The Republic of Honduras
National Autonomous Service
of Aqueducts and Sewerage

PREPARATORY SURVEY FOR THE PROJECT OF MICRO-HYDROELECTRIC POWER GENERATION IN METROPOLITAN AREA OF TEGUCIGALPA IN THE REPUBLIC OF HONDURAS

FINAL REPORT

March 2013

Japan International Cooperation Agency
(JICA)

NEWJEC Inc.
Japan Techno Co., Ltd.

PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to the consortium consists of NEWJEC Inc. and JAPAN TECHNO Co., Ltd..

The survey team held a series of discussions with the officials concerned of the Government of the Republic of Honduras, and conducted field investigations. As a result of further studies in Japan, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Honduras for their close cooperation extended to the survey team.

March, 2013

Hidetoshi IRIGAKI
Director General,
Industrial Development and Public Policy Department,
Japan International Cooperation Agency

SUMMARY

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1. Overview of Honduras

The Republic of Honduras (hereinafter "Honduras") is located at about 15˚ north latitude in the central part of Central America. It has an area of 112,492 km^2 and a population of about 775,500 according to World Bank statistics of 2011.

Honduras is situated in the heart of Central America and is bordered to the east by Nicaragua, to the west by Guatemala, to the north by the Caribbean Sea and to the south by El Salvador and the Pacific Ocean. The Honduran territory consists of undeveloped swamp in the eastern part, mountain ranges in the western part, plains along the coasts in the northern and southern parts, and highlands in the central area. 65% of its land is covered by mountains, and a plateau of 1,000 to 1,500 m above sea level spans from the central to the northern area.

The climate of Honduras is subtropical, hot and humid across the plains in the north, the east and the south. Annual mean precipitation is about 1,500 mm in the north, and about 3,000 mm in the Caribbean region. There is a temperature difference between summer and winter in the highlands of the central and western parts, and those parts have a dry season from November through April and a rainy season from May through October. Tegucigalpa City where the target sites are located has an annual rainfall of about 800 to 1,000 mm, and the mean temperature is 24˚C. Temperature varies from 15 to 30˚C and there is no big temperature change throughout the year.

Hurricanes travel inland from the eastern Caribbean to the west gaining strength during August to October every year. During this time of year, floods and high waves cause much damage. Especially, Hurricane Mitch hit Central America in 1998 and it devastated Honduras the most of Central America.

Honduras is one of the underdeveloped and poor countries in Central and South America, and large imcome gap between cities and rural areas have emerged. The Gross Domestic Product (GDP) was about 17,400 million US$ and GDP per person was 2,162 US$/person in 2011. (World Economic Outlook Database, 2012) In Comparision with GDP's ratio of each industrial sector of Honduras, GDP's ratio of primary sector of industry is around 12.8%, that of secondary sector around 26.6% and that of tertiary sector around 60.6%. (Central Intelligence Agency The World Fact Book ,2012) The economic growth rates between 2004 to 2008 were around 3.0 to 6.0 % a year, but the rate fallen -2.1% in 2009 due to the grobal serious financial crisis occurred from the latter half of 2008, in addition the social chaos by the coup d'etat in 2009. In 2010 the rate was 2.8%, then the rate recoverd upto 3.6% in 2011. (Honduras Central Bank)

Honduras has depended on export of coffee, banana etc. traditionally, but the Government of Honduras (the GOH) recently promotes to develop new industries and diversify domestic industries such as manufacturing industries (especially, texitile factories) in maquiladora (manufacuring operations in a bonded proceeding zone), tourist business, export of cultured shrimps, melon and so on. Coffee and banana plantations were heveily damaged due to attack of Hurricane Mitch, but the export value recovers slowly. In these year Honduras faced political turmoil by the coup d'etat in June 2009, domestic economy becomes in a severe situation, security deterionates and natural disasters such as hurricanes occurs frequently, so those problems become major hindrances to the sustanable development of the country.

Regarding balance of trade in 2011, import value was around 720 million US$ and export value was 1,030 million US$, so trade defisit was around 310 million US$.

Dificits in national finances of the GOH continues for recent 10 years. Ratios of deficit values to GDP from 2005 to 2008 varied in the -1% range, then ratios and values of budget deficits were -4.7% and -12,500 million Lps. in 2009, -2.9% and -8,500 million Lps. in 2010 and -2.8% and 3,100 million Lps. in 2011

2. Background of the Project

In the "National Vision 2010-2038" and "National Plan 2010-2022" promulgated in 2011 as long-term national development goal, the GOH decleaed the policy to introduce the renewable energy aggresively and promotes power development utilizing the renewable energy projects such as rehabilitation of existing hydroelectric power plants and small hydroelectric power projects from the aspect of Energy security/Diversification of primary energy sources, Control of the greenhouse gas emission and so on.

Electricity in Honduras is mostly generated by thermal power plants where small-scale diesel engines are fed with imported fossil fuel. The use of renewable energy and an improvement in energy use efficiency, therefore, are crucial in order to reduce the dependence on diesel-fueled thermal power generation. Such efforts are desired in the country in view of ensuring energy security (less dependence on imported fossil fuel) and reducing emissions of greenhouse gases. The GOH has placed the introduction and expansion of renewable energy use among national priority policies. In the "National Plan 2010-2022", the GOH launched the plan to increase the proportion of renewable energy resources in its primary energy use up to 60% by 2022.

National Autonomous Service of Aqueducts and Sewerage (SANAA) uses large amounts of electricity to operate water treatment facilities and pump up groundwater, and the electricity bills are a heavy financial burden to SANAA. By selling the electricity generated by the power plant to be installed, the Project will contribute to reducing the large expense on electricity and its influence on water tariffs and facility investment capacity, and to helping SANAA improve its water and sewage services as well as introduction of renewable energy. The Project is to furnish small-scale hydroelectric power generation equipment using the unutilized water-head potential in the existing water treatment plants (Concepcion and Picacho Plants) owned and operated by SANAA, which are providing water and sewage services to Tegucigalpa City.

The GOH requested Japanese Government the grant aid to construct small-scale hydroelectric power plants. As requested by the GOH, JICA conducted Data Collection Survey in November 2011 (preliminary study) in order to confirm outline of concerned parties of Honduras side, background of the requested contents etc.

This preparatory survey is to be carried out as a part of a governmental request framework for the promotion of “green growth (alternative energy introduction and promotion)”, in 2011 and design policy is to be considered as a premise for utilizating the high quality products and technologies developed by small and medium-size Japanese manufactures etc..

3. Results of Preparatory Survey and Scope of Project

Subsequently JICA desided to carry out preparatory survey based on the result of the preliminaly study and dispatched a preparatory survey team from August 8, 2012 to September 21,2012. The survey team conducted field investigations, collection of relevant data, topographic survey, environmental and social survey and had discussion about contents of the Project with the concerned parties of the GOH.

After coming back to Japan, the survey team examined the necessity, relevance and effectiveness of the Project based on the result of the site survey and relevant data, and prepared a Draft Preparatory Survey Report. The survey team visited Honduras again between December 12, 2012 and December 24,2012 and submitted the Draft Report. After explaination and discussion of the contents of the Report, JICA and the GOH signed the minutes of discussion (M/D). The responsible and implementing is SANAA.

In the Study outline design of the apprppriate project components and their scale, general project cost estimate and implementation schedule, allocation of responsibilities of Honduras side, preparation of soft component plan for management, operation and maintenance of power plants etc. were conducted. As the result of the Study, the Project was conceived to provide power generation plants in the existing Concepcion and Picacho Water Treatment Plants, by installing small-scale hydroelectric power equipment for utilizing the unutilized water-head (potential energy). Total capacity of the power plants are 430kW.

Based on the government policy, design of main components of small-scale hydroelectric power plant such as hydraulic turbines and generators was conducted as a premise for utilizing the products made by small and medium-size Japanese manufactures. The procurement policy is to introduce such products on the basis of design.

The Project outline is as below. The summary of facilities and equipment to be provided by the Project is given in the following tables.

Concepcion Hydroelectric Power Plant

At the Concepcion Site, the residual potential energy of raw water for water supply between the Conception Reservoir and the powerhouse is planned to be used for power generation at the aerator located upstream of the plant. The installed capacity of the Concepcion Hydroelectric Power Plant is 250 kW. To utilize the existing water-head effectively, the Concepcion Project will construct a new ductile cast-iron pipeline of a 700 mm internal diameter for about 3 km, parallel to the smaller pipe segment (internal diameter 900 mm) of the existing pipeline (steel pipe, internal diameters of 1,100 and 900 mm) of approximately 6.3 km between the dam and the aerator.

Picacho Hydroelectric Power Plant

At the Picacho Site, pressurized treated water for water supply at the water pressure reducing valve on a water supply pipe (L22 pipeline, internal diameter of 400 mm) located downstream of the water treatment plant is planned to be used for power generation. The installed capacity of the Picacho Hydroelectric Power Plant is 180 kW.

Grid Interconnection

The energy generated by the Concepcion and Picacho Hydroelectric Power Plants is planned to be all sold to ENEE, via interconnection to the nearby distribution line.

Outline of Facilities

<table>
<tr><th colspan="2">Power Plant Name</th><th>Unit</th><th>Concepcion Hydroelectric Power Plant</th><th>Picacho Hydroelectric Power Plant</th></tr>
<tr><td colspan="2">Maximum power discharge</td><td>m^3/s</td><td>1.5</td><td>0.3</td></tr>
<tr><td colspan="2">Maximum gross head</td><td>m</td><td>42.06</td><td>91.44</td></tr>
<tr><td colspan="2">Effective head for rated power</td><td>m</td><td>27.46</td><td>86.16</td></tr>
<tr><td colspan="2">Installed capacity</td><td>kW</td><td>250</td><td>180</td></tr>
<tr><td colspan="2">Estimated annual generated energy</td><td>MWh</td><td>1,650</td><td>520</td></tr>
<tr><td rowspan="4">Headrace</td><td>Type</td><td>-</td><td>Buried pipe</td><td>-</td></tr>
<tr><td>Material</td><td>-</td><td>Ductile cast-iron</td><td>-</td></tr>
<tr><td>Diameter</td><td>-</td><td>700 mm</td><td>-</td></tr>
<tr><td>Length</td><td>m</td><td>2,973</td><td>-</td></tr>
<tr><td rowspan="4">Powerhouse</td><td>Type</td><td>-</td><td>Open type</td><td>Open type</td></tr>
<tr><td>Structure</td><td>-</td><td>Single–story reinforced concrete structure</td><td>Single–story reinforced concrete structure</td></tr>
<tr><td>Height</td><td>m</td><td>7.00</td><td>7.00</td></tr>
<tr><td>Area</td><td>m^2</td><td>174 m^2 (8.50 × 20.50 m)</td><td>174 m^2 (8.50 × 20.50 m)</td></tr>
</table>

Outline of Equipment

Power Station Name	Concepcion Hydroelectric Power Plant	Picacho Hydroelectric Power Plant
Hydraulic Turbine		
Type	Horizontal single runner, single flow spiral type Francis turbine	Horizontal single runner, single flow spiral type Francis turbine
Governor	PD control type	PD control type
Inlet valve	Electric motor driven	Electric motor driven
Rated output	273 kW	204 kW
Rated speed	900 rpm	1,200 rpm
Generator		
Type	Horizontal, direct coupled, 3-phase-3-wire and horizontal shaft synchronous generator	Horizontal, direct coupled, 3-phase-3-wire and horizontal shaft synchronous generator
Insulation class	Class F	Class F
Rated voltage	480 V	480 V
Rated power	314 kVA	235 kVA
Power factor	80%	80%
Frequency	60 Hz	60 Hz
Speed	900 rpm	1,200 rpm
Turbine/Generator Control System		
Type	Programmable Logic Controller	Programmable Logic Controller
Low Voltage distribution Board		
Type	Air insulated (3 panels)	Air insulated (3 panels)
Control System		
Type	Supervisory Control and Data Acquisition System	Supervisory Control and Data Acquisition System
High Voltage Switchgear		
Type	Metal-enclosed, indoor	Metal-enclosed, indoor
Transformer		
Type	Oil immersed type, self-cooled, outdoor use	Oil immersed type, self-cooled, outdoor use
Voltage	480 V/34.5 kV	480 V/13.8 kV
Rated power	400 kVA	250 kVA
Connection	Delta/star	Delta/star

4. Project Implementation Schedule and Project Cost Estimate

The project will be implemented in about 24 months upon conclusion of the E/N, including 7 months for pre-implementation consists of fiels survey, detailed design, bid preparation and evaluation.

Implemantation of construction and procurement for small-scale hydroelectric power plants will takes 16 months. The time necessary for completion is mainly determined by the process of manufacture and delivery of Electro-mechanical equipment, installation, adjustment works and commissioning. The other construction works, such as pipeline works, proceed in parallel with the manufacture and delivery of the equipment.

Since this Project is implemented within the framework of grant aid, the initial costs, such as the construction, procurement, installation costs and so on, is granted. Total Project costs, such as acquisition of lands, diversion of existing pipeline etc. covered by the Honduras side are estimated 3,678,000 Lps. (approx.15.1 Million JPY).

5. Project Evaluation

5.1 Relevance

The relevance of the Project is described below.

- The Project meets the development policy of Honduras: to secure energy and control the greenhouse gas emission of Honduras, which depends on imported fossil fuel (mainly oil) for power generation for nearly 60 % of the total power output (1,579 MW), by introducing small-scale hydroelectric power generation that is domestic renewable energy, less of a burden on the environment and society, and constructed in a short amount of time.

- The Project aims to mitigate the environmental impact on climate change by improving energy efficiency and promoting renewable energy, and is positioned by Japan as a climate change measure for development cooperation with Honduras.

- The Project meets the policy of the Government of Japan, which is to support promotion of “green growth” in developing countries by means of its enhanced technology in the field of new energy.

- The financial condition of SANAA should improve by selling the surplus electricity to ENEE as this should cover the operation and maintenance cost of hydroelectric power facilities.

5.2 Effectiveness

The Project is expected the following beneficial effects

(1) Quantitative Effects

Target figures on quantitative effects are shown in the table below.

Quantitative Effects

Indicator	Baseline figure (Year 2012)	Target figure (Year 2018) [3 years after Project completion]
Generated energy at the power generating end (MWh/year)	-	1,650 MWh/year (Concepcion HEP) 520 MWh/year (Picacho HEP)
Reduction of CO_2 emissions (ton/year)[*1]	-	645 t/year (Concepcion HEP) 203 t/year (Picacho HEP)
Electricity rate reduction (US$/year)[*2]	-	225,967 US$/year (Concepcion HEP) 71,214 US$/year (Picacho HEP)

Note: *1: A reduction coefficient of 391 g/kWh is used to calculate the CO_2 emissions reduction of the Project. (Source: CO_2 EMISSIONS FROM FUEL COMBUSTION-Highlight, 2011 Edition, IEA)

*2: The rate electricity reduction is calculated using the electricity buying rate of 0.13695 US$/kWh (inclusive of 10% incentive for renewable energy) for small-scale hydroelectric power generation in 2012.

(2) Qualitative Effects

The qualitative effects are as below.

- Promotion of renewable energy utilization is expected, which should contribute to advanced socio-economic development and a reduction in greenhouse gas emissions.

- This project is expected to promote renewable energy by utilizing unutilized energy of the existing water treatment facilities, which is the first such pilot project in Honduras.

- Water supply service is expected to improve because the huge electricity consumption by pump operation, water treatment, etc., which places enormous financial burden on SANAA, will be reduced.

- Diversification of electric power supply sources in Honduras is expected.

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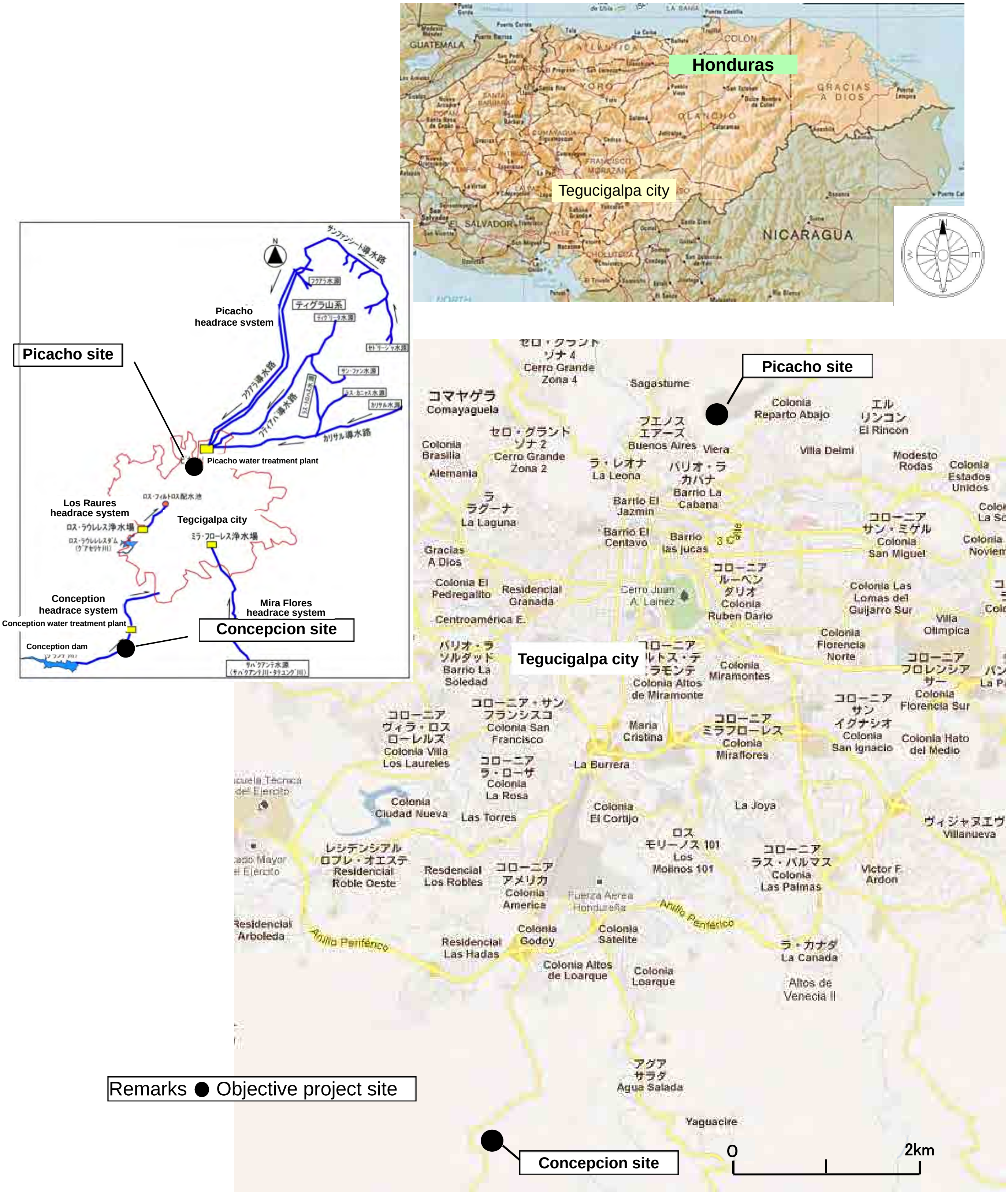
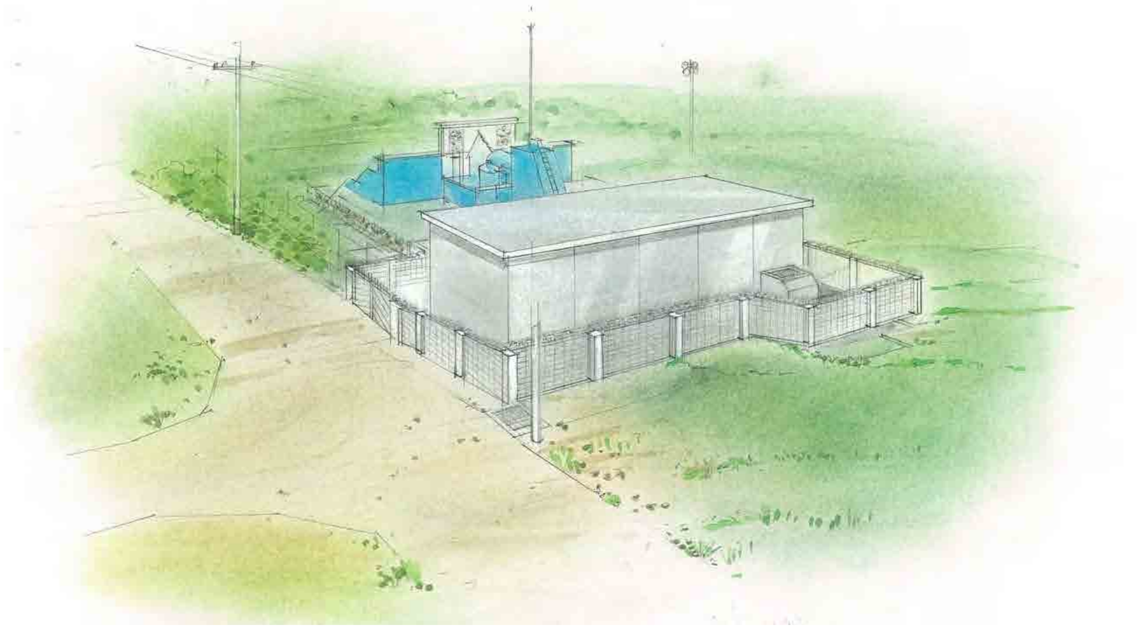
4. Minutes of Discussions (M/D)
5. Soft Component (Technical Assistance) Plan
6. References

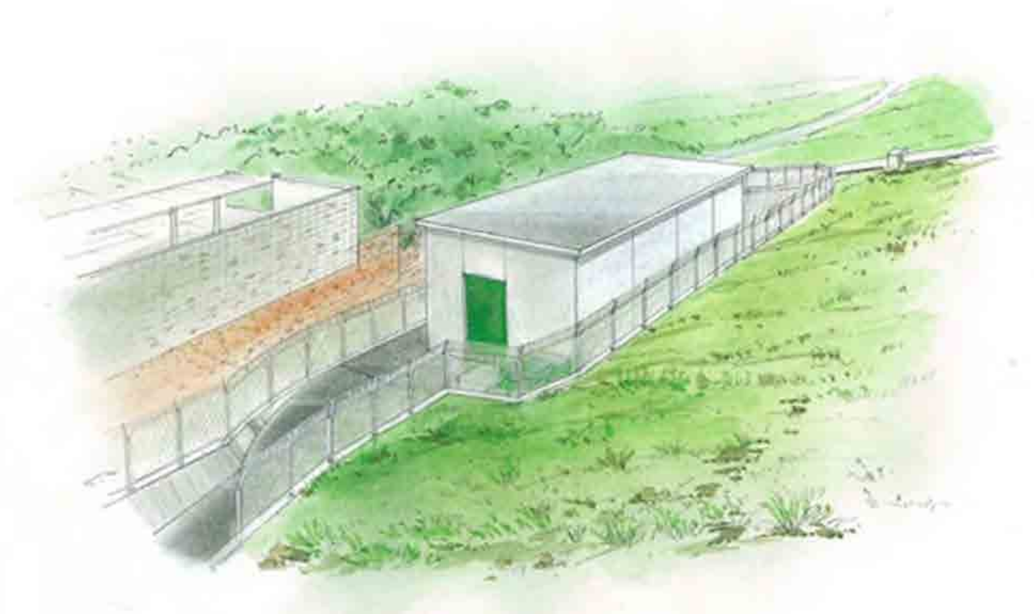
PROJECT LOCATION MAP



PERSPECTIVE OF SMALL-SCALE HYDROELECTRIC POWERHOUSE



Concepcion Hydroelectric Powerhouse



Picacho Hydroelectric Powerhouse

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ABBREVIATIONS AND UNITS

Abbreviations

AMDC	Alcaldía Municipal del District Central	Municipal Office of Central District
BCIE	Banco Centroamericano de Integración Económica	Central American Bank of Economic Integration
CNE	Comisíon Nacional de Energía	National Energy Commission
COSANA	Consejo Nacional de Agua Potable y Saneamiento	National Water and Sanitation Council
DECA	Dirección de Evaluación y Control Ambiental	Department of Environmental Evaluation and Control
DEI	Dirección Ejecutiva de Ingresos	Department of Income
ENEE	Empresa Nacional de Energía Eléctrica	National Electricity Power Company
ERSAPS	Ente Regulador de los Servicios de Agua Potable y Saneamiento	Portable Water and Sanitation Regulatory Agency
JICA	Agencia de Cooperación Internacional del Japón	Japan International Cooperation Agency
SANAA	Servicio Autónomo Nacional de Acueductos y Alcantarillados	National Autonomous Service of Aqueducts and Sewerage
SEPLAN	Secretaría Técnica de Planificación y Cooperación Externa	Technical Ministry of Planning and International Cooperation
SERNA	Secretaría de Recursos Naturales y Ambiente	Ministry of Natural Resource and Environment
SIAFI	Sistema Integrado de Administracion Financiera	Integrated System of Financial Administration
SINEIA	Sistema Nacional de Evaluación de Impact Ambiental	National System of Evaluation of Environmental Impact

Unit

mm	:	Millimeters	JPY	:	Japanese Yen
cm	:	Centimeters (10 mm)	kV	:	Kilo volts (1,000 V)
m	:	Meters (100 cm)	kA	:	Kilo-amperes
km	:	Kilometers (1,000 m)	W	:	Watts (active power) (J/s: Joule/second)
m^2	:	Square-meters	VA	:	Volt-amperes
km^2	:	Square-kilometers	kW	:	Kilo watts (1,000 W)
m^3	:	Cubic-meters	kWh	:	Kilo-Watt-Hour (1,000Wh)
sec.	:	Seconds	kVA	:	Kilo volt-amperes (1,000VA)
US$	:	United States Dollars	MW	:	Mega watts (10^6 W)
Lps.	:	Lempiras	MVA	:	Mega volt-amperes (10^6 VA)

CHAPTER 1

BACKGROUND OF THE PROJECT

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In the "National Vision 2010-2038" and "National Plan 2010-2022" promulgated in 2011 as long-term national development goal, the Government of Honduras (the GOH) decleaed the policy to introduce the renewable energy aggresively and promotes power development utilizing the renewable energy projects such as rehabilitation of existing hydroelectric power plants and small hydroelectric power projects from the aspect of Energy security/Diversification of primary energy sources, Control of the greenhouse gas emission and so on.

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1-2 NATURAL CONDITIONS

1-2-1 Topography and Geology

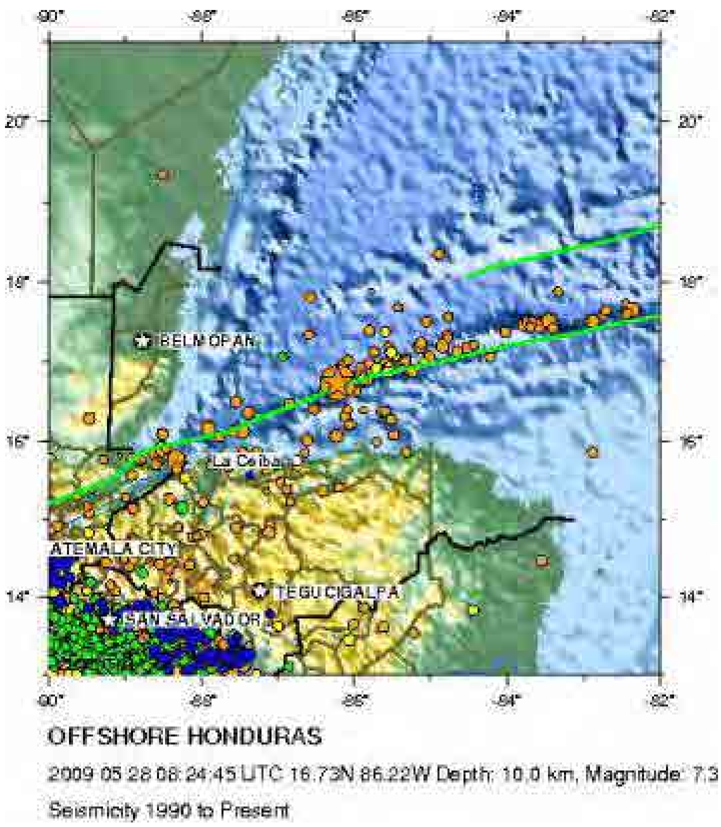

Fig. 1-2-1 Earthquake Record in Honduras (1990 - 2012)

Source : USGS http://neic.usgs.gov/neis/eq_depot/2009/eq_090528_heak/neic_heak_h.html

The Republic of Honduras (hereinafter “Honduras”) is located at about 15˚ north latitude in the central part of Central America. It has an area of 112,492 km^2 and a population of about 775,500 according to World Bank statistics of 2011.

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The target sites are located in Tegucigalpa, the capital city of the country. Around Tegucigalpa, the area is nestled in a bowl-shaped valley centering on the city. Mountains around the city form a hill shape or a tableland shape. The tableland is about EL 1,000 m and the mountain region is about EL 1,300 to 1,700 m. Mudstone, sandstone and siltstone of the Paleozoic-cretaceous Era are distributed in the eastern area of the Choluteca River, which runs through the middle of the city from north to south. Those stones are covered by a tertiary sedimentary rock layer, volcanic rock layer and sedimentary rock of pyroclastic flow. The western area is composed mainly of volcanic rocks.

The earthquake record around Honduras is shown below. The Pacific side bordering Guatemala and El Salvador is on the volcanic belt and earthquakes occur frequently. On the other hand, there is no record of big earthquakes around the central area where Tegucigalpa City and the target sites of this Project are located. In addition, a 7.3 M (magnitude) earthquake occurred in May 2009 in the northern part of the country bordering the Caribbean Sea. The quake devastated the northern region.

The Concepcion Site is located in the southern part of Tegucigalpa City, on the east side of the Concepcion Dam. The elevation near the power station is about EL 1,110 m. The geography of a predetermined land for the power station is plain.

The Picacho Site is located in the north-eastern part of Tegucigalpa City and is on the hill from where the city can be seen. The elevation near the power station is about EL 1,100 m. The power station will be constructed on a comparatively gentle slope which is 10 m higher than ordinary roads.

1-2-2 Temperature and Rainfall

The climate of Honduras is subtropical, hot and humid across the plains in the north, the east and the south. Annual mean precipitation is about 1,500 mm in the north, and about 3,000 mm in the Caribbean region. There is a temperature difference between summer and winter in the highlands of the central and western parts, and those parts have a dry season from November through April and a rainy season from May through October. Hurricanes travel inland from the eastern Caribbean to the west gaining strength during August to October every year. During this time of year, floods and high waves cause much damage. Especially, Hurricane Mitch hit Central America in 1998 and it devastated Honduras the most of Central America.

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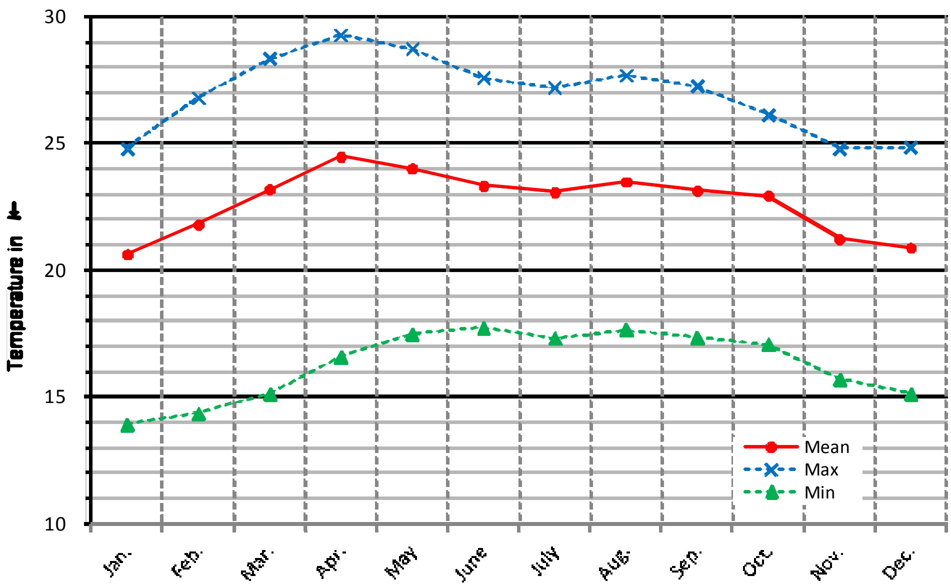
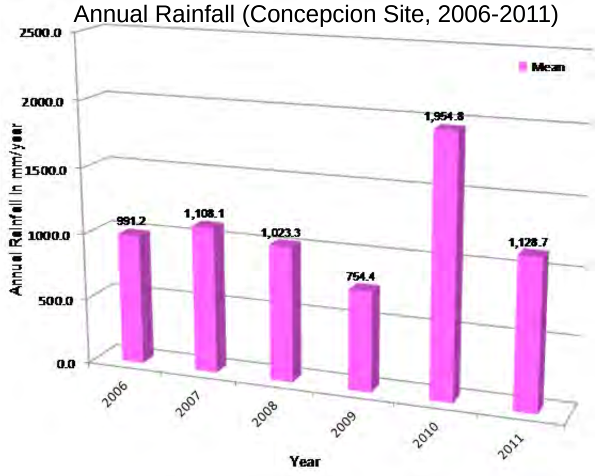
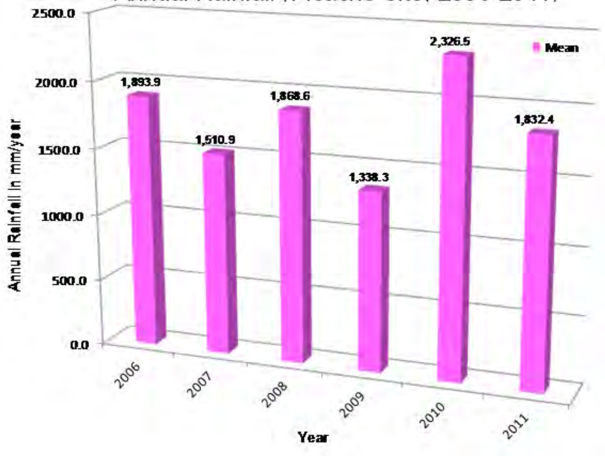


Fig. 1-2-2 Temperature in Tegucigalpa (1990 - 2007)

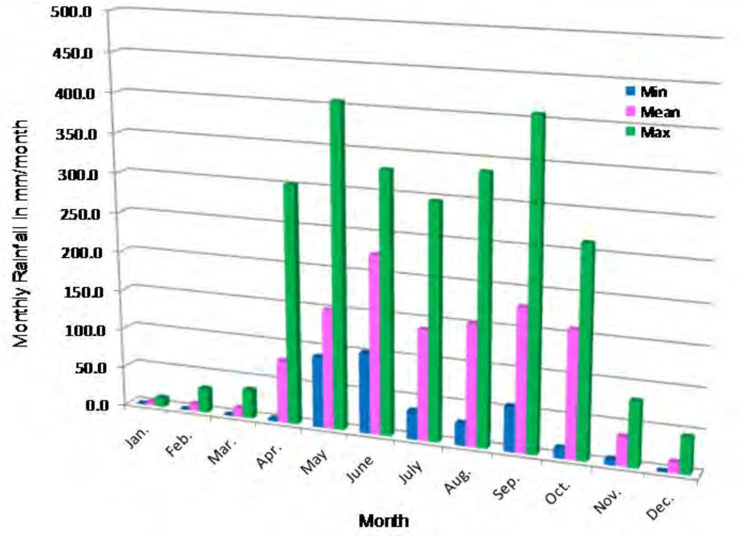
Annual Rainfall (Concepcion Site, 2006-2011)



Annual Rainfall (Picacho Site, 2006-2011)



Monthly Mean, Max and Minimum Rainfall (Concepcion Site, 2006-2011)



Monthly Mean, Max and Minimum Rainfall (Picacho Site, 2006-2011)

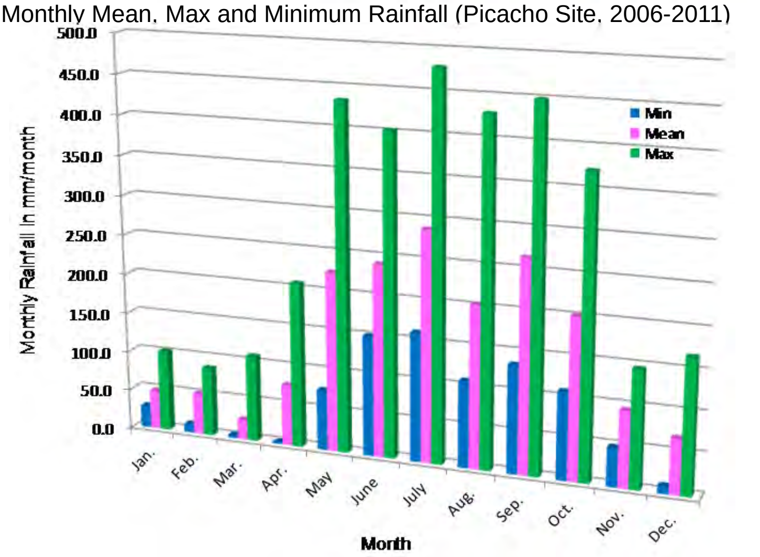


Fig. 1-2-3 Rainfall at Picacho Site and Concepcion Site (2006 - 2011)

1-2-3 Water Level, Flow Volume

(1) Concepcion Site

Water level of the Concepcion Dam and intake water from the dam from 2000 to 2011 are shown in the right figure. After work to raise the dam in 2005, the water level of the dam has been kept high and the intake water has been increased. The highest water level used to be 1,155 m before the enbankment work, but it is 1,157.28 m after the construction.

The water level is the lowest between March when the dry season ends and May when the rainy season starts. When the water level drops dramatically, a booster pump starts sending a predetermined volume of water to the Concepcion Water Treatment Plant.

Following table shows mean, maximum and minimum intake water from the dam.

