# CHAPTER I INTRODUCTION

## 1.1 General

### 1.1.1 Background

In response to the request of the Government of the Republic of the Philippines (hereinafter referred to as "the Government of the Philippines" or "GOP"), the Government of Japan has decided to carry out "the Study on Water Resources Development for Metro Manila in the Republic of the Philippines" (hereinafter referred to as "the Study"), in accordance with the relevant laws and regulations in force in Japan. At the official request of GOP, Japan International Cooperation Agency (hereinafter referred to as "JICA"), responsible for the implementation of the technical cooperation of the Government of Japan, dispatched a Preparatory Study Team from November 28 to December 22, 2000 to discuss and determine the Implementing Arrangement for the Study. During the stay in the Philippines, the Preparatory Study Team had a series of discussions with the authorities concerned of GOP, in particular, with the National Water Resources Board (hereinafter referred to as "NWRB"), to conclude the Implementing Arrangement.

In March 2001, JICA determined to entrust the Study to a joint venture of Nippon Koei Co., Ltd. and NJS Consultants (hereinafter referred to as "the JICA Study Team").

On the part of GOP, NWRB acts as a counterpart agency for the JICA Study Team and also as a coordinating body in relation with the relevant governmental and non-governmental organizations concerned for smooth implementation of the Study. For supervising the study activities, NWRB organized a Steering Committee and a Technical Committee, both of which are composed of representatives from the concerned agencies. NWRB also nominated counterpart personnel to coordinate closely with the JICA Study Team. Tables 1.1, 1.2 and 1.3 show the list of the Committees members, Technical Working Group members and Counterpart personnel, respectively.

The JICA Study Team was assigned to the Philippines on March 31, 2001 to carry out the 1st Field Investigation Work for a period of about 4.5 months towards August 22, 2001. As outcomes from the 1st Field Investigation Works, the JICA Study Team submitted the Progress Report (1) to NWRB, which contains the findings of field investigations and also various study results including the preliminary formulation of alternative development plans. The 1st Field Investigation ended on 22nd August 2001 when all members of the JICA Study Team left the Philippines.

In the middle of September 2001, the JICA Study Team commenced the 1st Home Office Work in accordance with the original work schedule. This Report has been prepared, based on all the results of investigations and studies performed in the Phase I consisting of the 1st Field Investigation and 1st Home Office Work.

### 1.1.2 Objectives of the Study

The objectives of the Study are:

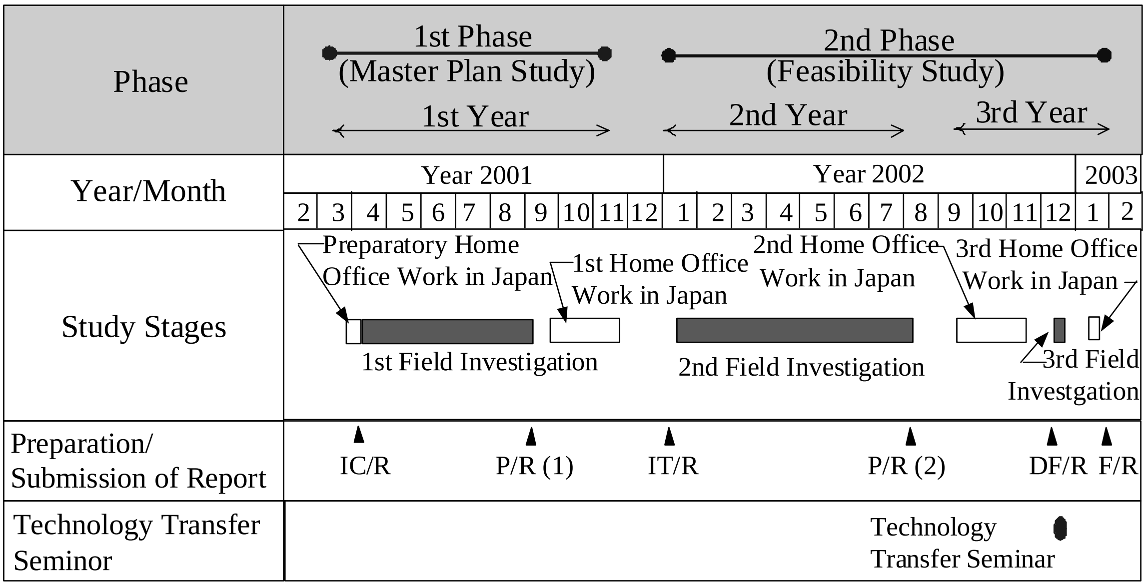
- To formulate a master plan on water resources development in the Agos River Basin (including Kanan and Kaliwa River Basins) to supply domestic/ municipal and industrial water to Metro Manila,
- To conduct a feasibility study on the priority project(s) which will be selected from the master plan,
- To carry out technology transfer to Philippine counterpart personnel in the course of the Study.

### 1.1.3 Study Area

The Study area is Metro Manila/MWSS service area and the Agos River Basin including the Kanan and Kaliwa River Basins.

### 1.1.4 Overall Work Schedule of the Study

The Study will be carried out dividing the work period into two phases, namely Phase I: the Master Plan Study (M/P) spanning between March 2001and November 2001, and Phase II: the Feasibility Study (F/S) on selected priority project spanning between January 2002 and November 2002.




IC/R: Inception Report    P/R: Progress Report    IT/R: Interim Report
DF/R: Draft Final Report    F/R: Final Report

Note: The above shows the schedule envisaged as at January 2002. Actually, the completion of the Study had to be postponed till March 2003 due to longer period required for the 2nd field investigation work. See chapter I of Volume IV for the actual work progress achieved.

**Overall Work Schedule of the Study**

In line with the above overall schedule, this Volume II (originally prepared as the Interim Report) has been prepared to describe the study results of the Phase I Study carried out in 2001.

## 1.2 Progress of Phase I Study

### 1.2.1 Activities during the First Field Investigation Stage (March-August 2001)

(1) Explanation and Discussion of Inception Report

After arrival of the JICA Study Team in the Philippines, the JICA Study Team submitted 30 copies of the Inception Report to the National Water Resources Board (NWRB), the Counterpart Agency for the Study, on April 3, 2001. The JICA Study Team had a preliminary discussion on the Inception Report with Executive Director and Counterpart Staff of the NWRB on the same day. Subsequently, NWRB delivered copies of the Inception Report to the member agencies of the Steering Committee by the middle of April 2001. The members of Steering Committee and Technical working Group for the Study are listed in Tables 1.1 and 1.2, respectively.

The Steering Committee Meeting for the explanation of and discussion on the Inception Report was held at the conference room of at NIA DCIEC Building in Quezon City on April 19, 2001. The Meeting discussed the Inception Report in sufficient detail. As a result, the approaches and methods for the Study proposed in the Inception Report were in principle accepted by the Steering Committee.

(2) Field Reconnaissance

The JICA Study Team carried out field reconnaissance surveys to acquire necessary information on the field, with assistance of the Counterpart Personnel. A constraint was the difficulty of access to the Kanan River upstream reaches due to security problem. This compelled the JICA Study Team to gather the relevant information on the Kanan River Basin from aerial-photograph interpretation and also from the previous survey reports. There were no major security problems for access to the Agos River reaches and the Kaliwa River middle-lower reaches.

(3) Field Investigation on Subcontract Basis

The JICA Study Team conducted the following two investigation works by subletting to local survey firms:

(a) Hydrological Investigation Works

The hydrological investigation works consist of four activities: i.e. (i) installation of three (3) new stream flow gauging stations, one each at Agos, Kaliwa and Kanan Rivers, (ii) discharge measurements at the three stations, (iii) river water sampling and laboratory tests for suspended sediment load analysis, and (iv) river water sampling and laboratory test for water quality analysis. The contract was signed on May 5, 2001 and the work continued up to August 2001. The details of the work carried out are described in “Part-C: Hydrology” of the Supporting Report.

(b) Initial Environmental Examination (IEE)

In view of the importance of environmental aspects to be examined in the Study, the IEE survey was carried out at the 1st Field Investigation stage by subletting it to a local survey firm. The contract for the work was concluded on May 31, 2001. The main objective of the survey was to delineate potential environmental problems and issues that may be relevant to dam development and water conveyance plans conceived at the initial stage of 1st Field Investigation. The IEE attempted to define the screening and scoping of the potential environmental issues for each of the alternative development schemes.

(4) Study Works in the JICA Study Team's Office in Metro Manila

The JICA Study Team visited various agencies to collect the necessary data and information relevant to the Study. Based on data and information collected, the JICA Study Team carried out preliminary analytical and planning studies during the 1st Field Investigation. The main activities in the JICA Study Team's Office of Metro Manila are socio-economic studies, water demand projection, hydrological analyses, geological assessment, plan formulation studies, preliminary design and cost estimate, and socio-environmental studies. The results of the studies are presented in the Progress Report (1) submitted to NWRB in the middle of August 2001.

(5) Explanation and Discussion of Progress Report (1)

After the submission of the Progress Report (1) to NWRB, the Steering Committee Meeting was held in a conference room of Building of MWSS on 20th August 2001 to discuss the contents of the Progress Report (1) and the interim results of comparison study for 6 alternative development schemes (Development Scenario A to F). While the Steering Committee accepts those outcomes of the 1st Field Investigation described in the Progress Report (1), the Steering Committee members from MWSS requested the JICA Study Team to examine the following two additional alternative development schemes in the subsequent 1st Home Office Work in Japan:

- Development Scenario G : Kaliwa Low Dam + Laiban High Dam + Agos Dam
- Development Scenario H : Laiban Dam + Kanan No.2 Dam

On the other hand, the JICA Study Team asked MWSS to determine and notify to the JICA Study Team the basic policy on implementation of the Laiban Dam and interim water supply projects including 300 MLD Bulk Water Supply Project (Laguna Lake Development Project) by October 2001.

### 1.2.2 Supporting Works Undertaken by NWRB

Concerning the 3 new streamflow gauging stations installed in the Agos River Basin during the 1st Field Investigation, NWRB has continued their proper operation and maintenance since the JICA Study Team left the Philippines on 22nd August 2001.

### 1.2.3 First Home Office Work (September-November 2001)

The 1st Home Office Work in Japan continued for about 2 months from the middle of September to the middle of November 2001. During the period, the JICA

Study Team examined the additional development scenarios (Development Scenarios G and H) in response to the request of MWSS raised at the Steering Committee meeting on 20th August 2001 and submitted to MWSS in September 2001 a brief explanation paper which summarizes the results of preliminary comparison study on a total of 8 alternative development scenarios.

The main study works undertaken by the JICA Study Team during the 1st Home Office Work were as follows:

- Further refinement of the findings presented in the Progress Report (1)
- Preparation of a master plan for the water resources development of the Agos river basin
- Evaluation of the proposed master plan from a viewpoint of economic, technical and social aspects
- Selection of priority project(s) which will be taken up for the feasibility study

On the basis of the results of the study works performed in the 1st Home Office Work, this Report (Volume II) was prepared in the middle of November 2001 as was originally scheduled.

## 1.3 Master Plan Study Reports

This Volume II summarizes the results of the Master Plan Study in the Phase I, which was conducted for about 9 months conducted from March 2001 to November 2001.

The Master Plan Report is composed of a Main Report (Volume II) and a Supporting Report (Volume III). The Main Report describes the essential parts of the Study outcomes obtained in the Phase I, while the Supporting Report presents the results of the respective disciplines in detail.

In the Phase I study of 2001, all the study results were based on the available data/information derived mainly from the previous studies and through site reconnaissance survey without any in-situ physical field investigation works. The contents and conclusion presented in the Master Plan Reports will be further refined, based on the results of the subsequent feasibility study in the Phase II, in which the detailed field investigation and survey works will be carried out as may be required.

## 1.4 Necessity of Water Resources Development in the Agos River Basin

### 1.4.1 General

MWSS has long conceived the Agos River Basin as a promising water resource to meet the future water demand of Metro Manila since 1970's as represented by the Studies on the Laiban Dam Project on the Kaliwa River under Manila Water Supply Project III (MWSP III), while hydropower development plans on the Kanan River and Agos Mainstream were proposed by NPC independently of the MWSS's water supply plan. Although the Laiban Dam Project has proceeded to detailed design and some structures including diversion tunnel were already constructed in the 1980’s, further implementation has been suspended so far due to the difficulty in solving the social problems attributed to resettlement of people residing in the reservoir area.

On the other hand, the water demand of Metro Manila is constantly increasing owing to the rapid economic growth as well as population increase in Metro Manila. Since a relatively long period, say around 10 years or more, is required for realization of water resources development, a large-scale water resources development needs to be commenced at the earliest opportunity. The previous studies concerned with water supply to Metro Manila have revealed that the Agos water resource is the only large-scale and bulk water supply source exploitable for the purpose of water supply to Metro Manila to meet the future water demand.

This Section explains the critical situation of water demand and supply balance in Metro Manila, the national policy on water supply for Metro Manila, and the background of the priority of the Agos water resources development for the purpose of water supply to Metro Manila, so as to justify the necessity for water resources development of the Agos River Basin.

### 1.4.2 Present Situation of Water Demand and Supply Balance in Metro Manila

The current water shortage in Metro Manila is compounded by the high increase of water demand on account of rapid growth of the economy and population and also by the occurrence of unusual climatic conditions like El Nino, as experienced in 1997 and 1998. The damage to the economy due to water shortage should not be allowed particularly in Metro Manila, the capital of the Country.

Currently, 11 million residents of the capital city and many industries still suffer from water rationing. Due to limited supply of water, private extraction of groundwater has become extensive. The uncontrolled extraction of groundwater has caused depletion of aquifers and intrusion of saline water in some areas. According to the findings in the Master Plan Study on Water Resources Management in the Republic of Philippines (JICA, 1998), Metro Manila is one of the identified water critical areas in the country.

The present water demand of Metro Manila in 2001 is estimated in this Study to be 3,660 MLD in day average volume as discussed in Chapter II. The water is almost all supplied from the existing Angat reservoir (35 $m^3$/sec) with augmented flow from Umiray-Angat transbasin tunnel (9 $m^3$/sec), which has a total yield capacity of about 3,700-3,800 MLD. The capacity of water conveyance and treatment plant of the Angat water supply system is 4,000 MLD at the maximum operation. On the other hand, the present peak water demand of Metro Manila is derived to be at about 4,430 MLD taking into account the day peak demand ratio of about 21 % that is adopted in this Study. Accordingly, the present water supply capacity is already at a critical level, exceeding the day peak demand and thereby causing the water rationing. This situation shows the necessity for urgent realization of interim projects to meet the water demand till year 2010, provided that the demand after year 2011 can be met by water source development project in the Agos River Basin. The earliest attainable completion of the Agos water supply project is foreseen to be around the year 2010.

### 1.4.3 National Policy of Expansion of Water Supply Capacity for Metro Manila

The basic policy of the GOP on expansion of the MWSS's service area is clearly mentioned in the following two economic development plans prepared by NEDA.

(1) The Philippine National Development Plan (NEDA, 1998)

This Plan mentioned the future plan of Metro Manila water supply to be as follows:

"Targeted accomplishment between the Plan period 1999-2004 is presented in incremental number of population meant to be provided with the necessary facilities to avail the services needed. In water supply, MWSS is foreseen to extend its services to some 3.4 million people (incremental population to be served), while present population served is about 6.5 million in Metro Manila."

The above indicates the Government policy of expanding water supply coverage in Metro Manila, supported with the expansion of supply capacity by exploiting necessary water sources.

(2) Mid-Term Philippine Development Plan (NEDA, 2001)

The latest version of the Mid-Term Philippine Development Plan has not been publicized as of the middle of August 2001 (finalization stage at present). The JICA Study Team has received a partial information from NEDA with regard to the proposed plan of Water Resources sector.

According to the information obtained, the Mid-Term Plan envisages a drastic expansion of water supply coverage in Metro Manila. The total population directly served by MWSS through its two concessionaires as of December 2000 is 5.88 million or 44.12% of the 13.33 total population under the MWSS service area. The Plan foresees that MWSS will extend its services to cover 14.4 million people in 2004, which is 90% population of the total 16 million in 2004.

Although the Plan does not mention the program of water source development, the expansion of service coverage (increase of population served) apparently infers the need for development of water sources. The proposed Agos project is regarded as a water source exploitation scheme on the line of the water supply expansion program proposed in the national plan since the Agos River Basin is only the water source capable of meeting the growing water demand, as has been identified in the previous studies.

### 1.4.4 Prioritized Water Supply Projects for Metro Manila in Previous Studies

With the aforesaid expansion of the MWSS's service area as well as the accelerated economic growth, the average daily water demand of Metro Manila is projected to increase to 6,980 MLD or 1.9 times the present demand in year 2025, the target year of this Study. This implies that total water development requirement toward year 2025 is about 3,300 MLD in terms of average daily demand. This scale of source development will only be achievable, when the source development in relatively large river basin is made possible.

The following previous studies examined the main potential water resources around Metro Manila and recommended the Agos River Basin as the most favorable water resources to meet the long-term water demand:

i) Manila Water Supply III Project (MWSP III), Electrowatt Engineering Services, Ltd., December 1979

ii) Master Plan Study on Water Resources Management in the Republic of the Philippines (JICA, 1998)

The results of the above previous studies are summarized in the following paragraphs:

(1) Manila Water Supply Project III (MWSP III), Electrowatt Engineering Services, Ltd., December 1979

The study of Manila Water Supply Project III in 1979 identified the promising water sources in and around the Metro Manila area in order to meet the future water demand in Metro Manila and compared them from the economic and environmental aspects. Figure 1.1 shows the nine (9) water sources identified through the study, out of which the following seven (7) water sources of surface water were estimated to have a relatively large water supply capacity of more than 700 MLD.

- Kaliwa River Basin (Laiban Dam)
- Marikina River Basin
- Kanan River Basin (Kanan No.2 Dam)
- Umiray River Basin
- Pampanga River Basin
- Laguna Lake
- Taal Lake

As a result of the comparative study of the seven alternative water sources, the study finally proposed the development of water resources in the order of the Kaliwa River Basin, Kanan River Basin, Umiray River Basin and Laguna Lake in order to meet the water demand of Metro Manila over a long range.

Out of the above seven alternative water sources, water resources of the Kaliwa River Basin and Kanan River Basin that are situated in the Agos River Basin have not been exploited yet. On the other hand, water of the Umiray River Basin has been already developed through the completion of the Umray-Angat Transbasin Project and the water is now being conveyed to Metro Manila. With regard to the remaining four water sources, namely Marikina River Basin, Pampanga River Basin, Laguna Lake, and Taal Lake, it is no longer possible to develop a large-scale water resource for water supply to Metro Manila because of the environmental problems and issues and/or relatively high capital and O&M costs as explained in Table 1.4. In reality, the Laguna Lake scheme is planned to have only a water supply capacity of 300 MLD according to the latest development plan. Thus, the Agos River Basin is assessed to be the sole water source that enables to develop as a large-scale water resource in and around Metro Manila.

(2) Master Plan Study on Water Resources Management in the Republic of the Philippines (JICA, 1998)

The previous master plan study overviewed the need of water resources development in the whole country and proposed a framework plan of future water resources development on a nation-wide basis. The study also looked into the urgency of water resources development from the sectoral and regional aspects. Among others, water supply for Metro Manila as well as Metro Cebu and Baguio City were foreseen to be the most critical in the future as well as under the present condition. With regard to Metro Manila water supply, the study identified various water resources to meet the future water demands, which include the Agos River Basin, Laguna Lake, Pampanga River Basin, and Angat River Basin (Massim and Bayabas Dams Project). However, it was found that only the Agos River Basin be the most promising water resource to suffice water demand of Metro Manila over a long range, taking into account the smaller quantity of exploitable water in other basins. From a long-term aspect, hence, the study recommended the water resources development of the Agos River Basin.

It is clarified through the aforesaid previous studies that the water resources of the Agos River Basin was assessed to be the only water resource to meet the water demand of Metro Manila on a long-term basis. In case the exploitation of water resources of the Agos River Basin will become hardly possible, there might be such a case that the future water supply for Metro Manila will rely on desalination of sea water and/or through water use management including strict water rationing.

### 1.4.5 Interim Water Supply Schemes Contemplated by MWSS

The 1998 master plan study also mentioned the need for development of interim schemes which are defined to be water supply schemes to be commissioned before water resources development projects in the Agos River Basin.

At present, MWSS and/or several BOT proponents have proposed several interim schemes. However, most of those interim schemes are of relatively small-scale development and still at a premature study level. The exceptions are the Laguna Lake 300 MLD scheme examined at a pre-feasibility study level, and the Wawa River 50 MLD scheme being under study by MWSS/MWCI. Nevertheless, these interim schemes are only be worthy of consideration for meeting the immediate demand growth of Metro Manila for a short period.

### 1.4.6 Necessity of Agos Water Resources to Meet Water Demand of Metro Manila

For the time being, it is unforeseeable on which of the interim schemes mentioned above will surely be realized. Accordingly, this Study estimated the water to be exploited in other water sources than the interim projects to be 3,000 MLD so as to meet the water demand up to 2025 as discussed in Chapter II. Since there is no potential water resource around Metro Manila, comparable to the Agos River Basin with exploitable water resources of 3,000 MLD as mentioned above, the water resource of the Agos River Basin is only the long-term water source to suffice water demands until year 2025.

At present, the water supply for Metro Manila relies mostly on existing Angat water supply system as mentioned above. The Angat dam is located in the northern part of Metro Manila and is linked to central parts of Metro Manila through the water conveyance facilities extending from north to south as shown in Figure 1.1. In the 1998 master plan study, MWSS expressed the strong preference to build a new bulk water supply system in the near future that is independent of existing Angat system, since it was too risky to overload the Angat Dam in terms of water supply for Metro Manila. Tremendous social disorder will take place in Metro Manila, in the case water supply from the Angat dam stops due to the occurrence of emergency such as destruction of and/or damage to the Angat system. In reality, MWSS is planning to implement the rehabilitation project of the Angat system, since about 40 years have already passed since its completion and recent investigation indicated a possibility for the Angat system to be considerably affected by earthquake. In this respect, the water resources development schemes of the Agos River Basin, functioning as a supplemental water supply system independent from the Angat system, contribute to the increasing the security of water supply in the Metro Manila.

This Study will formulate a water resources development plan for the Agos River Basin, aiming at meeting the water demand of Metro Manila for a planning till year 2025.

## Table 1.1 Members of Steering Committee

| No. | Agency | Position | Name |
|---|---|---|---|
| 1 | National Water Resources Board (NWRB) | Chairman | Mr. Hector A. Dayrit<br>(Executive Director of NWRB)<br>*Alternate:*<br>*Jesus G. De Leon*<br>*(Deputy Executive Director of NWRB)* |
| 2 | National Economic and Development Authority (NEDA) | Member | Mr. Ruben S. Reinoso, JR<br>(Director of NEDA, Infrastructure Staff)<br>*Alternate:*<br>*Librado Quitorano*<br>*(OIC, Assistant Director of NEDA, Infrastrcuture Staff)* |
| 3 | Metropolitan Waterworks and Sewerage System (MWSS) | Member | Ms. Macra A. Cruz<br>(Deputy Administrator of MWSS) |
| 4 | Department of Public Works and Highways (DPWH) | Member | Mr. Erlinda Templo<br>(Director of DPWH, Planning Services) |
| 5 | National Power Corporation (NPC) | Member | Rodolfo German<br>(Department Manager of NPC,<br>Angat Reservoir HEP, GENCO 2) |
| 6 | Department of Environment and Natural Resources (DENR) | Member | Romeo T. Acosta<br>(Director of DENR, Forest Management Bureau (FMB)) |
| 7 | Department of Interior and Local Government (DILG) | Member | Serafin M. Benaldo<br>(Regional Director, National Capital Region) |
| 8 | Department of Agriculture (DA) | Member | (To be nominated) |

**Table 1.2 Members of Technical Working Group**

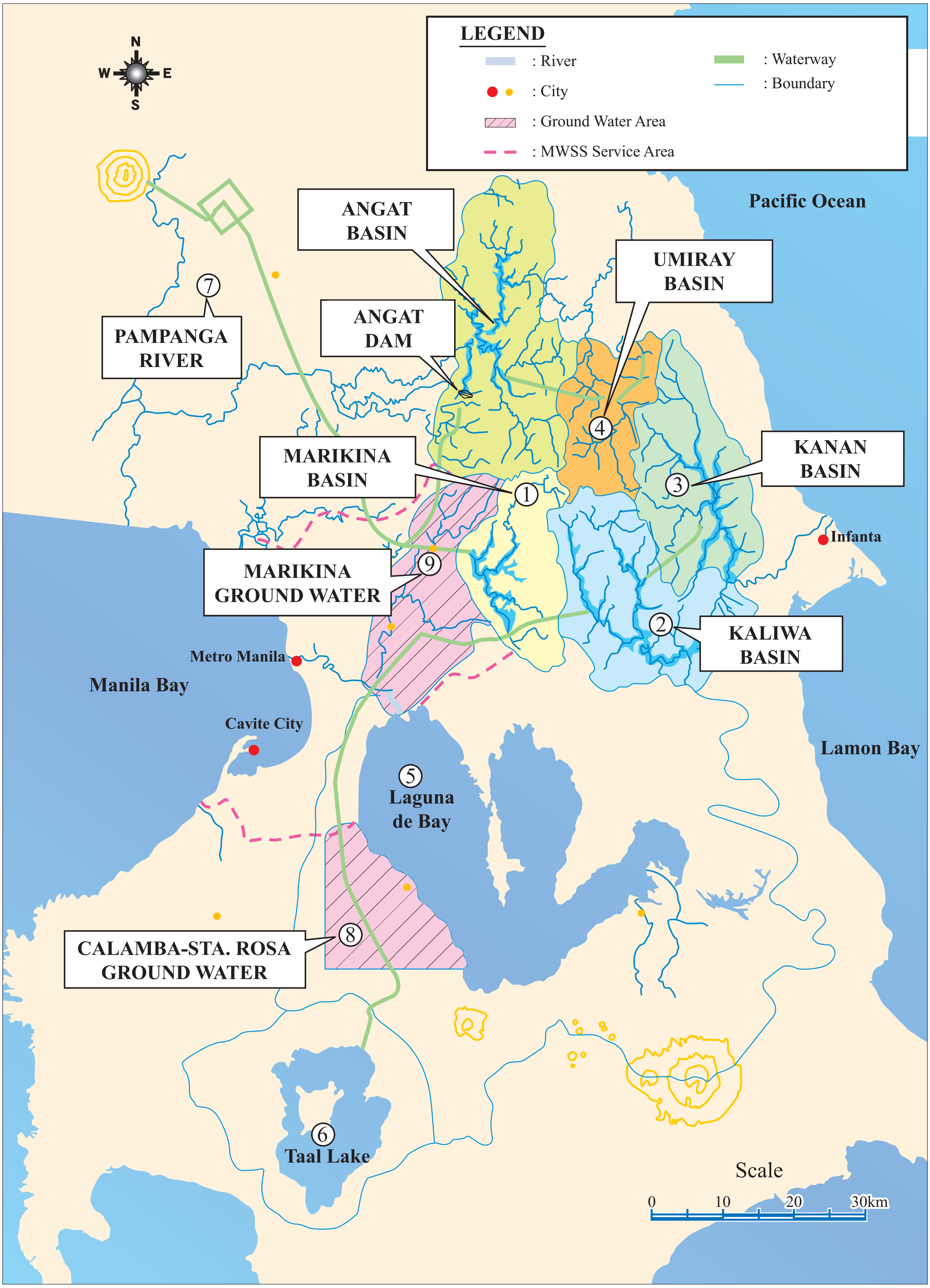
| No. | Agency | Position | Name |
|---|---|---|---|
| 1 | National Water Resources Board (NWRB) | Chairman | Mr. Lope R. Villenas<br>(Chief, Policy and Program Division of NWRB)<br>*Alternate:*<br>*Ms. Isidra D. Penaranda*<br>*(Planning Officer of NWRB)* |
| 2 | National Economic and Development Authority (NEDA) | Member | Mr. Rufino C. Guinto<br>Supervising Eco. Dev. Specialist<br>Infrastructure Staff<br>*Alternate* :<br>Mr. Dennis Von Custodio<br>(Supervising Eco. Dev. Specialist,<br>Infrastructure Staff of NEDA) |
| 3 | Metropolitan Waterworks and Sewerage System (MWSS) | Member | Mr. Jose M. Dimatulac<br>(Acting Manager, PMO, MWSS) |
| 4 | Metropolitan Waterworks and Sewerage System (MWSS) | Member | Mr. Arsenio N. Macaspac<br>(In-House Consultant of MWSS) |
| 5 | National Power Corporation (NPC) | Member | Mr. Romualdo Ma. T. Beltran<br>(Acting Principal A, Planning and Development Dept., PMES, NPC) |
| 6 | Department of Environment and Natural Resources (DENR) | Member | Mr. Jesus A. Javier<br>(Chief, Forest Mgt. Specialist Forest Management Bureau (FMB), DENR) |
| 7 | National Irrigation Administration (NIA) | Member | Mr. Milo M. Landicho<br>(Chief, Water Resources Utilization Division, Project Dev. Dept., NIA) |
| 8 | Manilad Water Services, Inc. (MWSI) | Member | Mr. Philip E. Cases<br>(SAVP, Regulatory Affairs, MWSI) |
| 9 | Manila Water Company, Inc. (MWCI) | Member | Mr. Roberto A. Santiago<br>(Strategic Planning Specialist, Asset Management Dept., MWCI) |

## Table 1.3 Counterpart Personnel of NWRB

| No. | Designation | Name of Counterpart Personnel |
|---|---|---|
| 1 | Team Leader of Counterpart Personnel | Pacita F. Barba |
| 2 | Dam Planner | Dolores S. D. Cleofas |
| 3 | Hydrologist | Joey C. Castro |
| 4 | Design Engineer | Emmanuel Abalain |
| 5 | Water Conveyance Planner | Panfilo Manalastas |
| 6 | Geologist / Geophysist | Ricarte Olarte |
| 8 | Sociologist/Resttlement Planner | Francis Hilarie |
| 9 | Construction Planner | Josephine Billones |
| 10 | Economist and Insitutional Planner | Cristina Arellano |
| 11 | Environmentalist | Joey Beltran |
| 12 | Water Supply Planner | Ma. Victoria Astraquillo |
| 13 | Surveyor/Coastal Engineer | Melchor Abril |

