No.

Japan International Cooperation Agency
Department of Energy, Republic of the Philippines
Provincial Government of Palawan, Republic of the Philippines

The Master Plan Study of Power Development In Palawan Province Republic of the Philippines

Final Report (Annex)

September 2004

Chubu Electric Power Co., Inc.

Nomura Research Institute, Ltd.

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Contents

Attachment - A

Mini and Micro Hydropower Development Plan

A.1 Outline of the Study on Mini and Micro Hydropower Development

A.1.1 Study Objective

The Master Plan for Power Development in Palawan (hereinafter referred to as the "Master Plan") consists of two main plans for power development in Palawan, one is the barangay electrification plan, and the other one is the power development plan of the EC-grid.

As for the barangay electrification, to achieve the main goal of the Master Plan, name electrification of all barangays by 2006, several power sources are selected reflecting the social and economic conditions of each barangay. Hydropower technology using hydro resources that exists near the demand site, which is referred to as a micro hydropower plant, can be a candidate power source for electrification by a mini-grid system.

On the other hand, all existing power plants in the EC-grid system are diesel power plants and presently there are no hydropower plants in the EC-grid. Generally, hydropower plants have some advantages over diesel power plants, and they can also be candidate power sources for the expansion of the EC-grid system.

In this context, an examination on the possibilities for hydropower development in Palawan is one of the essential contents for formulating the Master Plan.

The objectives of the study on Mini and Micro Hydropower Development in the Master Plan Study are as follows:

1) To create the plan for mini and micro hydropower development based on the evaluation of energy potential of hydropower and the environmental considerations in Palawan

2) To transfer the techniques and expertise to the counter parts assigned from the DOE and the PGP through the collaborative work for creating the plan

A.1.2 Scope of the Study

The area examined in the study covers all of Palawan, and the contents are as follows:

- To collect the information on hydropower development in the Philippines and Palawan
- To review and evaluate past desk studies
- To find new potential sites for mini and micro hydropower in Palawan
- To design the facilities of the power plants evaluated as appropriate sites
- To estimate the power plant development costs
- To select the projects for barangay electrification and the power development of the EC-grid.

A.1.3 Operational Unit

In the Study, the PGP organized the Working Groups in each study fields and each technical field in order to establish a more efficient technical transfer system. And the WG for mini and micro hydropower was organized and staff from DOE, PGP and NPC were assigned to them. Then the study on mini and micro hydropower development was carried out in collaboration among these groups.

Table A.1.1 shows the list of members of the WG for mini and micro hydropower in the Study.

Table A.1.1 Members of the WG for Mini and Micro Hydropower in the Study

Name	Affiliation
Yoshiki MIZUGUCHI	JICA Study Team
Hiroshi OZAWA	JICA Study Team
Roberto ABACIAL	PGP
Arturo F. TORRALBA, JR.	DOE
Epifanio G. GACUSAN, JR.	DOE
Winifredo S. MALABANAN	DOE
Arnulfo M. ZABALA	DOE

A.1.4 Basic Policy of the Study on Mini and Micro Hydropower Development

The study on the mini and micro hydropower was conducted with the basic policy outlined below, which was formulated along the basic policy of the Master Plan Study.

The basic policy is as follows:

Making the plan based on the examination of the potential energy

Hydropower heavily depends on the site conditions such as topography, river flow and geology. Therefore, the quantity of the potential hydropower energy based on the objective data should be evaluated and it can improve the precision of the results of the study.

Taking into account environmental conservation

As with the basic policy of the Master Plan, the Study team took into account environmental conservation in the planning of mini and micro hydropower developments. In examining the potential energy, the constraints from ECAN were considered. And the cost of the environmental impact assessment for installing the power plant was included in the project cost.

Making the Plan in Collaboration with the Counterparts

The objective of the Master Plan is not only formulating the power development plan, but also facilitating the technical transfer to the counterparts in the Study. Therefore, the Study team basically conducted the survey in the Philippines. The study for mini and micro hydropower was also conducted with the staffs of the WG and they accompanied the data collection and field surveys with the Study team.

A.1.5 Study Flowchart

Figure A.1.1 shows the flowchart for the study on mini and micro hydropower development.

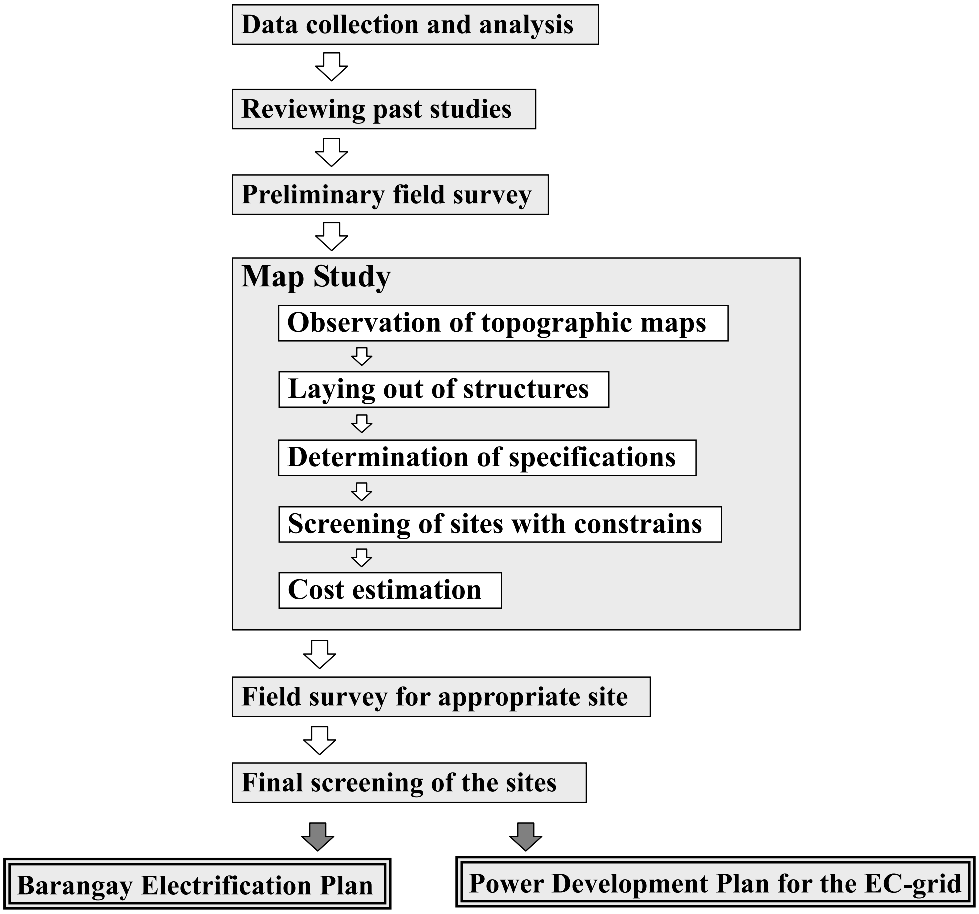


Figure A.1.1 Study Flowchart

A.2 Organizations Involved with Mini and Micro Hydropower in the Philippines

In this section, the organizations involved with mini and micro hydropower are listed in order to make it easier to understand who is in charge of different aspects and to make it easier to contact these parties when there are questions.

A.2.1 Renewable Energy Management Division, Department of Energy (REMD, DOE)

Address: Energy Center, Merritt Road, Fort Bonifacio, Taguig, Metro Manila
Phone Number: (632) 840-1401 Ex.204 **Fax Number:** (632) 840-2092
URL: http://www.doe.gov.ph/

The Renewable Energy Management Division is one division in DOE, which is responsible for promoting new and renewable energy such as micro hydropower, solar power, wind power and ocean power under the Republic Act 7638, which is called the "Department of Energy Act of 1992."

The Republic Act mandated the DOE to formulate and implement a program for the accelerated development of non-conventional energy systems and the promotion and commercialization of their application. Therefore, the DOE established a Renewable Energy Management Division to implement these kinds of projects directly.

The roles of REMD are:

(1) To promote indigenous new and renewable energy in the Philippines
(2) To study potential sites for micro hydro, wind, solar, biomass and ocean power
(3) To help other organizations such as LGUs, NGOs and private companies develop new and renewable energy technically and financially
(4) To collect technical information about new and renewable energy by making use of international conferences, reports, thesis and other materials.
(5) To raise the barangay electrification ratio and household electrification ratio in the Philippines in cooperation with NEA using new and renewable energy

REMD is distributed in two major compartments; namely the hydropower team and the new and renewable energy team. There are 8 staff members in the hydropower team including 5 civil engineers, 2 geologists and 1 clerical staff. They studied potential hydropower sites throughout the Philippines and give technical advice to ANECs, local government units, NGOs, and other organizations according to proposals submitted to REMD. Private companies that are eager to run new and renewable energy projects are included. REMD also allocates a renewable energy fund to them if a proposal deserves the fund from such viewpoints as environmental aspects, organizational aspects and technical aspects. Therefore, consulting REMD when planning a renewable energy project is strongly recommended.

The hydropower potential in the entire Philippines, which DOE has found so far, is shown in Figure A.2.1 as a reference[1].

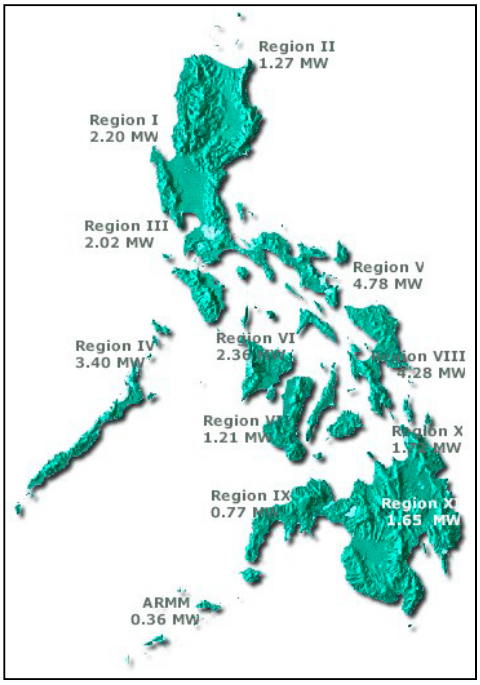


Figure A.2.1 Hydropower Potentials in the Philippines

A.2.2 National Power Corporation-Small Power Utility Group (NPC-SPUG)

> **Address:** Agham Road Corner Quezon Avenue, Diliman, Quezon City
> **Phone Number:** (632) 921-3319 (Mr. Rene B. Barruela) **Fax Number:** (632) 921-3230
> **URL:** http://www.napocor.gov.ph/

National Power Corporation is a Filipino government-owned electric power company. NPC possess generators, transmission lines and substations in the Philippines and monopolistically buys electricity from IPPs.

Small Power Utility Groups in NPC has responsibility for the generation and transmission of electricity in areas where the power business is not profitable (so-called "missionary electrification") and sells electricity to rural electrification cooperatives. In order to promote

[1] Source: DOE homepage

missionary electrification, NPC-SPUG is given the universal charge by the government that is collected from each customer.

In Palawan, NPC-SPUG runs only transmission business from Puerto Princesa to Brooke's Point. Although rural areas in Palawan can be missionary areas, NPC-SPUG is not very interested in operating generators because of the flow of NPC privatization. However, since NPC-SPUG has experience in the construction and operation of hydropower, they have the hydropower expertise and techniques and the willingness to give technical assistance. When planning a hydropower project, they should be asked for help in planning, construction, operation and other aspects.

A.2.3 Palawan Electrification Cooperative (PALECO)

Address: National Highway, Bgy. Tiniguiban, Puerto Princesa City
Phone Number: (6348) 433-2001 **Fax Number:** (6348) 433-9144

An Electrification Cooperative is a cooperative to supply electricity to determined areas with the guidance and funds from NEA. Since NEA has a responsibility to supply electricity to rural areas, ECs under NEA have also the same responsibility and so locates in rural areas. There are 115 ECs under NEA and 4 ECs out of NEA's management in the Philippines. The main functions of an EC are as follows:

(1) Distribute electricity to customers
(2) Collect electricity charges
(3) Maintain distribution lines
(4) Plan distribution lines
(5) Report financial conditions to NEA

The Palawan Electrification Cooperative is one EC that has the responsibility to distribute electricity in Palawan Province. PALECO should be consulted for the planning of not only distribution lines, but also mini-grids in Palawan as well.

A.2.4 Palawan Council for Sustainable Development (PCSD)

Address: Balay Y Ang Banua, Sports Complex Road, Sta. Monica Heights, Puerto Princesa City, Palawan
Phone Number: (6348) 433-8605 **Fax Number:**
URL: http://www.pcsd.ph/ **Email:** oed@pcsd.ph

The Palawan Council for Sustainable Development is directly under the Office of the President of the Republic of the Philippines and is a multi-sectoral and inter-disciplinary body, which under the law is charged with the governance, implementation and policy direction of the Republic Act 7611 or the Strategic Environmental Plan for Palawan Act. Its functions are as follows:

(1) Formulate plans and policies as may be necessary to carry out the provisions of this Act
(2) Coordinate with the local governments to ensure that the latter's plans, programs and projects are aligned with the plans, programs and policies of the SEP
(3) Coordinate with local government and private agencies/organizations for cooperation and assistance in the performance of its functions
(4) Arrange, negotiate for and accept donations, grants, gifts, loans and others for the SEP
(5) Recommend to the Congress of the Philippines such matters that may require legislation in support of the objectives of the SEP
(6) Delegate its powers and functions to its support staff
(7) Establish policies and guidelines on compensation and staffing patterns
(8) Adopt, amend and rescind such rules and regulations related to the SEP
(9) Enforce the provisions of the SEP Law
(10) Perform related functions that shall promote the development, conservation, management, protection and utilization of the natural resources of Palawan.

PCSD is mainly in charge of management, protection and provision of ECAN, which is described in detail in the Chapter 3 of the Technical Background Report. In planning mini and micro hydropower, we should consider the ECAN zoning since most of hydropower plants are generally constructed in mountain areas where there is the possibility of being in some environmentally strict zones.

Under the present condition that the zoning has been verified and updated, however, the planning of potential hydropower areas would be outside of the strict zones after updates are made. Therefore, confirmations must be made with PCSD regarding whether the area is in or out of the strict zones when planning the project.

Also, PCSD has periodically measured the river flows once or twice a year for some rivers. The detail description of river flow measurements is provided in A.3.6.

A.2.5 Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)

Address: Science Garden Complex, Agham Road, Diliman, Quezon City
Phone Number: (632) 434-2696 **Fax Number:** (632) 434-2696
URL: http://www.pagasa.dost.gov.ph/

Philippine Atmospheric Geophysical and Astronomical Services Administration is a national organization that provides protection against natural calamities and utilizes scientific knowledge as an effective instrument to insure the safety, well-being and economic security of all the people, and promotes of national progress.

PAGASA has the following functions:

(1) Maintain a nationwide network pertaining to observation and forecasting of weather and other climatological conditions affecting national safety, welfare and economy
(2) Undertake activities relative to observation, collection, assessment and processing of atmospheric and allied data for the benefit of agriculture, commerce and industry
(3) Engage in studies of geophysical and astronomical phenomena essential to the safety and welfare of the people
(4) Undertake research on the structure, development and motion of typhoons and formulate measures for their moderation
(5) Maintain effective ties with scientific organizations here and abroad, and promote exchanges of scientific information and cooperation with personnel engaged in atmospheric, geophysical and astronomical studies

PAGASA has measured climatological conditions all over the Philippines such as rainfall, humidity, atmospheric pressure, wind power and wind direction. In Palawan Province, PAGASA has three measuring points (Puerto Princesa, Coron and Cuyo).

In planning mini and micro hydropower, weather data such as the rainfall and humidity are significant and so need to be collected to grasp the weather conditions in the potential areas for the plan.

A detail description about the weather data is provided in A.3.3.

A.2.6 National Mapping Information Authority (NAMRIA)

Address: Lawton Avenue, Fort Andres Bonifacio 1201, Makati City, Metro Manila
Phone Number: (632) 810-4831 **Fax Number:** (632) 810-5468
URL: http://www.namria.gov.ph/

The National Mapping Information Authority is an agency attached to the Department of Environment and Natural Resources (DENR). It provides geographic and resource information through its surveying, land classification, remote sensing, mapping, information management and dissemination services to both the public and private sectors. Especially in mapping, the remote sensing services are provided by the National Remote Sensing Center (NRSC). Services include the analysis, interpretation and processing of satellite data for the inventory, assessment and monitoring of environment and natural resources.

NAMRIA provides paper-based maps, digital data maps, satellite imageries and aerial photography. The paper-based maps and digital data maps of Palawan are as follows.

Table A.2.1 Paper-Based Maps

Topographic Maps		
	1:250,000	11 maps
	1:50,000	94 maps
Land Use & Forest Type Maps		
	1:100,000	14 maps
Land Cover Maps		
	1:250,000	7 maps
Administrative Maps		
	1:100,000	1 maps
Nautical Maps		
	1:402,000	1 maps
	Depending	30 maps

Table A.2.2 Digital Data Maps

Administrative Boundary Database		
	1:100,000	0.433MB
Land Cover Database		
Nautical Charts		
	1:100,000	2 sets

A.2.7 Mines and Geosciences Bureau (MGB)

Address: 2/F J. Fernandez Bldg., MGB Comp. North Ave.Diliman Quezon City, Metro Manila
Phone Number: (632) 928-8310 (Publication Section)
URL: http://www.mgb.gov.ph/ **Email:** central@mgb.gov.ph

The Mines and Geosciences Bureau is an organization that is responsible for the administration of mineral lands, geoscientific surveys and research, improvement of geo-technology and provision of geoscientific information. The mandates of MGB are as follows:

(1) Directly in charge of the administration and disposition of the country's mineral lands and mineral resources
(2) Undertake geoscientific surveys and research in the fields of land and marine geology, mining, mine environment, metallurgy, mineral economics and mine geodetic surveys
(3) Recommends to the Secretary the granting of Mineral Agreements and endorses the Secretary, for approval by the President, the granting of Financial or Technical Assistance Agreements (FTAA)
(4) Provide laboratories and other technical services to the public and other government entities
(5) Provide technical assistance to local government units in their performance of devolved functions on small-scale mining and quarry/sand and gravel mining operations
(6) Provide staff support and technical advice to the Office of the Secretary on mining and geology matters

MGB also provides geological maps that are significant for hydropower planning in the determination of a dam sites and a penstock sites. Although geological information is not so important for mini and micro hydro planning because of its scale, this information could be a used in the criterion for selecting an appropriate site.

The number of available maps that have been completed and published as of October 2003 is 11.

A.2.8 National Irrigation Authority(NIA)

Address: Government Center, EDSA, Diliman, Quezon City
Phone Number: (632) 929-6071
URL: http://www.nia.da.gov.ph/Index.htm

The National Irrigation Authority is an organization that is responsible for the promotion and maintenance of irrigation systems in the Philippines.

The powers and functions of NIA stipulated under Republic Act 3601 and PDs 552 and 1702 are:

(1) To investigate, study and develop all available water resources in the country, primarily for irrigation purposes
(2) To plan, design, construct and/or improve all types of irrigation projects and appurtenant structures
(3) To operate, maintain and administer all national irrigation systems (NIS)
(4) To supervise the operation, maintenance and repair, or otherwise, administer temporarily all communal and pump irrigation systems constructed, improved and/or repaired wholly or partially with government funds
(5) To delegate the partial or full management of NIS to duly organized cooperatives or associations; and to charge and collect from the beneficiaries of all irrigation systems constructed by or under its administration such fees or administration charges as may be necessary to cover the costs of operations, maintenance and insurance; and to recover the costs of construction within a reasonable period of time to the extent consistent with government policy; to recover funds or portions thereof expended for the construction and/or rehabilitation of communal irrigation systems (CIS) that shall be accrued to a special fund for irrigation development

NIA has also been measuring daily river flows in rivers in which NIA has irrigation structures or is planning such structures. The data can also be used for mini and micro hydropower development planning. Therefore, when planning it is useful to ask NIA the river flow data they have for parts of Palawan.

A.2.9 Department of Public Works and Highways (DPWH)

Address: A. Bonifacio Drive, Port Area , Manila
Phone Number: (632) 304-3397 (Bureau of Construction)
URL: http://www.dpwh.gov.ph/

The Department of Public Works and Highways is one of the three departments of the government undertaking major infrastructure projects. The DPWH is mandated to undertake (a) the planning of infrastructure, such as roads and bridges, flood control, water resources projects and other public works, and (b) the design, construction, and maintenance of national roads and bridges, and major flood control systems. These activities are undertaken in support of the national objectives of (a) alleviating rural poverty and attaining food security, and (b) expanding industries for greater productivity and global competitiveness as envisioned in the Medium-term Philippine Development Plan for 1999 to 2004.

Since DPWH is an orderer of public works, including civil works, it posses much information about unit costs for civil works such as concrete works, form works and paving works. Therefore, their information is useful for estimating the costs of civil works in the planning of a mini and micro hydropower plants. However, it should be noted that most of this kind of information is confidential. Careful attention is needed to acquire this information.

A.2.10 Philippine National Construction Corporation (PNCC)

Address: EDSA corner Reliance Street, Mandaluyong City, Metro Manila
Phone Number: (632) 631-8431
URL: http://www.pncc.net/

The Philippine National Construction Corporation is a state-owned corporation entrusted with the construction of roadways and industrial infrastructure projects. Established in 1966, PNCC has provided big construction projects such as the San Juanico Bridge between Western Samar and Northern Leyte, Light Rail Transit and the Metro Manila Skyway in Metro Manila.

Since PNCC has a great deal of construction experience, it also posses much information about the unit costs of civil works. Therefore, their information is useful for estimating costs of civil works when planning projects.

A.2.11 Affiliated Non-Conventional Energy Center (ANEC)

SPCP-ANEC (State Polytechnic College of Palawan-ANEC)
Address: State Polytechnic College of Palawan, Aborlan, Palawan
c/o Ms. Ericka dela Pena SPCP-IMS, Sta Monica Heights Tiniguiban, Puerto Princesa City, Palawan
Phone Number: (6348) 433-4480

An Affiliated Non-Conventional Energy Center is a college or university, which the Renewable Energy Management Division in DOE has entered into an agreement to oversee the administration and management of Area-Based Energy Programs with the goal of developing and promoting the use of technically and economically viable new and renewable energy systems. ANECs are entrusted with the formulation of these local energy plans and assists in the coordination, monitoring and implementation of projects and activities identified in consultation with REMD and other concerned institutions. The activities of ANECs are as follows:

(1) Conduct of nationwide census of all NRE system installations
(2) Establish and maintain a provincial-level energy database
(3) Assess energy resources in the province
(4) Conduct provincial-level studies
(5) Formulate Area-Based Energy Plans
(6) Implement, coordinate, monitor and evaluate various projects and activities under the plan

There are 20 ANECs throughout the Philippines, and one in Palawan. The State Polytechnic College of Palawan-ANEC is one such ANEC in Palawan. SPCP-ANEC has experience in setting up and managing PV systems, but does not have any experience in hydropower. Therefore, in order to develop and promote mini and micro hydropower plants effectively and efficiency, training SPCP-ANEC and having close relationships with them are both essential and significant.

A.3 Information Concerning Hydropower in Palawan

A.3.1 Data Collection

The Study team collected plenty of data for the potential survey of mini and micro hydropower from various organizations and agencies described in Section A.2. Table A.3.1 shows a list of the collected data in the Study for mini and micro hydropower development..

Table A.3.1 List of Data Collected for the Potential Survey of Mini and Micro Hydropower

Item	Source Agency	Specification	Remarks
Topographic Maps	NAMRIA	Scale 1:50,000, approx. 90 sheets	
Geological Maps	MGB	Scale 1:50,000	Northern part
Rainfall Data	PAGASA	Puerto Princesa City , Cuyo, Coron	40 years
	PIADPO	14 sites	1 to 9 years
Discharge Data		16 sites	2 to 5 years
ECAN Maps	PGP	All of Palawan	GIS DATA*
Barangay Base Maps	PGP	All of Palawan	GIS DATA*
Past Studies on Potential Sites	DOE	47 sites	Desk study
	NPC		
	NEA		
	PGP		
F/S Report	DOE	Cabinbin, Langogan, Babuyan, Batang Batang	Feasibility study

*Note: Only shape file for GIS data is available to use

A.3.2 Topographic Conditions and Constraints in Palawan

Palawan Province consists of a main island, "Palawan Island", and many small islands. In the smaller islands there are generally no rivers. Even if there are rivers, they tend to be short and have little water, which makes them unsuitable for hydropower on these islands.

Palawan Island is approximately 390km in length and 8km in width at the narrowest point. There are backbone mountains at the center of island from north to south and a series of mountains taller than 1,000m height (see Figure A.3.1). These mountains determine the direction for most of the rivers in Palawan,

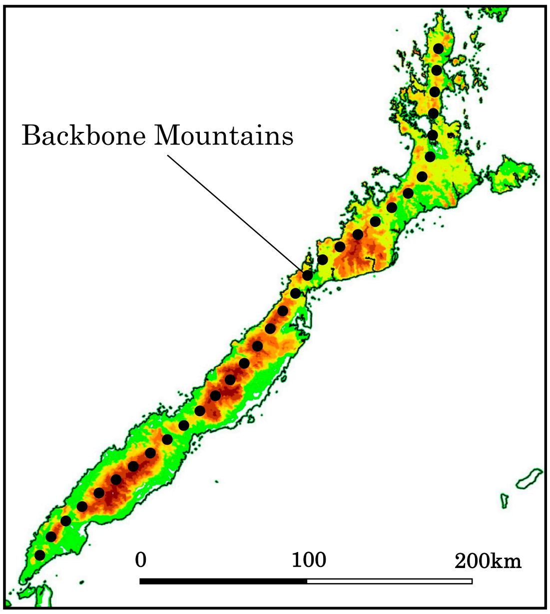


Figure A.3.1 Topographic Conditions in Palawan which are mainly toward the northwest on the north side and to the southeast on south side (see Figure A.3.2).

As a result, the lengths of most of rivers in Palawan Island are relatively short and also the river catchment areas are small. However, some rivers have relatively big catchment areas.

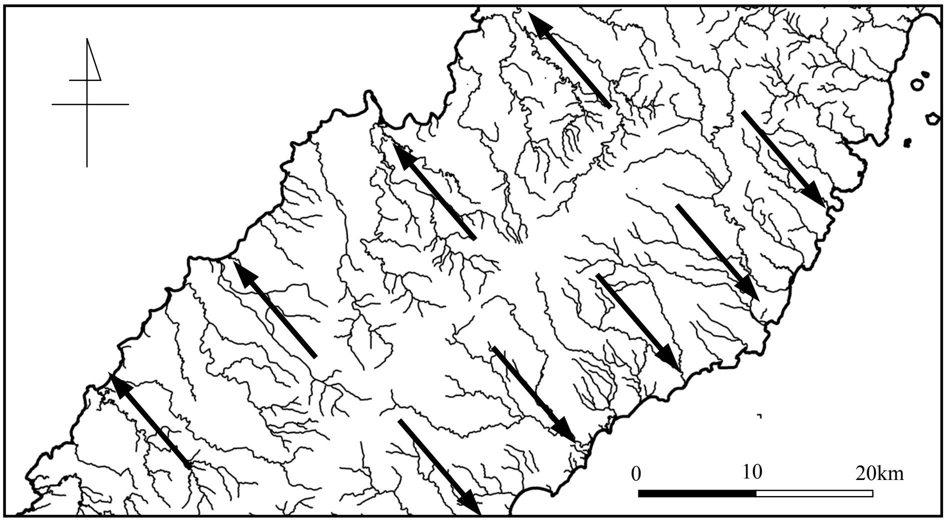


Figure A.3.2 Directions of River Flows in Palawan

Figure A.3.3 shows an example of a typical river in Palawan. In this case, the river flows from northwest to southeast. Around downstream of the river there is an alluvial plain field. At the midstream of river, the topography suddenly becomes mountainous. In the figure almost half of the river length flows in the plain field.

An appropriate site for hydropower is generally located in a mountainous area. Therefore, a candidate site for hydropower is limited by the characteristic of river location as in this example.

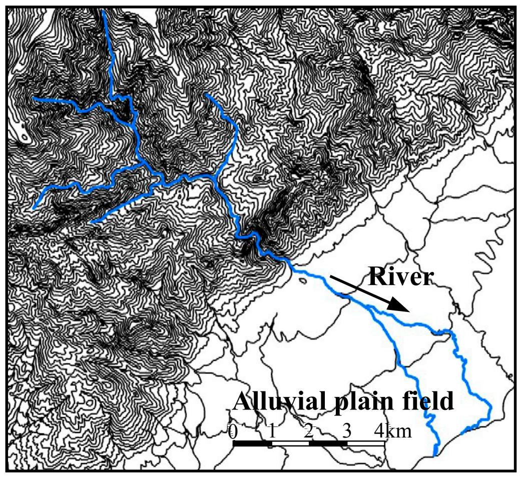


Figure A.3.3 Locations of River in Palawan

A.3.3 Precipitation Conditions and Constraints in Palawan

Palawan has a tropical monsoon climate, with a distinct rainy season and a dry season. PAGASA has a series of past rainfall data that was measured at 3 gauging stations (Cuyo, Coron and Puerto Princesa) in Palawan. All of these stations are located on the east coast side (see Figure A.3.4).

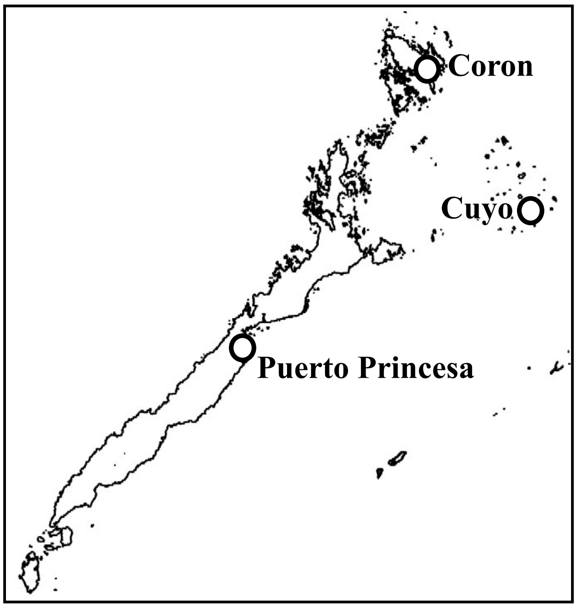


Figure A.3.4 Locations of Rainfall Gauging Stations

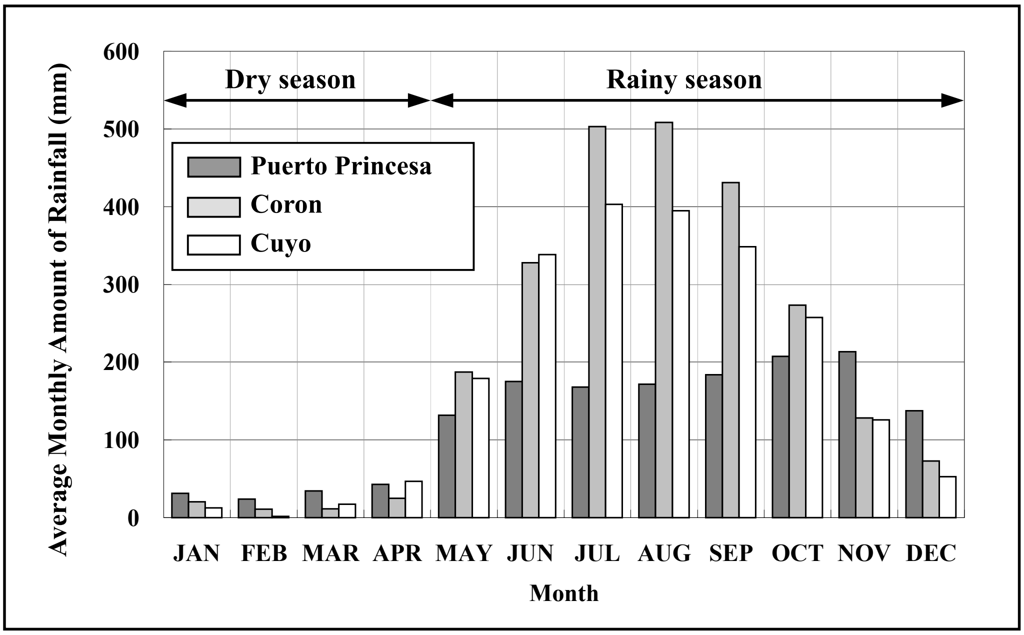
The gauging period for the data that was collected in the Study is from 1961 to 2000. Although some data are missing, they have been interpolated using averaging data for each month. Table A.3.2 shows the average annual amount of rainfall, which indicates that the average annual rainfall of Puerto Princesa is 1,521mm.

Most of the rainfall occurs in the period from May to December. The period from January to April is the dry season in Palawan and there is only a trace of rainfall in this dry season (see Figure A.3.5).

Table A.3.2 Average Annual Rainfall

Name of Gauging Station	Average Annual Rainfall
Puerto Princesa	1,521 mm
Coron	2,500 mm
Cuyo	2,177 mm

Source: PAGASA



(Source: PAGASA)

Figure A.3.5 Average Monthly Amount of Rainfall

A.3.4 Geological Conditions and Constraints in Palawan

The geology of Palawan is presented in the published 1:1,000,000 scale Geologic Map of the Philippines (Bureau of Mine, 1964) and described in a report "Small Hydropower Projects of the Visayas Islands (Feasibility Study Volume IV: Palawan Projects)" (by Sir William Halcrow & Partners Ltd., October 1992) provided below.