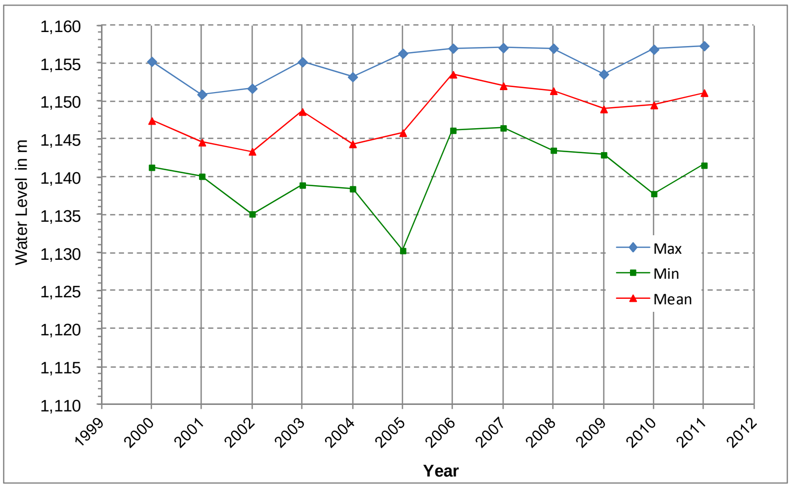


Fig. 1-2-4 Mean, Max and Minimum Water Level of Concepcion Dam (2000 - 2011)

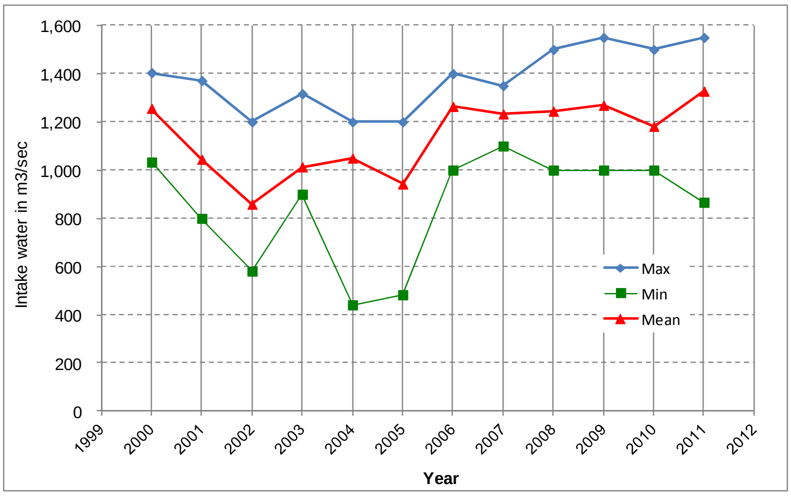


Fig. 1-2-5 Daily Mean, Max and Minimum Intake Water of Concepcion Dam (2000 - 2011)

Table 1-2-1 Mean, Max and Minimum Intake Water at Concepcion Site

	2000 - 2011	2000 - 2005	2006 - 2011
Mean (liter/sec)	1,140.25	1,027.45	1,253.06
Maximum (liter/sec)	1,550.00	1,404.17	1,550.00
Minimum (liter/sec)	441.67	441.67	866.67

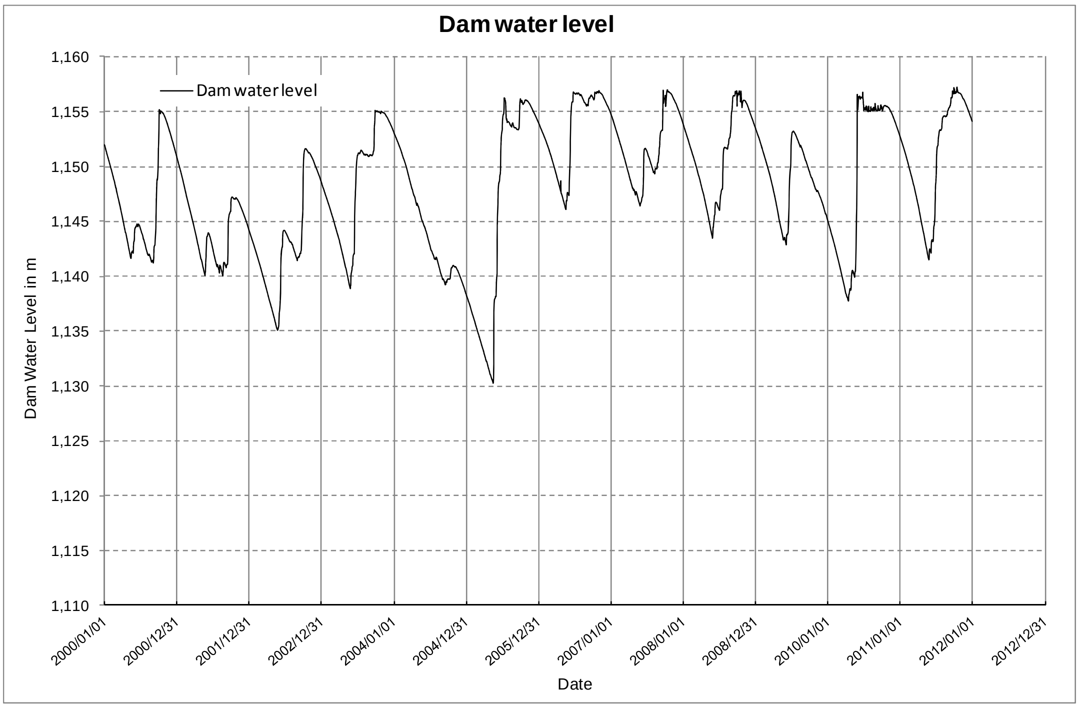


Fig. 1-2-6 Daily Variation in Concepcion Dam Water Level (2000 - 2011)

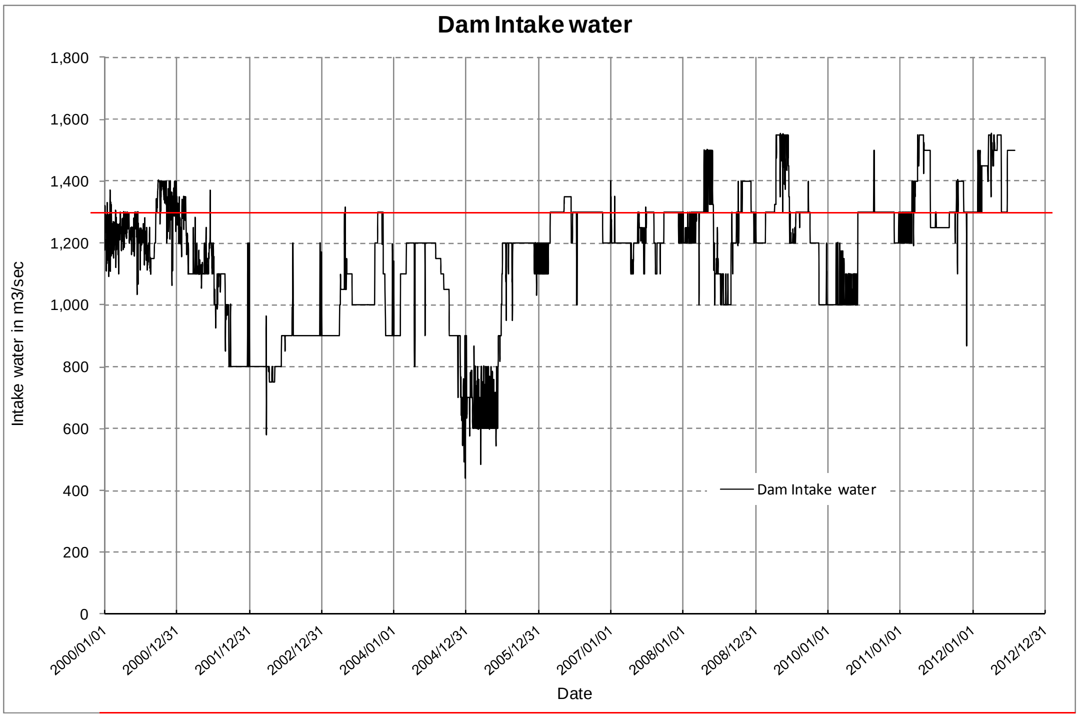


Fig. 1-2-7 Daily Variation in Concepcion Dam Intake Water (2000 - 2011)

(2) Picacho Site

Daily production volume at the Picacho Water Treatment Plant from 1999 to 2011 is shown in the following figure. The water volume treated is very different between the rainy season (from June through November) with an average of more than 700 liters/sec and the dry season (from December through May) with an average of less than 500 liters/sec. Water from the Picacho Water Treatment Plant is distributed to nine (9) pipelines in total via manifold valves in the treatment plant. Because the production volumes are very different between the dry and the rainy season, SANAA adjusts the operation pattern of each pipeline and the distribution volume according to season.

There is no data of water flow in the L22 pipeline, which is a targeted pipeline in this Project. SANAA conducted flow measurements utilizing an acoustic doppler current profiler upon request.

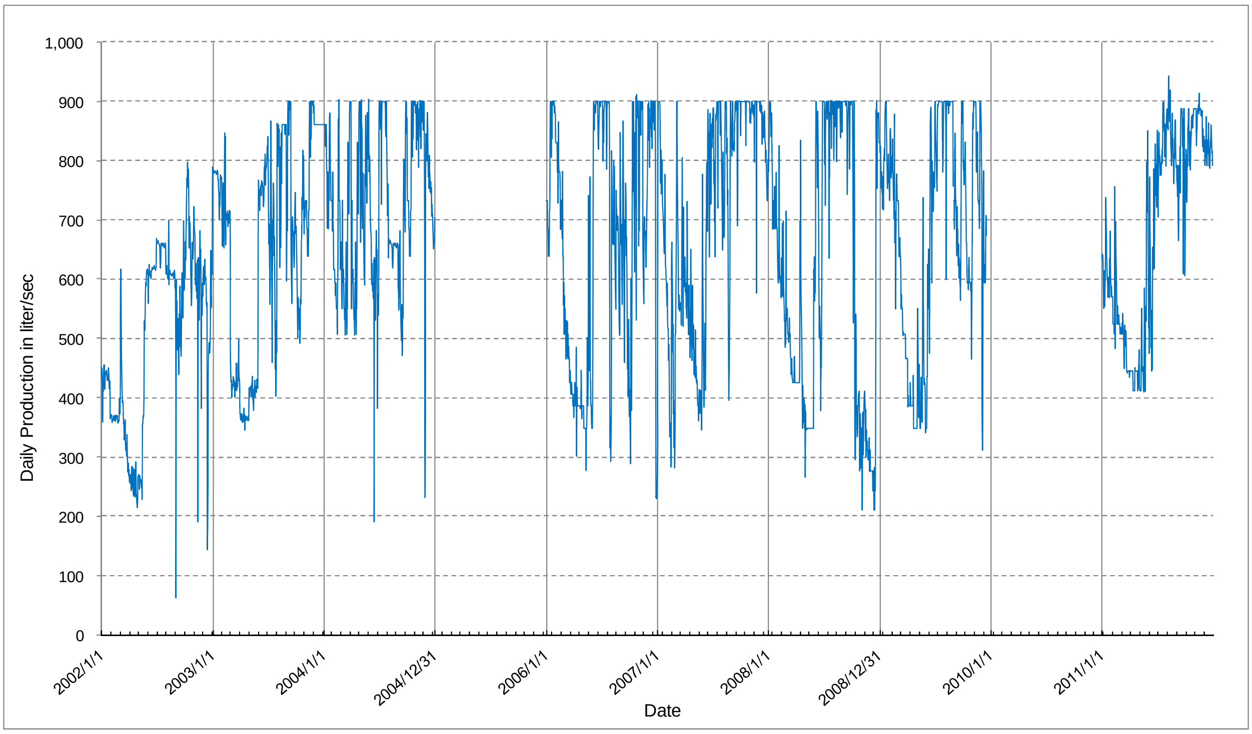


Fig. 1-2-8 Mean, Max and Minimum Daily Water Treatment Quantity of Picacho Water Treatment Plant (2002 - 2011)

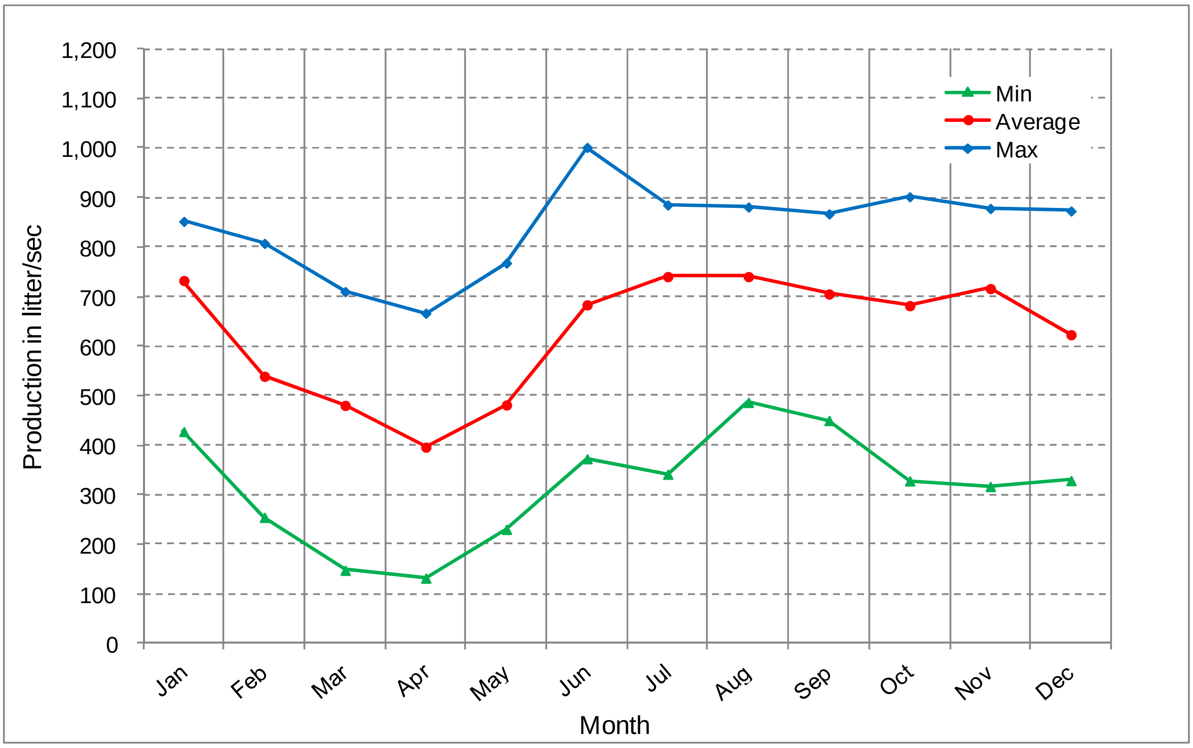


Fig. 1-2-9 Mean, Max and Minimum Monthly Water Treatment Quantity of Picacho Water Treatment Plant (2002 - 2011)

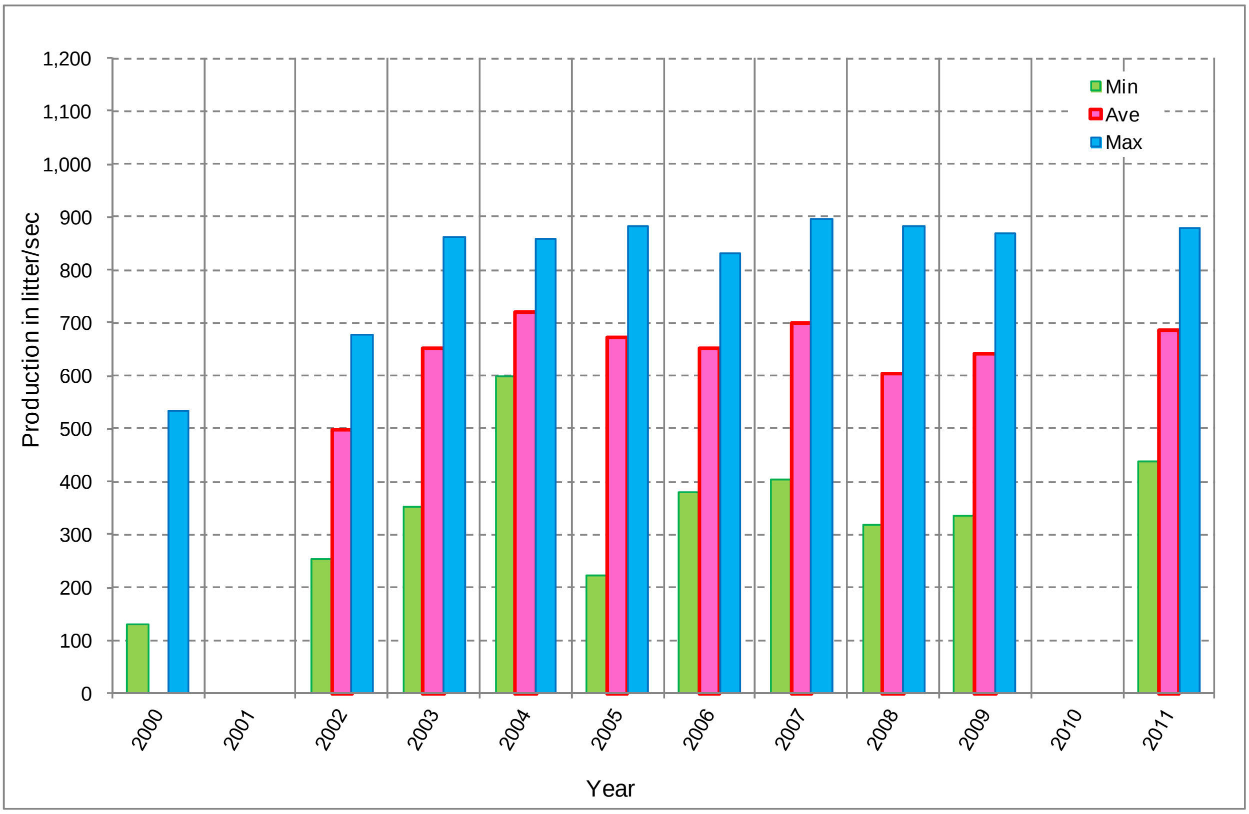


Fig. 1-2-10 Mean, Max and Minimum of Annual Water Treatment Quantity of Picacho Water Treatment Plant (2002 - 2011)

1-3 ENVIRONMENT AND SOCIAL CONSIDERATIONS

1-3-1 Outline of Project Components that have Environmental and Social Impacts

The Project consists of small-scale hydroelectric power plant facilities such as powerhouse buildings, buried pipeline, turbines, generators, transformers, etc. There are no dams, intakes, reservoirs, head tanks or tailraces because the planned power plant utilizes such structures of the existing water treatment facilities and the Project Sites are located in the existing water service facilities area.

Therefore, it is assumed that the environmental impact is small. Therefore, according to JICA guidelines for environmental and social considerations, the Project is classified as category B in the sector of hydropower, dams and reservoirs.

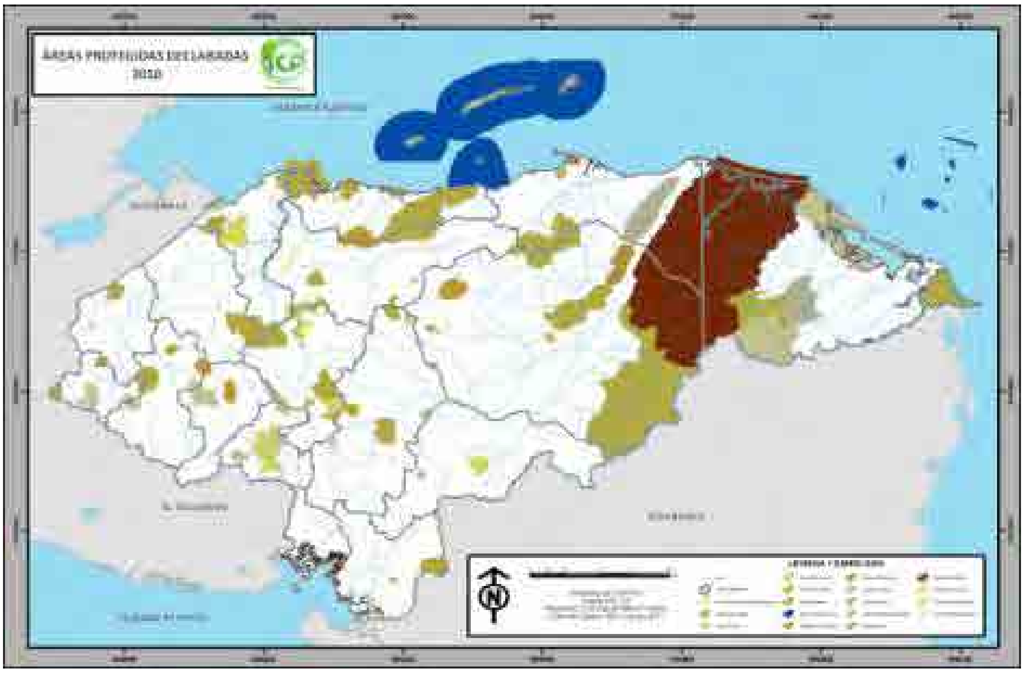
1-3-2 Environment and Social Conditions in Project Area

The Picacho Site is located in the northern part of Tegucigalpa City and belongs to Mt. Tigra. The Picacho Water Treatment Plant of SANAA is on the hillside called “Cerro el Picacho” of the mountain and the plant faces the Naciones Unidas National Park. Upstream of the Picacho Site is one of the important water resource areas in Tegucigalpa City. There are some residences near the project site.

The Concepcion Site is located in the southwest part of Tegucigalpa City. The Concepcion Reservoir Dam that is administrated by SANAA is upstream of the plant. There is new residential area near the project site.

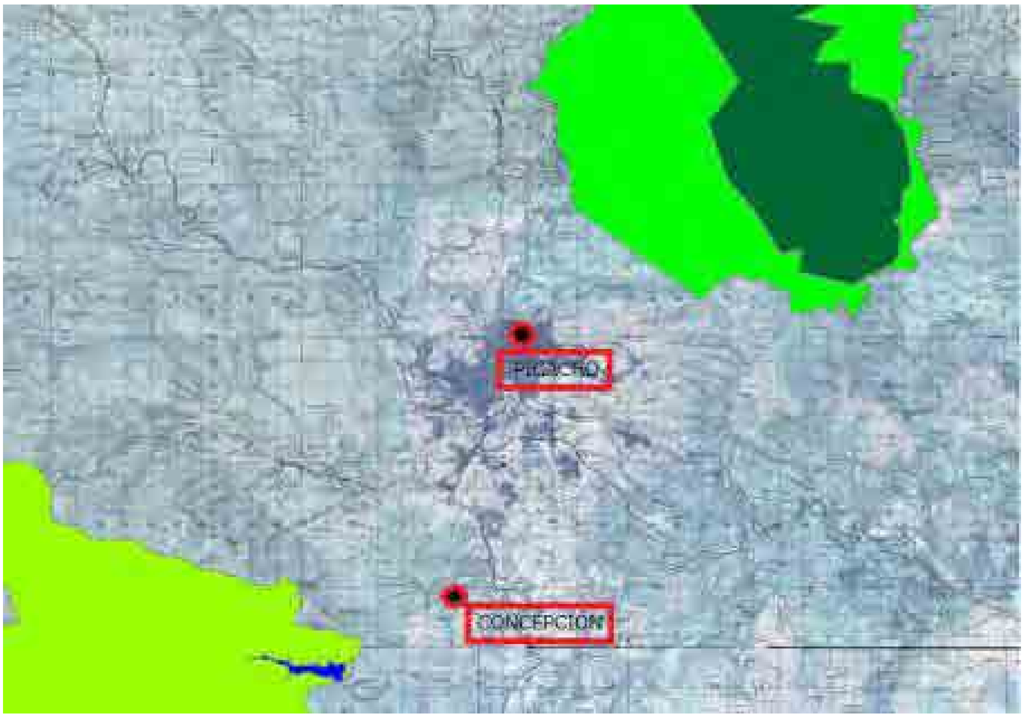
(1) Protected Areas

A forest law was established in 2007 in Honduras. The law specifies to organize a national institute to protect the forests, protected areas and wildlife. Also, the protected areas are defined. In case that the construction site is in a protected area, the SINEIA (Sistema Nacional de Evaluación de Impacto Ambiental) category will be upgraded. However, according to the law, neither the Picacho nor Concepcion sites are in protected areas. The official map of the protected areas is below.



Source : Areas protegidas Declaradas 2010 / ICF

Fig. 1-3-1 Protected Areas in Honduras



Source : SANAA

Fig. 1-3-2 Relation between Sites and Protected Areas

(2) Concepcion Site

The water resource of the Concepcion Water Treatment Plant is the Concepcion Reservoir Dam. Forest land upstream of the dam is protected area under SANAA's control. However, the construction site is around 6 km away from the protected area.

Photo 1-3-1 Planned Powerhouse Construction Site in Concepcion Site

(The blue structure in the background is an aerator.)

Photo 1-3-2 Planned Powerhouse Construction Site in Concepcion Site

Photo 1-3-3 Upstream of Concepcion Dam

Photo 1-3-4 Reservoir of Concepcion Dam

(3) Picacho Site

There is the Naciones Unidas National Park near the planned construction site of the Picacho Hydroelectric Power Plant. However, this 'national park' does not mean a park that should be protected for its ecosystem, as it is a recreational park for the nation. In addition, the construction site is not inside the park as shown on the below map.

The water sources of the Picacho Water Treatment Plant are located in the La Tigra National Park in the northeast. Some parts of this national park (total area of 238 km^2) are designated protected area to protect the ecological system. The project site is about 10 km from the designated protected area.

Source : Cadastral map (Tegucigalpa Municipality)

Fig. 1-3-3 Positional Relationship between Park and Project Site

Photo 1-3-5 Planned Powerhouse Construction Site in Picacho Site

Photo 1-3-6 Existing L22 pipeline at Picacho Site

Water Source

Water Pipeline

Intake Weir

Photo 1-3-7 Water Source, Pipeline and Intake Weir of Picacho Water Treatment Plant

1-3-3 Legal Framework

(1) Laws and Legislation regarding Environmental and Social Considerations

Honduras has regulations on the implementation of the Project with regard to environmental and social considerations, called the National Evaluation System of Environmental Impact (Sistema Nacional de Evaluación de Impacto Ambiental "SINEIA".) SINEIA was established on March 5th 1994, and then revised in 2003, and its new reforms were enacted on December 31, 2009.

All projects are classified into four (4) categories in view of the magnitude of impacts on the environment.

Table 1-3-1 Environmental Categories

Category	Impact Level
Category 1	Low environmental impact
Category 2	Moderate environmental impact
Category 3	High environmental impact
Category 4	Very high environmental impact

Category 1 projects should submit Form F-01. EIA is not required. The term for procedure is 15 days. Category 2 and 3 projects should submit Form F-02 to SERNA. SERNA reviews the project by means of site inspection (environmental audit) and issues environmental permits for the implementation of projects. The term for procedure is between 30 and 45 days. Projects that are placed in Category 4 are obliged to conduct investigations and submit Environmental Impact Assessment (EIA) documents to SERNA. SERNA reviews the project by means of site inspection and issues environmental permits for the implementation of projects.

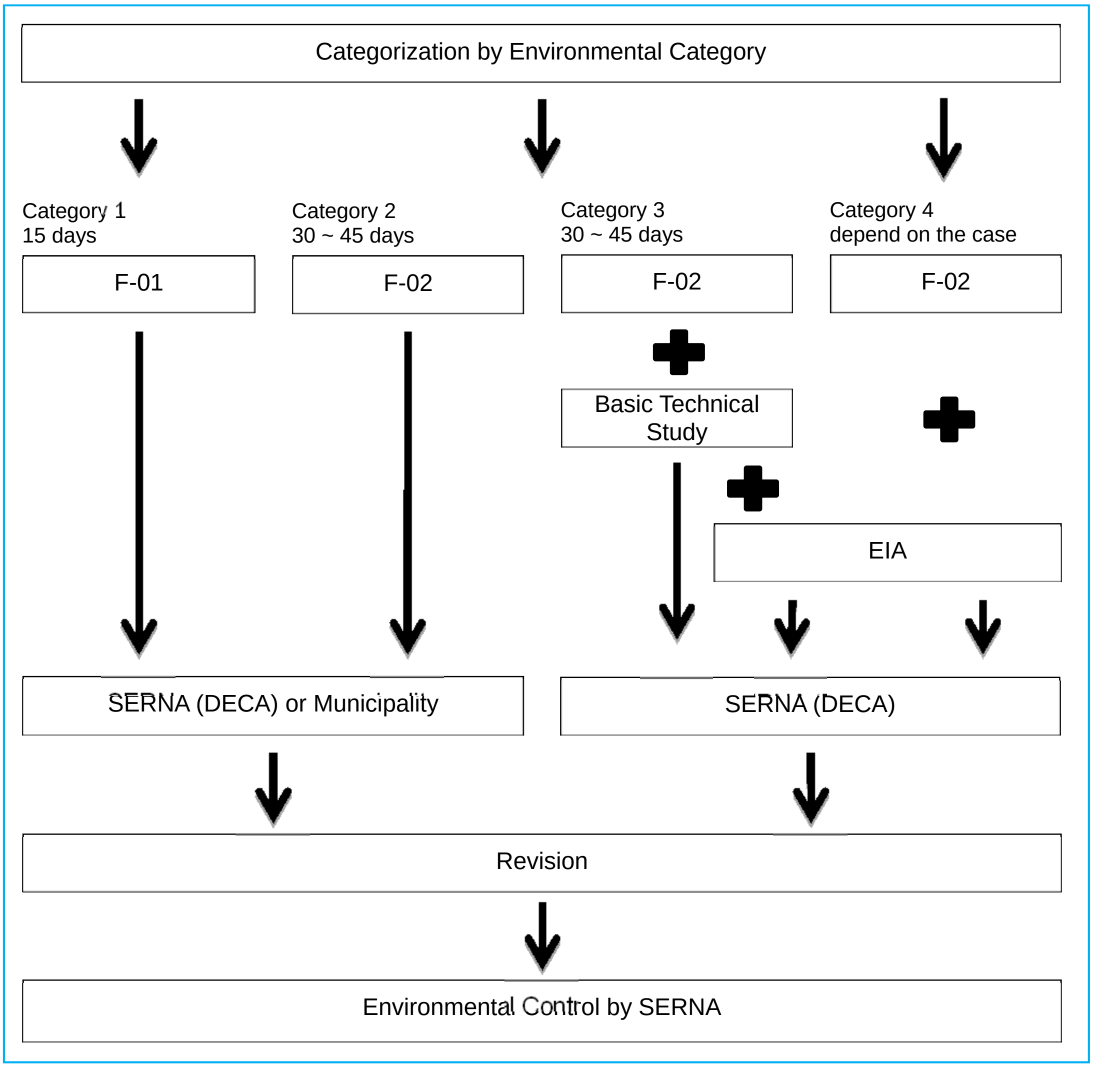
The project is classified according to the Environmental Category Table in SERNA's regulation No. 1714-2010. The related part for small-scale hydroelectric power is shown below.

Table 1-3-2 Category for Construction of Hydroelectric Power Plant

Category	Division	Name of Activity	Description	Categories of Impact / Environmental and Sanitary Risk			
				1	2	3	4
E. Basic Service Sector	Electricity, gas and water	Generating electricity from hydraulic sources	Hydropower	to 3MW	>3-15MW	>15-30MW	>30MW

Source : Acuerdo No. 1714-2010

(2) Flowchart for Environmental Permit



Source : SINEIA

(3) Environmental Categories

1) Category Classification of Projects

The Environmental Category Table in SINEIA indicates that the project is classified as category 1. EIA is not required. The necessary documents are only Form F01 and a land certificate.

2) Form F01

Form F01 and a land certificate are required for category 1 projects. Form F01 contains general information such as project area and use, and environmental information such as water resource, land, electricity, vegetation, air, noise, water, culture, etc. The items are below.

- Water resource of the project
- Expected amount of water use
- Land use
- Expected amount of electricity
- Amount of tree cutting
- Amount of discharge of gas, ash, smoke, dust
- Noise
- Method for treating drainage and rain water
- Method for treating waste
- Amount of earth digging
- Influence on cultural heritages
- Quantity of hydrocarbons
- Use of agricultural chemicals
- Use of dangerous objects

(4) Another Application

If it is necessary to cut trees in the planned construction site, an application form should be submitted to the environmental department of the Tegucigalpa Municipality as per regulations (Acuerdo No.35/Articulo 155, 2009).

1-3-4 Alternatives

(1) Place to Install New Buried Pipe at Concepcion Site

At the Concepcion Site, initial plan for the new buried pipeline was parallel to the existing pipeline. However, there are a lot of residences over the pipeline route. So, the route of the new pipeline was changed to be installed along the road to avoid resettlement due to construction.

(2) Powerhouse Construction Site in Picacho Site

During the preliminary study, the powerhouse site was studied in the pressure reducing valve pit embedded in the road. However, considering the possibility of rain water infiltration, the influence of vibrations from vehicles and the necessity of exhaust heat, the present site was selected during the preparatory survey.

(3) Selection of Hydraulic Turbine

A hydraulic turbine that is free from oil leakage was selected in order to prevent the possibility of water contamination.

1-3-5 Scoping and TOR of Environmental and Social Considerations Survey

(1) Scoping Plan

Scoping is defined as the process of identifying the content and extent of evaluation items regarding important or likely important environmental and social considerations. The result of scoping of both the Concepcion and Picacho Sites is below.

Table 1-3-3 Scoping Results

Category		Impact	Evaluation		Reasons
			During Construc-tion	During Opera-tion	
Pollution Control	1	Air pollution	C	D	During Construction: Air quality is expected to temporarily deteriorate due to operation of construction equipment and vehicles. During Operation: None of the operations are expected to cause air pollution.
	2	Water pollution	C	C	During Construction: Water quality is expected to temporarily deteriorate due to operation of construction equipment and vehicles. During Operation: A turbine will be installed in the water pipe. Oil leaks from the turbine are expected.
	3	Noise and vibrations	C	C	During Construction: Noise and vibrations by equipment and vehicles are expected. During Operation: Noise and vibrations by the waterwheel and generator are expected.
	4	Waste	C	D	During Construction: Waste materials during construction are expected to occur. During Operation: None of the operations are expected to generate waste materials.
	5	Soil pollution	D	D	None of the operations are expected to cause soil pollution.
	6	Ground subsidence	D	D	None of the operations are expected to cause ground subsidence.
	7	Offensive odors	D	D	None of the operations are expected to cause offensive odors.
Natural Environment	8	Protected area	D	D	There is no protected area in the project sites.
	9	Ecosystem	D	D	The construction is a small scale hydropower plant. The impact to the ecosystem is extremely small.
	10	Water usage	D	D	Treated water from the water treatment plant is used. There is no impact to river and ground water.
	11	Topographical and geographical features	D	D	The construction is a small-scale hydroelectric power plant. Topographical and geographical impacts are not expected.
	12	Global warming	D	D	It is a renewable energy project. The project contributes to the reduction of CO_2.
Social Environment	13	Involuntary resettlement	D	D	There is no resettlement in the project area.
	14	Local economies, such as employment, livelihoods, etc.	D	D	The project utilizes existing water service facilities. No impact to local economies is expected.
	15	Land use and use of local resources	C	D	The project utilizes existing water service facilities. No impact to local resources is expected. However, a part of the planned construction site is in private lands. There is a possibility to need to cut down some trees. But, it is not a huge impact.
	16	Social institutions such as social infrastructure and local decision-making institutions	D	D	The project utilizes existing water service facilities. No impact to social institutions or local decision-making institutions are expected.

Category		Impact	Evaluation		Reasons
			During Construc-tion	During Opera-tion	
Social Environment	17	Existing social infrastructure and services	C	D	During Construction: Traffic jams are expected because of construction vehicles. During Operation: The purpose of the project is to improve SANAA's service level by reducing electricity bills that SANAA is paying and generating renewable energy.
	18	Misdistribution of benefits and damages	D	D	The project utilizes existing water service facilities. No misdistribution of benefits or damages is expected.
	19	Local conflicts of interest	D	D	The project utilizes existing water service facilities. No local conflicts of interest are expected.
	20	Poor, indigenous or ethnic people	D	D	There are no indigenous or ethnic people near by the project sites.
	21	Gender	D	D	The project utilizes existing water service facilities. No social influence is expected from a gender viewpoint.
	22	Children's rights	D	D	The project utilizes existing water service facilities. No social influence is expected from the viewpoint of children's rights.
	23	Infectious diseases such as HIV/AIDS	D	D	There is no large-scale construction. The possibility of spreading infectious disease is not expected.
	24	Cultural heritages	D	D	There are no cultural heritages near by the project sites.
	25	Landscape	D	D	The planned construction is small in scale. No impact to landscapes is expected.
	26	Labor environment	C	D	During Construction: Labor environment must be considered. During Operation: There is no operation that would have a bad influence upon the labor environment.

Rating: A: Significant impact is expected.
B: Some impact is expected.
C: Extent of impact is unknown. (Further examination is needed and the impact could be clarified as the study progresses.)
D: No impact is expected.

(2) TOR of Environmental and Social Considerations Survey

The TOR of the environmental and social consideration survey for seven (7) environmental items that were evaluated as C is shown below.

Table 1-3-4 TOR of Environmental and Social Considerations Survey

Environmental Item	Survey Item	Method
Air pollution	①Environmental standard	①Information collection from the related organization ②Investigation of related legal framework
Water pollution	①Environmental standard ②Actual situation of water quality	①Information collection from the related organization ②Field study and hearing investigation
Noise and vibration	①Environmental standard ②Condition of the expected source origin	①Information collection from the related organization ②Field study and hearing investigation
Waste	①Treating method	①Information collection from the related organization ②Investigation of existing reports
Land use and use of local resources	①Scale of land acquisition ②Flowchart of land acquisition	①Field study and hearing investigation ②Information collection from the related organization
Existing social infrastructure and services	①Actual condition of the sites	①Field study and hearing investigation ②Information collection from the related organization
Labor environment	①Labor safety measure	①Investigation of existing reports ②Investigation of similar cases

1-3-6 Results of Environmental and Social Considerations Survey

Results of the environmental and social considerations survey are given in the following table based on scoping results.