## Table 1.4 Comparison of Water Sources in and around Metro Manila in Study of MWSP III, 1979

| Water Source for Metro Manila Water Supply | Assessment in the study of MWSP III (1979) | | | | Present Status |
|---|---|---|---|---|---|
| | Average Inflow ($m^3$/sec) | Design Yield (MLD) | Assumed Capital Cost ($10^6$ PHP) | Project Feature and Conceived Problems/Issues | |
| 1 Kaliwa River Basin (Laiban Dam scheme) | 25.2 | 1,909 | 2,757 | - The Laiban Dam scheme (a yield of 22.1 m3/sec) in the Kaliwa River Basin was contemplated to be developed as a two-staged scheme with the Kanan No.2 Dam scheme in the Kanan River basin (a total yield of 58.8 m3/sec).<br>- The Kaliwa River Basin was evaluated to be the most economical water source out of the 7 alternative water sources in and around Metro Manila area.<br>Problems/Issues<br>- It was needed to resettle about 1,000 families residing in the Laiban Dam reservoir. | · The Laiban Dam scheme is in the most matured state out of the water development plans in the Agos River Basin. The detailed design has been completed and a part of the construction works (diversion tunnel and access roads) was implemented during 1982 and 1984.<br>· However, the subsequent construction works had to be suspended due chiefly to problems of resettlement of people residing in the Laiban Dam reservoir.<br>· According to the latest survey, the number of families to be resettled is reported to increase to about 3,000 families. Accordingly, it is essential to solve the social problems in order to resume the implementation of the Laiban Dam scheme. |
| 2 Marikina River Basin | 18.3 | 1,280 | 2,145 | - The Marikina River Basin was planned to be developed either as an independent scheme (a yield of 14.8 m3/sec) or as a two-staged scheme with the Kaliwa River basin (a yield of 38.3 m3/sec)<br>- Two alternative sites for the WTP were considered: Novaliches and Nangka (Novaliches site was more economical.)<br>- Main components of proposed scheme<br>Main Dam: Rockfill w/ inclined core, Dam Height 158m, Crest Width<br>WTP: Conventional type, Installed Capacity 16.7m3/sec<br>Main Dam: Rockfill w/ inclined core, Dam Height 158m, Crest Width<br>WTP: Conventional type, Installed Capacity 16.7m3/sec<br>Problems/Issues<br>- The scheme was socially unacceptable owing to the concern and apprehension that would be created by a dam being situated in the Montalban Gorge.<br>- It was needed to resettle about 600 families for constrcution of the scheme.<br>- It was needed to relocate the pig farms in the Bosoboso valley (The number is already included in above figure). | · The high dam scheme in the Marikina River Basin was abandoned for various reasons including the social problem. Instead, the 50 MLD Wawa River scheme is under study by MWSS. |
| 3 Kanan River Basin (Kanan No.2 Dam scheme) | 50.7 | 3,170 | 4,840 | - It was not adequate to develop the Kanan River Basin independently for the single-purpose of Metro Manila water supply, because the Kanan basin is very far from Metro Manila. Hence, it was planned to be developed as the 2nd Phase of MWSP III, after completion of the Laiban Dam in the Kaliwa River Basin (The Kaliwa River Basin and Kanan River Basin are to be connected by a interbasin tunnel.).<br>- The water yield at the Kanan No.2 Damsite was estimated at 36.7 m3/sec.<br>- Available head at the interbasin tunnel from Kanan to Kaliwa was insufficient to justify a hydropower plant.<br>- The Kanan River Basin was virtually uninhabited and remote from centers of population, therefore, it was assessed to be socially acceptable.<br>Problems/Issues<br>- The access to the Kanan River Basin was very difficult and hydrological insufficient.<br>- The development of the Kanan Basin might have adverse effects on natural environment thereof. | · To date, no water in the Kanan River Basin has been tapped, although hydropower development plans were formulated by NPC and Quezon Province.<br>· Therefore, a high potential of water resources development remains unexploited in the Kanan River Basin. |
| 4 Umiray River Basin | 20.6 | 777 | 1,430 | - The proposed scheme consisted of construction of five diversion dams and 23 km of tunnels for diverting water of 9 m3/sec from the Umiray to existing Angat Dam.<br>- The quality of water in the Umiray River Basin was assured.<br>- There wre no social implications in relation to the dvelopment of the Basin.<br>Problems/Issues<br>- Angat reservoir needed to be drawn down below the present MOL during the construction of the scheme. | · The Umiray-Angat Water Conveyance Project has already been completed and the water of the Umiray River Basin is being conveyed to Metro Manila through existing Angat Dam.<br>· There is no potential water resource to be exploited for Metro Manila water supply. |
| 5 Pampanga River Basin | 122 | 2,592 | 4,254 | - It was estimated that river diversions w/o storage would yield 5 $m^3$/sec<br>w/storage of 225 x $10^6$ $m^3$ would yield30 $m^3$/sec<br>- 1st stage: 15 $m^3$/sec; 2nd stage: 15$m^3$/sec<br>- Supply from the Pampanga River required a river intake facility, two pumping stations and a 62 km long pipeline.<br>- Project Works: pumping stations, intake, storage Reservoir, ring dike in Candaba Swamp as storage, WTP at Novaliches (18.8 m3/sec), a 62 km Pipeline<br>Problems/Issues<br>- The energy consumption for pumping to convey water to Metro Manila was estimated to be very high at about 680 GWh annually.<br>- The Pampanga River Basin was assessed to be the most costly water source in terms of unit water cost among the 7 alternative water sources in and around Metro Manila. | · For the time being, no water conveyance plan for Metro Manila from the Pampanga River Basin is suggested for the following reasons:<br>- High unit water cost for water supply to Metro Manila<br>- Pollution of river water by discharge of waste water from factories existing along the Pampanga River.<br>- Scarcity of the river water available for Metro Manila water supply because of on-going irrigation development utilizing the river water, although water of the Cagayan is going to be diverted to the Pampanga River after completion of the Casecnan Dam Project. |
| 6 Laguna Lake (Entire Lake)<br><br>(East Bays only) | 122<br><br>80 | 2,592<br><br>1,728 | 2,481<br><br>2,045 | - Laguna Lake was estimated to yield water of about 30 m3/sec or more for Metro Manila water supply.<br>- Water quality in the central and eastern bays of Laguna Lake was assessed to be better than in the western bay.<br>- For the east bays development, it was estiamted that construction of dikes would be required to separate the western bay from the eastern part of the lake.<br>- Laguna Lake was assessed to be not suitable for water source of Metro Manila water supply due to the pollution and contamination of the lake water.<br>- Major drainage and pollution control works, and strictly enforced land use regulation were required. | · Instead of large-scale water resources development plan of Laguna Lake in the MWSP III, MWSS is planning to implement the 300 MLD Laguna lake development plan (300 MLD Bulk Water Supply Project), which is categorized as the Interim Project.<br>· However, there are still the following problems/issues on the Interim Project:<br>- High pollution and high salinity of the lake water<br>- Adverse effect on the lake fishery and compensation to the fishermen<br>- High unit water cost attributed to provision of costly marine pipeline and high water treatment cost for brackish water. |
| 7 Taal Lake | 14.8 | 864 | 1,322 | - The water from Taal Lake needed to be mixed with non-saline source to reduce the concentration of chloride to meet the Philippine National Standards for Drinking Water in the Philippines.<br>- Construction of about 70 km long pipelines was required to convey the water of Taal Lake to Metro Manila.<br>Problems/Issues<br>- Taal Lake water might contain high contents of chloride and total dissolved solids from volcanic activities.<br>- The neighboring volcanic activity was hazardous to pumping stations and appurtenant hydraulic works. In 1965, 189 people were killed due to eruption, and the lake was silted by a thick volcanic debris. It was estiamted that, at the event of reoccurrence of the volcanic eruption, the lake water quality would be much more aggravated. | · No water conveyance plan for Metro Manila from Taal Lake has been suggested so far due to the smaller exploitable water in comparison with high unit water cost resulting from provision of a long pipeline (about 70km) and high water treatment cost, as well as possibility of occurrence of volcanic eruption. |




Source: Manila Water Supply Project Ⅲ (1979)

Figure 1.1 Water Resources Potential Area to Metro Manila

# CHAPTER II SOCIO-ECONOMIC FRAMEWORK OF STUDY AREA AND WATER DEMAND PROJECTION

## 2.1 Present Socio-Economic Conditions of the Study Area

### 2.1.1 Current Status of Socio-Economy in the Philippines

#### 1) Asian Crisis and El Nino Phenomenon

The Philippine economy was affected by two external disasters recently: one is the Asian financial crisis that emerged in July 1997 and another is the El Nino phenomenon that brought one of the hardest experiences of drought to farmers. This compounded effect was evidenced by the negative GDP growth (minus 0.5%) in 1998. The Philippines, however, was one of the three countries that have their pre-crisis GDP levels as shown below. Other two countries were Singapore and South Korea.

**Comparison of GDP Growth Rates affected by Asian Financial Crisis**

| | 1997 | 1998 | 1999 | Growth: 97-99 |
|---|---|---|---|---|
| Philippines | 5.2 | -0.5 | 3.2 | 2.7 |
| Malaysia | 7.7 | -7.5 | 5.4 | -2.5 |
| Indonesia | 4.7 | -13.2 | 0.2 | -13.0 |
| Thailand | -1.8 | -10.2 | 4.2 | -6.4 |
| Singapore | 8.4 | 0.4 | 5.4 | 5.8 |
| South Korea | 5.5 | -6.7 | 10.7 | 3.3 |
| Hong Kong | 5.0 | -5.1 | 2.9 | -2.3 |

Source: The President's 1999 Socio-economic Report, NEDA, March 2000

Owing to the fact that the Philippines was damaged relatively milder 0.5% contraction in 1998, it could recover in 1999 a level of GDP that was 2.7% higher than in 1997.

#### 2) Economic Recovery in 1999

Overall, the economy recovered in 1999 with a growth rate of 3.2%. The recovery was mainly supported by the agriculture sector that experienced a high growth of 6.6% after the El Nino drought in 1997 and 1998. The industry sector's performance continued to be sluggish with only 0.5% growth in 1999 affected by the depressed domestic demand. The low growth of industry sector is attributed to the slow shifting of output and labor force from rural area to industry. The GDP share of industry contracted from more than 40% two decades ago to less than 35% in 1999. In 2000 however, the industry sector achieved 3.9% growth. The manufacturing sub-sector, which dominates more than 70% of the sector, expanded due to the demand increase in US semiconductors.

#### 3) Political and Social Turbulence in 2000

The Philippines encountered serious political problems in 2000. These included ethnic conflict in Mindanao, social insecurity like kidnapping of tourists group, the eruption of Mt. Mayon and the onset of typhoon. The recent depreciation of Peso is deemed to be reflecting these disturbances in this country. The foreign direct investment to the Philippines has been reducing after the Asian financial crisis. In order to invite foreign investors more, the social and political stability are now required.

2.1.2 Profiles of Region, Province and Municipality

The Study area extends to National Capital Region (NCR) and three Provinces in the Region IV (Southern Tagalog Region) including Rizal, Cavite and Quezon Provinces. Of these administrative divisions, NCR and Rizal Province are wholly included in the Study area, but Cavite and Quezon Provinces are included only partially. In order to comprehend the whole characteristics of the Study area, each area is compared with the whole Philippines in terms of the land area, population, GRDP, employment structure and family income and expenditures as shown in Table 2.1.

Details of regional profiles of NCR, Rizal Province, Cavite Province, Quezon Province, Infanta Municipality and General Nakar Municipality are accommodated in Part A of Volume III.

## 2.2 National Economic Development Plan

2.2.1 Long-term Philippines Development Plan (LTPDP)

The Long-term Philippines Development Plan (LTPDP) covering the plan period of 2005-2025 was prepared in August 21, 1997. The growth targets of the LTPDP are summarized in Table 2.2. Since this was prepared at the onset of the Asian financial crisis, targets were set with somewhat rosy perspectives for the future economy. For example, GDP growth rate was targeted at 10% per annum in real terms for the period of 2005-2025 in the high growth scenario.

The LTPDP is so ambitious plan that, as a result of the high growth, it aims to reach the existing income status of South Korea by 2025.

2.2.2 Medium-term Philippines Development Plan (MTPDP)

Following the LTPDP, the Medium-term Philippines Development Plan (MTPDP) was publicized covering the period of 1999-2004 in September 1999. Reflecting the recessive economic conditions of post-financial crisis in Asian countries, the economic growth rate was set at a moderate level of 4.7% to 5.3% per annum in average up to 2004 as shown in Table 2.3.

In the medium-term, GDP growth target will allow an average growth in employment of at least 3.3%. Hence, the unemployment rate shall decrease from 10.1% in 1998 to 6.7% to 8.0% in 2004. Consistent with the GDP growth targets, poverty incidence is expected to improve from 32% in 1997 to around 25 to 28 % by 2004. This is anticipated to stem from the growth of the services sector and industry, which will absorb most of the labor force including those that will be released by a modernizing agricultural sector.

## 2.3 Socio-Economic Projection

### 2.3.1 Population Projection

(1) Introduction

In the present Study, the future population in the Study area covering NCR, Rizal Province and a part of Cavite Province and Quezon Province was projected up to 2025 that is set as the target year of the present Study. This projection aims at providing basic data for the estimate of future water demand at city-municipality level. The fundamental principles for the population projection were the following:

a. Existing projections are to be esteemed and utilized as far as possible.

b. A reasonable method of projection should be sought and applied consistently without any arbitrary judgement.

The statistics used include the following:

i) "1995 Census-based City/municipal Population Projections" NSO, December 1999: ("NSO Projection-1")

ii) "1995 Census-based National, Regional and Provincial Population Projections" NSO, June 1999: ("NSO Projection-2")

iii) "2000 Census of Population and Housing" (Final Counts) from Web site of NSO : ("Census 2000")

iv) "Philippine Statistical Yearbook 2000" NSCB, October 2000: ("PSY 2000")

(2) Method of Projection

1) Modification of NSO Projection-1

Since the NSO Projection-1 was the projection at city/municipal level up to 2010, we relied on it principally after reviewing. The Census 2000 of final count became available, however, and we modified the NSO Projection-1 through replacing its data for 2000 by the result of Census 2000. For this modification, annual average growth rates projected in NSO Projection-1 were adopted and applied to obtain the population up to 2010.

2) Population Projection in 2015 and 2020

Population projection at provincial level in 2015 and 2020 was available in NSO Projection-2. In projecting the population of city/municipal level in 2015 and 2020, future ratios of city/municipality to region (in case of NCR) and/or province (in cases of Region IV) were firstly projected by extrapolating the past trend of these ratios. This was based on our observation that these ratios of city/municipality to region and/or province are stable in the long term. Secondly, these projected ratios were applied to the total population of region/provinces already projected in NSO Projection-2 to obtain the city/municipal populations in 2015 and 2020. In this computation, the aggregate of ratios of each city/municipality was adjusted before applying to become 100% in total of region and/or province.

3) Population Projection in 2025

Population in 2025 at regional level was projected by applying the average growth rate in the period of 2015-2020. These average growth rates were computed at 0.5% per annum for NCR, 1.8% for Cavite, 4.0% for Rizal and 0.7% for Quezon provinces respectively. Thereafter, population of city/municipality level was projected by applying the same process as applied for calculating the population in 2015 and 2020. Population of the Philippines and the Region IV in 2025 was computed for reference sake only. The average growth rate of 1.5% per annum projected in Long-term Philippine Development Plan (LTPDP) was applied for the former and the growth of 2015-2020 for the latter.

(3) Result of the Projection

The result of projection is compiled in Table 3.1 of Chapter III of Volume IV, Main Report of Feasibility Study.

1) NCR

Municipalities of Las Pinas and Taguig that constitute the peripheral of expanding Metro Manila are anticipated to grow faster than other areas and exceed more than one million in 2025. Their population density will be over 30 thousands persons per sq. km. While, the population growth is expected to become sluggish or decrease in municipalities with population currently exceeding one million like Manila, Caloocan and Quezon in the near future. As a matter of fact, the population growth has shown negative (-0.9% per annum) in Manila during the period of 1995-2000. This was the second time negative growth for Manila during five times of Population Census in these 25 years after 1975 Population Census. As the result, the population of Manila is projected to be 1.0 million in 2025 reducing from the present 1.7 million. The population density of Manila, however, will be still as high as 26,400 persons per sq. km in 2025.

2) Rizal Province

What is peculiar to Rizal is the rapid growth of Antipolo City. The population of Antipolo currently occupying 28% of the total province is expected to increase up to nearly half of 48% in 2025. High growth rates are anticipated such as 7.6% in the period of 2000-2010 and 6.3% in the period of 2010-2025 respectively. The population density in 2025 with a population of 2.5 million, however, is computed as low as at 8,000 persons per sq. km due to the fact that its land area is relatively wide enough (306 sq. km) to accommodate this large population. Being situated at the edge of Metro Manila area with gradual hilly undulation, development of residential complex has been already in progress. Antipolo is expected to absorb growing population in the capital zone in the future.

3) Cavite Province

The Study area currently accommodates more than one-third of the total population of the province with a land area of only 11% of the total provincial land. As the result, the population density in the Study area (5,200 persons per sq. km) is more than three times the provincial average (1,600 persons per sq. km). It is one of the most urbanized areas in the province due to its proximity to Metro Manila. Along with a growing trend of industrial development in this area, the population is anticipated to grow with more than the average growth of the whole province bringing its population share from the current 37% to 43% of the total provincial population in 2025. The expected population density in the Study area is 9,300 persons per sq. km in 2025.

4) Quezon Province

In Quezon Province, our concern is limited to the municipalities of Infanta and General Nakar that are lying within the catchment area of the Agos River. The average population growth in Infanta was as high as 5% per annum in the period of 1995-2000. And it is also anticipated to expand with growth rates higher than the national average in the future. General Nakar is also expected to grow with a speed more than the national average in the future. As stated in Socio-economic Profile of General Nakar, a bridge crossing the Agos River would bring a big demographic change to this area in the future. The future construction of Marikina-Infanta Road would also give impact to the population enhancement in this region. The present projection naturally does not consider this infrastructure change in the future.

### 2.3.2 GRDP Projection

#### (1) Introduction

In this Study, the gross regional domestic products (GRDP) in the Study area namely NCR and Region IV was projected by three major sectors of agriculture, industry and services up to 2025, the target year of the present Study. This projection was needed to provide basic data for the estimate of future municipal and industrial water demands in the area. The gross domestic products (GDP) were projected not for its own purpose but to facilitate the GRDP projection.

In projecting GDP/GRDP, existing government's projections were esteemed as far as possible since the economic activities of a country is largely dependent on government's policy. And the government's projection is usually more reliable since it can collect more data and information that contribute to improve the accuracy of the projection.

The statistics we used included the following:

i) "Medium-term Philippine Development Plan 1999-2004" NEDA, December 1998 ("MTPDP")
ii) "Long-term Philippine Development Plan 1999-2025" NEDA, 1998 ("LTPDP")
iii) "Philippine Statistical Yearbook 2000" NSCB, October 2000: ("PSY 2000")

(2) Method of GDP/GRDP Projection

1) Historical Data of 1993-1999

The GDP/GRDP data for the period of 1993-1999 was collected from the statistics of PSY 2000. The statistics at the constant price level of 1985 were available by major sectors of agriculture, industry and services by each region of NCR and Region IV.

2) Projection for 2000-2004

The GDP/GRDP were projected for 2000-2004 based on 1999 figures by applying annual growth rates planned in MTPDP by sector by Region for each year. For GDP projection, the low growth scenario was adopted taking into consideration the worldwide trend of low growth economy to be prospected in the medium term.

3) Projection for 2005-2025

For the period of 2005-2025, the LTPDP planned 10.0% p.a. growth of GDP for high growth scenario and 8.0% p.a. for low growth scenario respectively.[1] Since the LTPDP did not seem, judging from the time of its preparation, to have fully incorporated the influence of Asian financial crisis, we considered that MTPDP is better than LTPDP for us to rely on for the current projection. Therefore, at this moment, we followed the direction presented in MTPDP that seemed to have been prepared taking account of the post-economic conditions of the Asian financial crisis. Thus, the growth rates projected in MTPDP for the final stage of the medium term plan namely those in the year 2004 were adopted and applied to derive the GDP for the period of 2005-2025 for each sector.

For GRDP projection, we paid attention from the historical statistics that the sector GRDP at the regional level had very stable share in GDP. Therefore, these GRDP shares in each sector were extrapolated and applied to the corresponding sector GDP to obtain the GRDP of each sector (Table 3.2 of Chapter 3 of Volume IV, Main Report of Feasibility Study).

(3) Review of the Result of GDP/GRDP Projections

i) Fundamentally our projection relied on MTPDP. The GDP growth rates stipulated in MTPDP for the plan period were incorporated and those growth rates planned at the final stage of the plan period were adopted and applied to derive the future GDP growth after 2005.

ii) In the current Study, GDP was projected to grow at the average annual growth rate of 5.5% for the period up to 2025. Although the agriculture sector is deemed hard to grow high, the industrial sector (6.5% p.a.) as well as service sector (5.8% p.a.) will lead the economy.

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1 During the Study period, a new MTPDP was publicized and updated forecast of GDP growth rate was availed to us by NEDA. These included GDP growth rates for medium term covering 2001-2006 and for long term covering 2007-2025, though the latter is for internal projection only. However, since the breakdown thereof by three major sectors was not available yet, these up-dated figures could not be incorporated in the present Study. Meanwhile, the up-dated growth rate for 2007-2025 was 6.5%-7.5% in stead of 8.0%-10% depicted in LTPDP.

iii) The per capita GDP was computed for the year of 2025 by assuming GDP deflators, exchange rate and future population (Table 2.10 of Part A of Volume III). Per capita GDP (at current price bases) of the Philippines was estimated to reach US$ 9,660 in 2025 from the present US$ 1,630. This is the same level as Korea (US$ 9,670) in 1997 that is before the Asian financial crisis. The per capita GDP of Korea was estimated at US$ 8,580 in 1999 that was lessened due to the depreciation of Korean Won to US dollar. Table 9.3 in LTPDP (p.9-23) stipulates that the long-term (2005-2025) growth scenario will target between US$ 7,833 and US$ 12,912 of per capita GDP (in nominal terms) for low case and high case respectively. Our projected per capita GDP of US$ 9,660 in 2025 falls in between this range.

iv) The GRDP of NCR and Region IV is projected to grow with 6.0% per annum and 5.6% per annum respectively for the period of 2000-2025 that is higher than the GDP growth. In this plan period up to 2025, the industrial sector of NCR is projected to reduce its share in the industrial sector GDP. It may be reasonable judging from the current high concentration of the industry into NCR with almost one third of the nation's industrial production in this area. The rapid expansion of industry is also expected in Region IV with high growth rate of 6.5% per annum in this period. The accumulation of GRDP in these two regions of NCR and Region IV will be enlarged from 45.9% of the whole nation in 1999 to 50.1% in 2025.

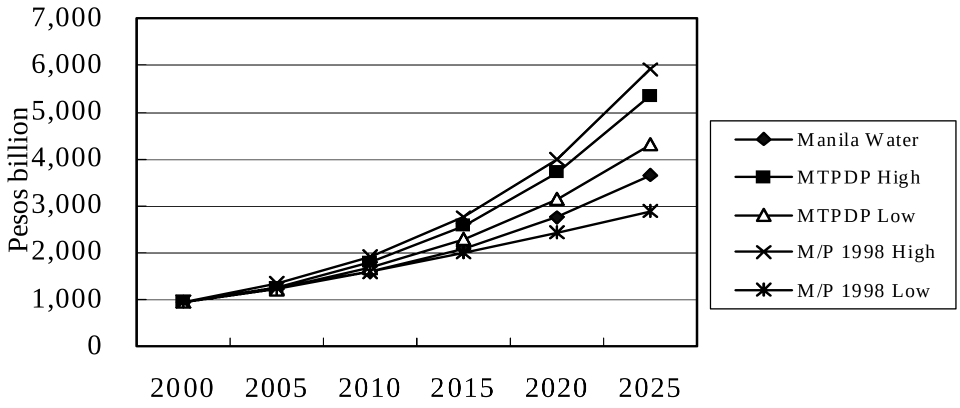
(4) Comparison of GDP projections

In order to verify the adequacy of our GDP projection, it was compared with other projections such as those conducted in the Master Plan Study on Water Resources Management of JICA in 1998 and those availed to us by NEDA in July 2001. The GDP value in 2000 (preliminary estimate) was taken as the base GDP to which projected growth rates of each projection were applied to obtain the GDP value in each five-year term. With a favor of NPPS of NEDA, the GDP growth rates amended for MTPDP was provided for medium-term of 2001-2006. And an internal projection of NPPS for the long-term of 2007-2025 was availed to us, which was valid enough for checking purpose. As cleared from the above explanation, the GDP values of these three projections, as summarized below, are, except for that of the present Study, not those presented in each projection but those processed by us through the above-mentioned method. The following are the GDP projections modified and summarized for comparison purpose and their trend curves for 2000-2025.

**Comparison of GDP Projections**

| | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 | Growth 2000-2025 |
|---|---|---|---|---|---|---|---|
| Manila Water | 962 | 1,236 | 1,604 | 2,098 | 2,760 | 3,652 | 5.5%p.a. |
| MTPDP High case | 962 | 1,258 | 1,805 | 2,592 | 3,721 | 5,342 | 7.1%p.a. |
| MTPDP Low case | 962 | 1,225 | 1,678 | 2,299 | 3,149 | 4,315 | 6.2%p.a. |
| M/P 1998 High case | 962 | 1,361 | 1,935 | 2,760 | 3,995 | 5,914 | 7.5%p.a. |
| M/P 1998 Low case | 962 | 1,257 | 1,604 | 1,999 | 2,432 | 2,889 | 4.5%p.a. |

Note: GDP values in Peso billion at 1985 prices




**Comparison of GDP Projections**

As depicted in the above chart, the GDP projection of our Study is, though being placed beneath the low case of the MTPDP projection, positioned between the high and low cases of the 1998 Master Plan Study. The GDP growth rates of six projected results are tabulated in the right-most column of the above table. The projected average growth rate of our Study of 5.5% per annum for the period of 2000-2025 is second lowest among these six growth rates. However, according to the statistics available in Tables 2.7 and 2.8 of Part A of Volume III, the GDP growth rate larger than 5.5% per annum is very few. During the 12 years time from 1993 to 2004 including MTPDP projection period of 2001-2004, the growth rate larger than 5.5% per annum is found in only two years (1996 and 2003). As an average growth rate in the long-term, this projection is deemed to be sufficiently reasonable for the Study purpose.

## 2.4 Current Situation of Water Supply in Metro Manila

### 2.4.1 Privatization of MWSS and Present Situation of Water Supply

The MWSS has performed the role of the public water utility to the Metro Manila region and its surrounding areas for over 100 years. Recent economic growth and population increase in Manila had outpaced the expansion of water and wastewater conditions. In order to upgrade and expand the existing facilities and services of MWSS, the Government of the Philippines enacted the National Water Crisis Act in 1995, empowering the President Fidel Ramos to privatize MWSS. The privatization process took more than two years to complete and two concessionaires were awarded: MWCI (Manila Water Company Inc.) for East Zone and MWSI (Maynilad Water Service Inc.) for West Zone of Metro Manila area. The Concession Agreement was signed on August 1, 1997. The Regulatory Office is set up within the MWSS to oversee the two private companies.

### 2.4.2 Service Area and Population Served

Figure 2.1 shows cities/municipalities to be served under the Concession Agreement.

Presently, the recipient city/municipality under MWCI are Manila (part), Quezon City (part), Makati, Mandaluyong, San Juan, Marikina, Pasig, Pateros and Taguig of NCR and Antipolo, Cainta, Taytay, Rodoriguez and San Mateo of Rizal province.

Other municipalities in Rizal province are also included in service areas under Concession Agreement, however, those municipalities are served by Water District/s, municipal waterworks, community waterworks and privately owned waterworks (Refer to Part-B, Volume III).

The MWSI supplies the water to Manila, Quezon City, Makati (part), Caloocan, Pasay, Malabon, Navotas, Valenzuela, Paranaque, Las Pinas and Muntinlupa of NCR and Cavite City, Bacoor, Imus, Kawit, Noveleta and Rosario of Cavite province. Thus, Manila, Quezon City and Makati are divided into the jurisdictions of the two concessionaires.

According to the latest Census 2000, the total population of service area managed by two (2) concessionaires counts to about 11,847,000 (excluding 9 municipalities of Rizal province being served by WDs/municipal waterworks/community waterworks). The present population served is estimated at 8,120,000 (3,273,000 at MWCI and 4,847,000 at MWSI) on an assumption of 9.2 persons per connection. Thus, the gross service coverage in year 2000 is derived at 69%, which consists of 72% (MWCI) and 67% (MWSI). Table 2.4 shows the present population served by city/municipality. Higher service coverage has been already achieved at Manila, Quezon City, Makati, Pasay, Malabon, Mandaluyong, Marikina, Pasig, Pateros and San Juan, while, Caloocan, Las Pinas, Muntinlupa, Paranaque, Taguig and other municipalities in Rizal and Cavite Provinces are not adequately served by the two concessionaires yet. Current water supply condition by concessionaire is summarized as below.

**Current Water Supply Condition by Concessionaire**

| Item | Operating Body | | Total |
|---|---|---|---|
| | East Zone | West Zone | |
| | Manila Water Company Inc. (MWCI) | Maynilad Water Service Inc. (MWSI) | |
| Area | 1,400 $km^2$ (72%) | 540 $km^2$ (28%) | 1,940$km^2$ |
| Population* | 4,562,000 (39%) | 7,285,000 (61%) | 11,847,000 |
| Pop. Served | 3,273,000 | 4,847,000 | 8,120,000 |
| Coverage | 72% | 67% | 69% |

Note: * excluding nine (9) municipalities in Rizal Province

### 2.4.3 Existing Water Supply Facilities

#### (1) Water Sources

Water sources for Metro Manila resort to the Angat Dam on the Angat River and deep wells. Raw water from Angat River, as main source of water sources for Metro Manila, occupies about 4,000 MLD (98%), and deep wells provide water to limited area with about 90 MLD (2%) at present. Figure 2.2 shows a schematic diagram of the headworks of Angat system. The details of the facilities are described in Part-B of Volume III.

Water from Angat Dam on the Angat River is fully utilized to cover the current water demand. The latest completion of the Umiray-Angat Transbasin Project augmented the water source for Balara and La Mesa WTPs with 9 $m^3$/sec (800

MLD) by transbasin diversion of raw water from the Umirai River to the Angat Reservoir.

(2) Water Conveyance Facilities

Existing water conveyance facilities are broken down into three (3) components, which consists of Ipo Dam-La Mesa Dam system, La Mesa Dam-Balara WTPs system and NP Junction-La Mesa WTPs. The location and principal features are shown in Figure 2.2 and the details in Part-B of Volume III.

These water conveyance facilities were constructed during the period from 1929 to 1992. Among them, the aqueduct to Balara No. 1 WTP is the oldest one that has been used for more than 70 years. Presently, the conditions of the facilities are being inspected and studied from the technical aspects (structural strength, water leakage, etc.).

(3) Water Treatment Facilities

The majority of East Zone under MWCI is supplied with water from Balara No.1 and No.2 WTPs. Likewise, West Zone under MWSI is supplied from La Mesa No.1 and No.2 WTPs. The relative location of WTPs is shown in Figure 2.2. Principal features of the WTPs are as follows (refer to Part-B of Volume III for detail):

(a) Balara No.1 WTP

The nominal plant capacity is 470 MLD. The WTP consists of 2 units of accelerator/sedimentation tank and 10 units of dual media filter (anthracite + sand) with filtration rate of 290 m/day.

(b) Balara No.2 WTP

The nominal plant capacity is 1,130 MLD. Each of the WTP units consists of flocculation basin, sedimentation basin and 20 units of dual media filter with filtration rate of 348 m/day.

(c) La Mesa No.1 WTP

La Mesa No. 1 WTP was constructed in 1985 with a design capacity of 1,500 MLD. Main facilities consist of 6 units of flush mixing tank, 12 units each of flocculation and sedimentation basins and 24 units of dual media filter with filtration rate of 348 m/day.

(d) La Mesa No.2 WTP

La Mesa No. 2 WTP was constructed in 1994 with a design capacity of 900 MLD. Main facilities consist of 4 units of flush mixing tank, 8 units of pulsator and 20 units of dual media filter with filtration rate of 280 m/day.

Water quality of the treated water depends on the production rate and raw water quality, feeding rate of coagulant/s and performance of filter washing. Although the treated water complies with the Philippine National Standards for Drinking Water (PNSDW), the overloaded operation affects the quality of treated water. In addition, the difference in water treatment performance (turbidity of treated water in particular) is observed among the above WTPs.

(4) Distribution Facilities

For the East Zone (MWCI), the treated water from Balara WTPs is delivered to major distribution facilities such as San Juan Reservoir, Pasig Reservoir, Balara Pump Station and others. From these facilities, water is distributed to service areas by gravity or booster pump. For the West Zone (MWSI), the treated water from La Mesa WTPs is delivered to major distribution facilities such as Bagbag Reservoir, Algeciras Reservoir, La Mesa Reservoir and others. Details on major service reservoirs and pump stations are described in Part-B, Volume III.

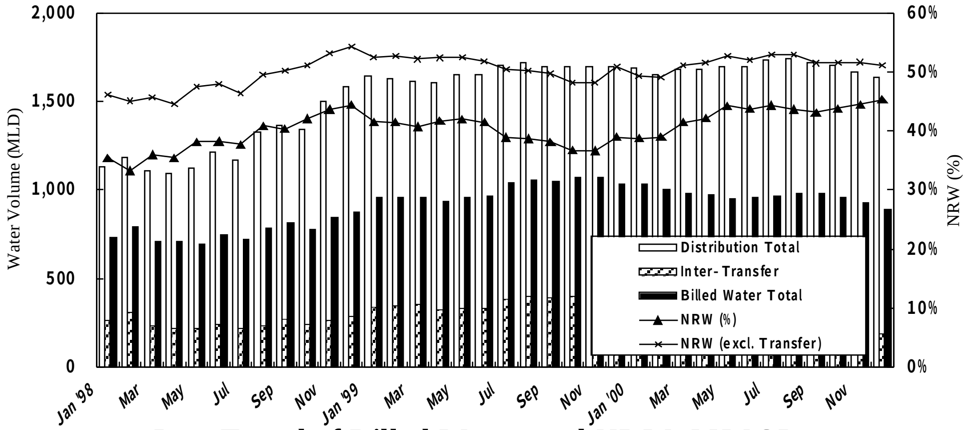
As for the distribution pipes, the total length of pipes with a diameter of 50 to 3,000 mm, is estimated at approximately 6,200 km (2,500 km for MWCI and 3,700 km for MWSI) within the service area as of 2001. Pipe materials are steel (SP), cast iron (CIP), asbestos (ACP), poly vinyl chloride (PVC) and others. The deteriorated pipes and improperly installed pipes are main causes of water leaks.

Although the water pressure at the faucet is recommended to be more than 1.1 $kg/cm^2$, the service area meeting this criterion is limited. The area of 24-hour supply with due pressure is estimated at 40 - 50% of the total service area (refer to Part-B, Volume III).

2.4.4 Current Water Production and Billed Water

(1) Water Production and Billed Water

Tables 2.5 and 2.6 show the trend of quantities of water production/distribution, billed water and non-revenue water (NRW) in the MWCI and MWSI service areas for the last three (3) years, respectively. Figure below shows the past trend graphically.




**Past Trend of Billed Water and NRW, MWCI**

Average daily water production in year 2000 was about 1,700 MLD for MWCI and 2,000 MLD for MWSI, respectively. The water produced/distributed by MWCI includes the cross boundary transfer to MWSI, which is estimated at about 280 MLD. A total of water production is estimated at about 3,700 MLD in 2000. Likewise, for the billed water for year 2000, the average water volume of MWCI and MWSI is estimated at about 680 MLD (excluding cross boundary transfer) and 760 MLD, respectively.

Thus, the total billed water is estimated at 1,440 MLD, which corresponds to 39% of the total water production.

It is noted that Metro Manila experienced an unusual decrease of water supply in 1997-1998 as shown in Table 2.7. This is due to El Nino phenomenon occurring in 1997, which seriously affected the water production in 1998 due to reduced water yield from the Angat Dam. Except for 1997-1998 period, water supply volume has generally increased year by year.

(2) Assumed Composition of Billed Water by City/Municipality

No data were made available to the Study Team with regard to area distribution of the billed water in year 2000. Thus, water consumption by city/municipality was estimated based on the data of billed water in 1999 by business area for the MWCI supply area and the number of service connections by city/municipality for the MWSI supply area (refer to Part-B, Vol. III). Table 2.8 summarizes the estimated water consumption by area and by water use.