Basement rocks of north-eastern Palawan are of Palaeozoic and Mesozoic age and are widely believed to be part of a continental unit which includes Mindoro and the northern tip of Panay. The unit is thought to have been rifted from the coast of China during late Cretaceous or Palaeogene times at the onset of sea-floor spreading which created the South China sea.

North-east Palawan is tectonically separated from the south-west side of the island by a fault, the Ulugan Bay Fault, which is orientated from north to south. The fault is visible on Landsat photographs of the sea. It is reported (Hutchinson and Tayler, 1978) that high-grade mercury ore is mobilizing along the trace of the fault, supporting the tectonic significance of the zone.

West of the fault is a complex mixture of ophiolites and Tertiary melange (an imbricated mixture of highly sheared rocks and scaly clay) which continues along the Palawan submarine ridge towards the coast of Borneo. Overlying this disturbed zone are largely under formed Lower Miocene and more recent strata.

According to a staff of the DOE, geological formations made from the limestone are spread widely throughout Palawan. And a staff member with the PGP commented that the limestone formations are especially common in the area around the St. Paul Mountain, which is located in the middle of the main island (see Figure A.3.6).

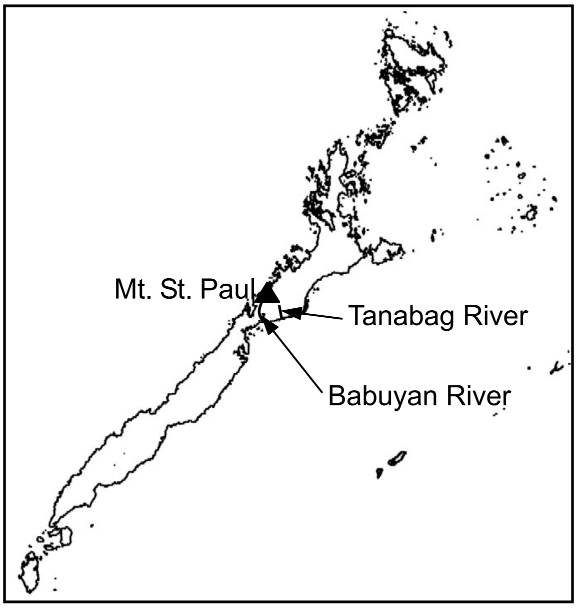


Figure A.3.6 Locations of Mt. St, Paul, Tanabag Riv., Babuyan Riv.

Actually, in the report by Harclow it is described that in the area along Babuyan river, which flows from the St. Paul Mountain into Honda Bay, there are remnant limestone stacks of the St. Paul's Limestone. Additionally, according to the river flow data at Tanabag River, which flows in the above area, although the site of the gauging station has a catchment area of 52 km^2, there is no water in the river during the dry season. The total number of days without water in a year is around 110 days. In the Study, the Study team could not confirm the river conditions since the Study team did not visit the site. However, it is thought that limestone widely spread around the area causes this river condition.

Table A.3.3 shows the river flow data of the Tanabag River from 1995 to 1999.

Table A.3.3 River Flow Data of Tanabag River

Year	1995	1996	1997	1998	1999	Average
No. of Days (Flow)	290	279	240	249	217	255
No. of Days (No water)	75	86	125	116	148	110
Ratio of No. of Days (No water)in a year (%)	20.5	23.6	34.2	31.8	40.5	30.1

(Source: PIADPO)

A.3.5 Topographic Maps of Palawan

The topographic maps on the scale of 1:50,000 and 1:250,000 are available for Palawan. These maps are available for purchase at NAMRIA.

There are 94 maps covering all of Palawan. Maps of a larger scale are required for the detailed designs of hydropower structures.

Figure A.3.7 shows the map numbers and the coverage area of 1:50,000 topographic maps.

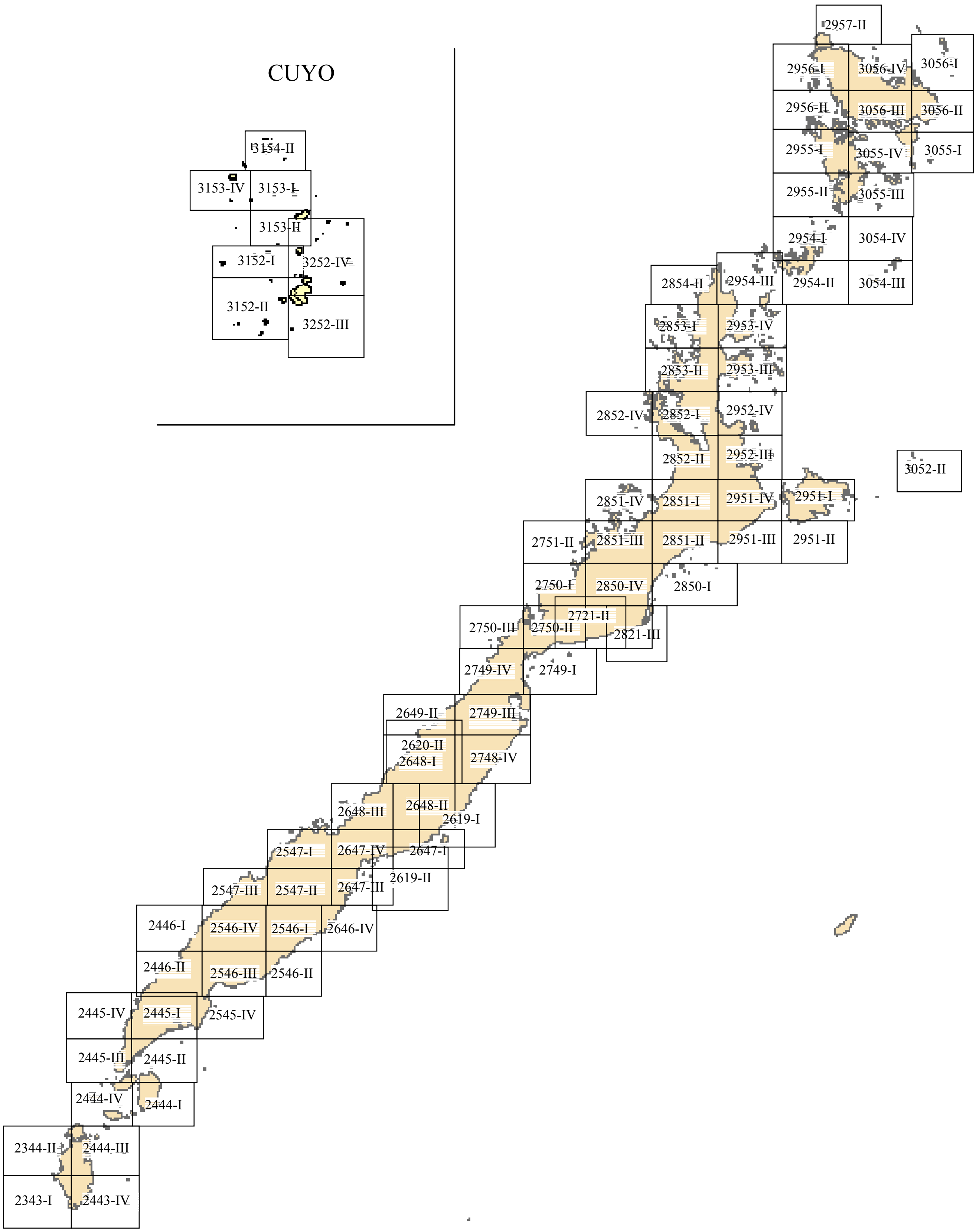


Figure A.3.7 Topographic Map Numbers and Coverage

A.3.6 River Flow Data in Palawan

In recognition of the major gaps in water resources data in Palawan, in 1984 the Hydrometric Network Program (HNP), which is fully financed by the European Economic Community (EEC), was initiated by the Palawan Integrated Area Development Project Office (PIADPO). The program aims to gather and compile hydro-meteorological data in sufficient quantity and quality, which will be very useful for water resources planning in the province. As of 1985, twenty (20) river stations have been established.

Before, PIADPO used flow database software for processing and storing river level data, stage discharge current meter data and flow data in an ordered manner. This makes the data easily accessible, and the processed data can be tabulated and plotted in a form suitable for presentation and for hydrological analysis.

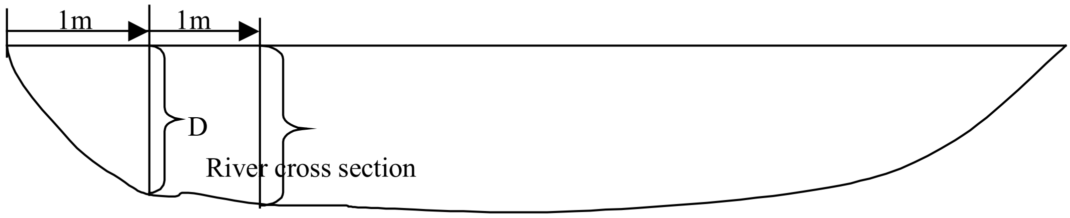
At present, there are two personnel assign for measuring river discharge. Measurements are scheduled for every quarter of the year or in four-month interval. There are 11 river-flow gauging stations located in the southern part and 3-river flow gauging stations in the northern part of Palawan. There are no differences in the measuring methods and instruments used from the launch until present. A list of gauging stations is shown in Table A.3.4.

Table A.3.4 List of River Flow Gauging Stations in Palawan

Gauging Stations	Barangay / Municipality	Location		Drainage Area (km2)
		Northing	Easting	
Abongan river	Abongan / Taytay	10º 39' 28"	119º 25' 59"	59.0
Inandeng river	San Vicente	9º 33' 57"	118º 35' 25"	19.0
Guineratan river	Magara / Roxas	10º 15' 36"	119º 11' 48"	126.0
Bacungan river	Bacungan / PPCity	9º 54' 37"	118º 41' 44"	34.0
Iraan river	Iraan / Aborlan	no data	no data	no data
Aborlan river	Tagpait / Aborlan	no data	no data	no data
Batang - Batang river	Princess Urduija / Narra	9º 15' 31"	118º 18' 6"	123.0
Calatuegas river	Calatuegas / Narra	no data	no data	no data
Aramaywan river	Aramaywan / Narra	no data	no data	no data
Panitian river	Panitian / Quezon	no data	no data	no data
Labog river	Labog / Española	no data	no data	no data
Pulot river	Pulot / Española	9º 0' 30"	117º 55' 54"	83.0
Tigaplan river	Tigaplan / Brooke's Point	no data	no data	no data
Tamlang river	Tamlang / Brooke's Point	no data	no data	no data

Valleport flow meters are used for measuring river flow. These stations measure the river flow for every 1 meter interval across the river (see Figure A.3.8). Flow meters are placed at the middle of the height of the water for every measuring point. But the location of each flow meter depends on the conditions of the river flow. They can be placed it in the middle or higher or lower than the middle of the height of the water. Even if a flood occurs, they don't measure the shape of the riverbed, but they always just measure the height of the water.

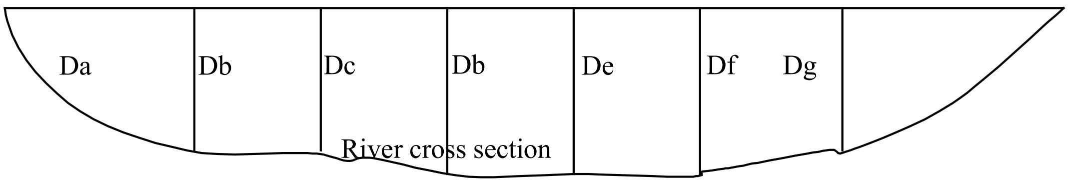
Figure A.3.8 shows the measuring method, which is used by PCSD.



Where : D = Water height

To find the discharge of the river for every section they used the formula

Discharge = 1m x Dx flow velocity



Discharge of river $= D_a + D_b + D_c + D_e + D_f + D_g$

Figure A.3.8 River Flow Measuring Method in Palawan

Locations of the gauging stations for discharge data are shown in Figure A.3.9.

The data from 2 stations is limited in terms of the gauging period (2 years) and the data from 1 other station is not applicable. As a result, data from 13 stations is available. The data from the gauging station is daily discharge data. There are some areas in which data is insufficient, so these data have been interpolated by averages for other existing data of the same day in other years in the Study.

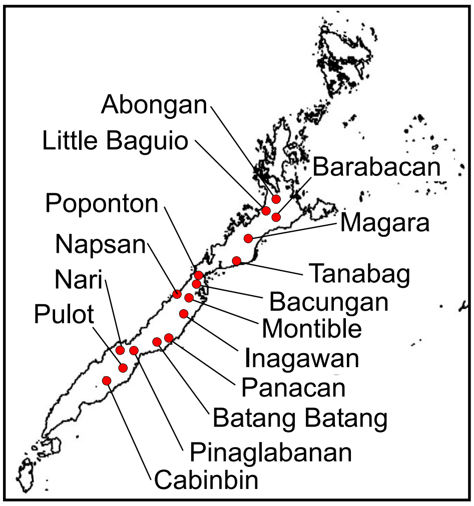


Figure A.3.9 Locations of Gauging Stations for River Flow

There are some problems in using the data. One is the gauging period for updates, and the other is the collapse of the system.

The gauging period is only from 1995 to 1996, which is a remarkably short period for the examination for a hydropower generation plan. Generally, historical data on river flows over 40 or

50 years is required for design of hydropower generation. Therefore, this may result in poor accuracy for the design.

As for the updating of data, PCSD conducts a field survey for gauging river flow at the gauging sites once or twice a year.

However, gauging needs to be conducted more frequently to better grasp the current conditions of the river.

Collapse of the gauging stations is significant problem. According to a staff member from PCSD, PCSD has no budget for recovering collapsed stations at present and are trying to find the fund for recovering them.

The goal for the continued gauging of river flow is to monitor the forest conditions upstream from the station. PCSD uses the gauged data as an index for evaluating the forest destruction. However, river flow data is useful for several sectors. For example, the data is used for designing the bridge and planning the irrigation project. It is expected that the gauging stations are managed steadily for multi-purpose uses.

Moreover, more detailed studies of hydropower than the Master Plan study, such as a feasibility studies, require the recent and long-term data on river flows. Therefore, early reformation of the system and early installation of the new gauging stations are required for promoting the development of hydropower in Palawan.

A.3.7 Environment Constraints in Palawan

There are six environmentally categorized zones in Palawan, which are called ECAN Zoning" defined by PCSD. Development is prohibited in these zones. These categories would be used for the screening of potential sites (for details, refer to Section 3.7.1 in the Technical Background Report).

The zones are classified according to the criteria of elevation, topographic features, vegetation and land use. As for topographic criteria, the area with slope gradients of over 36% are categorized into the Core Zone or Restricted Use Zone, where all development is prohibit. On the other hand, in regards to elevation, the area with an elevation of over 500m is categorized into these zones. Since the appropriate site for hydropower is generally located in mountainous area and narrower and steeper valleys are generally better for the development of hydropower, this criteria for categorizing works against the development of hydropower.

There are some points that should be noted for the screening of the site for hydropower. One is the accuracy of current ECAN zoning map and the other is the effectiveness of the ECAN zoning.

In the ECAN zoning map, it seems that there are many incomprehensibly categorized areas. For example, the area with gentle slopes categorized as a Restricted Use Zone. Actually, PCSD plans to reexamine the categories. Therefore, when the detailed study for development of hydropower is conducted, planers should ascertain the category of the developed site from PCSD.

As for the effectiveness of the restrictions, ECAN strictly prohibits any development activity in Core Zone and Restricted Use Zone at present. However, if a strongly recommended site for hydropower development is located in one of these restricted zones, the developer or the planer should meet for consultations on the possibility of the implementation of the project.

A.3.8 Land Use in Palawan

Most of the inland area of the main island of Palawan is covered with dense forests, only the narrow coastal flats are devoted to agricultural development. Rice, coconut, bananas and ground-nuts are the traditional products, but the mainstay of the economy is fishing.

Development of the southern half of the island appears to be ahead of the rest of the area as a result of the government's policy and injection of aid by foreign agencies. Pilot plants of more diversified agricultural products are being established, prawn hatcheries are developing and there is a crocodile firm near Puerto Princesa for supply to the tanning industry.

A.3.9 Capability of Contractors for Hydropower Development in Palawan

Contractors in Palawan generally construct buildings, roads, small bridge and other such structures. In Palawan there are some weirs for irrigation and some contractors in Palawan seem construct them. Therefore, it seems that some contractors in Palawan have the capabilities build the structures needed for hydropower such as weirs, intakes, open channeled headraces and tailraces. On the other hand, since some mining companies have mountains for mines, which are mainly located in the southern section of Palawan, and are now mining there, some workers have the basic capabilities for the construction of small diameter tunnels.

In this context, contractors and workers have the capabilities for the construction of some hydropower structures. However, constructing hydropower facilities requires more complex technologies, such as laying penstocks and generators and the constructing of head tanks.
When developing hydropower facilities support from engineers, who have the experience in practical work for hydropower construction, will be essential.

A.3.10 Capability of Organizations involved in Hydropower Development in Palawan

There are no hydropower plants or hydropower engineers in Palawan at present.

In the Philippines, some persons are generally assigned from an ANEC when a micro hydropower project for barangay electrification is approved for implementation.

In Palawan, there is one ANEC in Municipality ABORLAN, but they do not have anyone for hydropower development is there. Therefore, some persons are likely to be transferred from another ANEC to the ANEC in Palawan when a micro hydropower facility is installed in Palawan. However, after completing the installation, they may return back to their original ANEC.

Also there is no on in Palawan that can provide for maintenance of hydropower structures and equipment. After installing the hydropower plants, someone must be responsible for their operation and maintenance.

Consequently, it is important to not only to set up an organization at the beginning of the project, but also to make a program during the installation phase to bring up the persons who will be in charge of the operation and maintenance of the power plant.

A.4 Review of Past Data on Mini and Micro Hydropower in Palawan

A.4.1 Past Map Studies

The potential sites for mini and micro hydropower in Palawan Province that were studied in the past are the 47 sites shown in the Table A.4.1. These are all sites taken from the "Water Resources Inventory Project" studied by DOE in 1995, and other material and information from NEA, NPC and PGP. The past F/S sites are excluded.

Before 1990 NEA was responsible for mini and micro hydropower development in rural areas and so NEA conducted planning of hydropower such as the selection of potential sites and site surveys. The Republic Act No. 7156 promulgated in 1990, however, prescribed that these duties should be transferred to OEA (the present DOE). Therefore, at present, DOE posses these results. Furthermore, NPC-SPUG, an operation and maintenance organization for hydropower, have been conducting surveys for finding potential mini and micro hydropower sites by itself, and has reported this information to DOE. However, mini and micro hydropower are mainly for rural electrification, almost all of which sites are not profitable. Micro hydropower especially has small capacity so that its connection to a grid system is difficult. Therefore, NPC-SPUG is not interested in mini and micro hydropower development. As such, DOE plays almost all roles for the planning of mini and micro hydropower.

After the transfer of the competence, DOE has been conducting mini and micro hydropower site surveys. However, because of the limitations of the DOE's budget and its manpower, the site surveys by DOE have been limited to almost exclusively inside Luzon island. There are no site surveys conducted by DOE on their own.

Table A.4.1 The List of Potential Sites in Palawan Map-Studied in the Past

No.	Name of Site	Location	Name of River	Head (m)	Catchment Area (km^2)	Discharge (m^3/s)	Capacity (kW)	Data from	Remarks
1	Talakaigan	Cabigaan, Aborlan	Talakaigan	80	25.45	1.32	840	DOE	
2	Baraki	Baraki, Aborlan	Aborlan	60	38.05	2.02	960	DOE	
3	Batang Batang	Urduja, Narra	Batang-Batang	80	100.50	5.46	3,590	DOE	FS data
4	Malatgao (1)	Estrella Village, Narra	Malatgao	70	100.45	5.60	3,130	DOE	
5	Malatgao (2)	Taretien, Narra	Malatgao	50	85.00	5.00	1,645	PGP	
6	Iwahig (1)	Bagong Bayan, Puerto Princesa	Iwahig	50	38.00	2.05	820	DOE	
7	Iwahig (2)	Montible, Puerto Princesa	Iwahig	6	-	4.50	20	DOE	

No.	Name of Site	Location	Name of River	Head (m)	Catchment Area (km^2)	Discharge (m^3/s)	Capacity (kW)	Data from	Remarks
8	Iwahig (3)	Montible, Puerto Princesa	Iwahig	35	96.00	5.00	1,310	PGP	
9	Inagawan (1)	Inagawan, Puerto Princesa	Inagawan	60	76.00	4.00	870	PGP	
10	Inagawan (2)	Inagawan, Puerto Princesa	Inagawan	50	103.60	5.80	2,320	DOE PGP	
11	Isaub	Aborlan	Isaub	30	-	0.20	80	DOE	
12	Balsahan	Simpucan, Puerto Princesa	Balsahan	12	-	0.10	15	DOE	
13	Bontong	Puerto Princesa	Bontong	10	-	0.10	8	DOE	
14	Lake Manganao	Taytay	-	10	-	1.20	100	DOE	Pending
15	Barong Barong	Aribungos, Brooke's Point	Barong Barong	15	-	0.10	12	DOE	
16	Sinabayan Falls	Busuanga	-	23	-	0.40	80	DOE	Pending
17	Cabinbin	Brooke's Point	Lala	-	-	-	800	NPC	FS data
18	Estrella falls	El Vita, Narra	Estrella	10	-	1.00	15	DOE	Not suitable
19	Iraan	Aborlan	Iraan		-	0.50	-	DOE	Not suitable
20	Babuyan (1)	Puerto Princesa	Babuyan	20	-	-	-	DOE	Not suitable
21	Babuyan (2)	Puerto Princesa	Babuyan	43.7	172.00	15.40	5,600	PGP	FS data
22	Ilian	Taytay	Ilian	-	-	-	-	DOE	
23	Langogan	Roxas	Langogan	91	59.00	8.90	6,800	DOE PGP	FS data
24	Rizal	Roxas	Rizal	20	-	-	-	DOE	Pending
25	Irahuan	Puerto Princesa	Irahuan	12	-	0.20	20	DOE	
26	Tarabanan	-	-	-	-	-	2,200	NEA	Pending
27	Aborlan	Cabigaan, Aborlan	Aborlan	-	-	-	1,400	NEA	
28	Maoyon	Puerto Princesa	-	-	-	0.20	-	NEA	

No.	Name of Site	Location	Name of River	Head (m)	Catchment Area (km^2)	Discharge (m^3/s)	Capacity (kW)	Data from	Remarks
29	Tanabag	Puerto Princesa	Tanabag	60		-	-	NEA	
30	Tiga	Aribungos, Brooke's Point	Tiga Plan	120	-	-	-	NEA	
31	Lara	Mainit, Brooke's Point	Lara	100	-	-	-	NEA	
32	Imulnod	Imulnod, Brooke's Point	Imulnod	60	-	-	-	NEA	
33	Filantropa	Maasin, Brooke's Point	Filantropa	40	-	-	-	NEA	
34	Bulalakao	Milihud, Bataraza	Bulalakao	80	-	-	-	NEA	
35	Pangbilian	Brooke's Point	Pangbilian	60	-	-	-	NEA	
36	Sabsaban Falls	Brooke's Point	-	5	-	-	-	NEA	Pending
37	Turao	Taytay	Turao	40	-	0.10	30	NEA	
38	Turung Falls	Taytay	-	10	-	0.06	4	NEA	Pending
39	Bakungan	Puerto Princesa	Bacungan	23	60.00	1.00	500	PGP	
40	Nicanor Zabala	Roxas	Tulariquin	120	15.00	2.10	1,700	PGP	
41	Caruray	San Vicente	Caruary	120	3.50	0.49	60	PGP	
42	Sto. Nino	San Vicente	Erawan	160	1.00	0.14	150	PGP	
43	Poblacion	San Vicente	Inandeng	80	2.00	0.28	20	PGP	
44	Bulalakao (1)	El Nido	Bulalakao	140	2.40	0.34	50	PGP	
45	Bulalakao(2)	El Nido	Bulalakao	280	1.60	0.22	60	PGP	
46	Pasadena	El Nido	Nagcalitcalit	120	4.00	0.14	20	PGP	
47	Villa Paz	El Nido	Batacalan	150	1.02	0.14	20	PGP	

Presently, DOE posses the results of the map studies conducted by NEA and NPC-SPUG. However, there is no detailed data used in the studies such as ground plans and back data. Even if there is some partial data such as plant discharge water and catchment areas, most of the data they have is only basic data such as site names, effective heads and installed capacities. The reasons can be inferred that (1) the data has been scattered and lost as more than 10 years have passed since the transfer of jurisdiction, and (2) the back data was seen as personal belongings and so was not taken over by DOE.

A.4.2 Potential Survey for Hydropower

In October 2000 the report "Assessment of Micro-hydro Resourced in the Philippines" was submitted by USAID to DOE. The report is a part of the project report for "Task 7Ba Report Philippine Renewable Energy Project", which was conducted in cooperation with USAID for promotion of investments in the development of micro hydropower in the Philippines.

In the study, the potential for micro hydropower throughout the Philippines was indicated on maps. However, there is only information about maximum capacity and no information about specifications for each micro hydropower plant such as gross head and discharge water. The study also lacks any financial discussions.

The details of micro-hydro potential in Palawan are not described in the report. According to the potential map for Palawan, approximately 50 rivers are described. Most of the rivers have a potential of over 100kW, 34 rivers for over 500kW and 23 rivers for over 1,000kW.

After reviewing the potential data on the map by using GIS software, the sum of the maximum potential for each river was estimated to be approximately 36,000kW for all of Palawan, with the largest one being approximately 3,700kW.

This map may prove to be useful for making preliminary assessments for site surveys in order to find appropriate hydropower sites in Palawan.

However, as mentioned in the report, potential evaluated in the study is based on the calculation by using mean annual rainfall. It is essential for the planning of hydropower to estimate the amount of stream water during the dry season, especially in the case of the development of hydropower with installed capacity of less than 100kW, because they are often developed for electrification of rural areas that are far from the grid system and so should be designed on the premises of providing electricity for nearly 365 days of the year.

Additionally, the study does not consider topographic conditions for laying out civil structures because the objective of the study is to evaluate the amount of potential for micro-hydropower. So, there are some rivers along which maximum potential sites are indicated around estuaries (see Figure A.4.1). Generally, a hydropower weir for diverting water cannot be constructed around estuaries because of the difficulty in securing enough head and width of river.

As a result, the Study Team does not use the potential sites from this desk study for subsequent work.

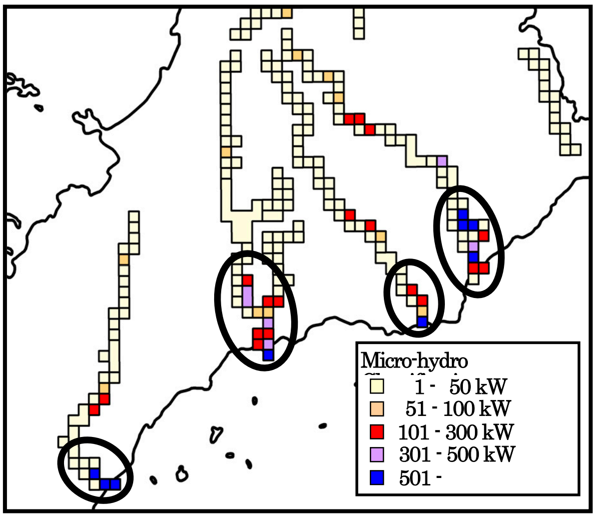


Figure A.4.1 Potential Sites around Estuaries

A.4.3 Feasibility Study

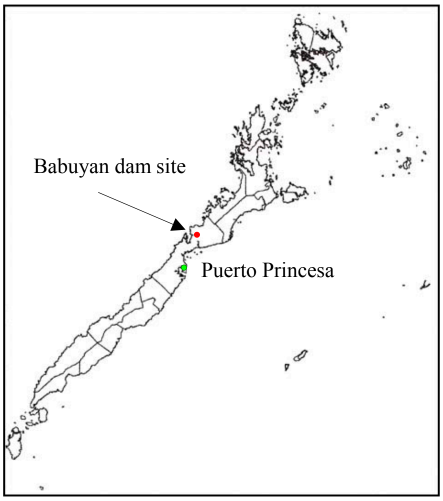
As will be briefly described, there are 5 feasibility studies on mini hydropower plants conducted in Palawan, which are; (1) Babuyan River Project、(2) Langogan River Project、(3) Cabinbin Mini-hydro Project, (4) Batangbatang Mini-Hydro Project and (5) Kandawaga Hydropower Project. The Study Team reviewed these as follows in order to evaluate them in terms of providing candidates in the Palawan Power Development Plan. More detail contents can be found in each F/S report.

A.4.3.1 Babuyan Hydropower Project

(1) Outline

NPC conducted a series of surveys named "Small Hydroelectric Projects of the Visayas Islands" for the purpose of feasibility studies on hydropower in Visayas. The British consultant company, Sir William Halcrow & Partners Ltd. conducted the study and completed the reports in October 1992. The Babuyan hydropower station is one surveyed in the study.

The Babuyan hydropower station is on Babuyan River in Municipality Puerto Princesa, 45km north from the provincial capital, Puerto Princesa. It is designed as a 3-hour operated run-of-river type and its installed capacity is 5.6MW. The location of the Babuyan hydropower station is shown on the right.



(2) Conducted survey

The following are the items covered in the study.

(a) Hydrometeorology

The hydrometeorological survey was not newly conducted in the study, and neither NIA nor PIADPO, which have the flow discharge data in Palawan, possess the data at the dam site. Therefore, the site discharge data was estimated using meteorology data and discharge data at other observation points. Through the calculations, the correlation between the catchment area and mean daily flow was estimated, and the approximate expression $Q = 0.0424\ A^{1.05}$ (Q : flow discharge (m^3/s), A : catchment are (km^2) was obtained. The average river flow was estimated using this equation.

(b) Geography and geology

<Geography>

The origin of the Babuyan River is northeast to southwest for its upstream half, and then the river turns in a southerly direction to enter the Sulu Sea at Honda Bay. The length of the river is almost 40km so that it is one of the longest rivers in Palawan. The Babuyan catchment is elongated in shape and extends generally parallel with the northwestern coastline of Palawan. The head of the catchment is adjacent to the Langogan Basin and the highest elevation, Stripe Peak (1,475m) is located along this boundary line. Further downstream the Babuyan Basin occupies an area between two spectacular ranges with peak elevations approaching 1,000m above sea level. The catchment area, especially the upstream half, is densely forested and retains water, so that distributes water fairly evenly throughout the year.

<Geology>

In addition to the reconnaissance of the dam site, headrace and vicinity of the power station, a borehole survey was conducted in the study. 8 boreholes (4 for the dam site, 2 for the headrace and 2 for the power station) with depths of 10 to 30.5m, were dug. Furthermore, 4 trial pits were dug in order to verify the surface soil. Using the cores obtained from the borehole survey, the properties of rocks such as description and strength were analyzed from a geotechnical point of view.

(3) Generation Plan

From the discharge analysis mentioned above, the maximum plant discharge is calculated as $15.4m^3/s$. Because of economical reason, the Babuyan hydropower facility has a 3-hour peak operation. The annual generation is 24.18GWh.

(4) Structures

Structure		Item	Description	Remarks
Weir		Weir type	Concrete gravity	
		Weir height	12 m	
		Fixed crest length	105 m	115m in the drawing
		Total crest length	625 m	Including zoned embankment
		Crest elevation	152 m	
		Reservoir area	172 ha	
Intake		Gate type	Powered fixed wheel	
Headrace	Open canal	Length	440 m	Concrete lined
			500 m	Unlined
		Cross section	4 m	Concrete lined, rectangular
			6 m	Unlined, trapezoid
	Tunnel	Length	1,280 m	Concrete
		Cross section	2.5 m	Horseshoe
Spillway		Designed flood	1,700 t/s	Main spillway 200 years return period
			3,400 t/s	Auxiliary spillway
Penstock		Number	2	
		Diameter	1.98 m	
		Length	210 m	
Power station		Installed capacity	5.6 MW	
		Net head	43.7 m	
		Max. discharge	15.4 m^3/s	
Outlet		Elevation	99.7 m	
Turbine		Type	Horizontal Francis	
		Unit number	2	
		Max. capacity	5.6 MW	2.8 MW ×2
		Rotation number	514.3 rpm	
Generator		Capacity	3.3 MVA	
		Voltage capacity	4.16 kV	
		Phase factor	0.85	
		Rotation number	514.3 rpm	
Related transmission system		Capacity	6.7 MVA	
		Voltage capacity	4.16kV/69kV	3-phase

(5) Construction plan

The term of construction for the Babuyan hydropower station is almost 38 months.

(6) Environmental impact assessment

(a) Terrain/Geology/Soil

Related impacts due to the project are minor topographic changes because of the construction of access roads, excavation of foundations for the weir, powerhouse and ancillary facilities, production of spoil and excavation of borrow and quarry areas. These alterations may lead to erosion and siltation problems. However, these will all be temporary and can be minimized by stabilization measures.