Table 1-3-5 Results of Environmental and Social Considerations Survey

Air pollution	Regulations on the generated emissions from fixed sources (Reglamento para el Control de Emisiones Generadas por Fuentes Fijos) are applicable to structures. However, there is no regulation on construction in Honduras.
Water pollution	Technical norms for drinking water quality provide water quality standards.
Noise and vibration	Chapter 52 of Tegucigalpa Ordinance (Plan de Arbitrios) is applicable for noise and vibrations.
Waste	It will be disposed of in accordance with Honduran law.
Land use and use of local resources	Both the Concepcion and Picacho Sites require land acquisition. There is one landowner in Concepcion and some owners in Picacho. SANAA is negotiating with them and will acquire the land.
Existing social infrastructure and services	Concepcion: The site faces a road. Traffic volume is not so big, but it is necessary to study the route of construction vehicles. Picacho: The site faces a causeway and traffic volume is big. Traffic jams by construction vehicles are expected. It is necessary to study the route.
Labor environment	It will be handled in accordance with Honduran law.

1-3-7 Assessment of Environmental and Social Impacts

Assessments of the environmental and social impacts of the Concepcion and Picacho sites are below.

Table 1-3-6 Assessment of Environmental and Social Impacts

Category		Environmental Item	Scoping Result		Assessment Result		Reason
			During Construction	During Operation	During Construction	During Operation	
Pollution Control	1	Air pollution	C	D	B	D	Because of an increase in construction vehicles, contaminating emission can increase.
	2	Water pollution	C	C	B	D	Oil leaks from the turbine were one of the concerns. However, a special turbine will be installed.
	3	Noise and vibration	C	C	B	B	During Construction: It is possible that noise and vibrations occur from heavy machinery. During Operation: It is possible that noise and vibrations occur from the turbine and generator.
	4	Waste	C	D	B	D	During Construction: It is assumed that waste will be generated from construction.
	5	Soil pollution	D	D	D	D	
	6	Ground subsidence	D	D	D	D	
	7	Offensive odors	D	D	D	D	

Category		Environmental Item	Scoping Result		Assessment Result		Reason
			During Construction	During Operation	During Construction	During Operation	
Natural Environment	8	Protected area	D	D	D	D	
	9	Ecosystem	D	D	D	D	
	10	Water usage	D	D	D	D	
	11	Topographical and geographical features	D	D	D	D	
	12	Global warming	D	D	D	D	
Social Environment	13	Involuntary resettlement	D	D	D	D	
	14	Local economies, such as employment, live hood, etc.	D	D	D	D	
	15	Land use and use of local resources	C	D	B	D	Both Concepcion and Picacho are vacant. However, SANAA should negotiate and come to terms with landowners.
	16	Social institutions such as social infrastructure and local decision-making institutions	D	D	D	D	
	17	Existing social infrastructure and services	C	D	B	D	There will be few construction vehicles, but temporary traffic jams may occur.
	18	Misdistribution of benefits and damages	D	D	D	D	
	19	Local conflicts of interest	D	D	D	D	
	20	Poor, indigenous or ethnic people	D	D	D	D	
	21	Gender	D	D	D	D	
	22	Children's rights	D	D	D	D	
	23	Infectious diseases such as HIV/AIDS	D	D	D	D	
	24	Cultural heritages	D	D	D	D	
	25	Landscape	D	D	D	D	
	26	Labor environment	C	D	B	D	During Construction: Labor conditions for workers should be studied.

Rating: A: Significant impact is expected.
B: Some impact is expected.
C: Extent of impact is unknown. (Further examination is needed and the impact could be clarified as the study progresses.)
D: No impact is expected.

1-3-8 Mitigation Measures and Costs

(1) Concepcion Site

As a study result of mitigation and management measures against major environmental and social impacts, expected adverse impacts of the above environmental items can be mitigated and managed by planning and implementing appropriate measures.

Table 1-3-7 Mitigation and Management Measures (Concepcion Site)

Environmental Item	Evaluation	Remarks
Air pollution	B	- Appropriate heavy machinery and construction vehicles - Regular maintenance - Instruction for workers to avoid unnecessary idling from construction vehicles
Water pollution	B	- Appropriate heavy machinery and construction vehicles - Regular maintenance - Selection of waterwheel that does not pollute water - Regular water quality inspection
Noise and vibration	B	- Conduct noisy operations in the daytime and on weekdays. - Inform residents of construction process and details.
Waste	B	- Environmental education to contractors and workers - Classification of garbage and waste by type - Use of materials without hazardous waste
Land use and utilization of local resources	B	- Procedure of land acquisition
Existing social infrastructure and services	B	- Study routes for vehicles. - Inform residents of construction process and details.
Labor environment	B	- Provide a labor environment based on suitable law. - Place temporary toilets.

Rating: A: Significant impact is expected.
B: Some impact is expected.
C: Extent of impact is unknown. (Further examination is needed and the impact could be clarified as the study progresses.)
D: No impact is expected.

(2) Picacho Site

Table 1-3-8 Mitigation and Management Measures (Picacho Site)

Environmental Item	Evaluation	Remarks
Air pollution	B	- Appropriate heavy machinery and construction vehicles - Regular maintenance - Instruction for workers to avoid unnecessary idling from construction vehicles
Water pollution	B	- Appropriate heavy machinery and construction vehicles - Regular maintenance - Selection of turbine that does not pollute water - Regular water quality inspection
Noise and vibration	B	- Conduct noisy operations in the daytime and on weekdays. - Inform residents of construction process and details.
Waste	B	- Environmental education to contractors and workers - Classification of garbage and waste by type - Use of materials without hazardous waste
Land use and utilization of local resources	B	- Procedure of land acquisition - Deforestation application to city office
Existing social infrastructure and services	B	- Study routes for vehicles. - Inform residents of construction process and details.
Labor environment	B	- Provide labor environment based on suitable law. - Place temporary toilets.

Rating: A: Significant impact is expected.
B: Some impact is expected.
C: Extent of impact is unknown .(Further examination is needed and the impact could be clarified as the study progresses.)
D: No impact is expected.

1-3-9 Monitoring Plan

In Honduras, regulations on emission gasses from fixed structures, technical norms on drinking water quality and Chapter 52 of the Tegucigalpa ordinance on noise and vibrations will be observed during construction and operation. There are not specific regulations and rules applying to construction works or construction equipment in Honduras. Monitoring forms (draft) are attached at the end of the chapter.

Table 1-3-9 Monitoring Plan

Environmental Item	Detail		Target	Deadline	Frequency	Responsibility
[Before construction]						
Stakeholder consultation	First	Explanation of outline	Residents who live nearby the sites	Before E/N	Once	SANAA
	Second	Explanation of details	Residents who live nearby the sites	Before construction starts	Once	SANAA
Land acquisition	Picacho	Agreement by negotiation	Landowners	Before E/N	Once	SANAA
		Conclusion by official document	Landowners	Within three months after E/N	Once	SANAA
	Concepcion	Agreement by negotiation	Landowners	Before E/N	Once	SANAA
		Conclusion by official document	Landowners	Within three months after E/N	Once	SANAA
Environmental permit	Fill in Form F01			Before E/N	Once	SANAA
	Submit to SERNA			After Land acquisition	Once	SANAA

Environmental Item	Item	Target	Method	Frequency	Responsibility
[During construction]					
Air pollution	Level of dust and soot, exhaust gas	Construction vehicles	Checking of auto emission certificate (Sampling survey)	Once just after construction starts	Contractor SANAA
Noise	Construction vehicles, heavy equipment	Houses that are nearby the sites	Simple measures (Average amount)	Once/month	Contractor SANAA
	Generator, turbine	Houses that are nearby the sites	Simple measures (Average amount)	Once just after equipment is placed	Contractor SANAA
Water pollution	Add to SANAA's regular inspection			Once after turbine is installed	SANAA
[After construction]					
Noise	Generator, turbine	Residents who live nearby the sites	Hearing investigation	Once/month	SANAA
Water pollution	Add to SANAA's regular inspection				SANAA

1-3-10 Stakeholder Consultation

Stakeholder consultation meetings will be held two (2) times respectively in both the Picacho and Concepcion Sites by SANAA (after E/N and before the commencement of construction). SANAA has experience with holding this kind of meeting during previous JICA Grant Aid projects and can manage the meetings well.

1-3-11 Land Acquisition

1-3-11.1 Necessity and Scale of Land Acquisition

(1) Concepcion Site

The planned powerhouse construction site at the Concepcion Site is private land. The land is vacant and resettlement is not necessary. However, SANAA should negotiate with the landowner. The required area is approximately 600 m^2.

(2) Picacho Site

There are no residences in the planned powerhouse construction site, but some part is private land of three (3) landowners. The land is vacant and resettlement is not necessary. But, land acquisition is necessary. The required area including the access road is approximately 1380 m^2.

1-3-11.2 Progress

Land acquisition is SANAA's responsibility. The reacquisition price is decided based on market price or municipal appraisal value in consideration of convenient public services such as public transportation, electricity, water supply, sewerage and so on. SANAA has already started to negotiate with landowners. Regarding the Concepcion Site, the landowner has agreed to sell the land, but an official document has not been signed yet. As for the Picacho Site, the official procedure is now underway.

For SANAA's internal procedure, actual land purchases will be conducted after E/N. Because their budget is secured after implementation of the Project is decided. SANAA is preparing to appropriate the budget by March 2013

There are a few landowners in both sites. Therefore, consolation and complaint procedures with them will be handled individually by SANAA.

1-3-11.3 Implementation Schedule

Necessary procedures conducted by SANAA up until commencement of the Project are scheduled below.

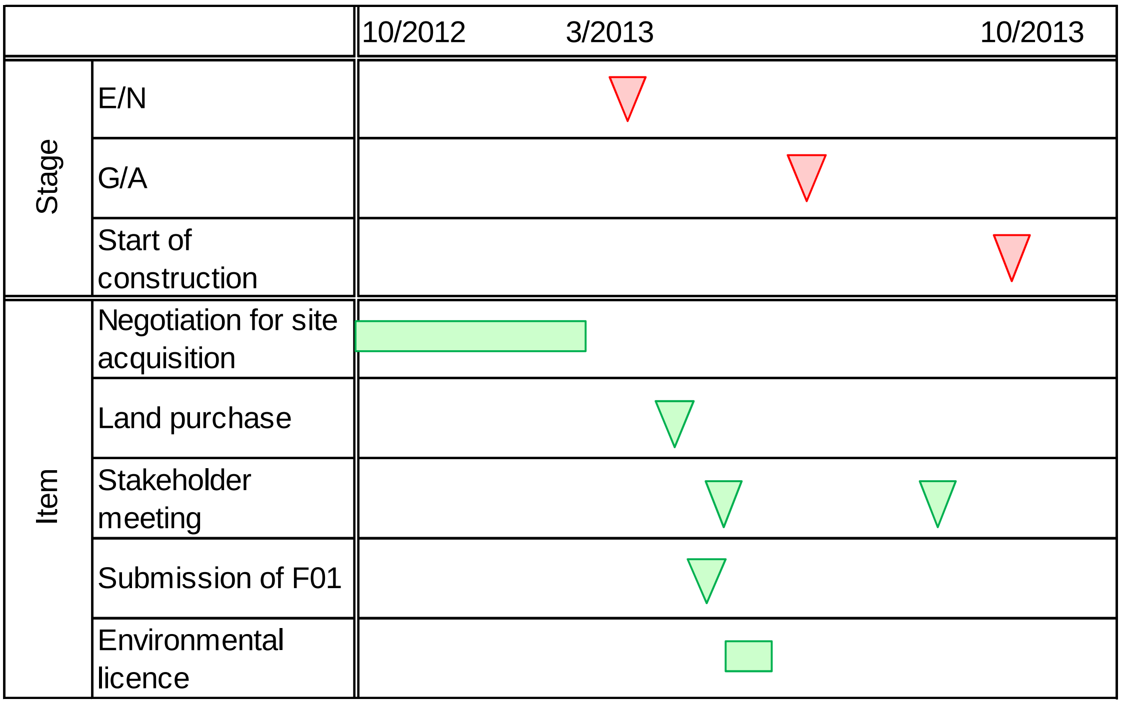


Fig. 1-3-4 Implementation Schedule

Reference 1 : Check List

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1. Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process?	(a) N	(a) EIA is not required for this project.
		(b) Have EIA reports been approved by authorities of the host country's government?	(b) N	(b) Same as above
		(c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?	(c) N	(c) Same as above
		(d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(d) N	(d) Environmental permits by F01 form is required. SANAA will submit document and obtain permit before construction starts, because it takes only 15 days and land acquisition is necessary.
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders?	(a) N	(a) SANAA hold meeting with stakeholders after E/N and before construction starts.
		(b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(b) N	(b) Same as above.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) Alternative plans of construction site in Picacho, pipeline route in Concepcion and type of waterwheel are considered.
2. Pollution Control	(1) Water Quality	(a) Does the water quality of dam pond/reservoir comply with the country's environmental water quality standards? Is there a possibility that proliferation of phytoplankton and zooplankton will occur?	(a) Y/N	(a) Water in existing waterworks facilities will be used. The water quality should be complied with National Technical Rule of drinking water quality (Norma Técnica Nacional para la calidad del agua potable)
		(b) Does the quality of water discharged from the dam pond/reservoir comply with the country's ambient water quality standards?	(b) Y	(b) Special water wheel to avoid water contamination will be applied.
		(c) Are adequate measures, such as clearance of woody vegetation from the inundation zone prior to flooding planned to prevent water quality degradation in the dam pond/reservoir?	(c) Y	(c) There is no impact, because existing waterworks facilities is utilized.
		(d) Is there a possibility that reduced the river flow downstream will cause water quality degradation resulting in areas that do not comply with the country's ambient water quality standards?	(d) N	(d) Same as above
		(e) Is the discharge of water from the lower portion of the dam pond/reservoir (the water temperature of the lower portion is generally lower than the water temperature of the upper portion) planned by considering the impacts to downstream areas?	(e) N	(e) Same as above
	(2) Wastes	(a) Are earth and sand generated by excavation properly treated and disposed of in accordance with the country's regulations?	(a) Y	(a) Wasted as asphalt can be generated. Contractor treats under Honduran regulation by SANAA's direction.
3. Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) N	(a) Both pilot sites are not in the protected areas.
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?	(a) N	(a) There are no encompass primeval forests and tropical rain forests around the project sites.
		(b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions?	(b) N	(b) There is no protected habitat of endangered species in the project site.
		(c) Is there a possibility that the project will adversely affect downstream aquatic organisms, animals, plants, and ecosystems? Are adequate protection measures taken to reduce the impacts on the ecosystem?	(c) N	(c) There is no negative impact, because existing water facilities are utilized.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
3. Natural Environment	(2) Ecosystem	(d) Is there a possibility that installation of structures, such as dams will block the movement of the migratory fish species (such as salmon, trout and eel those move between rivers and sea for spawning)? Are adequate measures taken to reduce the impacts on these species?	(d) N	(d) Same as above.
	(3) Hydrology	(a) Is there a possibility that hydrologic changes due to the installation of structures, such as weirs will adversely affect the surface and groundwater flows (especially in "run of the river generation" projects)?	(a) N	(a) There is no negative impact, because existing water facilities are utilized.
	(4) Topography and Geology	(a) Is there a possibility that reductions in sediment loads downstream due to settling of suspended particles in the reservoir will cause impacts, such as scouring of the downstream riverbeds and soil erosion? Is there a possibility that sedimentation of the reservoir will cause loss of the storage capacity, water logging upstream, and formation of sediment deposits at the reservoir entrance? Are the possibilities of the impacts studied, and adequate prevention measures taken? (b) Is there a possibility that the project will cause a large-scale alteration of the topographic features and geologic structures in the surrounding areas (especially in run of the river generation projects and geothermal power generation projects)?	(a) N (b) N	(a) There is no negative impact, because existing water facilities are utilized. (b) Same as above.
4. Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Are the compensations going to be paid prior to the resettlement? (e) Are the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a) N (b) Y (c) Y (d) Y (e) N (f) N (g) Y (h) Y (i) Y (j) Y	(a) Resettlement does not occur, but land acquisition is required. (b) Resettlement does not occur. And SANAA is giving explanation to each landowner respectively. (c) Resettlement does not occur. The price of land is decided by market price and valuation that is considered with access to public service by municipality. (d) The land acquisition proceed before the construction starts. (e) The official document is now in preparation. (f) Resettlement does not occur. (g) Resettlement does not occur. Regarding agreement with land owner, SANAA is under negotiation. (h) Organizational budget including land acquisition is being deliberated at parliament. (i) Resettlement does not occur and related land owners are few. So SANAA attend to each individual. (j) Same as above
	(2) Living and Livelihood	(a) Is there any possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) Is there any possibility that the project causes the change of land uses in the neighboring areas to affect adversely livelihood of local people? (c) Is there any possibility that the project facilities adversely affect the traffic systems?	(a) N (b) N (c) Y	(a) Impact for the living condition of inhabitants is limited, because the project is carried out in existing water work facility area. (b) Same as above (c) There is a possibility that traffic increases. Explanation for residents and countermeasure are required.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4. Social Environment	(2) Living and Livelihood	(a) Is there any possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?	(a) N	(a) Impact for the living condition of inhabitants is limited, because the project is carried out in existing water work facility area.
		(b) Is there any possibility that the project causes the change of land uses in the neighboring areas to affect adversely livelihood of local people?	(b) N	(b) Same as above
		(c) Is there any possibility that the project facilities adversely affect the traffic systems?	(c) Y	(c) There is a possibility that traffic increases. Explanation for residents and countermeasure are required.
		(d) Is there any possibility that diseases, including infectious diseases, such as HIV, will be brought due to the immigration of workers associated with the project? Are adequate considerations given to public health, if necessary?	(d) N	(d) The project scale is not large. The possibility is limited.
		(e) Is the minimum flow required for maintaining downstream water uses secured?	(e) N	(e) There is no negative impact, because existing water facilities are utilized.
		(f) Is there any possibility that reductions in water flow downstream or seawater intrusion will have impacts on downstream water and land uses?	(f) N	(f) Same as above
		(g) Is there any possibility that water-borne or water-related diseases (e.g., schistosomiasis, malaria, filariasis) will be introduced?	(g) N	(g) Same as above
		(h) Is there any possibility that fishery rights, water usage rights, and common usage rights, etc. would be restricted?	(h) N	(h) Same as above
	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) There is no heritage around the project sites.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	(a) The project is small scale and there is no landscape to be considered.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples?	(a) N	(a) There is no ethnic minorities and indigenous peoples around the project sites.
		(b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources to be respected?	(b) N	(b) Same as above
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project?	(a) Y	(a) Contractor will consider under SANAA's direction.
		(b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials?	(b) Y	(b) Same as above
		(c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.?	(c) Y	(c) Same as above
		(d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(d) Y	(d) Same as above
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)?	(a) Y	(a) It will be considered by contractor under the Honduran regulation. Regular maintenance of construction vehicle, operation at daytime, classification of waste should be considered.
		(b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce the impacts?	(b) N	(b) Construction scale is small. The impact is limited.
		(c) If construction activities adversely affect the social environment, are adequate measures considered to reduce the impacts?	(c) N	(c) Same as above

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
5 Others	(2) Accident Prevention Measures	(a) Is a warning system established to alert the inhabitants to water discharge from the dam?	(a) N	(a) It is not necessary.
	(3) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) Y (b) Y (c) Y (d) N	(a) Water quality monitoring will be practiced by SANAA. Other items will be considered by contractor. (b) Same as above (c) Same as above (d) The monitoring report system is not determined. It should be decided.

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are requested to be made.
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

Reference 2 : Monitoring Form (Draft)

Environmental item	Detail		Target	Deadline	Frequency	Result	Responsibility	Remarks
[Before construction]								
Stakeholder consultation	First	Explanation of outline	Residents who live near by the sites	Before E/N	Once		SANAA	
	Second	Explanation of the detail	Residents who live near by the sites	Before construction starts	Once		SANAA	
Land acquisition	Picaho	Agreement by negotiation	Land owners	Before E/N	Once		SANAA	
		Conclusion by official document	Land owners	Within three months after E/N	Once		SANAA	
	Concepcion	Agreement by negotiation	Land owners	Before E/N	Once		SANAA	
		Conclusion by official document	Land owners	Within three months after E/N	Once		SANAA	
Environmental permit	Fill in F01 form			Before E/N	Once		SANAA	
	Submit to SERNA			After Land acquisition	Once		SANAA	

Environmental item	Item	Target	Method	Parameter	Result	Frequency	Responsibility	Remarks
[During construction]								
Air pollution	Level of dust and soot, exhaust gas	construction vehicle	Check of auto emission certificate (Sampling survey)	Acquisition of auto emission certificate		Once just after construction starts	contractor SANAA	
Noise	construction vehicle, heavy equipment	House that is near by the sites	Simple measure (average amount) The criterion is based on chapter 52 of municipal plan (Plan de arbitrios)	65 decibel		Once/month	contractor SANAA	
	generator, waterwheel	House that is near by the sites		65 decibel		Once just after equipment is placed	contractor SANAA	
Water pollution	Add to SANAA's regular inspection					Once after waterwheel is placed	SANAA	
[After construction]								
Noise	generator, waterwheel	Residents who live near by the sites	Hearing investigation	No. of complaint		Once/month	SANAA	
Water pollution	Add to SANAA's regular inspection						SANAA	

CHAPTER 2

CONTENTS OF THE PROJECT

CHAPTER 2 CONTENTS OF THE PROJECT

2-1 BASIC CONCEPT OF THE PROJECT

2-1-1 Overall Goal and Direct Objective of the Project

Electricity in Honduras is mostly generated by thermal power plants where small-scale diesel engines are fed with imported fossil fuel. The use of renewable energy and an improvement in energy use efficiency, therefore, are crucial in order to reduce the dependence on diesel-fueled thermal power generation. Such efforts are desired in the country in view of ensuring energy security (less dependence on imported fossil fuel) and reducing emissions of greenhouse gases. The Government of Honduras (hereinafter called "the GOH") has placed the introduction and expansion of renewable energy use among national priority policies. In the "National Plan 2010-2022", the GOH launched the plan to increase the proportion of renewable energy resources in its primary energy use up to 60% by 2022.

The Project is to furnish small-scale hydroelectric power generation equipment using the unutilized water-head potential in the existing water treatment plants (Concepcion and Picacho Plants) owned and operated by National Autonomous Service of Aqueducts and Sewerage (SANAA), which are providing water and sewage services to Tegucigalpa City. SANAA uses large amounts of electricity to operate water treatment facilities and pump up groundwater, and the electricity bills are a heavy financial burden to SANAA. By selling the electricity generated by the power plant to be installed, the Project will contribute to reducing the large expense on electricity and its influence on water tariffs and facility investment capacity, and to helping SANAA improve its water and sewage services.

Although its size is small, the Project is important in that it will be an impetus to the GOH's renewable energy policy, and will also be a pilot project that utilizes the hydro-potential in existing water treatment plants. It is expected that the Project will contribute to the expansion of renewable energy use in similar form, to be developed at water-related facilities in the country.

2-1-2 Outline of the Project

The Project was conceived to provide power generation operations in the existing Concepcion and Picacho Water Treatment Plants, by installing small-scale hydroelectric power equipment for utilizing the unutilized water-head (potential energy). The generated power is planned to be sold, which in effect will reduce the expense on electric power purchase from the National Electric Company (ENEE). The sale of electricity and the resulting financial surplus may be applied to improving water services of SANAA.

Concepcion Hydroelectric Power Plant

At the Concepcion, the residual potential energy of raw water for water supply between the Concepcion Reservoir and powerhouse is planned to be used for power generation at the aerator located upstream of the plant. The installed capacity of the Concepcion Hydroelectric Power Plant is 250 kW. To utilize the existing water-head effectively, the Concepcion Project will construct a new ductile cast-iorn pipeline of a 700 mm internal diameter for about 3 km, parallel to the smaller pipe segment (internal diameter 900 mm) of the existing pipeline (steel pipe, internal diameters of 1,100 and 900 mm) of approximately 6.3 km between the dam and the aerator.

Picacho Hydroelectric Power Plant

At the Picacho Site, pressurized treated water for water supply at the water pressure reducing valve on a water supply pipe (line L22, internal diameter of 400 mm) located downstream of the treatment plant is planned to be used for power generation. The installed capacity of the Picacho Hydroelectric Power Plant is 180 kW.

Grid Interconnection

The energy generated by the Concepcion and Picacho Hydroelectric Power Plants is planned to be all sold to ENEE, via interconnection to the nearby distribution line.

Table 2-1-1 Outline of Facilities

Power Plant Name		Unit	Concepcion Hydroelectric Power Plant	Picacho Hydroelectric Power Plant
Maximum power discharge		m^3/s	1.5	0.3
Maximum gross head		m	42.06	91.44
Effective head for rated power		m	27.46	86.16
Installed capacity		kW	250	180
Estimated annual generated energy [1]		MWh	1,650	520
Headrace	Type	-	Buried pipe	-
	Material	-	Ductile cast-iron	-
	Diameter	-	700 mm	-
	Length	m	2,973	-
Powerhouse	Type	-	Open type	Open type
	Structure	-	Single–story reinforced concrete structure	Single–story reinforced concrete structure
	Height	m	7.00	7.00
	Area	m^2	174 m^2 (8.50 × 20.50 m)	174 m^2 (8.50 × 20.50 m)

1 Calculated by daily dam water level and daily intake flow from 2006 ~ 2011.

Table 2-1-2 Outline of Equipment

Power Station Name	Concepcion Hydroelectric Power Plant	Picacho Hydroelectric Power Plant
Hydraulic Turbine		
Type	Horizontal single runner, single flow spiral type Francis turbine	Horizontal single runner, single flow spiral type Francis turbine
Governor	PD control type	PD control type
Inlet valve	Electric motor driven	Electric motor driven
Rated output	273 kW	204 kW
Rated speed	900 rpm	1,200 rpm
Generator		
Type	Horizontal, direct coupled, 3-phase-3-wire and horizontal shaft synchronous generator	Horizontal, direct coupled, 3-phase-3-wire and horizontal shaft synchronous generator
Insulation class	Class F	Class F
Rated voltage	480 V	480 V
Rated power	314 kVA	235 kVA
Power factor	80%	80%
Frequency	60 Hz	60 Hz
Speed	900 rpm	1,200 rpm
Turbine/Generator Control System		
Type	Programmable Logic Controller	Programmable Logic Controller
Low Voltage distribution Board		
Type	Air insulated (3 panels)	Air insulated (3 panels)
Control System		
Type	Supervisory Control and Data Acquisition System	Supervisory Control and Data Acquisition System
High Voltage Switchgear		
Type	Metal-enclosed, indoor	Metal-enclosed, indoor
Transformer		
Type	Oil immersed type, self-cooled, outdoor use	Oil immersed type, self-cooled, outdoor use
Voltage	480 V/34.5 kV	480 V/13.8 kV
Rated power	400 kVA	250 kVA
Connection	Delta/star	Delta/star

2-2 BASIC DESIGN OF JAPANESE ASSISTANCE

2-2-1 Design Policy

2-2-1.1 Basic Design Policy

(1) Scope of the Project

The GOH made a request to the Government of Japan (GOJ) for Grant Aid to realize the small-scale hydroelectric power project using the unutilized water-head (potential energy) existing in water treatment plants identified by the study conducted by the Honduran-national consultants. Upon the receipt of the request, the Japan International Cooperation Agency (JICA) conducted a basic data collection survey in November 2011 on this small-scale hydroelectric power project. The JICA survey team reviewed the preliminary study report prepared by the national consultants and examined power generation plans for the Concepcion and Picacho Water Treatment Plants managed by SANAA. As a result, a 444 kW generation plan using the unutilized water-head (potential energy) in the two (2) sites was proposed. This preparatory study developed the optimum power generation plans for these water treatment plants on the basis of the results of site surveys. The electricity generated by the power plants to be installed at these sites by the Project will be sold to ENEE, via grid-interconnection of the generation equipment to the nearby distribution lines.

(2) Site Identification

The locations of the power plants, the stretch of new pipeline to be installed, generation capacities, etc. were identified for both the Conception and Picacho Water Treatment Plants, by examining information collected in the site survey, such as topography, geology, hydrology including pipeline discharges, residual water-head, results of discharge measurements, equipment related to grid-interconnection, etc.

The generation plan for the Concepcion Site is to harness the residual potential energy of raw water for water supply between the Conception Reservoir and the power plant, which will be constructed on the upstream side of the existing aerator. A new pipeline will be installed in order to make effective use of the unutilized potential energy of water.

At the Picacho Site, the generation plan is to use the potential energy of treated water at the water pressure reducing valve located on the L22 pipeline downstream of the Picacho Treatment Plant, by placing the hydraulic turbine in parallel to the said valve.

The locations of the power plant was selected in consideration of such factors as the availability of space for equipment, suitable environments for placing control equipment, vibrations from traffic, ease of construction and maintenance works, interruption of traffic during construction, etc.

The generation equipment will be grid-interconnected to the existing distribution system of ENEE.

(3) Generation Capacity Scale

The Project will effectively use the existing potential energy of either raw water or treated water in the existing water treatment plants for water supply, without disrupting the existing water supply and distribution system. The optimum scale of generation capacity was selected to maximize the generated energy.

For the Concepcion Site, it was decided that a new pipeline should be installed in order to make effective use of the unutilized potential energy, as the water head is variable due to the seasonal variation in water level in the reservoir and the effective water head is lowered by the friction loss of flow in the pipeline.

The Picacho Treatment Plant distributes water to nine (9) pipeline systems. Discharges for these pipelines vary according to supply schedule. The pipeline in question, L22, has a discharge of 120 to 150 liter per second, according to actual measurement. The power generation capacity was determined considering these measurement results, along with the maximum discharge of 225 liter per second shown in the basic design of the water treatment plant.

2-2-1.2 Design Policy on Natural Conditions

These sites are located in Tegucigalpa City, which is located at 14˚ north latitude, on a central highland inland on the Pacific side of the country. The altitude of these sites is about 1,100 m above sea level, which limits the monthly average temperature to less than 25˚C, with seasonal variations ranging 15 ˚C to 30˚C. The seasons are clearly divided in two: a rainy season between May and October, and a dry season for the rest of the year. The annual rainfall at the Concepcion Site is about 1,000 mm and at Picacho site 1,700 mm. During the rainy season intense storms occur. Therefore, construction works should pay attention to safety during excavation work for embedded pipes, and quality during backfilling work.

Tegucigalpa City and its surroundings have not experienced severe earthquakes. The two sites fall into level 4 (factor 0.25) of 6 (factor 0.10 to 0.35) under the seismicity standards of the country. When the power plant was designed in this study, a design horizontal seismicity of 0.1 was adopted, after due consideration on the regional factor, the importance of the building, geology, and the type of the structure. The design wind for these sites was also determined to be 120 kg per square meters on the basis of Honduran wind standards, considering windiness of the sites, the structure of the building, the importance of the building, and the reference wind speed (120 km per hour).

2-2-1.3 Design Policy on Socio Economic Conditions

The Concepcion Site has an installation of new pipeline to be embedded underground along the existing road. There are residences nearby, which requires countermeasures against noise, vibration, and dust during construction works. There also are residences around the candidate sites for the powerhouses. In designing the powerhouses buildings, countermeasures for noise during the operation of the powerhoues should be considered as well.

2-2-1.4 Construction and Procurement Conditions

As part of the construction procedure, it is necessary for SANAA to acquire construction permission from Tegucigalpa City for the pipe-laying works along a municipal road near the Conception Site. If necessary, SANAA needs to request assistance or cooperation from institutions such as the telecommunication company or electric company in advance of the construction works.

It is confirmed that the construction materials necessary for the project, such as ready-mix-concrete, deformed steel bar, cement, wood, aggregates, sand, etc. are readily available locally and they are of acceptable quality. Therefore, it is planned to use them for the construction works.

On the other hand, large diameter ductile iron pipes, steel pipes, valves, etc. are not available locally. Therefore, it is considered to supply them from Japan or a third country.

A procurement plan should be formulated in consideration of the required transportation periods from Japan or a third country since they may take as much as two (2) months.

Moreover, a deterioration of public safety has been reported by some construction companies who have experience carrying out previous JICA project in Honduras. Therefore, it is important to take all necessary measures to ensure security for project staff, by hiring licensed private security companies or requesting assistance from the local police.

2-2-1.5 Application of Local Resources

There are many local construction companies in Honduras that are judged to be capable of conducting the necessary work of constructing the planned facilities under the guidance and supervision of the Japanese contractor. These local companies will, therefore, be actively used for the project, partly for the purpose of vitalizing the local economy, creating local employment opportunities and transferring construction technologies to these companies.

Moreover, in addition to the civil engineering works, installation works of the power generation equipment will be carried out by local contractors.

The main components of the works are civil engineering works (earth work, concrete work, pipe laying work, etc.), facility installation works, and electrical works.

It is necessary to dispatch engineers from Japan for quality control, process control, safety control, equipment installation instruction, test adjustment, etc.

2-2-1.6 Operation and Maintenance

The operations of the water service business will be transferred from SANAA to the municipality of Tegucigalpa in October 2013, as provided by law. SANAA has been facing financial difficulties in settling payments including the pensions of SANAA employees. The power generation facilities constructed by this Project will also be transferred to the municipality. On the other hand, water services will have to be operated and managed by SANAA engineers even after the transfer, as they have the knowledge and know-how of the business. Therefore, the techniques and knowledge required for operation and maintenance of the power generation facilities will have to be given to SANAA engineers. Meanwhile, SANAA does not have any experience in operating hydroelectric power facilities. Soft components of this Project should provide necessary technical support to SANAA and develop their capacity to operate and maintain the hydroelectric power facilities in a sustainable manner, without causing problems to water services. Soft components will cover such techniques and knowledge required in daily-level, light-duty maintenance works. Overhaul and heavy-duty maintenance works including the replacement of large parts in the facilities are planned to be contracted to manufacturers in accordance with the mid- to long-term maintenance plan formulated in soft components.

SANAA has rich experience in the operation and maintenance of water service facilities, owing to their mechanical and electrical engineers. These engineers are well-equipped to master the techniques and knowledge of the hydroelectric power engineering, and SANAA has shown a positive attitude to acquire and distribute such techniques and knowledge in the organization. Therefore, SANAA is considered to capable of securing the necessary human resources to act as the receiving end of technical transfers in hydroelectric power engineering. It will be very effective if this Project sees the involvement of electric and mechanical maintenance departments of SANAA, and also that of ENEE, who has vast experience with electrical facilities.

2-2-1.7 Standards Applied to the Project

Civil engineering facilities are designed according to the technical standards of Honduras such as design horizontal seismic intensity and wind load.

The powerhouse building is of reinforced-concrete structure, considering sound control since both sites stand close to the residential lands. During construction, in case that rock excavation is required in the construction area, a non-blasting method is to be employed, considering the impact on neighboring houses and facilities due to construction vibration and noise. Also, as sound and vibration control associated with construction, low-noise and less-vibration type construction machinery is to be used as much as possible.

Based on the government policy, main components of small-scale hydroelectric power plant such as hydraulic turbines and generators was designed as a premise for utilizing the products made by small and medium-size Japanese manufactures. The following standards are to be applied to designing the facilities.

- ♦ The International Electrotechnical Standards (IEC)
- ♦ Japanese Industrial Standards (JIS)
- ♦ Standards of the Japanese Electrotechnical Committee (JEC)
- ♦ Standards of the Japan Electrical Manufacturers' Association (JEM)
- ♦ Japanese Electric Wire & Cable Makers' Association Standards (JCS）

However, it is noted that the facilities is not to have complicated components or specifications in consideration of the technological level of the operation and maintenance sections of SANAA, which will carry out operation and maintenance of the system after the project. Moreover, the materials to be procured from third countries, such as medium-voltage switchgears, power transformers, etc. is to conform to international standards and specifications applied by SANAA and ENEE.

The hydroelectric power plants are planned to be inter-connected to nearby distribution lines. The design of distribution facilities is to conform to the standards applied by ENEE.

2-2-1.8 Construction/Procurement Method and Schedule

In the construction process, the construction methods should be chosen to minimize the excessive noise and impact to the neighboring residents since the sites are close to residential areas.
Moreover, the cooperation of the Honduras side, in matters such as sites acquisition, is essential to complete the project within the predetermined time frame and to attain the expected outcome. Therefore, it is necessary to formulate the project schedule in consideration of the administrative procedure such as tax exemption, construction approval, etc.

2-2-2 Basic Plan (Construction Plan / Equipment Plan)

2-2-2.1 Power Generation Planning

(1) Generation Capacity for Concepcion Site

The Concepcion Water Treatment Plant is fed with raw water transported at a rate of 1.5 m^3/sec maximum, through an around 7 km long pipeline, from the Concepcion Dam (68 meter high) located on the lower stretch of the Rio Grande, southwest of Tegucigalpa City. The powerhouse plant for the Concepcion Site will be placed on the upstream side of the aerator, about 6.3 km downstream of the dam. Power will be generated, using the residual water head of the raw water at this point.

The Concepcion Dam is a gravity dam constructed in 1991 for water supply purpose, with support from Italy. In the same year, the Concepcion Water Treatment Plant was constructed downstream from there with assistance from Italy and France. When inaugurated, the water treatment capacity of the plant was 1,200 liter/sec, which was later in 2006 augmented by 300 liter/sec by Italian assistance, and is now 1,500 liter/sec. At the same time of this augmentation of the treatment capacity, the water level of the Concepcion Dam was raised by adding tumble gates to the spillway. As a result, the high water level (HWL) of the dam was raised from EL 1,155 m to EL 1,157.28 m. The lowest operating water level is EL 1,114 m, and the effective storage of the reservoir is 33 million m^3.

The existing pipeline is made of steel pipes of an internal diameter of 1,100 mm for the upper segment of 3.67 km, and 900 mm for the lower segment of 2.61 km in length. The pipes are deteriorated and the friction loss of water head is large. For the purpose of power generation, a new pipeline will be constructed in parallel to reduce the loss of water head.

Power generation capacity was considered and generated energy calculated using data on the daily average water intake rate and daily average water level of the dam for 12 years (2000 to 2011) provided by SANAA.

1) Water Intake Flow and Dam Water Level

Operating water levels at the dam and intake flows were unquestionably increased after 2006, when the dam water levels were raised by the installation of spillway gates, and the treatment capacity at the Concepcion Treatment Plant was increased from 1,200 liter/sec to 1,500 liter/sec.

The average water level of the dam after 2006 has been 5.4 m higher than that for the period between 2000 and 2005. The average intake flow after 2006 has been 1,253 liter/sec, 20% larger than that in the preceding 6 years. The water supply flow from the dam to the treatment plant after 2006 has been stable, although there is some seasonal variation. The tables below show the average, highest and lowest water levels, and the average, largest and smallest water intake flows at the dam, for the three different periods. Also, Fig. 2-2-1 shows the average, largest and smallest water intake flows, and Fig. 2-2-2 the average, highest and lowest water levels, at the dam for every year in the period of 2000 through 2011.