(3) Non-Revenue Water (NRW)

As for the Metro Manila water supply system, a high NRW has been the most serious issue to date. Out of the total water production of 3,700 MLD in year 2000, about 2,230 MLD or 61% of water volume (730 MLD in MWCI area and 1,500 MLD at MWSI area) is estimated as the physical and commercial losses, which is defined as the NRW. Tables 2.5 and 2.6 show the ratios of non-revenue water (NRW) of MWCI and MWSI supply areas for the last three (3) years, respectively. NRW ratio of the MWCI's service area was more or less 50% and seems to have a sign of slight improvement. While, the NRW ratio of the MWSI's was around 66% and is still slightly increasing.

With regard to composition of NRW, a ratio of about 55% is assumed as the physical loss ratio referring to the latest reports (Technical Annex of Business Plan both of the MWCI and MWSI). Thus, physical and commercial losses are assumed at 33.5% and 27.4% of the total water production in Metro Manila, respectively.

(3) Issues and Problems

(a) Water sources and insufficient capacity of water supply facilities

The existing water source of 4,090 MLD seems to be already insufficient to meet maximum daily water demand of Metro Manila. The current average water production is about 3,700 MLD. If a day peak demand factor of 1.21 is assumed, the maximum daily demand is about 4,400 MLD (3,700 MLD x 1.21). This already exceeded the design capacity of Balara and La Mesa WTPs (a total of 4,000 MLD). In fact, Balara WTPs (design capacity of 1,600 MLD) and La Mesa WTPs (2,400 MLD) sometimes produce treated water up to 1,800 MLD and 2,700 MLD, respectively. This means that the existing WTPs are occasionally operated under the 10% overloaded condition for meeting the supply requirement.

Furthermore, the insufficient capacity of water distribution facilities (service reservoirs, booster pumps and distribution pipes) is not able to provide acceptable service to the water recipients equally. For example, 50-60% of the service areas is under insufficient water pressure.

(b) Non-revenue water (NRW)

Presently, a large volume of NRW, which corresponds to 61% of distributed water, affects operation/management of water supply seriously. Physical loss, which is estimated at about 34% of distributed water, causes unnecessary use of water sources/water production. This situation directly relates to shortage of water supply capacity mentioned above.

(c) Water supply to the municipalities presently unserved by Concessionaire

Water supply for fringe municipalities (Angono, Baras, Binangonan, Cardona, Jala-Jala, Morong, Pillia, Taytay and Teresa) in Rizal province would need to be coordinated between the Concessionaire and LWUA/community water works, before implementation of the long-term water supply project.

2.4.5 Water Tariff in MWSS's Service Area

Average tariff rate as of the middle of 2001 is 2.95 Pesos/$m^3$ for MWCI customers and 6.58 Pesos/$m^3$ for MWSI's. There is a large difference in tariff rate between the two concessionaires. Both companies, especially MWSI, has requested the Government of the Philippines for increasing tariff in order to recover the deficit affected by devaluation of the Peso currency since taking-over from MWSS. According to the latest report in newspapers in Manila, MWSS agreed to raise the water rate of MWSI by Peso 4.21 per cubic meter for 14 months from October 20, 2001 to December 2002. Consequently, the present difference in tariff between MWCI and MWSI is much more than before. Historical tariff is shown in Part-B of Volume III.

## 2.5 Water Demand Projection for Metro Manila

Basically, water demand consists of billed water and non-revenue water (NRW).

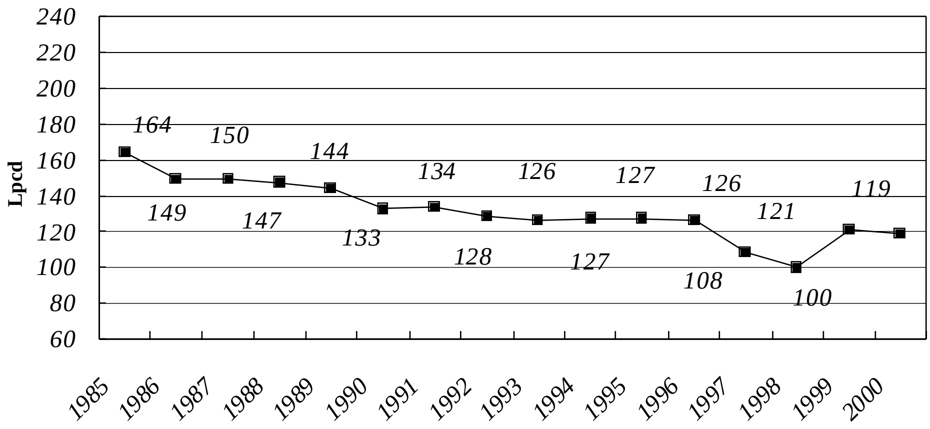
Water demand = Billed water (domestic water + commercial water + industrial water) + NRW

Planning factors used in the projection of future water demand are; per capita consumption, projected population, service coverage, commercial and industrial water demand, NRW ratio and peak day demand factor.

2.5.1 Domestic Water Demand

(1) Per Capita Consumption

The past trend (1985 - 2000) of average per capita consumption is shown in a figure below. Average per capita consumption (about 140 - 160 Lpcd) in the late 1980s decreased to 119 Lpcd in 2000. This infers that water supply capacity could not meet the growth of water demand due mainly to delay of system expansion/rehabilitation (distribution system in particular) for the last 10 years. In addition to this, El Nino phenomenon affected the water supply in Metro Manila, as indicated by unusual drop of unit consumption in 1997 and 1998.




**Per Capita Consumption**

In assuming per capita consumption, the relationship between per capita consumption and per capita income (or per capita GRDP) is usually employed. In the case of Metro Manila, however, various constraints such as limited water sources, insufficient capacity of water supply facilities and other factors has distorted the normal growth of past domestic water demand. In addition, the actual data on area distribution of domestic water supply were not available at two concessionaires. Thus, the examination on correlation between per capita consumption and per capita income was discarded.

This Study took the following approach:

i) Per capita consumption in the base year 2000

The current average per capita consumption (119 Lpcd in 2000) is applied commonly to all of the concerned cities/municipalities as the base year's per capita consumption.

ii) Per capita consumption in the target year 2025

Per capita consumption in the target year 2025 was determined by adopting the value proposed in a previous JICA study (Metro Manila Water Supply and Sewerage Master Plan, 1995). Per capita consumption for the blighted was fixed at 40 Lpcd.

iii) Per capita consumption in year 2005

Per capita consumption in year 2005 is fixed at 125 Lpcd uniformly for all cities/municipalities assuming that a large scale water source development will not be realized within the next 5 years.

iv) Per capita consumption in year 2010, 2015 and 2020

Per capita consumption in intermittent years (year 2010, 2015 and 2020) are estimated by linear interpolation between those in year 2005 and 2025.

Under the above assumption, average per capita consumption in late 1980's will be recovered in year 2015-2020 period. The average per capita consumption will reach 188 Lpcd within a range from 163 to 200 Lpcd by city/municipality as shown in Table 2.9. Proposed average per capita consumption by concessionaire is summarized as below. Further details are contained in Part-B, Volume III.

**Proposed Average Per Capita Consumption (Lpcd)**

| Service Area | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|
| East Zone | 119 | 125 | 139 | 155 | 172 | 191 |
| West Zone | 119 | 125 | 138 | 152 | 168 | 185 |
| Total | 119 | 125 | 139 | 153 | 170 | 188 |

(2) Service Coverage

In setting up the future targets of service coverage by city/municipality, it is planned that the service coverage ratios scheduled in the Concessionaire Agreement should be achieved in year 2025. As for the targets in the near future (Year 2005 and 2010), more realistic targets shall be established considering the current service coverage. The details of scheduling of service coverage ratios are described in Part-B in Volume III.

The proposed service coverage by city/municipality is scheduled as shown in Table 2.10 and the same by concessionaire summarized in table below.

**Proposed Service Coverage**

| Service Area | Year | | | | | |
|---|---|---|---|---|---|---|
| | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 |
| East Zone | 72% | 63% | 61% | 71% | 82% | 95% |
| West Zone | 67% | 77% | 86% | 90% | 93% | 98% |
| Total | 69% | 71% | 75% | 81% | 88% | 97% |

The decrease of service coverage in East zone till 2010 is because of pending of water supply to the municipalities in the Rizal Province, such as Angono, Baras, Binangonan, Cardna, Jala-Jala, Morong, Pilillia, Tanay and Teresa, while demand in the areas will be increasing.

Based on the projected population, the served population is calculated as shown in Table 2.11. Total population to be served will reach 19.1 million in 2025 (9.2 million in MWCI service area and 9.9 million in MWSI service area).

(3) Domestic Water Demand

Applying the per capita consumption with the served population estimated above, domestic water demand by city/municipality is computed (see Tables 2.13 to 2.16). Water demand for domestic use in year 2025 will reach 3,596 MLD (1,752 MLD in MWCI supply area and 1,845 MLD in MWSI supply area). Table below summarizes the projected water demand by concessionaire.

**Projected Domestic Water Demand (MLD)**

| Service Area | Year | | | | | |
|---|---|---|---|---|---|---|
| | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 |
| East Zone | 423 | 455 | 556 | 835 | 1,206 | 1,752 |
| West Zone | 496 | 758 | 1,009 | 1,281 | 1,536 | 1,845 |
| Total | 919 | 1,213 | 1,565 | 2,116 | 2,742 | 3,596 |

### 2.5.2 Commercial Water Demand

Correlation between water consumption and GRDP was applied in estimating the commercial water demand. Although there were some fluctuations on water consumption during the time, a correlation coefficient between water consumption and GRDP was derived at 0.723 by a regression formula below:

Commercial Water Demand (MLD) = 134.114 + 0.00076 x GRDP (Million Pesos)

Applying the GRDP projected in Section 2.3, the commercial water demand is computed as shown below. Water demand for commercial use in year 2025 will reach 1,082$m^3$/d. Details on water demand projection for commercial use are referred to Part-B, Volume III.

**Projected Commercial Water Demand (MLD)**

| Year | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|
| Water Demand | 428 | 528 | 662 | 842 | 1,082 |

### 2.5.3 Industrial Water Demand

Correlation between water consumption and GRDP was applied in the same manner as adopted for the demand projection of commercial water. Although there is a slight decrease in water consumption due to lack of water sources in the period affected by El Nino phenomenon, a correlation coefficient between industrial water consumption and GRDP was derived at 0.867 by a formula below:

Industrial Water Demand (MLD) = 26.500+ 0.00019 x GRDP (Million Pesos)

Water conservation by recycling/re-use is taken into consideration for the projection of industrial water use. The recycling rate is set at 5% in year 2010 and 20% in year 2025 referring to a previous JICA study (Master Plan Study on Water Resources Management in the Philippines, 1998). The rates in both years are interpolated to determine the rates in their intermediate years.

Consequently, the industrial water demands are projected as shown below. Water demand for industrial use in year 2025 will reach 208 $m^3$/d. Details on water demand projection for industrial use are referred to Part-B, Volume III.

**Projected Industrial Water Demand (MLD)**

| Year | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|
| Water Demand | 99 | 117 | 141 | 170 | 208 |

### 2.5.4 Total Water Demand

#### (1) Billed Water

On the basis of sectoral water demand projections described above, table below summarizes the total water demand on a billed water basis. Water demand in 2025 is estimated to reach 4,886 MLD, which is about 3.41 times the present billed water. The share of domestic water to total water demand is estimated to increase from 64% in 2000 to 74% in 2025 in accordance with population growth as well as increase of targeted service coverage in residential areas.

**Projected Water Demand (Billed Water Base)**

| Year | Water Demand by Use (MLD) | | | |
|---|---|---|---|---|
| | Domestic | Commercial | Industrial | Total |
| 2000 | 919 | 418 | 94 | 1,433 |
| 2005 | 1,213 | 428 | 99 | 1,740 |
| 2010 | 1,565 | 528 | 117 | 2,210 |
| 2015 | 2,116 | 662 | 141 | 2,919 |
| 2020 | 2,742 | 842 | 170 | 3,754 |
| 2025 | 3,596 | 1,082 | 208 | 4,886 |

#### (2) Proposed Target of NRW

As mentioned in Subsection 2.4.4, the reduction of NRW has been a big issue since early stage of the water supply. The several recent studies (Metro Manila Water Supply and Sewerage Master Plan, Master Plan Study on Water Resources Management in the Philippines, Manila Water Supply Project III, etc.) assumed 20 to 30% for NRW ratio as the final target to be achieved.

To set up NRW ratio in this Study, the actual attainment in the Manila Water Supply Rehabilitation Project (MWSRP) I (1984-1993) and II (1991-1994) are considered as references. It was reported that 72% of NRW ratio before the project decreased to 31% after the project under the MWSRP I and from 60% to 24% under the MWSRP II, respectively (details are referred to Part-B, Volume III).

In addition, according to the ADB Water Utility Data Book (1993), NRW ratios in Asian cities such as Karachi, Delhi, Bangkok, Calcutta and Bombay have achieved a level of 24 to 36%.

Considering the above overall, the final target of NRW ratio is set at 30% (20% for physical loss and 10% for commercial loss) as a feasible target. Table below shows a staged target of NRW reduction set forth in this Study. To achieve such targets, the measures to be exercised are discussed in Section 2.7 hereinafter.

**Proposed NRW Reduction Target**

| Year | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|
| NRW Ratio | 60.9% | 54% | 48% | 42% | 36% | 30% |
| - Physical Loss | 33.5% | 30% | 28% | 26% | 23% | 20% |
| - Commercial loss | 27.4% | 24% | 20% | 16% | 13% | 10% |

(3) Average and Maximum Daily Water Demand

In addition to the total water demand in terms of the average daily demand examined above, the peak day demand factor (ratio of maximum daily demand to average daily demand) is taken into account to project the maximum daily demand. The factors of 1.21 to 1.25 are adopted in the previous studies. In this Study, a peak factor of 1.21, which was recommended in the latest study (Project Review of Manila Water Supply Project III), is adopted.

As the result, the average and maximum daily demands are projected as shown below. The average and maximum daily demand in target year 2025 will be 6,980 MLD and 8,446 MLD, respectively.

**Average and Maximum Daily Demand Projection**

| Year | Billed Water (MLD) | | | | NRW | | Average Daily Demand (MLD) | Maximum Daily Demand (MLD) |
|---|---|---|---|---|---|---|---|---|
| | Domestic | Commercial | Industrial | Sub-total | (MLD) | (%) | | |
| 2000 | 919 | 418 | 94 | 1,433 | 2,230 | 60.9% | 3,663 | 4,090 |
| 2005 | 1,213 | 428 | 99 | 1,740 | 2,043 | 54.0% | 3,783 | 4,577 |
| 2010 | 1,565 | 528 | 117 | 2,210 | 2,040 | 48.0% | 4,250 | 5,143 |
| 2015 | 2,116 | 662 | 141 | 2,919 | 2,114 | 42.0% | 5,033 | 6,090 |
| 2020 | 2,742 | 842 | 170 | 3,754 | 2,112 | 36.0% | 5,866 | 7,097 |
| 2025 | 3,596 | 1,082 | 208 | 4,886 | 2,094 | 30.0% | 6,980 | 8,446 |

(4) Area Distribution of Water Demand

For estimation of area distribution of the sectoral water demand between year 2005 and 2025, the following conditions were assumed:

i) The domestic water demands are as per projected by city/municipality in Subsection 2.5.1.

ii) For the commercial and industrial water use until year 2010, the projected water demand is distributed to each city/municipality based on the current share to total demand (details are referred to Part-B, Volume III).

iii) After year 2010, the commercial and industrial water in the municipalities of Rizal province (Angono, Baras, Binangonan, Cardona, Jala-Jala, Morong, Pililla, Tanay and Teresa) is met from new water sources in the Agos River basin. The demand was estimated based on the current share in other city/municipality of Rizal province. Then, the balance is distributed in the same manner as adopted for (ii) above.

Tables 2.13 to 2.16 present the projected water demand by city/municipality in 2005, 2010, 2015, 2020 and 2025, respectively.

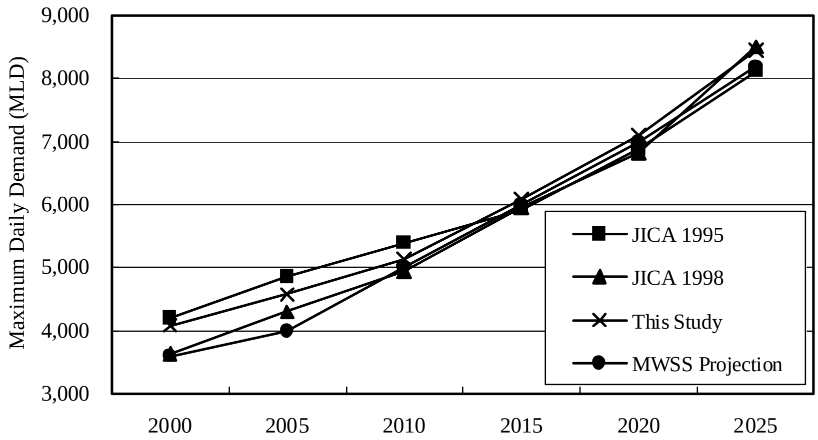
2.5.5 Comparison with Previous Water Demand Projections

Water demand projected in this study is compared with the demand projection in previous studies such as Metro Manila Water Supply and Sewerage Master Plan (1995), Master Plan Study on Water Resources Management in the Philippines JICA studies (1998) and Manila Water Supply III (MWSS). Since the demand projection in JICA study 1995 covers the period only up to year 2015, water demand after 2015 was assumed using regression formula. Demand projection in JICA study 1998 was modified using population projected in this Study. Table and figure shown below present the result of comparison.

**Comparison of Water Demand Projection with Previous Studies**

| Year | JICA Study 1995 [1)] | JICA Study 1998 [2)] | MWSS Projection [3)] | This Study |
|---|---|---|---|---|
| 2000 | 4,200 | 3,635 | 3,600 | 4,090 |
| 2005 | 4,861 | 4,297 | 4,000 | 4,577 |
| 2010 | 5,405 | 4,943 | 5,000 | 5,143 |
| 2015 | 5,932 | 5,955 | 6,000 | 6,090 |
| 2020 | 6,880 | 6,838 | 7,000 | 7,097 |
| 2025 | 8,124 | 8,509 | 8,200 | 8,446 |

Note: 1) Water demand for year 2020 and 2025 is assumed by using regression formula.
2) Water demand was modified using population projected in this Study.
3) NRW ratio assumed in MWSS Projection is 21% in 2025.




**Comparison with Previous Demand Projection**

The projected water demand in this Study falls within a range of previous projections as indicated in the figure above.

## 2.6 Water to be Exploited in the Agos River Basin to Meet Water Demand of MWSS's Service Area

### 2.6.1 Interim Water Supply Projects Envisaged by MWSS

According to the latest information obtained from the MWSS and two concessionaire during the first field investigation period (as of July 2001), the following water source development are contemplated as the possible water sources to meet the impeding water demands in Metro Manila:

(a) Angat Dam

The present supply from Angat River is 4,000 MLD. According to the MWCI, two (2) projects are now under study: (i) Rehabilitation plan of Angat water conveyance aqueducts to augment delivery capacity by 350 MLD; (ii) Antipolo Water Supply Project utilizing the Angat water source with a total capacity of 120 MLD.

(b) Wawa River

A 50 MLD Wawa Extraction Project is now under study by MWSS. The purposed project is to deliver 50 MLD of treated water to Rodriguez and San Mateo by year 2005. For realization of the project, the MWSS is seeking financial source.

(c) Laguna Lake

The MWSS has studied a 300 MLD Bulk Water Supply Project, which aims at exploiting the lake water for water supply to Las Pinas, Montenlupa, Paranaque, Cavite City, Bacoor, Imus, Kawit, Noveleta and Rosario. The MWSS intends to implement the project on BOT basis by year 2007.

(d) Deep Well

It is estimated that a total of 90 MLD of deep well water is presently extracted in the MWCI and MWSI supply areas. As for the utilization of groundwater, Metro Manila has already been facing serious problem of saline water intrusion as well as lowering groundwater table due to over pumping. Further development of deep well sources is presumed not feasible. (Refer to Part-B, Volume III for detail)

After the above interim water supply schemes are completed, the total supply capacity becomes 4,790 MLD. In case the Angat water conveyance augmentation will not be push forward, another scheme of 350-400 MLD capacity should be developed to fill the demand-supply gap foreseen for the period up to 2010.

### 2.6.2 Water Demand and Supply Balance Until 2025

On the basis that three interim schemes are implemented by year 2005, water demand and supply balance is depicted in a table below. The supply capacity including those of three interim schemes will meet the day peak demand for the period up to around year 2007. The shortage of supply capacity in year 2025 will be 3,656MLD, which corresponds to the average daily demand of 3,021MLD.

**Water Sources and Daily Peak Demand**

| Year | Water Demand | | Exploitable Water Sources (MLD Daily Peak) | | | | | Balance |
|---|---|---|---|---|---|---|---|---|
| | | | Angat River | Laguna Lake | Wawa River | Deep Wells | Total | |
| 2000 | Peak | 4,090 | 4,000 | | | 90 | 4,090 | 0 |
| | Avg. | 3,663 | | | | | | |
| 2005 | Peak | 4,577 | 4,350 | 300 | 50 | 90 | 4,790 | 213 |
| | Avg. | 3,783 | | | | | | |
| 2010 | Peak | 5,143 | 4,350 | 300 | 50 | 90 | 4,790 | △ 353 |
| | Avg. | 4,250 | | | | | | |
| 2015 | Peak | 6,090 | 4,350 | 300 | 50 | 90 | 4,790 | △ 1,300 |
| | Avg. | 5,033 | | | | | | |
| 2020 | Peak | 7,097 | 4,350 | 300 | 50 | 90 | 4,790 | △ 2,307 |
| | Avg. | 5,866 | | | | | | |
| 2025 | Peak | 8,446 | 4,350 | 300 | 50 | 90 | 4,790 | △ 3,656 |
| | Avg. | 6,980 | | | | | | △ 3,021 |

### 2.6.3 Water to be Exploited in the Agos River Basin to Meet Water Demand up to 2025

As indicated in table above, the deficit of water source against maximum daily water demand is anticipated to occur in 2010 and increases to 3,656 MLD in terms of day peak supply requirement. In order to secure water supply for Metro Manila, the development of new water source is required. This Study assumes that the deficit would be met by development of the water resources of the Agos River basin. If a peak day factor of 1.21 is assumed, the water resource to be exploited is about 3,000 MLD in terms of average daily quantity.

This subject is described in more detail in Subsection 5.1.2 in Chapter V.

## 2.7 Recommended Measures to Reduce Non-Revenue Water Ratio

There is no stipulation in the existing Concession Agreement with regard to NRW ratio to be accomplished. However, two concessionaires are attempting their NRW reduction programs in line with the previous plans worked out by MWSS.

The following are considered as the main items of NRW reduction programs:

- Repair of all visible leaks within one month of reporting
- Periodical field survey of water leakage
- Regular patrolling/monitoring of the rehabilitated zones or sub-zones at least every quarterly
- Monitoring of all large meter bills
- Carrying out comprehensive rehabilitation works
- Improvement of meter reading and water tariff collection system
- Community involvement

### 2.7.1 Field Survey to Clarify Water Leakage

Daily flow, night flow and billed water monitoring shall be carried out in order to determine the priority order of the rehabilitation work by area. Ideally, it should be carried out for each small-divided zone of 5,000-10,000 connections at least every quarterly. Updating of the inventory and drawings of the concerned facilities is requisite for conducting the survey

### 2.7.2 Recommended Rehabilitation Works for Reducing Water Leakage

Practices for the rehabilitation works have already been accumulated through the Manila Water Supply Rehabilitation Project I and II (details are referred to Part-B, Volume III). As the result of the projects, the reduction of NRW ratio by about 10 % was achieved between 1985 and 1992.

Presently, MWCI has a NRW reduction plan with the investment of 1.4 billion Pesos towards the end of concession period. However, it is considered that additional financial arrangement (2-3 times the presently contemplated budget) will be required to attain a significant result from the rehabilitation project. MWSI will also proceed with NRW reduction program with necessary financial arrangements.

The Study recommends the following components of rehabilitation works to be carried out:

(a) Rehabilitation of Distribution Facilities

Rehabilitation of distribution facilities includes: i) leak repairs; ii) closing/legalizing of illegal connections; iii) testing/repair/replacement of meters: iv) repair/replacement/installation of valves; v) replacement of service connections and “spaghetti” connections; vi) replacement/ rehabilitation/interconnection of water mains; vii) laying of new water mains; viii) closing of inactive connections; ix) installation of flow pressure monitoring stations; and x) procurement of equipment, instruments, vehicles, tools, and other supplies for the investigation, design and carrying out of rehabilitation works.

(b) Operational and Institutional Support

Operational modernization is required to strengthen the operation and maintenance activities by providing equipment, instrument, vehicles, tools and other supplies. Likewise, institutional support to train staff shall also be extended.

(c) Community Involvement

For comprehensive rehabilitation works, participation/cooperation of beneficiaries/communities shall be considered.

2.7.3 Water Tariff Collection System on a Community Basis

Since 1998, the MWCI has been implementing a NRW reduction program; called “Tubig Para sa Barangay” (details are referred to Part-B, Volume III).

Through the project, all of the service pipes in the specified Barangays were properly replaced and individual water meters placed at selected locations for easier meter readings. At some Barangays, the water volume consumed is measured with a bulk meter(s) and water bills are paid as a total amount of the Barangay. Barangay officials collect water bills based on the individual meter. It looks like a kind of community water supply and the practice/operation under the program contributes to the NRW reduction relative to illegal connection, meter error and water leakage from service pipes. The MWCI intends to continue this program up to year 2005 and the budgetary arrangement for year 2001 was made with a total of 61 million Pesos.

The MWSI also commenced carrying out the similar program (Tubig Bayan). Actual implementation, however, has been delayed due to financial constraints.

## 2.8 Present Condition of Power Market

2.8.1 Power Sector in the Philippines

The main participants in the power sector of the Philippines consist of National Power Corporation (NPC) and its group companies, independent power producers (IPPs), electric power distributors and retailers, and other regulatory agencies.

As of year 2001, either NPC or other power producers undertake the power generation through energy conservation arrangements, but the bulk transmission lines are exclusively owned by NPC (TRANSCO after its establishment). The Government regulatory bodies with regard to power supply are the Department of Energy (DOE) and the Energy Regulatory Board (ERB). The DOE is the policy-making body in the energy sector, while the ERB regulates the prices of electricity and petroleum products. As an electric power distributor and retailer, Manila Electric Company (Meralco) distributes the power in and around Metro Manila.

Because of restructuring of power sector, NPC will dismantle its generation sector with the sale of power plants to six generation companies. Further, NPC plans to establish a transmission company (TRANSCO) in 2002.

Note: The above describes the conditions prevailed in the early part of 2001. NPC was re-structured afterward. Annex H of Volume V describes the structural change of NPC.

Present power supply system in major islands is divided into three: Luzon, Visayas and Mindanao systems. Major islands of Luzon and Visayas have already been interconnected and the Mindanao system will also be interconnected by year 2004 as shown in Figure 2.3.

### 2.8.2 Power Development Program by NPC

NPC prepared the 2000 Power Development Program (PDP) in November 2000. It presents a comprehensive assessment of the required generation and transmission facilities that will sustain the future power requirement of the country up to the year 2010.

(1) Power Demand Projection

According to power demand projection in the PDP, Luzon system is projected to grow at an average rate of 7.8 %, Visayas at 8.7 % and Mindanao at 7.9 %. The projected energy sales and peak power demand are shown in Table 2.17. (See Part-E of Volume III for further detail)

Energy sale and peak power demand of the interconnected system in 2010 will be 91,284 GWh and 15,794 MW, respectively, which is 2.3 times the present level both in energy sale and peak demand. This implies that the system is large enough to absorb the power from the Agos river basin development, which is in the range from 10 to 200 MW in installed capacity varying by scheme.

(2) Capacity Addition

Table 2.18 shows the system capacity addition program for the three main grids during the period 2000-2010. The program foresees installing a total capacity of 9,844 MW.

The PDP foresees that combined capacity from existing and committed plants (after deduction of retirement of some plants) is more than enough to sustain the growth in power demand up to year 2007. The system will need an additional capacity of 5,028 MW to meet the demand of year 2007 onward.

(3) Future IPP Projects

The remaining 5,028 MW will have to be identified and commissioned during the period of 2007-2010 over and above the ongoing and committed projects. The PDP states that, because of impending restructuring of power industry, NPC is no longer in a position to build or contract for additional capacity. The IPPs, in cooperation with the distribution utilities, will bear responsibility of expanding the power generation capacity in the future.

Following this basic policy of future power development, power schemes of the Agos river basin will be formulated as private-initiated project (e.g. BOT scheme).

(4) Meralco Power Supply System

Manila Electric Company (Meralco) distributes the power in and around Metro Manila as a power distributor and retailer. The Meralco's franchise area covers NCR, southern part of Bulacan Province, Rizal Province, Cavite Province, Laguna Province, middle part of Quezon Province and around Batangas City.

Operating Statistics of the Meralco power supply system are shown in Table 2.19, which was re-produced from the Meralco Annual Report for year 2000.

Meralco purchased 87 % of its requirement from NPC in 2000, a drop from 96 5 % in 1999. The reduced dependence on NPC was due to the commercial operation of Meralco's two IPPs, namely, First Gas and Quezon Power.

Further detail of the Meralco system is described in Part-E of Volume III and the latest operating statistics in Annex H in Volume V.

(5) Power Tariff

Power tariff of the Luzon Grid is around Peso 3.9/kWh (NPC) in the early part of 2001. Effective rate has increased from Peso 3.0/kWh to Peso 3.9/kWh during the period from March 2000 to March 2001. The power tariff in 2000-2001 is shown in Part-E of Volume III

In the Meralco system, average selling rate increased by14.9 % to Peso 4.71/kWh from a Peso 4.10/kWh level in 1999. The rise resulted from mainly from an 18.8 % increase in purchased power cost (PPC) from Peso 2.87/kWh in 1999 to Peso 3.41/kWh in 2000.

NPC has no clear-cut criteria for the price of power purchase from the IPPs, which would be, according to NPC, determined through negotiation on individual project basis.

Note: The latest power rates of both the NPC and Meralco systems are described in Annex H of Volume V.

