA

SADDLE DAMS

SADDLE DAMS ACCESS ROAD

UG 17, From Damsite to 5 km D/S GLEESON GRAVEL-SANDS

GLEESON ISLAND

UG 11

URU CREEK BORROW AREA

UG 19, 9 to 26 km KONE GRAVEL-SANDS

KONE VILLAGE

UG 18, 0 to 9 km PIDE GRAVEL-SANDS

UG 16, 5km D/S to 14 km D/S HOU GRAVEL-SANDS

WABO POWER PROJECT

WORKS AREA

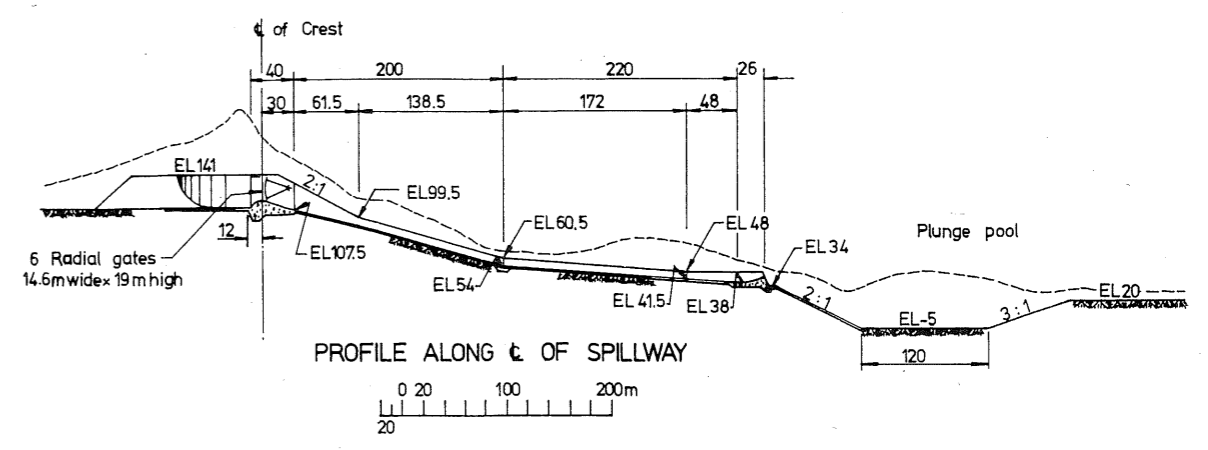
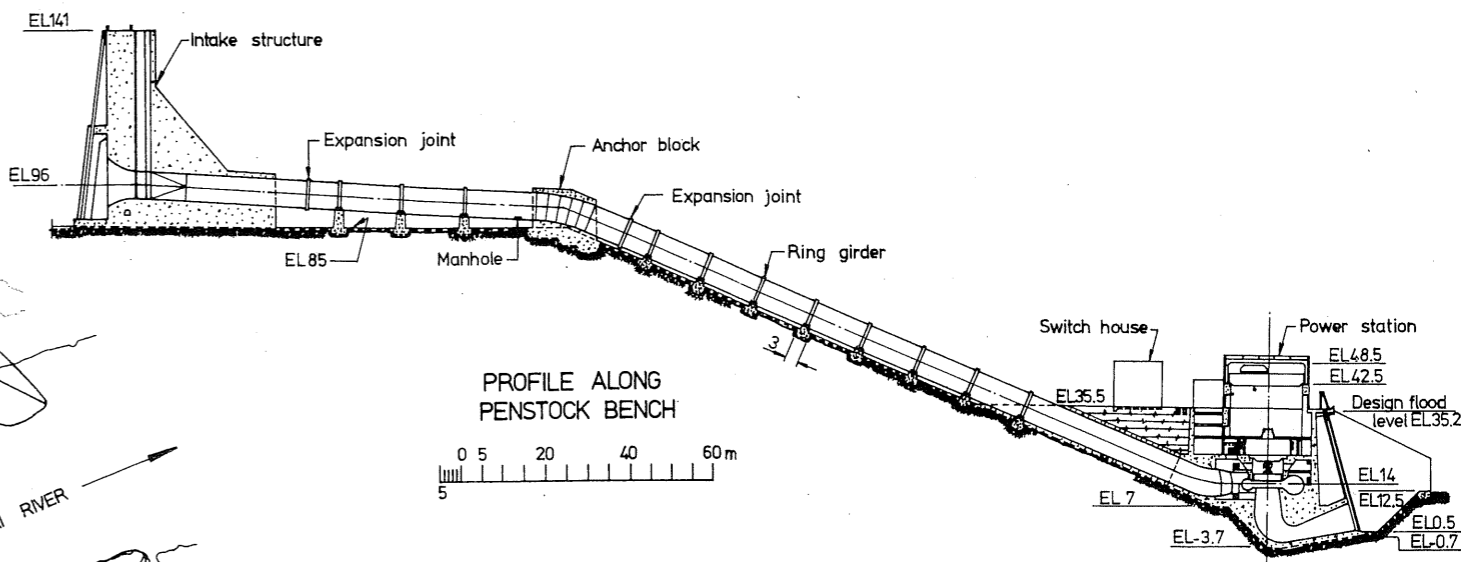
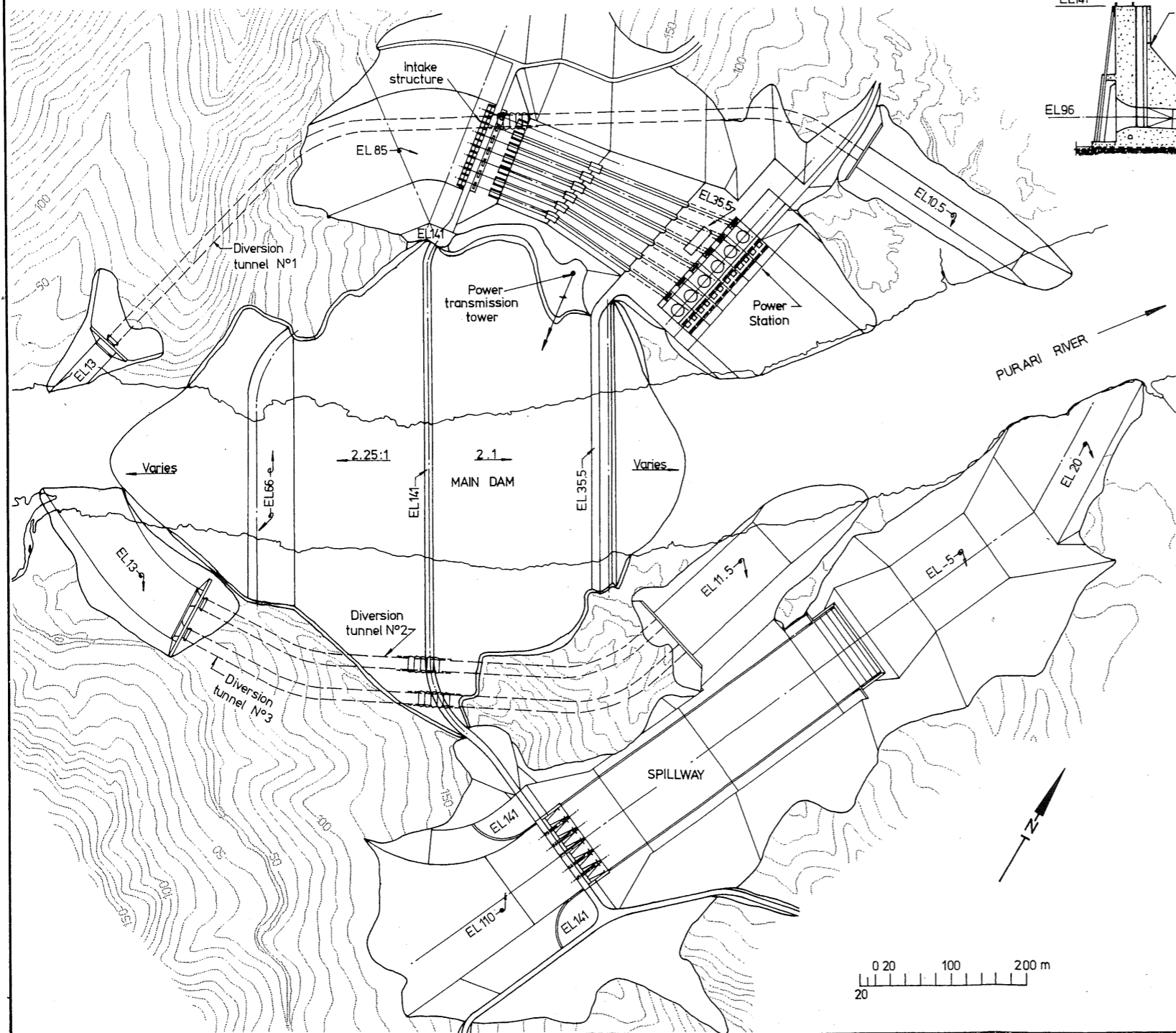
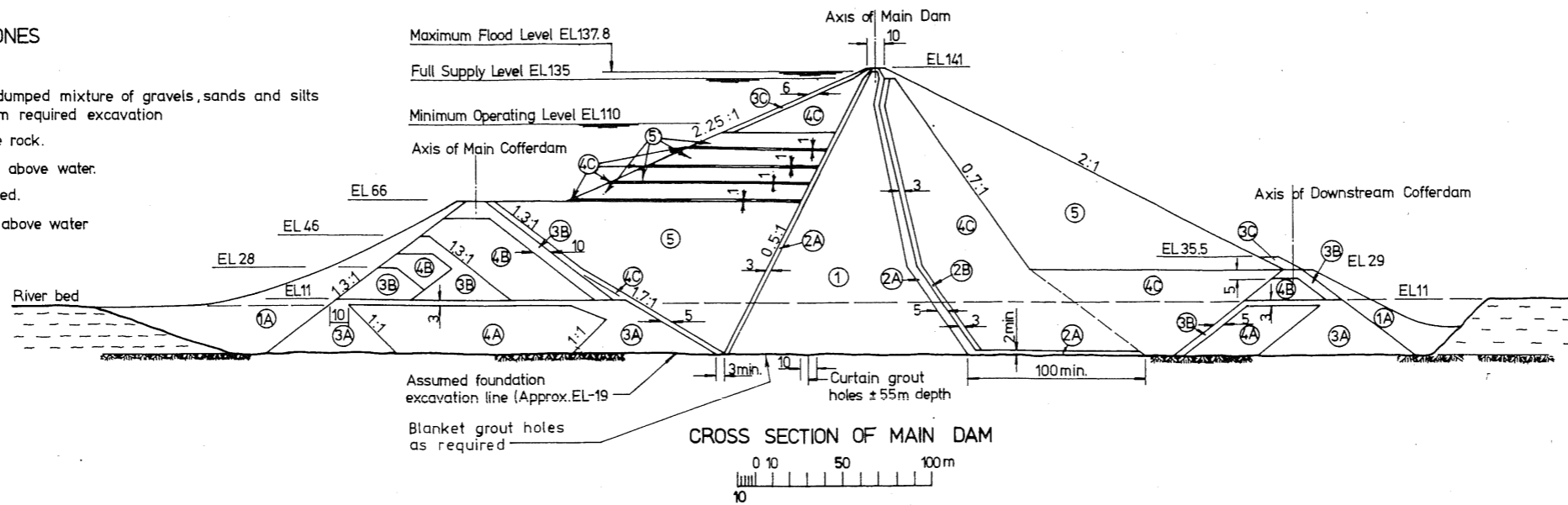
Figure 3