(b) Hydrology/Water quality/River uses

The surface water of the Babuyan River is relatively clear at the dam site. Construction activities will alter the water condition by increasing turbidity levels. However, a reservoir will create a trap to settle down sediments for many years so that the clearness of the water will be back to the level before the construction. Furthermore, reduction in river flow will be felt downstream of the dam, but this is not very significant since only few river users are dependent on this stretch of the river.

(c) Terrestrial ecology

The vegetative cover of the weir site is secondary growth forest interspersed with grasslands. The powerhouse will be constructed in a valley heavily wooded with secondary growth, but on the edge of a cultivated area mixed with grasslands and bush lands. No data are available on the faunal composition of the project site. Therefore, a comprehensive study must be made before project implementation. Also, the reservoir area should be cleared of vegetation before impounding to prevent eutrophication.

(d) Land use

Although site reconnaissance reveals that the weir site is deeply forested, the land use maps made by the National Mapping and Resources Information Authority (NAMRIA) indicate that the site is mixed agricultural lands. A tailrace route cuts through the cultivated agricultural land planted for rice having the tailrace terminating in a mangrove area that opens to Ulugan Bay. Agricultural lands along the Babuyan River and upstream are privately owned or have pending applications for titling and have existing tax declarations. Therefore, these are subject to compensation.

(7) Cost

(a) Construction cost

Total Construction Cost : US$ 17,697,500

(b) Financing

No detailed description of financing.

(8) Financing evaluation

Net Profit Value (NPV) and Economic Internal Rate of Return (EIRR) are calculated in two cases, Base case (US$17.7M) and Base case + 10% (US$19.5M).

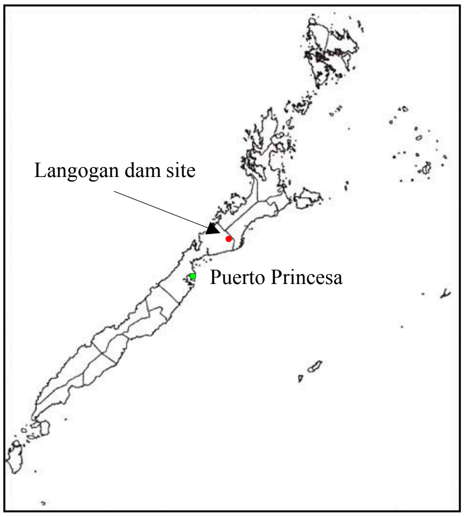
Case	Capital Cost (US$M)	NPV ($M)	EIRR (%)
Base case	17.7	0.6	12.7
Base case + 10%	19.5	-0.5	11.5

From the results, the project will be approved as an investment only in the Base case. Also, 12% EIRR indicates that the project is not so profitable.

A.4.3.2 Langogan River Project

(1) Outline

The Langogan Hydropower Project is also one of the surveyed projects in the "Small Hydroelectric Projects of the Visayas Islands" conducted by NPC in addition to the Babuyan River Project.



The Langogan River Station is a 6.8 MW run-of-river type hydropower station located on the Langogan River in Puerto Princesa Municipality, 55km northeast away from the provincial capital, Puerto Princesa. It has a main weir on Langogan River and a creek intake weir on Cabuyao Creek and is designed as 3-hour operation facility for peak demand. The location of the Langogan hydropower station is shown on the right.

(2) Conducted survey

The following are the items covered in the study.

(a) Hydrometeorology

Using the same method explained in the Babuyan section, the mean annual flow for the Langogan Project was calculated.

(b) Geography and Geology

<Geography>

The Langogan River flows generally south from the mountainous region that forms the southern part of Northern Palawan. The estuary is on the east coast where the mountain range falls directly to the sea with no costal plain. The catchment area (59km^2) of the project is mountainous with steep, incised valleys. Most of the catchment is covered by primary forest. The river gradient in the project area is approximately 30m/km.

The project is located over a 2.2km length of the river between the confluences of the Cabuyao and Nagmatong creeks some 22km upstream of the small town of Langogan at the river mouth.

There are no detailed descriptions about the geography of the weir site and the power station.

<Geology>

In addition to the reconnaissance of the dam site, headrace and vicinity of the power station, the borehole survey, as conducted in the study, was also performed. 4 boreholes (2 for the dam site, 1 for the headrace and power station each) with depths 15 to 25m were dug. Using the cores obtained from the borehole survey, the properties of rocks such as description and strength were analyzed from geotechnical points of view.

(3) Generation plan

From the same discharge analysis as Babuyan, the maximum plant discharge was calculated as 8.9m^3/s. Because of economical reason, the Langogan hydropower facility has 3-hour peak operations. The annual generation is 27.12GWh.

(4) Structures

Structure			Item	Description	Remarks
Dam	Main dam		Dam type	Concrete gravity	
			Dam height	19.5 m	
			Crest length	34 m	
			Crest elevation	188 m	
			Intake capacity	8.9 t/s	
	Creek diversion weir		Weir type	Concrete gravity	
			Weir height	1.5 m	
			Crest length	130 m	
			Crest elevation	147 m	
			Intake capacity	1.2 t/s	
Intake			Designed flood	942 t/s	200 years return period
			Gate type	Powered fixed wheel	
Headrace	Upper		Length	130 m	
			Cross section	2 m x2.3 m	Concrete box culvert
	Down		Length	270 m	
			Cross section	2 m x2 m	Concrete lined
Headpond			Weir type	Rock-fill type	Centered Core-Zone
			Reservoir capacity	102,000 m^3	
			Intake capacity	8.9 t/s	
			Gate type	Powered fixed wheel	
Penstock			Number	2	
			Diameter	2.1 m	
			Length	1,430 m	
Power station			Installed capacity	6.8 MW	
			Net head	91.2 m	
			Max. discharge	8.9 m^3/s	
Outlet			Elevation	89.2 m	
Turbine			Type	Horizontal Francis	
			Unit number	2	
			Max. capacity	6.8 MW	3.4 MW x2

(5) Construction Plan

The term of construction for the Babuyan hydropower project is almost 32 months.

(6) Environmental impact assessment

(a) Terrain/Geology/Soil

Project construction will result in alteration of the existing terrain in the area due to the construction of 19 km of access roads leading to the weir and power station sites. This impact will have a minimal effect since sediment flushing will be done infrequently and when the river is at a high stage with an already considerable sediment load.

(b) Hydrology/Water quality/River Uses

Due to the presence of silty clay soil in the burden in the Langogan River, the water of the Langogan River appeared to be slightly turbid during the reconnaissance survey in October of 1991. Various construction activities will degrade water quality, but for only a short time. The river water will attain its normal condition during project operation due to stabilization and revegetation of altered open areas.

Reduction in flow in the section between the weir site and the power station is considered insignificant since there are no water users in this river stretch.

(c) Terrestrial ecology

The weir will be located in a primary forest area while the power station will be located in grasslands surrounded by residual forest. A 19km access road will be constructed and 17km will be traversed by the transmission line. Since the access road construction will create added accessibility to the primary forest in the area, poaching and marginal logging activities will increase. NPC should implement mitigating measures such as reforestation and guarding the area in order to minimize the impacts that the projects may have on the area. Watershed stability will also be part of NPC's agenda.

The presence of rare, threatened and endangered species in the proposed project area is possible. This is based on extrapolation from Palawan's existing data on biodiversity. However, further studies must be conducted in order to confirm if such species are present in the project area. Although the catadromous Anguilla eels have been found in the river, the low weir proposed should not form a barrier to the migration of this species, and it is likely that the eels will find alternative migration routes downstream of the weir. A number of tributaries are located along this stretch.

(d) Land use

The dam site is densely forested, but the area for the powerhouse site and its related structures has patches of agricultural land. The transmission line route will traverse 6.5km of forest and 10.5km of cultivated land mixed with grass and shrub land. Likewise, the access road would pass through 14.7km of forest land and 4.3km cultivated land.

(7) Cost

(a) Construction cost

Total Construction Cost : US$ 14,947,000

(b) Financing

No detailed description of financing.

(8) Financing evaluation

Net Profit Value (NPV) and Economic Internal Rate of Return (EIRR) are calculated in two cases, Base case (US$15.6M) and Base case + 10% (US$17.2M).

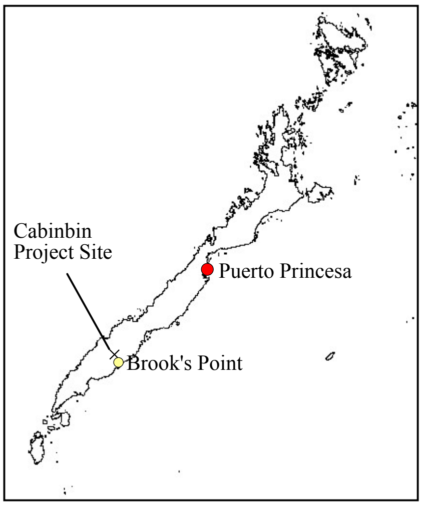
Case	Capital Cost (US$M)	NPV ($M)	EIRR (%)
Base case	15.6	3.3	17.0
Base case + 10%	17.2	2.3	15.2

The project yields an attractive rate of return under all conditions considered, even with a 10% increase in construction cost. Oil prices would have to fall to below 10US$/bbl in order for diesel generation to be competitive.

A.4.3.3 Cabinbin Mini-hydro Project

(1) Outline

The project site is located in Mainit Barangay, Brooke's Point Municipality and its maximum capacity is 800kW. The preliminary study was conducted by the Filipino consultant, Vergel III in 1987, but the cost data had not been modified until 1999 (12 years later). The research items covered in the 1987 survey were; (1) data collection, (2) reconnaissance, (3) data analysis and preparation for development scheme, and (4) assessment of cost estimation.



This preliminary project was presented at the Mini-hydro business meeting / conference at Puerto Princesa in April of 1999.

(2) Conducted survey

The following are the items covered in the study.

(a) Hydrometeorology

In the 1987 survey the data on the rainfall intensity and duration at the project site, and the river flow data for Cabinbin River acquired from PIADPO was analyzed.

The river flow data was daily flow that was measured at the gauging station set up by PIADPO for 17 months. The gauging station was adjacent to the power station site of the project. Firstly the duration curve was made at the station point using the flow data, and secondly the duration curve at the dam site was calculated using the data and the ratio of catchment area.

(b) Geography and geology

The project site is located at the north of Brook's Point, which is 145km southwest from the provincial capital, Puerto Princesa. The power station site is located at an alluvial cone 11km from the estuary of Cabinbin River.

The reconnaissance and the geological research were conducted in the 1987 survey. From the results of the research, it was understood that the foothold around generation structures was stiff enough and there were no existing faults.

(3) Generation plan

From the above-mentioned river flow data, the maximum plant discharge is set to $0.93m^3$/sec, 85% of the probability of fluid, for one turbine (sum is for two turbines). Therefore, the total maximum plant discharge is 1.86m3/sec, and the probability of fluid is about 60%. Since this project is a run-of-river type, the average of these two fluid probabilities, 72.5%, is the maximum plant discharge for the power plants, and then the annual generation is calculated as 5.08x1GWh.

(4) Structures

Structure	Item	Description	Remarks
Dam	Dam type	Concrete gravity	
	Dam height	4 m	
	Spillway length	20.50 m	= Crest length
	Crest elevation	163 m	
	River bed elevation	159 m	
Headrace	Type	Steel pipe	
	Length	1,800 m	
	Diameter	1.30 m	
	Invert level	159.7 m	Intake point
		157.9 m	Head tank point
	Gradient	0.1 %	
Head tank	Reservoir capacity	192 m^3	
	Bottom area	25 m^2	
	Surface area	262.44 m^2	
	Depth	5.6 m	
Penstock	Inner diameter	0.85 m	Main pipe
	Length	250 m	Main pipe
	Inner diameter	0.60 m	Branch pipe
	Length	60 m	Branch pipe
	Material	A-36 steel	
Power station	Installed capacity	800 kW	
	Net head	56.9 m	
	Floor area	200 m^2	
	Elevation	100 m	
Turbine	Type	Horizontal Franci	HL-110-WJ-60
	Country of manufacture	China	
	Number of units	2	
	Max. capacity	892 kW	446 kW * 2
	Rotation number	720 rpm	
Generator	Type	AC	SFW-K400-10/990
	Country of manufacture	China	
	Voltage	480 V	3-phase
	Phase factor	0.80	
	Capacity	800 kW	400 kW * 2
	Number of units	2	
	Rotation number	720 rpm	
	Frequency	60 Hz	
	Efficiency	93 %	
Access road	Length	1 km	From existing road to PS
	Width	6.50 m	

(5) Construction plan

There is no description about the construction plan such as time schedule and temporary materials.

(6) Environmental impact assessment

The environmental impact assessment for the project is not described. Meanwhile, the project site is in a Controlled Use Zone in the ECAN zoning.

(7) Cost

(a) Construction Cost
PHP 53.81 million

(b) Financing
No detailed description of financing.

(8) Financing evaluation

No detailed description of the financing evaluation.

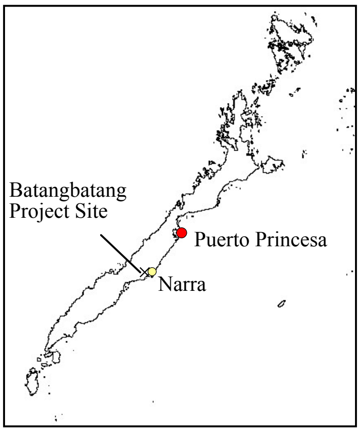
(9) Opinions from the Study Team

ECAN comment – The area where the dam site and the power station is located is categorized as being in a controlled use zone. And a part of the sites where the headrace is located is categorized as being in the Core Zone. Therefore, a further examination for ECAN evaluation is needed to move toward implementation.

A.4.3.4 Batangbatang Mini-Hydro Project

(1) Outline

This feasibility study was conducted in one of JETRO's schemes in 2000 called the "International Atmospheric and Environment Research Development Program". The project site is located in Princess Urduja Barangay, Narra Municipality. The project plan calls for the taking of water from both Batangbatang River and its tributary, Buhai river. The capacity of the project is 6,700kW.



The procedure for the feasibility study is as follows: (1) data collecting, (2) reconnaissance, (3) generation plan, (4) execution scheme, (5) estimation of project cost, (6) economical efficiency and financing evaluation, and (7) preliminary analysis of the impact on the environment.

(2) Conducted survey

The following are the items covered in the study.

(a) Hydrometeorology
The hydrometeorology data used for the project is acquired from PIADPO.
The study team could not get the rainfall data in the drainage basin of Batangbatang River, and so the NIA PMSIP data for the adjacent river (1982-1985) was used for the project.

Since PIADPO's rainfall data is daily, the team calculated monthly rainfall from the daily data to better understand the changes through the seasons.

The flow data used in the study is from Batangbatang gauging station of PIADPO (the catchment area is 123.00km^2), which is located downstream of the confluence of the Batangbatang River and Buhai River.

(b) Geography and Geology

<Geography>

The project site is located at the western part of Narra, which is 90km southwest from the provincial capitol, Puerto Princesa. The power station site is located 12km upstream from the estuary of the Batangbatang river, and the dam site is located at about 2.3 km upstream of the power station site.

Batangbatang River originates in the Victria mountain chain which extends over the center of Palawan's longer axis, and is a wide river with a width measuring several tens of meters.

The mid and the upstream area where the project site is located is in a precipitous mountain range, and the downstream area is in an expansive alluvial plain. In the project, 1/5,000 topographic maps around the project site were made based on 1/25,000 aerial photographs, and the level survey was conducted around the main structures sites.

<Geology>

In the feasibility study, the inspection of geology by visual observation in reconnaissance and the geological survey using the data from 3 new boring holes were conducted. Furthermore, the points of the lineament and landslide were ascertained.

From these results, the rock unit in the general vicinity of the project site consists of peridotites, serpentinizedpelidotits and serpentinites of the Mt. Beaufort Ultramaphics. Three lineaments and three landslides were observed. Although this geology can be stiff enough to support the construction of structures, it is recommended that an additional geological survey will be needed because the accordance of the talus slope and land slides can be observed in the project site. These faults may not be a big problem, although they could limit the specifications of the structures. As for landslides, since most of them have not been active, any problems cannot be pointed out without additional surveys around the planned structures.

(3) Generation Plan

To decide the optimal scale of the project, the team set a scale for which the generation cost is the least as a basic case, and estimated annual generation and rough construction costs of 3 cases of the maximum plant discharge (12.00, 15.50, 12.00m^3/sec), and then they determined the optimal scale using the construction cost per kWh. As a result, the maximum plant discharge was set as 15.50m^3/sec (maximum capacity is 6,700kW) in the project.

(4) Structures

Structure	Item	Description				
		Batangbatang Project				Buhai Project
		Main		Creek		
Weir	Type	Concrete Gravity Surface filled with Pebbles				
	Height	5.50 m		4.50 m		5.00 m
	Crest length	55.00 m		20.00 m		35.00 m
	Volume	1,470 m^3		410 m^3		840 m^3
Intake	Width	5.00 m * 2		3.00 m		5.00 m
	Height	3.00 m		1.50 m		2.00 m
	Length	21.50 m		12.20 m		15.00 m
Settling basin	Width	3.00 - 10.00 m		1.50 - 3.00 m		2.00 - 5.00 m
	Height	3.50 - 6.00 m		2.00 - 3.00 m		2.50 - 4.50 m
	Length	36.00		15.00 m		24.00 m
Headrace	Type	Channel	Tunnel	Channel	Conduit	Channel
	Width	2.00 - 5.00 m	2.50 - 2.80 m	1.00 - 2.20 m	1.50 - 3.18 m	1.50 - 3.18 m
	Height	2.50 m	3.25 - 3.40 m	1.00 m	1.40 m	1.40 m
	Length	1,020 m	730 m	900 m	2,850 m	600 m
Head tank	Width	2.50 - 8.00 m				
	Height	3.41 - 5.00 m				
	Length	30.00 m				
Penstock	Length	250.00 m				
	Diameter	1.00 - 2.50 m				
	Thickness	8 mm				
Outlet	Width	3.00 m				
	Height	3.00 m				
	Length	2.00 m				
Power station	Type	Semi-outdoor				Semi-outdoor
	Width	10.00 m				9.00 m
	Height	21.75 m				20.75 m
	Length	15.00 m				12.00 m
Turbine	Type	Horizontal Francis		Horizontal Francis		Horizontal Francis
	Capacity	1,290 kW		4,420 kW		1,270 kW
	Rotation	720 rpm		400 rpm		720 rpm
Generator	Type	Horizontal 3-Phase		Horizontal 3-Phase		Horizontal 3-Phase
	Capacity	1,300 kVA		4,470 kVA		1,280 kVA
	Voltage	6.6 kV		6.6 kV		6.6 kV
	Frequency	60 Hz		60 Hz		60 Hz
Transformer	Capacity	7,050 kVA				
	Voltage	6.6/69kV				

(5) Construction plan

The term of construction for the Batangbatang hydropower project is almost 24 months.

(6) Environmental impact assessment

In the report there are description about related organizations in the Philippines, environmental standards in the Philippines, the system of environmental impact assessments, and the results of the environmental impact assessments for the project.

(7) Cost

(a) Construction Cost

20 million US$ （as of December 2000, without interest during construction）

(b) Financing

It is recommended that for the funding of the project, PGP will secure 85% of the total construction cost from the Environment Yen Loan and the remaining 15% from banks in the Philippines.

(8) Economical evaluation

In the report EIRR, B/C and B-C were calculated setting the generation only as the economical profit. The result is shown on the right. From the result, the project economically dominates the other alternatives.

Alternatives	EIRR （%）	EIRR	B－C (1,000 US$)
Diesel	15.0	1.00	8.4
Gas turbine	19.9	1.25	5,343

(9) Financial evaluation

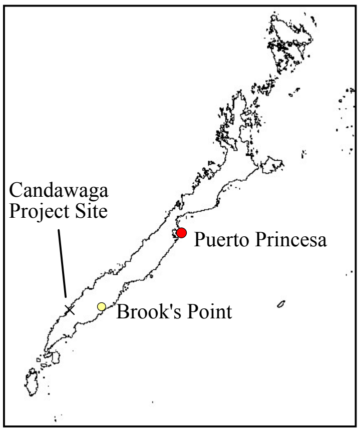
The FIRR in 40 years was calculated setting the construction cost and operation and maintenance cost as "cost," and the profit from selling as "benefit."

Based on the financial evaluation, the FIRR of the project was 7.42%, which will easily surpass the hurdle rate of 3.52%, indicating that the project is financially feasible. Furthermore, there will be no shortage of cash flow throughout the project life, and the project will earn profit of US$16 million in the final cash flow grand total.

A.4.3.5 Candawaga Hydropower Project

(1) Outline

JICA had made a low-interest loan to the Philippines Government to construct public facilities such as a school, a hospital and a church all tied to the Rio Tuba Nickel Mines (Rio Tuba Nickel Mining Corporation) since 1977. The project was planned as a grant aid in 1985 to cover increasing electricity demand in the mines and to send electricity to neighboring residents for co-prosperity with three diesel generators planned by the company. The electricity generated by Candawaga hydropower would be distributed to the southern part of Palawan through PALECO.



The capacity of the Candawaga hydropower project is 6 MW. It was planed in the project that the intake was set in the Candawaga River and the outlet was set in Culasian River.

Meanwhile, the main purpose of the project was not to sell electricity, but to increase the profits of the main company. Therefore, a financial analysis from a viewpoint of revenue from electricity charges was not the main target of the report.

(2) Conducted survey

The following are the items covered in the study.

(a) Hydrometeorology

The hydrometeorological survey was not newly conducted in the study. Although Rio Tuba Nickel Corporation had been measuring Candawaga River discharge, the data could not be used for the planning since its observation duration was too short and the number of measurements was not enough for the calculation. Therefore, the site discharge data was estimated using runoff analysis in the Tamlang River Development Plan because the character of the Tamlang River discharge is similar to that of the Candawaga River.

(b) Geography and geology

<Geography>

The geographical survey was conducted using topographic maps and the reconnaissance around the site. The origin of the Candawaga and Culasian rivers is the Mantalingajan mountain chain. The rivers on the east side of the divide go down to the Sulu Sea in a southeasterly direction and the rivers in west side go down to the South China Sea in northwesterly direction. The lengths of the Candawaga and Culasian rivers are 29km and 27 km, relatively. Furthermore, since the slopes on mountain side of these rivers are considerably steep, there are hardly any big confluents and the catchment area is relatively small.

<Geology>

The geological survey was conducted using geological maps and the reconnaissance around the site. The geological characteristics of both the Candawaga and Culasian rivers are similar. Namely, there have Ultrabasic Intrusive Rock in the upstream, Panas layers with Sandstone and Shale in the middle- and downstream, and alluvium in the plane field.

The rock system around the weir is mainly fresh massive and toughened shale with various sizes of Whitestone and Sandstone rocks distributed at 4 to 5-meter depths. In most of the areas for open channel-headrace, tunnel and penstock the basis is Sandstone and Shale, with Whitestone and Tuff breccia distributed upstream. Most of the rocks in the areas not far from river beds are fresh rocks, but those around the ridges and high elevations are relatively weathered.

(3) Generation plan

From the discharge analysis mentioned above, the maximum plant discharge is calculated as $3.85m^3/s$. Because of the usage of electricity for excavating mines and for the residents, the Candawaga hydro facility is base-load operated. The annual generation is 32.1GWh.

(4) Structures

Structure		Item	Description	Remarks
Weir		Weir type	Concrete gravity	
		Weir height	13.5 m	
		Crest length	51 m	
		Crest elevation	264 m	
Intake		Intake elevation	260 m	
Headrace	Open canal	Length	7,400 m	Concrete lined
		Cross section	B1.5 * H1.95 m	
	Tunnel	Length	300 m	Concrete
		Cross section	2.5 m	Horseshoe
Penstock		Number	1	
		Diameter	1.65 ～ 0.62 m	
		Length	52 m	
		Net head	185.1 m	
		Max. discharge	3.85 m^3/s	
Outlet		Elevation	63 m	
Turbine		Type	Horizontal Francis	
		Unit number	2	
		Max. capacity	6.0 MW	3.0 MW * 2
		Rotation number	1,200 rpm	
Generator		Capacity	3,320 kVA	
		Voltage capacity	4.16 kV	
		Phase factor	0.91	
		Rotation number	1,200 rpm	
		Frequency	60 Hz	
Related transmission system		Number of units	2	
		Capacity	6,600 kVA	
		Voltage capacity	4.16kV/69 kV	3-phase

(5) Construction plan

The term of construction of the Candawaga hydropower project is almost 28 months.

(6) Environmental impact assessment

There is no environmental impact assessment in the study.

(7) Cost

(a) Construction Cost

Total Construction Cost : JPY 3,950,000,000 (Y1985 rate)
(about US$ 35,909,000)

(b) Financing

No detailed description of financing since the project was planned as a Japanese grant aid.

(8) Financing evaluation

There are 11 FIRR evaluation cases for the project with various different conditions and 4 ROI evaluation cases. The results are as shown in the table below.

Table A.4.2 Comparison of FIRRs and ROIs

Case		FIRR (%)
(1) Base Case		10.55
(2) No supply for Residents and Use All Electricity for the Plants		10.66
(3) Increase and Decrease of Amount of Capital Investment		
	a) 5% increase	10.11
	b) 15% increase	9.32
	c) 5% decrease	11.04
	d) 10% decrease	11.58
(4) Increase or Sameness of Fuel Cost		
	a) 0.5%/year increase	9.46
	b) Fixed fuel cost	9.02
(5) Earning from Selling Electricity		
	a) 10% decrease of earning	10.31
	b) 20% decrease of earning	10.08
(6) Complex Case of (3)c, (4)b and (5)a		8.29
Case		**ROI (%)**
(1) 3.5% Inflation		9.64
(2) 5.9% Interest during Construction		9.59
(3) 8.0% Interest during Construction		9.29
(4) Complex Case of (1) and (2)		8.74

The report summarized the financial evaluations in the following manner.

(a) The effect of saving production costs, especially fuel cost is good and from a viewpoint of financial analysis, the project is feasible. However, since there is the possibility of stagnancy or decline in costs of oil-related items, the FIRR will be decreased. Furthermore, considering stagnancy of the international market price for nickel and political instability in the Philippines, the project is not suitable for a totally commercial-based business.

(b) Since the project is to supply electricity to neighboring residents through PALECO, the profitability of the project slightly decreases compared with the case that all electricity is distributed to the mine plants. However, because of residents' hopes and with a viewpoint toward making a regional contribution, the project deserves implementation.

Because of these two reasons, the project is deemed as being appropriate for public financing.

A.5 Study of Potential Mini and Micro Hydropower Sites

To secure generation for gird connections, to find environmental-friendly generation type -hydropower and to have candidates for the Barangay Electrification Plan, the Study Team reexamined the past potential sites discovered by DOE, NEA, NPC-SPUG and PGP and found some new potential hydropower sites in Palawan using 1:50,000 topographic maps. In this section, potential sites are explained from only technical viewpoints. The cost estimation for each site will be explained in Section A.6.

A.5.1 Basic Concepts and Criteria

The Study Team set basic concepts and/or criteria for finding potential hydropower sites in Palawan as follows.

(a) *Catchment area must be more than 10 km^2.*

One of the most important things in planning hydropower is to measure plant discharges since river flow is essential for hydropower generation. Grasping river flow in countries in which the differences of rain precipitations in the rainy season and dry season like the Philippines are big is never negligible for hydropower planning. Therefore, it should be confirmed whether there is always river flow, especially during the dry season.

In a feasibility study, the river flow of a site is certainly measured and used for detail planning. In a master plan study, however, it is difficult to measure the river flow of each potential site since it takes at least one year and needs more budget and manpower. Therefore, a river flow of a potential site should be estimated by interviews from adjacent residents, the size of the catchment area and the river flow data for nearby rivers. Because of the lack of data for all river flows, the Study Team decided to screen a possibility, which has river flow during the dry season first by the size of the catchment area. The reasons why the Study Team chose a catchment area are (1) the smaller the catchment area is, the lesser river flow is, (2) a catchment area can be easily calculated using topographic maps, and (3) the river flow data for nearby rivers can be proportionally applied to the potential site.

From the results of the preliminary reconnaissance, which will be described in Section A.5.6.1, the Study Team decided that the needed catchment area to secure enough water for generation to be more than 10 km^2.

(b) *Potential sites located in Core Zones or Restricted Zones in ECAN Zoning are omitted*

It is almost impossible to construct a hydropower structure in a Core Zone or a Restricted Zone since PCSD does not allow any human activities in these zones. Therefore, the Study Team omits any potential sites in these zones. However, because PCSD has been reexamining zones, as mentioned in Section A.3.7, and there is the possibility that the sites in these zones will depart from these areas, the Study Team records this potential information for the future.

(c) *Maximum plant discharges for hydropower were determined at 70% FUF and 100% FUF*

A plant discharge is one of the most important factors for hydropower capacity. In the run-of-river type hydropower plants in the Study, 70% Flow Utilization Factor (FUF) for grid connections and 100% FUF for mini-grid systems were used for capacity calculations.

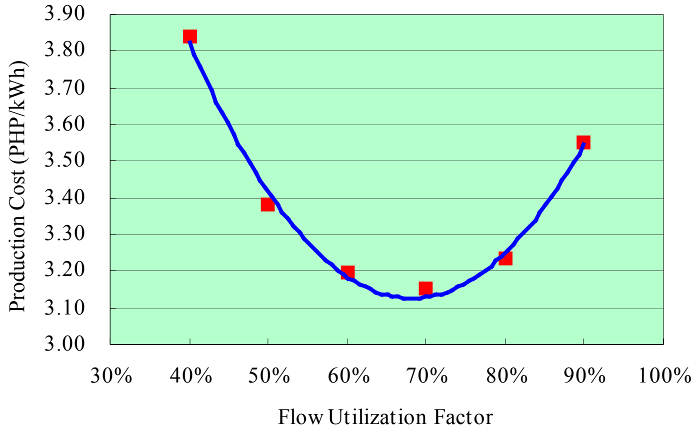


Figure A.5.1 Results of the Sensitivity Analyses of 70% FUF for the Talakaigan candidate site

The reasons why the Study Team used 70% FUF for grid connections are; (1) the sensitivity analysis of FUF for the Talakaigan candidate site indicates that the production cost of 70%FUF is the least as shown in Figure A.5.1, and (2) it is difficult for the Palawan power system, like in other developing countries, to consume all of the secondary energy and its energy value is much lower than the primary energy. Of course the best FUF is different for each site depending on the river system, geological features and structural features. Detailed studies of feasible candidate sites should be conducted in the future. And the reasons why the Study Team used 100% FUF for the mini-grid systems are; (1) the same generation hour is needed to simply make comparisons with diesel engine systems when making a barangay electrification plan, which generates power at any time, even if there are some advantages to hydropower, (2) in a mini grid system in the Palawan barangay electrification plan, kWh is more important than kW since a peak demand in kW in a common non-electrified barangay in Palawan is 30 to 40 kW in 2015 at the best from our demand forecast, and it is more significant to secure enough kWh than to increase FUF in order to gain kW.

(d) *Transmission lines from a power house to a connection of the backbone grid or a demand site must not be longer than 5 km*

It is obvious that a shorter transmission line is better for cost reduction and stable voltage, especially for smaller capacity such as micro hydropower. Even if there is no technical problems in terms of having a long transmission line (more than 10 km) from a power house to a connection of the backbone grid or a demand site, the construction cost of transmission will be very expensive and so it is not realistic. On the other hand, it is difficult to find potential sites within several hundred meters or 1 to 2 km from a connection point.

Therefore, the Study Team decided a transmission line to the potential sites for barangay electrification to be less than 5 km.

(e) *Weir height for run-of-river type is set as 3m in order to reduce the weir volume*

In mini and micro hydropower, especially in the run-of-river types, a high dam such as one with a weir of more than 15-m is not only extremely expensive, but it is meaningless since a weir is for just diverting river flow, not for gaining an effective head. From a technical viewpoint, a 3-m height is enough for diverting river flow for run-of-river type hydropower. Although the height of the weir should be decided individually in accordance with geological features, the Study Team decided that normally the weir height should be 3 meters in the Master Plan for easy understanding.

(f) *Sites for which a turbine cannot been chosen for technical reasons are omitted*

From a technical viewpoint, there are some sites at which effective heads are too short and maximum plant discharges are too small so that there are not available turbines for these sites. Actually there are such turbines, but they can hardly be found in the Philippines and the unit cost is relatively more expensive than other ordinary turbine types. Therefore, the Study Team omitted these potential sites with short effective heads and small discharges. The detail will be explained in A.5.3 (j).

A.5.2 Study Flow for Finding Potential Hydropower Sites

The Study Team reexamined the past potential hydropower sites and found some new sites. To find potential hydropower sites in the map study, there are two major ways, namely (1) Map Study from Site, which is "determination of a capacity from an appropriate site" and (2) Map Study from Demand, which is "determination of an appropriate site from electricity demand in the nearest barangay." These two methods have different approaches for finding potential hydropower sites.

(a) Map study from site

The approach of the Map Study from Site is, what we call, a normal procedure to find potential hydropower sites. Since the capacity of a hydropower plant is decided by the amount of plant discharge and the effective head, the goal is to find an appropriate site in which there is a narrow valley for a weir to reduce the amount of weir volume, steep slopes to secure enough effective head, and hopefully a slope for a penstock near the weir to shorten the headrace. Therefore, the main concept of this approach is clearly to find sites from a viewpoint of the geological features.