## Table 2.1 Comparison of Socio-Economic Indices in the Study Area

| | Province | | | Region | | Philippine |
|---|---|---|---|---|---|---|
| | **Rizal** | **Cavite** | **Quezon** | **Region IV** | **NCR** | |
| **(1) Land area (sq. km)** | 1,309 | 1,288 | 8,626 | 46,844 | 636 | 294,554 |
| | 0.4% | 0.4% | 2.9% | 15.9% | 0.2% | 100.0% |
| **(2) Population in 2000 (thousand)** | 1,708 | 2,063 | 1,679 | 11,794 | 9,933 | 76,499 |
| | 2.2% | 2.7% | 2.2% | 15.4% | 13.0% | 100.0% |
| **(3) Population density (persons/sq.km)** | 1,305 | 1,602 | 195 | 252 | 15,618 | 260 |
| (Index: Philippine = 100) | 502 | 617 | 75 | 97 | 6,014 | 100 |
| **(4) Population growth (% per annum)** | 5.4% | 5.1% | 1.6% | 3.6% | 1.0% | 2.3% |
| (Index: Philippine = 100) | 235 | 222 | 70 | 157 | 43 | 100 |
| **(5) GRDP in 1999 (Peso million)** | | | | | | |
| Agriculture | - | - | - | 35,218 | 0 | 183,407 |
| (% to nation total) | | | | 19.2% | 0.0% | 100.0% |
| Industry | - | - | - | 62,606 | 110,186 | 316,650 |
| (% to nation total) | | | | 19.8% | 34.8% | 100.0% |
| Services | - | - | - | 46,125 | 171,302 | 417,325 |
| (% to nation total) | | | | 11.1% | 41.0% | 100.0% |
| Total | - | - | - | 143,949 | 281,488 | 917,382 |
| (% to nation total) | | | | 15.7% | 30.7% | 100.0% |
| **(6) Labor force in April 2000 (thousand)** | | | | | | |
| Employed | 382 | 502 | 597 | 3,755 | 3,665 | 28,301 |
| Unemployed | 65 | 97 | 64 | 578 | 838 | 4,573 |
| Total labor force | 447 | 599 | 661 | 4,333 | 4,503 | 32,874 |
| Employment rate | 85.5% | 83.8% | 90.3% | 86.7% | 81.4% | 86.1% |
| Unemployment rate | 14.5% | 16.2% | 9.7% | 13.3% | 18.6% | 13.9% |
| **(7) Employment in April 2000 (thousand)** | | | | | | |
| Agriculture | 29 | 48 | 216 | 1,046 | 39 | 10,558 |
| | 7.6% | 9.6% | 36.2% | 27.9% | 1.1% | 37.3% |
| Industry | 134 | 164 | 105 | 913 | 858 | 4,571 |
| | 35.2% | 32.7% | 17.6% | 24.3% | 23.4% | 16.2% |
| Services | 218 | 290 | 276 | 1,793 | 2,770 | 13,167 |
| | 57.2% | 57.8% | 46.2% | 47.8% | 75.5% | 46.5% |
| Total | 381 | 502 | 597 | 3,752 | 3,667 | 28,296 |
| | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| **(8) Family income and expenditures (1997)** | | | | | | |
| Total number of families | 200,847 | 281,580 | 337,305 | - | 1,991,987 | 14,192,462 |
| Average annual family income (Pesc | 188,639 | 163,660 | 99,907 | - | 270,993 | 123,168 |
| Rank in all 78 Provinces | 1 | 2 | 23 | - | - | - |
| Average annual family expend. (Pes( | 128,776 | 128,122 | 82,010 | - | 217,840 | 99,537 |
| Rank in all 78 Provinces | 2 | 3 | 19 | - | - | - |
| Percent of expenditure share | | | | | | |
| Food | 48.4% | 45.5% | 44.9% | - | 35.8% | 44.2% |
| Rent | 14.1% | 14.7% | 13.0% | - | 21.9% | 14.2% |
| Transport & communic. | 5.7% | 5.9% | 4.3% | - | 7.4% | 5.6% |
| Education | 2.4% | 2.9% | 4.4% | - | 3.6% | 3.7% |
| Medical care | 1.7% | 1.4% | 3.4% | - | 1.8% | 2.2% |
| Recreation | 0.4% | 0.3% | 0.5% | - | 0.6% | 0.4% |
| Alcoholic & beverage | 0.6% | 0.6% | 0.9% | - | 0.6% | 0.9% |
| Tobacco | 1.2% | 1.5% | 1.6% | - | 0.8% | 1.3% |
| Fuel, light and water | 6.8% | 5.1% | 5.1% | 5.3% | 5.5% | 5.3% |
| Others | 18.7% | 22.1% | 21.9% | - | 22.0% | 22.2% |
| Total | 100% | 100% | 100% | - | 100% | 100% |

Source: "Philippine Statistical Yearbook 2000" NSCB, October 2000
"Population Census 2000 - Final count" from Web site of NSO
"The Coutryside in Figures" 2000 edition, NSCB,
"1997 Family Income and Expenditures Survey" NSO, June 1999

Note: GRDP value at 1985 constant prices

### Table 2.2 Growth Target under Philippine National Development Plan

| | 1997 | MT (1999-2004) | | LT (2005-2025) | |
|---|---|---|---|---|---|
| | Actual | High | Low | High | Low |
| **Targets** | | | | | |
| **Gross Domestic Products** | | | | | |
| Real growth rate (%) | 5.1 | 6.5 | 5.5 | 10.0 | 8.0 |
| Per capita GDP in US$ (nominal) | 1,163 | 1,405 | 1,253 | 12,912 | 7,833 |
| **Assumptions** | | | | | |
| Population growth (%) | 2.3 | 2.1 | 2.1 | 1.5 | 1.5 |
| Domestic savongs (% of GDP) | 20.2 | 24.0 | 22.1 | 30.0 | 28.0 |
| Current account deficit (% of GDP) | -5.4 | 3.5 | 4.0 | 0.0 | 4.0 |
| Investment (% of GDP) | 25.0 | 27.5 | 26.1 | 30.0 | 32.0 |
| ICOR | 4.9 | 4.3 | 4.7 | 3.0 | 4.0 |
| Inflation rate (%) | 5.1 | 5.2 | 5.2 | 3.0 | 3.0 |

Source: "The Philippine National Development Plan" NEDA, 1998

## Table 2.3 Growth Target under Medium-term Philippines Development Plan, 1999-2004

### (High Growth Scenario)

| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | Average |
|---|---|---|---|---|---|---|---|
| **Gross Domestic Products** | | | | | | | |
| Real growth rate (%) | 3.2 | 5.4 | 4.6 | 5.9 | 6.6 | 5.9 | 5.3 |
| Per capita GDP in Pesos (nominal) | 40,092 | 44,475 | 48,782 | 53,669 | 59,201 | 64,584 | 51,801 |
| **Sector breakdown (%)** | | | | | | | |
| Agriculture, Fishery and Forestry | 3.5 | 4.1 | 1.5 | 4.3 | 4.6 | 2.0 | 3.4 |
| Industrial Sector | 2.0 | 5.6 | 5.4 | 6.6 | 7.5 | 7.2 | 5.7 |
| Mining & quarrying | 5.9 | 6.5 | 7.5 | 6.5 | 7.5 | 8.0 | 7.0 |
| Manufacturing | 1.7 | 5.0 | 4.5 | 6.0 | 7.0 | 6.3 | 5.1 |
| Construction | 0.5 | 6.4 | 7.5 | 8.0 | 9.0 | 10.0 | 6.9 |
| Utilities | 5.0 | 7.8 | 7.3 | 7.9 | 8.8 | 8.6 | 7.6 |
| Service Sector | 4.0 | 5.8 | 5.3 | 6.0 | 6.7 | 6.4 | 5.7 |
| **Assumptions** | | | | | | | |
| Population growth (%) | 2.2 | 2.1 | 2.1 | 2.0 | 2.0 | 2.0 | 2.1 |
| Domestic savongs (% of GNP) | 21.1 | 20.8 | 21.3 | 21.8 | 21.9 | 22.2 | 21.5 |
| Foreign savings (% of GNP) | -2.1 | -1.2 | -0.6 | -0.2 | 0.6 | 1.3 | -0.4 |
| Investment (% of GNP) | 18.9 | 19.6 | 20.7 | 21.6 | 22.5 | 23.5 | 21.1 |
| ICOR | 6.8 | 4.0 | 4.9 | 4.0 | 3.7 | 4.5 | 4.7 |
| Inflation rate (%) | 9.0 | 7.5 | 7.0 | 6.0 | 5.5 | 5.0 | 6.7 |

### (Low Growth Scenario)

| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | Average |
|---|---|---|---|---|---|---|---|
| **Gross Domestic Products** | | | | | | | |
| Real growth rate (%) | 2.6 | 4.8 | 3.9 | 5.4 | 6.1 | 5.2 | 4.7 |
| Per capita GDP in Pesos (nominal) | 39,515 | 43,197 | 46,628 | 50,564 | 54,965 | 58,987 | 48,976 |
| **Sector breakdown (%)** | | | | | | | |
| Agriculture, Fishery and Forestry | 3.0 | 3.5 | 0.5 | 3.5 | 4.0 | 1.0 | 2.6 |
| Industrial Sector | 1.4 | 5.0 | 4.8 | 6.0 | 6.8 | 6.6 | 5.1 |
| Mining & quarrying | 5.5 | 6.0 | 7.0 | 6.0 | 7.0 | 7.5 | 6.5 |
| Manufacturing | 1.1 | 4.4 | 4.0 | 5.6 | 6.3 | 5.8 | 4.5 |
| Construction | 0.0 | 5.9 | 6.5 | 6.7 | 8.0 | 9.0 | 6.0 |
| Utilities | 4.0 | 7.4 | 7.0 | 7.5 | 8.0 | 7.5 | 6.9 |
| Service Sector | 3.5 | 5.3 | 4.7 | 5.6 | 6.4 | 5.8 | 5.2 |
| **Assumptions** | | | | | | | |
| Population growth (%) | 2.2 | 2.1 | 2.1 | 2.0 | 2.0 | 2.0 | 2.1 |
| Domestic savongs (% of GNP) | 21.1 | 20.8 | 21.3 | 21.8 | 21.9 | 22.2 | 21.5 |
| Foreign savings (% of GNP) | -2.1 | -1.2 | -0.6 | -0.2 | 0.6 | 1.3 | -0.4 |
| Investment (% of GNP) | 18.9 | 19.6 | 20.7 | 21.6 | 22.5 | 23.5 | 21.1 |
| ICOR | 6.8 | 4.0 | 4.9 | 4.0 | 3.7 | 4.5 | 4.7 |
| Inflation rate (%) | 8.0 | 6.5 | 6.0 | 5.0 | 4.5 | 4.0 | 5.7 |

Source: "Medium-Term Philippines Development Plan 1999-2004" NEDA, September 1999

## Table 2.4 Present Service Coverage by City/Municipality (CY 2000)

| City/Municipality | | Pop. Census 2000 | No. of Service Connection | Pop. Served* | Service Coverage | Pop. Served Adjusted** | Service Coverage Adjusted |
|---|---|---|---|---|---|---|---|
| (West Zone) | | | | | | | |
| NCR | Pasay | 355,000 | 31,920 | 294,000 | 83% | 294,000 | 83% |
| | Caloocan | 1,178,000 | 66,664 | 613,000 | 52% | 613,000 | 52% |
| | Las Pinas | 473,000 | 7,934 | 73,000 | 15% | 73,000 | 15% |
| | Malabon | 339,000 | 31,175 | 287,000 | 85% | 287,000 | 85% |
| | Valenzuela | 485,000 | 34,996 | 322,000 | 66% | 322,000 | 66% |
| | Muntinlupa | 379,000 | 1,710 | 16,000 | 4% | 16,000 | 4% |
| | Navotas | 230,000 | 17,896 | 165,000 | 72% | 165,000 | 72% |
| | Paranaque | 450,000 | 25,415 | 234,000 | 52% | 234,000 | 52% |
| Cavite | Cavite City | 99,000 | 8,785 | 81,000 | 82% | 81,000 | 82% |
| | Bacoor | 306,000 | 5,462 | 50,000 | 16% | 50,000 | 16% |
| | Imus | 195,000 | 1,182 | 11,000 | 6% | 11,000 | 6% |
| | Kawit | 63,000 | 5,091 | 47,000 | 75% | 47,000 | 75% |
| | Noveleta | 32,000 | 1,024 | 9,000 | 28% | 9,000 | 28% |
| | Rosario | 74,000 | 1,974 | 18,000 | 24% | 18,000 | 24% |
| (East Zone) | | | | | | | |
| NCR | Mandaluyong | 278,000 | 42,012 | 387,000 | 139% | 278,000 | 100% |
| | Marukina | 391,000 | 53,449 | 492,000 | 126% | 391,000 | 100% |
| | Pasig | 505,000 | 58,469 | 538,000 | 107% | 505,000 | 100% |
| | Pateros | 57,000 | 6,193 | 57,000 | 100% | 57,000 | 100% |
| | San Juan | 118,000 | 17,404 | 160,000 | 136% | 118,000 | 100% |
| | Taguig | 467,000 | 10,666 | 98,000 | 21% | 98,000 | 21% |
| RIZAL | Antipolo | 471,000 | 7,727 | 71,000 | 15% | 71,000 | 15% |
| | Cainta | 243,000 | 7,978 | 73,000 | 30% | 73,000 | 30% |
| | Angono | | | | | | |
| | Baras | | | | | | |
| | Binangonan | | | | | | |
| | Cardona | | | | | | |
| | Jala-Jala | | | | | | |
| | Morong | | | | | | |
| | Pililla | | | | | | |
| | Rodoriguez | 115,000 | 2,723 | 25,000 | 22% | 25,000 | 22% |
| | San Mateo | 136,000 | 3,595 | 33,000 | 24% | 33,000 | 24% |
| | Tanay | | | | | | |
| | Taytay | 198,000 | 4,509 | 41,000 | 21% | 41,000 | 21% |
| | Teresa | | | | | | |
| (Common Concession Area) | | | | | | | |
| NCR | Quezon City | 2,174,000 | 261,453 | 2,406,000 | 111% | 2,174,000 | 100% |
| | East | 994,000 | 121,489 | 1,118,000 | 112% | 994,000 | 100% |
| | West | 1,180,000 | 139,964 | 1,288,000 | 109% | 1,180,000 | 100% |
| | Manila | 1,591,000 | 204,949 | 1,885,000 | 118% | 1,591,000 | 100% |
| | East | 196,000 | 24,569 | 226,000 | 115% | 196,000 | 100% |
| | West | 1,395,000 | 180,380 | 1,659,000 | 119% | 1,395,000 | 100% |
| | Makati | 445,000 | 57,801 | 531,000 | 119% | 445,000 | 100% |
| | East | 393,000 | 48,091 | 442,000 | 112% | 393,000 | 100% |
| | West | 52,000 | 9,710 | 89,000 | 171% | 52,000 | 100% |
| | Total | 11,847,000 | 980,156 | 9,017,000 | 76% | 8,120,000 | 69% |
| | East | 4,562,000 | 408,874 | 3,761,000 | 82% | 3,273,000 | 72% |
| | West | 7,285,000 | 571,282 | 5,256,000 | 72% | 4,847,000 | 67% |

* Service connection x 9.2 persons/connection
** Adjusted pop. served due to overshooting in initial calculation

## Table 2.5 Water Production and Distribution, MWCI

(Source: Service Peformance Report)

| | | Water Production (MLD) | | | Billed Water (MLD) | | | Unbilled Water | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Balara Treatment Plant | Deep wells | Treated Water Sent to Distribution | Domestic, Commercial & Industrial | Interconnection Transfer | Total | NRW (MLD) | % | excl. inter-transfer |
| CY 1998 | Jan | 1,090 | 40 | 1,130 | 469 | 260 | 729 | 401 | 35.5% | 53.9% |
| | Feb | 1,136 | 46 | 1,182 | 477 | 312 | 789 | 393 | 33.2% | 54.8% |
| | Mar | 1,061 | 45 | 1,106 | 472 | 236 | 708 | 398 | 36.0% | 54.3% |
| | Apr | 1,049 | 45 | 1,094 | 484 | 222 | 706 | 388 | 35.5% | 55.5% |
| | May | 1,078 | 45 | 1,123 | 475 | 219 | 694 | 429 | 38.2% | 52.5% |
| | Jun | 1,171 | 41 | 1,212 | 504 | 244 | 748 | 464 | 38.3% | 52.1% |
| | Jul | 1,123 | 43 | 1,166 | 510 | 216 | 726 | 440 | 37.7% | 53.7% |
| | Aug | 1,289 | 41 | 1,330 | 555 | 231 | 786 | 544 | 40.9% | 50.5% |
| | Sep | 1,327 | 41 | 1,368 | 547 | 269 | 816 | 552 | 40.4% | 49.8% |
| | Oct | 1,303 | 38 | 1,341 | 538 | 238 | 776 | 565 | 42.1% | 48.8% |
| | Nov | 1,459 | 39 | 1,498 | 576 | 267 | 843 | 655 | 43.7% | 46.8% |
| | Dec | 1,542 | 39 | 1,581 | 593 | 285 | 878 | 703 | 44.5% | 45.8% |
| | | 14,628 | 503 | 15,131 | 6,200 | 2,999 | 9,199 | 5,932 | 39.2% | 51.1% |
| | | 1,219 | 42 | 1,261 | 517 | 250 | 767 | 494 | | |

(Source: Service Peformance Report)

| | | Water Production (MLD) | | | Billed Water (MLD) | | | Unbilled Water | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Balara Treatment Plant | Deep wells | Treated Water Sent to Distribution | Domestic, Commercial & Industrial | Interconnection Transfer | Total | NRW (MLD) | % | excl. inter-transfer |
| CY 1999 | Jan | 1,612 | 35 | 1,647 | 621 | 341 | 962 | 685 | 41.6% | 47.5% |
| | Feb | 1,598 | 34 | 1,632 | 605 | 350 | 955 | 677 | 41.5% | 47.2% |
| | Mar | 1,577 | 35 | 1,612 | 602 | 353 | 955 | 657 | 40.8% | 47.8% |
| | Apr | 1,571 | 33 | 1,604 | 608 | 326 | 934 | 670 | 41.8% | 47.6% |
| | May | 1,620 | 32 | 1,652 | 628 | 330 | 958 | 694 | 42.0% | 47.5% |
| | Jun | 1,621 | 35 | 1,656 | 637 | 332 | 969 | 687 | 41.5% | 48.1% |
| | Jul | 1,670 | 35 | 1,705 | 653 | 388 | 1,041 | 664 | 38.9% | 49.6% |
| | Aug | 1,682 | 36 | 1,718 | 658 | 396 | 1,054 | 664 | 38.6% | 49.8% |
| | Sep | 1,667 | 35 | 1,702 | 658 | 394 | 1,052 | 650 | 38.2% | 50.3% |
| | Oct | 1,665 | 35 | 1,700 | 672 | 403 | 1,075 | 625 | 36.8% | 51.8% |
| | Nov | 1,658 | 37 | 1,695 | 666 | 407 | 1,073 | 622 | 36.7% | 51.7% |
| | Dec | 1,660 | 37 | 1,697 | 640 | 395 | 1,035 | 662 | 39.0% | 49.2% |
| | | 19,601 | 419 | 20,020 | 7,648 | 4,415 | 12,063 | 7,957 | 39.7% | 49.0% |
| | | 1,633 | 35 | 1,668 | 637 | 368 | 1,005 | 663 | | |

(Source: Service Peformance Report)

| | | Water Production (MLD) | | | Billed Water (MLD) | | | Unbilled Water | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Month | Balara Treatment Plant | Deep wells | Treated Water Sent to Distribution | Domestic, Commercial & Industrial | Interconnection Transfer | Total | NRW (MLD) | % | excl. inter-transfer |
| CY 2000 | Jan | 1,653 | 40 | 1,693 | 673 | 363 | 1,036 | 657 | 38.8% | 50.6% |
| | Feb | 1,609 | 41 | 1,650 | 666 | 340 | 1,006 | 644 | 39.0% | 50.8% |
| | Mar | 1,636 | 44 | 1,680 | 667 | 316 | 983 | 697 | 41.5% | 48.9% |
| | Apr | 1,646 | 39 | 1,685 | 668 | 306 | 974 | 711 | 42.2% | 48.4% |
| | May | 1,660 | 40 | 1,700 | 674 | 273 | 947 | 753 | 44.3% | 47.2% |
| | Jun | 1,662 | 38 | 1,700 | 684 | 272 | 956 | 744 | 43.8% | 47.9% |
| | Jul | 1,699 | 35 | 1,734 | 681 | 284 | 965 | 769 | 44.3% | 47.0% |
| | Aug | 1,706 | 34 | 1,740 | 676 | 304 | 980 | 760 | 43.7% | 47.1% |
| | Sep | 1,690 | 34 | 1,724 | 700 | 280 | 980 | 744 | 43.2% | 48.5% |
| | Oct | 1,675 | 32 | 1,707 | 703 | 255 | 958 | 749 | 43.9% | 48.4% |
| | Nov | 1,635 | 31 | 1,666 | 692 | 232 | 924 | 742 | 44.5% | 48.3% |
| | Dec | 1,601 | 34 | 1,635 | 706 | 187 | 893 | 742 | 45.4% | 48.8% |
| | Total | 19,872 | 442 | 20,314 | 8,190 | 3,412 | 11,602 | 8,712 | | |
| | Ave. | 1,656 | 37 | 1,693 | 683 | 284 | 967 | 726 | 42.9% | 48.5% |

# Table 2.6 Water Production and Distribution, MWSI

(Source: Customer services, Regulatory Office)

| CY 1998 | Distributed Water (MLD) | | | | | Billed Water (MLD) | | | | | | | Unbilled Water* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Surface Water Total | Deep Wells | Surface + Ground Water | Net Cross Boundary Transfer | Grand Total | Residential | Semi-Business | Commercial | Industrial | Sea Transport | Water District | Total | NRW (MLD) | % |
| Jan | 1,123 | 31 | 1,154 | 239 | 1,392 | 347 | 19 | 171 | 42 | 14 | | 593 | 799 | 57.4% |
| Feb | 1,123 | 31 | 1,154 | 239 | 1,392 | 347 | 19 | 171 | 42 | 14 | | 593 | 799 | 57.4% |
| Mar | 1,123 | 31 | 1,154 | 239 | 1,392 | 347 | 19 | 171 | 42 | 14 | | 593 | 799 | 57.4% |
| Apr | 1,126 | 30 | 1,156 | 229 | 1,385 | 325 | 23 | 157 | 39 | 15 | | 559 | 826 | 59.6% |
| May | 1,126 | 30 | 1,156 | 229 | 1,385 | 325 | 23 | 157 | 39 | 15 | | 559 | 826 | 59.6% |
| Jun | 1,126 | 30 | 1,156 | 229 | 1,385 | 325 | 23 | 157 | 39 | 15 | | 559 | 826 | 59.6% |
| Jul | 1,272 | 32 | 1,304 | 240 | 1,544 | 343 | 25 | 169 | 42 | 18 | | 597 | 947 | 61.4% |
| Aug | 1,272 | 32 | 1,304 | 240 | 1,544 | 343 | 25 | 169 | 42 | 18 | | 597 | 947 | 61.4% |
| Sep | 1,272 | 32 | 1,304 | 240 | 1,544 | 343 | 25 | 169 | 42 | 18 | | 597 | 947 | 61.4% |
| Oct | 1,439 | 33 | 1,473 | 254 | 1,726 | 359 | 27 | 178 | 43 | 20 | | 627 | 1,099 | 63.7% |
| Nov | 1,439 | 33 | 1,473 | 254 | 1,726 | 359 | 27 | 178 | 43 | 20 | | 627 | 1,099 | 63.7% |
| Dec | 1,439 | 33 | 1,473 | 254 | 1,726 | 359 | 27 | 178 | 43 | 20 | | 627 | 1,099 | 63.7% |
| Total | 14,880 | 380 | 15,260 | 2,883 | 18,142 | 4,122 | 283 | 2,023 | 498 | 204 | | 7,130 | 11,012 | 60.7% |
| Ave. | 1,240 | 32 | 1,272 | 240 | 1,512 | 344 | 24 | 169 | 42 | 17 | | 594 | 918 | 60.7% |

*excl. Special

**Special water for Water District is included in Sea Transport

(Source: Customer services, Regulatory Office)

| CY 1999 | Distributed Water (MLD) | | | | | Billed Water (MLD) | | | | | | | Unbilled Water* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Surface Water Total | Deep Wells | Surface + Ground Water | Net Cross Boundary Transfer | Grand Total | Residential | Semi-Business | Commercial | Industrial | Sea Transport | Water District** | Total | NRW (MLD) | % |
| Jan | 1,755 | 35 | 1,790 | 350 | 2,139 | 481 | 16 | 197 | 41 | 20 | | 756 | 1,384 | 64.7% |
| Feb | 1,755 | 35 | 1,790 | 350 | 2,139 | 481 | 16 | 197 | 41 | 20 | | 756 | 1,384 | 64.7% |
| Mar | 1,755 | 35 | 1,790 | 350 | 2,139 | 481 | 16 | 197 | 41 | 20 | | 756 | 1,384 | 64.7% |
| Apr | 1,772 | 34 | 1,806 | 320 | 2,126 | 455 | 16 | 180 | 39 | 18 | | 708 | 1,418 | 66.7% |
| May | 1,772 | 34 | 1,806 | 320 | 2,126 | 455 | 16 | 180 | 39 | 18 | | 708 | 1,418 | 66.7% |
| Jun | 1,772 | 34 | 1,806 | 320 | 2,126 | 455 | 16 | 180 | 39 | 18 | | 708 | 1,418 | 66.7% |
| Jul | 1,806 | 36 | 1,843 | 393 | 2,235 | 462 | 17 | 198 | 41 | 19 | | 738 | 1,498 | 67.0% |
| Aug | 1,806 | 36 | 1,843 | 393 | 2,235 | 462 | 17 | 198 | 41 | 19 | | 738 | 1,498 | 67.0% |
| Sep | 1,806 | 36 | 1,843 | 393 | 2,235 | 462 | 17 | 198 | 41 | 19 | | 738 | 1,498 | 67.0% |
| Oct | 1,824 | 38 | 1,862 | 402 | 2,263 | 449 | 19 | 199 | 43 | 20 | | 730 | 1,534 | 67.8% |
| Nov | 1,824 | 38 | 1,862 | 402 | 2,263 | 449 | 19 | 199 | 43 | 20 | | 730 | 1,534 | 67.8% |
| Dec | 1,824 | 38 | 1,862 | 402 | 2,263 | 449 | 19 | 199 | 43 | 20 | | 730 | 1,534 | 67.8% |
| Total | 21,471 | 430 | 21,901 | 4,392 | 26,292 | 5,544 | 204 | 2,322 | 491 | 230 | | 8,792 | 17,500 | |
| Ave. | 1,789 | 36 | 1,825 | 366 | 2,191 | 462 | 17 | 194 | 41 | 19 | | 733 | 1,458 | 66.6% |

*excl. Special

**Special water for Water District is included in Sea Transport

(Source: Bilsum '00, Wprod Report, NRW Counceil and Service Performance Information 4th qtr. 2000, MWSI)

| CY 2000 | Distributed Water (MLD) | | | | | Billed Water (MLD) | | | | | | | Unbilled Water* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | La Mesa WTPs | Deep Wells | Production Total | Net Cross Boundary Transfer | Total | Residential | Semi-Business | Commercial | Industrial | Special (Sea Transport) | Special (Water District) | Total | NRW | % |
| Jan | 1,741 | 37 | 1,778 | 367 | 2,145 | 477 | 35 | 216 | 53 | 3 | 10 | 794 | 1,351 | 63.0% |
| Feb | 1,676 | 38 | 1,715 | 340 | 2,055 | 438 | 33 | 199 | 50 | 3 | 10 | 733 | 1,321 | 64.3% |
| Mar | 1,648 | 43 | 1,691 | 316 | 2,007 | 430 | 32 | 187 | 47 | 3 | 10 | 710 | 1,297 | 64.6% |
| Apr | 1,734 | 42 | 1,775 | 306 | 2,081 | 440 | 33 | 194 | 50 | 3 | 10 | 729 | 1,352 | 65.0% |
| May | 1,880 | 42 | 1,922 | 282 | 2,204 | 471 | 35 | 201 | 53 | 3 | 10 | 773 | 1,431 | 64.9% |
| Jun | 1,725 | 42 | 1,767 | 272 | 2,039 | 448 | 34 | 190 | 53 | 3 | 10 | 738 | 1,301 | 63.8% |
| Jul | 1,910 | 38 | 1,949 | 284 | 2,233 | 443 | 34 | 192 | 51 | 3 | 10 | 733 | 1,500 | 67.2% |
| Aug | 2,033 | 39 | 2,073 | 304 | 2,377 | 461 | 35 | 197 | 52 | 3 | 10 | 759 | 1,617 | 68.0% |
| Sep | 2,181 | 40 | 2,220 | 288 | 2,508 | 496 | 38 | 212 | 59 | 3 | 10 | 818 | 1,690 | 67.4% |
| Oct | 2,249 | 37 | 2,286 | 255 | 2,541 | 482 | 38 | 204 | 56 | 3 | 10 | 792 | 1,749 | 68.8% |
| Nov | 2,205 | 37 | 2,242 | 233 | 2,476 | 490 | 39 | 208 | 57 | 5 | 10 | 808 | 1,667 | 67.4% |
| Dec | 2,207 | 39 | 2,246 | 187 | 2,433 | 459 | 37 | 200 | 56 | 3 | 11 | 767 | 1,666 | 68.5% |
| Total | 23,191 | 474 | 23,665 | 3,433 | 27,098 | 5,535 | 421 | 2,400 | 638 | 38 | 121 | 9,154 | 17,944 | |
| Ave. | 1,933 | 39 | 1,972 | 286 | 2,258 | 461 | 35 | 200 | 53 | 3 | 10 | 763 | 1,495 | 66.2% |

*excl. Special Water

## Table 2.7 Past Trend of Water Volume

| Year | Production Capacity (MLD) | Distributed Water (MLD) | Domestic (MLD) | Commercial (MLD) | Industrial (MLD) | Billed Total (MLD) | (%) |
|---|---|---|---|---|---|---|---|
| 1985 | 3,190 | 2,107 | 503 | 287 | 41 | 831 | 39% |
| 1986 | 3,190 | 2,395 | 535 | 276 | 40 | 851 | 36% |
| 1987 | 3,190 | 2,287 | 598 | 279 | 45 | 922 | 40% |
| 1988 | 3,190 | 2,327 | 619 | 309 | 57 | 985 | 42% |
| 1989 | 3,190 | 2,433 | 647 | 314 | 69 | 1,030 | 42% |
| 1990 | 3,190 | 2,491 | 671 | 312 | 69 | 1,052 | 42% |
| 1991 | 3,190 | 2,466 | 694 | 296 | 69 | 1,059 | 43% |
| 1992 | 3,190 | 2,333 | 701 | 281 | 67 | 1,049 | 45% |
| 1993 | 3,190 | 2,556 | 731 | 290 | 67 | 1,088 | 43% |
| 1994 | 3,900 | 2,922 | 771 | 306 | 71 | 1,148 | 39% |
| 1995 | 3,900 | 3,287 | 800 | 300 | 69 | 1,169 | 36% |
| 1996 | 3,900 | 3,250 | 811 | 310 | 73 | 1,194 | 37% |
| 1997 | 3,900 | 3,076 | 746 | 297 | 67 | 1,109 | 36% |
| 1998 | 3,900 | 2,520 | 713 | 311 | 72 | 1,094 | 43% |
| 1999 | 3,900 | 3,488 | 904 | 369 | 79 | 1,351 | 39% |
| 2000 | 4,090 | 3,663 | 919 | 418 | 94 | 1,433 | 39% |

## Table 2.8 Assumed Share of Water Consumption by City/Municipality (CY 2000)

| City/Municipality | | Assumed Billed Water by Municipality (MLD) | | | | Share to Billed Water by Municipality (%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Domestic | Commercial | Industrial | Total | Domestic | Commercial | Industrial | Total |
| (West Zone) | | | | | | | | | |
| NCR | Pasay | 28.8 | 10.3 | 1.8 | 40.9 | 3.1% | 2.5% | 1.9% | 2.9% |
| | Caloocan | 59.3 | 21.8 | 9.6 | 90.7 | 6.5% | 5.2% | 10.2% | 6.3% |
| | Las Pinas | 7.7 | 1.2 | 0.1 | 9.1 | 0.8% | 0.3% | 0.1% | 0.6% |
| | Malabon | 27.7 | 10.6 | 5.4 | 43.7 | 3.0% | 2.5% | 5.7% | 3.1% |
| | Valenzuela | 31.2 | 11.7 | 5.3 | 48.2 | 3.4% | 2.8% | 5.6% | 3.4% |
| | Muntinlupa | 1.7 | 0.1 | 0.0 | 1.8 | 0.2% | 0.0% | 0.0% | 0.1% |
| | Navotas | 16.2 | 5.9 | 2.6 | 24.7 | 1.8% | 1.4% | 2.8% | 1.7% |
| | Paranaque | 22.5 | 8.4 | 0.9 | 31.8 | 2.5% | 2.0% | 0.9% | 2.2% |
| Cavite | Cavite City | 8.4 | 1.8 | 0.1 | 10.4 | 0.9% | 0.4% | 0.1% | 0.7% |
| | Bacoor | 5.2 | 1.1 | 0.1 | 6.4 | 0.6% | 0.3% | 0.1% | 0.4% |
| | Imus | 1.1 | 0.3 | 0.0 | 1.4 | 0.1% | 0.1% | 0.0% | 0.1% |
| | Kawit | 4.9 | 1.0 | 0.1 | 5.9 | 0.5% | 0.2% | 0.1% | 0.4% |
| | Noveleta | 1.0 | 0.1 | 0.0 | 1.1 | 0.1% | 0.0% | 0.0% | 0.1% |
| | Rosario | 1.9 | 0.3 | 0.0 | 2.3 | 0.2% | 0.1% | 0.0% | 0.2% |
| (East Zone) | | | | | | | | | |
| NCR | Mandaluyong | 43.5 | 38.3 | 3.5 | 85.4 | 4.7% | 9.2% | 3.8% | 6.0% |
| | Marukina | 56.8 | 11.2 | 3.5 | 71.5 | 6.2% | 2.7% | 3.7% | 5.0% |
| | Pasig | 64.6 | 15.6 | 5.4 | 85.6 | 7.0% | 3.7% | 5.7% | 6.0% |
| | Pateros | 6.1 | 1.0 | 0.2 | 7.3 | 0.7% | 0.2% | 0.2% | 0.5% |
| | San Juan | 18.5 | 16.3 | 1.5 | 36.3 | 2.0% | 3.9% | 1.6% | 2.5% |
| | Taguig | 10.1 | 1.7 | 0.3 | 12.1 | 1.1% | 0.4% | 0.3% | 0.8% |
| Rizal | Antipolo | 6.5 | 1.1 | 0.2 | 7.8 | 0.7% | 0.3% | 0.2% | 0.5% |
| | Cainta | 8.3 | 1.4 | 0.2 | 9.9 | 0.9% | 0.3% | 0.2% | 0.7% |
| | Angono | | | | | | | | |
| | Baras | | | | | | | | |
| | Binangonan | | | | | | | | |
| | Cardona | | | | | | | | |
| | Jala-Jala | | | | | | | | |
| | Morong | | | | | | | | |
| | Pililla | | | | | | | | |
| | Rodoriguez | 2.9 | 0.5 | 0.1 | 3.5 | 0.3% | 0.1% | 0.1% | 0.2% |
| | San Mateo | 3.8 | 0.7 | 0.1 | 4.6 | 0.4% | 0.2% | 0.1% | 0.3% |
| | Tanay | | | | | | | | |
| | Taytay | 4.7 | 0.8 | 0.1 | 5.7 | 0.5% | 0.2% | 0.1% | 0.4% |
| | Teresa | | | | | | | | |
| (Common Concession Area) | | | | | | | | | |
| NCR | Quezon City | 252.8 | 95.5 | 28.5 | 376.8 | 27.5% | 22.8% | 30.4% | 26.3% |
| | East | 125.1 | 58.4 | 15.7 | 199.2 | 13.6% | 14.0% | 16.7% | 13.9% |
| | West | 127.7 | 37.1 | 12.8 | 177.6 | 13.9% | 8.9% | 13.6% | 12.4% |
| | Manila | 164.8 | 102.1 | 14.8 | 281.6 | 17.9% | 24.4% | 15.7% | 19.7% |
| | East | 22.1 | 19.4 | 1.8 | 43.3 | 2.4% | 4.6% | 1.9% | 3.0% |
| | West | 142.7 | 82.6 | 13.0 | 238.3 | 15.5% | 19.7% | 13.8% | 16.6% |
| | Makati | 58.0 | 57.4 | 9.6 | 124.9 | 6.3% | 13.7% | 10.2% | 8.7% |
| | East | 50.1 | 52.0 | 8.3 | 110.4 | 5.4% | 12.4% | 8.9% | 7.7% |
| | West | 7.9 | 5.5 | 1.3 | 14.6 | 0.9% | 1.3% | 1.3% | 1.0% |
| | Total | 919.2 | 418.4 | 94.0 | 1,431.5 | 100.0% | 100.0% | 100.0% | 100.0% |
| | East | 423.2 | 218.4 | 41.0 | 682.5 | 46.0% | 52.2% | 43.6% | 47.7% |
| | West | 496.0 | 200.0 | 53.0 | 749.0 | 54.0% | 47.8% | 56.4% | 52.3% |