Table 2-2-1 Average, Highest and Lowest Water Levels at Concepcion Dam

	2000 - 2011	2000 - 2005	2006 - 2011
Average Water Level (m)	1,148.37	1,145.68	1,151.06
Highest Water Level (m)	1,157.28	1,156.29	1,157.28
Lowest Water Level (m)	1,130.29	1,130.29	1,137.79

Table 2-2-2 Average, Largest and Smallest Water Intake Flows at Concepcion Dam

	2000 - 2011	2000 - 2005	2006 - 2011
Average Intake Flow (liter/sec)	1,140.25	1,027.45	1,253.06
Largest Intake Flow (liter/sec)	1,550.00	1,404.17	1,550.00
Smallest Intake Flow (liter/sec)	441.67	441.67	866.67

Time series of daily dam water level and water intake flow are shown in Fig. 2-2-3. The figure reveals that the operation of the Concepcion Dam sees the water level bottoms from March to May when the dry season ends and the rainy season starts. In the dry season, water supply to Tegucigalpa City from other sources without reservoirs is decreased, and the Concepcion Plant, which has a reservoir, increases the treatment flow to its full-capacity and supplies water to the water distribution pond in areas with short supply. Consequently, the water level at the dam falls, and natural water head becomes insufficient to send enough raw water to the Concepcion Plant. Therefore, three (3) booster pumps are operated to achieve the necessary rate.

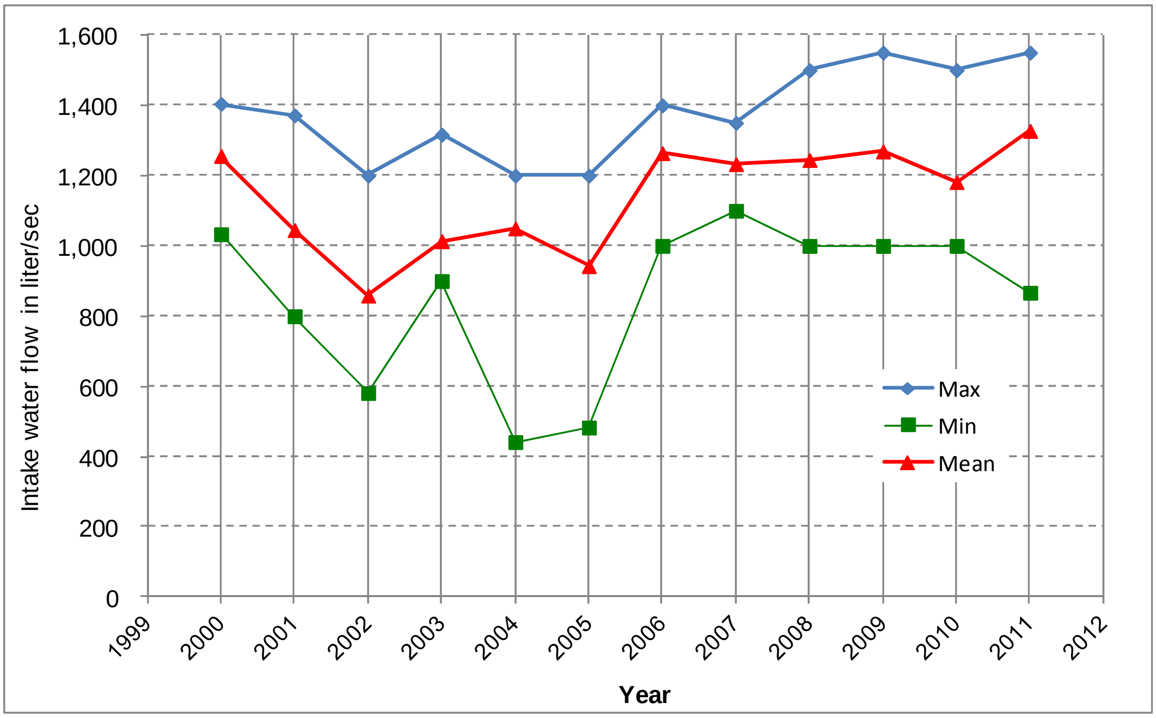


Fig. 2-2-1 Average, Largest and Smallest Water Intake Flows for Each Year

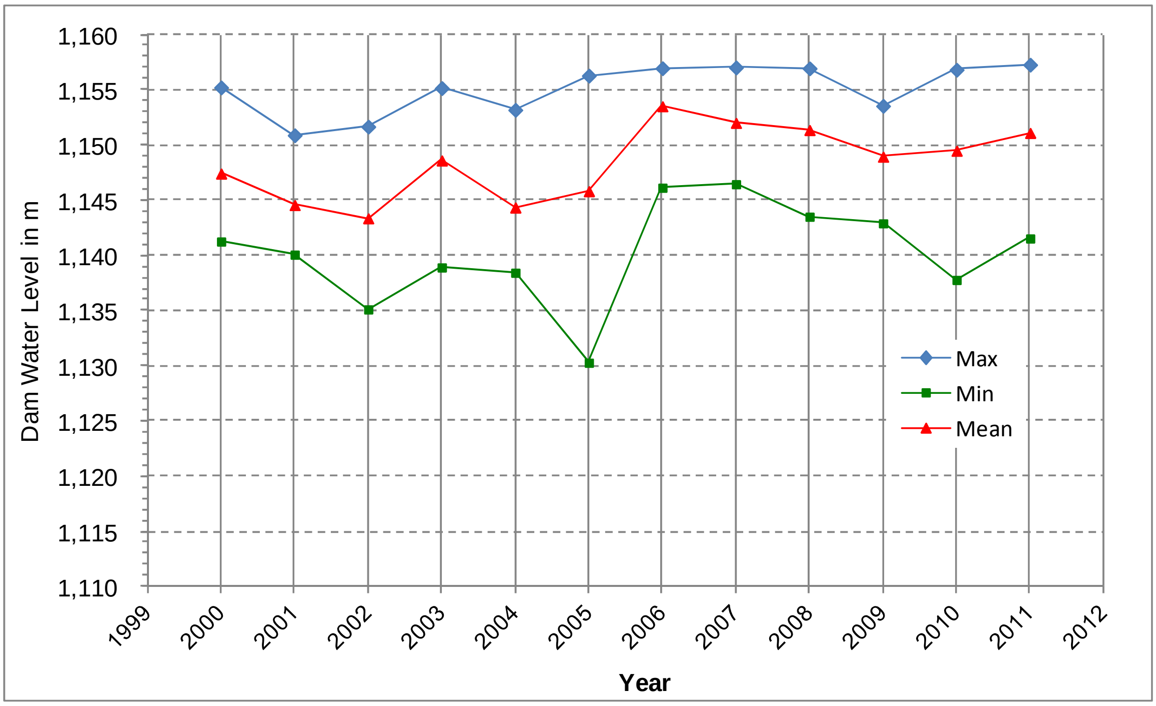


Fig. 2-2-2 Average, Highest and Lowest Water Levels for Each Year

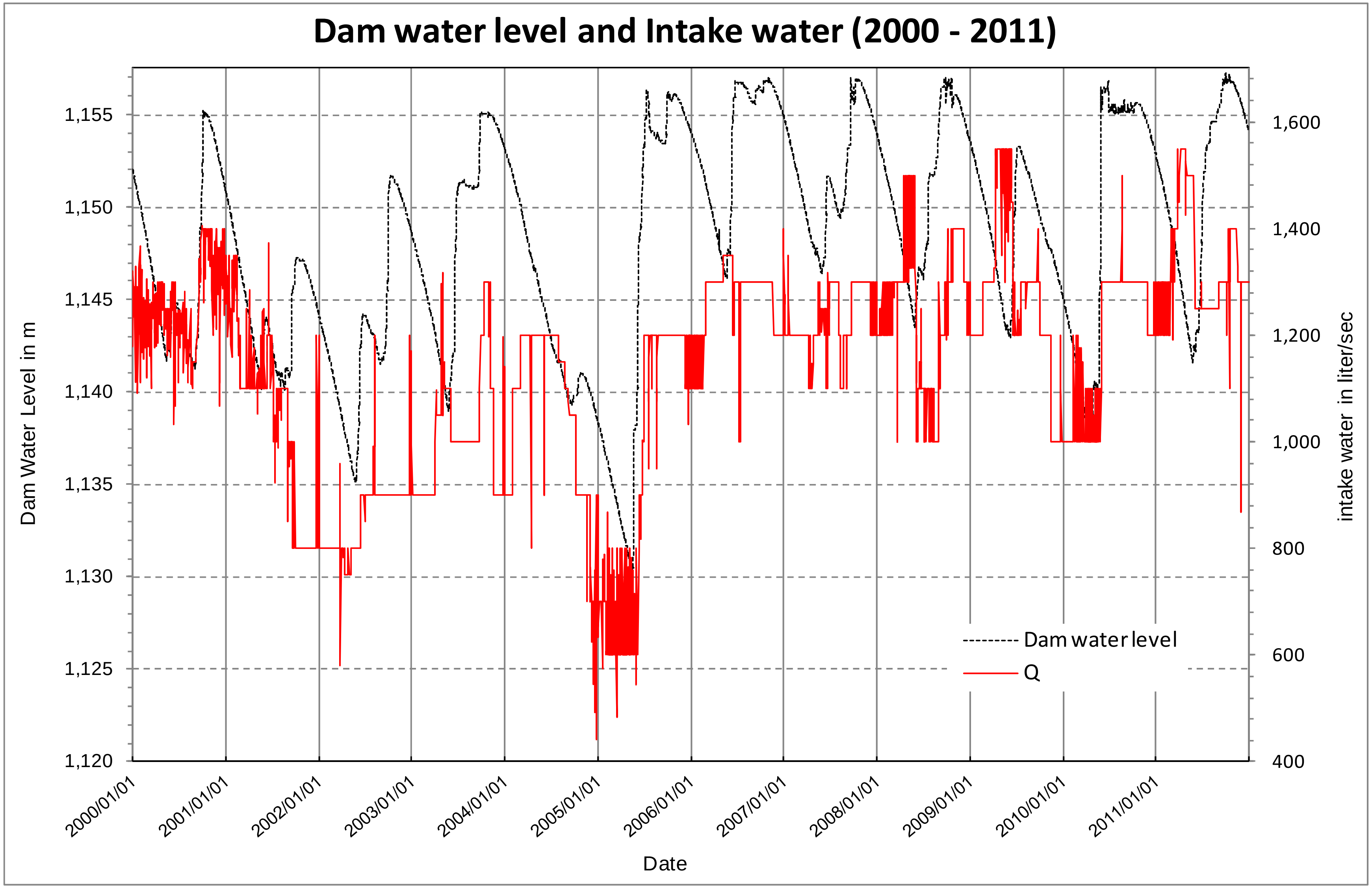


Fig. 2-2-3   Daily Water Level and Intake Flow at Concepcion Dam (2000 - 2011)

2) Determining Maximum Discharge for Power Generation

Since the water level at the dam was raised, water intake flow was increased and has been stable. To maximize power generation, the maximum discharge for power generation (Qpmax) was determined at the maximum intake flow, 1,500 liter/sec. Consequently, the minimum discharge for power generation (Qpmin) would be around 0.4 Qpmax, that is 600 liter/sec. As the duration curve in the figure below shows, the intake flow above 800 liter/sec is guaranteed.

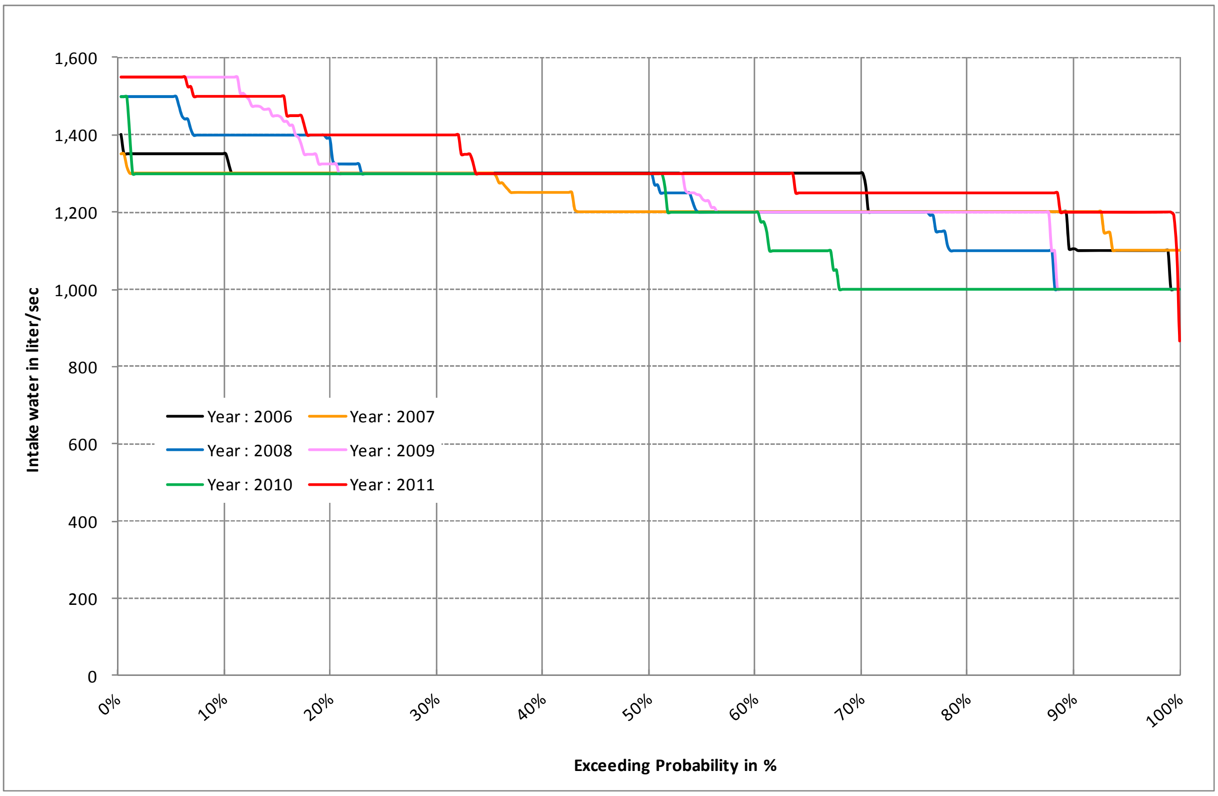


Fig. 2-2-4 Yearly Duration Curves of Intake Flow from Concepcion Dam (2006 - 2011)

3) Necessity of New Pipeline of Ductile Cast Iron

The length of the underground steel pipes between the Concepcion Dam and the aerator is approximately 6.3 km, with the upper segment of an internal diameter of 1,100 mm being 3.7 km long, and the lower segment of an internal diameter of 900 mm being 2.6 km long. When the water head on the upstream side of the aerator was measured, the discharge was at the maximum 1,500 liter/sec, and there was almost no residual water head. For the Project, installation of a new pipeline was planned: ductile cast iron pipes of an internal diameter of 700 mm will be laid underground over a 2,973 m length along the road, bifurcated at a point approximately 180 m upstream of the junction into a 1,100 mm diameter segment and a 900 mm diameter segment, and united again with the existing pipeline on the upstream side of the powerhouse. (See Section 2-2-2 (3) Concepcion Site - Considerations for Optimum Diameter of Ductile Pipeline.)

4) Calculation of Effective Water Head

The effective water head at the Concepcion powerhouse will be largely variable due to the changes in water level at the dam and in friction loss subject to the change in discharge. When the water level at the dam is low, increasing the discharge will decrease the effective water head. In such case, power generation can become unavailable, and further, booster pumps may have to be operated just to send water to the treatment plant.

For the case where a new pipeline of 700 mm diameter ductile cast iron pipes is installed, friction loss of the water head was calculated using the Hazen-Williams formula, which is summarized in the table below. At the maximum discharge, the friction loss is 22.27 m. The gross head when the water level at the dam is highest is 42.06 m, which leaves an effective head of He=19.79m. The velocity coefficient C=90 was used for the existing steel pipeline, and C=110 for newly installed ductile cast iron pipes[2].

Table 2-2-3 Friction Loss Head at Pipelines and Effective Head (New pipeline diameter of ϕ700 mm)

Discharge (m^3/sec)	Friction Loss Head (m)	Effective Head for Highest Water Level at Dam (m)
0.0	0.00	42.06
0.2	0.65	41.41
0.4	2.01	40.05
0.6	4.09	37.97
0.8	6.88	35.18
1.0	10.38	31.68
1.1	12.40	29.66
1.2	14.60	27.46
1.3	16.98	25.08
1.4	19.53	22.53
1.5	22.27	19.79

5) Generation Planning

For the Concepcion Site, the Project is planned to install new pipeline of a 700 mm internal diameter, bifurcating from the existing pipeline and running parallel for about 3 km. The water for power generation will flow in both the existing and newly-installed pipelines, to reduce the friction loss, thus increasing the effective head, and to increase the amount of power generation. The power to be generated is determined by the effective head and the power discharge. The rated output for the highest dam water level will be attained when the discharge is 1.2 m^3/sec, and the effective head 27.46 m. Assuming a turbine efficiency of

2 Velocity coefficient C represents the roughness of the internal surfaces of the pipes. For the existing pipeline, C was calculated with the water head measurement results; for the new ductile cast iron pipes, a design value of C=110 was used. (Source: Guideline for Design of Water-related Facilities)

0.845, the rated output[3] is calculated to be 273 kW[2]. Major parameters of power generation are summarized in the table below.

Table 2-2-4 Major Parameters of Power Generation for Concepcion Site

Description		values	remarks
Range of Power Discharge	Qp	0.60 ~ 1.50 m^3/sec	Qpmin =0.4 Qpmax
Maximum Power Discharge	Qpmax	1.5 m^3/sec	
Highest Dam Water Level	Hmax	1,157.28 m	
Tailrace Water Level	TWL	1,115.22 m	
Maximum Gross Head	Hg	42.06 m	= Hmax - TWL
Discharge for Rated Output	Qp	1.2 m^3/sec	
Friction Loss for Rated Output	Hloss	14.60 m	Calculated by Hazen-William formula Velocity coefficient for New Ductile Cast Iron Pipes C=110, existing steel pie C=90
Effective Head for Rated Output	He	27.46 m	
Rated Output	Pt	273 kW	Turbine efficiency: ηt＝0.845
Plant Output (Installed Capacity)	P	250 kW	80% of generator for output (314 kW)

The longitudinal profile of waterways and the plan view of the Concepcion Power Station are shown in the figure below.

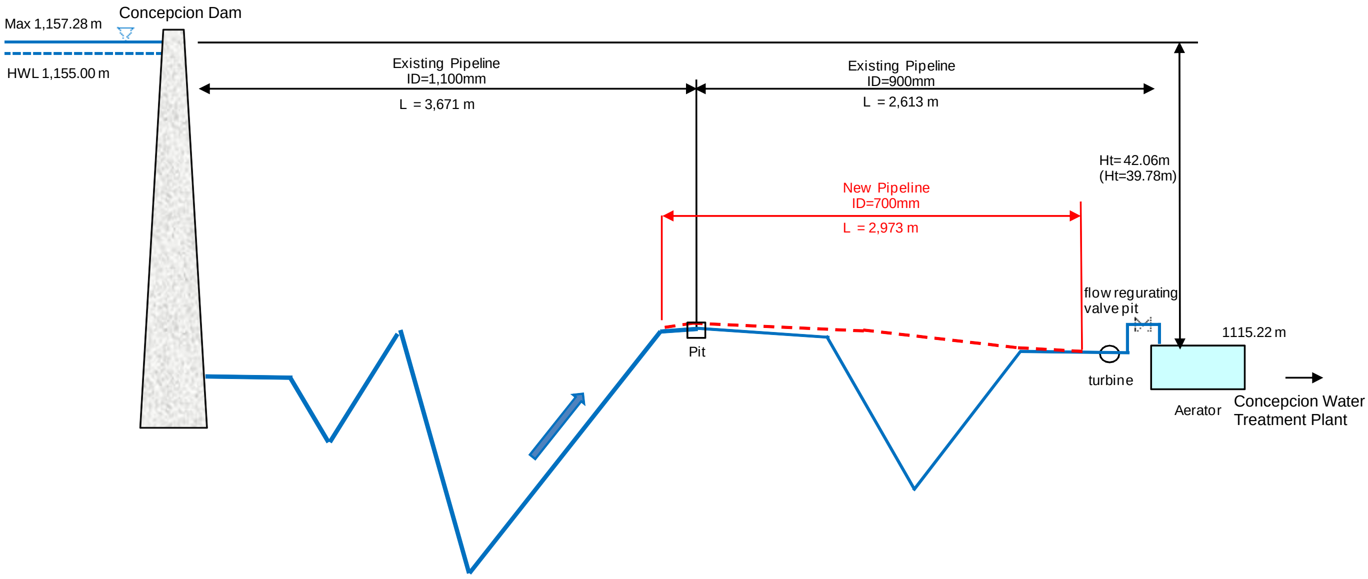


Fig. 2-2-5 Outline Layout of Concepcion Hydroelectric Power Plant

3 Pt=9.8 ηtQp He, where Pt: rated output in kW, ηt: turbine efficiency, Qp: power discharge for rated output m^3/sec, He: effective head (m).

6) Estimated Annual Generated Energy

The annual generated energy[4] is calculated using the daily discharge, daily dam water level, friction loss and effective head. When the effective head is less than 10 m, or when the discharge is less than 0.6 m^3/sec, power generation is considered unavailable and the generated energy is nil. The overall efficiency of the turbine and generator used in calculation was 0.8. As shown in the table below, the average annual generated energy for 2000 to 2011 was 1.495 GWh, while that for year 2006 to 2011 was 1.650 GWh. The plant factors (PF) for the average annual generated energy were 43.9% and 48.4%, respectively. Figure 2-2-6 shows the annual generated energy for each year and Fig. 2-2-7 the monthly generated energy for a year.

Table 2-2-5 Estimated Annual Generated Energy and Plant Factor of Concepcion Power Plant

Period of Data for Calculation		Average Annual Generated Energy	Maximum Annual Generated Energy	Minimum Annual Generated Energy
2006 - 2011	GWh	1.650	1.910	1.349
	PF	48.4%	56.0%	39.6%
2000 - 2011	GWh	1.495	1.910	1.201
	PF	43.9%	56.0%	35.2%

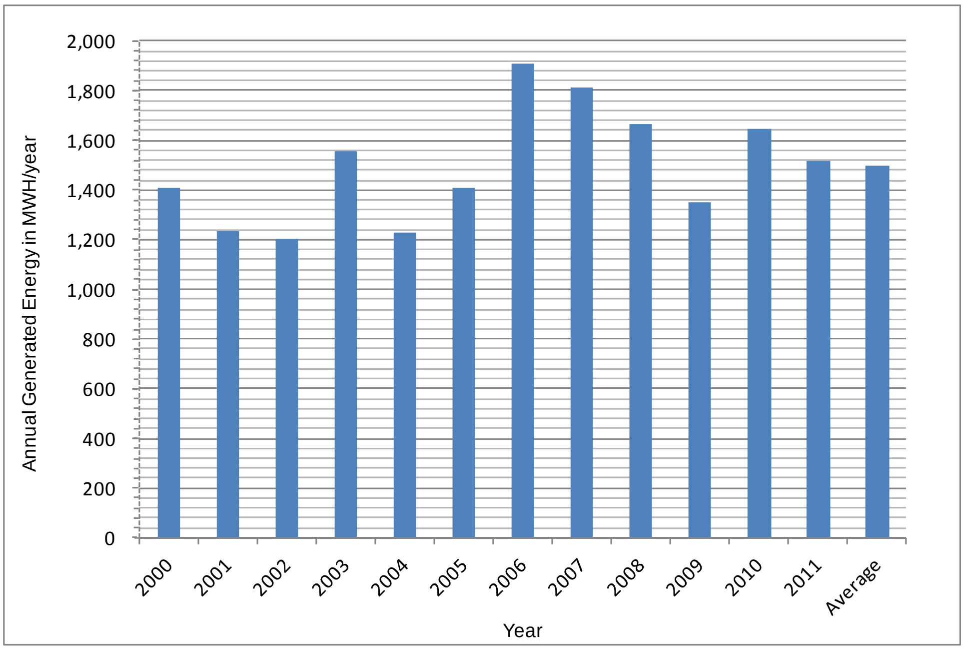


Fig. 2-2-6 Estimated Annual Generated Energy of Concepcion Power Plant

4 $E = \sum_{i=1}^{365} 24 \times Pi = \sum_{i=1}^{365} 24 \times 9.8 \times \eta \times Qi \times Hei$, where, E: annual generated energy (kWh), Pi: daily average power output (kW), Qi: daily power discharge (m^3/sec), Hei = daily effective head (m)

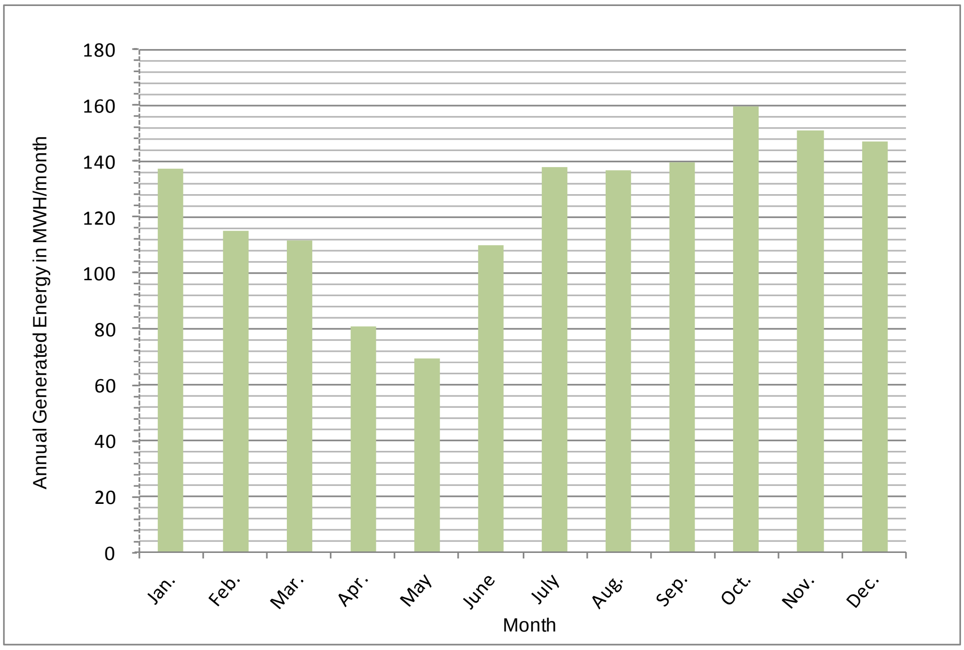


Fig. 2-2-7 Estimated Monthly Generated Energy of Concepcion Power Plant

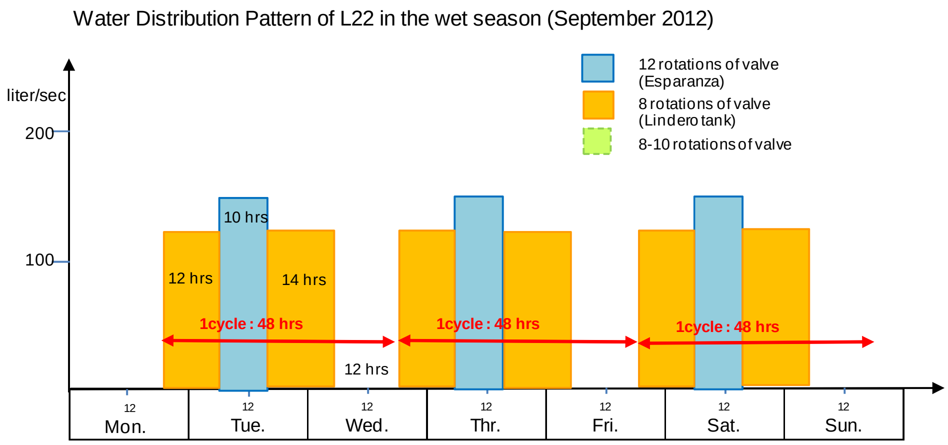
(2) Generation Capacity for Picacho Site

At the Picacho Site, the generation plan is to place a hydraulic turbine parallel to the water pressure reducing valve located on the L22 pipeline of an internal diameter of 400 mm, which is one of nine (9) pipelines belonging to the Picacho Treatment Plant. The water head on the downstream side of the pressure reducing valve needs to be 90 m in the basic plan, therefore the gross head should be 91.44 m. The pipeline in question is made of ductile cast iron pipes and located between the manifold at the treatment plant and the power generation point, approximately 330m long, which is not that long, and its internal diameter is large at 400 mm. Therefore, the friction loss is not predominant in the effective head, and the variation in the effective head will be small.

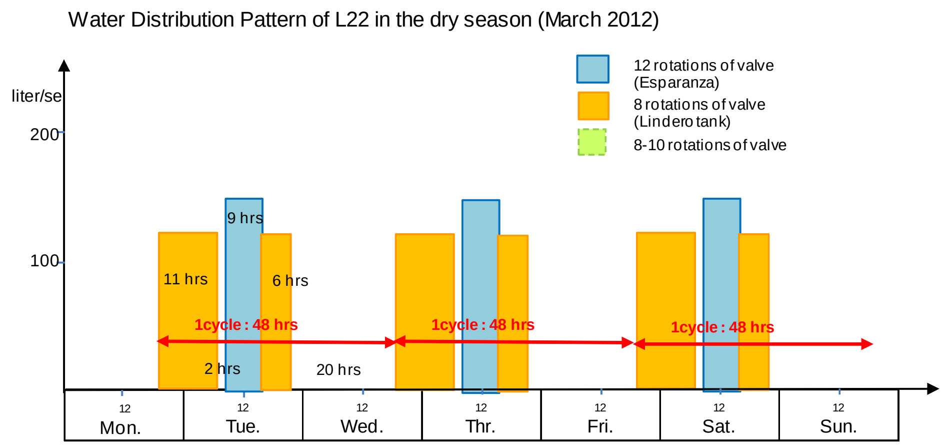
There were no records of discharge of the L22 pipeline available. Therefore, the generation capacity was considered and determined on the basis of the discharge measured in the survey and the design maximum distributino discharge, 225.54 liter/sec. The actual discharge of L22 is smaller than that, around 120 ~150 liter/sec. However, L22 has the largest diameter among nine pipelines belonging to the Picacho Treatment Plant, and its servicing area is also large, which points to the possibility that discharge may increase in the future. It was judged that the generation plan should allow the use of this design maximum discharge of L22 for power generation.

1) Discharge of L22 Pipeline and Water Treatment Rate of Picacho Plant

There was no daily flow data available for the L22 pipeline (internal diameter of 400 mm) of the Picacho Water Treatment Plant. Therefore, discharge was measured in the site survey. In usual operations for water distribution at the plant, discharges are controlled by the opening of valves at the manifolds of the plant. There are two (2) usual patterns of distribution: to supply the Lindero distribution pond and to supply the Esperanza residential area (without the distribution pond). The measurement using an ultrasonic flow velocity meter showed discharges of 120 liter/sec and 150 liter/sec, respectively. According to the operation manager of SANAA, water supply hours are changed for years and for seasons. However, the distribution pattern of this year shown in the figure below reveals that the valves are closed and no supply is provided 30% of the time in the rainy season, and 55% in the dry season.



Typical Water Distribution Pattern in L22 for Rainy Season



Typical Water Distribution Pattern in L22 for Dry Season

Fig. 2-2-8 Typical Water Distribution Pattern and Discharge in L22 Pipeline

The source of raw water of the Picacho Water Treatment Plant comes from mountain streams. As shown in the figure below, water intake flow varies greatly: 200 to 300 liter/sec in the dry season and 800 to 900 liter/sec in the rainy season. Water treatment capacity of the Picacho Plant was augmented in 2010 from 900 liter/sec to 1,100 liter/sec. However, the intake flow depends on the flow in the stream and low flow in the dry season affects the intake and treatment water rates.

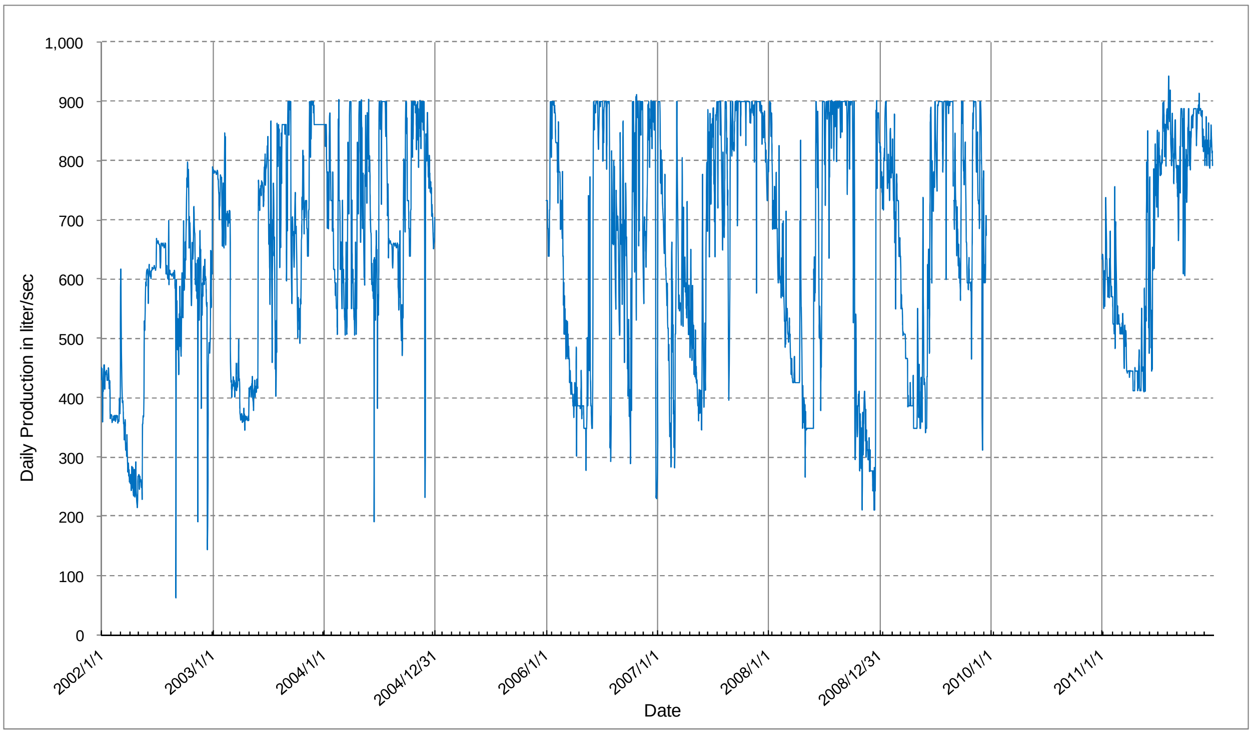


Fig. 2-2-9 Daily Average Water Production Rate at Picacho Plant (2002 - 2011)

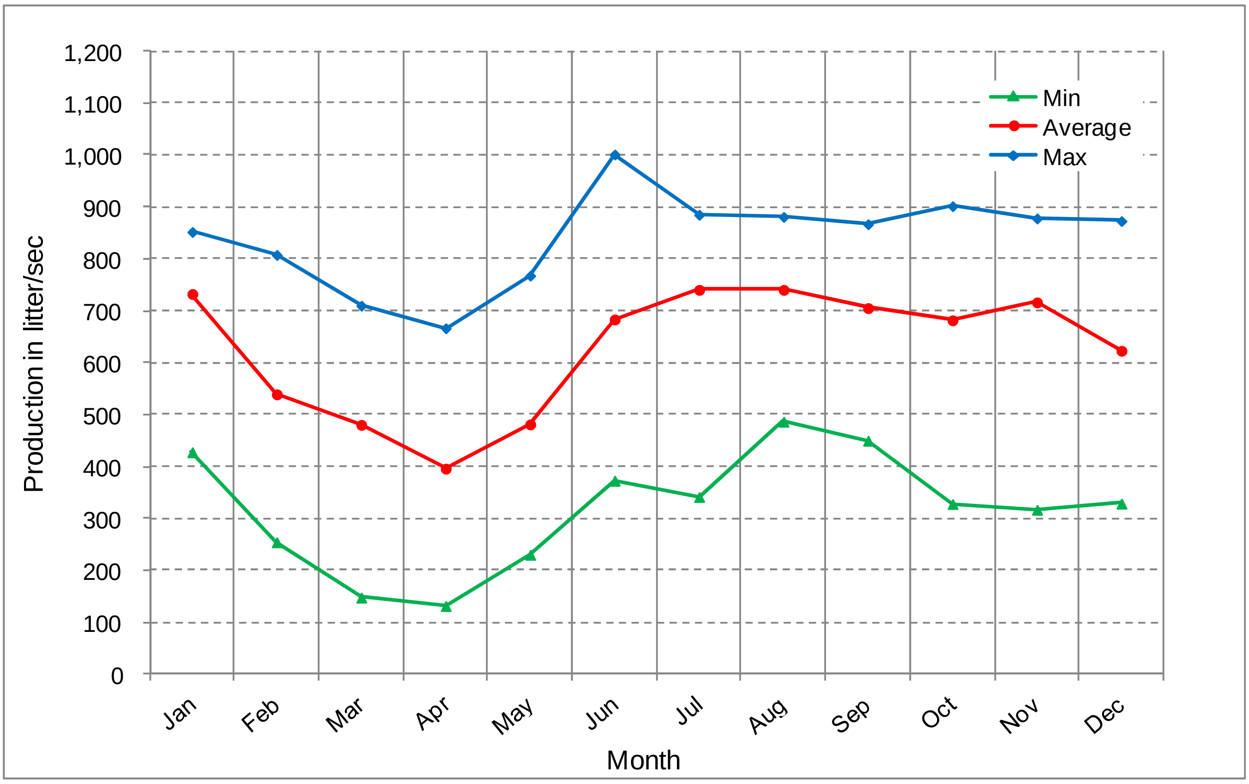


Fig. 2-2-10 Monthly Average, Maximum and Minimum Production Rate of Treated Water at Picacho Plant (2002 - 2011)

2) Residual Water Head at Pressure Reducing Valve

According to documents on the construction stage of the Emergency Water Supply Grant Program, the residual water head on the downstream side of the pressure reducing valve was designed to be 90 m. Therefore, the gross head available for power generation of this Project was calculated to be 91.44 m (water level of the Picacho Plant, 181.44 m, deducted by 90 m).