Because of its procedural features, results of the Map Study from Site are mainly used for grid connections. That is because in most of cases, the capacity of a potential site does not fit the demand of the nearest barangay since the demand is not mainly focused on in the procedure and its capacity is determined by only geological aspects. Therefore, it is said that the Map Study from Site is used to find potential sites for grid connections. In the candidate sites for grid connection, the supply hour is basically considered to be 24 hours.

The procedure of the Map Study from Site is as follows.

a) Data Collection

To collect the following Palawan data
1) Topographic maps (1:50,000)
2) Geological maps (1:50,000)
3) Rainfall data
4) Temperature data
5) Humidity data
6) River flow data
7) Past potential site data (Table A.5.1 ～ Table A.5.2)
h) ECAN zoning maps
i) Barangay base maps
j) Unit costs data of civil works, generators etc.

b) Data Analyses

To analyze the following data
1) Average rainfall
2) Duration curve at each gauging station from river flow data
3) Specific run-offs at rivers in which the gauging stations exist

c) Study of Topographic Maps

Study the topographic maps to find potential hydropower sites
The key points are;
1) Narrow valleys for a weir
2) Steep slope in mountain ridge for a penstock
3) Relatively broad place at the bottom of the steep slope for a powerhouse
4) Short headrace
5) Distance from existing roads, the nearest barangay center and the backbone transmission lines

d) Screen by Catchment Area

To screen candidate sites by catchment areas bigger than 10 km^2

e) Calculation of River Flow at Potential Site

To calculate river flows at the potential sites

f) Arrangement of Civil Structures

To arrange civil structures such as a weirs, a headraces and a penstocks
1) To set a weir considering the valley width and height
2) To set a penstock and a powerhouse
3) To set a headrace connecting a weir and a penstock, along with a contour line
Tunnels can be considered if technically and geologically possible
4) To draw a road from existing roads to a weir site
5) To draw a transmission line from existing transmission line or the nearest barangay center to a powerhouse

g) Analyses of Ambient Surroundings

To analyze ambient surroundings such as
1) ECAN zoning as to whether or not a weir, headrace, penstock, powerhouse, roads and /or transmission line are in Core Zone(s) or Restricted Zone(s)
2) ECAN zoning as to whether there are mangrove zone(s) downstream of a tailrace
3) Population in the nearest barangay for possibility of mini grid
4) Electricity demand of the nearest barangay calculated from the population

h) Screen by ECAN Zoning

To screen candidate sites for all of which the civil structures are out of the Core zone(s) and Restricted zone(s)

i) Calculation of Potentials

To calculate the hydropower potential (kW and kWh) of each candidate site from the assumed structured and calculated river flow
To choose a turbine type according to the effective head and the maximum plant discharge

(b) Map study from demand

The Map Study from Demand is an approach used in mini-grid planning for rural electrification like the Barangay Electrification Plan in the Study. It is focused on mini-grids to electrify at least one non-electrified barangay and its capacity is determined by the electricity demand in the barangay. A planner adjusts the capacity of the hydropower site to the demand. Concretely speaking, the effective head and a weir site are set to meet the demand in the nearest barangay. More concretely, "set a weir site" means "set the river flow", which is a variable of a catchment area and affects the capacity.

The advantages of the Map Study from Demand are; (1) the over cost and the over capacity or less capacity toward the demand can be avoided, and (2) the profitability from the mini-grid can be easily calculated since its business is in the barangay. In the meanwhile, the disadvantages are; (1) additional generators such as diesel generators will be needed after the demand exceeds hydropower capacity, (2) since the civil structures are not designed at the most appropriate sites, the civil construction costs cannot be the cheapest, and (3) it needs a cumbersome procedure like many trials to find the capacity that meets the demand. This means a planner has to do trials many times to find the appropriate capacity for demand in the nearest barangay center.

Considering these advantages and disadvantages, a planner has to find potential hydropower sites for the rural electrification plan using the mini-grid system.

The procedure of the Map Study from Demand is as follows.

a) Data Collection

To collect the following Palawan data
1) Topographic maps (1:50,000)
2) Geological maps (1:50,000)
3) Rainfall data
4) Temperature data
5) Humidity data
6) River flow data
7) ECAN zoning maps
8) Barangay base maps
9) Unit costs data of civil works, generators etc.

b) Selection of Non-Electrified Barangays

To select non-electrified barangays from the barangay electrification data

c) Calculation of Demands in Non-Electrified Barangay

To calculate electricity demand in a non-electrified barangay using barangay population and unit demand

d) Data Analyses

To analyze the following data
1) Duration curve at an adjacent gauging station from river flow data
2) Specific run-offs at river in which the gauging station exists

e) Probe of Topographic Maps

To find potential hydropower sites according to the demand by referencing topographic maps
The key points are;
1) Narrow valleys for a weir
2) Steep slope in mountain ridge for a penstock
3) Relatively broad place at bottom of steep slope for a powerhouse
4) Short headrace
5) Distance from existing roads and the nearest barangay center

f) Screen by Catchment Area

To screen candidate sites by a catchment area bigger than 10 km^2

g) Calculation of River Flow at Potential Site

To calculate river flows at the potential sites

h) Arrangement of Civil Structures

To arrange civil structures such as a weir, a headrace and a penstock
1) To set a weir considering valley width and height
2) To set a penstock and a powerhouse
3) To set a headrace connecting a weir and a penstock, along with a contour line
   Tunnels can be considered if technically and geologically possible
4) To draw a road from existing roads to a weir site
5) To draw a transmission line from the nearest barangay center to a powerhouse

i) Analyses of Ambient Surroundings

To analyze ambient surroundings such as
1) ECAN zoning as to whether or not a weir, headrace, penstock, powerhouse, roads and /or transmission line are in Core Zone(s) or Restricted Zone(s)
2) ECAN zoning as to whether there are mangrove zone(s) downstream of a tailrace

j) Screen by ECAN Zoning

To screen candidate sites for all of which the civil structures are out of the Core zone(s) and Restricted zone(s)

k) Calculation of Potentials

To calculate the hydropower potential (kW and kWh) of each candidate site from the assumed structured and calculated river flow

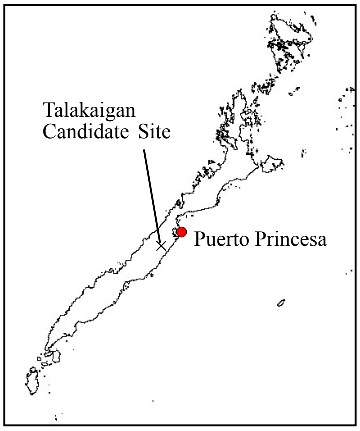
l) Refinement of Capacity

To refine the capacity of candidate civil structures to meet the electricity demand in the nearest barangay
- Go back to 5) and use a trial-and-error approach to meet the demand

To choose a turbine type according to the effective head and the maximum plant discharge

A.5.3 Procedures of Finding Potential Mini and Micro Hydropower Sites in the Map Study from Site

In this section, the procedure of finding potential mini and micro hydropower sites in the Map Study from Sites is explained step by step. For easy understanding, the Talakaigan candidate site in Barangay Cabigaan in Aborlan Municipality was sometimes used for a reference. Since this report is not a technical manual, detail technical indications are abbreviated.



(a) Data collection

The Study Team collected the needed data mentioned in A.3.1 for finding potential hydropower sites.

(b) Data analyses

(i) Average rainfall

Rainfall data is used for acquiring hydrologic and meteorological characteristics in a hydropower-planning site and the data can be essential for planning. Therefore, the Study Team firstly analyzed rainfall data.

The analyzed data was for Puerto Princesa, Cuyo and Coron and was given by PAGASA. The results are explained in A.3.3.

(ii) Flow duration curve

To examine river flow data that is essential for planning a hydropower plant, the Study Team collected the existing river flow data from PCSD and analyzed this data. In Talakaigan, however, there is no gauging station so that a duration curve of the river has to be estimated from river flow data for an adjacent river. There is a gauging station by the name of Panacan Gauging Station set by PIADPO (present PCSD) and the Study Team estimated the river flow using the existing data from September 4, 1985 to October 31, 1988 with some of the data missing. The yearly duration curve at the Panacan Gauging Station is shown in Figure A.5.2.

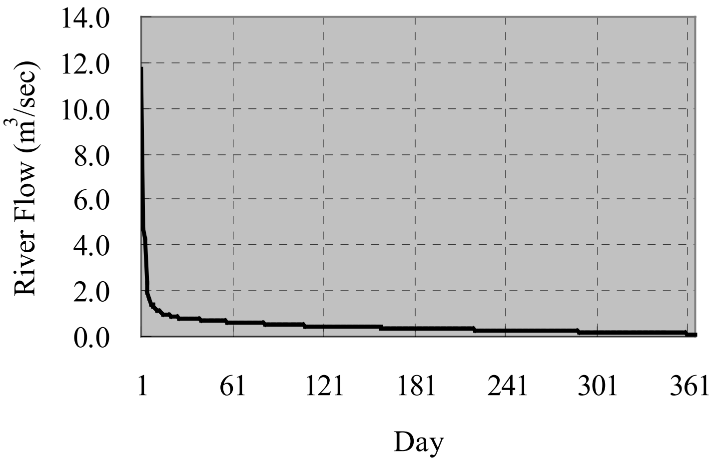


Figure A.5.2 Flow Duration Curve at the Panacan Gazing

(c) Verification of topographic maps

The adjacent geography of Talakaigan River is shown in Figure A.5.3.

From the estuary to about 15km, the geography is relatively flat, but after that mountains come up. Although the slopes of both banks are steep on the mountainside, the vertical interval is not so big and so that the river is still flat. In the mountainside, the river is anfractuous and at about 10km from the start of mountainside the banks becomes gradual again.

Based on the results, the Study Team researched the potential rivers again and picked up 45 potential sites. Although the Study Team also identified the locations of potential sites studied in the past and modified them as shown in Table A.5.1, 6 sites in Table A.5.2 could not be found because they might not be the appropriate sites on the topographic maps as the data told and even PGP residents did not know where the locations were. The potential sites newly found by the Study Team are shown in Table A.5.3.

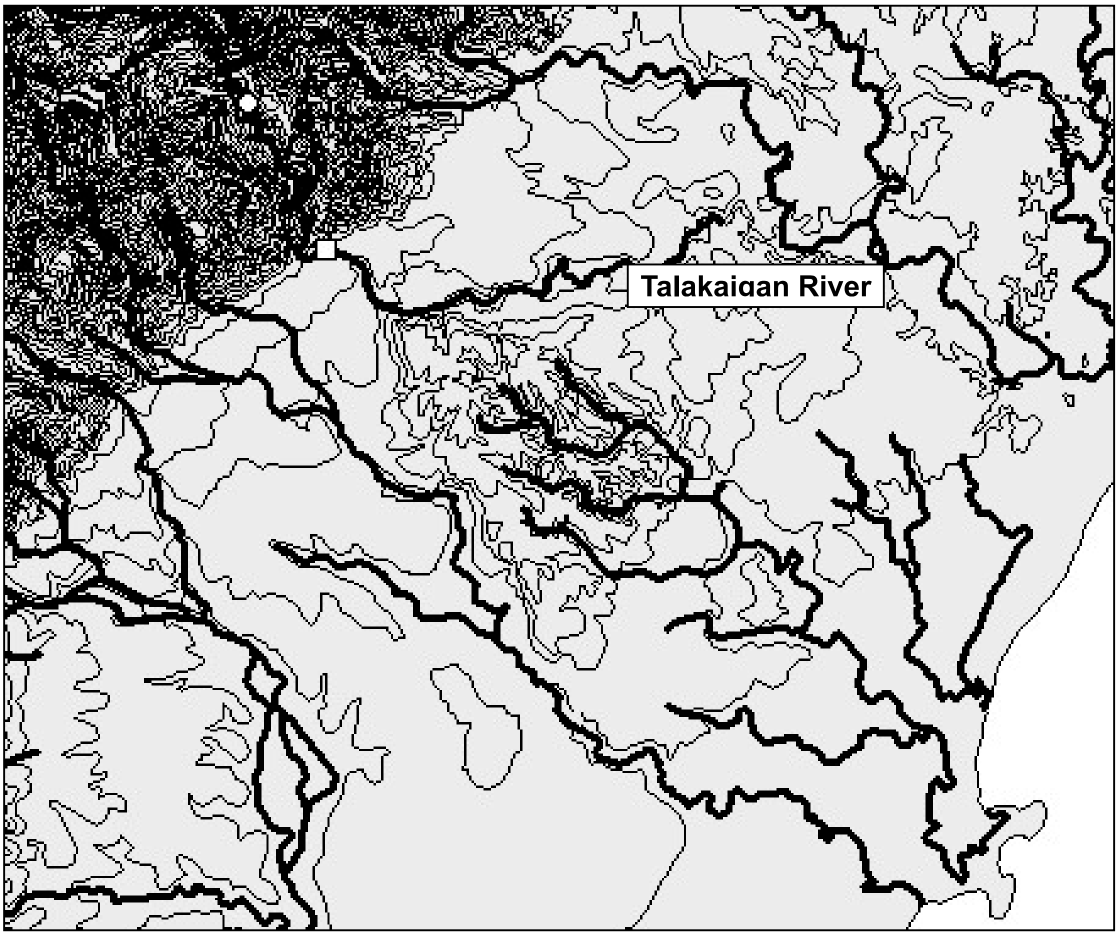


Figure A.5.3 Geography of Talakaigan River

Table A.5.1 Identified and Modified Past Potential Sites

No.	Name of Site	Location	Name of River	Approx. Head (m)	Catchment Area (km^2)	NAMRIA Map Number
1	Talakaigan	Cabigaan Aborlan	Talakaigan River	80	27.54	2648-II
2	Baraki	Baraki, Aborlan	Aborlan River	60	34.54	2648-II
4	Malatgao 1	Estrella Village, Narra	Malatgao River	70	99.15	2648-II
5	Malatgao 2	Taretien, Narra	Malatgao River	50	87.84	2648-II
6	Iwahig 1	Bagong Bayan, Puerto Princesa	Iwahig River	50	27.66	2749-III
7	Iwahig 2	Montible, Puerto Princesa	- ditto -	20	95.75	2749-III
8	Iwahig 3	- ditto -	- ditto -	20	97.15	2749-III
9	Inagawan 1	Inagawan, Puerto Princesa	Inagawan River	60	92.98	2748-IV
10	Inagawan 2	- ditto -	- ditto -	20	106.51	2748-IV
11	Isaub	Isaub, Aborlan	Isaub River	30	4.77	2720-III
12	Balsahan	Simpucan, Puerto Princesa	Balsahan River	70	12.58	2749-III
13	Bontong	Irahuan, Puerto Princesa	Bontong River	10	6.57	2749-III
15	Barong Barong	Aribungos, Brooke's Point	Barong Barong River	70	18.65	2546-I
18	Estrella falls	El Vita, Narra	Estrella River	30	11.79	2648-II
19	Iraan	Iraan, Aborlan	Iraan River	20	23.00	2720-III
20	Babuyan 1	Lucbuan, Puerto Princesa	Babuyan River	5	24.88	2750-II
22	Ilian	Itangil, Dumaran	Ilian River	20	14.96	2951-III
25	Irahuan	Irahuan, Puerto Princesa	Irahuan River	12	3.37	2749-III
27	Aborlan	Cabigaan, Aborlan	Aborlan River	80	38.91	2648-II
28	Maoyon	Maoyon, Puerto Princesa	Maoyon River	20	18.85	2750-II
29	Tanabag	Tanabag, Puerto Princesa	Tanabag River	60	48.04	2750-II
30	Tiga	Aribungos, Brooke's Point	Tiga Plan River	120	16.37	2546-I
31	Lara	Mainit, Brooke's Point	Lara River	100	27.79	2546-I
32	Imulnod	Imulnod, Brooke's Point	Imulnod River	60	19.22	2546-I
33	Filantropa	Maasin, Brooke's Point	Filantropa River	40	30.93	2546-I
34	Bulalakao	Milihud, Bataraza	Bulalakao River	80	15.58	2546-III
35	Pangbilian	Imulnod, Brooke's Point	Pangbilian River	60	37.61	2546-II
37	Turao	San Jose, Taytay	Turao River	40	0.30	2852-I
39	Bakungan	Bakungan, Puerto Princesa	Bakungan River	23	28.57	2749-IV
40	Nicanor Zabala	Nicanor Zabala, Roxas	Tulariquin River	120	15.15	2821-III
41	Caruray	Caruray, San Vicente	Caruray River	120	3.60	2850-IV

42	Sto. Nino	Sto. Nino, San Vicente	Erawan River	160	1.01	2851-I
43	Poblacion	Poblacion, San Vicente	Inandeng River	80	1.56	2851-I
44	Bulalakao 1	Mabini, El Nido	Bulalakao River	140	0.83	2853-I
45	Bulalakao 2	- ditto -	- ditto -	280	1.84	2853-I
46	Pasadena	- ditto -	Nagcalitcalit River	120	1.19	2853-I
47	Villa Paz	- ditto -	Batacalan River	150	0.22	2853-I

Table A.5.2 Past Studied Potential Sites that could not be Found

No.	Name of Site	Location	Name of River	Head (m)	Catchment Area (km^2)	Discharge (m^3/s)	Capacity (kW)	Data Source
14	Lake Manganao	Taytay	-	10	-	1.20	100	DOE
16	Sinabayan Falls	Busuanga	-	23	-	0.40	80	DOE
24	Rizal	Roxas	Rizal	20	-	-	-	DOE
26	Tarabanan	-	-	-	-	-	2,200	NEA
36	Sabsaban Falls	Brooke's Point	-	5	-	-	-	NEA
38	Turung Falls	Taytay	-	10	-	0.06	4	NEA

Table A.5.3 Newly Found Potential Sites

No.	Name of Site	Location	Name of River	Approx. Head (m)	Catchment Area (km^2)	NAMRIA Map Number
N1	San Rafael 1	San Rafael, Puerto Princesa	-	40	5.78	2750-II
N2	San Rafael 2	- ditto -	Branch of Babuyan River	20	13.74	2621-II
N3	San Rafael 3	- ditto -	-	20	6.15	2721-II
N4	Pamantolon	Pamantolon, Taytay	-		5.59	2852-I
N5	Labog	Panitian, Soflonio Española	-	50	32.09	2647-III
N6	Magara	Magara, Roxas	-		2.57	2850-IV
N7	Malatgao 3	Malatgao, Narra	Branch of Panitian River		7.93	2547-II
N8	Bataraza	Bataraza	Marangas River	40	37.13	2546-III
N9	Tinitian 1	Tinitian, Roxas	Tinitian River	30	11.74	2821-III
N10	Tinitian 2	- ditto -	- ditto -	20	11.74	- ditto -
N11	Talakaigan 2	Cabigaan, Aborlan	Talakaigan River	100	25.35	2648-II
N12	Samanñana	Samanñana, Brooke's Point	-	80	37.58	2546-III
N13	Culacian	Culasian, Rizal	Culasian River	40	37.42	- ditto -
N14	Candawaga	Candawaga, Rizal	Candawaga River	40	38.44	- ditto -
N15	Ira-Iraan	Iraan, Rizal	Ira-Iraan River	140	28.83	2546-IV
N16	Lamakan	Calumpang, Quezon	Lamakan River	20	47.04	2547-II
N17	Iwahig 4	Maasin, Quezon	Iwahig River	60	25.74	2647-IV

N18	Berong	Berong, Quezon	Berong River	60	18.64 3.83	2648-II
N19	Tagbolante	- ditto -	Tagbolante River	40	22.86	- ditto -
N20	Saraza	Saraza, Brook's Point	-	60	18.76	2546-III
N21	Malatgao 4	Malatgao, Quezon	Malatgao River	60	39.67	2647-II
N22	Malatgao 5	- ditto -	- ditto -	50	7.93	2547-II
N23	Salongan 1-1	Salongan, Brooke's Point	-	20	38.63	2546-III
N24	Salongan 1-2	- ditto -	-	- ditto -	- ditto -	- ditto -
N25	Salongan 2-1	- ditto -	-	40	38.63	- ditto -
N26	Salongan 2-2	- ditto -	-	- ditto -	- ditto -	- ditto -
N27	Salongan 3-1	Samanñana, Brook's Point	-	70	15.10	- ditto -
N28	Salongan 3-2	- ditto -	-	- ditto -	- ditto -	- ditto -
N29	Salongan 4	Salongan, Brook's Point	-	70	27.38	- ditto -
N30	Aporawan 1	Aporawan, Aborlan	Iliwan River	30	6.71	2620-II
N31	Aporawan 2-1	- ditto -	Inagawan River	30	7.39	- ditto -
N32	Aporawan 2-2	- ditto -	- ditto -	- ditto -	- ditto -	- ditto -
N33	Aporawan 3-1	- ditto -	Aborlan River	20	26.13	- ditto -
N34	Aporawan 3-2	- ditto -	- ditto -	- ditto -	- ditto -	- ditto -
N35	Baraki 1	Baraki, Aborlan	Baraqui River	40	11.32	2620-II
N36	Baraki 2	- ditto -	- ditto -	60	- ditto -	- ditto -
N37	Baraki 3	- ditto -	- ditto -	70	10.68	- ditto -
N38	Baraki 4	- ditto -	- ditto -	100	- ditto -	- ditto -
N39	Inagawan Sub Colony	Inagawan Sub Colony, Puerto Princesa	Branch of Inagawan River	30	8.90	2720-III
N40	Culandanum 1	Culandanum, Aborlan	Branch of Kulandanum River	20	6.77	2648-I
N41	Culandanum 2	- ditto -	Kulandanum River	40	7.87	- ditto -
N42	Culandanum 3	- ditto -	Branch river of Malatgao River	60	12.25	2648-II
N43	Napsan	Napsan, Puerto Princesa	Panagurian River	30	11.82	2649-II
N44	Marufinas 1-1-1	Marufinas, Puerto Princesa	Babuyan River	20	15.36	2721-II
N45	Marufinas 1-1-2	- ditto -	- ditto -	- ditto -	- ditto -	- ditto -
N46	Marufinas 1-2-1	- ditto -	- ditto -	60	- ditto -	- ditto -
N47	Marufinas 1-2-2	- ditto -	- ditto -	- ditto -	- ditto -	- ditto -
N48	Marufinas 2-1	- ditto -	Branch Rriver of Babuyan River	20	19.60	- ditto -
N49	Marufinas 2-2	- ditto -	- ditto -	50	17.33	- ditto -

N50	Conception 1	Conception, Puerto Princesa	Tarabanan River	20	21.05	2721-II
N51	Conception 2	- ditto -	- ditto -	40	16.31	- ditto -
N52	Binduyan 1-1-1	Binduyan, Puerto Princesa	-	20	17.45	2721-II
N53	Binduyan 1-1-2	- ditto -	-	- ditto -	- ditto -	- ditto -
N54	Binduyan 1-2-1	- ditto -	-	80	16.63	- ditto -
N55	Binduyan 1-2-2	- ditto -	-	- ditto -	- ditto -	- ditto -
N56	Binduyan 1-3-1	- ditto -	-	130	15.43	- ditto -
N57	Binduyan 1-3-2	- ditto -	-	- ditto -	- ditto -	- ditto -
N58	Binduyan 2	- ditto -	-	30	10.33	- ditto -
N59	Binduyan 3	- ditto -	-	40	7.40	- ditto -
N60	Binduyan 4-1	- ditto -	Branch River of Langogan River	30	14.53	- ditto -
N61	Binduyan 4-2	- ditto -	- ditto -	150	13.10	- ditto -

(d) Screen by catchment area

As mentioned in A.5.1. (a), the potential sites are screened by the catchment areas that are less than $10km^2$. As a result, the following 11 past studied potential sites and 12 of the newly found potential sites shown in Table A.5.4 were omitted.

Table A.5.4 Potential Sites Omitted by the Catchment Area

Past Studied Potential Sites			**Newly Found Potential Sites**		
No.	**Name**	**CA (km^2)**	**No.**	**Name**	**CA (km^2)**
11	Isaub	4.77	N1	San Rafael 1	5.78
13	Bontong	6.57	N3	San Rafael 3	6.15
25	Irahuan	3.37	N4	Pamantolon	5.59
37	Turao	0.30	N6	Magara	2.57
41	Caruray	3.60	N7	Malatgao 3	7.93
42	Sto. Nino	1.01	N22	Malatgao 5	7.93
43	Poblacion, San Vicente	1.56	N30	Aporawan 1	6.71
44	Bulalakao (1)	0.83	N31	Aporawan 2	7.39
45	Bulalakao (2)	1.84	N39	Inagawan Sub Colony	8.90
46	Pasadena	1.19	N40	Culandanam 1	6.77
47	Villa Paz	0.22	N41	Culandanam 2	7.87
			N59	Binduyan 3	7.40

(e) Calculation of river flow at potential sites

Using the river flow data calculated in A.5.3 (b) (ii), the Study Team estimated river flow at the weir site of each potential site that is calculated in the proportion of the catchment area in the nearest gauging station and the catchment area in the potential site.

In the Talakaigan potential site, its catchment area is 27.54 km^2 and the nearest gauging station is the Panacan Gauging Station as mentioned in A.5.3 (b) (ii). Since the catchment area of the Panacan Gauging Station is 10.0 km^2, the ratio between the Panacan and the Talakaigan is 1:2.754. From this assumption, the river flows at the Talakaigan potential site are shown in the Table A5.5.

Table A.5.5 River Flows at the Talakaigan Potential Site

Item	Panakan	Talakaigan
Specific Runoff ($m^3/s/km^2$)	0.047	0.047
Catchment Area (km^2)	10	27.54
Mean Discharge (m^3/s/year)	0.473	1.304
25% Discharge (m^3/s)(95 days)	0.513	1.413
50% Discharge (m^3/s)(185 days)	0.337	0.929
75% Discharge (m^3/s)(275 days)	0.235	0.646
90% Discharge (m^3/s)(328 days)	0.188	0.518
95% Discharge (m^3/s)(355 days)	0.140	0.386
70%FUF (m^3/s)		1.382

The flow duration curve and the 70% FUF curve at the weir of the Talakaigan potential site is shown in the Figure A.5.4.

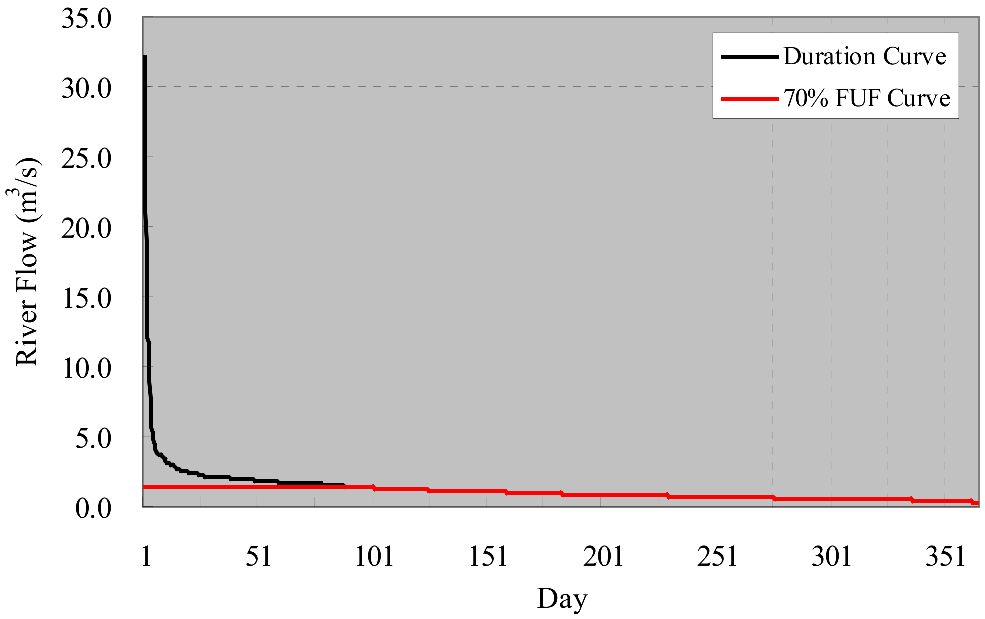


Figure A.5.4 Flow Duration Curve of Talakaigan Potential

(f) Arrangement of civil structures

The Study Team arranged civil structures such as a weir, a headrace and a penstock adjusting to the geological conditions in each remaining potential site. The structures in each potential site will be shown in Section A.5.5.

In the Talakaigan potential site, the Study Team has set civil structures like those in Figure A.5.5 based on the river conditions explained in A.5.3 (c).

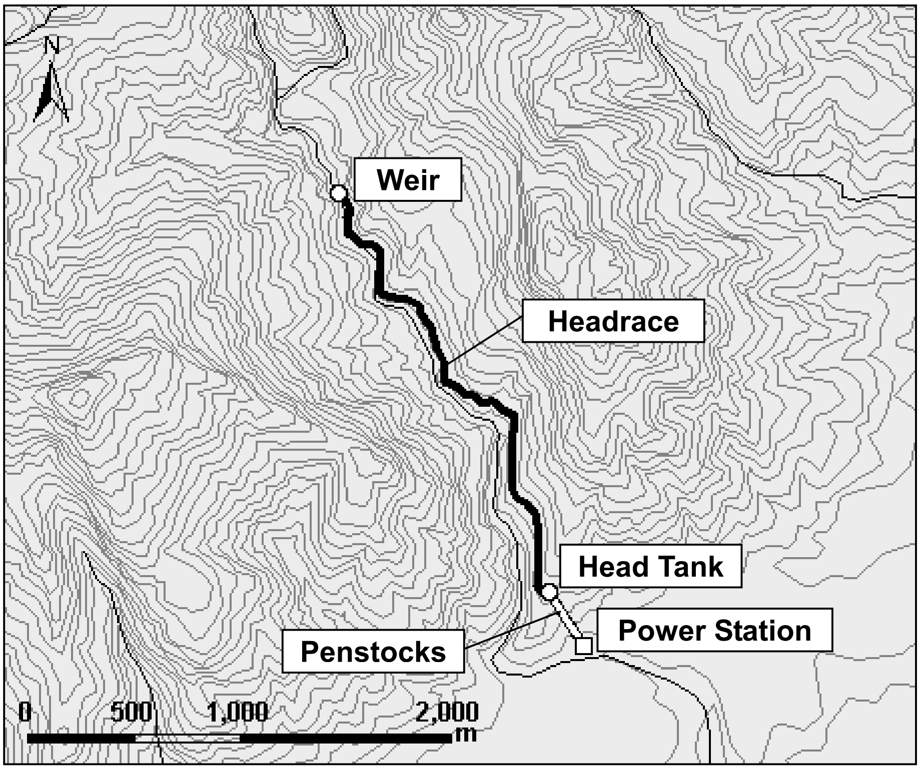


Fig. A.5.5 Civil Structure Arrangement at Talakaigan Potential Site

Although the weir site should be a narrow valley and is preferably vertical to the direction of the river flow, there appears to be no good site. However, from viewpoints of increasing the catchment area to acquire more river flows and comparing with the past data that indicates the location of the Talakaigan potential site, the Study Team decided on the locations of the weir and the powerhouse. Although the Study Team revised the location a little, the locations have been respectfully decided by the past data.

From the arrangement, the specifications of civil structures in the Talakaigan potential site are as follows.

Table A.5.6 Specifications of Civil Structures in Talakaigan Potential Site

Weir								
Generation Type	**Dam Type**	**Dam Height (m)**	**Crest Length (m)**	**Crest Elevation (m)**	**Headrace Length (m)**	**Penstock Length (m)**	**Latitude**	**Longitude**
Run-of-River	Rubble Masonry	3	30	180	2,950	352	9°28'19"	118°26'07"

Powerhouse			
Powerhouse Elevation (m)	**Effective Head**	**Latitude**	**Longitude**
90	86.6	9°26'53"	118°26'47"

(g) Analyses of ambient surroundings

From existing materials and data, the Study Team examined ambient surroundings for each site such as the name of the nearest barangay, the number of households in the barangay, distance from potential site to the nearest barangay center and distance to the backbone transmission line.

In the Talakaigan potential site, the following data was collected and/or measured on the topographic maps.

Table A.5.7 Ambient Surrounding Data at Talakaigan Potential Site

Data Item			Data	Data Source
Barangay Data	Name of Nearest Barangay		Apoc-apoc	Barangay Map Data
	Nearest Barangay Electrification Status		Non-Electrified	PALECO Data
	Distance from Powerhouse to Barangay Center		1.85 km	Topographic maps, Barangay Map Data
	Number of Households		140	Census
	Potential Demand at Nearest Barangay Center	kW	28 kW	Calculated from Census
		kWh	70,000 kWh/yr	
Transmission Data	Distance from Transmission Line to Powerhouse		9.3 km	Topographic maps, transmission construction plan
	Capacity of Transmission Line		130 kV	Existing transmission data and transmission construction plan
Accessibility	Distance from Weir to Nearest Road		2.3 km	Topographic maps and GIS data

(h) Screen by ECAN zoning

Using the ECAN Zoning Map, the Study Team identified the location of each site and found out whether the site and the civil structures fell within Core Zones or Restricted Zones as mentioned in A.5.1 (b). According to the criterion, 43 potential sites (58 sites if counting each case) for which a part of the site is in a Core Zone and/or a Restricted Zone were omitted. Even though the following potential sites in Table A.5.8 are pending based on this criterion, the basic information for these sites, such as specifications for civil structures, is shown in Table A.5.9 for future use.