## Table 2.9 Proposed Per Capita Consumption

Unit: Lpcd

| City/Municipality | Proposed Per Capita Consumption | | | | | | Growth Rate |
|---|---|---|---|---|---|---|---|
| | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 | (2005-2025) |
| (WEST ZONE) | | | | | | | |
| Pasy | 119 | 125 | 138 | 152 | 168 | 186 | 2.01% |
| Caloocan | 119 | 125 | 136 | 148 | 161 | 175 | 1.70% |
| Las Pinas | 119 | 125 | 141 | 158 | 178 | 200 | 2.38% |
| Malabon | 119 | 125 | 137 | 151 | 166 | 182 | 1.90% |
| Valenzuela | 119 | 125 | 137 | 150 | 164 | 180 | 1.84% |
| Muntinlupa | 119 | 125 | 141 | 158 | 178 | 200 | 2.38% |
| Navotas | 119 | 125 | 137 | 151 | 166 | 182 | 1.90% |
| Paranaque | 119 | 125 | 141 | 158 | 178 | 200 | 2.38% |
| | | | | | | | |
| Cavite City | 119 | 125 | 134 | 143 | 153 | 163 | 1.34% |
| Bacoor | 119 | 125 | 134 | 143 | 153 | 163 | 1.34% |
| Imus | 119 | 125 | 134 | 143 | 153 | 163 | 1.34% |
| Kawit | 119 | 125 | 134 | 143 | 153 | 163 | 1.34% |
| Noveleta | 119 | 125 | 134 | 143 | 153 | 163 | 1.34% |
| Rosario | 119 | 125 | 134 | 143 | 153 | 163 | 1.34% |
| | | | | | | | |
| (EAST ZONE) | | | | | | | |
| Mandaluyong | 119 | 125 | 140 | 158 | 177 | 199 | 2.35% |
| Marikina | 119 | 125 | 140 | 156 | 174 | 195 | 2.25% |
| Pasig | 119 | 125 | 139 | 155 | 173 | 193 | 2.20% |
| Pateros | 119 | 125 | 140 | 156 | 174 | 195 | 2.25% |
| San Juan | 119 | 125 | 141 | 158 | 178 | 200 | 2.38% |
| Taguig | 119 | 125 | 140 | 156 | 174 | 195 | 2.25% |
| | | | | | | | |
| Antipolo | 119 | 125 | 140 | 158 | 177 | 199 | 2.35% |
| Cainta | 119 | 125 | 140 | 158 | 177 | 199 | 2.35% |
| Angono | 119 | 125 | 134 | 144 | 155 | 166 | 1.43% |
| Baras | 119 | 125 | 134 | 144 | 155 | 166 | 1.43% |
| Binanonan | 119 | 125 | 134 | 144 | 155 | 166 | 1.43% |
| Cardona | 119 | 125 | 134 | 144 | 155 | 166 | 1.43% |
| Jala-jala | 119 | 125 | 134 | 144 | 155 | 166 | 1.43% |
| Morong | 119 | 125 | 134 | 144 | 155 | 166 | 1.43% |
| Pililla | 119 | 125 | 134 | 144 | 155 | 166 | 1.43% |
| Rodoriguez | 119 | 125 | 134 | 144 | 155 | 166 | 1.43% |
| San Mateo | 119 | 125 | 134 | 144 | 155 | 166 | 1.43% |
| Tanay | 119 | 125 | 134 | 144 | 155 | 166 | 1.43% |
| Taytay | 119 | 125 | 134 | 144 | 155 | 166 | 1.43% |
| Teresa | 119 | 125 | 134 | 144 | 155 | 166 | 1.43% |
| | | | | | | | |
| (COMMON CONCESSION AREA) | | | | | | | |
| Quezon City | 119 | 125 | 140 | 156 | 174 | 195 | 2.25% |
| East | 119 | 125 | 140 | 156 | 174 | 195 | 2.25% |
| West | 119 | 125 | 140 | 156 | 174 | 195 | 2.25% |
| Manila | 119 | 125 | 138 | 153 | 169 | 187 | 2.03% |
| East | 119 | 125 | 138 | 153 | 169 | 187 | 2.03% |
| West | 119 | 125 | 138 | 153 | 169 | 187 | 2.03% |
| Makati | 119 | 125 | 140 | 158 | 177 | 199 | 2.35% |
| East | 119 | 125 | 140 | 158 | 177 | 199 | 2.35% |
| West | 119 | 125 | 140 | 158 | 177 | 199 | 2.35% |

## Table 2.10 Proposed Service Coverage

| City/Municipality | | Proposed Service Coverage | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 |
| (West Zone) | | | | | | | |
| NCR | Pasay | 83% | 72% | 77% | 85% | 92% | 100% |
| | Callocan | 52% | 55% | 60% | 73% | 87% | 100% |
| | Las Pinas | 15% | 58% | 91% | 93% | 95% | 98% |
| | Malabon | 85% | 91% | 96% | 97% | 99% | 100% |
| | Valenzuela | 66% | 80% | 85% | 90% | 95% | 100% |
| | Montinlupa | 4% | 53% | 86% | 88% | 90% | 95% |
| | Navotas | 72% | 74% | 79% | 86% | 93% | 100% |
| | Paranaque | 52% | 76% | 100% | 100% | 100% | 100% |
| Cavite | Cavite City | 82% | 100% | 100% | 100% | 100% | 100% |
| | Bacoor | 16% | 58% | 90% | 92% | 93% | 95% |
| | Imus | 6% | 36% | 61% | 63% | 65% | 72% |
| | Kawit | 75% | 93% | 98% | 99% | 99% | 100% |
| | Noveleta | 28% | 52% | 57% | 71% | 86% | 100% |
| | Rosario | 24% | 75% | 80% | 83% | 87% | 90% |
| (East Zone) | | | | | | | |
| NCR | Mandaluyong | 100% | 100% | 100% | 100% | 100% | 100% |
| | Marukina | 100% | 100% | 100% | 100% | 100% | 100% |
| | Pasig | 100% | 100% | 100% | 100% | 100% | 100% |
| | Pateros | 100% | 100% | 100% | 100% | 100% | 100% |
| | San Juan | 100% | 100% | 100% | 100% | 100% | 100% |
| | Taguig | 21% | 25% | 30% | 53% | 77% | 100% |
| RIZAL | Antipolo | 15% | 20% | 25% | 49% | 73% | 97% |
| | Cainta | 30% | 34% | 39% | 52% | 66% | 79% |
| | Angono | | | | 33% | 67% | 100% |
| | Baras | | | | 19% | 39% | 58% |
| | Binangonan | | | | 29% | 58% | 87% |
| | Cardona | | | | 19% | 39% | 58% |
| | Jala-Jala | | | | 19% | 39% | 58% |
| | Morong | | | | 19% | 39% | 58% |
| | Pililla | | | | 19% | 39% | 58% |
| | Rodoriguez | 22% | 34% | 39% | 59% | 78% | 98% |
| | San Mateo | 24% | 41% | 46% | 64% | 82% | 100% |
| | Tanay | | | | 25% | 51% | 76% |
| | Taytay | 21% | 33% | 38% | 59% | 79% | 100% |
| | Teresa | | | | 20% | 41% | 61% |
| (Common Concession Area) | | | | | | | |
| NCR | Quezon City | 100% | 100% | 100% | 100% | 100% | 100% |
| | East | 100% | 100% | 100% | 100% | 100% | 100% |
| | West | 100% | 100% | 100% | 100% | 100% | 100% |
| | Manila | 100% | 100% | 100% | 100% | 100% | 100% |
| | East | 100% | 100% | 100% | 100% | 100% | 100% |
| | West | 100% | 100% | 100% | 100% | 100% | 100% |
| | Makati | 100% | 100% | 100% | 100% | 100% | 100% |
| | East | 100% | 100% | 100% | 100% | 100% | 100% |
| | West | 100% | 100% | 100% | 100% | 100% | 100% |
| | Total | 69% | 71% | 75% | 81% | 88% | 97% |
| | East | 72% | 63% | 61% | 71% | 82% | 95% |
| | West | 67% | 77% | 86% | 90% | 93% | 98% |

## Table 2.11 Projected Population Served

| City/Municipality | | Projected Population Served | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 |
| (West Zone) | | | | | | | |
| NCR | Pasay | 294,000 | 258,000 | 272,000 | 291,000 | 289,000 | 282,000 |
| | Callocan | 613,000 | 736,000 | 883,000 | 1,247,000 | 1,589,000 | 1,956,000 |
| | Las Pinas | 73,000 | 353,000 | 691,000 | 886,000 | 1,058,000 | 1,264,000 |
| | Malabon | 287,000 | 336,000 | 374,000 | 403,000 | 406,000 | 404,000 |
| | Valenzuela | 322,000 | 448,000 | 530,000 | 647,000 | 734,000 | 823,000 |
| | Muntinlupa | 16,000 | 248,000 | 480,000 | 562,000 | 614,000 | 684,000 |
| | Navotas | 165,000 | 181,000 | 200,000 | 230,000 | 246,000 | 258,000 |
| | Paranaque | 234,000 | 385,000 | 554,000 | 637,000 | 683,000 | 725,000 |
| Cavite | Cavite City | 81,000 | 97,000 | 94,000 | 92,000 | 89,000 | 85,000 |
| | Bacoor | 50,000 | 210,000 | 379,000 | 453,000 | 525,000 | 606,000 |
| | Imus | 11,000 | 86,000 | 176,000 | 210,000 | 246,000 | 305,000 |
| | Kawit | 47,000 | 62,000 | 70,000 | 74,000 | 78,000 | 80,000 |
| | Noveleta | 9,000 | 18,000 | 21,000 | 29,000 | 38,000 | 47,000 |
| | Rosario | 18,000 | 62,000 | 72,000 | 87,000 | 103,000 | 122,000 |
| (East Zone) | | | | | | | |
| NCR | Mandaluyong | 278,000 | 281,000 | 277,000 | 280,000 | 264,000 | 246,000 |
| | Marukina | 391,000 | 436,000 | 472,000 | 530,000 | 556,000 | 576,000 |
| | Pasig | 505,000 | 555,000 | 595,000 | 658,000 | 679,000 | 694,000 |
| | Pateros | 57,000 | 57,000 | 56,000 | 57,000 | 55,000 | 52,000 |
| | San Juan | 118,000 | 109,000 | 98,000 | 93,000 | 82,000 | 71,000 |
| | Taguig | 98,000 | 147,000 | 213,000 | 478,000 | 809,000 | 1,227,000 |
| RIZAL | Antipolo | 71,000 | 138,000 | 246,000 | 674,000 | 1,358,000 | 2,379,000 |
| | Cainta | 73,000 | 115,000 | 177,000 | 307,000 | 481,000 | 706,000 |
| | Angono | | | | 41,000 | 95,000 | 160,000 |
| | Baras | | | | 7,000 | 15,000 | 24,000 |
| | Binangonan | | | | 77,000 | 172,000 | 281,000 |
| | Cardona | | | | 9,000 | 17,000 | 25,000 |
| | Jala-Jala | | | | 6,000 | 12,000 | 19,000 |
| | Morong | | | | 9,000 | 19,000 | 27,000 |
| | Pililla | | | | 11,000 | 23,000 | 37,000 |
| | Rodoriguez | 25,000 | 44,000 | 56,000 | 101,000 | 157,000 | 223,000 |
| | San Mateo | 33,000 | 65,000 | 83,000 | 140,000 | 209,000 | 290,000 |
| | Tanay | | | | 28,000 | 60,000 | 95,000 |
| | Taytay | 41,000 | 75,000 | 97,000 | 178,000 | 277,000 | 392,000 |
| | Teresa | | | | 8,000 | 18,000 | 28,000 |
| (Common Concession Area) | | | | | | | |
| NCR | Quezon City | 2,174,000 | 2,285,000 | 2,343,000 | 2,533,000 | 2,554,000 | 2,549,000 |
| | East | 994,000 | 1,044,000 | 1,071,000 | 1,158,000 | 1,168,000 | 1,165,000 |
| | West | 1,180,000 | 1,241,000 | 1,272,000 | 1,375,000 | 1,386,000 | 1,384,000 |
| | Manila | 1,591,000 | 1,473,000 | 1,345,000 | 1,286,000 | 1,146,000 | 1,011,000 |
| | East | 196,000 | 181,000 | 165,000 | 158,000 | 141,000 | 125,000 |
| | West | 1,395,000 | 1,292,000 | 1,180,000 | 1,128,000 | 1,005,000 | 886,000 |
| | Makati | 445,000 | 443,000 | 432,000 | 426,000 | 391,000 | 356,000 |
| | East | 393,000 | 391,000 | 381,000 | 376,000 | 345,000 | 314,000 |
| | West | 52,000 | 52,000 | 51,000 | 50,000 | 46,000 | 42,000 |
| | Total | 8,120,000 | 9,703,000 | 11,286,000 | 13,785,000 | 16,147,000 | 19,109,000 |
| | East | 3,273,000 | 3,638,000 | 3,987,000 | 5,384,000 | 7,012,000 | 9,156,000 |
| | West | 4,847,000 | 6,065,000 | 7,299,000 | 8,401,000 | 9,135,000 | 9,953,000 |

# Table2.12 Projected Water Demand by City/Municipality for Year 2005

| City/Municipality | | Projected Water Demand (MLD) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Domestic | Commercial | Industrial | Billed Total | NRW (54%) | Average Daily | Max Daily |
| (West Zone) | | | | | | | | |
| NCR | Pasay | 32.3 | 10.6 | 1.9 | 44.7 | 52.5 | 97.2 | 117.6 |
| | Caloocan | 92.0 | 22.3 | 10.1 | 124.4 | 146.0 | 270.4 | 327.2 |
| | Las Pinas | 44.1 | 1.3 | 0.1 | 45.5 | 53.4 | 98.9 | 119.7 |
| | Malabon | 42.0 | 10.9 | 5.7 | 58.6 | 68.8 | 127.3 | 154.1 |
| | Valenzuela | 56.0 | 12.0 | 5.6 | 73.6 | 86.3 | 159.9 | 193.5 |
| | Muntinlupa | 31.0 | 0.1 | 0.0 | 31.1 | 36.5 | 67.6 | 81.8 |
| | Navotas | 22.6 | 6.1 | 2.8 | 31.5 | 37.0 | 68.5 | 82.8 |
| | Paranaque | 48.1 | 8.6 | 0.9 | 57.6 | 67.6 | 125.2 | 151.5 |
| Cavite | Cavite City | 12.1 | 1.9 | 0.1 | 14.2 | 16.6 | 30.8 | 37.3 |
| | Bacoor | 26.3 | 1.2 | 0.1 | 27.5 | 32.3 | 59.7 | 72.3 |
| | Imus | 10.8 | 0.3 | 0.0 | 11.1 | 13.0 | 24.0 | 29.1 |
| | Kawit | 7.8 | 1.0 | 0.1 | 8.8 | 10.3 | 19.1 | 23.1 |
| | Noveleta | 2.3 | 0.1 | 0.0 | 2.4 | 2.8 | 5.2 | 6.3 |
| | Rosario | 7.8 | 0.3 | 0.0 | 8.1 | 9.5 | 17.6 | 21.3 |
| (East Zone) | | | | | | | | |
| NCR | Mandaluyong | 35.1 | 39.2 | 3.7 | 78.1 | 91.6 | 169.7 | 205.3 |
| | Marukina | 54.5 | 11.5 | 3.7 | 69.7 | 81.8 | 151.4 | 183.2 |
| | Pasig | 69.4 | 16.0 | 5.7 | 91.0 | 106.8 | 197.8 | 239.4 |
| | Pateros | 7.1 | 1.1 | 0.2 | 8.4 | 9.8 | 18.2 | 22.0 |
| | San Juan | 13.6 | 16.7 | 1.6 | 31.9 | 37.4 | 69.3 | 83.9 |
| | Taguig | 18.4 | 1.8 | 0.3 | 20.4 | 24.0 | 44.4 | 53.8 |
| Rizal | Antipolo | 17.3 | 1.1 | 0.2 | 18.6 | 21.8 | 40.4 | 48.9 |
| | Cainta | 14.4 | 1.4 | 0.2 | 16.1 | 18.9 | 34.9 | 42.3 |
| | Angono | - | - | - | - | - | - | - |
| | Baras | - | - | - | - | - | - | - |
| | Binangonan | - | - | - | - | - | - | - |
| | Cardona | - | - | - | - | - | - | - |
| | Jala-Jala | - | - | - | - | - | - | - |
| | Morong | - | - | - | - | - | - | - |
| | Pililla | - | - | - | - | - | - | - |
| | Rodoriguez | 5.5 | 0.5 | 0.1 | 6.1 | 7.2 | 13.3 | 16.1 |
| | San Mateo | 8.1 | 0.7 | 0.1 | 8.9 | 10.5 | 19.4 | 23.4 |
| | Tanay | - | - | - | - | - | - | - |
| | Taytay | 9.4 | 0.8 | 0.1 | 10.3 | 12.1 | 22.5 | 27.2 |
| | Teresa | - | - | - | - | - | - | - |
| (Common Concession Area) | | | | | | | | |
| NCR | Quezon City | 285.6 | 97.8 | 30.0 | 413.5 | 485.4 | 898.8 | 1,087.6 |
| | East | 130.5 | 59.8 | 16.6 | 206.9 | 242.8 | 449.7 | 544.1 |
| | West | 155.1 | 38.0 | 13.5 | 206.6 | 242.5 | 449.1 | 543.5 |
| | Manila | 184.1 | 104.5 | 15.5 | 304.2 | 357.1 | 661.3 | 800.1 |
| | East | 22.6 | 19.9 | 1.9 | 44.4 | 52.1 | 96.5 | 116.8 |
| | West | 161.5 | 84.6 | 13.7 | 259.8 | 305.0 | 564.7 | 683.3 |
| | Makati | 55.4 | 58.8 | 10.1 | 124.2 | 145.9 | 270.1 | 326.8 |
| | East | 48.9 | 53.2 | 8.8 | 110.8 | 130.1 | 240.9 | 291.5 |
| | West | 6.5 | 5.6 | 1.3 | 13.4 | 15.7 | 29.2 | 35.3 |
| | Total | 1,212.9 | 428.5 | 98.9 | 1,740.3 | 2,042.9 | 3,783.2 | 4,577.6 |
| | East | 454.8 | 223.7 | 43.1 | 721.5 | 847.0 | 1,568.5 | 1,897.9 |
| | West | 758.1 | 204.8 | 55.8 | 1,018.7 | 1,195.9 | 2,214.6 | 2,679.7 |

## Table 2.13 Projected Water Demand by City/Municipality for Year 2010

| City/Municipality | | Projected Water Demand (MLD) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Domestic | Commercial | Industrial | Billed Total | NRW (54%) | Average Daily | Max Daily |
| (West Zone) | | | | | | | | |
| NCR | Pasay | 37.5 | 13.1 | 2.2 | 52.8 | 48.8 | 101.6 | 122.9 |
| | Caloocan | 120.1 | 27.5 | 12.0 | 159.6 | 147.3 | 306.9 | 371.3 |
| | Las Pinas | 97.4 | 1.6 | 0.1 | 99.1 | 91.5 | 190.6 | 230.7 |
| | Malabon | 51.2 | 13.4 | 6.7 | 71.4 | 65.9 | 137.3 | 166.2 |
| | Valenzuela | 72.6 | 14.8 | 6.6 | 94.0 | 86.8 | 180.8 | 218.7 |
| | Muntinlupa | 67.7 | 0.1 | 0.0 | 67.8 | 62.6 | 130.4 | 157.8 |
| | Navotas | 27.4 | 7.5 | 3.3 | 38.2 | 35.3 | 73.5 | 88.9 |
| | Paranaque | 78.1 | 10.6 | 1.1 | 89.8 | 82.9 | 172.6 | 208.9 |
| Cavite | Cavite City | 12.6 | 2.3 | 0.2 | 15.1 | 13.9 | 29.0 | 35.1 |
| | Bacoor | 50.8 | 1.4 | 0.1 | 52.3 | 48.3 | 100.6 | 121.7 |
| | Imus | 23.6 | 0.4 | 0.0 | 24.0 | 22.1 | 46.1 | 55.8 |
| | Kawit | 9.4 | 1.2 | 0.1 | 10.7 | 9.8 | 20.5 | 24.8 |
| | Noveleta | 2.8 | 0.2 | 0.0 | 3.0 | 2.7 | 5.7 | 6.9 |
| | Rosario | 9.6 | 0.4 | 0.0 | 10.1 | 9.3 | 19.4 | 23.5 |
| (East Zone) | | | | | | | | |
| NCR | Mandaluyong | 38.8 | 48.4 | 4.4 | 91.5 | 84.5 | 176.0 | 213.0 |
| | Marukina | 66.1 | 14.1 | 4.4 | 84.6 | 78.1 | 162.7 | 196.9 |
| | Pasig | 82.7 | 19.7 | 6.7 | 109.1 | 100.7 | 209.8 | 253.9 |
| | Pateros | 7.8 | 1.3 | 0.2 | 9.4 | 8.7 | 18.0 | 21.8 |
| | San Juan | 13.8 | 20.6 | 1.9 | 36.3 | 33.5 | 69.7 | 84.4 |
| | Taguig | 29.8 | 2.2 | 0.4 | 32.3 | 29.9 | 62.2 | 75.3 |
| Rizal | Antipolo | 34.4 | 1.4 | 0.2 | 36.1 | 33.3 | 69.4 | 84.0 |
| | Cainta | 24.8 | 1.8 | 0.3 | 26.9 | 24.8 | 51.6 | 62.5 |
| | Angono | - | - | - | - | - | - | - |
| | Baras | - | - | - | - | - | - | - |
| | Binangonan | - | - | - | - | - | - | - |
| | Cardona | - | - | - | - | - | - | - |
| | Jala-Jala | - | - | - | - | - | - | - |
| | Morong | - | - | - | - | - | - | - |
| | Pililla | - | - | - | - | - | - | - |
| | Rodoriguez | 7.5 | 0.6 | 0.1 | 8.2 | 7.6 | 15.9 | 19.2 |
| | San Mateo | 11.1 | 0.8 | 0.1 | 12.1 | 11.1 | 23.2 | 28.1 |
| | Tanay | - | - | - | - | - | - | - |
| | Taytay | 13.0 | 1.0 | 0.2 | 14.2 | 13.1 | 27.3 | 33.0 |
| | Teresa | - | - | - | - | - | - | - |
| (Common Concession Area) | | | | | | | | |
| NCR | Quezon City | 328.0 | 120.6 | 35.6 | 484.3 | 447.0 | 931.3 | 1,126.8 |
| | East | 149.9 | 73.8 | 19.6 | 243.3 | 224.6 | 467.9 | 566.2 |
| | West | 178.1 | 46.9 | 16.0 | 240.9 | 222.4 | 463.3 | 560.6 |
| | Manila | 185.6 | 128.9 | 18.4 | 332.9 | 307.3 | 640.3 | 774.7 |
| | East | 22.8 | 24.5 | 2.2 | 49.5 | 45.7 | 95.3 | 115.3 |
| | West | 162.8 | 104.3 | 16.2 | 283.4 | 261.6 | 545.0 | 659.4 |
| | Makati | 60.5 | 72.5 | 11.9 | 144.9 | 133.8 | 278.7 | 337.3 |
| | East | 53.3 | 65.6 | 10.4 | 129.3 | 119.4 | 248.7 | 301.0 |
| | West | 7.1 | 6.9 | 1.6 | 15.6 | 14.4 | 30.0 | 36.3 |
| | Total | 1,564.9 | 528.4 | 117.3 | 2,210.6 | 2,040.6 | 4,251.2 | 5,143.9 |
| | East | 555.9 | 275.8 | 51.1 | 882.9 | 815.0 | 1,697.9 | 2,054.4 |
| | West | 1,009.0 | 252.6 | 66.2 | 1,327.7 | 1,225.6 | 2,553.3 | 3,089.5 |

# Table 2.14 Projected Water Demand by City/Municipality for Year 2015

| City/Municipality | | Projected Water Demand (MLD) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Domestic | Commercial | Industrial | Billed Total | NRW (54%) | Average Daily | Max Daily |
| (West Zone) | | | | | | | | |
| NCR | Pasay | 44.2 | 16.3 | 2.7 | 63.2 | 45.8 | 109.0 | 131.8 |
| | Caloocan | 184.6 | 34.3 | 14.3 | 233.2 | 168.9 | 402.1 | 486.5 |
| | Las Pinas | 140.0 | 2.0 | 0.2 | 142.1 | 102.9 | 245.0 | 296.5 |
| | Malabon | 60.9 | 16.8 | 8.0 | 85.7 | 62.0 | 147.7 | 178.7 |
| | Valenzuela | 97.1 | 18.5 | 7.9 | 123.4 | 89.4 | 212.7 | 257.4 |
| | Muntinlupa | 88.8 | 0.2 | 0.0 | 89.0 | 64.4 | 153.4 | 185.6 |
| | Navotas | 34.7 | 9.4 | 3.9 | 48.0 | 34.8 | 82.8 | 100.2 |
| | Paranaque | 100.6 | 13.2 | 1.3 | 115.1 | 83.4 | 198.5 | 240.2 |
| Cavite | Cavite City | 13.2 | 2.9 | 0.2 | 16.3 | 11.8 | 28.1 | 34.0 |
| | Bacoor | 64.8 | 1.8 | 0.1 | 66.7 | 48.3 | 114.9 | 139.1 |
| | Imus | 30.0 | 0.4 | 0.0 | 30.5 | 22.1 | 52.6 | 63.6 |
| | Kawit | 10.6 | 1.5 | 0.1 | 12.2 | 8.8 | 21.0 | 25.4 |
| | Noveleta | 4.1 | 0.2 | 0.0 | 4.3 | 3.1 | 7.5 | 9.1 |
| | Rosario | 12.4 | 0.5 | 0.0 | 13.0 | 9.4 | 22.4 | 27.1 |
| | | | | | | | | 298.7 |
| (East Zone) | | | | | | | | |
| NCR | Mandaluyong | 44.2 | 60.4 | 5.3 | 109.9 | 79.6 | 189.5 | 229.2 |
| | Marukina | 82.7 | 17.6 | 5.3 | 105.6 | 76.4 | 182.0 | 220.2 |
| | Pasig | 102.0 | 24.6 | 8.0 | 134.6 | 97.5 | 232.0 | 280.8 |
| | Pateros | 8.9 | 1.6 | 0.3 | 10.8 | 7.8 | 18.6 | 22.5 |
| | San Juan | 14.7 | 25.7 | 2.2 | 42.6 | 30.9 | 73.5 | 88.9 |
| | Taguig | 74.6 | 2.7 | 0.4 | 77.7 | 56.3 | 134.0 | 162.1 |
| Rizal | Antipolo | 106.5 | 1.8 | 0.3 | 108.5 | 78.6 | 187.1 | 226.4 |
| | Cainta | 48.5 | 2.2 | 0.3 | 51.1 | 37.0 | 88.1 | 106.6 |
| | Angono | 5.9 | 0.5 | 0.1 | 6.6 | 4.8 | 11.3 | 13.7 |
| | Baras | 1.0 | 0.1 | 0.0 | 1.1 | 0.8 | 1.9 | 2.3 |
| | Binangonan | 11.1 | 1.0 | 0.2 | 12.3 | 8.9 | 21.2 | 25.7 |
| | Cardona | 1.3 | 0.1 | 0.0 | 1.4 | 1.0 | 2.5 | 3.0 |
| | Jala-Jala | 0.9 | 0.1 | 0.0 | 1.0 | 0.7 | 1.7 | 2.0 |
| | Morong | 1.3 | 0.1 | 0.0 | 1.4 | 1.0 | 2.5 | 3.0 |
| | Pililla | 1.6 | 0.1 | 0.0 | 1.8 | 1.3 | 3.0 | 3.7 |
| | Rodoriguez | 14.5 | 0.8 | 0.1 | 15.5 | 11.2 | 26.7 | 32.3 |
| | San Mateo | 20.2 | 1.0 | 0.2 | 21.3 | 15.5 | 36.8 | 44.5 |
| | Tanay | 4.0 | 0.4 | 0.1 | 4.5 | 3.2 | 7.7 | 9.3 |
| | Taytay | 25.6 | 1.3 | 0.2 | 27.1 | 19.6 | 46.7 | 56.6 |
| | Teresa | 1.2 | 0.1 | 0.0 | 1.3 | 0.9 | 2.2 | 2.7 |
| (Common Concession Area) | | | | | | | | |
| NCR | Quezon City | 395.1 | 150.6 | 42.5 | 588.3 | 426.0 | 1,014.3 | 1,227.3 |
| | East | 180.6 | 92.1 | 23.5 | 296.2 | 214.5 | 510.7 | 617.9 |
| | West | 214.5 | 58.5 | 19.1 | 292.1 | 211.5 | 503.6 | 609.4 |
| | Manila | 196.8 | 160.9 | 22.0 | 379.7 | 275.0 | 654.7 | 792.2 |
| | East | 24.2 | 30.6 | 2.7 | 57.5 | 41.6 | 99.1 | 119.9 |
| | West | 172.6 | 130.3 | 19.4 | 322.2 | 233.3 | 555.6 | 672.2 |
| | Makati | 67.3 | 90.5 | 14.3 | 172.1 | 124.6 | 296.8 | 359.1 |
| | East | 59.4 | 81.9 | 12.4 | 153.7 | 111.3 | 265.1 | 320.7 |
| | West | 7.9 | 8.6 | 1.9 | 18.4 | 13.3 | 31.7 | 38.4 |
| | Total | 2,115.8 | 662.3 | 140.8 | 2,918.9 | 2,113.7 | 5,032.5 | 6,089.3 |
| | East | 834.9 | 346.9 | 61.7 | 1,243.5 | 900.4 | 2,143.9 | 2,594.1 |
| | West | 1,281.0 | 315.4 | 79.1 | 1,675.4 | 1,213.2 | 2,888.6 | 3,495.2 |

# Table 2.15 Projected Water Demand by City/Municipality for Year 2020

| City/Municipality | | Projected Water Demand (MLD) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Domestic | Commercial | Industrial | Billed Total | NRW (54%) | Average Daily | Max Daily |
| (West Zone) | | | | | | | | |
| NCR | Pasay | 48.6 | 20.6 | 3.2 | 72.4 | 40.7 | 113.1 | 136.9 |
| | Caloocan | 255.8 | 43.5 | 17.3 | 316.6 | 178.1 | 494.7 | 598.5 |
| | Las Pinas | 188.3 | 2.5 | 0.2 | 191.0 | 107.4 | 298.4 | 361.1 |
| | Malabon | 67.4 | 21.3 | 9.7 | 98.3 | 55.3 | 153.7 | 185.9 |
| | Valenzuela | 120.4 | 23.4 | 9.5 | 153.3 | 86.2 | 239.5 | 289.8 |
| | Muntinlupa | 109.3 | 0.2 | 0.0 | 109.5 | 61.6 | 171.1 | 207.0 |
| | Navotas | 40.8 | 11.9 | 4.7 | 57.5 | 32.3 | 89.8 | 108.6 |
| | Paranaque | 121.6 | 16.7 | 1.6 | 139.9 | 78.7 | 218.5 | 264.4 |
| Cavite | Cavite City | 13.6 | 3.7 | 0.3 | 17.6 | 9.9 | 27.4 | 33.2 |
| | Bacoor | 80.3 | 2.3 | 0.1 | 82.7 | 46.5 | 129.2 | 156.4 |
| | Imus | 37.6 | 0.6 | 0.0 | 38.2 | 21.5 | 59.7 | 72.3 |
| | Kawit | 11.9 | 1.9 | 0.1 | 14.0 | 7.8 | 21.8 | 26.4 |
| | Noveleta | 5.8 | 0.2 | 0.0 | 6.1 | 3.4 | 9.5 | 11.5 |
| | Rosario | 15.8 | 0.7 | 0.0 | 16.5 | 9.3 | 25.7 | 31.1 |
| (East Zone) | | | | | | | | |
| NCR | Mandaluyong | 46.7 | 76.5 | 6.3 | 129.6 | 72.9 | 202.4 | 244.9 |
| | Marukina | 96.7 | 22.3 | 6.3 | 125.4 | 70.5 | 195.9 | 237.1 |
| | Pasig | 117.5 | 31.1 | 9.7 | 158.3 | 89.0 | 247.3 | 299.2 |
| | Pateros | 9.6 | 2.1 | 0.3 | 12.0 | 6.7 | 18.7 | 22.6 |
| | San Juan | 14.6 | 32.5 | 2.7 | 49.8 | 28.0 | 77.9 | 94.2 |
| | Taguig | 140.8 | 3.4 | 0.5 | 144.7 | 81.4 | 226.1 | 273.6 |
| Rizal | Antipolo | 240.4 | 2.2 | 0.3 | 242.9 | 136.6 | 379.6 | 459.3 |
| | Cainta | 85.1 | 2.8 | 0.4 | 88.4 | 49.7 | 138.1 | 167.1 |
| | Angono | 14.7 | 1.3 | 0.3 | 16.4 | 9.2 | 25.6 | 30.9 |
| | Baras | 2.3 | 0.2 | 0.1 | 2.6 | 1.5 | 4.0 | 4.9 |
| | Binangonan | 26.7 | 2.4 | 0.6 | 29.6 | 16.7 | 46.3 | 56.0 |
| | Cardona | 2.6 | 0.2 | 0.1 | 2.9 | 1.6 | 4.6 | 5.5 |
| | Jala-Jala | 1.9 | 0.2 | 0.0 | 2.1 | 1.2 | 3.2 | 3.9 |
| | Morong | 2.9 | 0.3 | 0.1 | 3.3 | 1.8 | 5.1 | 6.2 |
| | Pililla | 3.6 | 0.3 | 0.1 | 4.0 | 2.2 | 6.2 | 7.5 |
| | Rodoriguez | 24.3 | 1.0 | 0.1 | 25.5 | 14.3 | 39.8 | 48.2 |
| | San Mateo | 32.4 | 1.3 | 0.2 | 33.9 | 19.1 | 52.9 | 64.1 |
| | Tanay | 9.3 | 0.8 | 0.2 | 10.3 | 5.8 | 16.1 | 19.5 |
| | Taytay | 42.9 | 1.6 | 0.2 | 44.8 | 25.2 | 70.0 | 84.7 |
| | Teresa | 2.8 | 0.2 | 0.1 | 3.1 | 1.7 | 4.8 | 5.9 |
| (Common Concession Area) | | | | | | | | |
| NCR | Quezon City | 444.4 | 190.8 | 51.3 | 686.5 | 386.1 | 1,072.6 | 1,297.8 |
| | East | 203.2 | 116.6 | 28.3 | 348.2 | 195.8 | 544.0 | 658.2 |
| | West | 241.2 | 74.1 | 23.0 | 338.3 | 190.3 | 528.6 | 639.6 |
| | Manila | 193.7 | 203.8 | 26.6 | 424.1 | 238.5 | 662.6 | 801.7 |
| | East | 23.8 | 38.8 | 3.2 | 65.9 | 37.0 | 102.9 | 124.5 |
| | West | 169.8 | 165.0 | 23.3 | 358.2 | 201.5 | 559.7 | 677.2 |
| | Makati | 69.2 | 114.7 | 17.2 | 201.1 | 113.1 | 314.2 | 380.2 |
| | East | 61.1 | 103.8 | 15.0 | 179.8 | 101.1 | 280.9 | 339.9 |
| | West | 8.1 | 10.9 | 2.3 | 21.3 | 12.0 | 33.3 | 40.3 |
| | Total | 2,742.4 | 841.6 | 170.4 | 3,754.4 | 2,111.9 | 5,866.3 | 7,098.2 |
| | East | 1,206.0 | 442.1 | 75.1 | 1,723.2 | 969.3 | 2,692.6 | 3,258.0 |
| | West | 1,536.4 | 399.5 | 95.3 | 2,031.2 | 1,142.5 | 3,173.7 | 3,840.2 |