3) Maximum Discharge for Power Generation

The current maximum water distribution rate was found to be approximately 150 liter/sec, according to measurements done in the site survey.

The L22 pipeline qualified for the project under the Emergency Water Supply Grant Program, therefore the new installation and refurbishment of pipes were done with pipes of an internal diameter of 150 to 400 mm for a length of 15 km. The basic plan of the project determined the maximum discharge of the pipeline to be 225.54 liter/sec. Therefore, the maximum discharge for power generation (Qpmax) should be 250 liter/sec. Since the smallest of the standard Francis type hydraulic turbine lineup found on the market is 300 liter/sec, it was judged economical to use such standard model for the Project. (Table 2-2-8 compares the maximum discharge for power generation.)

4) Necessity of Installation of New Waterway

Assuming the design maximum discharge of 225 liter/sec runs in the existing 400 mm diameter ductile cast iron pipes, the friction loss was calculated to be 2.49 m (using the Hazen-Williams formula with a velocity coefficient of C=110)[5], which is small and only 3% of the gross water head. Therefore, installing a new pipeline would not be effective towards increasing the effective head and resulting generated energy. The figure below shows the friction loss for each level of discharge.

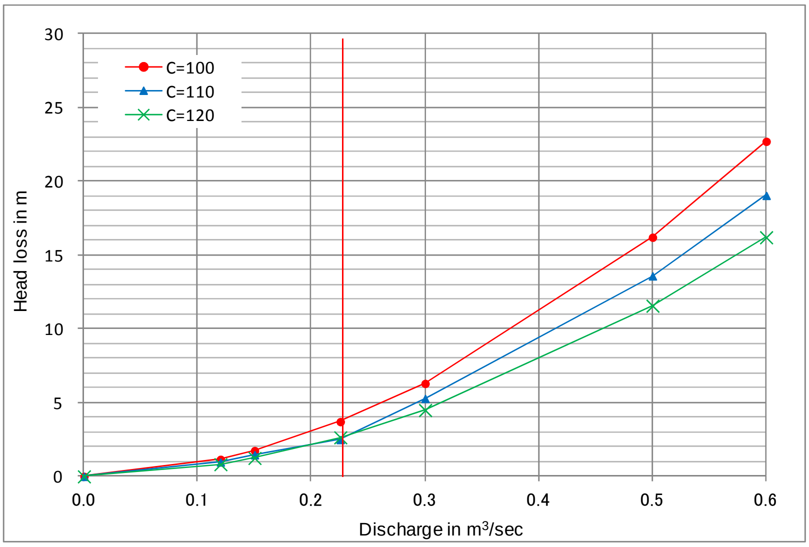


Fig. 2-2-11 Friction Loss Head for Range of Discharge at Different Velocity Coefficients

5 The value of C depends on the roughness of the internal surface of the pipes, bends and bifurcations of the pipeline and their numbers. The design value of C=100 was determined for the newly installed pipes with losses at bends. (Source: Guidelines for Design of Water-related Facilities)

6) Effective Head

Table 2-2-6 Friction Loss Head of Waterway and Effective Head

Discharge (m^3/sec)	Friction Loss Head (m)	Effective Head (m)
0.000	0.00	91.44
0.120	0.97	90.47
0.150	1.46	89.98
0.225	2.49	88.95
0.300	5.28	86.16

The pipeline between the water treatment plant and the pressure reducing valve is 327 m in length and made of ductile cast iron pipes of an internal diameter of 400 mm. The difference in elevations of the water treatment plant and the pressure reducing valve is 181.44 m. The gross head for power generation is calculated by this elevation difference deducted for the required necessary head of 90 m on the downstream side of the hydraulic turbine, that being 91.4 m. Using the Hazen-Williams formula with an assumed velocity coefficient of C=110 [5], the friction loss head was calculated. The results are shown in the Table 2-2-6. For the maximum discharge for power generation of 300 liter/sec, the friction loss head will be 5.28 m. The effective head (He) will be 86.16 m, deducting the friction loss head from the gross head of 91.44 m.

7) Generation Planning

For the maximum discharge for power generation of 300 liter/sec, the effective head will be 86.16 m. Assuming a hydraulic efficiency of 0.806, the rated output (Pt) is calculated to be 204 kW. Chief parameters of power generation are summarized in the table below. Fig. 2-2-12 shows the longitudinal profile of waterways of the Picacho Power Station

Table 2-2-7 Parameters of Power Generation for Picacho Site

Description		Values	Remarks
Range of Power Discharge	Qp	0.12 ~ 0.30 m^3/sec	Qpmin =0.4 Qpmax
Maximum Power Discharge	Qpmax	0.300 m^3/sec	
Highest Water Level	Hmax	1,301.44 m	
Tailrace Water Level	TWL	1,210.00 m	
Gross Head for Rated Output	Hg	91.44 m	=Hmax - TWL
Discharge for Rated Output	Qp	0.30 m^3/sec	
Friction Loss for Rated Output	Hloss	5.28 m	Calculated by Hazen-William formula Velocity coefficient for New Ductile Cast Iron Pipes C=110
Effective Head	He	86.16 m	
Rated Output	Pt	204 kW	turbine efficiency: ηt=0.806

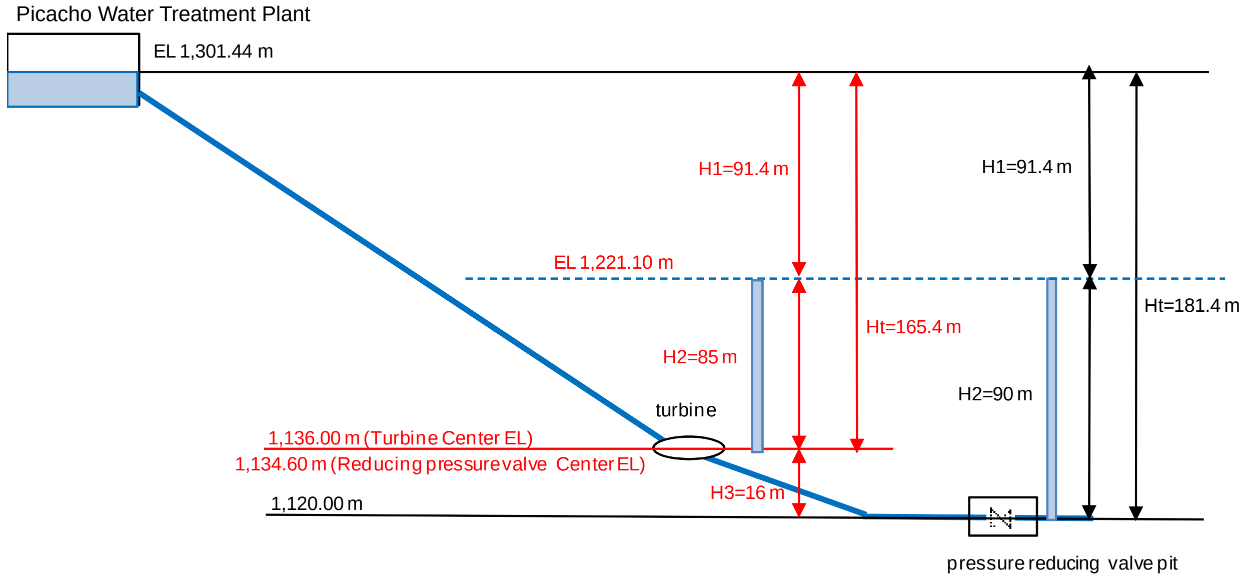


Fig. 2-2-12 Longitudinal Profile of Picacho Hydroelectric Power Plant

7) Estimated Annual Generated Energy

With the discharges measured in the site survey (120 liter/sec and 150 liter/sec) and actual operation information on water distribution provided by SANAA (water is distributed for 75% of the time in the rainy season, 54% in the dry season[6]), the annual generated energy was estimated to be 0.52 GWh. If the maximum discharge of 225 liter/sec was distributed for 60% of the time in the rainy season and 80% in the dry season, the estimated annual generated energy would increase to 0.95 GWh.

6 In the rainy season, the typical distribution pattern is to supply at 120 liter/sec for 26 hours over a 48 hour period and at 150 liter/sec for 10 hours over a 48 hour period (75% total).
In the dry season, the typical distribution pattern is to supply at 120 liter/sec for 17 hours over a 48 hour period and at 150 liter/sec for 9 hours over a 48 hour period (75% total).

Table 2-2-8 Maximum Discharge for Power Generation and Generation Planning for Picacho Power Station

Max. power discharge Max. power output	Discharge Distribution	Generated Energy	Turbine Price	Others (Total Cost, Future Expansion)	Evaluation
150 liter/sec Pt = 106 kW	In the measured flow range of 120 ~ 150 liter/sec, all water flows through the turbine; at more than 150 liter/sec, all water flows through the bypass valve and the hydropower plant does not generate electricity.	The hydropower plant generates electricity up to 150 liter/sec at a maximum and until 60 liter/sec (40% of Qmax) at a minimum. The reduction in generated energy is the largest when distribution water increases. ×	The turbine is order-made. Additional costs are added for design, testing, etc., so the price is relatively expensive. △	The pipe arrangement around the turbine, valves and generator are smaller in size, but facilities except for the above are the same scale. No additional piping is required, so the overall facility cost is not very different. In case the flow increases and expansion is required, the generator and control system will need upgrading, so the cost is relatively expensive. △	△
200 liter/sec Pt = 140kW	In the measured flow range of 120 ~ 150 liter/sec, all water flows through the turbine; at more than 200 liter/sec, all water flows through the bypass valve and the hydropower plant does not generate electricity.	The hydropower plant can generate electricity up to 200 liter/sec at a maximum and until 80 liter/sec (40% of Qmax) at a minimum. The amount of generated energy is reduced if distribution water increases. △	Same as above △	Same as above △	△
250 liter/sec Pt = 175kW	At the maximum distribution of 225.4 liter/sec, water flows through the turbine and the hydropower plant generates electricity.	The hydropower plant can generate electricity up to 250 liter/sec at a maximum and until 100 liter/sec (40% of Qmax) at a minimum. ○	Same as above △	No additional pipeline or facilities are required. Expansion is not necessary. ○	○
300 liter/sec Pt = 204kW	Same as above	The hydropower plant can generate electricity up to 300 liter/sec at a maximum and until 120 liter/sec (40% of Qmax) at a minimum. ○	The turbine is of standard type, so the cost is not expensive. ○	Same as above ○	◎

(3) Concepcion Site - Considerations for Optimum Diameter of Ductile Cast Iron Pipes

The existing pipeline between the Concepcion Dam and the aerator is made of steel pipes of an internal diameter of 1,100 mm for the upper segment of 3.67 km in length, and an internal diameter of 900 mm for the lower segment of 2.61 km long. It has been more than 20 years since the construction of the pipeline, and its total length is very long, more than 6 km. Therefore, the friction loss of this pipeline is rather large. In order to increase power generation, a new pipeline made of ductile cast iron pipes is planned to be constructed, which help reduce head loss in the waterway.

The results of analyses on the length and the optimum diameter for new pipeline are summarized below. The economic efficiency of this new pipeline was confirmed to be sufficient, by comparing the incremental income from power sales due to, and the cost to be incurred in, the construction of the new pipeline.

1) Length of New Pipeline

The length of new pipeline to be constructed was determined to effectively reduce head loss in the existing pipeline, as per the considerations shown below.

For the upper and lower segments of the existing pipeline, the friction losses were calculated using the Hazen-Williams formula. The results are shown in the table below. It is obvious in the table that the friction loss in the lower segment with an internal diameter of 900 mm makes up 65% of the total loss, although the length of the segment is approximately 1,000 m shorter than the upper segment. The head loss per unit length is three times larger in the lower segment than in the upper segment. Therefore, the new pipeline should be constructed parallel to the lower segment, which has a diameter of 900 mm. The bifurcation point should be determined in consideration of the topography and land use of the surrounding area, and the underground depth, to be investigated in the site survey. (See Section 2-2-2.2 (2) a))

Table 2-2-9 Friction Head Loss of Existing Steel Pipes

Discharge m^3/sec	Friction Head Loss (m)			
	Upper Segment: D=1,100 mm		Lower Segment: D=900 mm	
	L=3,671m		L=2,613 m	
	Over Total Length	Per 100 m	Over Total Length	Per 100 m
0.200	0.30	0.008	0.57	0.022
0.400	1.10	0.030	2.07	0.079
0.600	2.32	0.063	4.39	0.168
0.800	3.95	0.108	7.47	0.286
1.000	5.97	0.163	11.29	0.432
1.200	8.36	0.228	15.82	0.605
1.300	9.70	0.264	18.34	0.702
1.500	12.64	0.344	23.90	0.915

(The Velocity Coefficient is assumed to be C=90 for existing steel pipes.)

2) Estimation of Head Loss and Flow Velocity Coefficient of Existing Buried Steel Pipes

During a data collection survey in November 2011 and the first field investigation in August 2012, water pressure was measured in the existing pipeline at the Conception Site. In November 2011, water pressure was measured only at the aerator and in August 2012 at a total of four (4) locations including the aerator, with various flows.

Friction head loss was calculated by using the Hazan-Williams formula with various coefficients of flow velocity (C = 90, 100 and 110), as it shows the roughness of the inner pipe surface, loss of bending portions, etc. These values were compared to measured values as shown in Fig. 2-2-13.

As a result, the calculated value using C=90 matched measured value well. This value is in the range of 80 ~ 100, applied to old steel pipes, so it is judged to be an appropriate estimated value. On the other hand, the C value of new ductile cast-iron pipes is 110 (reference: Water Supply Facilities Design Guidelines).

Hazan-Williams formula

$$H\,f = 10.666 \times L \times Q^{1.85} / (C^{1.85} \times d^{4.87})$$

Where, H f : friction loss head (m)
L : Length of pipeline (m)
Q : Flow (m^3/sec)
D : Inner diameter (m)
C : Flow velocity coefficient

Kind of pipe	C value
New ductile cast-iron pipe	130
Old ductile cast-iron pipe	100
New steel pipe	120-130
Old steel pipe	80-100

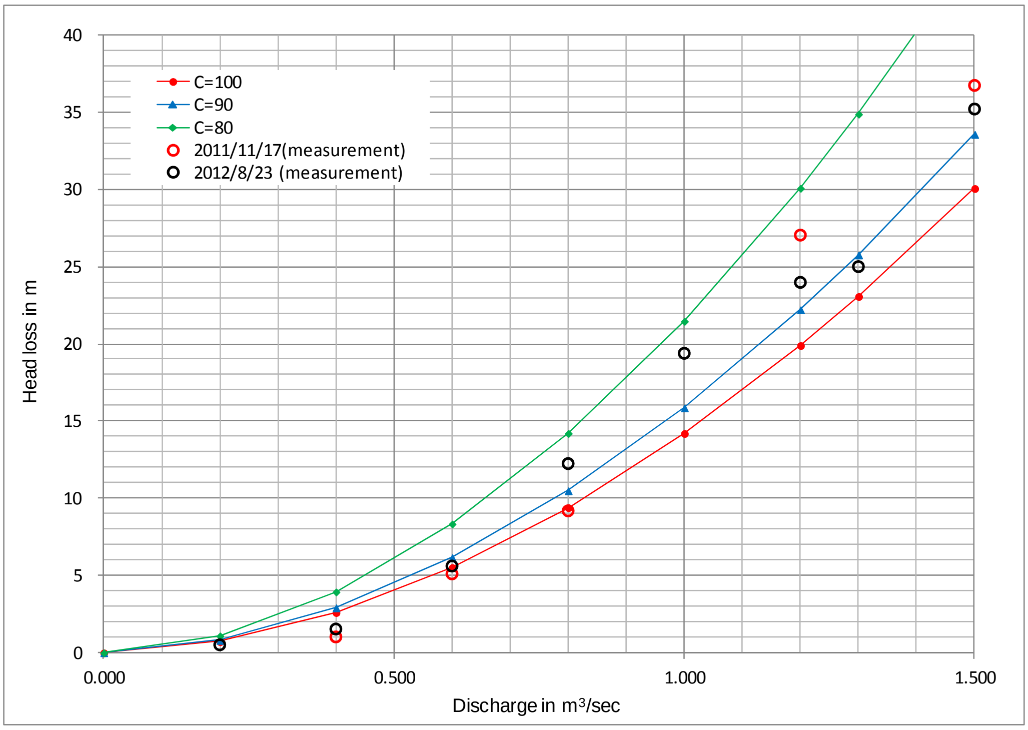


Fig. 2-2-13 Comparison between Measured Value and Calculated Value of Loss Head (Just before aerator)

2) Study on the Optimum Diameter of New Ductile Cast-Iron Pipes

To identify the optimum diameter of new pipeline, an economic comparison was conducted of ductile cast-iron pipes of 500 mm, 600 mm, 700 mm and 800 mm in inner diameter. The unit pipe material cost for each pipe is the lowest price of cost estimates and the pipe installation cost is roughly estimated. The total length of new pipeline is 2,973 m.

Table 2-2-10 Pipe Material and Installation Costs for New Pipes of Each Diameter

	Unit	500 mm	600 mm	700 mm	800 mm
Unit cost of pipe material per m	US$/m	289	399	497	627
Pipe material cost (Total length)	Million JPY	68.8	94.9	118.2	149.2
Pipe installation cost (Total length)	Million JPY	41.5	43.0	44.5	46.1
Total	Million JPY	110.2	137.9	162.8	195.3

Note : 1US$ = 80 JPY

The total head loss of the entire pipeline was calculated by using the Hazen-Williams formula. The C value of existing steel pipeline is 90 based on measured values and that of new pipeline is 110 based on the design value (refer to the Water Supply Facilities Design Guidelines). The turbine-generator combined efficiency is assumed to be 0.8. If the effective head is less than 10 m or power discharge is less than 0.6 m^3/sec (= 0.4 Qpmax = 0.4 × 1.5 m^3/sec), the power plant cannot generate electricity. Daily dam water level and intake water flow were used to calculate the generated energy. The annual average generated energy and its increment (minus generated energy without a new pipeline) for each diameter is given in the following table and the annual generated energy for each diameter of new pipeline is shown in Fig. 2-2-14 to Fig. 2-2-18. A comparison of average generated energy for each diameter is shown in Fig. 2-2-19. In 2006, tumble gates were installed at the Concepcion reservoir dam and water treatment capacity increased to 1,500 liter/sec, therefore dam water level has become higher and intake water has also increased, and, in this connection, the generated energy has increased.

Table 2-2-11 Estimated Annual Generated Energy for New Pipes of Each Diameter

MWh/year

Item	Period of data	Without New Pipe	500 mm	600 mm	700 mm	800 mm
Annual generating energy (MWh/year)	2006 - 2011 average	653	1,268	1,472	1,650	1,802
	2000 - 2011 average	602	1,136	1,342	1,495	1,616
Increment of annual generating energy (MWh/year)	2006 - 2011 average		615	819	997	1,149
	2000 - 2011 average		534	740	893	1,014

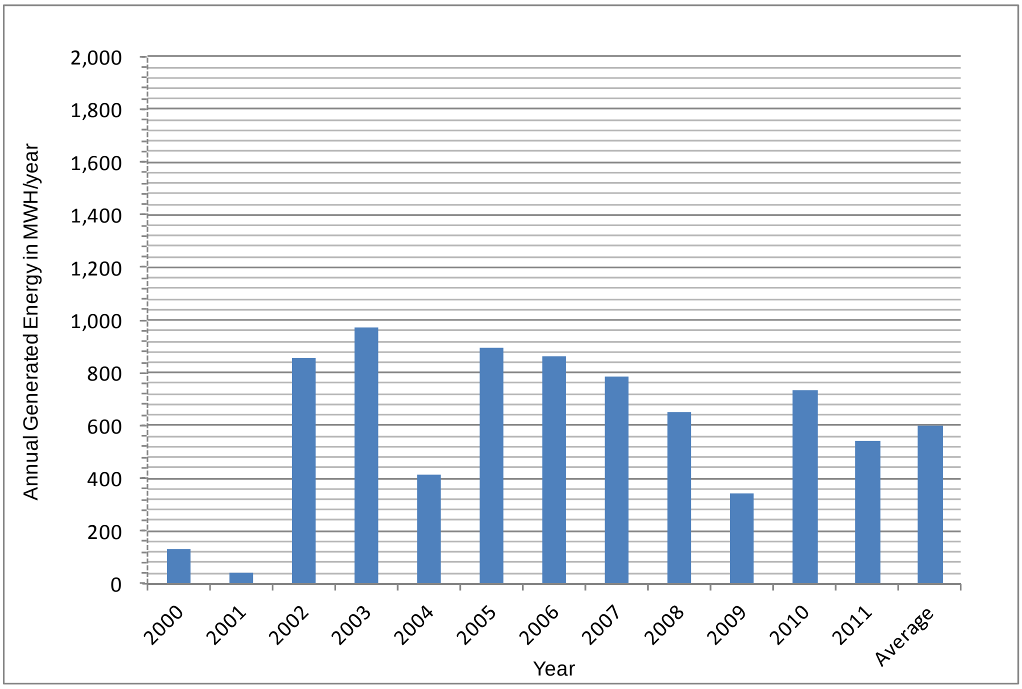


Fig. 2-2-14 Calculation Result of Annual Generated Energy (Without New Pipe)

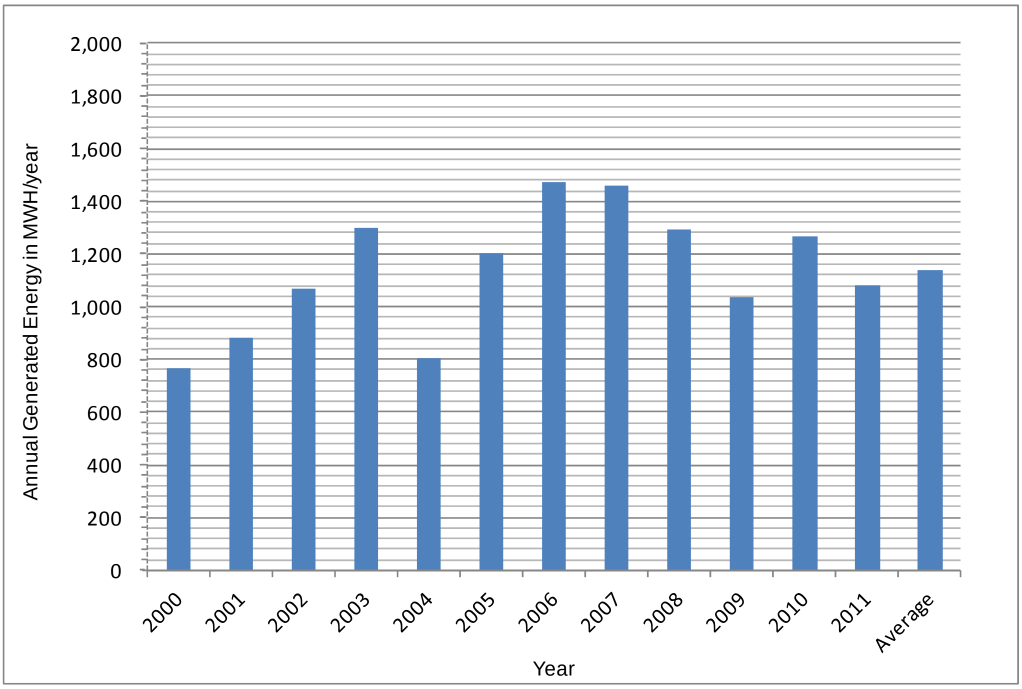


Fig. 2-2-15 Calculation Result of Annual Generated Energy (ID 500 mm New Pipe)

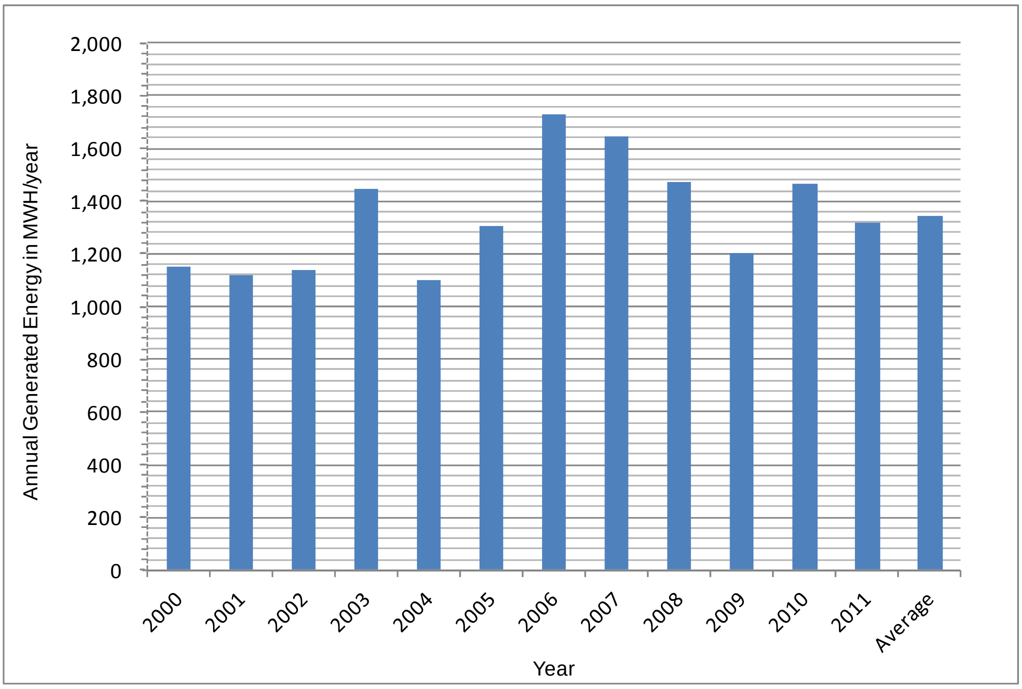


Fig. 2-2-16 Calculation Result of Annual Generated Energy (ID 600 mm New Pipe)

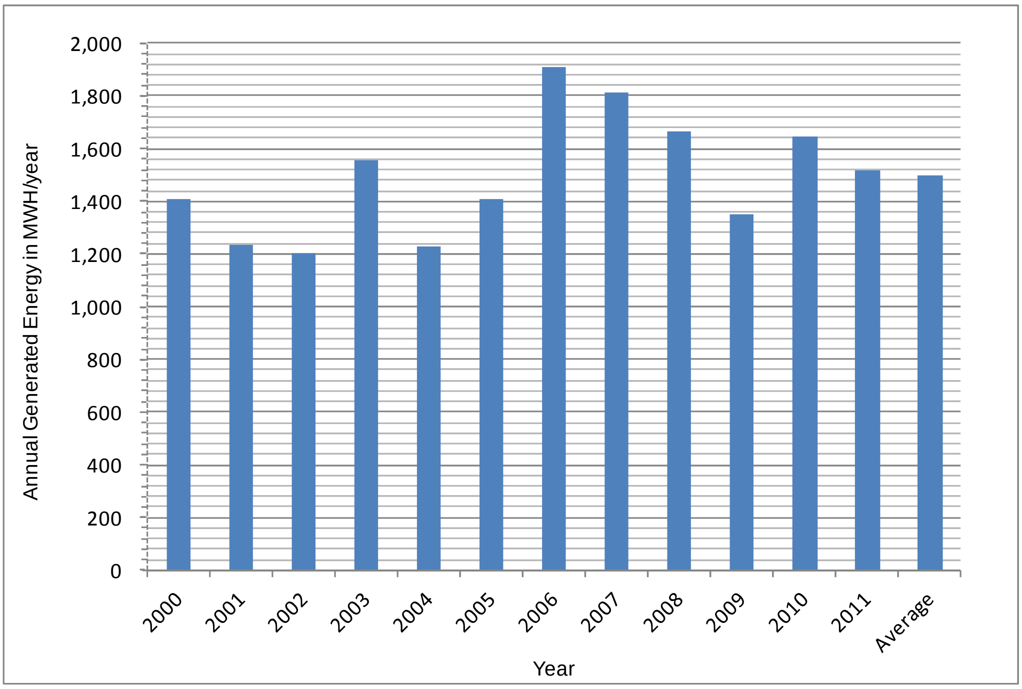


Fig. 2-2-17 Calculation Result of Annual Generated Energy (ID 700 mm New Pipe)

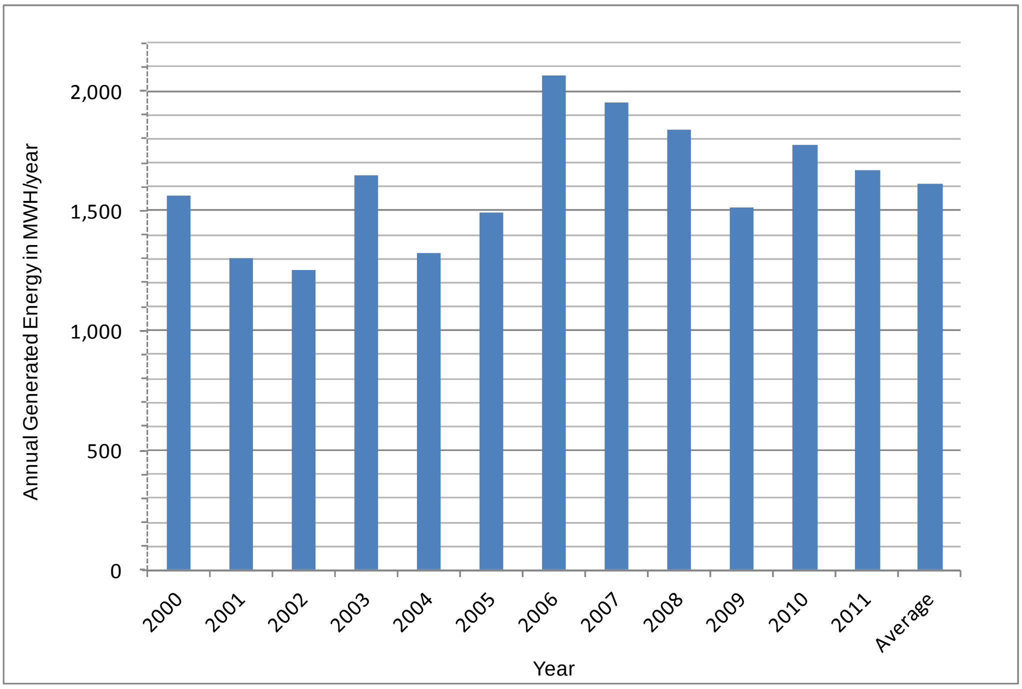


Fig. 2-2-18 Calculation Result of Annual Generated Energy (ID 800 mm New Pipe)

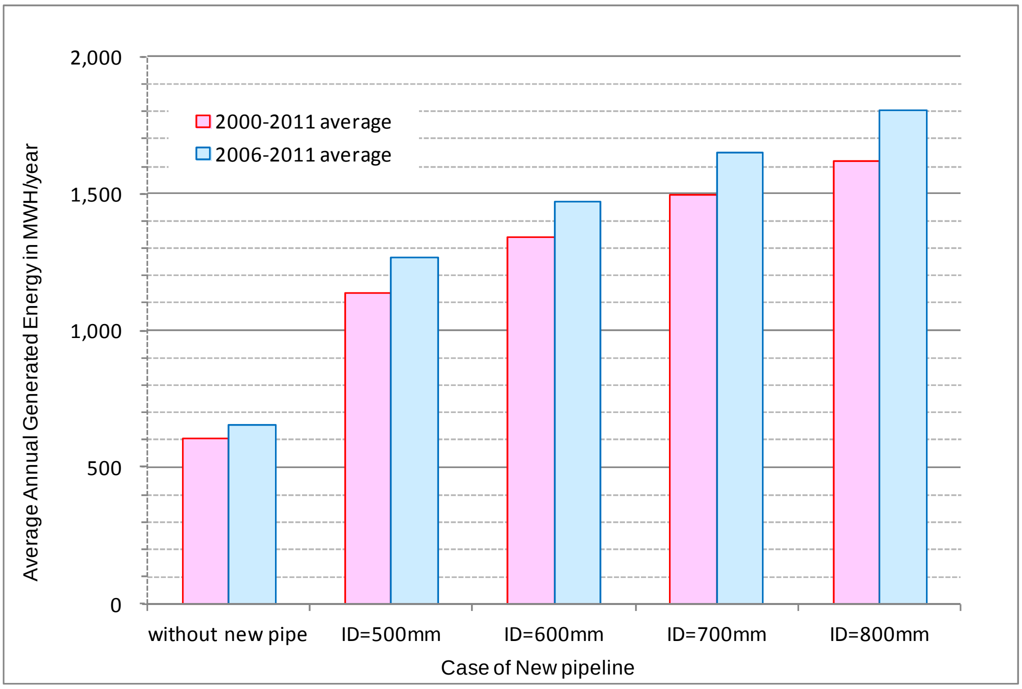


Fig. 2-2-19 Estimated Annual Average Generated Energy for Each Diameter of New Pipe

The economic parameter is a unit construction cost per kWh (increment value) consisting of pipe material and installation costs. As shown in Table 2-2-12 and Fig. 2-2-20, the unit construction cost per kWh of new pipe of 700 mm in inner diameter is the cheapest, so it is judged that installation of new pipe of 700 mm is the most profitable.

For reference, based on the annual equivalent cost (C) supposing the lifetime of ductile cast-iron pipe is 40 years and the annual electricity selling benefit (B) obtained by incrementally generated energy due to new pipe installation, B-C and B/C are calculated. (The electricity selling price is 0.13695 kWh/US$, which was applied to renewable energy in 2011.)

The balance of the annual equivalent cost (C) for a 40 year lifetime and the electricity selling benefit (B) obtained by new ductile pipe of 700 mm in inner diameter is estimated about 6.85 million JPY per year. Therefore, it is judged that new pipe installation is economical.

Table 2-2-12 Economic Indicators Value for Each Pipe Diameter of New Pipe

Economic parameters	Period of data	500 mm	600 mm	700 mm	800 mm
Unit pipe construction cost per kWh (JPY/kWh)	2006 - 2011 average	179	168	163	170
	2000 - 2011 average	206	186	182	186
B-C (Million JPY/year)	2006 - 2011 average	398	552	685	771
	2000 - 2011 average	310	466	571	639
B/C	2006 - 2011 average	2.45	2.60	2.68	2.58
	2000 - 2011 average	1.95	2.12	2.14	2.09

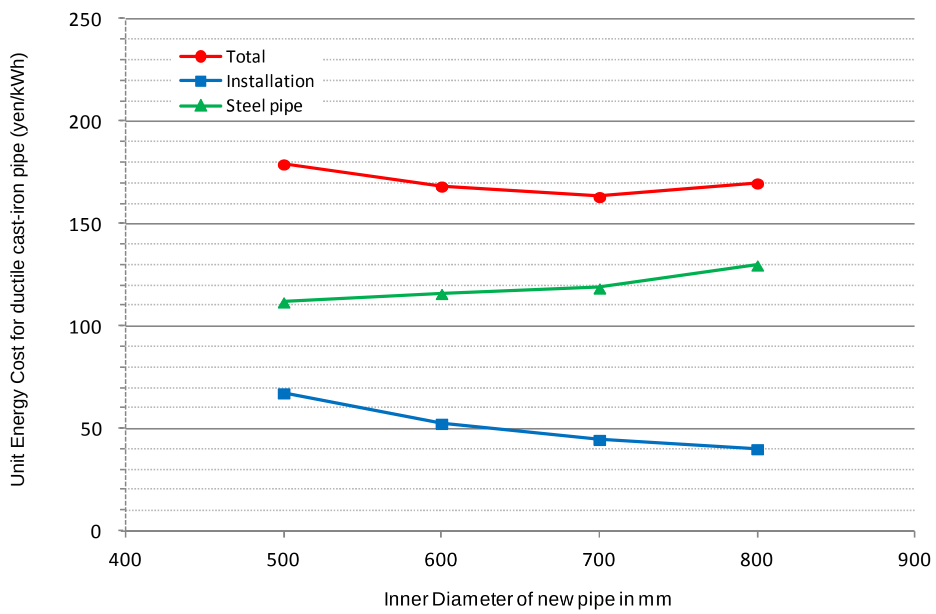


Fig. 2-2-20 Comparison of Unit Construction Cost per kWh for Each Pipe Diameter of New Pipe (2006 - 2011 Average)

2-2-2.2 Facility Plan (Civil Engineering Facilities)

(1) Overall Plan

This Project is to construct small-scale hydroelectric power plants in the existing Concepcion and Picacho Water Treatment Plants in Tegucigalpa City, which are managed by SANAA and sell the electricity generated by those plants by grid interconnection to the nearby ENEE distribution line.

At the Concepcion Site, the powerhouse is to be built just upstream of the existing aerator and generate energy using the residual head between the Concepcion reservoir dam and the power plant. In order to use the unutilized energy more effectively, the installation of the new pipe is planned. The new pipe was divaricated from the existing water conveying steel pipe of a total length of about 6.3 km from the reservoir dam to the aerator, which consists of two (2) zones with pipes of 1,100 mm and 900 mm in inner diameter. New ductile cast-iron pipe of 700 mm in inner diameter is to be installed in the portion of the pipe of 900 mm in inner diameter. The total length of the new pipe is 2,973 m.

On the other hand, at the Picacho Site, the turbine is to be installed parallel to the pressure reducing valve on the L22 system distribution pipeline downstream of the Picacho Water Treatment Plant, and hydroelectric power plant is planned to generate electricity by utilizing the treated water.

From the manifold of the water treatment plant to the planned powerhouse site, ductile cast-iron pipe of an inner diameter of 400 mm runs along a steep slope of about 30˚. The powerhouse site is planned to be positioned in the slope area about 10 m higher than the nearby pressure reducing valve pit located directly below the road.

Civil engineering facilities are designed according to design standards in Honduras. Structural analyses of the powerhouse buildings are done by static analysis method. A design horizontal seismic coefficient of 0.1 at the site, which was obtained based on the national standard, is to be applied and a wind load of 120 kg/m^2 is to be applied to design for wind pressure.

(2) Concepcion Site

1) New Buried Water Pipeline

a) Bifurcation point of the new pipe

From the aspect of head loss, it is effective that the new pipe be installed in the same segment of the existing pipe of 900 mm in inner diameter. Therefore, the upstream bifurcation point is to be selected as the boundary between the existing pipe of 1,100 mm in inner diameter and that of 900 mm. However, the boundary point is in the No. 1 inspection pit (pit opening area is about 1 × 1 m) located about 10 m below the ground surface, therefore it is very difficult to connect the new pipe. Therefore, a site investigation was conducted near the boundary from technical, construction, safety, and economical viewpoints.