Table A.5.8 Potential Sites Omitted by ECAN Zoning

Past Studied Potential Sites				Newly Found Potential Sites			
No.	**Name**	**ECAN Zone**		**No.**	**Name**	**ECAN Zone**	
		Weir	**Powerhouse**			**Weir**	**Powerhouse**
5	Malatgao 2	Core	Controlled	N2	San Rafael 2	Core	Controlled
9	Inagawan 1	Core	Core	N5	Labog	Core	Multiple
10	Inagawan 2	Core	Controlled	N8	Bataraza	Core	Controlled
12	Balsahan	Core	Controlled	N9	Tinitian 1	Core	Controlled
18	Estrella Falls	Core	Multiple	N10	Tinitian 2	Core	Controlled
22	Ilian	Core	Core	N12	Samanñana	Core	Controlled
23	Langogan	Core	Controlled	N13	Culacian	Controlled	Core
30	Tiga	Core	Controlled	N14	Candawaga	Traditional	Core
31	Lara	Core	Controlled	N16	Lamakan	Core	Controlled
34	Bulalakao	Controlled	Restricted	N18	Berong	Core	Core
35	Pangbilian	Core	Controlled	N21	Malatgao 4	Core	Core
40	Nicanor Zabala	Core	Core	N23	Salogan 1	Core	Core
				N25	Salogan 2	Core	Core
				N27	Salogan 3	Core	Controlled
				N29	Salogan 4	Core	Controlled
				N33	Aporawan 3	Core	Core
				N35	Baraki 1	Core	Core
				N36	Baraki 2	Core	Controlled
				N37	Baraki 3	Core	Core
				N38	Baraki 4	Core	Controlled
				N42	Culandanum 3	Core	Core
				N43	Napsan	Restricted	Core
				N44	Marufinas 1	Core	Core
				N48	Marufinas 2	Core	Core
				N50	Conception 1	Core	Core
				N51	Conception 2	Core	Core
				N52	Binduyan 1-1	Core	Core
				N54	Binduyan 1-2	Core	Core
				N56	Binduyan 1-3	Controlled	Core
				N58	Binduyan 2	Restricted	Core
				N60	Binduyan 4	Core	Core

(i) Calculation of potential

The Study Team calculated the output for each selected site from the effective head and the maximum plant discharge considering losses by headrace, penstock, efficiencies of turbine and generator.

At the Talakaigan potential site, the firm capacity and the maximum capacity are 370 kW and 990 kW, respectively, as shown in Table A.5.9. The turbine and generation efficiencies are considered to be 88% and 96%, respectively.

Table A.5.9 Capacities of Talakaigan Potential Site

90% Discharge (m^3/s)	**70% FUF (m^3/s)**	**Effective Head (m)**	**Firm Capacity (kW)**	**Maximum Capacity (kW)**
0.518	1.382	86.6	370	990

(j) Selection of turbine type

The turbine type is also selected for each site considering its effective head and the maximum plant discharge. The Study Team basically used the figure in "Guide Manual for Development Aid Programs and Studies of Hydro Electric Power Projects" published by NEF, 1996 to choose the turbine types, but also consulted European turbine companies through their suppliers in the Philippines, such as Pilipinas Engine and Turbine Control, INC, Hydro Electric Development Corporation and Northern Mini Hydro Corporation. Since the suppliers could not show turbine types for all potential sites, the Study Team used Figure A.5.6 for the remaining sites.

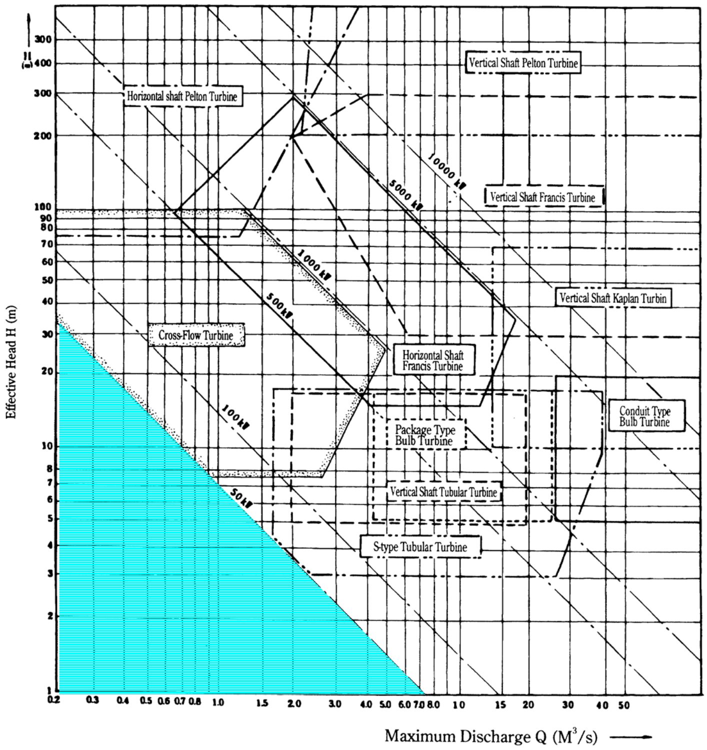


Figure A.5.6 Turbine Selection Diagram: 10 MW less

As mentioned in A.5.1 (f), the turbine types can not be chosen for the sites for which the effective heads are short and maximum plant discharges are small because of technical reasons. Therefore, the Study Team omitted the sites that are in the blue area in Figure A.5.6. The 3 omitted sites are listed in Table A.5.10.

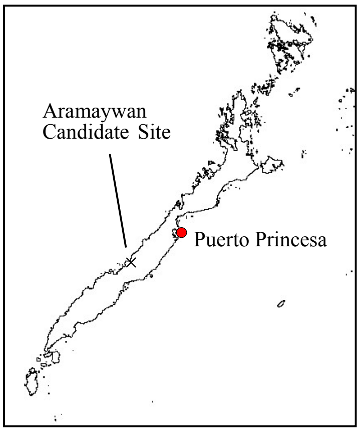
Table A.5.10 Omitted Sites because of No Turbine Type

Past Studied Potential Sites			
No.	**Name**	**Effective Head (m)**	**Maximum Plant Discharge (m^3/s)**
19	Iraan	20	0.198

The turbine type selected for the Talakaigan potential site is a cross flow type.

A.5.4 Procedures of Finding Potential Mini and Micro Hydropower Sites in the Map Study from Demand

In this section, the procedure of finding potential mini and micro hydropower sites in the Map Study from Demand is explained step by step using the Aramaywan candidate site in Barangay Aramaywan, Quezon. Although the steps are different from that of the Map Study from Demand, the contents of each step are almost the same. Therefore, the different contents are mainly explained in this section.



(a) Data collection

Same as the Map Study from Site, Section A.5.3 (a).

(b) Selection of un-electrified barangays

From the data in Table 5.2.1 in the Technical Background Report, which was made from the barangay electrification data, the Study Team selected un-electrified barangays in Palawan.

(c) Calculation of Demand in un-electrified barangay

The Study Team calculated electricity demand in each un-electrified barangay as shown in Table 5.2.1 in the Technical Background Report.

(d) Data analyses

Same as the Map Study from Site, Section A.5.3 (b).

(e) Study of topographic maps

Same as the Map Study from Site, Section A.5.3 (c). Since the target electrified barangays have been determined, however, all topographic maps do not need to be studied.

Through the study of the maps, the Study Team found the following 2 potential sites for the barangay electrification.

Table A.5.11 Newly Found Potential Sites by Map Study from Demand

No.	Name of Site	Location	Name of River	Barangay Demand in 2015 (kW)	Approx. Head (m)	Catchment Area (km^2)	NAMRIA Map Number
D1	Aramaywan	Aramaywan, Quezon	-	31	20	20.74	2648-III
D2	Culasian	Culasian, Rizal	Culasian River	45	40	40.59	2546-IV

The geography of the Aramaywan potential site is shown in Figure A.5.7.

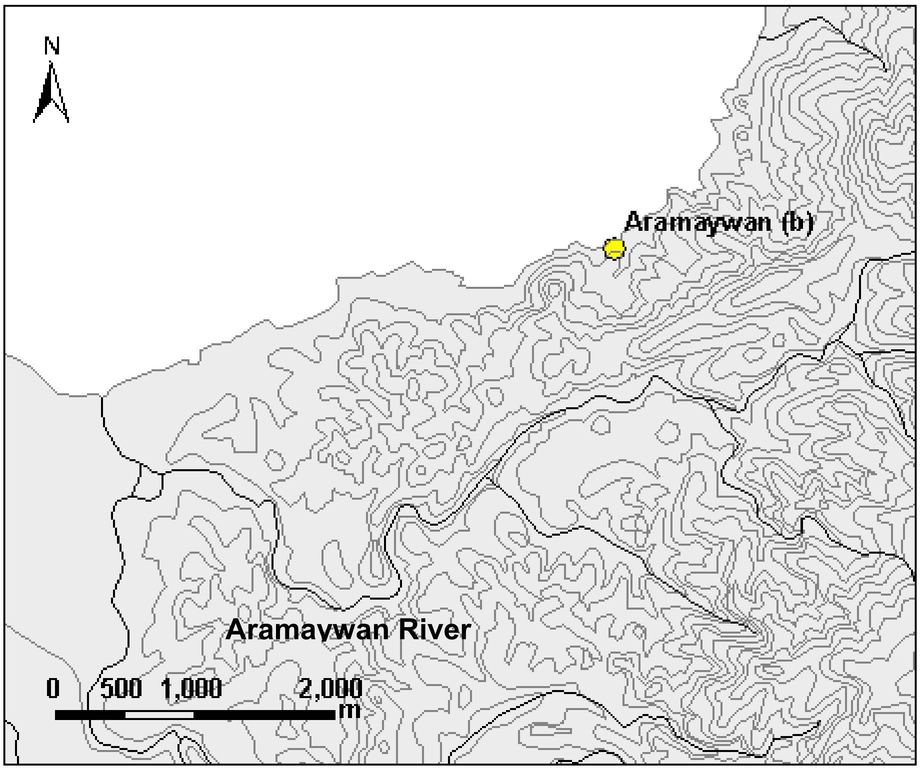


Figure A.5.7 Geography of Aramaywan Potential Site

(f) Screen by catchment area

Same as mentioned in Section A.5.3 (d). However, in this case there are no potential sites with catchment areas less than 10 km^2, and so no sites were omitted.

(g) Calculation of river flow at potential Site

Same as Section A.5.3 (e).

In order to calculate the duration curve at the Aramaywan potential site, the Study Team used the data of the Princes Urdja Gauging Station. Since the proportion of the catchment areas between the Princes Urdja Gauging Station and the Aramaywan potential site is 128:38.91, the river flow data of the Aramaywan is calculated to about 30.4% of the Princes Urdja. Figure A.5.8 shows the flow duration curve and 100% discharge curve at the Aramaywan potential site.

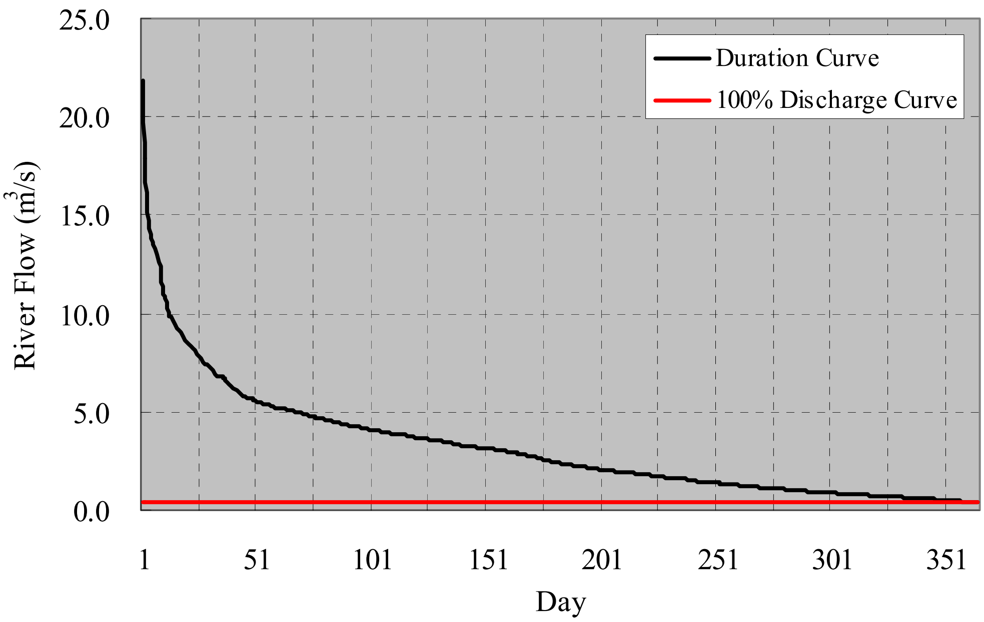


Figure A.5.8 Flow Duration Curve and 90% FUF Curve of Talakaigan Potential Site

(h) Arrangement of civil structures

Same as mentioned in Section A.5.3 (f).

At the Aramaywan potential site the Study Team has set a trial civil structure like the one shown in Figure A.5.9 based on the river conditions explained in A.5.3 (c).

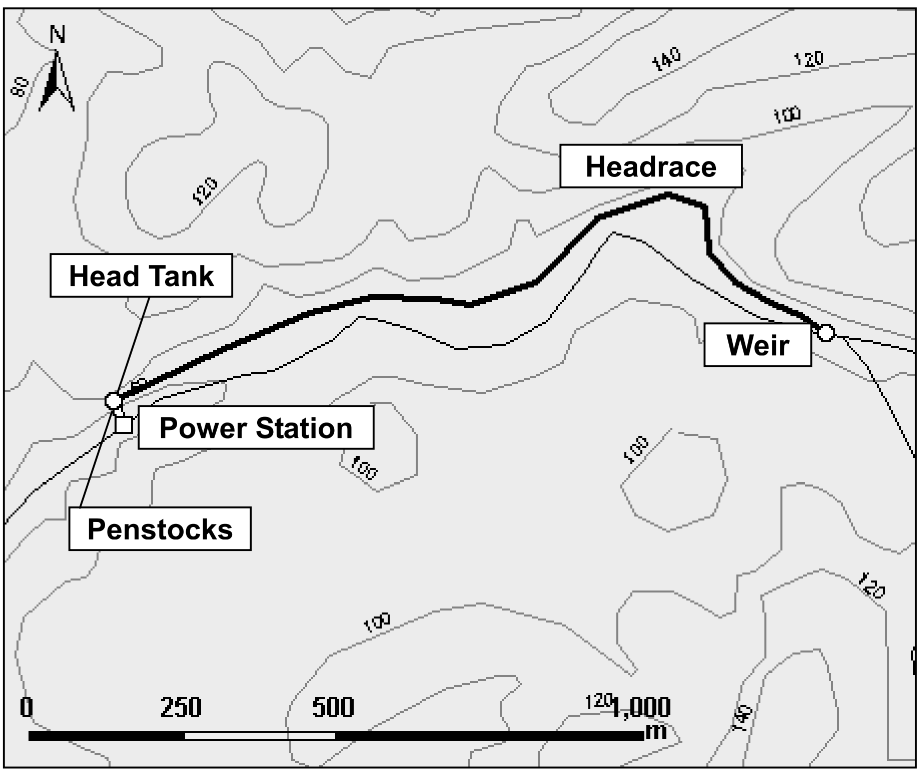


Figure A.5.9 Trial Civil Structure Arrangement at Aramaywan Potential Site

From this arrangement the specifications for civil structures at the Talakaigan potential site are as follows.

Table A.5.12 Specifications of Civil Structures at the Aramaywan Potential Site

Weir								
Generation Type	**Dam Type**	**Dam Height (m)**	**Crest Length (m)**	**Crest Elevation (m)**	**Headrace Length (m)**	**Penstock Length (m)**	**Latitude**	**Longitude**
Run-of-River	Rubble Masonry	3	60	80	180	55	9°23'47"	118° 10'59"

Powerhouse			
Powerhouse Elevation (m)	**Effective Head**	**Latitude**	**Longitude**
58	20.7	9°23'41"	118°10'19"

(i) Analyses of ambient surroundings

Same as Section A.5.3 (g).

The following data was collected and/or measured on topographic maps for the Aramaywan potential site.

Table A.5.13 Ambient Surrounding Data at Aramaywan Potential Site

Data Item		**Data**	**Data Source**
Barangay Data	Distance from powerhouse to barangay center	1.85 km	Topographic maps, Barangay Map Data
Accessibility	Distance from weir to nearest road	2.0 km	Topographic maps and GIS data

(j) Screening by ECAN zoning

Same as Section A.5.3 (h). According to the criterion, none of these sites are located in the Core Zones and/or Restricted Zones as shown in Table A.5.14.

Table A.5.14 Potential Sites ECAN Zones

No.	**Name**	**ECAN Zone**
D1	Aramaywan	Multiple Use
D2	Culasian	Control Use

(j) Calculation of potential

Same as Section A.5.3 (i).

At the Aramaywan potential site, the maximum capacity is 65kW. However, since the demand in the Aramaywan Barangay Center is only 31kW, 65kW capacity is too big for the center demand. Therefore, in order to find the appropriate capacity, the Study Team probed the topographic maps going back to Section A.5.4 (e).

Through a process of trial and error, the Study Team found new potential sites that meet the demand as shown in Table A.5.15. Since the difference between the demand and the capacity is only 25%, the Study Team determined the capacity to be appropriate. This is a type of limitation encountered when trying to find appropriate sites using 1:50,000 topographic maps.

Table A.5.15 New Specifications of Civil Structures in Aramaywan Potential Site

Weir								
Generation Type	Dam Type	Dam Height (m)	Crest Length (m)	Crest Elevation (m)	Headrace Length (m)	Penstock Length (m)	Latitude	Longitude
Run-of-River	Rubble Masonry	3	60	80	890	55	9°'"	118°'"

Powerhouse				Capacity (kW)
Powerhouse Elevation (m)	Effective Head	Latitude	Longitude	
66	12.5	9°23'48"	118°10'34"	39

Although the turbine type cannot be chosen from Figure A.5.6, the Study Team chose a cross flow type based on the interview with turbine and generator suppliers in the Philippines.

The final arrangement of the Aramaywan potential site is shown in Figure A.5.10.

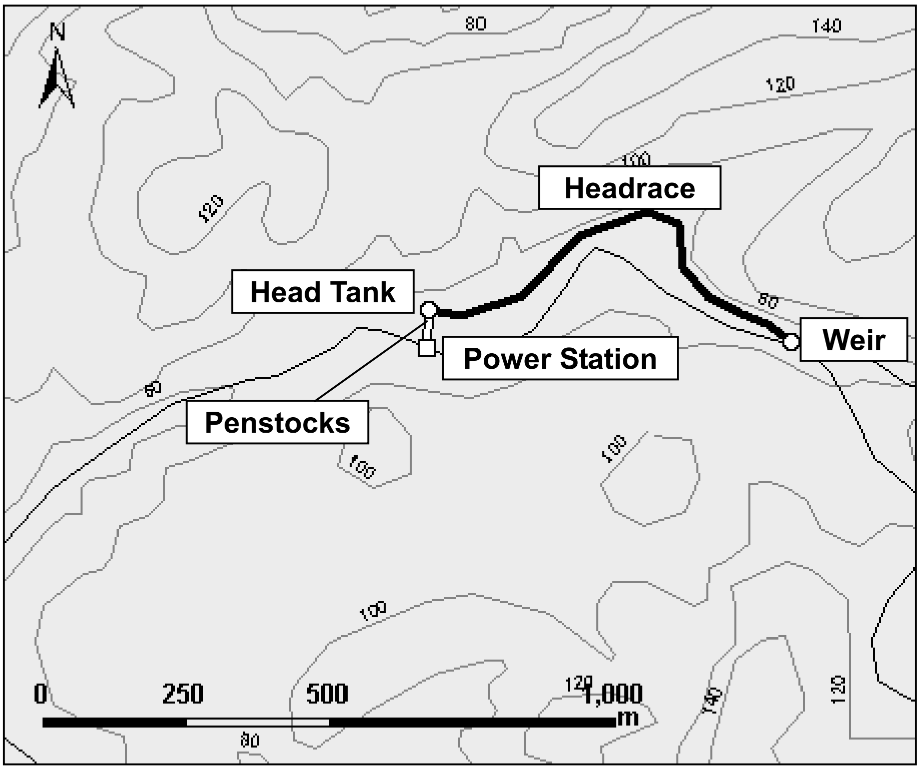


Figure A.5.10 Final Civil Structure Arrangement at Aramaywan Potential Site

A.5.5 Specification of Potential Mini and Micro Hydropower Sites

The lists of potential mini and micro hydropower sites in both the run-of-river type and the pondage type, as well as the diagrams of each site, are shown in Table A.5.16. The list of sites that are located in the Core Zones and/or Restricted Zones of ECAN Zoning is also shown because the zones may be changed in the future, making the sites candidates if they then fall out of these zones. And the sites that were pended because of the catchment areas are also listed since there might be river flows during the whole year and so they can also be candidates for potential sites. These sites are listed as "pended sites."

The figures of candidate sites are shown in APPENDIX A-I.

Table A.5.16 List of Mini and Micro Hydropower Potential Sites in Palawan (Selected Sites)

No.	Names of Site	Location	Names of River	NAMRIA Map Number	Catchment Area (km^2)	90% Discharge (m^3/s)	Maximum Plant Discharge (m^3/s) (70%FUF)	Backbone Line Data: Distance from Backbone Line (km)	Backbone Line Data: Capacity (kV)	Accessibility: Distance from Dam to Nearest Road (km)	ECAN Zoning	Generation Type	Civil Structure: Dam Height (m)	Civil Structure: Crest Length (m)	Civil Structure: Headrace Length (m)	Civil Structure: Pen-stock Length (m)	Electrical & Mechanical Equipment: Efective Head (m)	Electrical & Mechanical Equipment: Firm Capacity (kW)	Electrical & Mechanical Equipment: Designed Capacity (kW)	Electrical & Mechanical Equipment: Type of Turbine	Ope-ration hours (hr/day)	Annual Generation (kWh/yr)
1	Talakaigan	Cabigaan, Aborlan	Talakaigan river	2648-II	27.54	0.518	1.382	9.3	138 (planned)	3.8	Controlled Use Zone	Run-of-River	3	30	2,950	352	86.6	370	990	Cross Flow	24	6,083,534
2	Baraki	Baraki, Aborlan	Aborlan river	2648-II	34.54	0.650	1.733	8.8	138	6.8	Controlled Use Zone	Run-of-River	3	20	640 / Tunnel 2,880	209	58.8	320	840	Cross Flow	24	5,179,986
4	Malatgao (1)	Estrella Village, Narra	Malatgao river	2648-II	99.15	1.866	4.983	9.1	138	10.1	Controlled Use Zone	Run-of-River	5	200	1,250	405	52.7	820	2,200	Horizontal Francis	24	13,335,223
6	Iwahig (1)	Bagong Bayan, Puerto Princesa	Iwahig river	2749-III	27.06	0.145	0.557	13.2	138	12.7	Multiple Use Zone	Run-of-River	3	40	3,500	130	45.6	55	210	Cross Flow	24	1,285,235
7	Iwahig (2)	Montible, Puerto Princesa	Iwahig river	2749-III	95.75	0.511	1.949	5.7	138	5.6	Controlled Use Zone	Run-of-River	14	60	3,500	155	33.5	140	540	Cross Flow	24	3,312,354
8	Iwahig (3)	Montible, Puerto Princesa	Iwahig river	2649-III	97.15	0.519	1.982	5.3	138	5.6	Controlled Use Zone	Run-of-River	2	40	2,910	162	17.6	76	290	Cross Flow	24	1,768,597
15	Barong Barong	Aribungos, Brooke's Point	BarongBarong river	2546-I	18.65	0.266	1.106	7.0	69	1.1	Controlled Use Zone	Run-of-River	3	55	1,000	92	67.3	150	620	Cross Flow	24	3,772,253
20	Babuyan (1)	Puerto Princesa	Babuyan river	2750-II	24.88	0.133	0.513	1.3	138 (planned)	1.3	Multiple Use Zone	Run-of-River	3	40	950	61	3.5	4	15	Cross Flow	24	90,696
27	Aborlan	Cabigaan, Aborlan	Aborlan river	2648-II	39.42	0.742	1.985	8.5	138	2.6	Multiple Use Zone	Run-of-River	4	40	2,920	202	18.4	110	300	Cross Flow	24	1,851,954
28	Maoyon	Puerto Princesa	Unnamed river	2750-II	18.85	0.746	0.789	0.9	138 (planned)	0.8	Controlled Use Zone	Run-of-River	3	35	Tunnel 570	101	12.4	76	80	Cross Flow or Submerged Pomp	24	494,036
32	Imulnod	Imulnod, Brooke's Point	Imulnod river	2546-I	19.22	0.274	1.141	9.8	69	3.5	Controlled Use Zone	Run-of-River	14	60	Tunnel 800	168	48.0	110	450	Cross Flow	24	2,773,602
33	Filantropa	Maasin, Brooke's Point	Filantropa river	2546-I	30.93	0.115	0.554	8.2	69	5.6	Controlled Use Zone	Run-of-River	7	60	Tunnel 1,260	80	38.3	36	180	Cross Flow	24	1,073,187
39	Bakungan	Puerto Princesa	Bacungan river	2749-IV	26.04	0.248	1.042	0.2	138 (planned)	3.5	Controlled Use Zone	Run-of-River	3	40	Tunnel 3,400	21	14.2	29	120	Cross Flow	24	750,378
N11	Talakaigan (2)	Cabigaan, Aborlan	Talakaigan river	2648-II	25.35	0.477	1.272	9.3	138	4.1	Controlled Use Zone	Run-of-River	20	70	3,100	362	105.6	420	1,100	Cross Flow	24	6,822,767
N15	Ira-Iraan	Iraan, Rizal	Ira-Iraan river	2546-IV	28.83	0.410	1.711	25.0	69	14.2	Controlled Use Zone	Run-of-River	3	50	Tunnel 2,830	350	139.7	480	2,000	Cross Flow	24	12,102,545
N19	Tagbolante	Begon, Quezon	Tagbolante river	2648-II	22.86	0.394	1.751	45.0	69	17.2	Controlled Use Zone	Run-of-River	3	50	Tunnel 2,000	57	38.3	130	560	Cross Flow	24	3,400,602
N20	Saraza	Saraza, Brook's Point	Unnamed river	2546-III	18.76	0.267	1.114	20.5	69	2.4	Controlled Use Zone	Run-of-River	3	45	100 / Tunnel 1,640	109	58.4	130	540	Cross Flow	24	3,295,372
P1	Cabigaan	Cabigaan, Aborlan	Aborlan river	2619-I	35.28	0.664	3.985	11.5	138	5.0	Controlled Use Zone	Pondage	30	91	—	34	27.8	150	920	Horizontal Francis	4	2,963,199
P3	Dumanguena	Dumanguena, Narra	Branch river of Malatgao river	2648-II	24.51	0.461	2.768	10.4	138	0.5	Controlled Use Zone	Pondage	25	108	—	31	22.8	87	520	Cross Flow	4	1,688,323
P8	Quinlogan	Quinlogan, Quezon	Linlugan	2547-II	35.18	0.056	0.388	3.4	69	4.2	Multiple Use Zone	Pondage	25	70	—	31	22.8	11	63	Cross Flow	4	375,687
F1	Babuyan (FS)	Tagabinat, Puerto Princessa	Babuyan	2750-II	155.00	—	15.400	25.0	138 (planned)	5.0	Multiple Use Zone	Pondage	12	Aprox. 600	940 / Tunnel 1,280	210	43.7	—	5,600	Horizontal Francis	3	24,180,000
F3	Cabinbin (FS)	Mainit, Brooke's Point	Cabinbin	2646-II	26.66	—	1.860	5.0	13.2 Dist.Line	1.0	Controlled Use Zone	Run-of-River	4	21	1,800	250	56.9	—	800	Horizontal Francis	24	5,080,000
F4	BatangBatang (FS)	Princess Urduja, Narra	BatangBatang river	2647-IV	103.75	—	15.500	13.0	138	10.0	Controlled Use Zone	Run-of-River	6	55	4,770 / Tunnel 730	250	41.3	—	6,700	Horizontal Francis	24	27,400,000

No.	Names of Site	Location	Names of River	NAMRIA Map Number	Catchment Area (km^2)	90% Discharge (m^3/s)	Maximum Plant Discharge (m^3/s) (100%)	Barangay Data: Distance from Barangay Center (km)	Barangay Data: Needed Demand in 2015 (kW)	Accessibility: Distance from Dam to Nearest Road (km)	ECAN Zoning	Generation Type	Civil Structure: Dam Height (m)	Civil Structure: Crest Length (m)	Civil Structure: Headrace Length (m)	Civil Structure: Pen-stock Length (m)	Electrical & Mechanical Equipment: Efective Head (m)	Electrical & Mechanical Equipment: Designed Capacity (kW)	Electrical & Mechanical Equipment: Type of Turbine	Ope-ration hours (hr/day)	Sold Annual Generation in 2015 (kWh/yr)
D1	Aramaywan	Aramaywan, Quezon	Unnamed river	2648-III	20.74	0.670	0.384	1.1	30	2.0	Multiple Use Zone	Run-of-River	3	60	890	55	12.5	39	Cross Flow	6	51,370

Table A.5.17 List of Mini and Micro Hydropower Potential Sites in Palawan (Pended Sites)

No.	Names of Site	Location	Names of River	NAMRIA Map Number	Catchment Area (km^2)	90% Discharge (m^3/s)	Maximum Plant Discharge (m^3/s) (70%FUF)	Backbone Line Data: Distance from Backbone Line (km)	Backbone Line Data: Capacity (kV)	Accessibility: Distance from Dam to Nearest Road (km)	ECAN Zoning	Generation Type	Civil Structure: Dam Height (m)	Civil Structure: Crest Length (m)	Civil Structure: Headrace Length (m)	Civil Structure: Pen-stock Length (m)	Electrical & Mechanical Equipment: Efective Head (m)	Electrical & Mechanical Equipment: Firm Capacity (kW)	Electrical & Mechanical Equipment: Designed Capacity (kW)	Electrical & Mechanical Equipment: Type of Turbine	Ope-ration hours (hr/day)	Annual Generation (kWh/yr)
5	Malatgao (2)	Taretien, Narra	Malatgao river	2648-II	87.84	1.654	4.412	12.4	138	14.6	Core Zone	Run-of-River	5	90	1,670	147	30.9	423	1,130	Cross Flow	24	6,928,746
9	Inagawan (1)	Inagawan, Puerto Princesa	Inagawan river	2748-IV	92.98	0.497	1.896	4.9	138	8.2	Core Zone	Run-of-River	3	50	6,400	96	50.2	207	789	Cross Flow	24	4,830,280
10	Inagawan (2)	Inagawan, Puerto Princesa	Inagawan river	2748-IV	106.51	0.497	2.172	4.4	138	4.1	Core Zone	Run-of-River	3	40	2,360	45	18.3	75	329	Cross Flow	24	2,015,391
12	Balsahan	Simpucan, Puerto Princesa	Balsahan river	2749-III	12.58	0.067	0.264	1.3	138	3.5	Core Zone	Run-of-River	3	70	2,830	157	67.6	38	148	Pelton	24	895,642
18	Estrella falls	El Vita, Narra	Estrella river	2648-II	11.79	0.222	0.597	6.6	138	5.6	Core Zone	Run-of-River	5	50	270	85	24.5	45	121	Cross Flow	24	739,675
30	Tiga	Aribungos, Brooke's Point	Tiga Plan river	2546-I	14.91	0.212	0.883	8.2	69	4.4	Core Zone	Run-of-River	3	30	2,390	260	139.2	245	1,018	Horizontal Pelton or Cross Flow	24	6,231,889
31	Lara	Mainit, Brooke's Point	Lara river	2546-I	27.79	0.396	1.646	7.6	69	2.9	Core Zone	Run-of-River	3	70	1,880	412	94.6	310	1,289	Cross Flow	24	7,888,409
34	Bulalakao	Milihud, Bataraza	Bulalakao river	2546-III	15.58	0.222	0.926	37.1	69	0.8	Ristricted Use Zone	Run-of-River	5	55	360 / Tunnel 370	117	60.3	111	463	Cross Flow	24	2,828,827
35	Pangbilian	Brooke's Point	Pangbilian river	2546-II	37.11	0.528	2.202	7.9	69	4.3	Core Zone	Run-of-River	3	15	1,260	85	46.3	203	845	Cross Flow	24	5,166,435
40	Nicanor Zabala	Roxas	Tulariquin river	2821-III	15.26	0.133	0.511	4.1	138 (planned)	6.8	Core Zone	Run-of-River	3	25	2,100	235	119.4	131	506	Horizontal Pelton or Cross Flow	24	3,083,471
N5	Labog	Panitian, Soflonio Española	Unnamed river	2647-III	32.09	0.191	0.917	1.8	69	4.1	Core Zone	Run-of-River	11	40	800	130	48.2	76	366	Cross Flow	24	2,237,686
N8	Bataraza	Bataraza, Bataraza	Marangas river	2546-III	37.13	0.518	2.152	29.7	69	1.1	Core Zone	Run-of-River	19	60	500	98	38.4	165	684	Cross Flow	24	4,190,317
N9	Tinitian (1)	Tinitian, Roxas	Tinitian river	2821-III	11.74	0.102	0.395	1.5	138 (planned)	2.7	Core Zone	Run-of-River	3	50	1,400	72	30.4	26	99	Cross Flow	24	604,170
N10	Tinitian (2)	Tinitian, Roxas	Tinitian river	2821-III	11.74	0.102	0.395	1.5	138 (planned)	2.6	Core Zone	Run-of-River	3	21	970	27	23.7	20	77	Cross Flow	24	471,040
N12	Samanñana	Samanñana, Brook's Point	Unnamed river	2546-III	37.58	0.535	2.227	12.9	69	1.5	Core Zone	Run-of-River	3	40	1,550	157	77.9	345	1,436	Cross Flow	24	8,791,671
N13	Culacian	Culasian, Rizal	Culasian river	2546-III	37.42	0.533	2.214	25	69	12.3	Core Zone	Run-of-River	3	20	1,850	146	37.9	167	695	Cross Flow	24	4,253,909
N14	Candawaga	Candawaga, Rizal	Candawaga river	2546-III	38.44	0.547	2.274	22	69	11.1	Core Zone	Run-of-River	3	40	1,050	50	38.4	174	723	Cross Flow	24	4,426,086
N16	Lamakan	Calumpang, Quezon	Lamakan river	2547-II	47.04	0.075	0.406	10.2	69	11.1	Core Zone	Run-of-River	3	25	780 / Tunnel 600	46	20.6	13	69	Cross Flow	24	421,823
N17	Iwahig(4)	Maasin, Quezon	Iwahig river	2647-IV	25.74	0.041	0.226	12.6	69	13.5	Core Zone	Run-of-River	3	60	2,670	118	59.9	20	112	Cross Flow	24	677,983
N18	Berong	Berong, Quezon	Berong river	2648-II	18.64 / 3.83	0.387	1.720	45	69	No nearest road	Core Zone	Run-of-River	3	20 / 40	1,960 / 1,000	125 / 125	58.2	186	828	Cross Flow	24	5,072,871
N21	Malatgao(4)	Malatgao, Quezon	Malatgao river	2647-II	39.67	0.747	1.995	15.2	69	9	Core Zone	Run-of-River	3	40	1,820	163	57.8	357	955	Cross Flow	24	5,852,347
N23	Salogan (Case1-1)	Salogan, Brooke's Point	Unnamed river	2546-III	39.02	0.556	2.304	12.8 (Brooke's Point)	69	0.8	Core Zone	Run-of-River	3	14	380	35	19.7	91	377	Cross Flow	24	2,308,036
N25	Salogan (Case2-1)	Salogan, Brooke's Point	Unnamed river	2546-III	38.63	0.550	2.280	12.8 (Brooke's Point)	69	1.4	Core Zone	Run-of-River	3	16	890	67	40.5	184	764	Cross Flow	24	4,684,833
N27	Salogan (Case3-1)	Samarinana, Brooke's Point	Unnamed river	2546-III	15.10	0.215	0.897	12.8 (Brooke's Point)	69	6.4	Core Zone	Run-of-River	3	25	630	113	70.3	125	522	Cross Flow	24	3,193,464
N29	Salongan (Case 4)	Salongan, Brook's Point	Unnamed river	2546-III	27.38	0.390	1.622	16.6	69	6.9	Core Zone	Run-of-River	20	50	1,200	139	67.1	216	900	Cross Flow	24	5,512,039
N33	Aporawan 3 (case1)	Aporawan, Aborlan	Aborlan river	2620-II	26.13	0.492	1.317	18.3	138	19.5	Core Zone	Run-of-River	3	34	1,200	32	15.6	64	170	Cross Flow	24	1,040,812
N35	Baraki (Case1)	Baraki, Aborlan	Baraqui river	2620-II	11.32	0.213	0.573	10.2	138	4.9	Core Zone	Run-of-River	3	18	410	56	37.6	66	179	Cross Flow	24	1,089,918
N36	Baraki (Case2)	Baraki, Aborlan	Baraqui river	2620-II	11.32	0.213	0.573	9.6	138	4.9	Core Zone	Run-of-River	3	18	960	132	64.1	113	304	Cross Flow	24	1,857,674