# Table 2.16 Projected Water Demand by City/Municipality for Year 2025

| City/Municipality | | Projected Water Demand (MLD) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Domestic | Commercial | Industrial | Billed Total | NRW (54%) | Average Daily | Max Daily |
| (West Zone) | | | | | | | | |
| NCR | Pasay | 52.5 | 26.5 | 3.9 | 82.8 | 35.5 | 118.3 | 143.2 |
| | Caloocan | 342.3 | 55.8 | 21.0 | 419.0 | 179.6 | 598.6 | 724.3 |
| | Las Pinas | 252.8 | 3.2 | 0.2 | 256.2 | 109.8 | 366.0 | 442.9 |
| | Malabon | 73.5 | 27.3 | 11.8 | 112.6 | 48.2 | 160.8 | 194.6 |
| | Valenzuela | 148.1 | 30.0 | 11.5 | 189.7 | 81.3 | 270.9 | 327.8 |
| | Muntinlupa | 136.8 | 0.3 | 0.0 | 137.1 | 58.7 | 195.8 | 236.9 |
| | Navotas | 47.0 | 15.2 | 5.8 | 67.9 | 29.1 | 97.1 | 117.5 |
| | Paranaque | 145.0 | 21.4 | 1.9 | 168.3 | 72.1 | 240.5 | 291.0 |
| Cavite | Cavite City | 13.9 | 4.7 | 0.3 | 18.9 | 8.1 | 27.0 | 32.7 |
| | Bacoor | 98.8 | 2.9 | 0.1 | 101.8 | 43.6 | 145.5 | 176.0 |
| | Imus | 49.7 | 0.7 | 0.0 | 50.5 | 21.6 | 72.1 | 87.2 |
| | Kawit | 13.0 | 2.4 | 0.1 | 15.6 | 6.7 | 22.3 | 27.0 |
| | Noveleta | 7.7 | 0.3 | 0.0 | 8.0 | 3.4 | 11.4 | 13.8 |
| | Rosario | 19.9 | 0.9 | 0.0 | 20.8 | 8.9 | 29.7 | 35.9 |
| (East Zone) | | | | | | | | |
| NCR | Mandaluyong | 49.0 | 98.1 | 7.7 | 154.7 | 66.3 | 221.0 | 267.5 |
| | Marukina | 112.3 | 28.6 | 7.7 | 148.6 | 63.7 | 212.3 | 256.9 |
| | Pasig | 133.9 | 39.9 | 11.8 | 185.6 | 79.5 | 265.1 | 320.8 |
| | Pateros | 10.1 | 2.7 | 0.4 | 13.2 | 5.7 | 18.8 | 22.8 |
| | San Juan | 14.2 | 41.7 | 3.3 | 59.2 | 25.4 | 84.6 | 102.3 |
| | Taguig | 239.3 | 4.4 | 0.6 | 244.3 | 104.7 | 349.0 | 422.3 |
| Rizal | Antipolo | 473.4 | 2.9 | 0.4 | 476.7 | 204.3 | 681.0 | 824.0 |
| | Cainta | 140.5 | 3.6 | 0.5 | 144.6 | 62.0 | 206.6 | 250.0 |
| | Angono | 26.6 | 2.4 | 0.6 | 29.5 | 12.6 | 42.2 | 51.0 |
| | Baras | 4.0 | 0.4 | 0.1 | 4.4 | 1.9 | 6.3 | 7.7 |
| | Binangonan | 46.6 | 4.1 | 1.0 | 51.8 | 22.2 | 74.0 | 89.6 |
| | Cardona | 4.2 | 0.4 | 0.1 | 4.6 | 2.0 | 6.6 | 8.0 |
| | Jala-Jala | 3.2 | 0.3 | 0.1 | 3.5 | 1.5 | 5.0 | 6.1 |
| | Morong | 4.5 | 0.4 | 0.1 | 5.0 | 2.1 | 7.1 | 8.6 |
| | Pililla | 6.1 | 0.5 | 0.1 | 6.8 | 2.9 | 9.7 | 11.8 |
| | Rodoriguez | 37.0 | 1.3 | 0.2 | 38.5 | 16.5 | 55.0 | 66.5 |
| | San Mateo | 48.1 | 1.7 | 0.2 | 50.0 | 21.4 | 71.5 | 86.5 |
| | Tanay | 15.8 | 1.4 | 0.4 | 17.5 | 7.5 | 25.0 | 30.3 |
| | Taytay | 65.1 | 2.1 | 0.3 | 67.4 | 28.9 | 96.3 | 116.6 |
| | Teresa | 4.6 | 0.4 | 0.1 | 5.2 | 2.2 | 7.4 | 8.9 |
| (Common Concession Area) | | | | | | | | |
| NCR | Quezon City | 497.1 | 244.6 | 62.3 | 804.0 | 344.6 | 1,148.5 | 1,389.7 |
| | Easdt | 227.2 | 149.6 | 34.3 | 411.1 | 176.2 | 587.3 | 710.6 |
| | West | 269.9 | 95.1 | 27.9 | 392.9 | 168.4 | 561.2 | 679.1 |
| | Manila | 189.1 | 261.4 | 32.2 | 482.7 | 206.9 | 689.5 | 834.3 |
| | East | 23.4 | 49.8 | 3.9 | 77.0 | 33.0 | 110.1 | 133.2 |
| | West | 165.7 | 211.6 | 28.3 | 405.6 | 173.8 | 579.5 | 701.2 |
| | Makati | 70.8 | 147.1 | 20.9 | 238.8 | 102.3 | 341.1 | 412.8 |
| | East | 62.5 | 133.1 | 18.2 | 213.7 | 91.6 | 305.3 | 369.4 |
| | West | 8.4 | 14.0 | 2.7 | 25.1 | 10.8 | 35.8 | 43.4 |
| | Total | 3,596.4 | 1,081.9 | 207.7 | 4,885.9 | 2,094.0 | 6,979.9 | 8,445.7 |
| | East | 1,751.5 | 569.6 | 92.0 | 2,413.2 | 1,034.2 | 3,447.4 | 4,171.3 |
| | West | 1,844.8 | 512.2 | 115.7 | 2,472.8 | 1,059.8 | 3,532.6 | 4,274.4 |

**Table 2.17 Energy Sales and Peak Power Demand in 2000 Power Development Program (Low Forecast without PISP Load)**

| Year | Luzon | | Visayas | | Mindanao | | Total | |
|---|---|---|---|---|---|---|---|---|
| | (GWH) | (MW) | (GWH) | (MW) | (GWH) | (MW) | (GWH) | (MW) |
| 1999 | 30,485 | 5,226 | 4,106 | 787 | 5,012 | 892 | 39,603 | 6,905 |
| 2000 | 32,593 | 5,557 | 4,416 | 847 | 5,335 | 916 | 42,344 | 7,320 |
| 2001 | 34,598 | 5,898 | 4,725 | 906 | 5,640 | 968 | 44,963 | 7,772 |
| 2002 | 37,365 | 6,370 | 5,145 | 987 | 6,054 | 1,039 | 48,564 | 8,396 |
| 2003 | 40,655 | 6,931 | 5,729 | 1,099 | 6,577 | 1,129 | 52,961 | 9,159 |
| 2004 | 44,293 | 7,551 | 6,274 | 1,203 | 7,179 | 1,232 | 57,746 | 9,986 |
| 2005 | 47,742 | 8,139 | 6,802 | 1,304 | 7,745 | 1,330 | 62,289 | 10,773 |
| 2006 | 51,466 | 8,774 | 7,391 | 1,417 | 8,368 | 1,436 | 67,225 | 11,627 |
| 2007 | 55,470 | 9,457 | 8,054 | 1,544 | 9,053 | 1,554 | 72,577 | 12,555 |
| 2008 | 59,783 | 10,192 | 8,741 | 1,676 | 9,809 | 1,684 | 78,333 | 13,552 |
| 2009 | 64,437 | 10,985 | 9,462 | 1,814 | 10,644 | 1,827 | 84,543 | 14,626 |
| 2010 | 69,458 | 11,841 | 10,259 | 1,967 | 11,567 | 1,986 | 91,284 | 15,794 |
| 2000-2010 | 7.77 | 7.72 | 8.68 | 8.68 | 7.9 | 7.55 | 7.89 | 7.81 |

Source: 2000 Power Development Program, NPC, November 2000

## Table 2.18 System Capacity Addition - 2000 Power Development Program

(For Main Grids only)

| Year | Luzon Grid | | | | Visayas Grid | | | | Mindanao Grid | | | | Phil. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mo. | Plant Addition | MW Cap. | Cum. MW | Mo. | Plant Addition | MW Cap. | Cum. MW | Mo. | Plant Addition | MW Cap. | Cum. MW | Cum. Total |
| 2000 | | **Duracom II *2** | **130** | 1,630 | | | | | | | | | 1,630 |
| | | **Quezon power *2** | **460** | | | | | | | | | | |
| | | **First Gas Power A *2** | **1,040** | | | | | | | | | | |
| 2001 | | **Provincial IPPs *3** | **16** | 1,856 | | | | | | | | | 1,866 |
| | Feb. | **Bakun A/C Hydro *1** | **70** | | | | | | | | | | |
| | Mar. | **Casecnan Hydro *1** | **140** | | | | | | | | | | |
| 2002 | Jan. | **Ilijan Natural Gas *1** | **1,200** | 3,581 | Jan. | Uprating Leyte-Cebu TL | | 30 | | | | | 3,611 |
| | | **First Gas Power B *2** | **525** | | Jan. | Leyte-Bohol Inter. II | | | | | | | |
| | | | | | Jan. | Panay Peaking | 30 | | | | | | |
| 2003 | Jan. | **Kalayaan 3&4 PS *1** | **350** | | Jan. | Panay Peaking | 30 | 90 | | | | | 4,061 |
| | | **Bulacan Byomass *2** | **40** | | Jan. | Negros Peaking | 30 | | | | | | |
| 2004 | Jan. | **San Pascual Cogen. *1** | **300** | 4,271 | Jan. | Uprating Cebu-Negros TL | | 160 | Jan. | Leyte-Mindanao Interc. | | | 4,431 |
| | | | | | Jan. | Cebu Peaking | 60 | | | | | | |
| | | | | | Jan. | Bohol Diesel | 10 | | | | | | |
| 2005 | Jan. | **San Roque Hydro. *1** | **345** | 4,616 | Jan. | Cebu Diesel | 50 | 310 | | | | | 4,926 |
| | | | | | Jan. | Panay Baseload | 50 | | | | | | |
| | | | | | Jan. | Panay Peaking | 30 | | | | | | |
| | | | | | Jan. | Bohol Diesel | 20 | | | | | | |
| 2006 | | | | | Jan. | Cebu Peaking | 30 | 440 | Jan. | **Mindanao Coal *1** | **200** | 200 | 5,266 |
| | | | | | Jan. | Panay Peaking | 60 | | | | | | |
| | | | | | Jan. | Bohol Diesel | 40 | | | | | | |
| 2007 | Jan. | Base Load Plant | 600 | 5,216 | Jan. | Cebu Coal | 100 | 680 | | | | | 6,069 |
| | | | | | Jan. | Panay Baseload | 50 | | | | | | |
| | | | | | Jan. | Negros Coal | 50 | | | | | | |
| | | | | | Jan. | Bohol Diesel | 40 | | | | | | |
| 2008 | Jan. | Base Load Plant | 600 | 5,966 | Jan. | Cebu GT | 30 | 760 | Jan. | Tagoloan Hydro | 68 | 268 | 6,994 |
| | | Peaking Plant | 150 | | Jan. | Bohol Diesel | 20 | | | | | | |
| | | | | | Jan. | Negros GT | 30 | | | | | | |
| 2009 | Jan. | Base Load Plant | 1,200 | 7,166 | Jan. | Cebu Coal | 100 | 950 | Jan. | Agus III Hydro | 225 | 543 | 8,659 |
| | | | | | Jan. | Panay Coal | 50 | 1,010 | Jan. | Mindanao GT | 50 | | |
| | | | | | Jan. | Mambucal Geo. | 40 | | | | | | |
| 2010 | Jan. | Base Load Plant | 600 | 8,066 | Jan. | Panay Coal | 50 | | Jan. | Pulangi V Hydro | 225 | 768 | 9,844 |
| | Jan. | Peaking Plant | 300 | | Jan. | Bohol Diesel | 10 | | | | | | |

Bald Letter: Ongoing and Comitted Project *1 NPC *2 Meralco *3 Provincial IPP

Source: 2000 Power Development Program, NPC, November 2000

## Table 2.19 Meralco System - Operating Statistics

| Year | Number of Customers | | | | | |
|---|---|---|---|---|---|---|
| | Resudential | Commercial | Industrial | Others | Total | % Change |
| 1990 | 1,728,820 | 185,245 | 10,439 | 3,395 | 1,927,899 | 4.8% |
| 1991 | 1,818,553 | 192,525 | 11,144 | 3,097 | 2,025,319 | 5.1% |
| 1992 | 1,935,736 | 201,384 | 11,099 | 3,362 | 2,151,581 | 6.2% |
| 1993 | 2,072,642 | 209,159 | 11,719 | 3,562 | 2,297,082 | 6.8% |
| 1994 | 2,234,052 | 226,889 | 12,246 | 3,789 | 2,476,976 | 7.8% |
| 1995 | 2,406,959 | 237,576 | 12,936 | 4,044 | 2,661,515 | 7.5% |
| 1996 | 2,596,687 | 255,640 | 13,073 | 4,132 | 2,869,532 | 7.8% |
| 1997 | 2,787,974 | 269,382 | 13,287 | 3,999 | 3,074,642 | 7.1% |
| 1998 | 3,010,868 | 286,591 | 13,453 | 3,845 | 3,314,757 | 7.8% |
| 1999 | 3,181,751 | 298,846 | 12,553 | 3,834 | 3,496,984 | 5.5% |
| 2000 | 3,341,738 | 314,383 | 12,291 | 4,008 | 3,672,420 | 5.0% |
| Compound Growth Rate: | | | | | | |
| | | | | | | |
| 5 Years | 6.8% | 5.8% | -1.0% | -0.2% | 6.7% | |

| Year | Energy Sales (in Million kWh) | | | | | |
|---|---|---|---|---|---|---|
| | Resudential | Commercial | Industrial | Others | Total | % Change |
| 1990 | 3,593 | 3,813 | 4,069 | 90 | 11,565 | 4.6% |
| 1991 | 3,754 | 3,751 | 4,335 | 92 | 11,931 | 3.2% |
| 1992 | 3,941 | 3,816 | 4,430 | 92 | 12,279 | 2.9% |
| 1993 | 4,029 | 3,782 | 4,333 | 107 | 12,251 | -0.2% |
| 1994 | 4,652 | 4,747 | 5,048 | 107 | 14,555 | 18.8% |
| 1995 | 5,294 | 5,140 | 5,327 | 115 | 15,876 | 9.1% |
| 1996 | 5,976 | 5,805 | 5,909 | 120 | 17,811 | 12.2% |
| 1997 | 6,526 | 6,314 | 6,213 | 127 | 19,180 | 7.7% |
| 1998 | 7,348 | 6,870 | 5,953 | 135 | 20,306 | 5.9% |
| 1999 | 7,284 | 7,039 | 5,974 | 137 | 20,434 | 0.6% |
| 2000 | 7,880 | 7,507 | 6,360 | 133 | 21,881 | 7.1% |
| Compound Growth Rate: | | | | | | |
| 10 Years | 8.2% | 7.0% | 4.6% | 4.0% | 6.6% | |
| 5 Years | 8.3% | 7.9% | 3.6% | 2.9% | 6.6% | |

| Year | Substation Capacity Versus Peak Demand in MW | | | | | | Load Factor |
|---|---|---|---|---|---|---|---|
| | Total No. of Subatations | Total No. of Banks | Aggregate MVA Capacity | | | Total | |
| | | | 230, 115& 69 kV | 3.45 kV & below | Total | | |
| 1991 | 88 | 152 | 3,338 | 1,782 | 5,120 | 2,350 | 0.6803 |
| 1992 | 95 | 159 | 4,205 | 1,129 | 5,334 | 2,386 | 0.6908 |
| 1993 | 94 | 166 | 5,146 | 1,146 | 6,292 | 2,398 | 0.6936 |
| 1994 | 103 | 172 | 5,626 | 1,148 | 6,774 | 2,695 | 0.7258 |
| 1995 | 106 | 178 | 6,106 | 1,149 | 7,255 | 2,901 | 0.7202 |
| 1996 | 108 | 183 | 6,740 | 1,116 | 7,856 | 3,222 | 0.7183 |
| 1997 | 114 | 195 | 8,137 | 1,105 | 9,242 | 3,550 | 0.7059 |
| 1998 | 111 | 188 | 8,080 | 1,057 | 9,138 | 3,834 | 0.6875 |
| 1999 | 110 | 182 | 8,634 | 975 | 9,609 | 3,838 | 0.6893 |
| 2000 | 112 | 192 | 9,435 | 963 | 10,398 | 4,153 | 0.6696 |

Source: Meralco Annual Report 2000

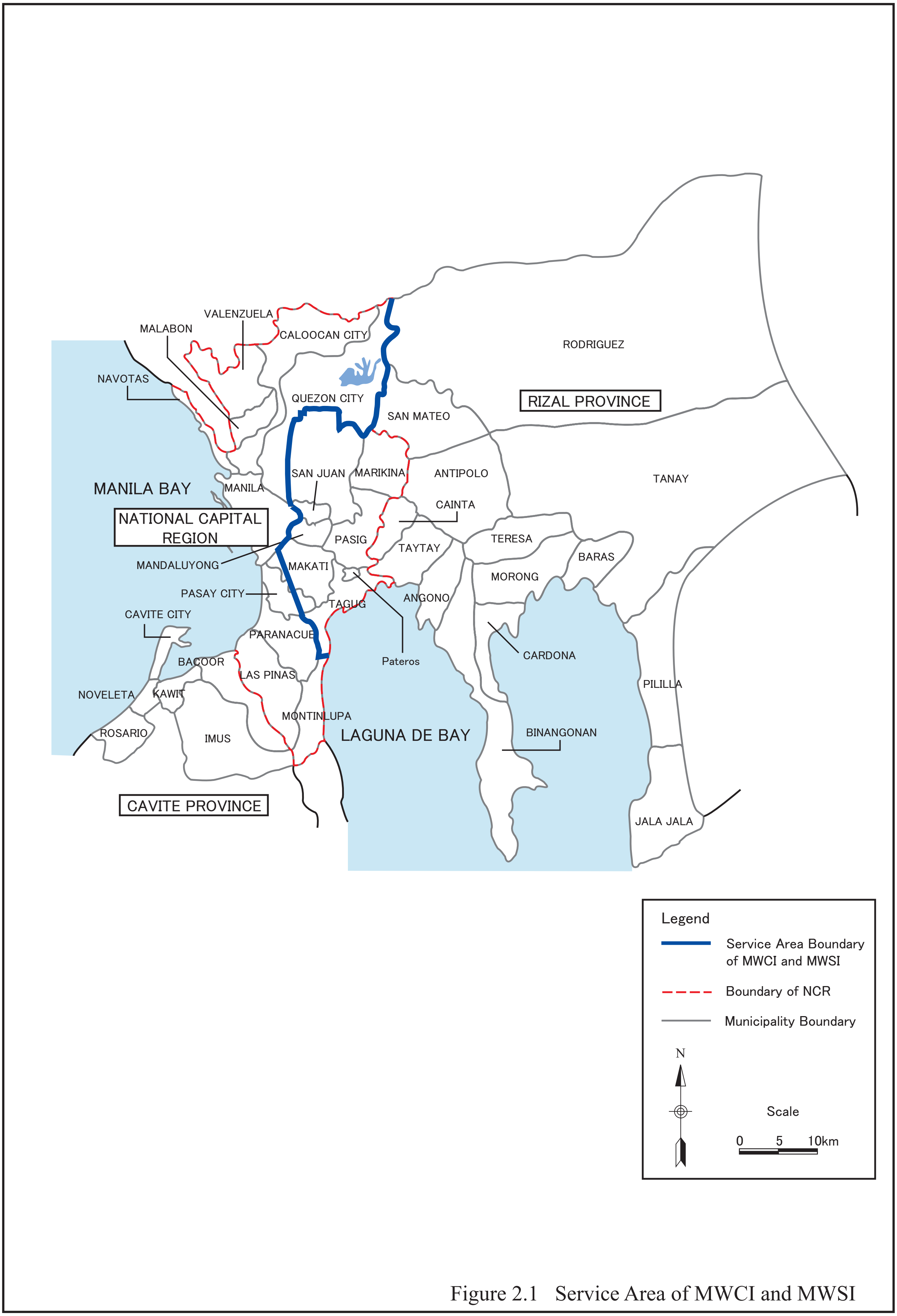



Figure 2.1 Service Area of MWCI and MWSI

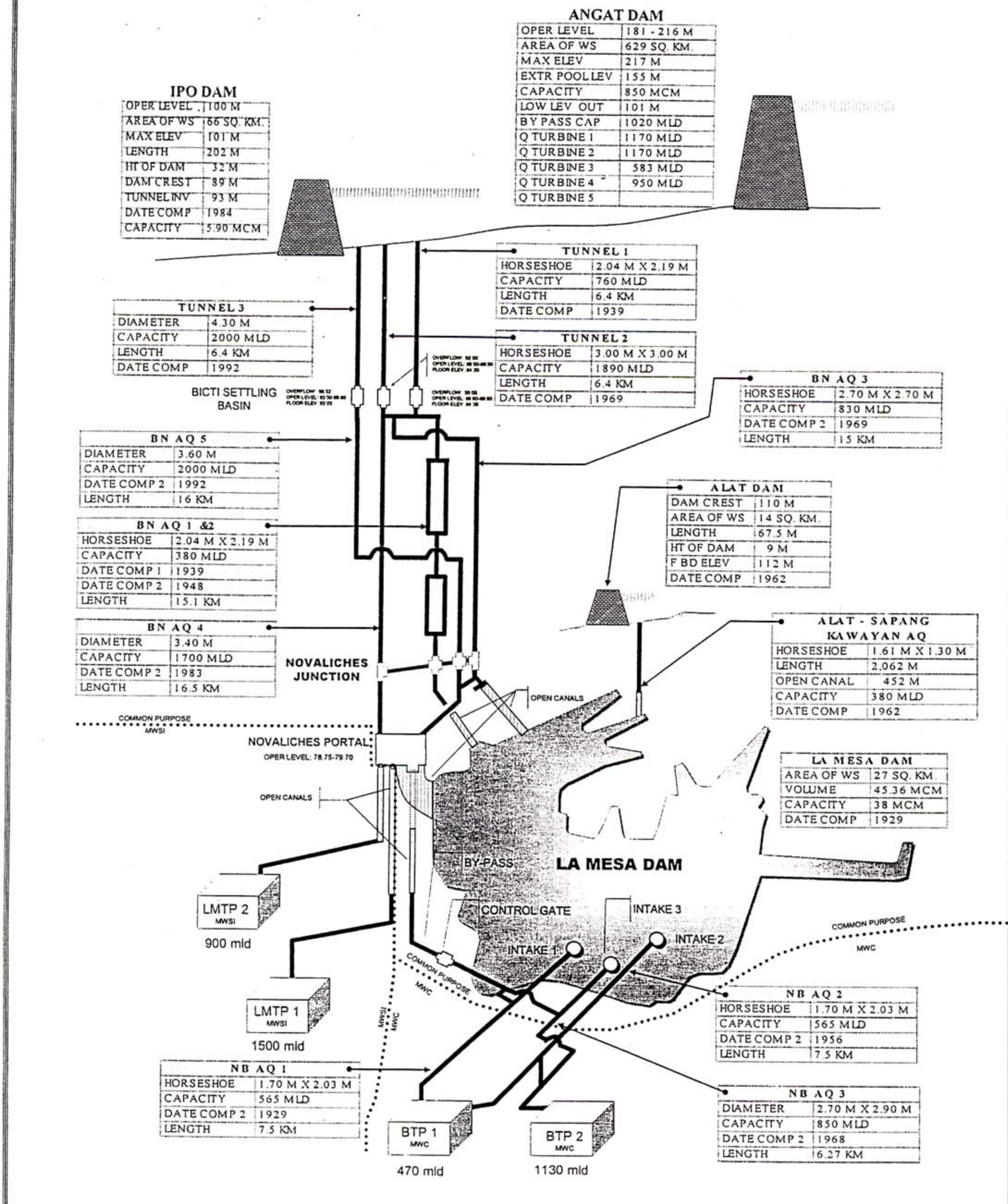
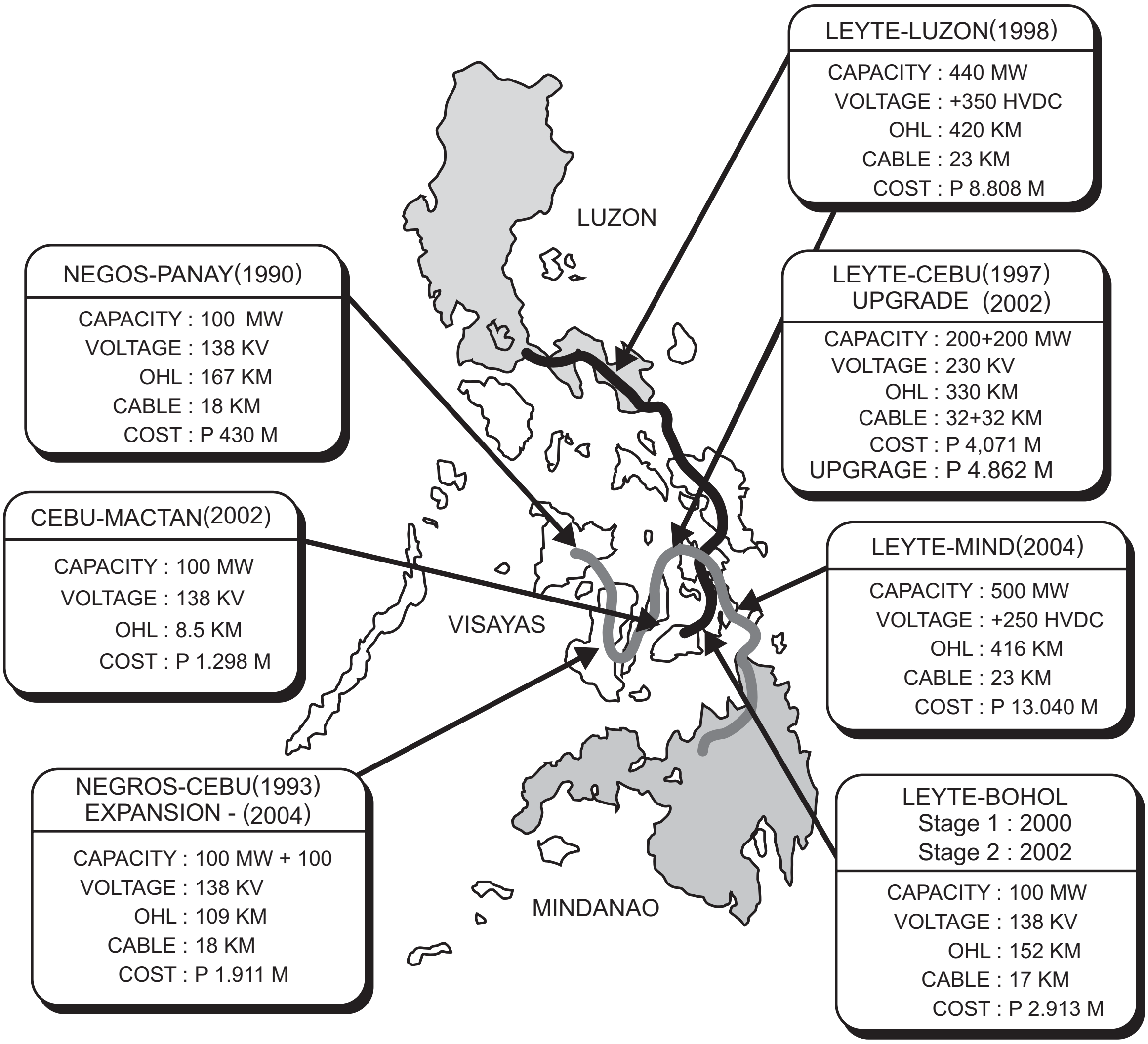



**Figure 2.2 Schematic Diagram of MWSS Headworks**




Source : 2000 Power Development Program, NPC, Nov. 2000

Figure 2.3 Major Interconnection Projects

# CHAPTER III THE AGOS RIVER BASIN

## 3.1 Geography and Topography

### 3.1.1 Geography

The Agos River Basin with a total drainage area of 940km$^2$ is located in the easternmost part of Central Luzon Island, between 14 ° 32’ and 15 ° 00’ north latitude and between 121 ° 18’ and 121 ° 40’ east longitude. The two major tributaries of the Agos River, the Kanan and Kaliwa Rivers, join about 23km upstream of the river mouth where the Agos River pours into the Pacific Ocean, forming braided river courses.

The coastal plain spreads along the lowermost reach, in which the two municipalities of Infanta and General Nakar are situated. The Agos River Basin is divided into three subbasins, namely the Kanan and Kaliwa Basins and the Agos mainstream Basin lying downstream of the former two tributaries’ confluence, which occupy a catchment area of 393km$^2$, 473km$^2$, and 74km$^2$, respectively.

The most upstream of the Kanan River Basin rises about 36km northwest of Infanta and generally flows from north to south until it reaches the confluence with the Kaliwa River. Due to the steep mountainous topography as well as the limited accessibility to the upstream reach, most of the Kanan River Basin is covered by virgin forest, although it is reported that illegal logging has been active since the old times. The Kanan River Basin is adjacent to the Umiray River Basin to the west, whose water is now being conveyed to existing Angat Dam for the purpose of water supply to Metro Manila after completion of the Umiray-Angat Transbasin Project. The total course of the Kanan River to the confluence with the Kaliwa River is about 54.5km and its bed slope is as steep as 1/176 forming rapids at many locations along the river course. The topographic condition as well as high annual rainfall of about 6,000mm makes hydropower development in the Kanan River Basin very attractive. The previous studies identified three hydropower potential sites on the Kanan River, namely the Kanan No.1 site, Kanan No.2 site, and Kanan B1 site from upstream to downstream, as shown in Figure 5.1 in Chapter V.

The Kaliwa River Basin occupying the southwestern part of the Agos River Basin is located adjacent to the Marikina River Basin to the west and a drainage area of Laguna Lake to the south. In the Kaliwa River Basin, especially the upper basin, the mountainous area is of moderate slope as compared with the Kanan River Basin and is suitable for cultivating agricultural products. Due to the topographic condition as well as the easier accessibility than the Kanan, the Kaliwa River Basin has significantly developed in the past due to intensive logging activities. At present, the deforested areas are utilized for many small farms where coconuts, bananas and cereal crops are cultivated. The upper Kaliwa is further divided into the basins of two major tributaries, the Lenatin and Limutan, which join just upstream of the Laiban Dam site on the Kaliwa River. There exit two lanes of diversion tunnels on the right bank of the Laiban Dam site. These diversion tunnels were built in the early 1980s in order to construct the Laiban Dam under the Manila Water Supply Project III (MWSP III), but the implementation of Laiban Dam Project has been suspended to date due to the resettlement problems. The Lenatin River Basin, the western tributary basin of the Kaliwa, is characterized by the aggravated basin conditions resulting from the past logging activities. It was observed during the site reconnaissance that forest remains only in limited areas in the Lenatin River Basin. On the contrary, the Limutan River Basin situated adjacent to the Kanan River Basin is comparatively covered by thick forest.