Near the boundary, the depth of the existing buried pipe is 10m or more. From construction, safety, and economical viewpoints, further site investigation was conducted around the shallow portion, i.e. about 3m to 4m from the ground surface, where the bifurcation pipe is to be connected. As the result of the investigation, since, in the portion of the pipe of 900 mm in inner diameter (Bifurcation Point 1), the road width is shallow and houses are in close formation, it is very difficult to ensure work space for excavation work as well as safety. On the other hand, since, in the segment of the pipe of 1,100 mm in inner diameter (Bifurcation Point 2), the houses are scarce and allow enough work space, it is easy for construction, thus Bifurcation Point 2 was selected.

On the other hand, the downstream bifurcation point is to be near the proposed powerhouse location just upstream of the aerator. The location was selected so that enough work space is obtained and the excavation depth is less or equal to 3 m. There are no houses or buildings near the bifurcation point and few problems regarding construction matters were found.

Fig. 2-2-21 Upstream Bifurcation Point of New Pipeline Route

Photo 2-2-1 Candidate Sites of Upstream Bifurcation Point

b) New water conveying pipe route

As the plan proposed in the Data Collection Survey conducted in November 2011, the new pipe was proposed to be installed parallel to the existing buried pipeline because the 3 m on both sides of the existing pipe is SANAA's land and the total length of the new pipe can be the shortest. But, now a lot of houses have been built on the route of the existing pipe and it was judged that it is very difficult to install the new pipe parallel to the existing pipe. Therefore, the new buried pipe route was selected along the municipal road so that no trouble with land properties occur between the resident and SANAA during the construction period. As the result of the new route selection, the total length of the pipeline is around 2,973m, i.e. about 500 m longer than that of above-mentioned plan.

The new buried pipe route was divided into 4 zones, Zone 1 to 4, considering geology, topography, land use (road, residential land, grassland, etc.). The characteristics of each zone were summarized in the following table. Based on these conditions, excavation sections, with or without earth support, backfill section, construction method, etc. were studied.

Photo 2-2-2 Road Slope Condition near Aerator

Photo 2-2-3 Excavated Slope Condition along Major Road

Photo 2-2-4 Flatland Condition along Major Road

Photo 2-2-5 Planned Bifurcation Point 2, Outcrop Condition

Table 2-2-13 Conditions of Each Zone of New Buried Pipeline

Zone	Location	Conditions of New Pipeline Route, Etc.
Zone 1 About 565 m	The most upstream portion from the upstream bifurcation point to the main road	Dominantly earth and sand mixed with cobbles The new pipe route runs partially through community managed land, then gravel road where houses exist on both sides of an asphalt pavement road. During construction, traffic control via a detour is necessary in a certain road section of 3 m width where walls exist on both sides of the road.
Zone 2 About 1080 m	Upstream of main road	Dominantly earth and sand mixed with cobbles In this zone, there are crossing portions of the existing pipe (ϕ900 mm), a community water supply pipe (ϕ100 mm) along the road, and water supply bifurcation pipes to houses (there are no drawings of community-base water supply pipes). In the upstream portion of about 1,080 m, the new pipes are to be installed parallel to the existing pipes.
Zone 3 About 809 m	Downstream of main road	About 100 m rock portion, and earth and sand mixed with cobbles New pipes are to be installed on the opposite side of the road, where the existing pipes are installed. The main road has an asphalt pavement.
Zone 4 About 519 m	The most downstream portion from the intersection of the main road to the upstream bifurcation point	Rocks along the mountain slope, earth and sand mixed with cobbles The new pipe runs about 80 m from the intersection to the Concepcion Water Treatment Plant along a gravel road, then through a backyard of the house, mountain slope, then comes to the same gravel road, runs along the gravel road and connects to the existing pipe upstream of the powerhouse.

c) Excavation section and construction method

Joints have developed in the exposed rock along the cut slope of the main road, where new pipes are to be buried. These rocks are heavily weathered and it is possible to break the rock easily by a hammer, which produces a dull sound. (The unconfined compressive strength of the rock was assumed to be 15 ~ 30 MPa in the Data Collection Survey Report of December 2011.)

Based on the interview with SANAA's employees regarding the existing pipe installation in the 1990s by Italy, blasting excavation was conducted during road construction in the portion with exposed rock slope of both sides in Zone 3 (Photo 2-2-3). At present, it is very difficult to conduct blasting work because there are a lot of houses near the site and a lot of traffic. Therefore, it is judged possible to excavate by using a breaker because rocks are not so hard. Considering noise and vibrations during construction and safety aspects, excavation is planned by using a 0.6 m^3-class backhoe equipped with a breaker.

Also, according to the interview with SANAA's employees, in case of excavation less than 2 m from the surface in Zone 2 and Zone 3 along the main road, earth and sand mixed with cobbles will be found. In the mountain slope portion in Zone 4, it is assumed that rocks exist about 30 cm below the ground surface.

Average excavation depth is shallow, at about 2 m, and relatively good soil (gravels, sandy soil) without spring water, etc. A built-up simple earth support method using wooden plates and pipe supports is to be applied.

Dewatering is necessary during excavation about 1.1 km downstream from the upstream bifurcation point, where the creek crosses the pipe route along the main road. It is judged that no dewatering is required along the pipe route except this location.

d) Installation and backfilling of pipeline

Concerning backfilling, a sand foundation of 30 cm thickness is to be applied to rock portions, and a direct foundation where large cobbles will be removed to avoid damage to the pipe is to be applied to soil mixed with cobbles. In rock portions, the pipe is to be backfilled with sand to a level 30 cm above the top of the pipe, then backfilled with soil and compacted into a 30 cm layer. Except in rock portions, the pipe is to be backfilled with soil free of large cobbles and compacted into a 30 cm layer. In the portion where the buried depth is shallow and the pipe crosses the road, protection concrete is to be placed around the pipe. The road pavement is to be restored to the original state.

In horizontal and vertical bending portions of the pipes, concrete blocks are to be constructed. The bending portion of the pipe is to be protected by concrete blocks so as not to push the pipe outward or dislodge the joints (deformed pipe) due to the unbalanced force of inner water pressure. The higher the water pressure and the larger the bending angle, the more unbalanced force will be. The size of the concrete block was determined according to the maximum inner water pressure, and horizontal and vertical alignment.

e) Appurtenant structures of pipeline

One (1) sludge drain valve pit is to be installed near the concave portion and two (2) air valve pits are to be installed near protrusion portions, in order not to affect the operation of both hydroelectric power and water distribution.
Also, two (2) gate valve pits are to be installed near the upstream and downstream bifurcations, in order to repair and replace the new pipe and make countermeasures against pipe leakage. Pits are to be reinforced concrete structures and have enough space for inspection. The locations of the pits are to be selected so as not to obstruct the traffic during inspection.

f) Selection of pipe material

There are several types of pipe such as ductile cast-iron pipe, steel pipe, and PVC pipe (unplasticized polyvinyl chloride pipe). For this project, a large pipe of 700 mm in inner diameter is required. Since PVC pipe of large diameter has some quality concerns such as durability, a comparison was done between ductile cast-iron pipe and steel pipe.

There are no local products of ductile cast-iron pipe in Honduras, so it will be imported from Japan or a third country (China, India, etc.) American-made production specified by ANSI/AWWA has no pipe of 700 mm in inner diameter, thus it must be specially ordered. The characteristics of ductile cast-iron pipe and steel pipe are summarized in the following table. As a result of comparison, ductile cast-iron pipe was selected.

Table 2-2-14 Comparison between Ductile Cast - Iron Pipe and Steel Pipe

Item		Ductile Cast-Iron Pipe	Steel Pipe
1. Standards		ISO 2531	ANSI, AWWA.
2. Scale	(1) Thickness (mm) (2) Pipe length(mm)	(1) 13.5 (2) 6,000	(1) 4 ~ 22 (2) 12,000
3. Pressure resistance	(1) Outer pressure resistance (2) Inner pressure resistance	(1) Bending strength is large. Withstands heavy load. (2) Withstands high pressure (> 32 bar).	(1) Ductility is higher than ductile cast-iron pipe. (2) Withstands high pressure (> 25 bar).
4. Joint	(1) Joint type (2) Water tightness (3) Expansion/ Contraction flexibility (4) Restraint resistance	(1) T, K, NS type, push-on type (2) Good, sealing with rubber ring (3) Due to flexibility of the joint, little forced stress occurs. (4) T shape-pipe has no restraint force. Restraint measures are required in portions where unbalanced pressure occurs due to unbalanced pressure in bending portions.	(1) Outer V groove, inner V groove, X groove (2) Water tightness is high via complete welding work. (3) Welded joints do not expand or contract, so it is required to install expansion and flexible joints properly. (4) Welding joints have high restraint resistance.
5. Constraints of construction	(1) Excavation work (2) Hanging installation work (3) Pipe connection	(1) Requires digging of pipe joint small pit. (2) Unit weight is heavier than that of steel pipe, but constraints to construction are almost the same. (3) For T shape-pipe, it takes a short time to connect using lever block and wire rope, and it is not affected by small amounts of spring water or climate conditions.	(1) A larger excavated section is required than for ductile cast-iron pipe because of welding work of each joint. (2) Same as above (3) Constraints to construction for steel pipe are inferior to those for ductile cast-iron pipe due to welding works. In addition, X-ray inspection is necessary. Welding work is affected by climate conditions. Possible spotty quality finds in inner welding (upper portion).
6. Durability	(1) Corrosion resistance (2) Inner anti-corrosion (3) Electric corrosion resistance	(1) High corrosion resistance by scientific characteristics (2) There is no spotty quality because mortal lining or epoxy fine particle paint is prepared at the factory and anti-corrosion treatment is to be conducted for joint portions and pipe body. (3) When insulated electrically by a rubber ring installed at the joint portion, little electric erosion occurs.	(1) If welding and painting are complete, high corrosion resistances can be obtained. (2) Because all joint welding is conducted at the site, spotty quality may result. (3) Electric erosion easily occurs because joint portions are welded and all pipes are integrated electrically.

Table 2-2-15 Study Results on Pipe Type Selection

Pipeline ϕ700 mm	Ductile Cast-Iron Pipe		Steel Pipe	
Applicability	○	Construction easiness and shorter construction period than steel pipe	×	Joint inner welding and painting of welding portions are required, but it is very difficult to find skilled labor to conduct the above works. Also, there is no inspection agency.
Procurement	○	It is easy to procure pipes from local agencies in Honduras because they have a track record.	×	Less used in Honduras. It is very difficult to procure the pipes local or from Central/South American agencies.
Impact on surroundings	○	None	○	Less impact, but construction period becomes longer.
Economical efficiency	○	Both material and construction costs are cheaper.	×	Material and construction costs are more expensive.
Validity	○	Advantageous from aspects of economical efficiency, procurement and construction	×	
Overall evaluation	Advantageous for all items. Material to be selected.			

2) Site Preparation and Foundation of Powerhouse

The powerhouse is to be built just upstream of the existing aerator. The area sits on flat land along a gravel road. Large-scale cutting and embankments are not necessary.

The geology of the planned powerhouse site consists of gravel and pyroclastic deposits including breccia. According to the results of standard penetration tests, sand including small stones is distributed to about 2 m from the ground surface, and rocks (tuff) are distributed below 2 m. It is judged that the foundations for the turbine, generator, valves, etc. are rock, and that the bearing capacity for those foundations is sufficient.

3) Powerhouse Buildings

The powerhouse is planned as an open type, single-story reinforced concrete building, where the turbine, generator, low-voltage and high-voltage distribution panels etc. are to be housed.

- A reinforced concrete building is to be constructed with noise prevention, security measures, etc.
- A steel entrance gate, steel building entrance door, and concrete block wall around the powerhouse lot with no entry barrier (barbed wire) on the top of the wall are to be installed.
- Car parking space is to be secured in the powerhouse lot and paved with asphalt.
- Water discharged from the powerhouse lot is to drain to an unlined ditch excavated alongside the gravel road in front of the powerhouse.

- Fans are to be installed to ventilate the powerhouse building.

- A manual traveling crane (8 m span) is to be installed to maintain the turbine, generator, valves, etc. and to lift them up and down by chain block.

- Gate valves are to be installed in the pits constructed outside of the powerhouse to minimize the building area.

- The area of the powerhouse building is 174 m^2 (width 8.50 x length 20.50) with a height of 7.00 m, where work space is provided to reassemble, assemble, repair, and inspect equipment.

Regarding design conditions of the powerhouse building, the design horizontal seismic coefficient (k_h) is 0.1 and the design wind pressure is 120 kg/m^2. The sectional force and reinforcement arrangement are studied based on a frame structure for columns and beams, and a simple beam structure for ceilings. The interval of columns is 5 m.

4) Control Room

The hydroelectric power plant is operated from the Concepcion Water Treatment Plant by means of a supervisory control and data acquisition (SCADA) system. The control room for the hydroelectric power facilities is placed in an open area of the existing plant control building. Therefore, building work is not necessary.

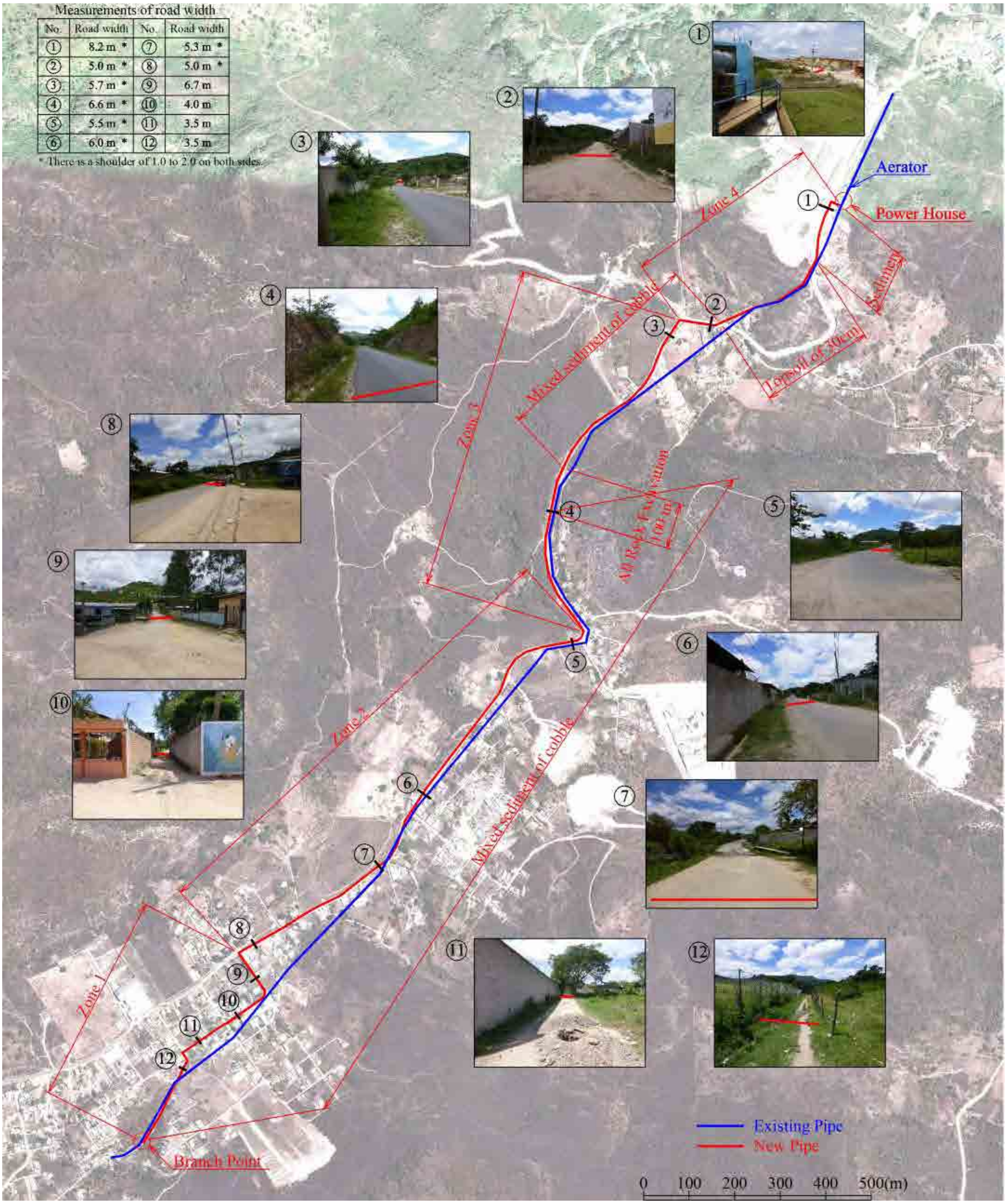


Fig. 2-2-22 Geological Conditions along New Pipeline Route (Concepcion Site)

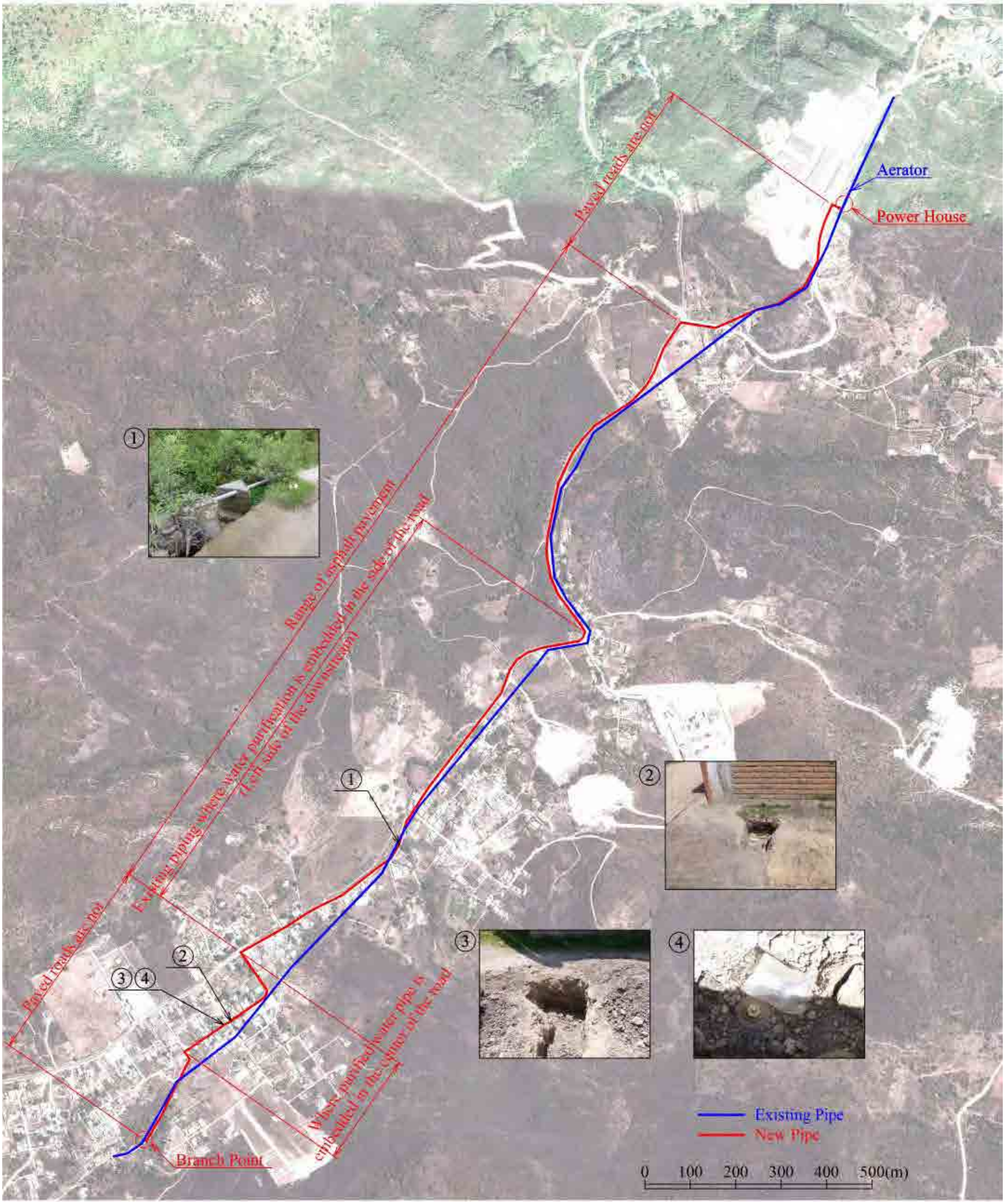


Fig. 2-2-23 Road and Local Circumstance Conditions along New Pipeline Route (Concepcion Site)

(3) Picacho Site

1) Powerhouse Site

Candidate sites for the powerhouse are either one in which the existing pressure reducing valve pit would have to be expanded beneath the road or one that includes a slope that is about 10 m higher than the valve pit. Problems of the former are a shortage of space (inner width 2.8 m, length 5.13 m and height 1.9 m), environmental problems for control equipment of the hydroelectric power plant facilities, vibrations due to traffic and traffic jams during construction, maintenance matters, etc. Therefore, the latter site was selected.

Civil engineering and building construction at the Picacho Site includes site preparation and construction of the powerhouse foundation, building and access road. The elevation of the powerhouse is about 5 m higher than the existing road, so the access road is necessary during construction, operation and maintenance. There is an existing concrete pavement, which has a steep slope (>20%), road for accessing the upland houses. A new access road is to be constructed to transport heavy equipment such as the turbine, generator, and construction equipment and materials. The powerhouse site is an open area where no houses or agricultural land exists, so resettlement is not necessary. However, there are houses near the site, therefore noise, vibrations, etc. during construction and operation periods are to be considered for the plan.

2) Access Road

Specifications of the access road are as below, referring to forest road regulations in Japan and considering vehicles for construction and maintenance.

Design speed	:	20 km/h
Width	:	4.0 m
Vertical slope	:	16 % (2nd class special value)
Minimum curve radius	:	10 m

3) Site Preparation and Foundation of Powerhouse

The planned powerhouse site is located in a sloped area, so site preparation is to be done considering the volume balance of excavation and filling. Also, the powerhouse site level is determined so that specifications of the access road are satisfied.

Cut slope is to be protected by retaining walls, and a concrete gravity wall is to be built in filling portions so as not to affect the stability of the downside houses. Drainage ditches are arranged in the powerhouse lot and access road, and the powerhouse lot is covered by asphalt pavement.

There are outcrops in spots in the powerhouse site. According to results of standard penetration tests, sand including small stones is distributed to about 2 m from the ground surface, and rocks (tuff) are distributed below the sand layer. It is judged that foundations for the turbine, generator, valves, etc. are rock and that the bearing capacity for those foundations is sufficient.

4) Powerhouse Buildings

The powerhouse is planned to be open type, single-story reinforced concrete building, where the turbine, generator, low-voltage and high-voltage distribution panels etc. are housed.

- A reinforced concrete building is to be constructed with noise prevention, security measures, etc.
- A steel entrance gate, steel building entrance door, and concrete wall around the powerhouse lot and access road, with steel fence on the top of the wall are to be installed.
- Car parking space on the powerhouse lot is to be secured and paved with asphalt.
- Water discharged from the powerhouse lot is to be drained to a ditch along the pavement road.
- Fans are to be installed in order to ventilate the powerhouse building.
- A manual traveling crane (8 m span) is to be installed to maintain the turbine, generator, valves, etc. and to lift them up and down by chain block.
- Bypass valves, gate valves, pressure reducing valves, and discharge adjustment valves are to be housed in the powerhouse building.
- The area of the powerhouse building is 174 m^2 (width 8.50 x length 20.50 m) with a height of 7.00 m, where work space is provided to reassemble, assemble, repair, and inspect equipment.

Regarding design conditions of the powerhouse building, the design horizontal seismic coefficient (k_h) is 0.1 and the design wind pressure is 120 kg/m^2. The sectional force and reinforcement arrangement are studied based on a frame structure for the columns and beams, and a simple beam structure for the ceilings. The interval of columns is 5 m.

5) Control Room

The hydroelectric power plant is operated from the Picacho Water Treatment Plant by means of a supervisory control and data acquisition (SCADA) system. The control room for the hydroelectric power facilities is built beside the existing plant control room on the 3rd of the existing control building.

2-2-2.3 Equipment Plan (Turbine, Generator and Electrical Equipment)

(1) Concepcion Site

1) Turbine Discharge

A standard type of scale turbine is more economical than an order-made turbine for small-scale hydroelectric power development. The standard type of scale turbine was selected for the Concepcion Site in order to reduce the turbine cost in accordance with the "Hydro-valley Development Guide" issued by the New Energy Foundation of the Agency for Natural Resources and Energy, Japan.

The maximum water flow, which is the designed water flow, is 1.50 m^3/s and the minimum water flow for the Concepcion Water Treatment Plant is 0.8 m^3/s according to operation records. A turbine discharge of 1.20 m^3/s enables the turbine maximum output, according to the study in Sub-section 2-2-2.1.

Hence, the following turbine discharges were selected.

a) Maximum discharge : 1.50 m^3/s
b) Rated discharge : 1.20 m^3/s
c) Minimum discharge : 0.80 m^3/s

2) Effective Head

The following effective heads are studied in Sub-section 2-2-2.1.

a) Dam maximum water level : EL 1,157.28 m
b) Tailrace water level (Aerator outlet level) : EL 1,115.22 m
c) Turbine center : EL 1,115.29 m
d) Maximum hydraulic pressure : 54.0 m
e) Gross head : 42.06 m
f) Maximum net head at 0.8 m^3/s : 35.18 m
g) Rated net head at 1.20 m^3/s : 27.46 m
h) Minimum net head at 1.50 m^3/s : 19.79 m

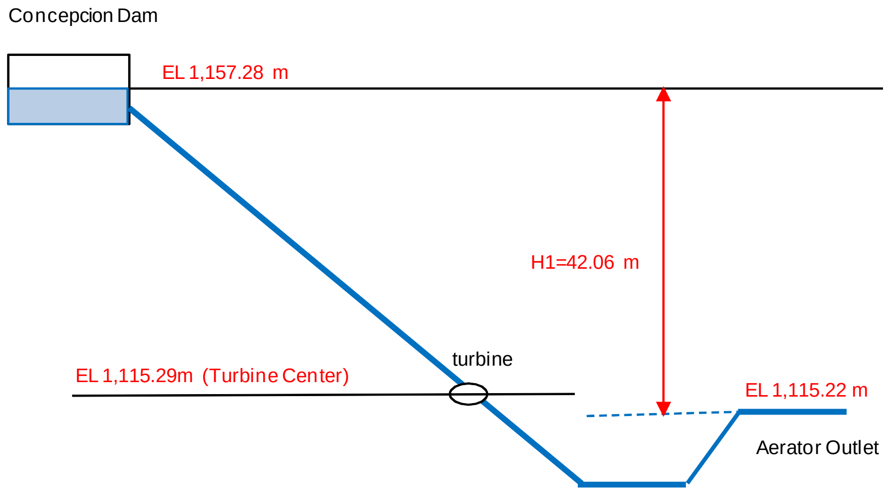


Fig. 2-2-24 Water Level and Gross Head of Concepcion Site

3) Hydraulic Turbine

A horizontal single runner, single flow spiral type Francis turbine was selected for the Concepcion Site from standard types of scale turbines, because of the effective heads and the turbine discharges as well as the conditions of both pipelines.

a) Quantity : One (1) unit
b) Type : Horizontal single runner, single flow spiral type Francis turbine

c) Rated head : 27.46 m

d) Maximum discharge : 1.50 m^3/s

e) Rated discharge : 1.20 m^3/s

f) Rated output : 273 kW

g) Speed : 900 rpm

h) Direction of rotation : Clockwise (Viewed from the generator)

i) Type of guide vane servomotor : DC electric motor driven

j) Performance Requirements

a. Operation range
Under the specified net head, the turbine is capable of operating from no-load to full load without generating excessive vibrations and/or noise.

b. Over-speed strength
The turbine safely withstands the maximum runaway speed for two (2) minutes.

c. Maximum hydraulic pressure
The maximum hydraulic pressure does not exceed the elevation of the inlet valve center under any operating conditions including sudden load rejection.

4) Valves

The following valves are provided for the turbine.

a) Inlet valve

The inlet valve is driven by a DC electric motor and controlled by a manual handle for both opening and closing operations. The actuator has an enough strength and capacity to close the valve during the maximum discharge of the turbine.

b) Outlet valve

The outlet valve is driven by a manual handle for both opening and closing operations.

c) Gate valve

The gate valve is driven by a manual handle for both opening and closing operations.

d) Bypass valve

The bypass valve is driven by a DC electric motor and controlled by a manual handle for both opening and closing operations. The actuator has an enough strength and capacity to close the valve during the maximum discharge.

5) Generator

A synchronous generator was selected for the Concepcion Site in consideration of 34.5 kV distribution line conditions to be connected by the generators.

a) Quantity : One (1) unit

b)	Type	:	The generator is a horizontal, direct coupled, 3-phase-3-wire and horizontal shaft synchronous generator with a revolving field of open type with protection and self-ventilating air cooling.
c)	Rated power	:	314 kVA
d)	Speed	:	900 rpm
e)	Power factor	:	0.8 (Lagging)
f)	Frequency	:	60 Hz
g)	Insulation class	:	Class F
h)	Over-speed strength	:	The generator withstands safely the maximum runaway speed of the turbine for two (2) minutes.

6) Governor

a) Type and Description of Governor

The governor is of PD control type and provided for quick response and stable control suitable for standalone operation. The frequency and load adjustments are made by the governor controller.

The governor comprises a governor control unit in a turbine/generator cubicle with all necessary control devices.
The governor is housed in the turbine/generator control cubicle.

b) Operating Requirements

The governor is equipped with all necessary automatic auxiliary devices to permit operations for starting, building up speed and voltage, picking up the load to the predetermined manual setting, and stopping the turbine-generator unit.

The governor is capable of controlling the speed of the turbine stably when operated at no load or at the rated speed with isolated load at any power output.

7) Excitation System

The AC exciter is of rotating armature type and insulated with F-class materials.

The rotating rectifiers are of three-phase bridge connection type and protected faithfully from abnormal voltages such as transfer voltage from the outside.

The field flashing for initial excitation is made from the station battery.

The excitation system has sufficient capacity that enables the generator to continuously supply the rated load, rated power factor and rated frequency.

The excitation system is housed in the turbine/generator control cubicle.

8) Turbine/Generator Control System

a) Outline

The turbine/generator control system has a communication system between the supervisory station to be installed in the control room at the water treatment plant and the turbine/generator control system to be installed in the powerhouse.

The turbine/generator control system consists of a programmable logic controller (PLC), operation and monitoring systems, measuring system, automatic synchronizing device, protective devices, etc.

The turbine/generator control system and protection equipment are housed in the turbine/generator control cubicle of a floor-standing metal enclosed type. Doors with locks are provided for easy access to the equipment. All measuring and control instruments are mounted in convenient locations.

b) Functions

The control system has the following functions.

a. Manual starting/stopping
b. Automatic starting/stopping
c. Automatic synchronizer
d. Load control
e. Inlet valve opening/closing
f. Bypass valve opening/closing
g. Guide vane v
h. Generator circuit breaker on/off
i. Automatic Voltage Regulator (AVR)
j. Automatic Power Factor Regulator (APFR)
k. Protection
l. System status indication
m. Measurement system
n. Surge protective device

9) Low Voltage Circuit

a) Generator Circuit Cubicle

A generator circuit cubicle is provided.

The generator circuit cubicle is complete with all necessary circuit breakers, molded case circuit breakers (MCCB), voltmeters, overcurrent, undervoltage and ground detector relays, voltage and current transformers, exciter transformer, islanding operation detection (Passive and Active types), surge protective devices, wiring and all other equipment to produce a complete working installation. The protection system for the generator circuit side is coordinated with the grid interconnection protection.

b) Station Service Power Supply Panel

The station service power supply panel is complete with all necessary voltmeters, power meters, surge protection devices, wiring and all other equipment to produce a complete working installation. A protection system of the 240-120V low voltage power supply panel has been selected and is coordinated with the 480V low voltage power supply panel.

The Contractor determines the rated power of the 480/240-120V transformer as well as the ratings, circuit quantities and protections of the 480V and 240-120V low voltage power supply panels.

c) 110V Battery Charger

The 110V battery charger consists of a battery charger, battery and distribution panel.

10) Control System

a) Outline

The control system, as a supervisory control and data acquisition (SCADA) system, embodies various functions such as sequences and interlocks, to operate the hydroelectric power generating system properly and safely, as well as the supervisory control, monitoring and data acquisition of the hydroelectric power generation system.

The control system consists of the supervisory station, an uninterruptible power supply (UPS) system to be installed in the water treatment plant and the turbine/generator control system to be installed in the powerhouse.

b) Supervisory Station

The supervisory station consists of a host computer system, a data base management system, a communication system between the supervisory station and the turbine/generator control system, two (2) sets of human-machine interfaces (HMI) and a color laser printer.

The host computer system and the data base management system are provided in the panels. The panels are installed in the control room in the water treatment plant.

c) Communication System

A communication system is installed between the supervisory station and the turbine/generator control system. The type and specifications of the optical fiber communication cable are proposed by the contractor.

11) 34.5 kV Medium Voltage Switchgear and Power Cable

a) 34.5 kV Medium Voltage Switchgear

The 34.5 kV medium voltage switchgear is of indoor, air-insulated, single-bus, metal-enclosed type, having front and rear hinged doors.

The circuit breaker (CB) is of vacuum, draw out, electrically and mechanically trip-free type, with a motor charged spring. The CB does not close unless the disconnector (DS) fully closes.

a.	Nominal voltage	:	34.5 kV
b.	Rated voltage	:	36 kV
c.	Rated frequency	:	60 Hz
d.	Number of phases	:	3-phase
e.	Rated lightning impulse withstand voltage	:	170 kV
f.	Rated short-duration power-frequency withstand voltage	:	70 kV
g.	Rated short-time withstand current	:	25 kA, 1 sec

b) 34.5 kV Power Cable

Cross-linked polyethylene (XLPE) insulated 34.5 kV 3-phase 3-core power cables are provided and installed by the contractor for interconnection between the existing 34.5 kV distribution line and 34.5 kV medium voltage switchgear, and between the 34.5 kV medium voltage switchgear and 34.5 kV power transformer.

a.	Cable type	:	XLPE insulated
b.	Nominal voltage	:	34.5 kV
c.	Rated voltage	:	36 kV
d.	Rated frequency	:	60 Hz
e.	Number of phases	:	3-phase
f.	Rated short-time withstand current	:	25 kA, 1 sec

12) 34.5 kV Power Transformer (Concepcion Site)

The power transformer is designed to deliver the rated power in the ambient conditions specified and has the capability to withstand fully through fault conditions without damage.

The power transformer is of oil-immersed, self-cooled, outdoor use type with an off-load tap changing device.

a)	Type	:	Outdoor, oil-immersed
b)	Rated power	:	400 kVA
c)	Rated frequency	:	60 Hz
d)	Primary rated voltage	:	480 V
e)	Secondary rated voltage	:	34.5 kV
f)	Number of phases	:	3-phase
g)	Connection	:	Delta-star
h)	Rated lightning impulse withstand voltage	:	170 kV
i)	Rated short-duration power-frequency withstand voltage	:	70 kV

(2) Picacho Site

1) Turbine Discharge

A standard type of scale turbine is more economical than an order-made turbine for small-scale hydroelectric power development. A standard type of scale turbine was selected for the Picacho Site in order to reduce the turbine cost in accordance with the “Hydro-valley Development Guide” issued by the New Energy Foundation of the Agency for Natural Resources and Energy, Japan.

The designed maximum water flow of the L22 pipeline is 225.54 liter/sec and the minimum discharge of the standard type of scale turbine under the relevant head of the Picacho Site is

0.30 m^3/s.

Hence, the following turbine discharges were selected.

a) Maximum discharge : 0.30 m^3/s
b) Rated discharge : 0.30 m^3/s
c) Minimum discharge : 0.12 m^3/s

2) Effective Head

The results of the studies in Fig. 2-2-25 are as follows.

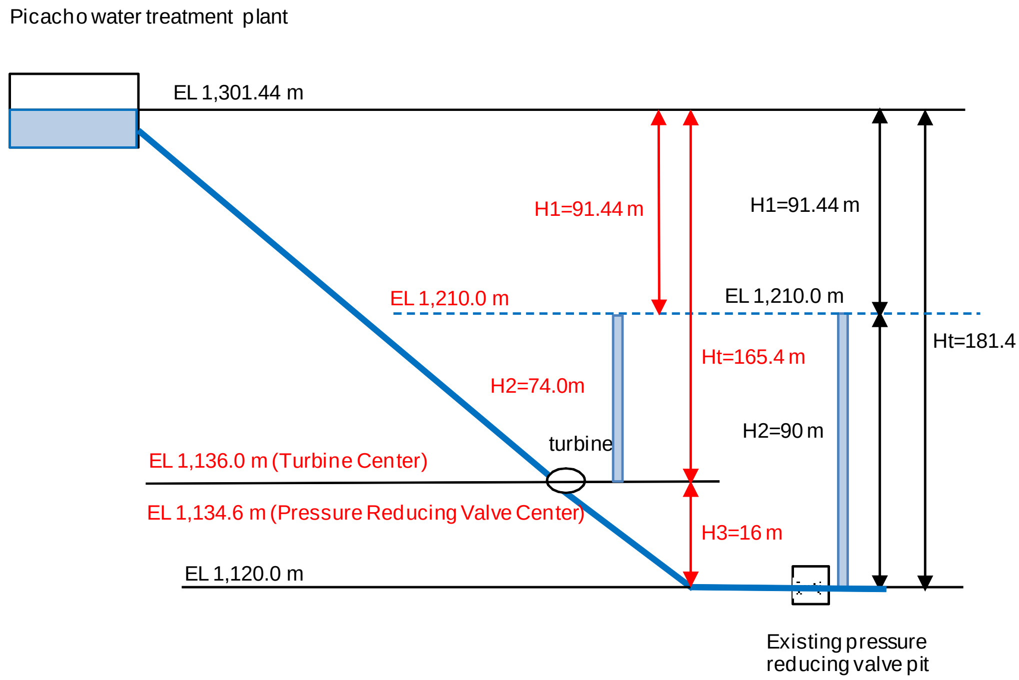


Fig. 2-2-25 Water Level and Gross Head of Picacho Site

a) Water tank water level : EL 1,301.44 m
b) Tailrace water level : EL 1,210.0 m
c) Turbine center : EL 1,136.0 m
d) Water reducing valve level : EL 1,134.6 m
e) Gross head : 91.44 m
f) Maximum net head at 0.12 m^3/s : 90.47 m
g) Rated net head at 0.30 m^3/s : 86.16 m
h) Minimum net head at 0.30 m^3/s : 86.16 m

3) Hydraulic Turbine

Horizontal single runner, single flow spiral type Francis turbines were selected from the standard type of scale turbines for both the Concepcion and Picacho Sites because of the effective heads and the turbine discharges, as well as the conditions of both pipelines.

a) Quantity : One (1) unit

b) Type : Horizontal single runner, single flow spiral type Francis turbine

c) Rated head : 88.16 m

d) Maximum discharge : 0.30 m^3/s

e) Rated discharge : 0.30 m^3/s

f) Rated output : 204 kW

g) Speed : 1,200 rpm

h) Direction of rotation : Clockwise (Viewed from the generator)

i) Type of guide vane servomotor : DC electric motor driven

j) Performance Requirements

a. Operation range
Under the specified net head, the turbine is capable of operating from no-load to full load without generating excessive vibrations and/or noise.

b. Over-speed strength
The turbine withstands safely the maximum runaway speed for two (2) minutes.

c. Maximum hydraulic pressure
The maximum hydraulic pressure does not exceed the elevation of the inlet valve center under any operating conditions including sudden load rejection.