Attachment - A

Mini and Micro Hydropower Development Plan

No.	Names of Site	Location	Names of River	NAMRIA Map Number	Catchment Area (km^2)	90% Discharge (m^3/s)	Maximum Plant Discharge (m^3/s) (70%FUF)	Backbone Line Data: Distance from Backbone Line (km)	Backbone Line Data: Capacity (kV)	Accessibility: Distance from Dam to Nearest Road (km)	ECAN Zoning	Generation Type	Civil Structure: Dam Height (m)	Civil Structure: Crest Length (m)	Civil Structure: Headrace Length (m)	Civil Structure: Pen-stock Length (m)	Electrical & Mechanical Equipment: Efective Head (m)	Electrical & Mechanical Equipment: Firm Capacity (kW)	Electrical & Mechanical Equipment: Designed Capacity (kW)	Electrical & Mechanical Equipment: Type of Turbine	Ope-ration hours (hr/day)	Annual Generation (kWh/yr)
N37	Baraki (Case3)	Baraki, Aborlan	Baraqui river	2620-II	10.68	0.201	0.540	10.2	138	5.7	Core Zone	Run-of-River	3	30	1,200	117	75.2	125	336	Cross Flow	24	2,053,167
N38	Baraki (Case4)	Baraki, Aborlan	Baraqui river	2620-II	10.68	0.201	0.540	9.6	138	5.7	Core Zone	Run-of-River	3	30	1,700	209	101.6	169	454	Cross Flow	24	2,775,330
N42	Culandanum 3	Culandanum, Aborlan	Branch river of Malatgao river	2648-II	12.25	0.231	0.620	10.6	138	4.8	Core Zone	Run-of-River	3	65	420	92	60.5	115	310	Cross Flow	24	1,894,145
N43	Napsan	Napsan, Puerto Princesa	Panagurian river	2649-II	11.82	0.039	0.265	far	138 (planned)	6.0	Core Zone	Run-of-River	3	41	730	42	26.6	9	59	Pelton	24	355,221
N44	Marufinas 1 (Case1-1)	Marufinas, Puerto Princesa	Babuyan river	2721-II	15.36	0.082	0.319	far	138 (planned)	22.5	Core Zone	Run-of-River	3	39	200	37	22.8	15	60	Cross Flow	24	366,117
N48	Marufinas 2 (Case1)	Marufinas, Puerto Princesa	Branch of Babuyan river	2721-II	19.60	0.105	0.405	far	138 (planned)	5.3	Core Zone	Run-of-River	3	19	900	30	18.7	16	63	Cross Flow	24	381,699
N49	Marufinas 2 (Case2)	Marufinas, Puerto Princesa	Branch of Babuyan river	2721-II	17.33	0.093	0.405	far	138 (planned)	6.2	Core Zone	Run-of-River	3	24	870	83	48.4	37	162	Cross Flow	24	876,494
N50	Conception (Case1)	Conception, Puerto Princesa	Tarabanan river	2721-II	21.05	0.183	0.703	9.7	138 (planned)	5.8	Core Zone	Run-of-River	3	25	500	31	20.7	31	121	Horizontal Francis	24	737,140
N51	Conception (Case2)	Conception, Puerto Princesa	Tarabanan river	2721-II	16.31	0.142	0.547	10.7	138 (planned)	7.1	Core Zone	Run-of-River	3	28	930	77	43.4	51	197	Cross Flow	24	1,198,615
N52	Binduyan 1 (Case1-1)	Binduyan, Puerto Princesa	Unnamed river	2721-II	17.45	0.152	0.584	0.4	138 (planned)	1.0	Core Zone	Run-of-River	3	30	470	30	18.8	24	91	Horizontal Francis	24	553,428
N53	Binduyan 1 (Case1-2)	Binduyan, Puerto Princesa	Unnamed river	2721-II	17.45	0.152	0.584	0.4	138 (planned)	1.0	Core Zone	Run-of-River	3	30	470	30	18.8	24	91	Horizontal Francis	24	553,428
N54	Binduyan 1 (Case2-1)	Binduyan, Puerto Princesa	Unnamed river	2721-II	16.63	0.144	0.556	0.4	138 (planned)	2.0	Core Zone	Run-of-River	3	33	1,200	113	75.2	90	346	Cross Flow	24	2,113,375
N55	Binduyan 1 (Case2-2)	Binduyan, Puerto Princesa	Unnamed river	2721-II	16.63	0.144	0.556	0.4	138 (planned)	2.0	Core Zone	Run-of-River	3	33	1,200	113	75.2	90	346	Cross Flow	24	2,113,375
N56	Binduyan 1 (Case3-1)	Binduyan, Puerto Princesa	Unnamed river	2721-II	15.43	0.134	0.516	0.4	138 (planned)	2.5	Core Zone	Run-of-River	3	45	2,000	244	140.4	156	600	Horozontal Pelton	24	3,660,669
N57	Binduyan 1 (Case3-2)	Binduyan, Puerto Princesa	Unnamed river	2721-II	15.43	0.134	0.516	0.4	138 (planned)	2.5	Core Zone	Run-of-River	3	45	2,000	244	140.4	156	600	Horizontal Francis	24	3,660,669
N58	Binduyan 2	Binduyan, Puerto Princesa	Unnamed river	2721-II	10.33	0.090	0.347	1.9	138 (planned)	2.6	Core Zone	Run-of-River	3	67	700	28	23.7	18	68	Cross Flow	24	415,435
N60	Binduyan 4 (Case1)	Binduyan, Puerto Princesa	Branch river of Langogan river	2721-II	14.53	0.126	0.487	15.6	138 (planned)	13.8	Core Zone	Run-of-River	3	38	600	37	25.7	27	104	Horizontal Francis	24	631,997
N61	Binduyan 4 (Case2)	Binduyan, Puerto Princesa	Branch river of Langogan river	2721-II	13.10	0.114	0.440	15.9	138 (planned)	16.4	Core Zone	Run-of-River	3	25	970	527	156.2	147	569	Horizontal Francis	24	3,466,801
P2	Braki (Case5)	Baraki, Aborlan	Baraqui river	2620-II	15.98	0.301	1.805	8.7	138	3.1	Core Zone	Pondage	35	49.7	no headrace	44	32.83	—	489	Horizontal Francis	4	1,583,101
P4	Conception (Case3)	Conception, Puerto Princesa	Tarabanan river	2721-II	34.4	0.299	1.792	3.9	138 (planned)	0.5	Core Zone	Pondage	30	85.2	no headrace	38	27.83	—	412	Cross Flow	4	1,989,589
P5	Tanabag	Tanabag, Puerto Princesa	Tanabag river	2721-II	36.93	0.321	1.924	6.1	138 (planned)	0.6	Core Zone	Pondage	25	84	no headrace	31	22.83	—	362	Horizontal Francis	4	1,795,918
P6	Inagawan Sub. Colony 2	Inagawan Sub. Colony, Puerto Prinsesa	Inagawan river	2720-III	106.86	0.571	3.426	4.9	138	3.2	Core Zone	Pondage	40	140	no headrace	50	22.83	—	1070	Horizontal Francis	4	5,440,297
P7	Ransang	Ransang, Rizal	Ransang river	2546-IV	34.35	0.055	0.330	22.2	69 (planned)	9.0	Core Zone	Pondage	35	90.7	no headrace	44	32.83	—	89	Cross Flow	4	646,267
P9	San Miguel	San Miguel, Roxas	Caramay river	2850-IV	35.27	0.306	1.838	10.6	138 (planned)	13.3	Core Zone	Pondage	35	128.8	no headrace	44	32.83	—	498	Cross Flow	4	2,467,059
F2	Langogan	Langogan, Puerto Princesa	Langogan river	2721-II	59.00	unknown	unknown		138 (planned)		Core Zone	Run-of-River	10	34	Pipe 1,430	590	91.2	—	6,800	Horizontal Francis	24	27,120,000
F5	Candawaga	Candawaga, Rizal	Candawaga river	2546-III	29.92	unknown	unknown	unknown	Sell electricity to mining company		Core Zone	Run-of-River	14	51	3,400 / Tunnel 300	52	185.1	—	5,500	Horizontal Francis	24	32,100,000

No.	Names of Site	Location	Names of River	NAMRIA Map Number	Catchment Area (km^2)	90% Discharge (m^3/s)	Maximum Plant Discharge (m^3/s) (100%)	Barangay Data: Distance from Barangay Center (km)	Barangay Data: Needed Demand in 2015 (kW)	Accessibility: Distance from Dam to Nearest Road (km)	ECAN Zoning	Generation Type	Civil Structure: Dam Height (m)	Civil Structure: Crest Length (m)	Civil Structure: Headrace Length (m)	Civil Structure: Pen-stock Length (m)	Electrical & Mechanical Equipment: Efective Head (m)	Electrical & Mechanical Equipment: Designed Capacity (kW)	Electrical & Mechanical Equipment: Type of Turbine	Ope-ration hours (hr/day)	Sold Annual Generation in 2015 (kWh/yr)
D2	Culasian	Culasian, Rizal	Culasian River	2546-IV	40.59	0.578	0.188	6.0	35	7.0	Controlled Use Zone	Run-of-River	3	25	2,500	90	29.0	45	Cross Flow	6	58,890

A.5.6 Results of Reconnaissance

The PGP members, DOE members and the Study Team conducted the reconnaissance in Palawan to confirm and adjust the located potential sites. The reconnaissance was conducted twice, the preliminary reconnaissance and the main reconnaissance. Each reconnaissance has different purposes for the Study. In the preliminary reconnaissance the main purpose is to acquire general information and knowledge of rivers in Palawan, and in the main reconnaissance the main purpose is to confirm the locations of some weir sites and power station sites that had been selected through the map study.

The details of both the preliminary and the main reconnaissance are explained as follows.

A.5.6.1 Preliminary Reconnaissance

(1) Outline and objectives

The team conducted a preliminary reconnaissance during the first work in the Philippines. The aims of the preliminary reconnaissance are:

- To acquire prior knowledge of river conditions
- To acquire basic information about areas around rivers in Palawan
- To take a look at the sites that had been studied on maps in the past
- To figure out how broad a catchment area is needed for securing enough river flow during the dry season

Since the time that the team could devote for the reconnaissance was only one day, the sites to be visits were chosen near the provincial capitol, Puerto Princesa. Also, getting the exact points is not a main objective.

The sites that the team visited are; Balsahan River and Bonton River in Barangay Iwahig and Irahuan River in Barangay Irahuan. All sites are located in Municipality Puerto Princesa. The locations of these sites are shown in the map on the right.

(2) Date and members

Date: February 28, 2002

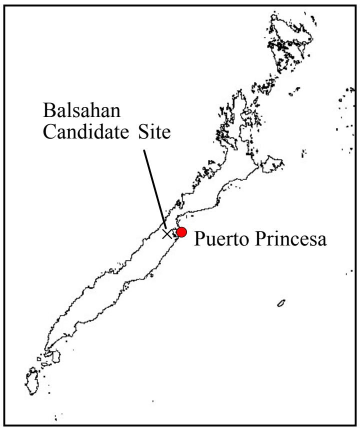
Members: Yoshitaka Saito, Yoshiki Mizuguchi, Hiroshi Ozawa, Roberto Abacial (PGP)

(3) Summary of reconnaissance

(a) Balsahan candidate site

1) Outline

The Balsahan site is a micro hydro project with capacity of 15kW, a 12m-head and $0.10m^3$/sec maximum plant discharge.



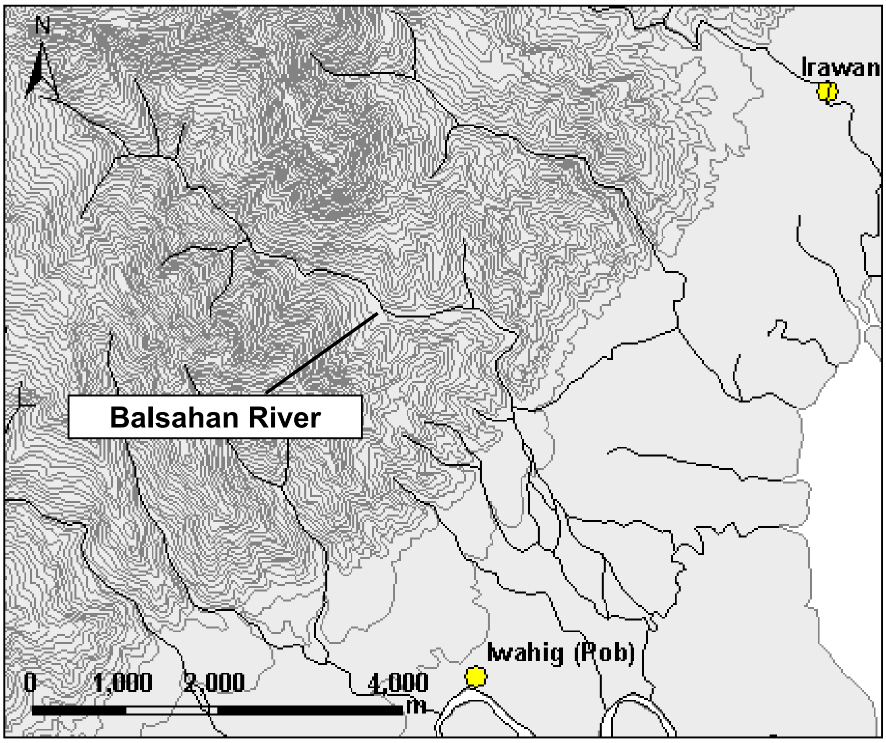


Figure A.5.11 Location and Topographic Map of Balsahan Candidate Site

Balsahan River originates between Thumb Peak (1,269m) and Mt. Beufort (1,098m). It passes from Barangay Bacungan to Barangay Irahuan with an approximately 18.4 km^2 total catchment area from its origin to confluence with Bonton River and almost a 7.5 km river channel length. From the topographic map NAMRIA No. 2749- III, the sea level of its origin is around 500m and the confluence point is around 30m.

The map study of Balsahan was conducted by NEA. In the past map study, only its capacity (15kW), the head (12m) and the plant discharge (0.10m^3/sec) were indicated. There is no information about the dam site and the power station site. Therefore, the team restudied the sites reviewing the topographic map, and defined them from the provided information. The sites which the team defined are:

Weir site:	Longitude 118°38' 33" Latitude 9°47' 06"
Power station site:	Longitude 118°39' 32" Latitude 9°46' 33"

2) Result

To go upstream you must pass through the Iwahig Penal Colony and there is a natural water pool in the colony at the end of the existing road. The river flow exists and its discharge was almost 0.2m^3/sec at the pool site by a visual observation. Near powerhouse site there was a flat space beside the river, which could house a power station.

However, steep inclines could not be observed from the riverside because of the dense forest. The riverbed was covered with pebbles that ranged in size from 5cm to 50cm. The team could not find the proper trail and it seemed that it would take a long time to reach the dam site, and so the team did not proceed. There was water flowing at the site reached by the team and it was assumed that the catchment area at the site was almost $18km^2$.

Pic. A.5.1 Preliminary Site Survey of Balsahan River

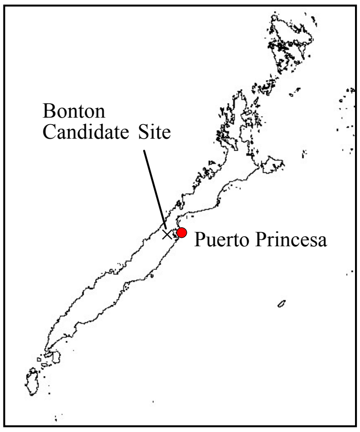
(b) Bonton candidate site

1) Outline

The Bonton site is a micro hydro project with capacity of 8kW, a 10m-head and $0.10m^3$/sec maximum plant discharge, according to the past data.

Bonton River originates from the hillside of Mt. Beufort and passes between Barangay Iwahig and Irahuan with a total catchment area of approximately $10.2km^2$ from its origin to confluence with Balsahan River and an almost 8 km river channel length. From the topographic map NAMRIA No. 2749- III, the sea level of its origin is around 500m and the confluence point is around 30m.

The map study of Bonton was also conducted by NEA. In the past map study only data covering the capacity, head and plant discharge was indicated. There is also no information about the dam site and the power station site. The only site that the team could select for a potential hydro site has $6.57km^2$ catchment area.



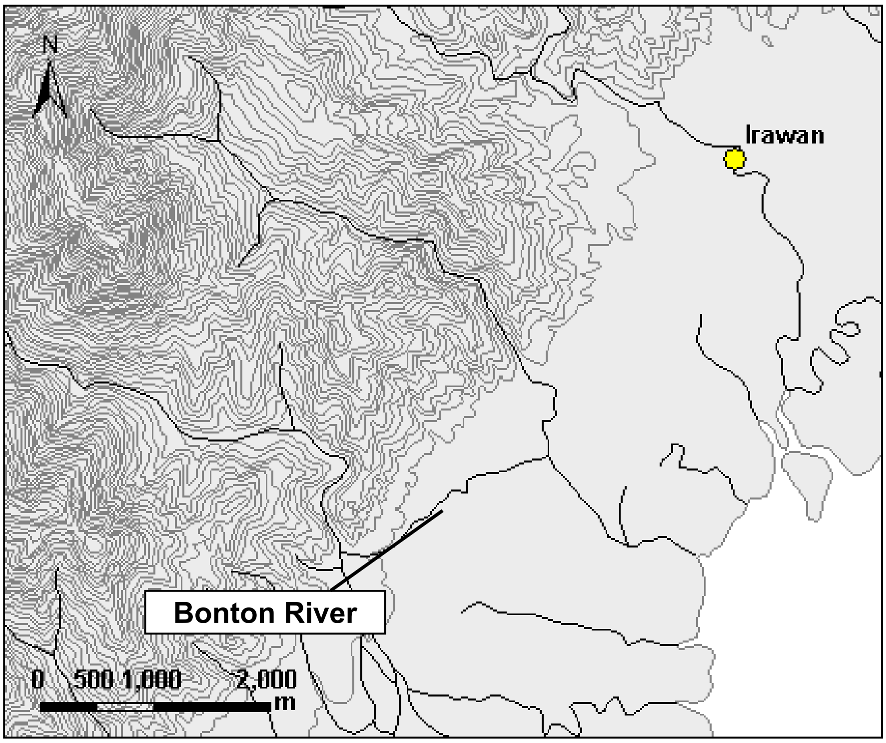


Figure A.5.12 Location and Topographic Map of Bonton Candidate Site

Picture A.5.2 River Bed of Bonton River

2) Result

The team went upstream through the trail, but there was no water in the river. Through an interview with a resident living just beside the river, it was learned that there was also no water during the dry season because there was an irrigation dam upstream taking water to Puerto Princesa. Certainly, the team found the water pipe near the river and ladies laundering clothes using leaking water from the pipe. Also, there was no water during the dry season even if the water is not pumped up for the water supply. It could be imagined that there is a needed to collaborate with NIA if the Bonton site would be selected as a mini hydropower candidate and the catchment area of Bonton, which is 6.57km^2,could not hold enough water for generation during the dry season.

(c) Irahuan candidate site

1) Outline

The Irahuan site is a micro hydro project with a capacity of 20kW, a 20m-head and $0.2m^3$/sec maximum plant discharge.

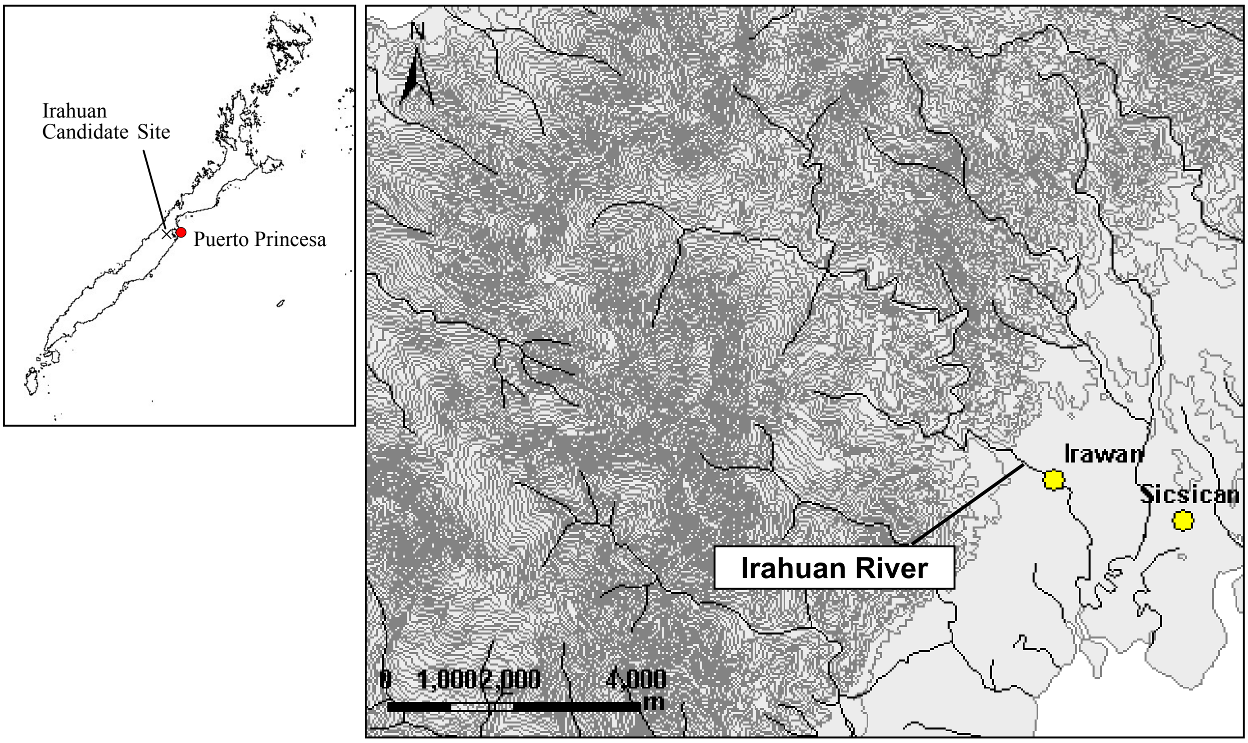


Figure A.5.13 Location and Topographic Map of Irahuan Candidate Site

The Irahuan River originates from north side of Mt. Beufort. It passes in Barangay Irahuan with a total catchment area of approximately 35 km^2 and an almost 16 km river channel length. From the topographic map NAMRIA No. 2749- III, the sea level of its origin is around 400m and it flows out to the Puerto Princesa Bay.

A map study of Irahuan was also conducted by NEA. In the past map study only its capacity, head and plant discharge were indicated, as well as mentioning two sites. There is no information about locations of the dam site and the power station site. Therefore, the team restudied the sites reviewing the topographic map, and defined them from the provided information. The sites which the team defined are:

Weir site:	Longitude 118°40' 42" Latitude 9°49' 24"
Power station site:	Longitude 118°41' 12" Latitude 9°48' 27"

2) Result

The team firstly found a weir for water supply to Puerto Princesa on the way to the dam site. From an interview with a staff member at the pumping station it was learned that $0.2m^3/s$ of water is supplied to Puerto Princesa using two diesel engines. Since it was the dry season and there was not enough water, they were supplying only $0.1m^3/s$ water using only one engine. They said there was water flow of more than $0.1m^3/s$ even in the dry seasons. The catchment area of the station is almost 31.6 km^2.

The team went upstream as far as possible to approach to the site but there were difficulties in crossing the area because of deep woods and time limitations. Therefore, the team stopped the reconnaissance at the site where the catchment area was almost 21.7 km^2. The team confirmed river water and concluded that there was water flow in even in the dry season.

(4) Assumption from preliminary reconnaissance

Through the preliminary reconnaissance, the team has set a minimum catchment area as follows to acquire river flow even in the dry season.

Table A.5.18 Correlation between Catchment Area at Observation Site and River Flow

Site Name	Balsahan	Bonton	Irahuan
Catchment Area (km^2)	16.9	6.8	21.7
River Flow	Existing (about $0.2m^3/s$)	No water flow	Existing (about 0.1～$0.2m^3/s$)

From the result mentioned above, the team assumed that river flow would exist at a site with a catchment area more than 10 km^2. Although it was possible to determine that a minimum catchment area would be 15 km^2 for safety reasons, the team used 10km^2 in order to increase the number of candidate sites for future use when screening by broadness of the catchment area is used.

A.5.6.2 Main Reconnaissance

(1) Outline and objectives

The team conducted a main reconnaissance during the third work in the Philippines. The aims of the main reconnaissance are:

- collect the general information about the selected sites
- T To confirm the locations of selected weir sites and power station sites
- To o select alternative sites if the original sites are not appropriate
- To observe river shapes, access to the sites and environmental conditions
- To inspect hydrological, topographical and geological conditions of rivers and neighborhood of civil structures
- To measure river widths and river flow
- To transfer techniques of reconnaissance to PGP staff

In the original plan the sites which would be given high priority in terms of cost estimation and would have been selected for the reconnaissance. Due to security reasons and time limitations, however, the sites for the reconnaissance should be selected around Puerto Princesa city. Because of this reason, it was impossible to choose higher prioritized sites in the cost estimations. Therefore, assigning the technical transfer a high priority in the main reconnaissance, Bacungan, Iwahig and Balsahan sites were chosen without consideration of the economical aspects.

(2) Members

- Yoshiki Mizuguchi (Mini and Micro Hydropower Development Plan 1)
- Hiroshi Ozawa (Mini and Micro Hydropower Development Plan 2)
- Roberto Abacial (PGP)
- Rex (PGP)
- Epifanio G.. Gaccuan, Jr. (DOE, Civil Engineer)
- Winifredo S. Malabanan (DOE, Geological Engineer)
- Two security guards
- One to three guides at each site

(3) Date and sites

October 8, 2003	: Bacungan, Barangay Bacungan, Puerto Princesa
October 7,	: Iwahig, Barangay Iwahig, Puerto Princesa
October 9,	: Balsahan, Barangay Puerto Princesa, Puerto Princesa

(4) Summary of reconnaissance

(a) Bacungan candidate site

1) Outline

Barangay Bacungan is located in the northern part of Puerto Princesa Municipality and is about 20 km away from Puerto Princesa City to the center of the barangay. Although the electrification stage of the Barangay Bacungan is "non-electrified," there are already distribution lines. However, the electricity has not been turned on yet because the lines are not connected to the backbone transmission lines. This means Barangay Bacungan will be electrified as soon as connected.

Bacungan River is originatedoriginates from Mountain Airey (peak is 626m) in Barangay Bacungan. It passes with an approximately 116km^2 total catchment area and an almost 20km river channel length. The river flows out to Honda Bay. The site is on the NAMRIA map 2749-IV.

From the center of the barangay it takes 10 minutes by car and 2 hours walking to the Bacungan weir site.

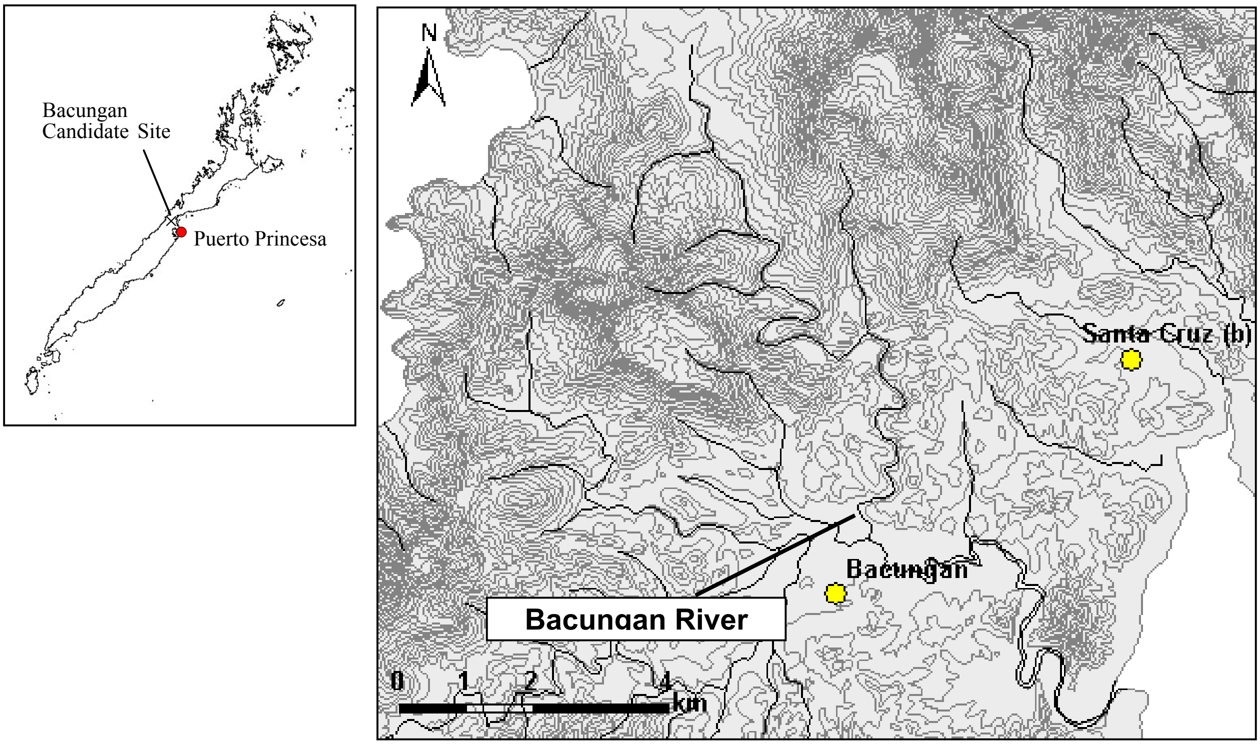


Figure A.5.14 Location and Topographic Map of Bacungan Candidate Site

2) Results

i) Overview

Although it seems that there are no major problems in the base rock of the weir site from a viewpoint of rock strength, the Bakungan candidate site is not good because of a river width that is too wide and because of the flat land. Furthermore, the team could not identify a good powerhouse location, such as a steep slope, since there was no appropriate site for a powerhouse as shown in the topographic map.

ii) Weir site

The team found the candidate weir site (N9°56'35" E118°42'33") along Bacungan River using the topographic map as shown in Picture A.5.3. However, the river width was relatively wide and it seemed that the surface alluvium was as thick as 2 or more meters in depth. Furthermore, the right bank was too flat and so the crest length would be unnecessarily long. Therefore, the team changed the weir sites.