After the confluence of the Lenatin and Limutan, the Kaliwa River takes its course to west and then to northeast continuous meanders until it reaches the confluence with the Kanan River. Barangay Daraitan, located about 5km downstream of the confluence of the Lenatin and Limutan, is a main hamlet in the middle reach of the Kaliwa. In the downstream reach of Barangay Daraitan, the narrow gorge continues with comparatively thick forest cover up to the confluence with the Kanan River.

### 3.1.2 Topographic Data Available for Master Plan Study

During the Phase I study of 2001 when the master plan study was carried out, the following topographic data were collected from the concerned agencies such as NAMRIA, NPC, MWSS and a local survey firm:

- Aerial photographs covering the whole Agos River Basin, taken in 1979-81;
- Arial photographs covering the water conveyance route linking the Kaliwa River Basin and Metro Manila, taken in 1995-2000;
- 1/50,000 scaled topographic maps with contour lines of 20 m intervals, which cover the whole Study area of the Agos River Basin and area of water conveyance facilities, produce d by NAMRIA;
- 1/5,000 scaled topographic maps with contour lines of 5 m intervals, which cover partially the Kanan and Kaliwa River Basins, produced by NPC in 1992 for the Kanan B1 Hydroelectric Project.

The plan formulation of dams as well as the water conveyance facilities is carried out principally based on 1/50,000-scaled topographic maps. Besides, the topographic maps produced in the preliminary design of previous studies including the Agos River Hydropower project (JICA, 1981) were extracted from the concerned reports to be used for the preliminary design of the present master plan study. Besides, the site conditions of the alternative water conveyance routes including land use and the requirement of resettlement and compensation were interpreted based on the existing 1/50,000 scaled topographic maps and aerial photographs.

## 3.2 Meteorology and Hydrology

The results of hydrological investigation and analyses are described in detail in Part-C of the Supporting Report for Master Plan (Volume III).

### 3.2.1 Available Data

The meteo-hydrological data of the Study area, including rainfall, discharge, temperature, evaporation, relative humidity, and wind speed/direction were collected from PAGASA, DPWH, NPC and previous study reports. Figure 3.1 shows the locations of the meteorological stations in and around the Kanan, Kaliwa and Agos mainstream basins. Figure 3.2 shows the duration of meteo-hydrological records made available at the respective stations.

In the Agos River basin, air temperature, relative humidity and wind speed/direction have been recorded at Infanta station for 40 years from 1961 to 2000. The average air temperature thereat is 26.9$^{O}$C, maximum temperature is 34.6$^{O}$C, and minimum temperature is 19.9$^{O}$C. The average relative humidity is 83% and average wind speed is 2 m. The evaporation records are available at Cuyambay station for 10 years from 1969 to 1978. The mean annual evaporation depth at Cuyambay meteorological station amounts to 1,423 mm.

During the Master Plan stage, the rainfall data at 19 rainfall gauging stations in and around the Agos River basin were collected from the concerned agencies including PAGASA. The observation periods of rainfall at these stations are generally short-term with many non-observed periods, except for Infanta station where rainfall has been continuously recorded since 1950.

The runoff data are available at 6 streamflow gauging stations in and around the Agos River basin. In addition, those at 2 streamflow gauging stations in the Marikina River basin were collected. Out of these streamflow gauging stations, the runoff data at Banugao streamflow gauging station on the Agos mainstream and those at streamflow gauging stations on the Lenatin and Limutan Rivers, major tributaries of the Kaliwa River, are key hydrological data for the present hydrological analysis.

The water level observation at Banugao streamflow gauging station was commenced in 1949, but it was abolished in 1980s. The hydrological data at Banugao streamflow gauging station have been utilized in many previous studies on water resources development in the Agos River basin, including the 1981 JICA study on the Agos hydropower development.

The water level observation at the Lenatin and Limutan Rivers was performed in 1980s under the MWSP III. These hydrological data on the Kaliwa River were used in the 1997 MWSP III study to generate long-term runoff data from rainfall data. These hydrological data are applied to the present hydrological analysis after reviewing the accuracy of their existing stage-discharge rating curves.

### 3.2.2 Hydrological Investigation Works Performed during the Master Plan Stage

During the first site reconnaissance conducted in April 2001 by the JICA Study Team and counterpart personnel of NWRB, the following three (3) new streamflow gauging sites were selected:

- On the Agos mainstream: near Barangay Magsaysay, about 10 km downstream of the Kanan-Kaliwa confluence.
- On the Kanan River: near Barangay Pagsangahan on the Kanan River, about 2-km upstream of the Kanan-Kaliwa confluence.
- On the Kaliwa River: near Barangay Daraitan, about 20 km upstream of the Kanan-Kaliwa confluence.

The locations of the above 3 new streamflow gauging stations installed during the First Field Investigation are shown in Figure 3.1. Out of the 3 new streamflow gauging stations, those on the Agos mainstream and Kanan River are equipped with an AWLR (Automatic Water Level Recorder) and cable system, while that installed on the Kaliwa River is a manual type. The cable system is used for discharge measurement during flood period.

Note: An additional streamflow gauging station was installed on the Kaliwa River at Pagsangahan, just upstream of the confluence with the Kanan River, in February 2002 during the Feasibility Study stage.

The outline of each new streamflow gauging station is presented in the following table:

**Outline of New Streamflow Gauging Stations**

| Station Name | Agos S.G.S. | Kanan S.G.S. | Daraitan S.G.S. |
|---|---|---|---|
| River | Agos Mainstream | Kanan | Kaliwa |
| Location | N 14°41’92”<br>E 121°34’56” | N 14°42’07”<br>E 121°31’76” | N 14°36’02”<br>E 121°26’03” |
| Height of Staff Gauges | 7 m (Right Bank) | 6 m (Left Bank) | 8 m (Left Bank) |
| Automatic Water Level Recorder | Installed (Right Bank) | Installed (Left Bank) | None |
| Cable System | Installed | Installed | None |

Note: Automatic water level recorder and cable system at Kanan S.G.S. were stolen in April 2002 and therefore are not in function at present.

The discharge measurements at each of the 3 new streamflow gauging stations was carried out for 4 months from May to August 2001 under the supervision of the JICA Study Team. The discharge measurement data recorded by that period were still insufficient for higher river stages so as to construct the stage-discharge rating curve (H-Q curve), since the comparatively dry period lasted during that period.

A total of 50 river water samples have been taken at the aforesaid 3 new streamflow gauging stations to be used for the suspended load analysis. The sediment sampling has been carried out for 4 months from May to August 2001. The suspended loads contained in the river water were analyzed in a laboratory under a local contract.

River water samples for water quality analysis were also taken at each of the aforesaid 3 new streamflow gauging stations in July 2001. The water samples were analyzed in the laboratory in accordance with the specifications prepared by the JICA Study Team.

### 3.2.3 Meteorology

Luzon Island, located between 12$^{o}$N and 19$^{o}$N in latitude, has a tropical climate, predominantly affected by the northeast monsoon prevailing from November to February and the southwest monsoon prevailing from July to September. The trade winds come from the east during the rest of the year and whenever the monsoon is weak. The mountain ranges in Luzon, generally run from north to south, receive rains on the slopes on the windward side, and on the other hand they also function as a barrier preventing the said humid air mass inflow into the inland area. Therefore, the seasonal rainfall patterns differ according to the locality and topographic conditions.

As the Kanan River basin is located near the east coast of Central Luzon, the rainy season in this area is affected mainly by the north-east monsoon, while the Kaliwa River basin is affected by both north-east and south-west monsoon due to its location in the midland. The basin is often affected by typhoons.

### 3.2.4 Runoff Analysis

#### (1) Methodologies Adopted

In the First Field Investigation period in 2001, the runoff analysis on the Kaliwa River basin was carried out based on monthly discharge data of the Limutan and Lenatin Rivers available from the MWSP study and those at Banugao streamflow gauging station on the Agos mainstream. At this study stage, the available monthly discharge records are analyzed to grasp the monthly pattern of runoff yields.

In the subsequent home office analysis, the Tank Model method was applied to estimate the long-term discharges in the Kaliwa River.

The results of runoff analysis carried out by means of these two methods (referred to as Method-1 and Method-2, respectively) were compared as described hereafter.

#### (2) Rainfall Analysis

The objective of rainfall analysis was placed to produce long-term rainfall data for use for Tank Model analysis for the Kaliwa River basin. Firstly, correlation between the monthly rainfall data observed at stations in the Kaliwa River basin and stations located around the basin was analyzed. For the latter stations, such stations as having long-term records were selected. Based on this method, gaps contained in the former stations were filled and long-term rainfall data generated.

The mean annual rainfall of the tributary basins and proposed water source sites in the Kaliwa River basin are estimated by the Thiessen Polygons method based on the generated rainfall data. The results are shown below.

**Annual Average Rainfall of the Kaliwa River Basin**

(Unit : mm)

| Location | Limutan River Basin | Lenatin River Basin | Kaliwa Low Damsite | Kaliwa Confluence |
|---|---|---|---|---|
| Annual Rainfall | 3,767 | 3,152 | 3,204 | 3,327 |

As shown in table above, it is estimated that the annual average rainfall of the Limutan River basin located close to the Kanan River basin is about 20% larger than that of the Lenatin River basin.

(3) Runoff Analysis by Tank Model Method

The water level observation of the Agos mainstream was conducted at Banugao streamflow gauging station for about 30 years until 1980s. With respect to the Kaliwa River basin, the water level observation was continued at streamflow gauging stations on the Limutan and Lenatin Rivers for several years in 1980s. In the Kanan River basin, no usable data, both rainfall and runoff records, are available.

Taking into account the very limited availability of meteo-hydrological data, especially for the Kanan River basin, the runoff analysis to estimate the long-term discharges at the proposed water source sites is carried out by adopting the following procedures:

i) To estimate long-term discharges at the respective sites in the Kaliwa River basin, including the Kanan-Kaliwa confluence, by means of the Tank Model method,

ii) To estimate long-term discharges at the Agos confluence (just downstream of the Kanan-Kaliwa confluence) by transposing runoff data observed at Banugao streamflow gauging station based on the catchment area ratio,

iii) To estimate long-term discharges of the Kanan River at the Kanan-Kaliwa confluence by deducting the Kaliwa discharges estimated in i) above from the discharges at the Agos confluence estimated in ii) above. The long-term discharge at other points of the Kanan River is estimated in proportion to their catchment area ratios to the Kanan-Kaliwa confluence.

The Tank Model is set up for the Kaliwa River basin in which the runoff records in 1980s are available. The runoff analysis by the Tank Model is performed in accordance with the following procedures:

i) The tank model parameters for the Kaliwa River basin are decided for catchment covered by the Limutan and Lenatin streamflow gauging stations where rainfall and runoff data on the Kaliwa River basin are available,

ii) The long-term discharges at Laiban damsite are estimated by adding long-term discharges at the Limutan and Lenatin streamflow gauging stations that are derived through the simulation by the Tank Model,

iii) The long-term monthly discharges at the proposed Kaliwa Low Damsite and the Kanan-Kaliwa confluence are simulated by the Tank Model using the parameters set up for the Limutan streamflow gauging station.

The mean monthly discharge data so estimated at respective sites in the Kaliwa River basin are shown in Table 3.1.

(4) Comparison of Results of Hydrological Analyses by Tank Model Method and Monthly Discharge Pattern

The mean monthly discharges at each water source site in the Kaliwa River basin that are estimated by means of the Tank Model method (Method-1) and the monthly discharge pattern (Method-2) are compared in the following table:

**Estimated Long-Term Mean Discharge**

(Unit : $m^3$/sec)

| Method | Laiban Damsite | Kaliwa Low Damsite |
|---|---|---|
| Method-1: Monthly Discharge Pattern | 25.8 | 32.1 |
| Method-2: Tank Model | 23.4 | 27.9 |

As shown in a table above, there is little difference between the long-term mean discharges estimated by the Method-1 and Method-2. The Method-1 adopts the monthly discharge pattern derived from the hydrological data observed for limited periods, while the Method-2 reflects the long-term rainfall patterns in the Kaliwa River basin. Therefore, it is determined to adopt the results of runoff analysis estimated by the Method-2 (Tank Model). The Method-2 estimates the Kaliwa discharges more conservatively than the Method-1 as shown in above table.

Table 3.1 also shows the long-term mean monthly discharges at the proposed water source sites on the Kanan River and Agos mainstream. As shown in Table 3.1, mean discharges at the Kanan No.2 damsite and Agos damsite are estimated at 54.8 $m^3$/sec and 113.3 $m^3$/sec, respectively. The flow duration curves at each of the proposed run-of-river scheme sites are summarized shown in Table 3.2.

### 3.2.5 Flood Study

The maximum discharge records for the Agos river basin are available for 26 years at Banugao streamflow gauging station. For estimating the probable floods, two theoretical probability distributions, Log Pearson Type III and Gumbel methods, were applied to the maximum discharges. The results of the frequency analysis are shown in the following table:

**Probable Flood at Banugao Streamflow Gauging Station**

| Return Period | Probable Discharge ($m^3$/sec) | |
|---|---|---|
| | Log Pearson Type III | Gumbel |
| 2-year | 1,535 | 1,690 |
| 5-year | 2,651 | 2,979 |
| 10-year | 3,530 | 3,832 |
| 20-year | 4,474 | 4,650 |
| 50-year | 5,845 | 5,709 |
| 100-year | 6,988 | 6,503 |
| 200-year | 8,230 | 7,294 |
| 1,000-year | 11,542 | 9,126 |
| 10,000-year | 17,472 | 11,744 |

As seen in table above, the Log Pearson Type III method gives higher values than the Gumbel method for recurrence period of 100 years and larger. Therefore, the figures estimated by Log Pearson Type III method were adopted in this Study.

The probable floods at proposed damsites were estimated by applying the drainage area ratio using the Creager's equation.

3.2.6 Sediment Study

In this stage, the sediment study was performed through reviewing the previous studies related to the Agos River basin.

The sediment analysis for the Agos River basin is available from the feasibility study on Agos River Hydropower Project (JICA 1981), which was carried out between November 1978 and May 1980. Most of the subsequent studies assessed the sediment yield of the Agos River basin with reference to the analysis results in this previous JICA study.

In the previous JICA study, 36, 11 and 19 sediment samples were collected at Mahabang Lalim streamflow gauging station on the Agos River, Binugawan streamflow gauging station on the Kanan River and Nio streamflow gauging station on the Kaliwa River, respectively. Since the runoff data at the latter two stream gauges were not available due to lack of stage-discharge rating curve, the sediment yield was estimated based only on the results of suspended load on the Agos mainstream. As a result, the following formula was constructed:

$$Qs = 0.005802 \times Q^{2.4515}$$

where, Qs : Suspended sediment load (ton/day)

Q : Mean daily discharge ($m^3$/sec)

Applying the above formula to the long-term mean daily discharges at the Agos damsite, the annual sediment yield consisting of suspended load and bed load was estimated at 557 $m^3/km^2$/year.

As the site reconnaissance conducted by helicopter in July 2000, on the other hand, it was confirmed that the Kaliwa flow contained much sediment, although the Kanan river water seems to be comparatively transparent probably because of the smaller rainfall in that month. Further, the sediment yield of 557 $m^3/km^2$/year might be slightly small as compared with annual sediment yield rates estimated for the existing and proposed reservoir dam projects in Luzon Island. The 1991 ELC's feasibility study on the Agos River Hydropower Project recommended adopting a sediment yield rate of 1,000 $m^3/km^2$/year.

In the Master Plan stage, a sediment yield of 1,000 $m^3/km^2$/year is tentatively adopted for the reason of a safer side planning of the proposed reservoir projects, taking into consideration the change of the basin conditions after the completion of the JICA feasibility study in 1981.

## 3.3 River Water Quality

### 3.3.1 Previous Water Quality Analysis

In the previous study of the Manila Water Supply Project III, water quality of the Kaliwa river (samples collected in 1981 to 1983) is summarized as follows:

(a) Color readings ranging from 5 to 1000 color units

(b) Iron content from 0.05 to 3.5 mg/l

(c) Alkalinity ranging from 100 to 200 mg/l as $CaCO_3$

(d) Hardness appears to be moderate with a low of around 70 and a high of about 100 mg/l as $CaCO_3$

(e) PH from 7.8 to 8.4

(f) Turbidity from a low of 0.2 to a maximum in excess of 420 turbidity units, with a mean of 3 NTU

(g) Pesticides and herbicides show no detectable level

(h) Total organic carbon (TOC) gives results varying from 0.6 to 5.9 mg/l

Further, the said report describes that additional sampling during 1985 and 1986 gave similar results for the turbidity, i.e. 3 NTU as the mean turbidity, with the 80$^{th}$ percentile of samples at 10 NTU. The condition of the catchment area can be regarded to be still 'in a good and unpolluted condition'.

### 3.3.2 Water Quality Analyses Carried out in the First Field Investigation Works

With regard to examination of appropriate water treatment process, water quality analysis was carried out for river water of one sample collected from each of the Kaliwa, Kanan and Agos Rivers. The results of water quality analysis are shown in Table 3.3.

Although the number of samples was very limited, water quality of the said rivers shows that concentration of health-related inorganic constituents such as arsenic, cadmium, chromium, cyanide, fluoride, lead, mercury and nitrate are very low and below the detectable limits. BOD5, COD, KMnO4 and ammonium, which are indicators of contamination, also show low levels.

### 3.3.3 Matters to be Considered in Design of Water Treatment Facility in Relation to River Water Quality

From the viewpoint of water treatment, color, turbidity, pH, alkalinity, iron, manganese, etc. are the items to be evaluated. Table 3.4 also shows raw water and treated water quality of La Mesa No.1 Water Treatment Plant in August 2000 and March 2001. In comparing the water quality of the Agos River Basin with that of La Mesa Dam, there is no significant difference between the water quality of Agos River Basin and La Mesa Dam. Thus, the conventional water treatment process adopted at La Mesa No1/Balara No.2 WTP can be employed for the treatment of Agos water sources.

Iron with a relatively high concentration observed in the samples can be easily removed by employing the conventional unit process (coagulation/flocculation, sedimentation and rapid sand filtration). In addition, the direct filtration may be applicable for low turbidity of water source during the dry season. For safety, feeding apparatus of activated carbon may be equipped to deal with unexpected water contamination in the future.

## 3.4 Geology

### 3.4.1 Regional Geology

The Philippine Islands are situated on the circumpacific seismic belt, which is one of the areas in the world that is most conspicuously subject to earthquake.

Geologically, the project area is bounded by the Philippine Fault system (Philippine Fault Zone: PFZ) on the east and northeast (a branch of which was identified near Infanta) and by the Valley Fault system on the west and southwest. Morphology indicates that the fault near Infanta has been active in comparatively recent geological times. Further, there are other two faults, starting from the proposed Marikina damsite in the SSW direction form the Marikina graben. Thus, the project area can be divided into four morphologically and geologically differing zones.

- The rugged mountains of Sierra Madre between the Philippine Fault (Infanta Fault) and the Faults running from Marikina in the SSW direction
- A triangular hilly zone between the SSW Faults and the Marikina graben
- The Marikina graben
- Gentle hills west of the Marikina graben, descending to the alluvial plain of Manila Bay

Land of the project area, from lithological viewpoint, consists mainly of eight (8) geological units, which include Quaternary Alluvium, Laguna, Tignoan, Madlum, Angat, Maybangain, Kinabuan, and Barenas-Baito Formations.

Table 3.5 summarizes the geological formations in the project area and Figure 3.3 shows regional geological map.

### 3.4.2 Faults

As noted above, the project area is situated within a zone of active tectonics represented by the Philippine Fault and the Valley Fault (Figure 3.4). Especially along the Philippine Fault, many large-scale earthquakes were recorded in the past years (Figure 3.5), and the relative movement of 6 cm was observed in 1991-1993 period. Therefore, it can be said that the Philippine Fault has potential for a very high seismic activity. According to the PHILVOLCS data, several "active faults" or "assumed active faults" are shown in the project area, and some pass through nearby the proposed damsites. In the previous studies, many faults have been identified in the project area. They are shown in Figure 3.6 and 3.7 together with the faults delineated by PHILVOLCS.

In the case an active fault passes nearby the proposed damsite, two problems should be solved in the design of the proposed structures.

- Seismicity caused by earthquakes occurring in active fault zone
- Deformation in dam-foundation caused by the movement of active fault

### 3.4.3 Seismicity

According to the previous studies, most of the proposed damsites would be subject to high peak acceleration and exposed to generally high degree of seismicity (Table 3.6). Especially, Agos damsite and Kanan damsite are located at only 7-8 km distant from the active Philippine Fault, where large earthquakes have been recorded around the areas (Figure 3.6). Therefore, at the detailed design stage, a dynamic analysis is required for the design of dam to confirm the behavior of the dam body on occurrence of large earthquake.

### 3.4.4 Geotechnical Evaluation of Respective Schemes

(1) General

The Study at this stage reviewed the previous reports and conducted field reconnaissance by paying attention particularly to the following items:

(a) Possibility of water leakage from the limestone mass distributed in the reservoir area of Laiban Dam

(b) Possibility of water leakage from the Daraitan limestone mass distributed in the reservoir area of Agos Dam and Kaliwa Low Dam

(c) Grasping of the geological condition of Kaliwa Low Dam Site

Figure 3.8 shows the distribution of limestone and young sediments around the Agos~Laiban reservoir areas.

(2) Laiban Dam

1) Background

Electrowatt & Renardet completed the detailed design in 1984, wherein Concrete Face Rockfill Dam (CFRD) is proposed. In a review study in 1997, two types of dam, CFRD and Roller Compacted Concrete Dam (RCCD), were compared. The conclusion was to retain CFRD in the tender design.

2) Dam Site

Lithology around the Laiban Dam site is older predominantly clastic sediments with limestone and intercalcations belonging to Barenas-Baito Formation of the Cretaceous period, and it is composed of mudstone and claystone, occasionally cherty or marly siltstone, wacke, breccias and conglomerate, and calcarenites. The previous reports have identified the following problems:

(a) Stability of the plinth foundation on the right bank side

(b) Many small scale faults

(c) Thick residual and colluvial soil on the right bank

(d) Need of groundwater monitoring on the narrow ridge part of the right bank

It seems that these problems are of nature that can be dealt with by suitable construction work. The previous study assessed that, geologically, the dam foundation would be suitable for both the CFRD and RCCD. The study pointed out that seismic risk is high around the damsite.

Figure 3.9 shows the geological profiles of the Laiban Dam axis prepared by MWSP III study in 1984.

3) Reservoir Watertightness

One of major concerns was the watertightness of the reservoir. The issue of solution-affected limestone mass distributing in the reservoir area has been examined by several studies since 1979. Electrowatt et al concluded, "the watertightness of the reservoir would be assured for operational level up to EL. 270 m".

In this JICA Study, it was observed that limestone mass does not distribute in so wide area as considered in the previous investigations, but the widths of some limestone bodies are a little wider than indicated by Electrowatt et al (1984) (Figure 3.8).

It seems that each rock body of the limestone is relatively small and distributes at shallow depths with limited continuity. Groundwater level appears to be relatively high. The elevation of the bottom layers of a largest limestone body situated at upper reach (a part of Masunguit limestone mass) is higher than EL. 270m. These observations indicate that there is less possibility of water leakage from the reservoir of Laiban Dam, provided that each limestone body is distributed discontinuously.

In the subsequent investigation, it is required to confirm the detailed distribution of limestone blocks (in particular, limestone blocks occurring just upstream of the damsite and another at 2.5 km east from San Andres), relative positions with a fault, and the continuity of each block. The investigation will be by analysis of aerial photographs, detailed field reconnaissance and core drilling with water pressure test as required.

(3) Kaliwa Low Dam

Of the two sites (No.1 and No.2 sites), the No.2 site was selected chiefly from river morphological and geological aspects. See Supporting Report, Part-D for detail.

The Kaliwa Low Dam No.2 site is located on the Kaliwa River, approximately 5-km downstream of Daraitan, between Ligundinan creek and Queboroso creek, both right bank tributaries of the Kaliwa River. The riverbed elevation is around EL.100 m. It is accessible by three trails, one from Daraitan, one from the confluence of Kanan and Kaliwa rivers in the dry season, and the other from Marcos Highway in the rainy season.

The distribution of stiff rock forms a comparatively narrow valley around the site. Rock at the site mainly consists of pyroclastic rocks[*1], which belong to the Maibangain Formation of early Palaeogene period. The bedrock is weathered deeper on the right bank, where the slope is gentler compared with the left bank. The river water channel is about 20-m wide in the dry season. As for the pyroclastic rock, the matrix part has a lower strength compared with the hard gravel part. The foundation rock is mostly massive, and there seems no fractured zone. The base rock of the site seems to have enough shear strength and low permeability, suitable for any type of low dam constructions.

Figure 3.10 shows a profile sketch of the Kaliwa Low Dam No.2 site.

Note: [*1] The base rock of finally selected dam axis consists of sandstone, conglomerate and shale which is firm and impermeable as same as the said pyroclastic rock.

(4) Agos Dam

1) Background

Two previous studies examined this scheme: one is by JICA in 1981 and the other by NPC/ELC in 1991. The 1981 study proposed an Earth Core Rockfill Dam (ECRD). On the other hand, the study in 1991 identified the possibility of constructing a Roller Compacted Concrete Dam (RCCD). The conclusion of 1991 study was that RCCD would be geologically acceptable and less costly than the ECRD by about 18 % at direct implementation cost level.

2) Dam Site

The damsite is located just downstream of the junction of Kanan River and Kaliwa River. Comparatively steep geographical features continue from the damsite for 8-km downstream stretch. The valley becomes wider in the further downstream reaches. The rocks around the damsite consist of the Maybangain Formation and the Tignoan Formation of early to middle stage in Palaeogene period.

The most important factor of damsite geology is the Philippine Fault (Infanta Fault), which develops in the N-S direction and passes about 8-km east of the damsite. The Philippine Fault is highly active. Furthermore, according to the PHILVOLCS data, one (1) assumed active fault passing near the Agos damsite by direction of NNW-SSE (Figure 3.6). This fault extends to the Kanan No.2 damsite located further north.

The base rock of the damsite consists of greywacke[*2], conglomerate, fine-sandstone, and shale. The most part of rock is massive and shows little bedding plane, except those observed in intercalation of thin layers of fine-sandstone and shale. Talus deposits composed of rock fragments and creeped residual soils develop at the foot of the slopes along the river. Terraces of flood deposits are not so dominant in sharp bends around the damsite. Riverbed deposit of sand and gravel has a thickness of 30 to 40 m along the dam axis.

Note: [*2] "Greywacke" is referred to as "sandstone" in the feasibility report.

According to the previous study report by JICA (1981), the following three (3) problems are pointed out for the Agos damsite:

- Thick residual soil and decomposed rock zone on the right abutment
- Thick riverbed deposit
- Fault in the riverbed and on the right bank

The possibility of landslide should be considered on the right abutment in view of thick residual soil and decomposed rock zone developed in the area.

As noted above, the depth of river deposit in the Agos damsite is some 40 m with the bottom elevation lower than the sea level in some parts. From geographical point of view, the depth of deposit seems too thick compared with the river width of some 100 m. The thick river deposit may be explained by the following factors:

- Marine transgression
- Possibility of regional subsidence of ground related with the movement of Philippine Fault or Philippine Trench

In the next stage, additional core-drilling and seismic prospecting investigations are required to reconfirm the thickness of riverbed deposit.

Low velocity zones were observed in the riverbed and on the right abutment by seismic exploration survey along the dam axis in the previous JICA study (1981). Especially in the riverbed, a sheared zone was observed at 110-120 m section in the borehole No. DDH-18 by the same study. There is no data, however, about the detail condition and distribution of this fault. Therefore, in the next stage, core-drilling investigation with water pressure test is required for confirmation of the condition of low velocity zones.

3) Comparison of dam type:

An Earth Core Rockfill Dam (ECRD) was proposed by JICA (1981). The same study mentioned the possibility of concrete gravity dam construction, provided that detailed investigation would be required to confirm the shear strength of foundation rock by in-situ rock test. On the other hand, Roller Compacted Concrete Dam (RCCD) was studied by ELC (1991) at a site 140 m upstream of the ECRD site. The study suggested that fresh part of foundation rock would have enough shear-strength for any type of dam. The following adverse factors, however, are considered for RCCD construction.

- Large amount of excavation in thick riverbed deposit
- Fault in riverbed in the foundation area
- Possibility of land slide on the abutment
- High risk of seismicity around the damsite
- Impact on river environments due to the recuperation of a large amount of riverbed deposits (for concrete aggregates) in the downstream reaches of the Agos River

Therefore, it can be said that fill type dam, which mainly consists of rock materials, seems more suitable for the Agos dam.

Figure 3.11 shows the geological profile along the Agos Dam axis.

4) Reservoir Watertightness

With regard to the Agos reservoir, the possibility of water leakage from Daraitan limestone mass was the focus in the previous studies. This problem is common to the pond, which would be created by the Kaliwa Low Dam.

Daraitan limestone mass is situated at the upstream part of reservoir area with the width of 1.5 km, distributing in N-S direction. MWS III study in 1979 indicated that "loss of water through the fault zone or limestone in a northerly direction is physically impossible. Towards the south, the limestone seems to wedge out or to be cut off by faults, which also would exclude water losses in this direction. Nevertheless, geologic evidence in this respect is not conclusive. Subsurface exploration, consisting mainly of boreholes with permeability tests and core sampling, would be necessary to definitely resolve the possibility".

Moreover, JICA study (1981) noted that "only a few developments of cavities have been found, but the problem of leakage seems negligible because of the shallow high water level at the limestone area and the presence of other impervious beds between this area and Laguna de Bay. Existence of not a few lines of surface water streams originating higher than El. 300 m in this area can be taken as a proof of high groundwater table and imperviousness of the bed rocks".

According to reconnaissance by JICA Study Team (2001), many cavities, holes, and water-spring points are observed in Daraitan limestone area, which indicates the possibility of existence of many natural water routes inside the deeper part of limestone mass. For example, along the Kaliwa

River, it is found that a natural tunnel of 1.5-m diameter gushes out water of 500 litters/min.

The dip and strike of bedding plane in Daraitan limestone is often disturbed by some faults and foldings. However, on the right side of the river, it seems to plunge toward southwest. Along the Matilatiday creek, a right tributary of the Kaliwa River, no surface water flow is observed in the dry season, so that there is a possibility of water leakage from this creek. Nevertheless, the volume of water flow in the Kaliwa River seems unchanged throughout the sections of limestone area. According to the study by EDCOP (2001), "flow measurements at selected sections upstream and downstream of the limestone body in Mt. Daraitan did not indicate any loss of water as the Kaliwa river flows through the said formation".

A matter to be confirmed is the possibility of water leakage from Daraitan limestone mass in the case of raising the water level by about 20 m after water impoundment in the reservoir. In the next stage of investigation, the following are subjects of further confirmation:

i) Continuity of Daraitan limestone mass toward the San Antonio area.

ii) Distribution and condition of the faults connecting with Daraitan limestone, especially in the San Antonio area.

Figure 3.12 shows an assumed geological profile of Mt.Daraitan~Pagus area.

(5) Agos Afterbay Weir

JICA study (1981) examined the construction of a floating type weir at a point of about 8 km downstream of the Agos Dam site, where the river width is some 260 m. Core drilling and seismic prospecting were carried out at the site.

Base rock of the site is composed of greywacke[*3] and conglomerate with thin layers of sandstone and shale, which are same as those distributed at the Agos damsite. The thickness of riverbed deposit, which consists of sand and gravel, reaches 50 m at maximum along weir axis. Therefore, a floating weir was proposed in the 1981 study.

Note: [*3] "Greywacke" is referred to as "sandstone" in the feasibility report.

The same study noted that "the possible leakage through the river deposit under the weir body, which is highly pervious but might not be effectively grouted, will be controlled by long flow lines created by means of apron and/or blanket. This will reduce the possibility of piping.

(6) Kanan No.2 Dam

This Study initially examined three potential dam schemes on the Kanan river: i.e. Kanan No.1 Dam, Kanan No.2 Dam and Kanan B1 Dam. Of these, Kanan No.2 dam was finally selected through geological assessment and cost comparison study. See Supporting Report Part-D for details of geological assessment of the three dams. The following describe the geological features of the Kanan No.2 Dam:

1) Background

Manila Water Supply III study (MWS III) by Electrowatt et al (1979) proposed that Kanan No.2 Dam should come up on development stream next to the Laiban Dam scheme. The scheme is virtually for water supply development, diverting the Kanan river water to the Laiban reservoir. The study proposed a 160-m high dam of earth-core rockfill construction at a preliminary design level.

It is noted that the Philippine Fault (Infanta Fault) with high activity exists at about 8 km east. This fault issue should be taken into account in the design of all the dams proposed on the Kanan River.

2) Kanan No.2 Dam Site

MWS III study (1979) carried out test pit digging and seismic prospecting to study the geological condition of the site. The No.2 site shows relatively gentle topographic feature compared with No.1 site. The base rock is composed of massive rocks such as conglomerates, agglomerates, occasionally lava flows, sandstone, mudstone with fossils, chert and graywacke. The seismic prospecting revealed 3.0 km/sec of P-wave velocity in fresh rock, which was evaluated as "indicating a comparatively good geotechnical quality".

The geology is equivalent to Mayabangain Formation of Palaeogene period, and almost similar to that occurring at the Kanan No.1 site, Agos site and Kaliwa Low Dam site. The weathering layer of abutments is comparatively thick, 10-20 m at the bottom of slope and 20-30 m at the upper part. There is a possibility of existence of unstable mass causing landslide or thick talus deposit.