4) Valves

The following valves are provided for the turbine.

a) Inlet Valve

The inlet valve is driven by a DC electric motor and controlled by a manual handle for both opening and closing operations. The actuator has an enough strength and capacity to close the valve during the maximum discharge of the turbine.

b) Outlet Valve

The outlet valve is driven by a manual handle for both opening and closing operations.

c) Gate Valve

The gate valve is driven by a manual handle for both opening and closing operations.

d) Bypass Valve

The bypass valve is driven by a DC electric motor and controlled by a manual handle for both opening and closing operations. The actuator has an enough strength and capacity to close the valve during the maximum discharge.

e) Pressure Reducing Valve

The pressure reducing valve reduces higher upstream pressure to the lower preset downstream pressure regardless of fluctuating demand or varying upstream pressure.

f) Water Regulating Valve

The water regulating valve is driven by a DC electric motor and controlled by a manual handle for both opening and closing operations. The actuator has an enough strength and capacity to close the valve during the maximum discharge of the turbine. The water regulating valve is equipped with a water regulating control panel in the powerhouse.

5) Generator

Synchronous generators were selected for the Picacho Site in consideration of 13.8 kV distribution line condition to be connected by the generator.

a)	Quantity	:	One (1) unit
b)	Type	:	The generator is of horizontal, direct coupled, 3-phase-3-wire and horizontal shaft synchronous type with a revolving field of open type with protection and self-ventilating air cooling.
c)	Rated power	:	235 kVA
d)	Speed	:	1,200 rpm
e)	Power factor	:	0.8 (Lagging)
f)	Frequency	:	60 Hz
g)	Insulation class	:	Class F
h)	Over-speed strength	:	The generator withstands safely the maximum runaway speed of the turbine for two (2) minutes.

6) Governor

a) Type and Description of Governor

The governor is of PD control type and provided for quick response and stable control suitable for standalone operation. The frequency and load adjustments are made by the governor controller.

The governor comprises a governor control unit in the turbine/generator cubicle with all necessary control devices.

The governor is housed in the turbine/generator control cubicle.

b) Operating Requirements

The governor is equipped with all necessary automatic auxiliary devices to permit operations for starting, building up speed and voltage, picking up of load to the predetermined manual setting, and stopping the turbine-generator unit.

The governor is capable of controlling the speed of the turbine stably when operated at no load or at the rated speed with isolated load at any power output.

7) Excitation System

The AC exciter is of rotating armature type and insulated with F-class materials.

The rotating rectifiers are of three-phase bridge connection type and protected faithfully from abnormal voltages such as transfer voltage from the outside.

The field flashing for initial excitation is made from the station battery.

The excitation system has sufficient capacity that enables the generator to continuously supply the rated load, rated power factor and rated frequency.
The excitation system is housed in the turbine/generator control cubicle.

8) Turbine/Generator Control System

a) Outline

The turbine/generator control system has a communication system between the supervisory station to be installed in the control room at the water treatment plant and the turbine/generator control system to be installed in the powerhouse.

The turbine/generator control system consists of a programmable logic controller (PLC), operation and monitoring systems, measuring system, automatic synchronizing device, protective devices, etc.

The turbine/generator control system and protection equipment are housed in the turbine/generator control cubicle of a floor-standing metal enclosed type. Doors with locks are provided for easy access to the equipment. All measuring and control instruments are mounted in convenient locations.

b) Functions

The control system has the following functions.

a. Manual starting/stopping
b. Automatic starting/stopping
c. Automatic synchronizer
d. Load control
e. Inlet valve opening/closing
f. Bypass valve opening/closing
g. Guide vane opening/closing
h. Generator circuit breaker on/off
i. Automatic Voltage Regulator (AVR)
j. Automatic Power Factor Regulator (APFR)
k. Protection
l. System status indication
m. Measurement system
n. Surge protective device

9) Low Voltage Circuit

a) Generator Circuit Cubicle

A generator circuit cubicle is provided.

The generator circuit cubicle is complete with all necessary circuit breakers, molded case circuit breakers (MCCB), voltmeters, overcurrent, undervoltage and ground detector relays, voltage and current transformers, exciter transformers, islanding operation detection (Passive and Active types), surge protective devices, wiring and all other equipment to produce a complete working installation. The protection system for the generator circuit side is coordinated with the grid interconnection protection.

b) Station Service Power Supply Panel

The station service power supply panel is complete with all necessary voltmeters, power meters, surge protection devices, wiring and all other equipment to produce a complete working installation. The protection system of the 240-120V low voltage power supply panel has been selected and is coordinated with the 480V low voltage power supply panel.

The Contractor determines the rated power of the 480/240-120V transformer as well as the ratings, circuit quantities and protections of the 480V and 240-120V low voltage power supply panels.

c) 110V Battery Charger

The 110V battery charger consists of a battery charger, battery and the distribution panel.

10) Control System

a) Outline

The control system, as a supervisory control and data acquisition (SCADA) system, embodies various functions such as sequences and interlocks, to operate the hydroelectric power generating system properly and safely, as well as the supervisory control, monitoring and data acquisition of the hydroelectric power generation system.

The control system consists of the supervisory station and an uninterruptible power supply (UPS) system to be installed in the water treatment plant and the turbine/generator control system to be installed in the powerhouse.

b) Supervisory Station

The supervisory station consists of a host computer system, a data base management system, a communication system between the supervisory station and the turbine/generator control system, two (2) sets of human-machine interfaces (HMI) and a color laser printer.

The host computer system and the data base management system are provided in the panel. The panels are installed in the control room in the water treatment plant.

c) Communication System

A communication system is installed between the supervisory station and the turbine/generator control system. The type and specifications of the optical fiber communication cable are proposed by the contractor.

11) 13.8 kV Medium Voltage Switchgear and Power Cable

a) 13.8 kV Medium Voltage Switchgear

The 13.8 kV medium voltage switchgear is of indoor, air-insulated, single-bus, metal-enclosed type, having front and rear hinged doors.

The circuit breaker is of vacuum, draw out, electrically and mechanically trip-free type, with a motor charged spring. The circuit breaker (CB) does not close unless the disconnector (DS) fully closes.

a.	Nominal voltage	:	13.8 kV
b.	Rated voltage	:	15 kV
c.	Rated frequency	:	60 Hz
d.	Number of phases	:	3-phase
e.	Rated lightning impulse withstand voltage	:	95 kV
f.	Rated short-duration power-frequency withstand voltage	:	36 kV
g.	Rated short-time withstand current	:	25 kA, 1 sec

b) 13.8 kV Power Cable

XLPE insulated 13.8 kV 3-phases 3-cores power cables are provided and installed by the Contractor for interconnection between the new 13.8 kV distribution line dead-end pole and 13.8 kV medium voltage switchgear, and between the 13.8 kV medium voltage switchgear and 13.8 kV power transformer.

a.	Cable type	:	XLPE insulated
b.	Nominal voltage	:	13.8 kV
c.	Rated voltage	:	15 kV
d.	Rated frequency	:	60 Hz
e.	Number of phases	:	3-phase
f.	Rated short-time withstand current	:	25 kA, 1 sec

12) 13.8 kV Power Transformer

The power transformer is designed to deliver the rated power in the ambient conditions specified and has the capability to withstand fully through fault conditions without damage.

The power transformer is of oil-immersed type, self-cooled, outdoor use type with off-load tap changing device.

a)	Type	:	Outdoor, oil-immersed
b)	Rated power	:	250 kVA
c)	Rated frequency	:	60 Hz
d)	Primary rated voltage	:	480 V
e)	Secondary rated voltage	:	13.8 kV

f) Number of phases : 3-phase
g) Connection : Delta-star
h) Rated lightning impulse withstand voltage : 95 kV
i) Rated short-duration power-frequency withstand voltage : 36 kV

(3) Distribution Lines

The Concepcion Hydroelectric Power Plant and Picacho Hydroelectric Power Plant will be connected to the existing 34.5 kV distribution line and existing 13.8 kV distribution line, respectively, as follows.

1) Concepcion Site

The Concepcion Hydroelectric Power Plant will be connected to the existing 34.5 kV distribution line (L307) that is connected to the 12.5 MVA 69/34.5 kV power transformer (T410) of the Santa Fe Substation. The short-time short-circuit current at the 34.5 kV bus bar of the 12.5 MVA 69/34.5 kV power transformer is 25 kA, 1 sec. The distribution line distance between the hydroelectric power plant and the substation is 10.6 km. The connection pole of the 34.5 kV distribution line is in front of the powerhouse location.

2) Picacho Site

The Picacho Hydroelectric Power Plant will be connected to the existing 13.8 kV distribution line (L231) that is connected to the 25 MVA 69/13.8 kV power transformer (T412) of the La Leona Substation. The short-time short-circuit current at the 13.8 kV bus bar of the 25 MVA 69/13.8 kV power transformer is 25 kA, 1 sec. The distribution line distance between the hydroelectric power plant and the substation is 1.4 km. The connection poles of the 13.8 kV distribution line are numbered L231, P19, and M3, and located in front of the powerhouse.

One circuit of the 13.8 kV distribution line is constructed by the Contractor between the new dead-end pole to be installed in the power station area and the existing 13.8 kV distribution line poles (L231, P19, M3) with necessary conductors, poles, apparatuses, materials, etc.

3) Grid Interconnection Negotiation

Grid interconnection negotiation is required between SANAA and ENEE in order that the Concepcion Hydroelectric Power Plant will be connected to the existing 34.5 kV overhead distribution line (L307) and the Picacho Hydroelectric Power Plant will be connected to the 13.8 existing kV distribution line (L231). The distribution impact study will be carried out by ENEE for ENEE's interfaces with the hydroelectric power generation systems based on SANAA's application with the required information for the grid interconnection to ENEE. The grid interconnection conditions will be negotiated between SANAA (the contractor) and ENEE during the design and engineering stage in the implementation of the project.

The following information for the grid interconnection is generally required as a best-effort clause. This information will be prepared by the Contractor based on the manufacturer's information.

a) Plan and profile of the hydroelectric power plant

b) Rated power and estimated average annual generation to deliver to ENEE

c) Plant factor and power factor

d) Date of commercial operation

e) Generator voltage

f) Substation, transmission or distribution line, and voltage level to the point of grid interconnection

g) Distance from the point of grid interconnection to the associated substation proposed

h) Protective devices to be used at the point of interconnection and generation equipment

i) Single line diagram

j) Electrical characteristics of power transformers such as voltage levels, impedances, electrical losses, and winding connections (star or delta). And, data it required on the tap changer such as the voltage variation for each step in %, the number of position changes, and if it has the ability to make changes to position under load.

k) Electrical characteristics of generators such as synchronous reactance (xd) and quadrature axis reactance (xq) in pu, and zero and negative sequence impedances in pu[7], and transient reactance (xd'), subtransient reactance (xd"), rotor type (eg. salient poles), inertia constant (H), and reactive power limits in pu and, also data of excitation and governor systems

l) Capability curve of generator

m) Electrical characteristics of the interconnection line such as overall length and type of conductor, separation distance between each of the phases, type of driver and guard wire height or neutral, and operating voltage, and geometric position of each of the phases of the transmission line, and structure type and terrain

7 Per-unit system

2-2-3 Outline Design Drawing

Outline Design Drawings of this Project are listed in the below table, and attached to the end of this report.

No.		Title
Concepcion Hydroelectric Power Plant		
Civil Engineering Works	CC-CV-01	Water Pipe, General Plan (1/2)
	CC-CV-02	Water Pipe, General Plan (2/2)
	CC-CV-03	Water Pipe, Profile (1/2)
	CC-CV-04	Water Pipe, Profile (2/2)
	CC-CV-05	Water Pipe, Typical Sections
	CC-CV-06	Valve Pits, Details
	CC-CV-07	Concrete Blocks, Details
	CC-CV-08	Powerhouse, General Layout Plan
	CC-CV-09	Powerhouse, Sections (1/2)
	CC-CV-10	Powerhouse, Sections (2/2)
	CC-CV-11	Powerhouse, Typical Sections
	CC-CV-12	Powerhouse, Concrete Outline Plan
	CC-CV-13	Powerhouse, Concrete Outline Profile and Sections
	CC-CV-14	Powerhouse, Reinforcement Arrangement
Electro-mechanical and Electrical Works	CC-EM-01	Equipment Layout Plan
	CC-EM-02	34.5 kV Single Line Diagram
	CC-EM-03	34.5 kV Power Cable Route
	CC-EM-04	Control Room (Concepcion Water Treatment Plan)
	CC-EM-05	Communication Cable Route
Picacho Hydroelectric Power Plant		
Civil Engineering Works	PC-CV-01	Powerhouse Area, General Plan
	PC-CV-02	Powerhouse, General Layout Plan
	PC-CV-03	Powerhouse, Sections (1/3)
	PC-CV-04	Powerhouse, Sections (2/3)
	PC-CV-05	Powerhouse, Sections (3/3)
	PC-CV-06	Powerhouse, Concrete Outline Plan and Sections
	PC-CV-07	Powerhouse, Concrete Outline Profile and Sections
	PC-CV-08	Powerhouse, Reinforcement Arrangement
Electro-mechanical and Electrical Works	PC-EM-01	Equipment Layout Plan
	PC-EM-02	13.8 kV Single Line Diagram
	PC-EM-03	13.8 kV Power Cable and Distribution Line Route
	PC-EM-04	Control Room (Picacho Water Treatment Plan)
	PC-EM-05	Communication Cable Route

2-2-4 Implementation Plan

2-2-4.1 Implementation Policy

The project will be executed according to the scheme for Government of Japan Grant Aid. Therefore, it needs a setup of suitable implementation structure and schedule plan in consideration of the grant-in-aid system.

A Japanese consultant will be responsible for the detailed design (preparation of design documents), assistance for the tender and supervision of the construction work. Following the signing of the E/N and G/A for Japan's grant aid for the Project, SANAA will conclude a consultancy agreement with a Japanese consultant in relation to the said consultancy services.

The construction work will be carried out by a Japanese construction company that will be selected by SANAA through tender in the presence of the consultant. The Japanese Contractor will conduct equipment/material procurement and facility construction based on the agreement with SANAA.

The implementing agency is SANAA. The implementation structure of this Project is shown in the figure below.

Based on the government policy, the procurement policy is to intorudce main components of small-scale hydroelectric power plant such as hydraulic turbines and generators made by small and medium-size Japanese manufactures on the basis of design.

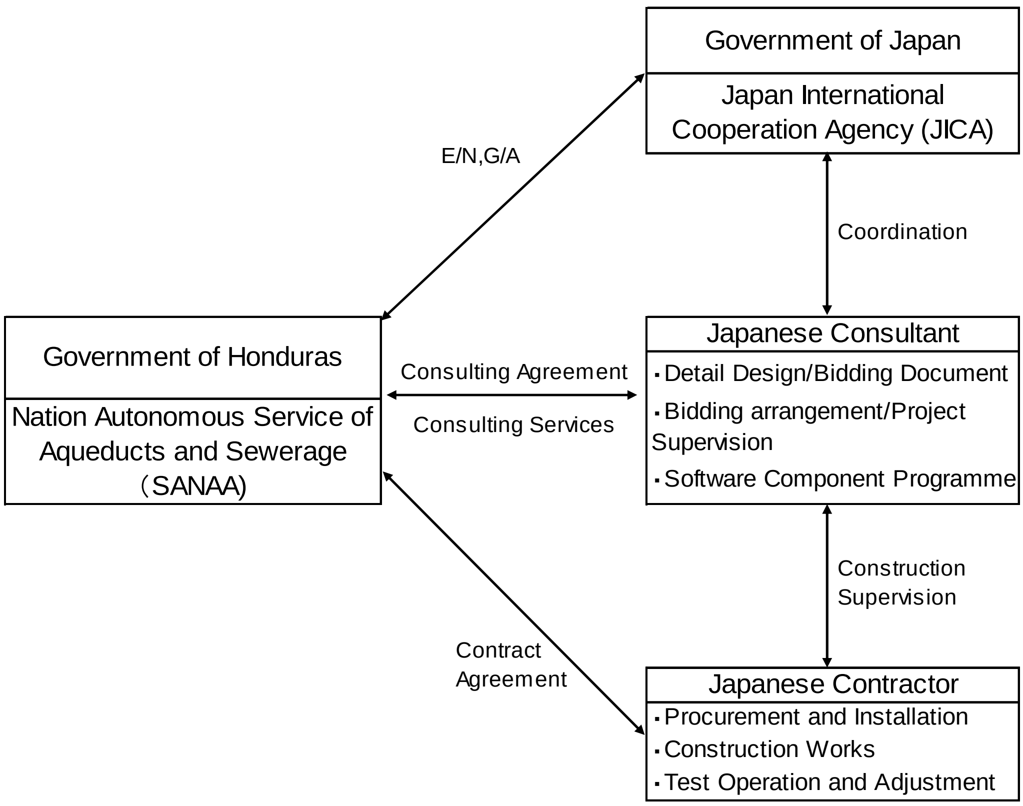


Fig. 2-2-26 Relevant Institutions and Implementation Structure

2-2-4.2 Implementation Conditions

(1) Cooperation with Relevant Institutions

Coordination, including acquiring construction approvals, with the Tegucigalpa Municipality Planning Bureau etc. should be required before implementation of the pipe laying works along the municipal road in the Concepcion Site. In addition, it is important to cooperate with ENEE with regard to power line installation works.

(2) Tax Exemption Application Process

From examples of past projects, it is expected that the tax exemption application process will take much time.

Therefore, although SANAA will take the lead in the administrative process, it is important for the consultant and the contractor to fully understand the concerning law of Honduras in order to facilitate the process.

(3) Weather Conditions

The climate of the construction areas belongs to a tropical savanna that has distinct dry and rainy seasons.

The rainy season lasts from May to October and the rain will affect the job-site productivity of labor and equipment because there is no adequate drainage near the construction sites.

Therefore, the rainy season should be incorporated into the construction schedule by carrying out construction works, which are susceptible to rain, in the dry season so that the whole time necessary for the completion may be shortened.

Moreover, since the drainage is in very poor condition during the rainy season, the contractor should take note of such condition in the case of the excavating work for the pipelines.

(4) Safety Management

The key safety measures are as follows.

1. For construction site safety, 24-hour site security is to be provided at construction related facilities, such as the materials stock yards.

2. Since the growth in large construction vehicle traffic is predicted during the construction, traffic signals and flagmen are to be arranged as safety measures for 3rd parties.

3. Safety barriers, signs, etc. are to be provided at all the construction sites to restrict public entry.

4. Construction material logistics plans are to be set up to prevent the overloading of vehicles. Moreover, since unlimited-access-roads are used for the transportation of materials, public safety is to be prioritized by observing traffic regulations and taking all possible measures against accident prevention.

5. During the pipe laying works, the backfill is to be carried out as soon as possible for public safety and pipe material theft prevention.

(5) Explanation to Customers Experiencing an Interruption in Water Supply

In connecting the new bifurcation pipe to the existing main water pipelines, an execution plan is to be carefully formed to ensure the minimum of disruption to users.

The suspension of water supply, which arises at the time of connection, is to be discussed with SANAA beforehand, and it is to publicize to residents to obtain the cooperation in the plan from residents in Tegucigalpa.

2-2-4.3 Scope of Works

The work demarcation between the Japanese and the Honduras sides is as follows.

Table 2-2-16 Allocation of Chief Responsibility

No.	Items	To Be Covered by Grant Aid	To Be Covered by Recipient Side
1	Acquisition and free provision of land necessary for the project		●
2	Acquisition and free provision of land necessary for the temporary works and land clearance		●
3	Provision of waste disposal sites		●
4	To construct roads within the sites	●	
5	Maintenance of roads outside of the sites		●
6	Procurement of small-scale hydroelectric power equipment	●	
7	Installation of small-scale hydroelectric power equipment	●	
8	Connection of new bypass pipeline (Concepcion)	●	
9	Connection of the new power line to the existing infrastructure	●	
10	Provision of free water for the construction works		●
11	To bear the following commissions applied by the bank in Japan for banking services based upon the Bank Arrangement (B/A):		
	1) Payment of bank commission		●
12	Application and acquisition of permits and licenses required for construction works		●
13	To ensure all the expense and prompt execution of unloading and customs clearance at the port of disembarkation in the recipient country		
	1) Marine or air transportation of the products from Japan or third countries to the recipient	●	
	2) All expenses and prompt execution of unloading, tax exemptions and customs clearance of the products at the port of disembarkation		●
	3) Internal transportation from the port of disembarkation to the project sites	●	
14	To accord Japanese nationals and/or nationals of third countries, including persons employed by the agent whose services may be required in connection with the components such as facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work.		●
15	To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the purchase of the components and to the employment of the agent will be exempted by the government of recipient country.		●
16	To maintain and use properly and effectively the facilities that are constructed and the equipment that is provided under the Grant.		●
17	To bear all the expenses, other than those covered by the Grant and its accrued interest, necessary for the purchase of components as well as for the agent's fees.		●
18	To ensure environmental and social considerations for the Program.		●

2-2-4.4 Consultant Supervision

This Project is to be carried out in accordance with a scheme of Japan's Grant Aid. The Consultant for this Project is to conduct design execution, construction supervision and technical assistance.

Major components of the consultancy work are outlined below.

Table 2-2-17 Outline of Consultant's Activities

Stage		Activities
1.	Pre-Implementation Stage (Detailed Design and Bidding)	Preparation of Detailed Design Preparation of Bid Documents Assistance with the Bidding
2.	Project Implementation Stage	Construction and Procurement Supervision Test and Operation Supervision Project Report Writing, etc.

As a result of a detail design survey, bid documents are drawn up, and the bid opening date is decided. During the bidding, the Consultant is to provide support to SANAA, evaluate bid results and provide assistance for signing contracts between SANAA and the wining contractor.

Personnel required in the pre-implementation stage are shown in the following table.

Table 2-2-18 Roles of Consultant Members during Detailed Design Stage

Consultant Staff	Main Scope of Work
Chief Consultant	Overall supervision of the detailed design
Engineer 1 Civil Engineering · Architecture	Preparation of detailed designs for the powerhouse and the appurtenant works
Engineer 2 Water Facilities	Preparation of detailed designs for the water facilities
Engineer 3 Construction Planning/Cost Estimate	Preparation cost estimates for the prospective bidding prices of the project

Table 2-2-19 Roles of Consultant Members during the Bidding Stage

Consultant Staff	Main Scope of Work
Chief Consultant	Overall supervision of the bidding process (Document preparation, bid announcement, clarification of bidding documents, examination and evaluation of bids)
Engineer 1 Civil Engineering · Architecture	Preparation of technical specifications for the overall civil engineering and architectural works and evaluation of bids
Engineer 2 Small-Scale Hydroelectric Power	Preparation of technical specifications for the small-scale Hydroelectric Power equipment and support of the bidding process (Bid announcement, clarification of bidding documents, examination and evaluation of bids)
Engineer 3 Drawing · Bill of Quantities	Preparation of construction drawings and bill of quantities for bids

During the construction period, the Consultant works in close cooperation with the relevant institutions in Honduras and keeps strict vigil on quality and progress of construction works taken on by the Contractor.
Moreover, the Consultant provides spot supervision for the soft component programs.

The policy during the implementation stage are as follows.

- Prioritize construction quality supervision because the new schemes are integrated to the existing water service facilities.

- Pay close attention to project implementation schedule including logistics and procurement plans, because the hydroelectric power equipment and the large diameter pipes will be from Japan or third countries.

- In consideration of worsening security in Honduras, place greater importance on safety supervision and maintain close communications with relevant authorities in Honduras, the Embassy of Japan in Honduras and JICA Honduras pipeline.

- Organize a monthly meeting with representative of SANAA and the Japanese Contractor to discuss problems and solutions. It is especially important to discuss work involved with the new pipeline connection to the existing water pipeline.

The personnel required in the project implementation stage are shown in the following table.

Table 2-2-20 Roles of Consultant Members during the Implementation Stage

Consultant Staff	Main Scope of Work
Chief Consultant	Coordination and technical control to ensure smooth progress of the construction work
Resident Engineer 1 Civil Engineering / Architecture	Daily project management and schedule control of construction works
Resident Engineer 2 Machine / Electric	Inspection of tests and commissioning of E/M equipment
Resident Engineer 3 Final Inspection	Final inspection of the project

2-2-4.5 Quality Control Plan

The Consultant's construction supervision staff supervises the items shown below to confirm whether the quality of equipment and installation satisfies the relevant stipulations in the Contract Documents (Technical Specifications, Drawings, etc.).

If the qualities of the works are questionable, the Consultant is to request the Contractor to make remedies, changes and/or adjustments.

(1) Quality Control of Installation Works

- Checking installation procedure statements, site tests, adjustments and site inspection procedure statements, and shop drawings

- Supervising installation work and witnessing test-runs, adjustments and inspections
- Verifying the shop drawings
- Checking finished work against shop drawings

(2) Quality Control of Civil Engineering Works

The main civil engineering works are the construction of the pipeline and powerhouse.

- During the backfilling of pipeline trenches, the thickness of soil layers and degree of compaction are to be carefully checked.
  As soon as pipe laying is complete, a hydraulic test is to be carried out to check the leak tightness of the system, search for leaks in joints, etc.

- Testing of the concrete such as slump tests, concrete air entrainment tests, and compressive strength tests, and testing of tensile strength of deformed steel bar are to be carried out by qualified public or private institutions. The time management is important to place ready-mix-concrete as soon as possible and the curing condition is to be checked after concrete casting.

- Inspection of concrete structures and pipeline construction works is to be carried out by verifying the amount of concrete placed, structure sizes, distance of pipeline, and the pipeline burial depth, with photographic recording.
  In construction photographs, a blackboard is to be attached for explanations and a leveling rod, pole, ribbon tape, etc. are to be used to verify the size of structures correctly.

2-2-4.6 Procurement Plan

(1) Procurement Plan

Main materials required for the civil engineering works, such as pipeline works, powerhouse construction works, and electric works, are concrete, deformed steel bars, sand, and ductile iron pipe.
Common construction materials such as cement, sand, aggregates, and wood forms can be easily obtained in Honduras. Therefore, they are to be purchased in Honduras.

There are about three (3) ready-mix concrete suppliers in Honduras and they own a fair number of mixer trucks and concrete testing equipment. Deformed steel bars meeting the requirements of ANSI (American National Standards Institute) standards Grade 40 and Grade 60 can be procured from the country's major industrial center, San Pedro Sula.

The construction aggregates to be used in this work are of Honduras origin and finely divided aggregates are to be used as sand. These locally available raw materials have been used in previous JICA projects and it has been confirmed that the materials of the right quality and quantity can be procured.

On the other hand, large diameter ductile cast-iron pipes, steel pipes, and valves required for the pipeline works are not available locally and they are to be procured from overseas.

General heavy construction equipment, such as cranes, backhoes, bulldozers and compressors, expected to be used in this project, can be hired locally.

The country of origin for the equipment being procured for the Project is to be fundamentally considered as shown in the following Table 2-2-21.

Table 2-2-21 Procurement Classification of Equipment

Item	Origin		
	Japan	Honduras	Other
Small-Scale Hydroelectric Power Equipment			
Turbine	○		
Generator	○		
Turbine / Generator Control System	○		
Low Voltage Circuit	○		
Control System	○		
Medium Voltage Switchgear			○
Power Transformer			○
High Voltage Power Cable			○
Construction Materials			
Ready-Mix-Concrete		○	
Cement		○	
Sand / Aggregate		○	
Deformed Bar		○	
Wood		○	
Ductile Cast Iron Pipe, Steel Pipe (more than ϕ200 mm)			○
Valves, Flow meter			○
Electric Line Pole		○	
Construction Machinery			
Crane		○	
Backhoe		○	
Dump Truck		○	
Bulldozer		○	

(2) Labor Employment

There are some local companies that have engaged in Japanese Grant Aid projects. These contractors have experience with similar water works and the concrete structure works required in this project, and they are expected to be able to handle works that meet the required standards of Japanese Grant Aid programs. Therefore, local contractors are to be utilized as much as possible in the works under the Prime Japanese Contractor. However, the dispatch of Japanese engineers is indispensable for installation works since there is no local company that has engaged in installation of Japanese-made small-scale hydroelectric power equipment.

(3) Transportation Plan

The small-scale hydroelectric power related electrical items procured in Japan are to arrive at the sole international port in El Salvador, Acajutla. The port consists of three (3) wharves with a depth between 7 and 15 m. The maximum capacity of the mobile crane is 49 ton, which is well beyond the needed capacity of 20 ton for the Project. The target sites are located in Tegucigalpa, which is located about 400 km from the port.

However, there are many experienced transport companies in Tegucigalpa and the access roads from the port to the sites are well maintained. Therefore, there is no concern related to the local transport of materials from Japan.

On the other hand, the materials and equipment delivered by 40 ft containers will be transferred to small trucks in Tegucigalpa because the city access roads near the sites are narrow and have steep gradients. The shipping and transport period is estimated to be about two months.

Moreover, it is necessary to prepare procurement plans in consideration of the traffic conditions since traffic congestions are common after 3:30 p.m.

2-2-4.7 Operation Guidance Plan

(1) Purpose

Operation guidance is to be provided by the Contractor to the operators and maintenance crews of the small-scale hydroelectric power plants in order to maintain the hydroelectric power plant facilities in proper operation and provide incident response to this first hydroelectric power plant of SANAA's.

(2) Operation Guidance

After the completion of the construction and installation of the hydroelectric power plant facilities and the distribution lines, operation guidance is to be provided by the Contractor to the operators and maintenance staff under the Consultant's supervision in order that the operators and the maintenance staff learn the starting and shutdown operations of the plant facilities as well as emergency countermeasures. Operation and maintenance manuals for the initial operation and maintenance guidance are to be prepared in Spanish by the Contractor before the commencement of guidance.

1) Operation Guidance Plan

The operation guidance plan during the commissioning of the hydroelectric power plant facilities is as follows.

a) Content, Period and Place

Lecture and practical guidance : about two (2) weeks at the sites

b) Instructors

Supervisors who are dispatched by the manufacturers of the turbine, generator, control system, switchgears and electrical equipment during the installation, commissioning and site tests are assumed to serve as instructors.

c) Trainees

Trainees from SANAA to receive the guidance are the following operators and maintenance crews to be involved in the direct operation and maintenance work as the operation and maintenance team of the hydroelectric power plants.

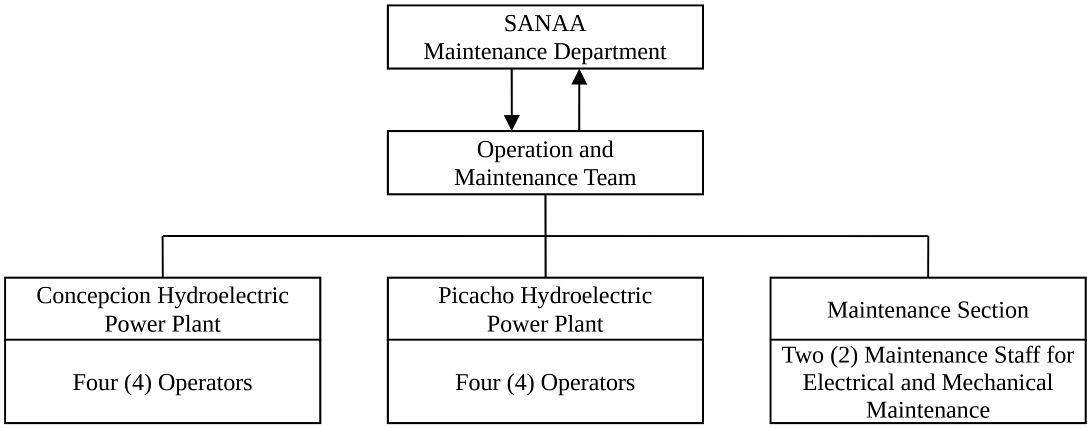


Fig. 2-2-27 Organization of Operation and Maintenance Team (Draft)

Table 2-2-22 Manpower of Operation and Maintenance for Hydroelectric Power Plants

Function		Persons	Main Activities
Manager of Maintenance Department		1	Making major decision
Team Leader (Chief Engine)		1	Detailed study of equipment management policy based on the background of the facilities
Operators	Electrical Technicians	8	Daily operation
Maintenance Staff	Electrical Technicians	2	Daily inspection and maintenance

d) Guidance Contents

a. Lecture

The following procedures with a focus on the hydroelectric power plant facilities to be installed by this project are be taught by using the operation and maintenance manuals.

- Description of contents of the operation and maintenance manuals
- Basic knowledge of operation, inspection and maintenance such as functions of the equipment, accidents and breakdown, storage of spare parts and maintenance tools, drawings, documents
- Distribution lines system

- Features and operation of the turbine and generator such as the triggering and functions of auxiliary devices and equipment including operation, shutdown and emergencies
- Operation of remote control (Remote control of the turbine/generator, supervisory methods, evaluation of data)
- Maintenance of the turbine and generator
- Overhaul of the turbine
- Operation and inspection of switchgears
- Inspection of power transformers

b. Practice at site

The following practices are to be carried out at the site during the commissioning.

- Features and operation of the turbine and generator such as the triggering and functions of auxiliary devices and equipment including operation, shutdown and emergencies
- Operation of remote control (Remote control of the turbine/generator, supervisory methods, evaluation of data)
- Maintenance of the turbine and generator
- Overhaul of the turbine
- Operation and inspection of switchgears
- Inspection of power transformer
- Introduction of meters, components, etc. of the facilities
- Supervision and visual inspection methods
- Maintenance of the facilities

2-2-4.8 Soft Component (Technical Assistance) Plan

(1) Background for Planning Soft Component

This project is not merely about hydroelectric power. It is most important to achieve both effective operational management of the water treatment plants and optimum operation of the small-scale hydroelectric plants to be installed in order to maximize the generated energy.

SANAA has sufficient capability to operate and manage the water treatment plants, however SANAA does not own any hydroelectric power plants at present, therefore they have no knowledge of power plant operation and maintenance or how to manage an electricity business. Therefore, it is necessary to facilitate capacity building and help them get organized. Moreover, it is essential to establish an appropriate management system in order to manage both the water treatment plants and hydro electric power plants as a single unified system.

SANAA has vast experience in operation, maintenance and management of water treatment plants, therefore there are mechanical and electrical engineers in their organization. Those engineers have the foundations for mastering hydroelectric generation technology and SANAA is willing to accept the technology transfer and master such technology in their organization. It is believed possible that SANAA can secure the proper engineering staff to support personnel capacity building and establish the necessary organization.

The water and sewerage service is slated to be legally transferred from SANAA to Tegucigalpa City in October 2013. SANAA is responsible with regard to the transfer of the water service and the implementation of this Project until completion, even if the water service business has been transferred in the course of project implementation. Therefore, it is believed not to impact this Project.

After completion of the Project, this power generation facility is also planned to be transferred to Tegucigalpa City, however the water service in Tegucigalpa City after the transfer is scheduled to be operated, maintained and managed by the engineers of SANAA from the view point of technical know-how and capacity. Therefore, the operation, maintenance and management technologies for sustainable operation of this generation facility are to be transferred to SANAA.

(2) Objective of Soft Component

The objective is to establish a management system for proper operation, maintenance and management of the existing water treatment plants and power generation facilities to be provided in this project by the implementing agency, i.e. SANAA, and sustainably manage the electricity business and water supply service.

(3) Activities of Soft Component

The following outcomes are anticipated if the above-mentioned goals are achieved.

i) Establishment of a proper management system and institution for electricity business

ii) Establishment of a proper management system for the hydroelectric power plants

iii) Establishment of a proper management plan and method of water treatment facility in coordination with power generation operation and facilities

To achieve the above-mentioned three (3) goals, the following activities are to be implemented.

1) Establishment of Proper Management System and Institution for Electricity Business

- Conduct seminars on power generation planning and electricity business.
- Facilitate the preparation of balance sheet reports.
- Provide guidance on preparing registers of facilities, spare parts and equipment.
- Prepare programs to monitor power generation and the distribution facility and water treatment facility.
- Prepare forms, procedures, etc. necessary for managing and monitoring the electricity business.

2) Establishment of Proper Operation and Maintenance System of Power Generation Facilities

- Conduct seminars on the basic knowledge of hydroelectric power technology.
- Conduct seminars on the basic knowledge of hydroelectric power and water distribution

facilities.

- Facilitate the preparation of forms, procedures, etc. for hydroelectric power plants.
- Prepare countermeasures to accidents and emergencies for power generation, and the power distribution and water distribution facilities.
- Confirm operation and management of the hydroelectric power plants.
- Develop mid- and long-term maintenance plans in consideration of the affects on the water supply service.