**COFFERDAM ZONES**

- Zone 1A- Sealing membrane  
Below existing riverbed level-barge dumped mixture of gravels,sands and silts  
Above riverbed-material stripped from required excavation
- Zone 3A-Quarry run, barge dumped limestone rock.
- Zone 3B-As for Zone 3A except end dumped above water.
- Zone 4A-Dredged gravel-sands, barge dumped.
- Zone 4B-Dredged gravel-sands,end dumped above water

**EMBANKMENT ZONES**

- Zone 1-Impervious core, mudstone compacted with tamping roller.
- Zone 2A-Fine filter, processed from dredged fine sands and silts.
- Zone 2B-Coarse filter, processed from dredged gravel-sands.
- Zone 3C-Slope protection,quarry run placed limestone rock, maximum size as required for wave action.
- Zone 4C-Dredged gravel-sands, compacted with 10 tonne or heavier vibrating drum roller.
- Zone 5-Random fill from required excavation in Era Bed sandstone.



WABO POWER PROJECT  
**MAIN DAM  
GENERAL ARRANGEMENT**  
**Figure 4**

### Appendix-3 Legislation related to Environmental Assessment/ Land Protection/ Land Acquisition

	Law/ regulation	Year of issue	description	Note
<b>Related to Environmental Assessment</b>				
1	the Environment Act 2000	2000	The law provides environmental impact assessment process in the country, namely Environmental Permit. This replaced three main pieces of legislation that dealt with environmental protection: the Environment Planning Act, Environmental Contaminant Act, and Water Resource Management Act.	○
2	The Environment Act, 2002 (the Act)	2002	This is a small amendment of the principle act dealing with environmental protection, the Environmental Act 2000.	○
3	Environment (Prescribed Activity) Regulations, 2002	2002	This Regulation aimed to provide for the prescribing of activities to be Level 1, Level 2 (Category A or Category B) and Level 3.  In Schedule 1 of the regulations describing Level 2 activities and Schedule 2 of the regulations describing Level 3 activities.	○
4	Environment (Fees and Charges) Regulation 2002	2002	This regulation relates to fees and charges in three sections. Part 1 of the regulation describes the fee payable for the submission of an environment impact statement, Part 2 describes water usage charges and Part 3 describes miscellaneous charges.	○
5	Environment (Permits and Transitional) Regulation 2002	2002	This Regulation guides Environment Permits, in terms of its procedures and requirements for obtaining an environment permit. This includes submission of application, processing of application, issue of permit, renewal of permit, transfer of permit, amendment in permit, surrender and cancellation of permit, appeals and transitional arrangements.	○
6	Environment (Procedures) Regulation 2002	2002	This Regulation provides procedures of the Environment Council. It describes procedures for calling of meetings, proceeding of the meetings, disclosure of the meetings, delegations and reporting requirements of Environment Council and Environmental Consultative Group. This also sets procedures for review of Director's decisions.	○
7	Environment (Water Quality Criteria) Regulation 2002	2002	This Regulation provides water quality criteria and describes water quality criteria and mixing zone.	○
<b>Guidelines</b>				
1	Guidelines for Conduct of Environmental Impact Assessment & Preparation of Environmental Impact Statement, 1st January 2004.	2004	This Information Bulletin is aimed at assisting prospective proponents of development activities that may be classified as a Level 2 or Level 3 activity in accordance with the Environment (Prescribe Activities) Regulation 2002 to meet their legal obligations under Section 48 of the Environment Act 2000.	○
2	Notification of Preparatory Work in Level-2 and Level-3 Activities, 1 January 2004.	2004	This Information Bulletin is aimed at assisting prospective proponents of development activities that may be classified as a Level 2 or Level 3 activity in accordance with the Environment (Prescribe Activities) Regulation 2002 to meet their legal obligations under Section 48 of the Environment Act 2000.	○
3	Guidelines for Submission of an Application for an	2004	This Information Guideline has been developed to guide proponents of Level 2 (Category B) activities and Level 3	○