Picture A.5.3 Original Weir Site of Bacungan

The modified site is located about 150m

upstream at latitude N9°56'34" and longitude E118°42'34". There is a low mountain at the left bank of the site and the right bank is almost flat at 30cm to 1.5m up from the river surface. There are plenty of 20 to 50 cm-horses on the river bed.

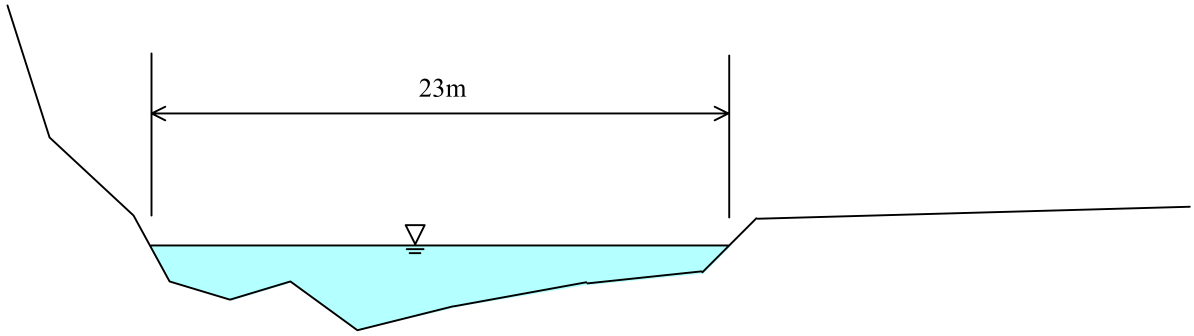


Figure A.5.15 River Section at Weir site on Bacungan River

The base rocks on both the left and right banks are ultramafic rocks and most of the exposed surfaces are weathered. The surface soil on the left bank partly covers rocks 20 to 30cm thick and those on the right bank are about 3m thick. The cracks trend to incline in a WSW-ENE direction at about 60° to the river flow.

3) Powerhouse site

The team tried to find a candidate powerhouse site, but could not identify a good location. From the topographic map there was a relatively steep slope that the Study Team thought could be a powerhouse site, but there was no promising site along the river. Therefore, the powerhouse site needs to be studied more for further planning.

4) River Flow

The team measured river flow at the candidate weir site (N9°56'34" E118°42'34") as shown in Table A.5.19. They used the "One-Point" Measuring method. The current speed of the river flow was measured at 60% depth from surface, and the speed is multiplied by the section area of a river to acquire the flow. The measuring situation is shown in Picture A.5.4.

Picture A.5.4 Measuring River Flow at Bakungan Weir Site

From the measurement, the river flow at the dam site is 3.405 m^3/s. This is enough for mini and micro hydropower generation but the data was measured at the end of the rainy season and so it can be said that the value is relatively high.

(b) Iwahig candidate sites

1) Outline

Barangay Iwahig is located on the east side of Puerto Princesa beyond Puerto Princesa Bay and is about 15 km away from Puerto Princesa City to the center of the barangay. Iwahig River originates from the east side of the Anepahan Peaks. It passes with an approximately 242km^2 total catchment area and an almost 31km river channel length. The river flows out to Puerto Princesa Bay. The site is on the NAMRIA map 2749-III.

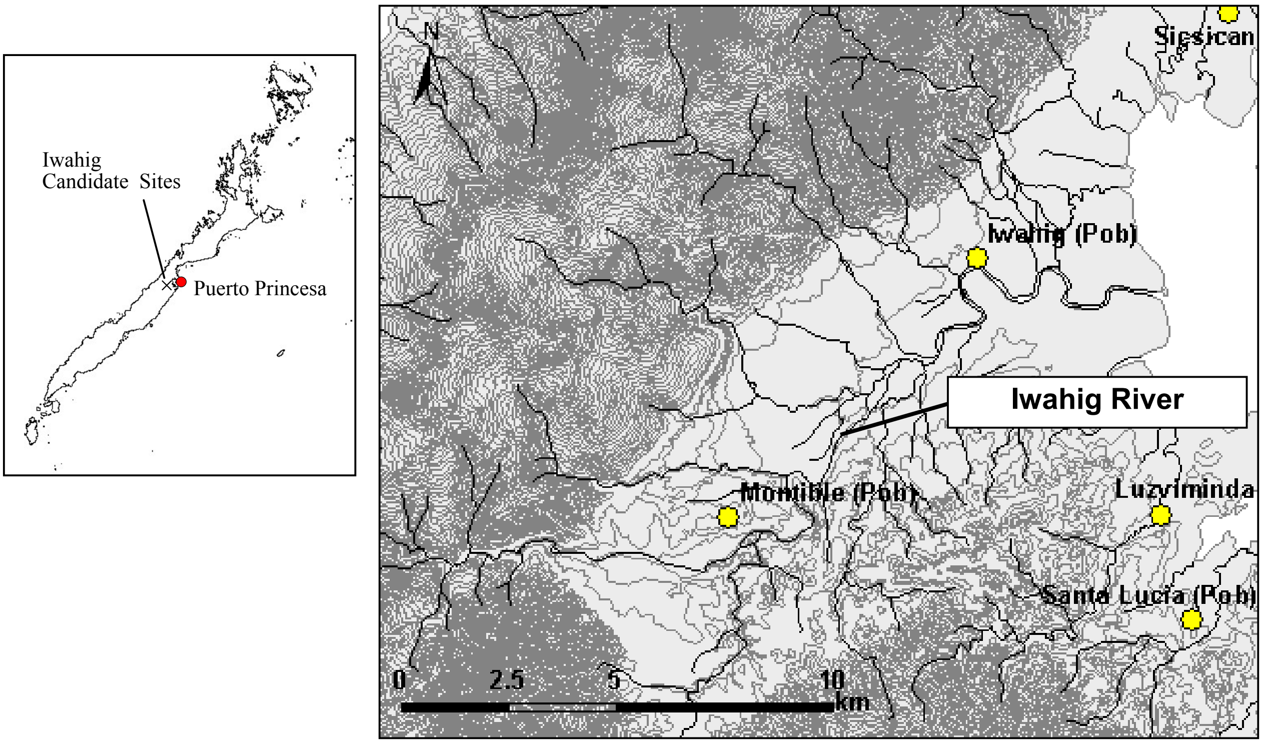


Figure A.5.16 Location and Topographic Map of Iwahig Candidate Site

From the center of the barangay it takes 1 hour by car and 30 minutes walking to the Iwahig 3 weir site.

(b) Results

i) Overview

All of the sites, Iwahig 1, Iwahig 2 and Iwahig 3, are not appropriate. The team found a relatively preferable weir site at the Iwahig 1 candidate site, although the Iwahig 2 and Iwahig 3 weir sites are not good enough because of the river width. However, the powerhouse candidate sites for the Iwahig 2 and 3 no longer exists, because the hill that the Study Team set as its powerhouse sites had been dug out for picking gravels. Therefore, the Study Team omitted the Iwahig 2 and 3 sites from the candidate sites.

ii) Weir site

The team walked along the Iwahig River downstream to upstream from the Iwahig 3 candidate site to the Iwahig 1 candidate site via the Iwahig 2 candidate site.

The Iwahig 3 weir site (N9°41' 24" E118°37'23") was too wide to construct a weir, as compared to the topographic map. Although the river width is about 15m, the river terrace at the left bank, which is flat and about 30cm higher than the river surface, is 45m. This means the crest length would be at least 70m. Furthermore, since the team could not see any exposed rocks, it seemed that the alluvium was relatively thick. Therefore, the team judged that Iwahig 3 was not appropriate for a weir site. The picture and the section image of the Iwahig 3 candidate site are shown in Picture A.5.5 and Figure A.5.17.

Picture A.5.5 Iwahig 3 Candidate Site

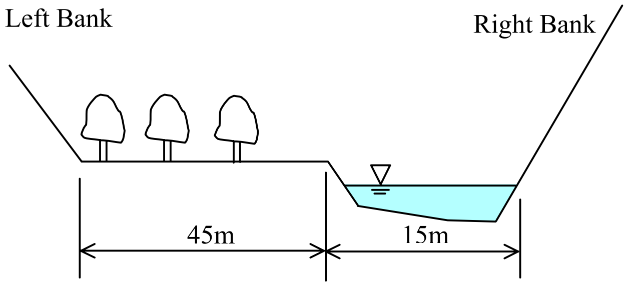


Figure A.5.17 Section Image of Iwahig 3 Weir Site

At the Iwahig 2 weir site (N9° 41'11" E118°36'57"), although the width of the river is almost 28m and the left bank arises from just the left edge of the river, the right bank is arete and river water spills down to downstream. This was not shown on the topographic map. The section image of A-A' is shown in Figure A.5.19. Therefore, it is geographically difficult to construct a weir at this site. The team conducted visible inspections around the Iwahig 2 weir site and a site that could be a candidate site for a weir 150m upstream from the original Iwahig 2 weir site. The width of the river was almost 45m. Although the shape of the right bank looks better than that of the original, it seems still weak and that could be worrisome for a weir. Therefore, the team determined that the Iwahig 2 weir site and its periphery would not be appropriate for a weir site.

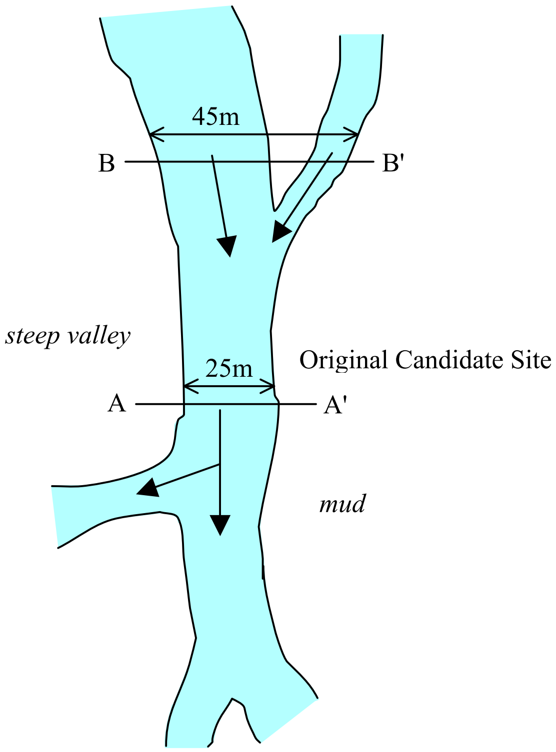


Figure A.5.18 Image of Iwahig 2 Weir Site

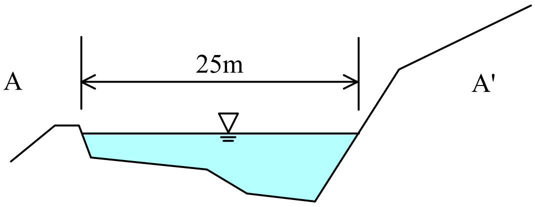


Figure A.5.19 Section A-A'

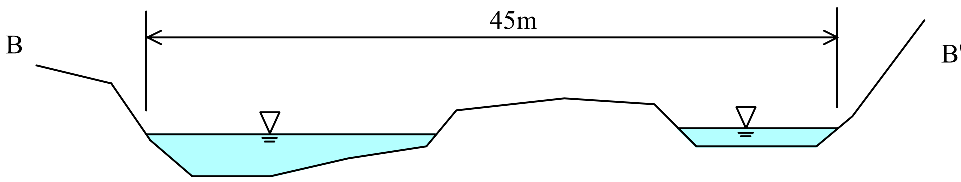


Figure A.5.20 Section B-B'

At the Iwahig 1 weir site (N9°41'02" E118°33'08"), which is 2km upstream from the Iwahig 2 weir site, the banks are steep and the river width is as narrow as 24m. Although the left bank is not so steep as compared with the right bank, it seems steep enough to support the load of a weir. There are plenty of 10 to 30cm pebbles on the river bed at a more than 1m depth.

A base rock, which is a massive ultramafic rock, was exposed on the left bank. The surface is weathered, but the entrails are stiff. Although the team could not go up to inspect the upstream area of the Iwahig 1 site because of the time limitations, there seems to be better sites upstream of the Iwahig 1 weir site. The upstream area will need to be studied more in the future.

Picture A.5.6 Iwahig 3 Weir Candidate Site

Picture A.5.7 Condition of Powerhouse Candidate Site for Iwahig 2 and 3

iii) Powerhouse site

For the powerhouse of the Iwahig 1 site, the team could not identify a good site because of the time limitations. Therefore, the identification of the powerhouse site will be needed for further study.

It would be impossible to construct the powerhouses of the Iwahig 2 and 3 because the predetermined areas (N9°41'55.6" E118°37'08.4") has been excavated for gravel picking and so the hills shown on the topographic map do not exist. The conditions of the powerhouse candidate sites for Iwahig 2 and 3 are shown in Picture A.5.7.

iv) River flow

The team measured the river flow at the Iwahig 2 weir site as shown in Table A.5.20. From the measurement, the river flow is 3.17m^3/s.

(c) Balsahan candidate site

1) Outline

The team conducted the main reconnaissance at Balsahan River to confirm river flow during the rainy season and to research the weir and the powerhouse sites. The outline of the Balsahan candidate site is explained in A.5.6 1 (3)(a)1).

At a natural water pool the discharge was almost 2m^3/sec by a visual observation, which was 10 times as much as at the preliminary reconnaissance since the main reconnaissance was conducted at the end of the rainy season.

From the natural water pool it takes 1 and half hours to walk to the Balsahan weir site.

2) Results

i) Overview

For both the weir candidate sites and the powerhouse candidate site, the Balsahan site is preferable as a candidate. Although there are two candidate weir sites, both can be weir sites from the viewpoint of geographical and geological conditions. There is a steep slope that would be good for a penstock. The team, however, could not confirm the headrace route. Therefore, more research of the headrace conditions will be needed.

ii) Weir site

The team found two candidate weir sites.

The Balsahan candidate weir site No.1 is located at N9°47'05.6" E118°38'31.1". Since the right side of the river is deep, there is little flow in the river. Through the visual observation, the turbidity is about 5 degrees.

Picture A.5.8 Balsahan Candidate Weir Site No.1

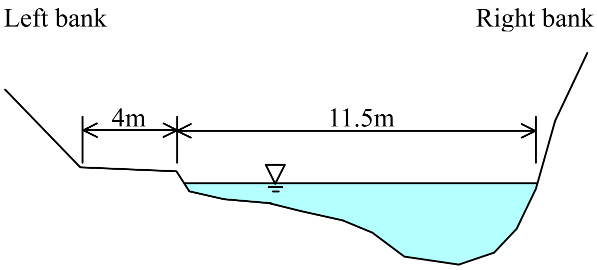


Figure A.5.21 Section Image of Balsahan Candidate Weir Site No.1

The river width at the site is 11.5m. On the right bank there are exposed ultramafic rocks with weathered surfaces. They are massive, but have some silty medium cracks. There is a bamboo grove on the left bank and behind the 4m-wide flat space from the edge of the river a relatively gentle slope arises. There are not any exposed rocks, but it seems that the base rocks exist under thin alluvium. The picture and the image of the Balsahan candidate weir site No.1 are shown in Picture A.5.8 and Figure A.5.21.

The Balsahan candidate weir site No.2 is located at N9°47'07.9" E118°38'34.1", just about 200m downstream of the No.1 site. The width of the river and geography become narrower than other places along the river. The river width is 13m and there is an 8.8m flat land on the right bank.

Picture A.5.9 Balsahan Candidate Weir Site No.2

Although there is a relatively thick alluvium layer on the right bank, the weathered ultramafic rocks are exposed on the left bank. Also at 20m upstream, there is a precipitous rock and a little spring from the rock surface. The picture and the section image of Balsahan candidate weir site No.2 are shown in Picture A.5.9 and Figure A.5.22.

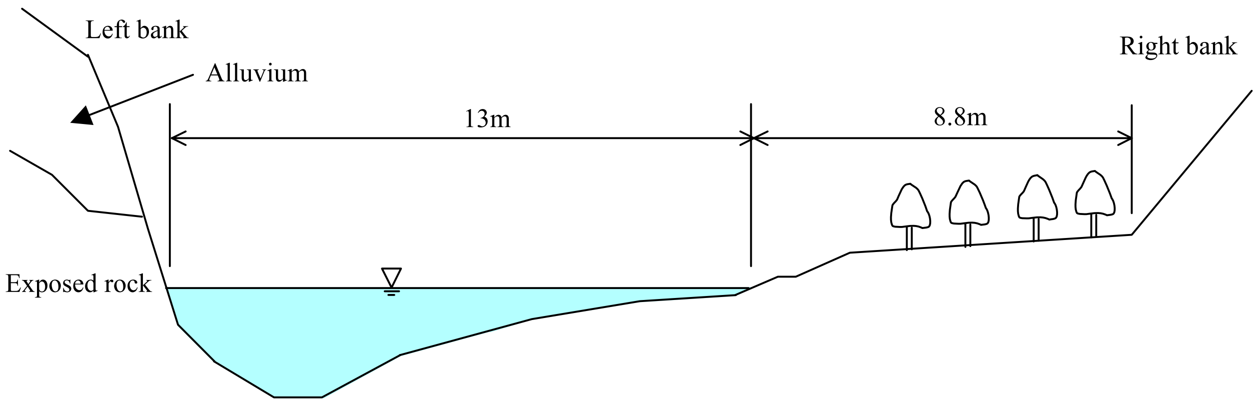


Figure A.5.22 Section Image of Balsahan Candidate Weir Site No.2

iii) Powerhouse site

The powerhouse candidate site (N9°4633.0" E118°39'33.3") looks very good because there is a roughly 60° steep slope, which can be a penstock site, and a flat space, which can be a powerhouse site, and it is 38m wide from the base of the bank and the riverside.

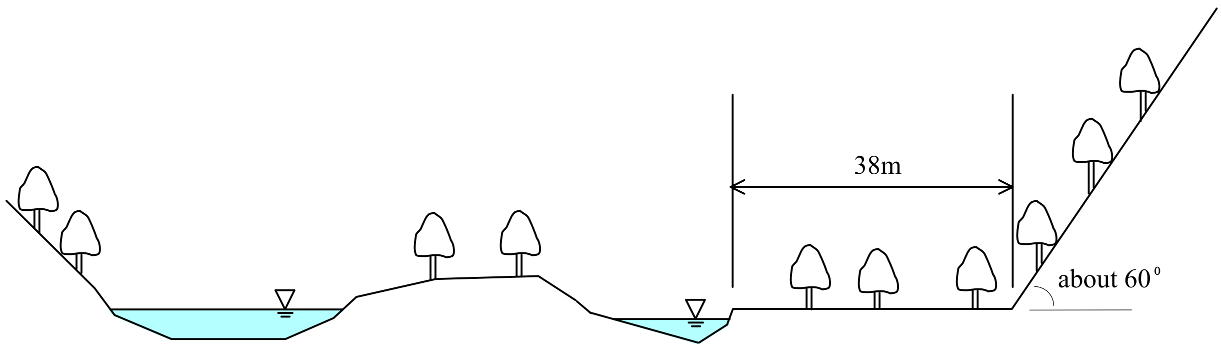


Figure A.5.23 Section Image of the Balsahan Powerhouse Candidate Site

iv) River Flow

The team measured the river flow at the Balsahan candidate weir site No.2 as shown in Table A.5.21 From the measurement, the river flow is 0.905m^3/s.

Table A.5.19 River Flow at Candidate Weir Site of Bacungan River

No.	Distance (m)	Depth (m)	Section Area (m^2)	Velocity (m^3/s) 1st	2nd	3rd	Ave.	Section Velocity (m/s)	Section River Flow (m^3/s)
1	0.0	0.000		0.00	0.00	0.00	0.00		
2	0.5	0.105	0.0700	0.02	0.04	0.04	0.03	0.033	0.002
3	1.0	0.105		0.15	0.19	0.20	0.18		
4	1.5	0.105	0.2250	0.28	0.24	0.29	0.27	0.270	0.061
5	2.0	0.345		0.50	0.48	0.47	0.48		
6	2.5	0.420	0.3975	0.46	0.47	0.46	0.46	0.463	0.184
7	3.0	0.405		0.34	0.37	0.40	0.39		
8	3.5	0.480	0.4763	0.38	0.40	0.40	0.39	0.393	0.187
9	4.0	0.540		0.52	0.46	0.47	0.48		
10	4.5	0.555	0.5400	0.65	0.59	0.58	0.61	0.607	0.328
11	5.0	0.510		0.71	0.70	0.71	0.71		
12	5.5	0.570	0.5625	0.45	0.42	0.44	0.44	0.437	0.246
13	6.0	0.600		0.57	0.43	0.47	0.49		
14	6.5	0.480	0.5175	0.39	0.40	0.39	0.39	0.393	0.204
15	7.0	0.510		0.13	0.09	0.09	0.10		
16	7.5	0.495	0.5288	0.24	0.25	0.25	0.25	0.247	0.130
17	8.0	0.615		0.13	0.14	0.20	0.16		
18	8.5	0.810	0.7988	0.11	0.15	0.21	0.16	0.157	0.125
19	9.0	0.960		0.15	0.21	0.18	0.18		
20	9.5	0.210	0.3938	0.15	0.14	0.11	0.13	0.133	0.053
21	10.0	0.195		0.12	0.14	0.17	0.14		
22	10.5	0.075	0.2138	0.29	0.30	0.26	0.28	0.283	0.061
23	11.0	0.510		0.58	0.51	0.57	0.55		
24	11.5	0.270	0.4650	0.40	0.45	0.43	0.43	0.427	0.198
25	12.0	0.810		0.24	0.30	0.24	0.26		
26	12.5	0.900	0.9375	0.35	0.30	0.28	0.31	0.310	0.291
27	13.0	1.100		0.47	0.43	0.41	0.44		
28	13.5	1.200	1.2000	0.30	0.30	0.29	0.30	0.297	0.356
29	14.0	1.300		0.20	0.15	0.20	0.18		
30	14.5	0.930	1.0013	0.34	0.36	0.33	0.34	0.343	0.344
31	15.0	0.885		0.33	0.31	0.29	0.31		
32	15.5	0.405	0.4800	0.33	0.29	0.31	0.31	0.310	0.149
33	16.0	0.225		0.25	0.22	0.21	0.23		
34	16.5	0.270	0.3188	0.28	0.33	0.31	0.31	0.307	0.098
35	17.0	0.510		0.23	0.22	0.17	0.21		
36	17.5	0.450	0.4388	0.14	0.14	0.14	0.14	0.140	0.061
37	18.0	0.345		0.22	0.23	0.24	0.23		
38	18.5	0.660	0.5475	0.29	0.29	0.36	0.31	0.313	0.172
39	19.0	0.525		0.33	0.30	0.30	0.31		
40	19.5	0.225	0.3188	0.26	0.28	0.30	0.28	0.280	0.089
41	20.0	0.300		0.10	0.04	0.07	0.07		
42	20.5	0.105	0.2138	0.29	0.25	0.26	0.27	0.267	0.057
43	21.0	0.120		0.22	0.21	0.20	0.21		
44	21.5	0.180	0.1200	0.09	0.09	0.09	0.09	0.090	0.011
45	22.0	0.000		0.00	0.00	0.00	0.00		
Total River Flow (m^3/s)									3.405

Table A.5.20 River Flow at Iwahig 2 Candidate Weir Site of Iwahig River

No.	Distance (m)	Depth (m)	Section Area (m^2)	Velocity (m^3/s)				Section Velocity (m/s)	Section River Flow (m^3/s)
				1st	2nd	3rd	Ave.		
1	0.0	0.270		0.12	0.07	0.09	0.09		
2	1.0	0.420	0.4850	0.25	0.17	0.16	0.19	0.193	0.094
3	2.0	0.450		0.25	0.17	0.16	0.19		
4	3.0	0.450	0.9150	0.23	0.25	0.27	0.25	0.250	0.229
5	4.0	0.480		0.36	0.34	0.30	0.33		
6	5.0	0.540	1.0500	0.25	0.24	0.27	0.25	0.253	0.266
7	6.0	0.540		0.26	0.27	0.29	0.27		
8	7.0	0.570	1.1400	0.39	0.32	0.30	0.34	0.337	0.384
9	8.0	0.600		0.23	0.24	0.27	0.27		
10	9.0	0.510	1.0950	0.29	0.32	0.35	0.32	0.320	0.350
11	10.0	0.570		0.24	0.29	0.31	0.28		
12	11.0	0.570	1.1325	0.30	0.24	0.25	0.26	0.263	0.298
13	12.0	0.555		0.29	0.28	0.21	0.26		
14	13.0	0.570	1.1775	0.32	0.38	0.36	0.35	0.353	0.416
15	14.0	0.660		0.24	0.23	0.21	0.23		
16	15.0	0.690	1.3950	0.29	0.27	0.28	0.28	0.280	0.391
17	16.0	0.750		0.18	0.21	0.17	0.19		
18	17.0	0.870	1.6950	0.19	0.21	0.18	0.19	0.193	0.328
19	18.0	0.900		0.17	0.15	0.22	0.18		
20	19.0	0.960	1.9350	0.16	0.15	0.13	0.15	0.146	0.282
21	20.0	1.050		0.06	0.05	0.08	0.06		
22	21.0	0.990	1.9950	0.04	0.06	0.08	0.06	0.060	0.120
23	22.0	0.960		0.05	0.04	0.05	0.05		
24	23.0	0.990	1.9200	0.02	0.00	0.00	0.01	0.007	0.013
25	24.0	0.900		0.00	0.00	0.00	0.00		
26	25.0	0.600	1.1550	0.00	0.00	0.00	0.00	0.000	0.000
27	26.0	0.210		0.00	0.00	0.00	0.00		
28	27.0	0.060	0.1650	0.00	0.00	0.00	0.00	0.000	0.000
29	28.0	0.000		0.00	0.00	0.00	0.00		
Total River Flow (m^3/s)									3.170

Table A.5.21 River Flow at Candidate Weir Site No.2 of Balsahan River

No.	Distance (m)	Depth (m)	Section Area (m^2)	Velocity (m^3/s)				Section Velocity (m/s)	Section River Flow (m^3/s)
				1st	2nd	3rd	Ave.		
1	0.0	0.000		0.00	0.00	0.00	0.00		
2	0.5	0.135	0.0900	0.00	0.00	0.00	0.00	0.000	0.000
3	1.0	0.135		0.06	0.03	0.03	0.04		
4	1.5	0.135	0.1125	0.00	0.00	0.00	0.00	0.000	0.000
5	2.0	0.045		0.00	0.00	0.00	0.00		
6	2.5	0.345	0.2775	0.09	0.07	0.09	0.08	0.083	0.023
7	3.0	0.375		0.08	0.09	0.08	0.08		
8	3.5	0.420	0.4238	0.08	0.08	0.08	0.08	0.080	0.034
9	4.0	0.480		0.10	0.11	0.12	0.11		
10	4.5	0.510	0.5100	0.07	0.10	0.11	0.09	0.093	0.048
11	5.0	0.540		0.09	0.11	0.12	0.11		
12	5.5	0.540	0.5588	0.09	0.10	0.09	0.09	0.093	0.048
13	6.0	0.615		0.11	0.11	0.10	0.11		
14	6.5	0.705	0.7163	0.10	0.11	0.10	0.10	0.103	0.074
15	7.0	0.840		0.09	0.09	0.10	0.09		
16	7.5	0.975	0.9450	0.12	0.11	0.11	0.11	0.013	0.074
17	8.0	0.990		0.11	0.13	0.11	0.12		
18	8.5	1.065	1.0650	0.13	0.14	0.11	0.13	0.127	0.135
19	9.0	1.140		0.11	0.11	0.12	0.11		
20	9.5	1.110	1.1400	0.11	0.10	0.10	0.10	0.103	0.118
21	10.0	1.200		0.13	0.16	0.12	0.14		
22	10.5	1.230	1.1700	0.15	0.16	0.14	0.15	0.150	0.176
23	11.0	1.020		0.13	0.13	0.13	0.13		
24	11.5	1.050	0.9750	0.10	0.10	0.11	0.10	0.103	0.101
25	12.0	0.780		0.14	0.12	0.11	0.12		
26	12.5	0.465	0.4275	0.10	0.09	0.08	0.09	0.090	0.038
27	13.0	0.000		0.00	0.00	0.00	0.00		
Total River Flow (m^3/s)									0.905

A.6 Cost Estimation

A.6.1 Basis of Cost Estimation for Civil Works

In order to estimate the total civil work cost for each candidate site, we must first collect the unit costs of civil works. Civil work cost depend on the site, such as distance from a material producer, shipping and hardness of a base rock. However, the Study Team decided to calculate an average value of each unit cost from the data that the Study Team collected. The collected data was from (1) DPWH, (2) NIA, (3) PNCC (4) Batangbatang report made by JETRO in 2001, and (5) local companies in Palawan.

All unit cost data was used and/or estimated in Palawan. However, the dates for each data are all different and all data could not be collected. This means the unit cost used in the estimation may not indicate real unit costs. This data was used just for estimation in the Master Plan and so re-estimating unit costs will be needed in future feasibility studies. The unit costs used in the Study are shown in Table A.6.1.

Table A.6.1 Unit Costs for Civil Works in the Study (PHP)

Item	Unit	DPWH	NIA	PNCC	Batang Batang	Local comp.	Study Team	Remarks
Structural Concrete Class A (4000PSi)	m^3	5,505.66	4,600.52	5,868.43			5,324.87	
Structural Concrete ClassA-1 (3000PSi)	m^3	4,462.27						
Concrete Class B	m^3		2,400.00		3,500.00	3,500.00	3,133.33	
Gabions	m^3	3,404.53						
Rubble Masonry	m^3		2,290.00					
Rubble Masonry Concrete	m^3						2,711.67	Ratio of Concrete to Masonry is 5:5
Rock Excavation	m^3	338.32	235.00	368.44			(313.92)	
Structure Excavation	m^3	49.53	85.00			260.00		
Common Excavation	m^3	103.53	50.00		47.00	35.00	(58.88)	
Excavation							135.39	(Ratio of Rock and Common is 3:7
Reinforcing Steel Bar	ton	27,900.00		36,700.00	21,000.00	38,000.00	30,900.00	
Concrete Spray (t=100mm)	m^2	932.39						
Concrete Spray	m^3				17,920.00		13,621.95	
Invert Concrete	m^3				4,990.00		4,990.00	No other reference
Access Road	m^2				250.00	226.50	238.25	
Gate	ton				547,000.0		547,000.0	No other reference
Screen	ton				10,000.0		10,000.0	No other reference
Conduit	ton				480,000.0		480,000.0	No other reference

A.6.2 Basis of Cost Estimation for Electrical and Mechanical Works

The Study Team also collected the costs of electrical and mechanical devices. However, it is impossible to estimate the mechanical-electrical equipment cost for each candidate site because the equipment is order-made and the cost depends on each machine. Therefore, the Study Team decided to estimate the cost from the correlations from various data.

First of all, the Study Team sent questionnaires, which included the plant discharge and the effective head for each candidate site, to local turbine and generator companies. Then from their answers the Study Team estimated the correlation between the plant output and the cost in a liner function. The graph of the correlation between a plant capacity and a mechanical-electrical equipment cost is shown in Figure A.6.1.