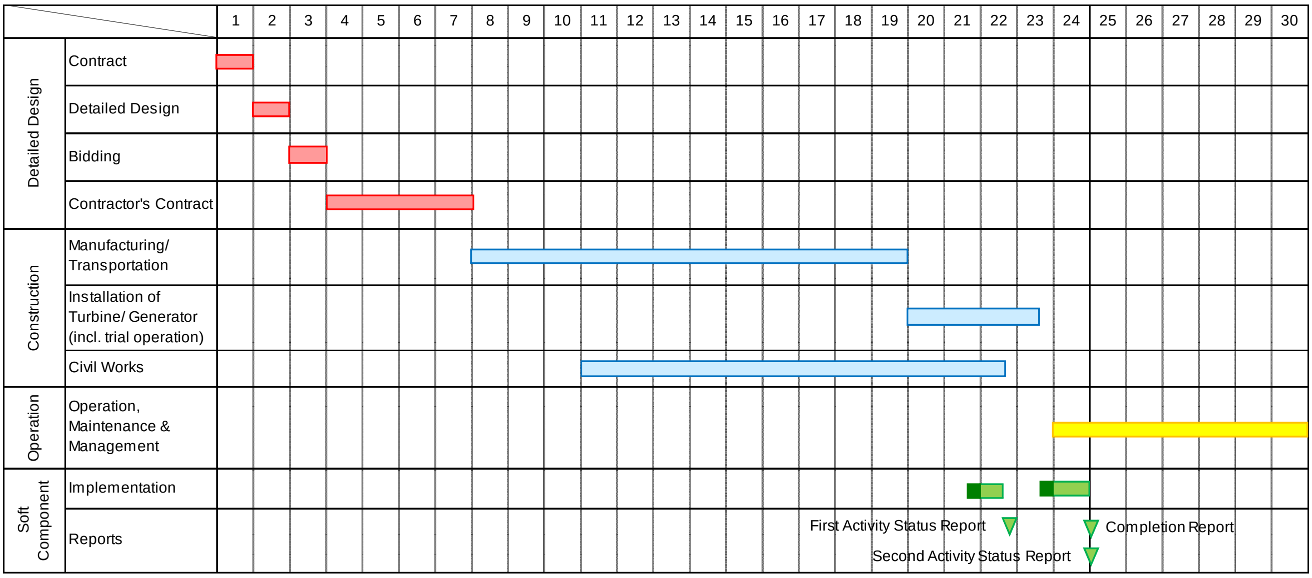
3) Establishment of Proper Management Plan and Method of Water Distribution in Coordination with Power Generation Operation and Facilities

- Develop operation and management plans (draft) and prepare management procedures on water distribution.
- Develop operation and management plans, workshops and discussions on management procedures for the water distribution facilities.

(4) Implementation Schedule of Soft Component

An overall implementation schedule of the soft component is shown in Table 2-2-23.

Table 2-2-23 Overall Implementation Schedule (Draft) of Soft Component



(5) Deliverables of Soft Component

Deliverables of the soft component are listed below.

- Management procedures for the electricity business
- Operational management procedures for the power generation plants
- Operational management plan for water distribution in coordination with power generation

management

- Operational management procedures for water distribution in coordination with power generation facility
- Periodic monitoring form
- Management registers for facilities and spare parts

2-2-4.9 Implementation Schedule

In drawing up the implementation schedule, it is necessary to take the grant aid scheme into full consideration and set up a proper implementation plan to complete the project within a given time frame

(1) Exchange of notes (E/N)
(2) Consultant agreement
(3) Detail study
(4) Tender document preparation
(5) Tendering and signing of contract with the selected contractor
(6) Manufacture and procurement of materials and equipment
(7) Construction works, installation and adjustment
(8) Implementation of soft component
(9) Completion and hand-over

The project will be implemented in about 24 months upon conclusion of the E/N. The law specifies a 6-day workweek from Monday to Saturday with a maximum of 44 hours per week.

The above conditions and non-working days due to adverse weather conditions and holidays are to be taken into consideration when preparing the construction schedule.

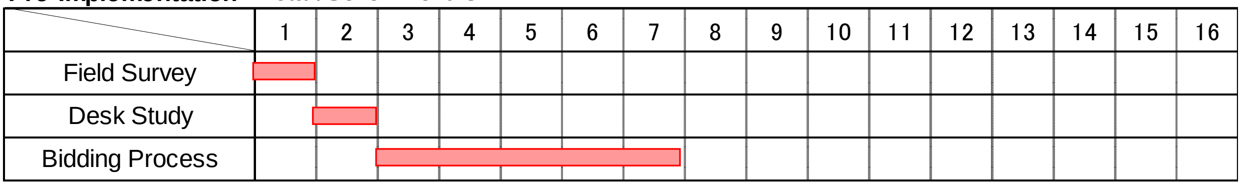
In this project, the time necessary for completion is mainly determined by the process of manufacture and delivery of small-scale hydroelectric power equipment, installation, and adjustment works.

The other construction works, such as pipeline works, proceed in parallel with the manufacture and delivery of the small-scale hydroelectric power equipment.

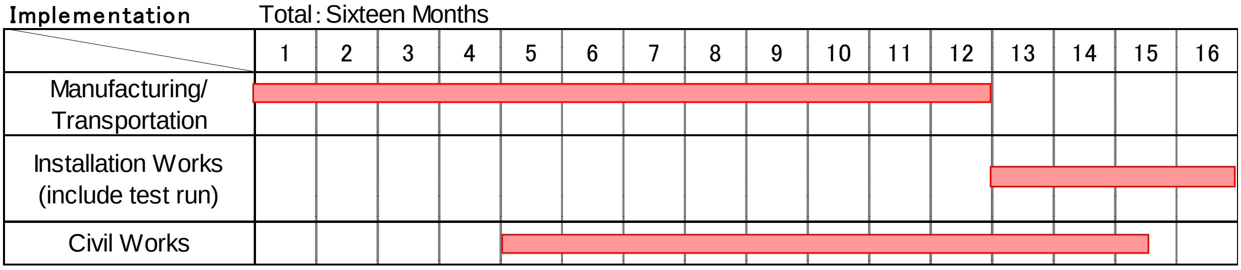
Based on the grant aid scheme of Japan, a preliminary implementation schedule is drawn up as shown below.

Table 2-2-24 Implementation Schedule

Pre-Implementation Total : Seven Months



Implementation Total : Sixteen Months



2-3 OBLIGATIONS OF RECIPIENT COUNTRY

The scope of the works to be undertaken by the Recipient Country is as follows.

Table 2-3-1 Obligations of Honduras Side and Allocation of Responsibilities

	Obligations	Allocation of Responsibilities
1	Acquisition and free provision of land necessary for the project	SANAA
2	Acquisition and free provision of land necessary for the temporary works and land clearance	SANAA
3	Provision of waste disposal sites	SANAA with Tegucigalpa Municipality
4	Maintenance of roads outside of the sites	SANAA with Tegucigalpa Municipality
5	Provision of free water for construction works	SANAA
6	Bearing of commissions applied by the bank in Japan for banking services based upon the Bank Arrangement (B/A) (ex; Payment of bank commission)	SANAA
7	Application and acquisition of permits and licenses required for the construction works	SANAA with relevant institutions and Tegucigalpa Municipality
8	All expenses and prompt execution of unloading and customs clearance at the port of disembarkation in the recipient country	SANAA
9	Accommodating of Japanese nationals and/or nationals of third countries, including persons employed by the agent whose services may be required in connection with the components such facilities, as may be necessary for their entry into the recipient country and stay therein for their works	SANAA
10	Ensuring that customs duties, internal taxes and other fiscal levies that may be imposed in the recipient country with respect to the purchase of the components and to the employment of the agent will be exempted by the Government of recipient country	SANAA with relevant institutions
11	Proper and effective maintenance and use of the facilities that are constructed and the equipment that is provided under the Grant	SANAA
12	All expenses, other than those covered by the Grant and its accrued interest, necessary for the purchase of the components as well as the agent's fees.	SANAA
13	Environmental and social considerations for the Program	SANAA with relevant institutions

2-4 PROJECT OPERATION PLAN

2-4-1 Basic Policy

The Concepcion and Picacho Small-scale Hydroelectric Power Plants are to be remotely operated by a control system consisting of the supervisory control and data acquisition system to be installed in the relevant water treatment plants, respectively. In order to operate the small-scale hydroelectric power plants sustainably into the future without interruption to the present water distribution operation, proper operation and maintenance of the turbine, generator and electrical equipment is essential.

To prolong the service-life of the turbine, generator and electrical equipment of the small-scale hydroelectric power plants and reduce repair costs, it is necessary to perform preventive maintenance such as daily patrol inspections and periodic inspections to evaluate the degree of deterioration of the turbine, generator and electrical equipment, and parts replacement.

In addition, safety management and emergency measures must be carefully considered from the standpoint of risk management during accidents. It is important to have in place an emergency contact system for accident response.

2-4-2 Operation and Maintenance Plan

The organization of SANAA and the organizations of the Concepcion and Picacho Water Treatment Plants are shown in Fig. 2-4-1 to Fig. 2-4-3, respectively. SANAA has abundant experience with the maintenance and management of water treatment plants and has mechanical and electrical engineers and technicians. SANAA has a foundation for learning the technology of the hydroelectric power plants, and SANAA is proactive about technology transfers and technological learning in its organization, therefore it is believed possible to secure appropriate personnel for transferring technology for operating and maintaining the hydroelectric power plants.

In order to operate the Concepcion and Picacho Small-scale Hydroelectric Power Plants, four (4) operators for each plant and two (2) maintenance satff, for a total of ten (10) persons, are to be assigned. They are to receive support in conjunction with the maintenance departments of the water treatment plants of the metropolitan division. The operation and maintenance organization (draft) of the Concepcion and Picacho Hydroelectric Power Plants is shown in Fig. 2-4-4.

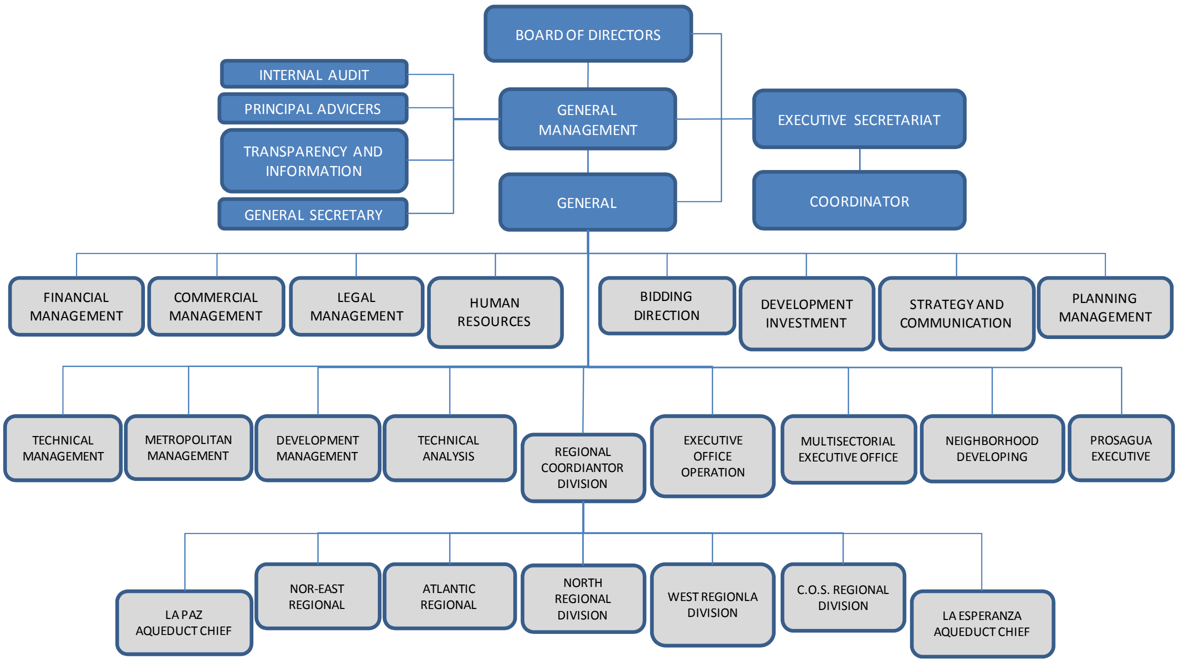


Fig. 2-4-1 Organization of SANAA

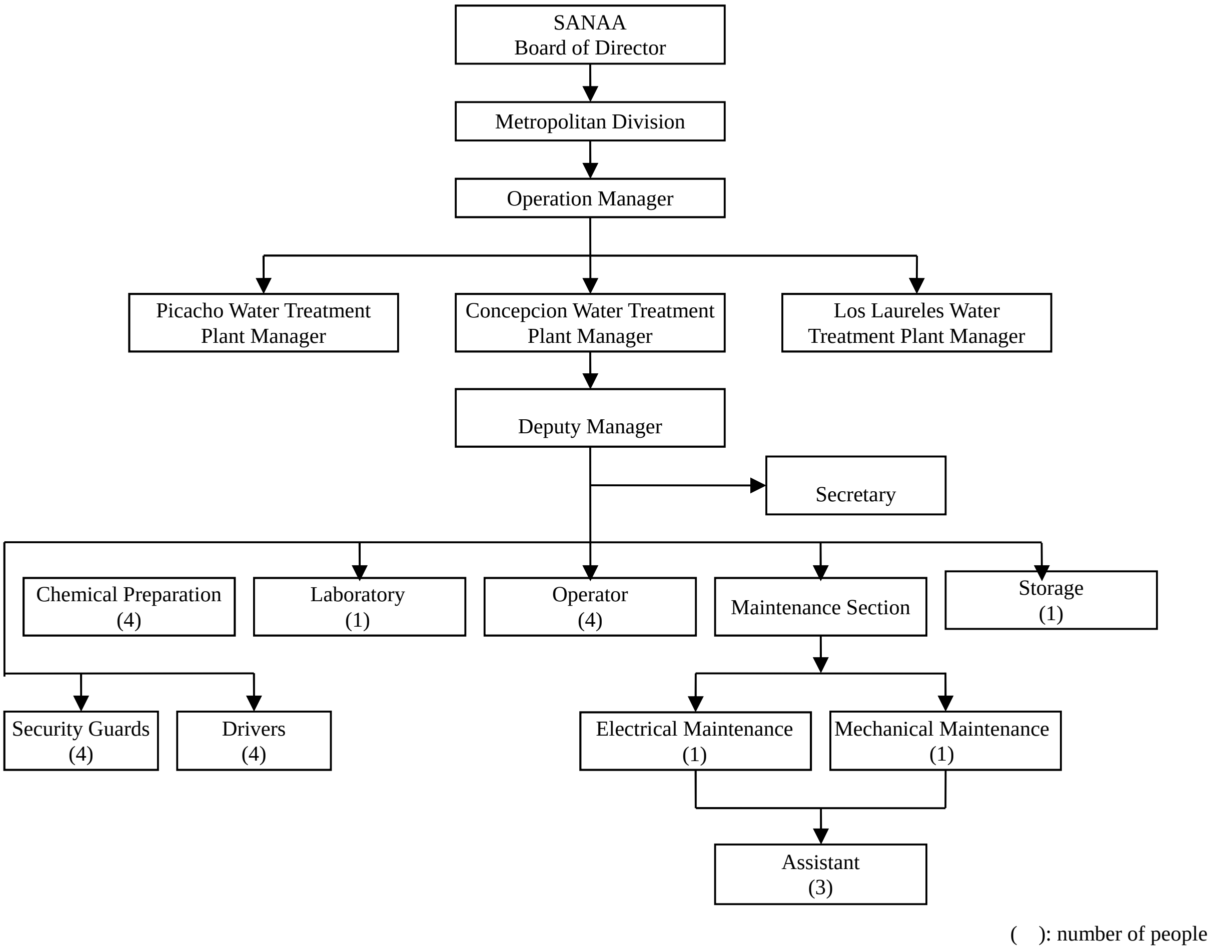


Fig. 2-4-2 Organization of Concepcion Water Treatment Plant

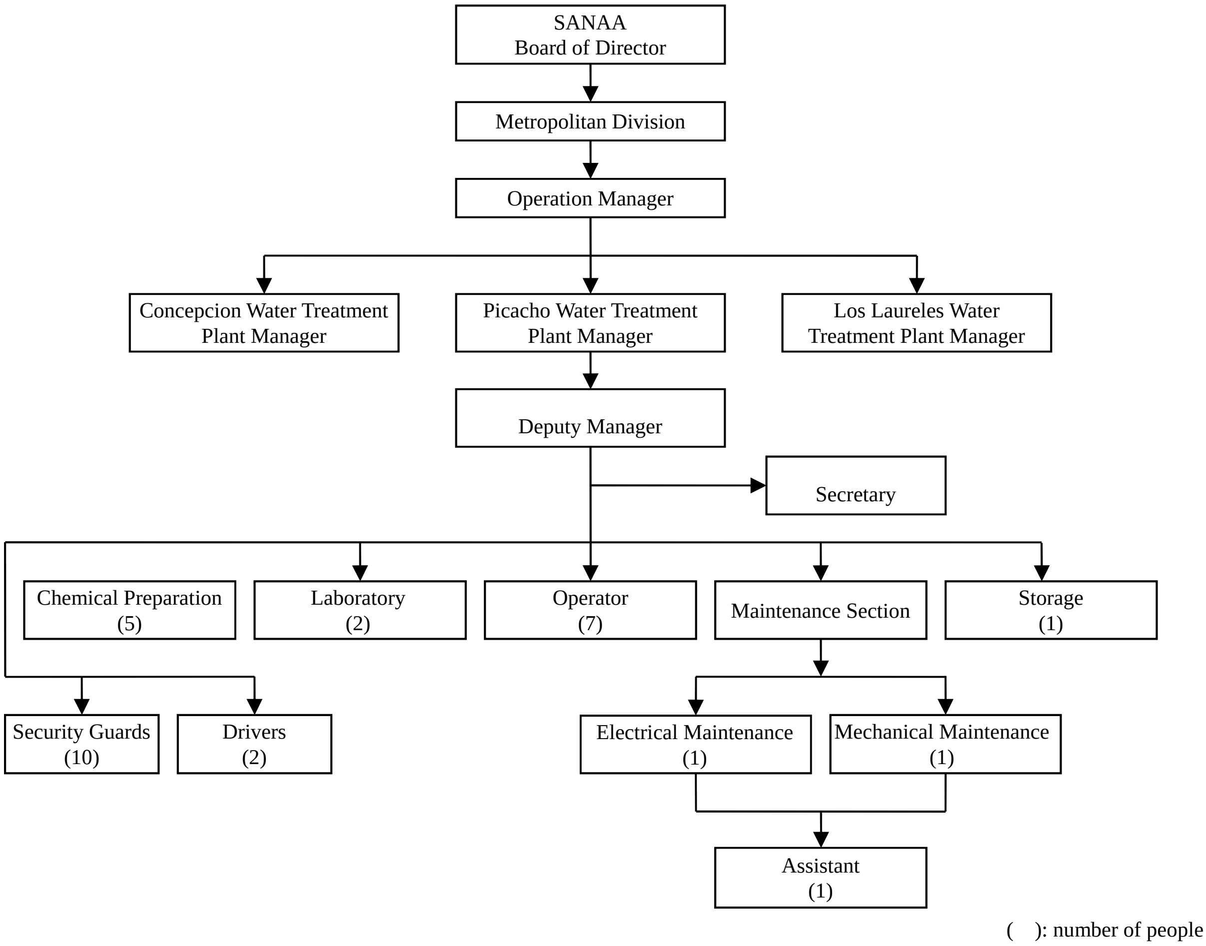


Fig. 2-4-3 Organization of Picacho Water Treatment Plant

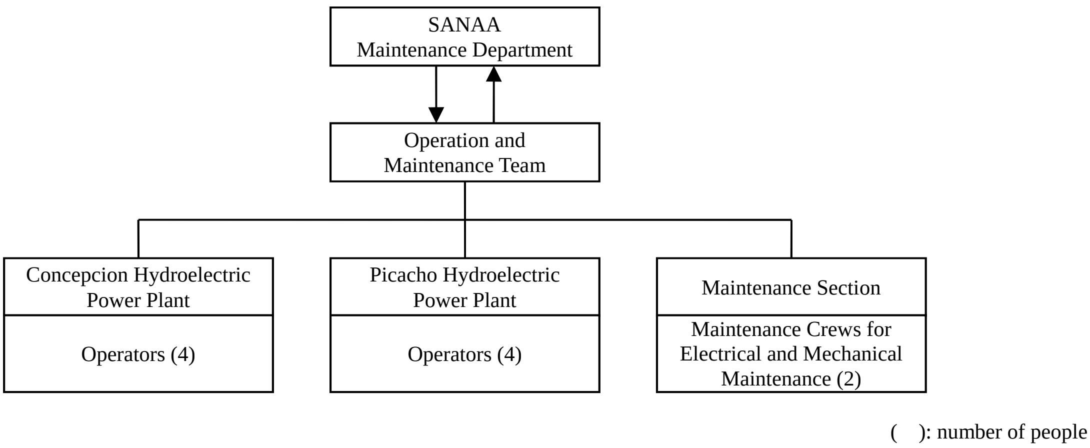


Fig. 2-4-4 Organization of Hydroelectric Power Plants

2-4-3 Control Items of Maintenance Activities

Overviews of the daily and periodic inspections as stated in the basic policy are provided below. The operation and maintenance activities for the existing water treatment plant facilities are to be performed by SANAA in a conventional manner. It is noted that SANAA should coordinate with the water treatment operation and maintenance teams on safety management and emergency measures during accidents and also share with ENEE safety management and emergency measures for the distribution lines as well.

(1) Daily Patrol Inspection

The daily patrol inspection is carried out every day in order to discover any abnormalities or signs of trouble with the turbine, generator and electrical equipment.

The daily patrol inspection can easily discover abnormal noise, vibrations, heat, and water, oil leaks, etc. in the turbine, generator and electrical equipment by visual, hearing and smell inspections. The daily patrol inspection is normally carried out one time/day by using the daily patrol inspection record book. Detailed inspections are performed if an abnormality is detected.

(2) Periodic Inspection and Deterioration Diagnosis

The periodic inspection is an inspection to be performed within a specified period. It serves to monitor damage, corrosion and wear in the turbine, generator and electrical equipment in order to prepare maintenance plans, repairs, etc.

The periodic inspection and the deterioration diagnosis are proposed to be carried out every three (3) years basically.

Table 2-4-1 Periodic Inspection and Deterioration Diagnosis

<table>
<tr><th colspan="2">Daily Patrol Inspection</th><th colspan="3">Periodic Inspection and Deterioration Diagnosis</th></tr>
<tr><th>Facility</th><th>Frequency</th><th>Facility</th><th>Item</th><th>Frequency</th></tr>
<tr><td rowspan="3">Turbine, Generator and Electrical Equipment</td><td rowspan="3">1 time/day</td><td rowspan="3">Turbine, Generator and Electrical Equipment</td><td>Periodic Inspection</td><td rowspan="2">1 time/three years</td></tr>
<tr><td>Deterioration Diagnosis</td></tr>
<tr><td>Detailed Inspection</td><td>When an abnormality is detected</td></tr>
</table>

(3) Overhaul

Target of overhauls of the turbine and valves is shown in Table 2-4-2.

The occurrence of cavitation or wear due to hard sediment transport in the turbine and valves are observed by overhaul to be done after one (1) year of service operation. On the basis of this result, the specific frequency and detailed inspection items of the overhaul are considered.

Table 2-4-2 Overhaul of Turbine and Valves

Item	Frequency
Overhaul after Operation	One (1) year after operation
Overhaul	1 time/10 years

(4) Procurement Plan for Spare Parts

As the policy on spare parts procurement, spare parts that are require replacing on a regular basis (every 5 to 10 years) and stocking so that operation of the power generation facility can continue without failure are to be procured with electro-mechanical equipment.

Parts that may require replacing on a regular basis are valve seals and turbine shaft water seal packing. The frequency of replacement is about every 5 to 10 years depending on operating hours, water quality, water pressure. etc. If spares are used in the repair work, it is necessary to purchase and keep them for future maintenance. SANAA is responsible for the replenishment of necessary spare parts.

Although the failure rate of generation equipment depends on generating hours, conditions of the installation site, frequency of lightning accidents within the electric power system and so on, if the equipment is damaged, it takes a very long time to receive replacement parts from the manufacturer (supposing Japanese small and medium manufacturer) once ordered as this includes order processing, manufacturing, delivery, etc. Therefore, power generation can be shut down for a very long time. In order to avoid such long interruptions, spare parts that may be damaged prior to overhauls scheduled ten (10) years after generation starts must be procured and kept in stock in advance.

Based on the above policy, the following table shows the spare parts to be delivered in this Project.

Table 2-4-3 List of Spare Parts

	Name	Quantity	Remarks
Concepcion Hydroelectric Power Plant			
1. Turbine	Bearings	1 set	
	Shaft water seal packing	1 lot	
	Packing	1 lot	
2. Generator	Bearings	1 set	
3. Control and Switchgear	Protection relay	1 set	
	Auxiliary relay	1 Set	
Picacho Hydroelectric Power Plant			
1. Turbine	Bearings	1 set	
	Shaft water seal packing	1 lot	
	Packing	1 lot	
2. Generator	Bearings	1 set	
3. Control and Switchgear	Protection relay	1 set	
	Auxiliary relay	1 Set	

2-4-4 Medium- and Long-term Monitoring and Maintenance Plan

The lifetime of the turbine and generator, which are the main pieces of equipment of the hydroelectric power plants, is estimated to be more than 20 years, and the battery is estimated to last about 10 years. The lifetime of the turbine is greatly affected by the occurrence of cavitation and wear due to transport of hard sediment in the turbine.

The actual lifetime of the equipment depends on the status of implementation of periodic inspections, frequency of parts replacement, and daily maintenance practices. If proper maintenance is not performed, not only do defective parts require replacing but also new equipment. As a result, this can incur great expense. Therefore, the results of appropriate daily patrol inspections and periodic inspections as well as the evaluations of the deterioration diagnosis are important. In addition, continuous recording of maintenance information such as operating hours, the contents and repair history of failures, and their evaluations are essential to help in the development of more effective maintenance planning.

SANAA will ask technical assistance of ENEE in operating and maintaining the hydroelectric power plants and distribution line facilities. Furthermore, it is assumed that the operation and maintenance team carries out monitoring on a regular basis and reports the monitoring results to ENEE and Japanese side.

2-5 PROJECT COST ESTIMATION

2-5-1 Initial Cost Estimation

(1) Cost of Honduras Side

Project costs covered by the Honduras side are estimated as follows.

Item	Amount (Lps.)	JPY Equivalent (Million JPY)	Remarks
Acquisition of lands	3,281,000	Approx. 13.4	Concepcion Site 1,382 m^2 Picacyo Site 604 m^2
Diversion of existing pipelines at proposed location of powerhouse at Picacho Site	160,000	Approx. 0.7	Pipe Diameter: 150 mm, Steel Pipe length: 48 m
Cost of banking services, B/A and A/P	240,000	Approx. 1.0	0.1% of total project cost
Total	3,678,000	Approx.15.1	

(2) Condition of Calculation

1) Time of calculation — August, 2012
2) Exchange rate of foreign currency — 1 US$ = 81.09 JPY, 1 Lps.=4.1798 JPY
3) Time of the event — Referred to Fig. 2-2-24
4) Remarks — The cost calculations are conducted according to the methods applied to Japan's Grant Aid Programs.

2-5-2 Operation and Maintenance Costs

SANAA has abundant experience with the maintenance and management of water treatment plants and has mechanical and electrical engineers and technicians. Therefore, there shouldn't be any problems establishing an organization with the required staff for the hydroelectric power plants.

Since this Project is implemented within the framework of grant aid, the initial costs, such as the construction, procurement, installation costs and so on, is granted. The effect of reducing electricity bills is estimated to be approximate 5.8 million Lps. per year because the generated energy by both hydroelectric power plants will be sold to ENEE. While necessary expenses for operation and maintenance of the power plants, which consists of the personnel costs of operators and maintenance staff, spare parts costs, consumables costs, overhaul costs for the turbine and generator (every 10 years), and so on, is estimated around 2.0 million Lps. per year. Therefore, the expenses can be covered by the estimated cost reduction from selling electricity to ENEE. In addition, the remaining amount can be utilized to improve SANAA's financial condition.

(1) Personnel Costs

As shown in Section 2-4 Project Operation Plan, four (4) operators for each hydroelectric power plant and two (2) maintenance staff, for a total of ten (10) persons, would be assigned as shown in Fig. 2-5-1 and Table 2-5-1.

Therefore, the estimated personnel cost is around 1.92 million Lps. per year (160,000 Lps./person × 12 month × 10 persons, equivalent to around 7.8 million JPY).

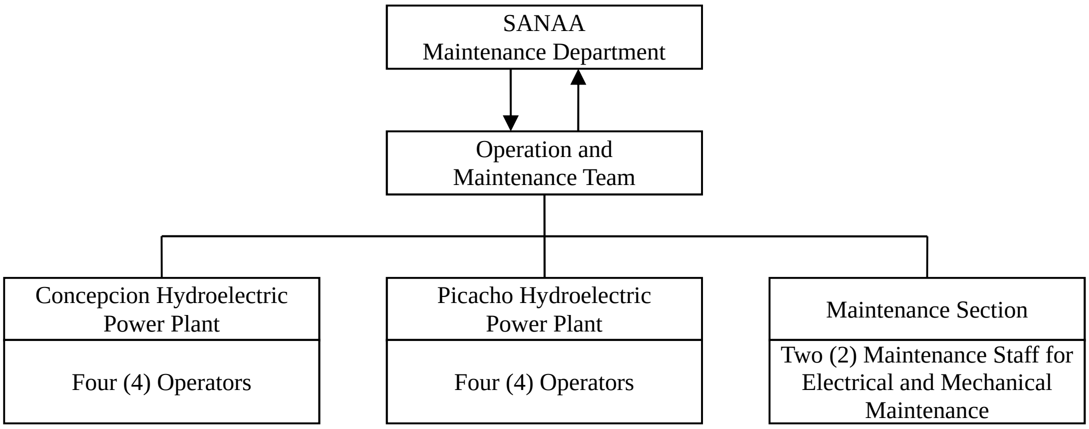


Fig. 2-5-1 Organization of Operation and Maintenance Team (Draft)

Table 2-5-1 Manpower of Operation and Maintenance for Hydroelectric Power Plants

Function		Persons	Main Activities
Manager of Maintenance Department		1	Making major decision
Team Leader (Chief Engine)		1	Detailed study of equipment management policy based on the background of the facilities
Operators	Electrical Technicians	8	Daily operation
Maintenance Staff	Electrical Technicians	2	Daily inspection and maintenance

(2) Purchase Costs of Spare Parts

The spare parts that require replacing on a regular basis are valve seals and turbine shaft water seal packing. This cost is estimated at Lps.25,000 per year (100,000 JPY/year).

(3) Other Direct Costs (Consumables)

Consumables such as printer cartridges for the printers in the control system, grease for the generator and office supplies are estimated at Lps.12,000 per year (approx. 100,000 JPY/year).

(4) Overhaul Costs, etc.

The overhaul of the turbine and the generator every ten (10) years would be implemented by the manufacturer's engineers. The replacement of the turbine water seal packing and the valve seals is assumably to be done during the overhaul.

The estimated overhaul cost is Lps.737,000/overhaul (about 3,000,000 JPY/overhaul) including the costs of dispatching the manufacturer's engineers and spare parts such as the turbine water seal packing and valve seals.

CHAPTER 3

PROJECT EVALUATION

CHAPTER 3 PROJECT EVALUATION

Preconditions for project implementation are described in Chapter 2-3 Obligations of Recipient Country. Major conditions are listed as follows.

3-1 PRECONDITIONS

(1) Land Acquisition

The Concepcion powerhouse shall be built in an open space of approximate 604 m^2 (30.5 m x 19.8 m) adjacent to the existing aerator. SANAA has already started negotiating acquisition with the owner, and expects to secure it upon E/N conclusion under the 2013 year budget. A newly constructed pipeline of around 3 km does not require land acquisition, since the buried-pipe route is along a municipality road.

The Picacho powerhouse is planned to be constructed in an open space of the slope of approximate 1,381 m^2 (including around 47 m long the access road). SANAA has already started negotiations with land owners for acquisition, and expects to secure the land at the same time as the land for the Concepcion powerhouse.

(2) Environment Approval

Under Honduran laws, this project to build a small-scale hydroelectric power plant of less than or equal to 3 MW belongs to Category 1, for which the environmental impact is small or negligible.

Furthermore, the site is located outside of the protected area and requires no resettlement because the dam and reservoir do not need to be constructed since the existing water treatment facilities can be utilized. Application form F0-1, which contains only a general project description, critical items of the environment and signatures of approval by land owners, is required for SERNA’s approval, in the case of Category 1. No environmental study is required, and SERNA approves in 15 days. Documents on the environment are to be submitted after conclusion of E/N.

(3) Tax Exemption Procedure

SANAA, as the implementing agency, is in charge of tax exemption procedures for customs duties and VAT levied under the Project. SANAA shall take into consideration tax exemptions and custom clearance with tax free handling during inland transportation from Port Acajutla, El Salvador where the main goods are assumed to be unloaded from Japan, to the construction sites in Honduras. SANAA shall obtain beforehand the approval from the Diet of the Government of Honduras for provisional legislation regarding tax exemption.

(4) Construction Permission

The Contractor shall obtain construction permission from Tegucigalpa City before commencing work, and environmental approval as well.

(5) Power Generating Operation License, etc.

Electricity generated at both power plants is to be sold to ENEE. In settling accounts between

SANAA and ENEE, a part of the due electricity payment to ENEE shall be written off as an electric power credit. The electricity buying rate by ENEE is reviewed once a year, and new rates shall be fixed with a 10% of renewable energy incentive added. The rate for 2012 is 0.13695 US$/kWh.

Grid interconnection negotiations are required between SANAA and ENEE, since electricity will be supplied to ENEE through existing distribution lines adjacent to each powerhouse, by means of interconnection. These negotiations are planned to be held at the time of drawing approval during the construction stage. SANAA and ENEE had a preliminary meeting on this matter during the preparatory study.

(6) Other Scope of SANAA

SANAA shall remove existing exposed water supply pipe from construction site of the Picacho powerhouse before starting the Project.

3-2 NECESSARY INPUTS BY RECIPIENT COUNTRY

(1) Securing of Operation and Maintenance Cost and Staffs

After completion of the Project, ownership and management of the hydroelectric power plants and a part of the water supply and sewerage services are to be transferred to Tegucigalpa City from SANAA. Thereafter, Tegucigalpa City and SANAA are responsible for proper budget allocations for O & M costs and assignment of O & M staff.

(2) Environmental and Social Considerations

The powerhouse buildings are designed considering noise prevention measures because both powerhouse building sites are surrounded by residential areas. Turbine design has been conducted so that no deterioration of water quality occurs. After completion of the Project, noise and water quality during power discharge is to be periodically monitored by SANAA.

3-3 IMPORTANT ASSUMPTIONS

Important assumptions for ensuring the benefits and sustainability of the Project are as follows.

- Serious damage to hydroelectric power and distribution facilities will not be caused by large-scale natural disasters, political turmoil, etc.

- A steady volume of raw water from the reservoir dam and treated water from the water treatment facility will be secured without any impact by malfunction or shutdown of the facilities or any decrease in intake water due to climate change.

- No power distribution stoppage will occur due to troubles, breakdown of ENEE distribution line facilities or transformer equipment of the powerhouse.

- A reasonable electricity selling rate will be ensured and necessary expenses for operation and maintenance works will not run up costs.

3-4 PROJECT EVALUATION

3-4-1 Relevance

The relevance of the Project is described below.

- The Project meets the development policy of Honduras: to secure energy and control the greenhouse gas emission of Honduras, which depends on imported fossil fuel (mainly oil) for power generation for nearly 60 % of the total power output (1,579 MW), by introducing small-scale hydroelectric power generation that is domestic renewable energy, less of a burden on the environment and society, and constructed in a short amount of time.

- The Project aims to mitigate the environmental impact on climate change by improving energy efficiency and promoting renewable energy, and is positioned by Japan as a climate change measure for development cooperation with Honduras.

- The Project meets the policy of the Government of Japan, which is to support promotion of “green growth” in developing countries by means of its enhanced technology in the field of new energy.

- The financial condition of SANAA should improve by selling the surplus electricity to ENEE as this should cover the operation and maintenance cost of hydroelectric power facilities.

3-4-2 Effectiveness

(1) Quantitative Effects

1) Generated Energy at Power Generating End

The annual average generated energy of the Concepcion Hydroelectric Power Plant is calculated using daily dam water level and daily intake flow from the dam from 2006 to 2011. On the other hand, the annual generated energy of the Picacho Hydroelectric Power Plant is estimated based on the actual flow measurement data obtained in the site survey and information from SANAA, since the actual flow records on the L22 pipeline are not available.

2) Reduction of CO_2 Emissions

The CO_2 reduction coefficient of the present domestic electric power system in Honduras is shown in the following table. A reduction coefficient of 391 g/kWh is used to calculate the CO_2 emissions reduction of the Project.

Table 3-4-1 CO_2 Reduction Coefficient

(Unit : g CO_2 / kWh)

	2007	2008	2009	Average for 3 years
Average of all fuels	418	409	344	391
Fuel oil	670	661	627	653

(Source: CO_2 EMISSIONS FROM FUEL COMBUSTION-Highlight, 2011 Edition, IEA)

3) Electricity Rate Reduction

The electricity rate reduction is calculated using the electricity buying rate of 0.13695 US$/kWh (inclusive of 10% incentive for renewable energy) for small-scale hydroelectric power generation in 2012. The due amount of the electricity bill to ENEE will be reduced as an electricity credit secured by SANAA.

Target figures on quantitative effects are shown in the table below.

Table 3-4-2 Quantitative Effects

Indicator	Baseline figure (Year 2012)	Target figure (Year 2018) [3 years after Project completion]
Generated energy at the power generating end (MWh/year)	-	1,650 MWh/year (Concepcion HEP) 520 MWh/year (Picacho HEP)
Reduction of CO_2 emissions (ton/year)	-	645 t/year (Concepcion HEP) 203 t/year (Picacho HEP)
Electricity rate reduction (US$/year)	-	225,967 US$/year (Concepcion HEP) 71,214 US$/year (Picacho HEP)

(2) Qualitative Effects

The qualitative effects are as below.

- Promotion of renewable energy utilization is expected, which should contribute to advanced socio-economic development and a reduction in greenhouse gas emissions.

- This project is expected to promote renewable energy by utilizing unutilized energy of the existing water treatment facilities, which is the first such pilot project in Honduras.

- Water supply service is expected to improve because the huge electricity consumption by pump operation, water treatment, etc., which places enormous financial burden on SANAA, will be reduced.

- Diversification of electric power supply sources in Honduras is expected.