	Environment Permit to Discharge Waste, 1 January 2004.		activities where Minister's Approval in Principle has been issued, to submit relevant information when applying for an Environment Permit to discharge wastes.	
4	Technical Guidelines for Noise, Air and Water & Land Discharges	2004	This is intended to assist applicants in submitting the relevant technical information in the permit application. Other similar guidelines will be developed in the future to address a specific environmental concern or to recommend best practice environmental guidelines in relation to a prescribed activity.	○
5	Guidelines for Preparation of Environmental Inception Report, 1 January 2004	2004	This Information Guideline is intended to assist prospective proponents of development activities in Papua New Guinea to meet their legal obligations under Section 52 of the Environment Act 2000 (the "Act"). The Act requires a person or company that intends to carry out a proposed Level 3 activity to prepare and submit an Environmental Inception Report.	○
<b>Related Protected Area</b>				
1	Fauna (Protection and Control) Act: 1966		This Act provides for the establishment of Wildlife Management Areas. Local communities are established (and gazetted ) and operational rules are prepared and approved (which must be compatible with the purpose of the Act).	○
2	National Parks Act 1982:		This Act provides a process for the establishment of National Parks.	○
3	Conservation Areas Act 1978		This Act provides for the establishment of protected conservation areas.	○
4	Forestry Act 1991		This Act provides the permission procedure on the forest use, namely "Timber Permit".	○
<b>Related to Land Acquisition</b>				
1	Land Act 1996	1996	The law provides procedures apply to the acquisition of land and assets by the State, legally owned/leased by other parties (persons) than the State. The also define the land tenure system in the country. The land categorized as two, customary and Alienated lands. The land acquisition by state made 2 ways, 1) by agreement; or 2) by compulsory process.	○
2	Land Groups Incorporation Act, 1974	1974	The law provides the outline of the registration of incorporated land groups and its procedure. The purposes of the Act are to encourage– (a) greater participation by local people in the national economy by the use of the land; and (b) better use of such land; and (c) greater certainty of title; and (d) the better and more effectual settlement of certain disputes, by– (e) the legal recognition of the corporate status of certain customary and similar groups, and the conferring on them, as corporations, of power to acquire, hold, dispose of and manage land, and of ancillary powers; and (f) the encouragement of the self-resolution of disputes within such groups.  (Current situation of the Land Groups Incorporation Act based on the governmental review (especially related to Mining)?)	○
3	Valuation Act 1967	1967	The law provides the valuation of the property on the registration of land values and other purposes.	○
4	Survey Act 1969	1969	The law provides the registration of surveyors and the regulation of the practice of land surveying, and for related purposes. This Act applies only to and in relation to surveys of	○

			the boundaries of, or for the purpose of the establishment, re-establishment or determination of titles to, land, and other surveys authorized by the Surveyor General.	
5	National Land Registration Act 1977	1977	The law provides the national land registration, for the registration in the Register of National Land of all land acquired or to be acquired by the State.	○
6	Land Registration Act 1981	1981	The law provides the registration of the land for its use, describing the case of lease the lands.	○
7	Land Disputes Settlement Act 1975	1975	The law provides efficient and effective machinery for the settlement of disputes in relation to interests in customary land by— (a) encouraging self-reliance through the involvement of the people in the settlement of their own disputes; and (b) the use of the principles underlying traditional dispute settlement processes.	○
8	Land (Tenure Conversion) Act 1963	1963	An Act Relating to the Conversion of the Tenure of Customary Land into Individualized Tenure, and for other purposes.	○
9	Organic Law on Provincial Governments and Local-level Governments,	2009	The law provides for some changes to the financial arrangements for the fiscal years 2004 to 2008 and a new intergovernmental financing system for the 2009 fiscal year and beyond aiming to have a similar financial capacity to meet the cost of its assigned service delivery functions and responsibilities between each Provincial Government, urban Local-level Government and rural Local-level Government. This consistent with the Constitution's Second National Goal and Directive Principle of equity and participation.	○

Source: ADB (2009) Papua New Guinea: Power Sector Development Plan, Legal Office FAO Lex: <http://faolex.fao.org/> , Pacific Islands Legal Information Institute - Pacific Law: <http://www.paclii.org/>