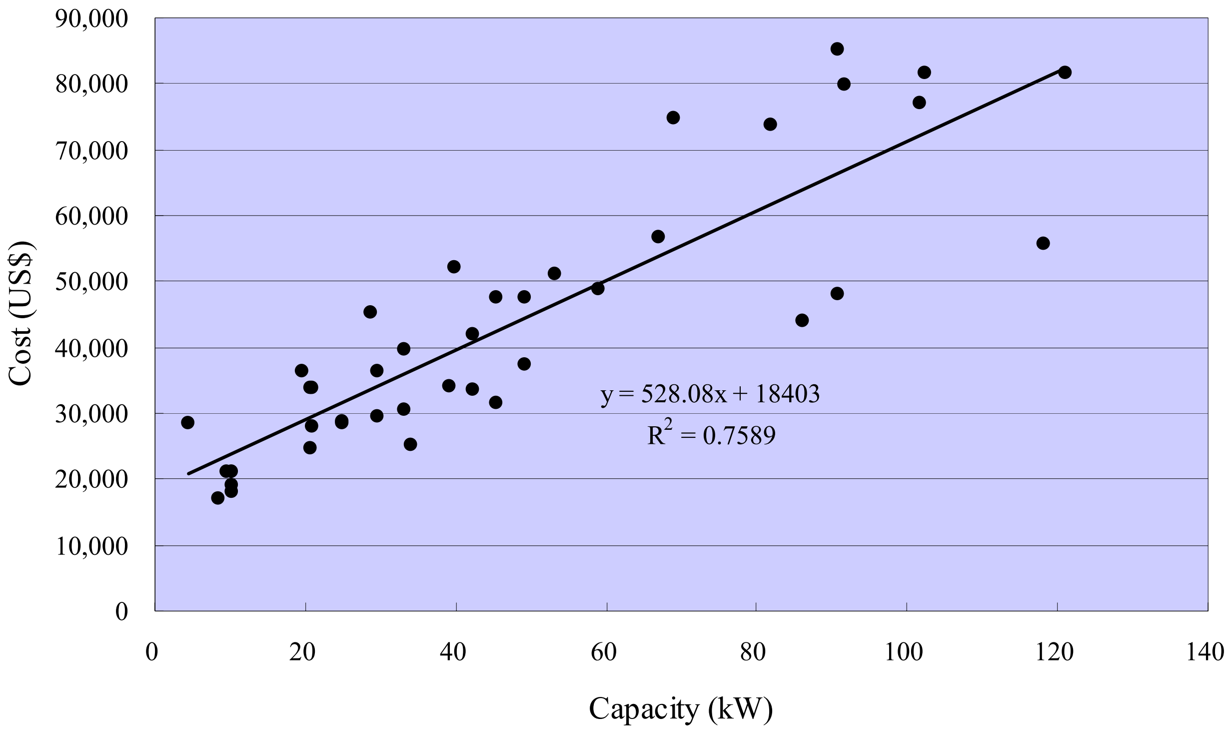


Figure A.6.1 Correlation between Capacity and Mechanical-Equipment Cost

From the result shown in Figure A.6.1, the correlation equation between a plant capacity and a mechanical-electrical equipment cost is indicated as following.

$$y = 528.08x + 18403$$

In order to estimate the mechanical-electrical equipment cost of each candidate site, the Study Team used the above equation.

A.6.3 Basis of Operation and Maintenance Cost

The operation and maintenance cost is usually estimated by a ratio of the construction cost. In Japan the cost of a hydropower station is about 2 to 4%. Since the average employment cost in the Philippines is cheaper than that in Japan, the Study Team decided the operation and maintenance cost as 2% of the construction cost.

A.6.4 Other Costs

The construction cost of transmission lines is estimated as 1.5MPhP/km based on the results from the distribution part and transmission part of the Study.

The concepts of other costs such as a camp and facilities for preparation work, miscellaneous cost and contingency cost followed the "Guide Manual for Development Aid Programs and Studies of Hydro Electric Power Projects," New Energy Foundation, Japan.

The Study Team set the interest for all cost at 12% based on discussions with DOE. Also, to estimate production cost, the Study Team set the life period as 40 years.

A.6.5 Cost Estimations of Potential Sites

The Study Team estimated the costs of each candidate site. The results are shown in APPNDIX A-II.

A.6.6 Optimization of Podage Type Hydropower

A.6.6.1 Finding the site for pondage type hydropower

The Study Team found the appropriate site for the podage type hydropower plant.

Generally the site that has a narrow valley is appropriate for a pondage type hydropower plant since the narrow valley helps to reduce the cost of constructing the dam and weir.

As a result of finding the sites on the map, the Study team found 9 new sites for the podage hydropower project.

Table A.6.2 shows the list of sites and Figure A.6.2 shows the location of them.

Table A.6.2 List of the Sites for Podage Type Hydropower Plant

Name of Site	Municipality	Barangay	NANRIA Map No.	Catchment Area (km^2)
Cabigaan	ABORLAN	Cabigaan	2619-I	35.28
Baraki (Case 5)	ABORLAN	Baraki	2620-II	15.98
Dumanguena	NARRA	Dumanguena	2648-II	24.51
Conception (Case 3)	PUERTO RINCESA	Conception	2721-II	34.40
Tanabag	PUERTO RINCESA	Tanabag	2721-II	36.93
Inagawan Sub. Colony 2	PUERTO RINCESA	Inagawan Sub.	2720-III	106.86
Ransang	RIZAL	Ransang	2546-IV	34.35
Quinlogan	QUEZON	Quinlogan	2547-II	35.18
San Miguel	ROXAS	San Miguel	2850-IV	73.00

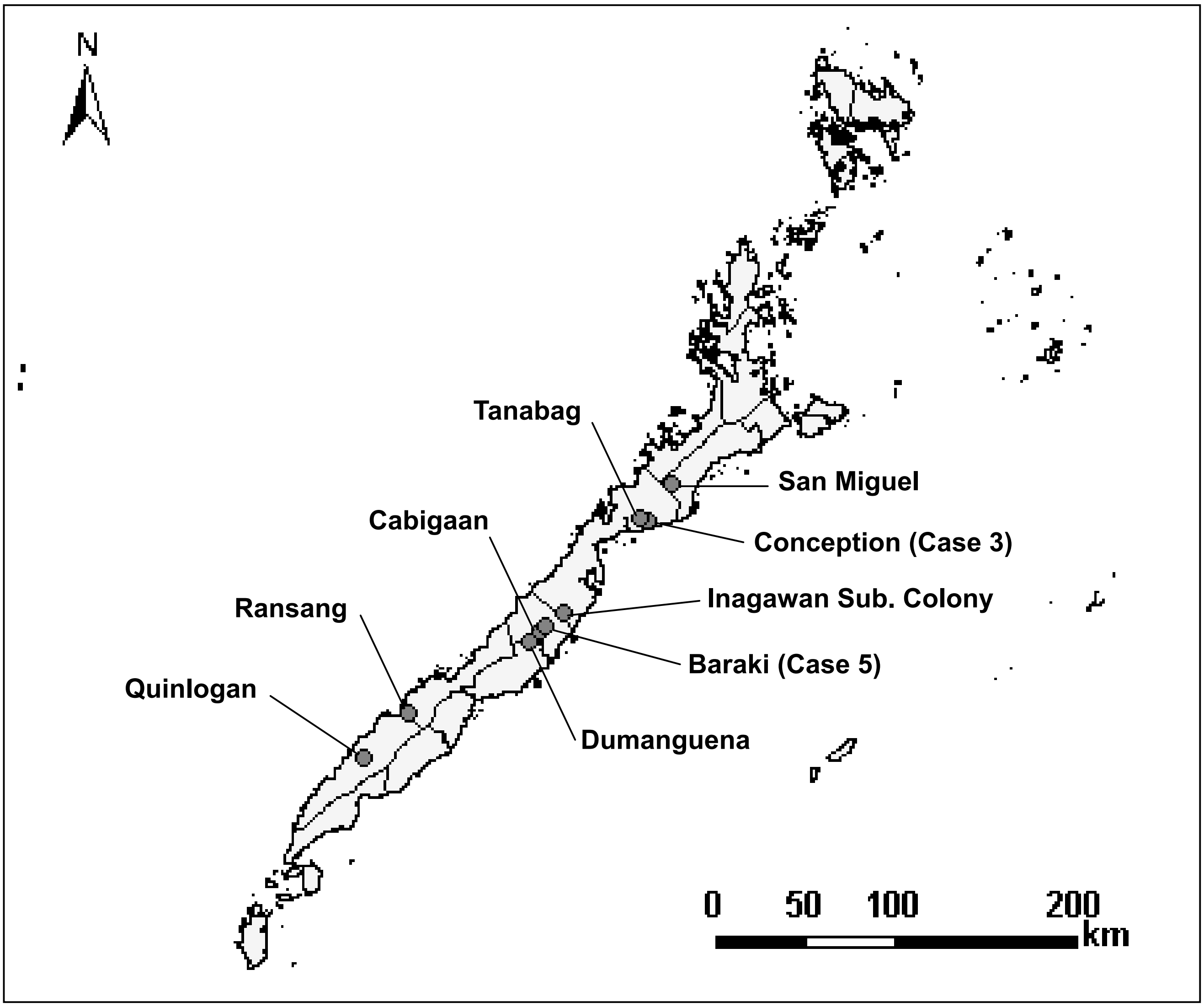


Figure A.6.2 Location Map of Pondage Type Hydropower Plant

A.6.6.2 Setting the service hours

The pondage type hydropower plant generates electricity for a limited number of hours in a day generally. Considering a period from 6 pm to 10 pm, when consumers use the most electricity in a day, the Study team set the service hours for the pondage hydropower plant as 4 hours in a day.

Figure A.6.3 shows the generation pattern of the plant.

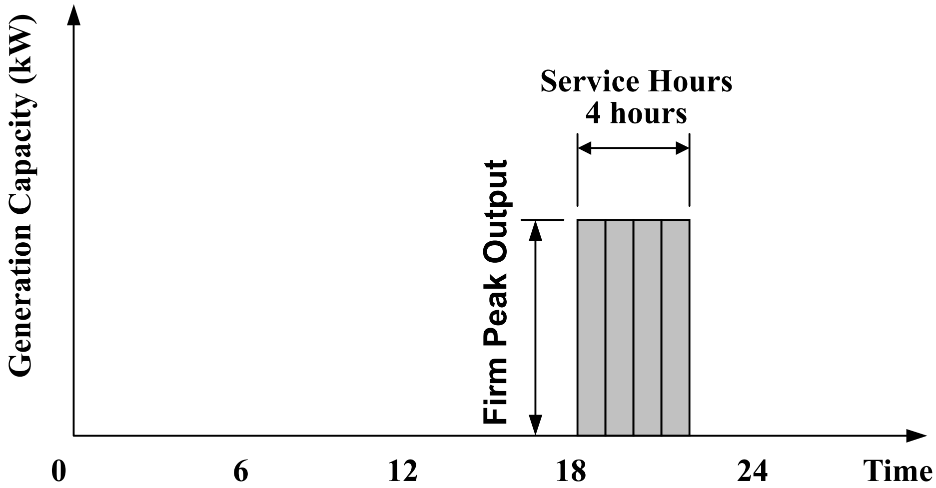


Figure A.6.3 Generation Pattern of Pondage Type Hydropower Plant

A.6.6.3 Sensitivity analysis on dam height

The pond of the pondage type hydropower has fluctuant surface water level because it generates electricity using the storage water. Therefore, this type of hydropower plant has a tunnel for diverting water to a head tank. However, the cost of tunnel construction is expensive compared to an open channel and it seems to increase project costs.

Consequently, the Study team applied the dam type to the pondage hydropower plant in the Study. Figure A.6.4 shows the system of the pondage type of hydropower examined in the Study.

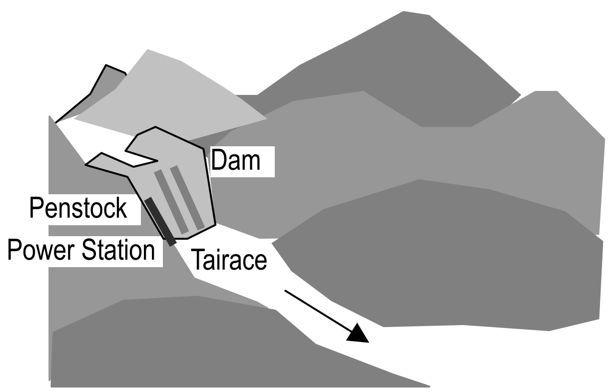


Figure A.6.4 Pondage Hydropower Plant System (Dam Type)

Dam type hydropower plants obtain the effective head from its dam height. The higher dam is built, the higher effective head becomes. However, this entails higher development cost. In this context, it is necessary to examine the optimal height of the dam when planning the dam type hydropower.

Figure A.6.5 shows the image of the optimal dam height.

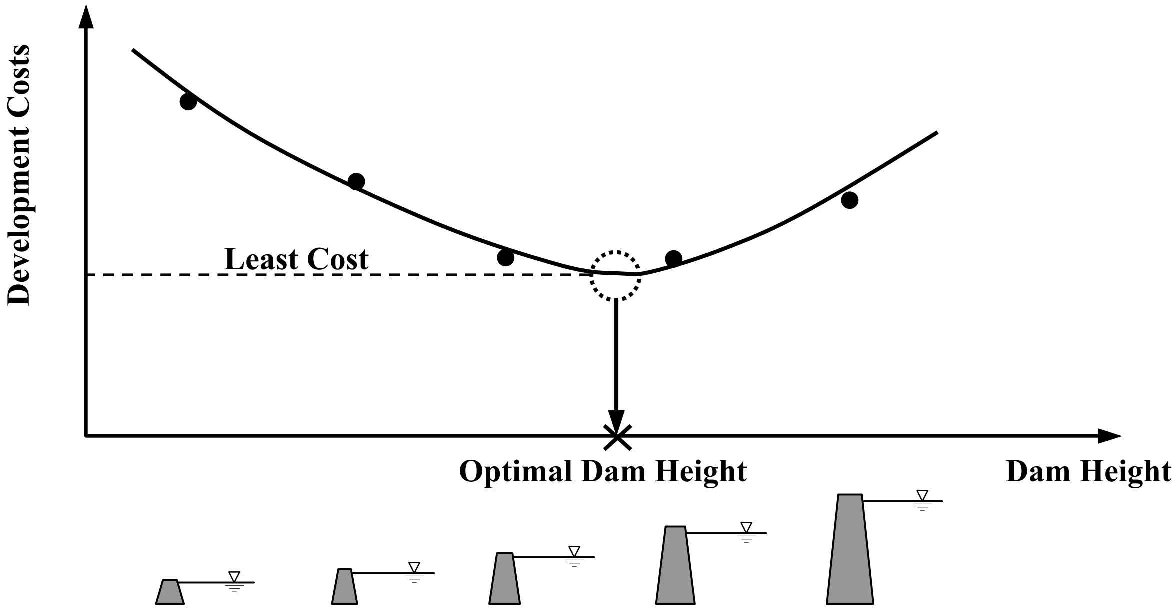


Figure A.6.5 Optimal Dam Height

Using the method shown above, the Study team obtained the optimal dam height for each of the potential sites. An example of optimization for the dam height is shown below.

Site Name : Inagawan Sub. Colony 2

Topographic map of Inagawan Sub. Colony is shown in Figure A.6.6.

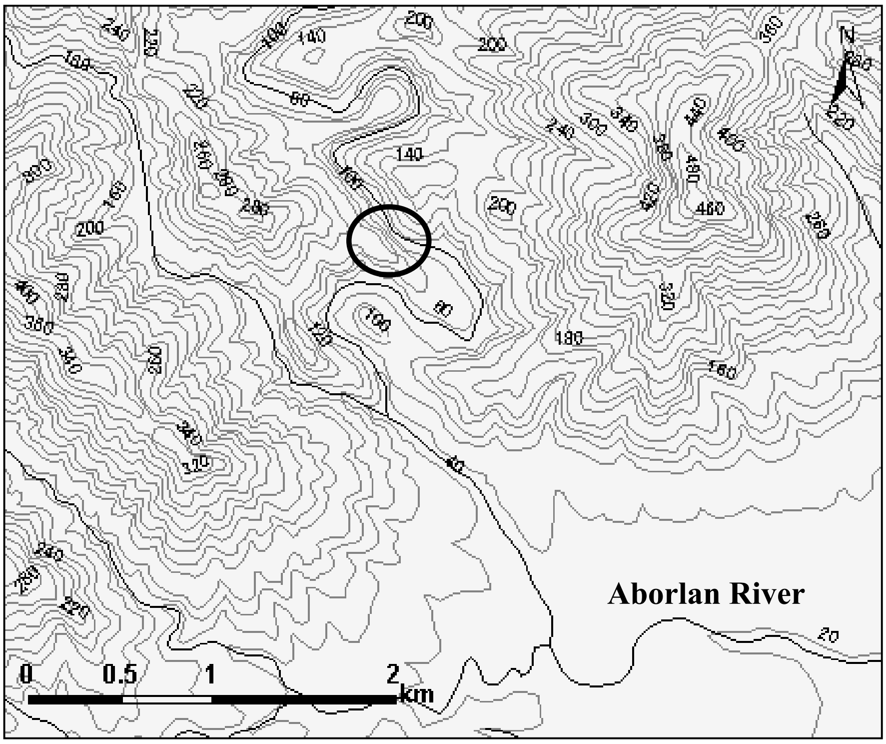


Figure A.6.6 Topographic Map of Inagawan Sub. Colony Sites

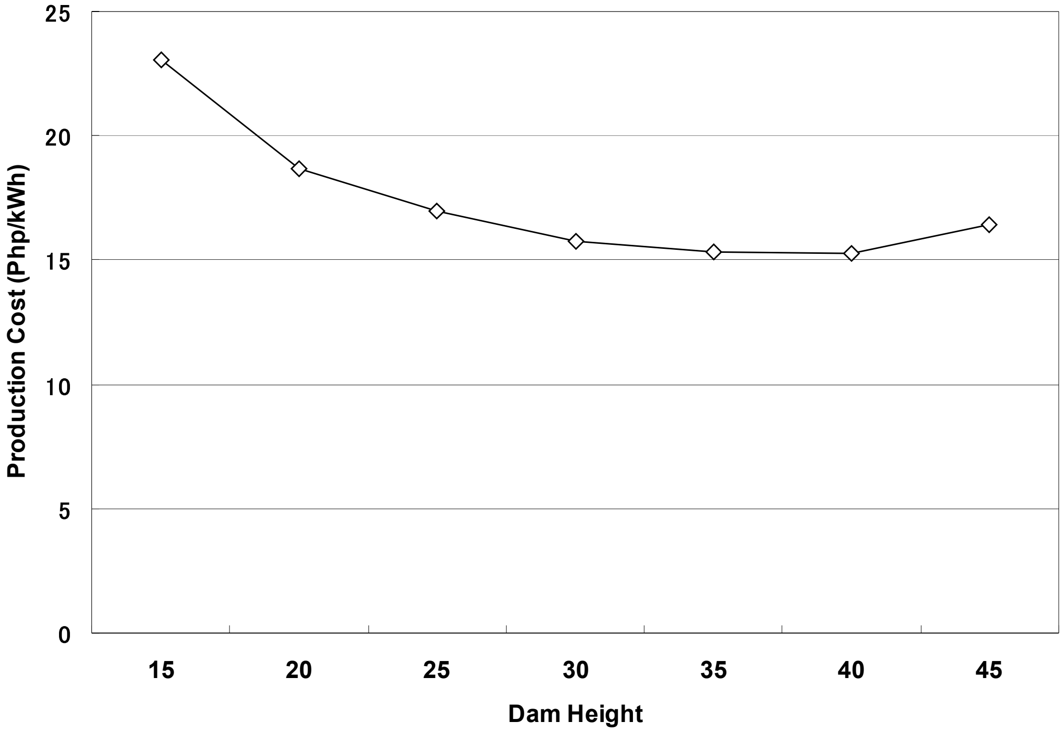
In the map the sites, which are indicated by circles, seem to be appropriate site for pondage hydropower plants since the surrounding valley is narrow.

The Study Team conducted a sensitivity analysis on the dam height at the site. Table A.6.3 and Figure A.6.7 shows the result of the sensitivity analysis.

Table A.6.3 Results of the Sensitivity Analysis on the Dam Height (Inagawan Sub. Colony)

Dam Height	Max. Discharge (m^3/sec)	Effective Head (m)	Maximum Output (kW)	Peak Duration Hour	Penstock Length (m)	Annual Generation (kWh)	Project Cost (US$)	Development Cost (US$/kW)	Production Cost (php/kWh)
5	3.426	2.83	79	4.0 h	7.0	405,420	4,280,943	54,189	81.54
10	3.426	7.83	221	4.0 h	13.0	1,124,717	4,876,912	22,067	33.49
15	3.426	12.83	362	4.0 h	20.0	1,843,809	5,510,099	15,221	23.08
20	3.426	17.83	504	4.0 h	26.0	2,563,107	6,201,185	12,304	18.68
25	3.426	22.83	646	4.0 h	31.0	3,282,610	7,218,562	11,174	16.98
30	3.426	27.83	787	4.0 h	38.0	4,001,702	8,177,067	10,390	15.78
35	3.426	32.83	929	4.0 h	44.0	4,721,000	9,356,516	10,072	15.31
40	3.426	37.83	1,070	4.0 h	50.0	5,440,297	10,733,237	10,031	15.24
45	3.426	42.83	1,212	4.0 h	56.0	6,159,595	13,083,196	10,795	16.40

Figure A.6.7 Correlation between Dam Height and Production Cost (Inagawan Sub. Colony)



A.7 List of Potential Mini and Micro Hydropower Sites

Through the technical and financial analyses the Study Team concluded that the potential mini and micro hydropower sites are as shown in the Table A.7.1. They are listed in order of least to highest production cost.

Table A.7.1 The List of Mini and Micro Hydropower Sites in the Study

No.	Names of Site	Location	Names of River	NAMRIA Map Number	Catchment Area (km^2)	90% Discharge (m^3/s)	Maximum Plant Discharge (m^3/s) (70%FUF)	Backbone Line Data: Distance from Backbone Line (km)	Backbone Line Data: Capacity (kV)	Accessibility: Distance from Dam to Nearest Road (km)	ECAN Zoning	Generation Type	Civil Structure: Dam Height (m)	Civil Structure: Crest Length (m)	Civil Structure: Headrace Length (m)	Civil Structure: Pen-stock Length (m)	Electrical & Mechanical Equipment: Efective Head (m)	Electrical & Mechanical Equipment: Firm Capacity (kW)	Electrical & Mechanical Equipment: Designed Capacity (kW)	Electrical & Mechanical Equipment: Type of Turbine	Ope-ration hours (hr/day)	Annual Generation (kWh/yr)	Development Cost: Total: US$	Development Cost: Total: 1,000PHP	Development Cost: Unit Cost: US$/kWh	Development Cost: Unit Cost: PHP/kWh	Production Cost: Cent/kWh	Production Cost: PHP/kWh
1	Talakaigan	Cabigaan, Aborlan	Talakaigan river	2648-II	27.54	0.518	1.382	9.3	138 (planned)	3.8	Controlled Use Zone	Run-of-River	3	30	2,950	352	86.6	370	990	Cross Flow	24	6,083,534	2,468,398	135,762	2,490	136,962	5.73	3.15
2	Baraki	Baraki, Aborlan	Aborlan river	2648-II	34.54	0.650	1.733	8.8	138	6.8	Controlled Use Zone	Run-of-River	3	20	640 / Tunnel 2,880	209	58.8	320	840	Cross Flow	24	5,179,986	3,164,050	174,023	3,749	206,173	8.63	4.75
4	Malatgao (1)	Estrella Village, Narra	Malatgao river	2648-II	99.15	1.866	4.983	9.1	138	10.1	Controlled Use Zone	Run-of-River	5	200	1,250	405	52.7	820	2,200	Horizontal Francis	24	13,335,223	5,281,747	290,496	2,428	133,557	5.60	3.08
6	Iwahig (1)	Bagong Bayan, Puerto Princesa	Iwahig river	2749-III	27.06	0.145	0.557	13.2	138	12.7	Multiple Use Zone	Run-of-River	3	40	3,500	130	45.6	55	210	Cross Flow	24	1,285,235	1,643,787	90,408	7,804	429,219	18.07	9.94
7	Iwahig (2)	Montible, Puerto Princesa	Iwahig river	2749-III	95.75	0.511	1.949	5.7	138	5.6	Controlled Use Zone	Run-of-River	14	60	3,500	155	33.5	140	540	Cross Flow	24	3,312,354	3,291,378	181,026	7,804	429,219	14.04	7.30
8	Iwahig (3)	Montible, Puerto Princesa	Iwahig river	2649-III	97.15	0.519	1.982	5.3	138	5.6	Controlled Use Zone	Run-of-River	2	40	2,910	162	17.6	76	290	Cross Flow	24	1,768,597	1,780,198	97,911	6,164	339,030	14.22	7.82
15	Barong Barong	Aribungos, Brooke's Point	BarongBarong river	2546-I	18.65	0.266	1.106	7.0	69	1.1	Controlled Use Zone	Run-of-River	3	55	1,000	92	67.3	150	620	Cross Flow	24	3,772,253	1,493,576	82,147	2,423	133,262	5.59	3.08
20	Babuyan (1)	Puerto Princesa	Babuyan river	2750-II	24.88	0.133	0.513	1.3	138 (planned)	1.3	Multiple Use Zone	Run-of-River	3	40	950	61	3.5	4	15	Cross Flow	24	90,696	586,638	32,265	39,451	2,169,795	91.40	50.27
27	Aborlan	Cabigaan, Aborlan	Aborlan river	2648-II	39.42	0.742	1.985	8.5	138	2.6	Multiple Use Zone	Run-of-River	4	40	2,920	202	18.4	110	300	Cross Flow	24	1,851,954	1,748,986	96,194	5,783	318,072	13.34	7.34
28	Maoyon	Puerto Princesa	Unnamed river	2750-II	18.85	0.746	0.789	0.9	138 (planned)	0.8	Controlled Use Zone	Run-of-River	3	35	Tunnel 570	101	12.4	76	80	Cross Flow or Submerged Pump	24	494,036	695,038	38,227	8,595	472,727	19.88	10.93
32	Imulnod	Imulnod, Brooke's Point	Imulnod river	2546-I	19.22	0.274	1.141	9.8	69	3.5	Controlled Use Zone	Run-of-River	14	60	Tunnel 800	168	48.0	110	450	Cross Flow	24	2,773,602	2,610,001	143,550	5,755	316,542	13.30	7.31
33	Filantropa	Maasin, Brooke's Point	Filantropa river	2546-I	30.93	0.115	0.554	8.2	69	5.6	Controlled Use Zone	Run-of-River	7	60	Tunnel 1,260	80	38.3	36	180	Cross Flow	24	1,073,187	1,509,383	83,016	8,578	471,783	19.87	10.93
39	Bakungan	Puerto Princesa	Bacungan river	2749-IV	26.04	0.248	1.042	0.2	138 (planned)	3.5	Controlled Use Zone	Run-of-River	3	40	Tunnel 3,400	21	14.2	29	120	Cross Flow	24	750,378	888,586	48,872	7,248	398,624	16.73	9.20
N11	Talakaigan (2)	Cabigaan, Aborlan	Talakaigan river	2648-II	25.35	0.477	1.272	9.3	138	4.1	Controlled Use Zone	Run-of-River	20	70	3,100	362	105.6	420	1,100	Cross Flow	24	6,822,767	4,812,384	264,681	4,329	238,077	9.97	5.48
N15	Ira-Iraan	Iraan, Rizal	Ira-Iraan river	2546-IV	28.83	0.410	1.711	25.0	69	14.2	Controlled Use Zone	Run-of-River	3	50	Tunnel 2,830	350	139.7	480	2,000	Cross Flow	24	12,102,545	5,472,160	300,969	2,766	152,135	6.39	3.51
N19	Tagbolante	Begon, Quezon	Tagbolante river	2648-II	22.86	0.394	1.751	45.0	69	17.2	Controlled Use Zone	Run-of-River	3	50	Tunnel 2,000	57	38.3	130	560	Cross Flow	24	3,400,602	3,831,864	210,753	6,899	379,444	15.92	8.76
N20	Saraza	Saraza, Brook's Point	Unnamed river	2546-III	18.76	0.267	1.114	20.5	69	2.4	Controlled Use Zone	Run-of-River	3	45	100 / Tunnel 1,640	109	58.4	130	540	Cross Flow	24	3,295,372	2,420,726	133,140	4,493	247,121	10.38	5.71
P1	Cabigaan	Cabigaan, Aborlan	Aborlan river	2619-I	35.28	0.664	3.985	11.5	138	5.0	Controlled Use Zone	Pondage	30	91	—	34	27.8	150	920	Horizontal Francis	4	2,963,199	6,800,979	374,054	7,425	408,356	32.23	17.73
P3	Dumanguena	Dumanguena, Narra	Branch river of Malatgao river	2648-II	24.51	0.461	2.768	10.4	138	0.5	Controlled Use Zone	Pondage	25	108	—	31	22.8	87	520	Cross Flow	4	1,688,323	5,460,502	300,328	10,461	575,340	45.41	24.98
P8	Quinlogan	Quinlogan, Quezon	Linlugan	2547-II	35.18	0.056	0.388	3.4	69	4.2	Multiple Use Zone	Pondage	25	70	—	31	22.8	11	63	Cross Flow	4	375,687	5,332,661	293,296	84,645	4,655,497	199.31	109.62
F1	Babuyan (FS)	Tagabinat, Puerto Princessa	Babuyan	2750-II	155.00	—	15.400	25.0	138 (planned)	5.0	Multiple Use Zone	Pondage	12	Aprox. 600	940 / Tunnel 1,280	210	43.7	—	5,600	Horizontal Francis	3	24,180,000	18,109,850	996,042	3,234	177,865	9.90	5.45
F3	Cabinbin (FS)	Mainit, Brooke's Point	Cabinbin	2646-II	26.66	—	1.860	5.0	13.2 Dist Line	1.0	Controlled Use Zone	Run-of-River	4	21	1,800	250	56.9	—	800	Horizontal Francis	24	5,080,000	2,093,164	115,124	2,616	143,905	5.82	3.20
F4	BatangBatang (FS)	Princess Urduja, Narra	BatangBatang river	2647-IV	103.75	—	15.500	13.0	138	10.0	Controlled Use Zone	Run-of-River	6	55	4,770 / Tunnel 730	250	41.3	—	6,700	Horizontal Francis	24	27,400,000	19,788,915	1,088,390	2,954	162,446	9.34	5.14

No.	Names of Site	Location	Names of River	NAMRIA Map Number	Catchment Area (km^2)	90% Discharge (m^3/s)	Maximum Plant Discharge (m^3/s) (100%)	Barangay Data: Distance from Barangay Center (km)	Barangay Data: Needed Demand in 2015 (kW)	Accessibility: Distance from Dam to Nearest Road (km)	ECAN Zoning	Generation Type	Civil Structure: Dam Height (m)	Civil Structure: Crest Length (m)	Civil Structure: Headrace Length (m)	Civil Structure: Pen-stock Length (m)	Electrical & Mechanical Equipment: Efective Head (m)	Electrical & Mechanical Equipment: Designed Capacity (kW)	Electrical & Mechanical Equipment: Type of Turbine	Ope-ration hours (hr/day)	Sold Annual Generation in 2015 (kWh/yr)	Development Cost: Total: US$	Development Cost: Total: 1,000PHP	Development Cost: Unit Cost: US$/kWh	Development Cost: Unit Cost: PHP/kWh	Production Cost: Cent/kWh	Production Cost: PHP/kWh
D1	Aramaywan	Aramaywan, Quezon	Unnamed river	2648-III	20.74	0.670	0.384	1.1	30	2.0	Multiple Use Zone	Run-of-River	3	60	890	55	12.5	39	Cross Flow	6	51,370	364,893	20,069	9,356	514,592	0.88	48.17

A.8 Recommendations

In this section some recommendations are given for achieving mini and micro hydropower in Palawan.

A.8.1 Further Study

- This Study is just a master plan study, and so it did not go into enough detail to carry out studies of the candidate sites immediately. Therefore, feasibility studies will still need to be conducted for prioritized candidate sites in order to acquire more detailed data.
- Detailed geographical studies will be needed for the higher prioritized sites since the study in the Master Plan used only 1:50,000 topographic maps that are not sufficient enough for geographical investigations. Therefore, making at least 1:10,000 topographic maps around the sites will be needed.
- River flow data is a core consideration for planning a hydropower plant since it affects the power generation that is directly linked to revenues. Therefore, studying river flows at the candidate sites is strongly recommended. The longer the study, the better it will be for accurate data collection.
- Although mini and micro hydropower planning does not require extremely stiff base rock since a weir in a run-of-river type would not have a high height, relatively detailed studies of base rocks at a weir site will be needed to ascertain the strength of the weir base rock.
- As mentioned in the report, there are many candidate sites in Core Zones of ECAN Zoning and they may be candidates depending on the result of the revision of the zones by PCSD. Therefore, the results of the revisions will need to be carefully monitored.

A.8.2 Construction

- Through the interviews, NPC-SPUG expressed that they did not have the willingness to achieve hydropower in Palawan by themselves because it was difficult to secure the needed budgets for the new construction of generators under the liberalization and privatization of the power sector in the Philippines. Furthermore, they also mentioned that it was difficult to operate hydropower plants. However, they mentioned that they would act as a construction coordinator if PGP is able to secure the needed budgets. Therefore, NPC-SPUG can help PGP to achieve hydropower constructions.

- Some ANECs have experiences in the construction of mini and micro hydropower plants. Although SPCP-ANEC does not have this experience, it can be assumed that PGP recommends SPCP-ANEC should study mini and micro hydropower through other ANECs and construct hydropower plants together. It will be beneficial for both PGP and SPCP-ANEC.

- NIA has experiences in the construction of dams and weirs. Accordingly, they will need to be asked to help in the planning of dams and/or weirs and for locating consultants and construction companies that have experience with hydropower.

- In some candidate sites, tunnels for headrace will be needed in some stage of a master plan. However, there are no construction companies who can construct tunnels. Though we should wait for the results of the feasibility studies, it may be prudent to start looking for tunnel constructors in Manila or other cities.

A.8.3 Organization for Operation and Maintenance

- In order to secure the sustainability of a hydropower plant and to accumulate a profit from the plant, an adequate organization for maintenance and operation of the plant will be needed.

- A residents' participation type organization should be considered for the operation and maintenance of a mini and micro hydropower plant. Because NPC-SPUG is not willing to manage hydropower plants anymore and because SPCP-ANEC does not have any experience to maintain them, other ways to provide this organization will be needed.