Figure 3.13 shows a geological profile of the Kanan No.2 Dam axis.

(7) Water Transfer Tunnels

General geology of several waterways was examined at a master plan study level. The following describe the geology of four (4) tunnels that are included in the Alternative Development Scenarios examined in Chapter V hereinafter.

1) Kaliwa~Abuyod Water Transfer Tunnel[*4]

This tunnel is envisaged in the Development Scenarios B, C, D. E and G (See Chapter V). The tunnel is laid out between Kaliwa Low Dam and a powerhouse located at Abuyod. The total length of waterway is about 28 km. A part of the proposed route is shown in Figure 3.8.

The tunnel is driven in the zones of Maybangain Formation consisting of pyroclastic rocks, sandstone, conglomerate, shale, etc. in the upper part and then Kinabuan Formation & Barenas-Baito Formation composed of shale, limestone, chert, basalt and pyroclastic rocks. In general, rocks are hard and impervious.

The tunnel will pass through Daraitan limestone zone[*5] for a length of 1 km, where many cavities and high permeability are foreseen. Although the tunnel passes in the area underneath the limestone mass of Masunguit Rocks, it is not certain at present whether the tunneling will actually encounter this limestone mass, depending on the actual depths of the Masunguit Rocks. The tunnel will encounter a fault designated by PHILVOLCS (2000) to be an active fault[*6]. This issue should be investigated in the subsequent stage.

Since the tunnel will pass relatively homogeneous and hard geological layers (Cretaceous-Old Tertiary period), it is presumed that tunneling by Tunnel Boring Machine (TBM) would possibly be effective.

Figure 3.14 shows the assumed geological profile along the Kaliwa-Abuyod tunnel.

Note: [*4] In the feasibility study, the alignment of the above tunnel was changed from a viewpoint of avoiding the risk of active fault. The finally selected tunnel was named "Tunnel No.1".

Note: [*5] According to the feasibility report, the Tunnel No.1 will not pass through the Daraitan limestone mass.

Note: [*6] The finally selected Tunnel No.1 alignment will encounter an "assumed active fault" indicated by PHILVOLCS.

2) Laiban~Tanay Water Transfer Tunnel

This tunnel is envisaged in the Development Scenarios H (See Chapter V). The tunnel is to convey water from Laiban Low Dam to a powerhouse located on the bank of Tanay River, about 5 km north of Tanay town. Further, the water is conveyed to a water treatment plant at Karan Batu via pipeline and tunnel. The total length of waterway is about 18.5 km. A part of the proposed route is shown in Figure 3.8.

The waterway consists of two tunnels: upper tunnel of 15-km long and lower tunnel of 2.5 km long. The upper tunnel is driven in the Kinabuan and Baremas-Baito Formations composed of shale, sandstone, chert, basalt, pyroclastic rocks, while the lower tunnel in the Laguna Formation composed of Quarternary deposits such as tuff, pyroclastic rock, tuffaceous sandstone, etc.

The lowermost section of the upper tunnel, about 3 km in length, will pass in the area just underneath the limestone mass of Masungit Rocks where many cavities and high permeability are foreseen. It is not certain at present whether the tunneling will actually encounter this limestone mass. Further, it is noted that the upper tunnel will cross a major fault designated as an active fault according to the PHILVOLCS map.

Since the upper tunnel passes relatively homogeneous and hard geological layers (Cretaceous-Old Tertiary period), it is presumed that tunneling by TBM would possibly be effective. The lower tunnel passes the Quarternary deposits consisting of varying layers of sand, soft rock and hard rock. Use of TBM in this section will presumably be not suitable.

Figure 3.15 shows the assumed geological profile along Laiban-Tanay tunnel.

3) Laiban~Pantay Water Transfer Tunnel

This tunnel is included in Development Scenarios A and F. The detailed design of the tunnel was completed by Electrowatt in 1984. Geology along the tunnel is composed of hard agglomerate, sandstone, and clastic rock, of which unconfined compressive strength is estimated to be more than 610 kgf/cm$^2$. Though the existence of major sheared zone has not been recognized by field reconnaissance and core drilling conducted to date, there is a possibility of encountering low quality rocks in some sections.

For the most downstream 400-m alignment, a steel-lined tunnel is proposed, since the overburden load is insufficient to withstand the internal pressure of tunnel.

Excavation by drilling and blasting method was recommended in the tender design. Re-evaluation in the 1997 review study suggested a possibility of using TBM.

4) Kanan~Laiban Transbasin Tunnel

Kanan~Laiban Transbasin Tunnel has a length of about 16 km, starting from Makalia River of the Kanan basin and ending at Limutan River of the Kaliwa basin. This tunnel is proposed in Development Scenarios A, D, G and H.

The tunnel passes through the Maibangain Formation, younger clastic series of Miocene, Kinabuan Formation and Barenas–Baito Formation. The first section is composed of clastic sediments. In some parts of this section, tunnel support work with systematic rock bolting and steel ribs are necessary. The remaining few kilometers section consists of younger clastic sediments with limestone lenses.

The final stretch of the tunnel alignment is in the zone of clastic and pyroclastic rocks with limestone intercalation, which is a typical geological pattern in the area of the Laiban reservoir.

There is possibility of water inflow in the limestone area, while clastic sediments and pyroclastic rocks have low permeability.

Use of TBM will be suitable for excavation of this tunnel.

(8) Construction Works around Antipolo-Tanay Area

Various structures, such as pipeline, tunnel, power station, water treatment plant and service reservoir, are planned in Antipolo-Tanay Area, where the location of structures vary by Development Scenario (See Figure 3.7). The proposed structures should be placed on firm geological foundation layers. MWS III study (1979 and 1984) pointed out the possibility of liquefaction, especially in the Marikina valley.

Antipolo~Tanay area can be divided into three (3) geomorphological areas: (a) a little steep-hilly area, (b) gentle-hilly area and (c) low flat area.

1) A little steep-hilly area

Limestone, sandstone, shale, conglomerate, basalt, etc. of Cretaceous to Neogene ages distributes in the relatively steep hills. Fresh part of them is assumed to be hard and to have enough bearing capacity for proposed structures. As for tunnel construction, though this area seems to have a good rock condition, attention should be paid to the thickness of weathered layer and high permeable limestone. According to a hazard map prepared by the Mines and Geosiences Bureau (MGB), this area falls in landslide prone areas. In selecting the location and preparing the design of structures, possibility of landslide should be considered and investigated.

2) Gentle-hilly area

The area consists mostly of Quaternary deposits of Laguna Formation, consisting of tuff, pyroclastic rock, tuffaceous sandstone, etc. and some parts are welded. For the foundation of structures, fresh part of these rocks seems to have comparatively good bearing capacity, but some part is possibly soft, especially in weathered zone or tuffaceous zone. Core drilling with standard penetration test is required to know the in-situ condition at each structure site.

For tunnel planning, detailed investigations with drilling and seismic prospecting are important because rock condition is not homogeneous. Potential landslide needs to be examined in some parts of this area where the collapse and disturbance is remarkable.

3) Low flat area

Unconsolidated sand, silt, clay and gravel form the low flat alluvial area. Some parts of this area may possibly be not suitable for spread foundation. Possibility of liquefaction by earthquake is a serious problem in the area. According to MGB`s hazard map, the area is in liquefaction-prone area (Figure 3.15). Core drilling with standard penetration test, hand-auger boring and some sounding tests are required for the investigation.

Antipolo~Tanay area also falls in a high seismic risk, which is located between the Philippine Central Fault and the Marikina Fault (see Figures 3.5). Therefore, in the preparation of plans or designs, high seismic risk should be taken into account. MWS III Review Study (1997) establishes the following peak ground acceleration for design of structures, except dam and intake works:

- Rock and Hard Soil = 0.25g
- Medium Soil = 0.40g,
- Soft Soil = 0.70g

### 3.4.5 Construction Materials

Construction materials described here consist of dam embankment materials such as core, filter, transition and rock materials, and concrete aggregates. At this study stage, main interest is the availability of suitable materials. In general, no major constraints or difficulties of serious extent are foreseen for all the dam schemes.

Only the noteworthy issues are described hereunder. Further details are contained in Supplemental Report Part-D in Volume IIII.

(1) Laiban Dam

Rockfill material for dam embankment will be quarried from a volcanoclastic deposit situated approximately 1 km upstream from the dam. Concrete aggregates will be obtained from gravel in the Kaliwa river channel.

(2) Kaliwa Low Dam

Main construction material is concrete aggregates. Riverbed deposit along Kaliwa River will be the source of concrete aggregates.

(3) Agos Dam[*7]

Previous studies, JICA (1981) and ELC (1991), conducted some investigations for construction materials through core-drilling, seismic exploration and laboratory test. The results are shown as follows:

Note: [*7] The quantity and location of various materials indicated below were modified in the feasibility study based on the revised design of structures.

1) Rock and Riprap Materials

3.5 millions $m^3$ of material can be collected from quarries on both banks of Kaliwa river at 500 m upstream from the Kanan-Kaliwa confluence. Additional 6.0 millions $m^3$ can be produced from the excavation in spillway area. The materials consist of sound greywacke, basalt and pyroclastic rock, having unconfined compressive strength of 1160 to 1430 $kgf/cm^2$[*8], which is hard and stable enough for rockfill embankment.

Note: [*8] According to the feasibility study, above fresh base rock mainly consists of sound sandstone and conglomerate, having unconfined compressive strength of 500-600 $kgf/cm^2$, which is hard and stable enough for rockfill embankment. According to the previous JICA study report (1981), however, compressive strength test on 3 core pieces sampled from nearby the Agos quarry site indicated 1160 to 1430 $kgf/cm^2$.

2) Concrete Aggregates

Coarse aggregates can be collected from riverbed deposits of the Agos River, and fine aggregates from the coastal beach sand and the river sand. On the other hand, ELC (1991) study envisaged to take concrete aggregates for RCCD construction from the river deposits: 2 millions $m^3$ from dam foundation area and 3 millions $m^3$ from the downstream reaches.

3) Core Material

JICA study (1981) stated that impervious core materials would be available from highly weathered rocks distributed in the areas of upper part of the Agos damsite, downstream river banks and Afterbay Weir site. ELC study (1991) suggested the blending of gravel collected from river deposits with residual soil.

(4) Agos Afterbay Weir

A quarry site for the Afterbay Weir construction was proposed in the area on the left bank of the weir site. The lithology of quarry site consists of massive conglomerates intercalated by fine sandstone layers.

(5) Kanan No.2 Dam

With regard to construction materials for Kanan dams, a series of test pitting and laboratory tests were carried out by MWS III study (1979), JICA feasibility study (1981) and Kanan B1 feasibility study (1992). The following are the findings from those studies:

1) Rock and Riprap Materials

Four (4) rock quarry sites were selected on both banks of the Kanan River, located upstream and downstream from the Kanan No.2 site within a distance of 1 to 2 km. The rocks are composed of hard pyroclastic rock and greywacke. The quarry is of almost same geology as the quarry site for the Agos dam. The rock materials seem to have enough strength and stability.

2) Concrete Aggregates

Coarse aggregate will be collected from quarry sites and from excavation of structure foundations. The materials are pyroclastic rock and sandstone. Though river sand is suitable for fine aggregates, the available quantity in the vicinity is supposed to be limited, only enough to suffice the production of 1.0 million $m^3$ of concrete. It is, therefore, necessary to take additional quantities from the river deposits downstream of the Kaliwa-Kanan confluence.

3) Filter and Transition Materials

Silty sand and sandy gravel deposits accumulated along the Kanan river at 9-13 km downstream from the Kanan No.2 site are possible sources of materials for the filter and transition zones of rockfill dam. Since the available volume is limited, it is planned to acquire additional quantities from river deposit around the Kaliwa-Kanan confluence.

4) Core Material

Lagmic and Pitigan areas, 7 to 15 km upstream from the proposed damsite, will be the candidate borrow areas.

## 3.5 Water Demand and Supply for Lowermost Reach of the Agos

According to the rainfall records at Infanta station, an average annual rainfall of about 4,000mm occurs in the lower Agos area where two major municipalities, Infanta and General Nakar, are situated. Thus, the lower Agos area is blessed with abundant rainfall. The municipal water for Infanta and General Nakar is being supplied with groundwater yielded by the abundant rainfall.

Another notable water use in the lower Agos area is irrigation water taken from the Agos mainstream. At present, NIA supplies water for an irrigation area of about

1,280 ha, which is going to be expanded to the total irrigable area 1,400 ha. NIA has already acquired the water right of 2.25 $m^3$/sec to irrigate the whole irrigable area. The water balance study described in Supporting Report Part-B (Volume III) takes into consideration the irrigation water required for the future irrigation water demand.

This Section examines whether the groundwater potential will be able to meet the future water demand in the two municipalities, in other words, whether the surface water needs to be developed to meet the water demands in the two municipalities.

### 3.5.1 Present Condition of Water Supply for Lowermost Reach of the Agos

At present, the municipalities of Infanta and General Nakar are served by the Infanta-General Nakar Water District. Considering the current number of service connection (1,666), population served is assumed at about 10,000 living in urban Barangays, which correspond to 13% of the total population of 75,000 (51,000 at Infanta and 24,000 at General Nakar). Thus, the majority of people are served by other community waterworks and privately owned wells.

Water sources of the Water District (WD) are deep wells with average daily production of 0.34 MLD. Current per capita consumption is calculated at 40 Lpcd only. With regard to this, the Water District planned expansion of water supply system, however, the project is delayed due to financial constraints. Thus, expansion plan is still the issue under discussion between LWUA and WD at present.

### 3.5.2 Future Water Demand and Availability of Water Source

Although Infanta and General Nakar are still in the above situation, the following are assumed in the water demand projection:

(a) Population in 2025 is projected with reference to the socio-economic projection described in Chapter II.

(b) Service target is set to conform to the national target (95% for urban area and 93% for rural area, Water supply, Sewerage and Sanitation Master Plan of the Philippines, 1988 - 2000) basically, except for the assumption that 10% of households will use privately owned wells in the future. Thus, 90% of service target is set up.

(c) 166 Lpcd of per capita consumption and share of domestic use (90%) to total water demand are employed considering current status of the two municipalities.

(d) Peak day demand factor of 1.21 is employed in line with this Study.

Thus, about 10 and 20 MLD of water demand are assumed for General Nakar and Infanta, respectively.

**Water Demand Projection for General Nakar and Infanta**

| Municipality | Population in 2025 | Service Coverage | Per Capita Consumption | Domestic Use | Ave. Day Demand | Max. Day Demand |
|---|---|---|---|---|---|---|
| General Nakar | 41,000 | 90% | 166 lpcd | 90% | 8MLD | 9 MLD |
| Infanta | 85,000 | 90% | 166 lpcd | 90% | 16 MLD | 19 MLD |

While, with regard to water sources, the potential well capacity for General Nakar and Infanta are assumed at 347 and 85 MLD, respectively, as shown below. Thus, it is considered that there are sufficient groundwater sources in the said area to meet the future demand.

**Well Capacity in General Nakar and Infanta**

| Municipality | Average Capacity per Well ($x\ 10^3$ Lpd) | | Inflow ($x\ 10^3$ Lpd) | | Potential Max. (No. of Wells) | | Potential Well Capacity (MLD) | | |
|---|---|---|---|---|---|---|---|---|---|
| | SW | DW | SW Area | DW Area | SW | DW | SW | DW | Total |
| Infanta | 37.2 | 671 | 78,363 | 3,688 | 2,110 | 10 | 78 | 7 | 85 |
| General Nakar | 37.2 | 671 | 18,401 | 331,225 | 490 | 490 | 18 | 329 | 347 |

(Source: Rapid Assessment of Water Supply Sources, May 1982, NWRB)

## 3.6 Flood Damages in Lowermost Reach of the Agos

### 3.6.1 General

The municipalities of Infanta and General Nakar of Quezon Province are the major municipalities within the Agos River Basin. The town proper areas of these municipalities are located in the low-lying alluvial plain formed by the Agos River.

To date, these areas have suffered from seasonal severe flood damages to public works, irrigation, agriculture, and personal property. The floods also caused bank erosion and scouring, which led to the change of its river course and width. The reasons of inundation are either or the combination of storm surge due to typhoons, overbank flow of the Agos River and the insufficient drainage facilities in the town area.

### 3.6.2 Major Typhoon Records and Flood Damage Records

According to the records of PAGASA on the major typhoons in the Philippines, there were 28 typhoons that hit Infanta and General Nakar in the past 27 years. The typhoon with recorded maximum 24-hr rainfall is Typhoon Kading in 1978. Table 3.7 lists the past destructive typhoons that affect the municipalities of Infanta and General Nakar with their corresponding maximum 24-hour rainfalls.

The flood damages in the municipalities of Infanta and General Nakar are summarized in Table 3.8. While, the collected data on crop damages from the Agos River Irrigation System Project Office, NIA are shown below:

**Damages to the Crops due to Typhoons**

| Date | Name of Typhoon | Total Damaged Cost of Crops |
|---|---|---|
| October, 1998 | Typhoon Iliang & Loleng | PHP 1,800,000.00 |
| October, 2000 | Typhoon Reming | PHP 1,400,000.00 |
| November, 2000 | Typhoon Seniang | |

### 3.6.3 Present Condition

(1) Land Use

The present land use of the lower Agos is agricultural croplands. The two major crops in this area are rice and coconut, which are almost equal in coverage.

In the Municipality of Infanta, 10,233 ha or 45.5 percent of the total area (some 22,500 ha) is used as agricultural croplands and 229 ha or 1.0 percent is used as special land uses.

**Present Land Use in the Municipality of Infanta**

(unit: ha)

| Item | Area Coverage |
|---|---|
| Agricultural Croplands | |
| Ricelands | 4,958.74 |
| Irrigated | 3,748.29 |
| Non-irrigated | 1,210.45 |
| Coconut lands | 5,274.52 |
| Coconut mainly | 2,615.33 |
| Coconut with shrubs | 1,321.55 |
| Coconut with pineapple | 1,337.64 |
| Subtotal | 10,233.26 |
| Special Land Uses | |
| Built up areas | 188.58 |
| Beach sand | 40.93 |
| Subtotal | 229.51 |

The present land use of low-flat lands of General Nakar is mostly of rice paddy, coconut field, and built-up area.

(2) Characteristics of the Lower Agos

The Infanta Peninsula lies in the lower Agos where the town propers of Infanta and General Nakar municipalities are located. Based on the existing topographical and geological data, it is assumed that the Infanta Peninsula is an alluvial fan which was formed with the deposite of sediment carried by the Agos River. The lower Agos changes its stream course in the alluvial fan, forming unstable river banks at some places.

To clarify the changes of the river channel, a 1:50,000 scaled topographic map of NAMRIA (1952) and a map developed in this Study from aerophotos taken in 1995 are compared as shown in Figure 3.16. Based on the comparison of these two maps, the following observations were made:

- The present river channel of the lower Agos has formed a larger meander than that in 1952;
- The shape of the Agos River mouth has been drastically changed;
- Due to the change of flow direction, a right river bank in Barangay Ilog, Infanta, has been eroded and left bank has been extended; in contrast, the lower area of left bank near the town proper area of General Nakar has been eroded.

During the First Field Investigation, the site reconnaissance was carried out to investigate the river condition. The massive bank erosions and scourings were identified in the site reconnaissance as shown in the Figure 3.17. Photo 1 shows the exisitng retaining wall to protect the right river bank. The agricultural land near the river bank decreases due to the bank erosion as shown in Photos 2 and 3. Moreover, the severe erosion caused by the strong current of Agos River during flood season is evidently shown in Photo 4. Photo 4 also shows a part of bridge in the Lamigan Creek (now a part of Agos River), which was used to connect two Puroks of Barangay Pinaglapatan, Infanta. Due to the bank erosion, approach to the bridge was washed away on both banks, and the bridge is left in the middle portion of the Lamingan creek. The people could no longer use the bridge.

The urgent river bank protection work is strongly recommended to prevent the bank erosion.

(3) Flood Damage Survey

The flood damage survey for the lower Agos was conducted in June 2001 covering municipalities of Infanta and General Nakar. The summary of the flood damage survey results is shown in Table 3.9.

(1) Municipality of Infanta

There are seven (7) Barangays suffering from flood due to the inundation of the Agos River, namely Barangay Ilog, Barangay Bantilan, Barangay Catambungan, Barangay Pinoglapatan, Barangay Boboain, Barangay Poblacion 38, and Barangay Poblacion 39. These Barangays usually experience two to three feet high inundation due to flooding every year. During the floods, Barangay halls, church, schools, and neighbors are used as evacuation centers. During the flood, water from the Agos River intruded from the Barangay Ilog and flowed toward the municipality office which is the lowest area with an elevation of seven meters amsl. The backwater of the Bantilan River also caused the municipality to be flooded. Based on the hearing, the duration of inundation is estimated at approximately 4 to 8 hours, depending on the location of the Barangays. When the tidal level lowered, the inundation subsided. Most likely, the inundation is composed of flood from the Agos River coupled with high tide. Some part of the municipality is drained by the drainage canals which are connected to the Bantilan River to improve the drainage condition. During the site reconnaissance conducted in the First Field Investigation, concerned Barangay captains emphasized the necessity of measures for river bank erosion. Due to the erosion, the river stream courses change every five years.

The calamity fund (approximately PHP 12,000), relief goods, and medicine are given to each Barangay.

2) Municipality of General Nakar

Erosion of the river bank is the imminent problem in Barangay Poblacion and Banglos. Previously, the municipal office (town proper) was very far from the river bank, but due to the massive erosion, the town proper has become just 200 meters from the river bank and the river width is widened. It is reported that a house was washed away very recently due to the bank erosion.

(4) Characteristics of Flood in Lower Agos

Judging from the survey in Infanta municipality, there are two areas where floodwater intrudes and causes the municipality areas to be inundated. One area is the low area in Barangay Ilog and Barangay Catambungan. Once floodwater enters the low land, it flows toward the town proper area which is the lowest land of Infanta municipality. General Nakar also suffers inundation from the Agos River since the town proper area is ground elevation of 4.5 to 6.0 m. Further examination on flood damage and erosion in Lower Agos is explained in Chapter X of Volume IV.

**Table 3.1 Estimated Mean Monthly Discharge (1/5) - Laiban Damsite**

Unit : m$^3$/sec

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 28.7 | 20.5 | 20.6 | 12.2 | 10.0 | 12.2 | 9.7 | 7.0 | 20.1 | 34.1 | 28.3 | 39.7 | 20.3 |
| 1951 | 20.9 | 14.6 | 8.8 | 6.6 | 5.4 | 5.9 | 14.9 | 15.2 | 18.3 | 15.7 | 50.6 | 44.0 | 18.4 |
| 1952 | 33.6 | 19.7 | 12.4 | 10.4 | 12.4 | 19.3 | 10.7 | 20.9 | 21.3 | 47.4 | 28.1 | 51.0 | 23.9 |
| 1953 | 29.3 | 21.2 | 12.9 | 14.0 | 10.9 | 11.1 | 15.5 | 12.7 | 9.7 | 37.8 | 40.9 | 70.0 | 23.8 |
| 1954 | 37.4 | 33.4 | 38.2 | 17.2 | 14.9 | 13.7 | 12.6 | 11.9 | 8.8 | 15.0 | 16.8 | 26.7 | 20.6 |
| 1955 | 36.4 | 17.7 | 10.0 | 6.4 | 4.7 | 24.9 | 18.9 | 13.4 | 15.3 | 45.5 | 62.8 | 36.1 | 24.3 |
| 1956 | 34.7 | 33.6 | 28.1 | 40.7 | 22.4 | 27.3 | 21.4 | 30.7 | 20.6 | 32.0 | 39.5 | 59.0 | 32.5 |
| 1957 | 46.4 | 24.0 | 16.1 | 11.6 | 8.0 | 5.5 | 12.5 | 14.7 | 10.7 | 19.1 | 20.1 | 16.5 | 17.1 |
| 1958 | 35.3 | 30.9 | 15.2 | 9.3 | 6.6 | 7.6 | 14.4 | 23.9 | 14.9 | 32.1 | 28.9 | 15.7 | 19.6 |
| 1959 | 23.0 | 18.0 | 16.4 | 9.2 | 12.8 | 9.2 | 17.4 | 11.8 | 18.0 | 24.4 | 38.0 | 40.5 | 19.9 |
| 1960 | 38.2 | 48.3 | 20.7 | 19.4 | 31.5 | 21.7 | 19.2 | 21.6 | 40.5 | 49.3 | 37.8 | 26.1 | 31.2 |
| 1961 | 13.2 | 7.8 | 4.9 | 3.5 | 5.6 | 44.4 | 49.8 | 25.3 | 55.5 | 44.1 | 28.2 | 14.8 | 24.8 |
| 1962 | 9.0 | 6.1 | 4.2 | 3.1 | 4.2 | 12.6 | 76.0 | 57.4 | 63.5 | 28.1 | 19.4 | 11.7 | 24.6 |
| 1963 | 7.2 | 4.8 | 3.5 | 2.6 | 2.3 | 36.3 | 42.0 | 51.2 | 59.6 | 33.5 | 17.8 | 16.4 | 23.1 |
| 1964 | 10.4 | 6.8 | 4.4 | 3.1 | 6.5 | 41.3 | 45.4 | 70.6 | 47.7 | 36.5 | 39.2 | 24.9 | 28.1 |
| 1965 | 13.4 | 8.4 | 5.3 | 3.5 | 10.1 | 14.8 | 51.8 | 24.6 | 46.8 | 22.4 | 21.7 | 13.1 | 19.6 |
| 1966 | 8.2 | 5.5 | 3.9 | 2.8 | 42.7 | 16.1 | 16.9 | 17.9 | 64.0 | 33.1 | 46.3 | 27.1 | 23.7 |
| 1967 | 14.3 | 8.9 | 5.5 | 3.5 | 2.7 | 26.8 | 22.3 | 62.0 | 54.3 | 29.9 | 19.0 | 11.4 | 21.7 |
| 1968 | 7.1 | 4.7 | 3.2 | 2.4 | 3.3 | 10.1 | 32.2 | 64.1 | 55.0 | 32.5 | 16.0 | 9.0 | 20.0 |
| 1969 | 5.2 | 3.4 | 2.4 | 2.0 | 1.8 | 3.0 | 15.4 | 40.4 | 49.2 | 35.5 | 19.4 | 14.2 | 16.0 |
| 1970 | 8.8 | 5.5 | 3.4 | 2.3 | 1.7 | 5.3 | 18.0 | 14.7 | 88.4 | 69.4 | 44.5 | 25.0 | 23.9 |
| 1971 | 13.3 | 7.7 | 4.7 | 3.5 | 14.0 | 25.5 | 45.1 | 34.4 | 20.3 | 41.8 | 38.1 | 30.7 | 23.3 |
| 1972 | 15.5 | 9.1 | 5.4 | 3.5 | 7.3 | 38.3 | 155.1 | 106.8 | 60.3 | 30.3 | 22.1 | 13.7 | 38.9 |
| 1973 | 8.6 | 5.6 | 3.8 | 2.8 | 2.4 | 20.2 | 29.8 | 19.2 | 22.8 | 42.1 | 35.5 | 22.0 | 17.9 |
| 1977 | 12.4 | 8.1 | 5.4 | 3.6 | 2.7 | 5.0 | 29.1 | 50.6 | 58.0 | 25.7 | 38.8 | 18.0 | 21.5 |
| 1978 | 9.5 | 5.7 | 3.7 | 2.6 | 4.2 | 11.6 | 23.2 | 69.9 | 70.9 | 88.6 | 37.7 | 20.0 | 29.0 |
| 1984 | 9.3 | 6.4 | 4.3 | 3.0 | 3.5 | 26.8 | 24.1 | 55.1 | 33.1 | 58.0 | 30.6 | 15.7 | 22.5 |
| 1985 | 9.5 | 5.9 | 3.9 | 3.0 | 2.5 | 46.9 | 42.3 | 35.0 | 44.2 | 58.7 | 31.1 | 17.4 | 25.0 |
| 1986 | 10.6 | 6.8 | 4.3 | 2.9 | 6.7 | 10.0 | 39.8 | 59.0 | 54.9 | 60.1 | 48.1 | 23.7 | 27.2 |
| 1987 | 13.2 | 8.4 | 5.3 | 3.3 | 3.2 | 9.3 | 16.5 | 37.7 | 41.0 | 24.8 | 30.2 | 24.4 | 18.1 |
| 1988 | 18.3 | 10.8 | 6.8 | 4.2 | 4.6 | 24.9 | 28.6 | 15.1 | 20.4 | 77.7 | 58.0 | 24.7 | 24.5 |
| Max | 46.4 | 48.3 | 38.2 | 40.7 | 42.7 | 46.9 | 155.1 | 106.8 | 88.4 | 88.6 | 62.8 | 70.0 | 38.9 |
| Min | 5.2 | 3.4 | 2.4 | 2.0 | 1.7 | 3.0 | 9.7 | 7.0 | 8.8 | 15.0 | 16.0 | 9.0 | 16.0 |
| Mean | 18.7 | 13.5 | 9.3 | 7.0 | 8.8 | 19.0 | 31.3 | 35.3 | 39.0 | 39.5 | 33.3 | 25.9 | 23.4 |

## Table 3.1 Estimated Mean Monthly Discharge (2/5) - Kaliwa Low Damsite

Unit : $m^3$/sec

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 32.0 | 27.2 | 25.7 | 17.5 | 13.0 | 13.4 | 11.9 | 9.9 | 20.8 | 37.2 | 35.1 | 45.5 | 24.1 |
| 1951 | 28.4 | 19.2 | 13.4 | 8.6 | 6.9 | 6.9 | 15.7 | 17.2 | 20.4 | 18.4 | 52.4 | 52.0 | 21.6 |
| 1952 | 41.5 | 26.5 | 17.4 | 12.8 | 13.1 | 20.5 | 14.3 | 22.0 | 24.5 | 50.3 | 36.2 | 56.1 | 27.9 |
| 1953 | 38.7 | 27.2 | 18.2 | 15.9 | 13.3 | 12.6 | 17.1 | 15.2 | 12.6 | 38.8 | 46.7 | 76.5 | 27.7 |
| 1954 | 49.9 | 41.1 | 44.7 | 25.3 | 18.0 | 16.3 | 14.9 | 14.2 | 12.0 | 16.1 | 19.2 | 29.4 | 25.1 |
| 1955 | 40.6 | 24.8 | 15.7 | 10.0 | 6.9 | 25.5 | 22.3 | 16.5 | 17.6 | 47.6 | 69.8 | 47.4 | 28.7 |
| 1956 | 42.3 | 40.6 | 34.3 | 45.2 | 29.3 | 31.6 | 26.7 | 34.9 | 26.5 | 36.0 | 45.3 | 66.0 | 38.2 |
| 1957 | 57.2 | 33.9 | 22.4 | 16.1 | 11.7 | 8.2 | 13.4 | 16.5 | 13.5 | 20.8 | 23.3 | 20.1 | 21.4 |
| 1958 | 38.1 | 36.9 | 21.8 | 14.3 | 9.4 | 8.5 | 14.7 | 25.6 | 18.9 | 34.5 | 34.4 | 21.6 | 23.2 |
| 1959 | 26.1 | 22.0 | 19.4 | 13.5 | 13.5 | 11.4 | 18.3 | 14.8 | 19.8 | 27.2 | 41.8 | 46.8 | 22.9 |
| 1960 | 45.4 | 55.0 | 30.3 | 23.3 | 34.6 | 27.0 | 23.4 | 25.3 | 44.0 | 56.0 | 46.7 | 33.9 | 37.1 |
| 1961 | 20.5 | 13.2 | 8.6 | 6.2 | 6.2 | 44.6 | 51.1 | 25.9 | 61.0 | 53.6 | 40.6 | 24.4 | 29.6 |
| 1962 | 16.3 | 11.8 | 8.1 | 5.8 | 5.2 | 13.5 | 77.2 | 64.4 | 71.1 | 40.6 | 28.9 | 19.2 | 30.2 |
| 1963 | 13.2 | 9.9 | 7.1 | 5.3 | 4.3 | 36.6 | 43.3 | 54.3 | 62.9 | 42.4 | 25.7 | 24.9 | 27.5 |
| 1964 | 17.4 | 12.4 | 8.4 | 5.9 | 7.5 | 41.5 | 49.1 | 71.7 | 57.6 | 46.3 | 50.9 | 36.3 | 33.7 |
| 1965 | 22.4 | 15.3 | 10.0 | 6.6 | 11.0 | 15.6 | 52.9 | 25.2 | 50.8 | 31.3 | 29.6 | 21.3 | 24.3 |
| 1966 | 14.6 | 10.3 | 7.5 | 5.5 | 42.9 | 16.9 | 17.6 | 18.6 | 65.2 | 44.9 | 56.6 | 41.9 | 28.5 |
| 1967 | 24.5 | 16.2 | 10.5 | 6.8 | 4.9 | 27.3 | 22.9 | 65.3 | 60.0 | 39.1 | 27.4 | 18.6 | 26.9 |
| 1968 | 13.2 | 9.3 | 6.5 | 4.8 | 4.0 | 11.0 | 32.6 | 65.2 | 59.1 | 41.2 | 23.9 | 14.8 | 23.8 |
| 1969 | 8.9 | 6.0 | 4.3 | 3.6 | 3.3 | 4.0 | 16.2 | 40.6 | 51.5 | 41.6 | 27.9 | 24.6 | 19.4 |
| 1970 | 16.2 | 10.8 | 6.8 | 4.5 | 3.4 | 6.3 | 18.7 | 15.5 | 89.6 | 80.6 | 60.4 | 38.7 | 29.3 |
| 1971 | 22.5 | 14.2 | 9.6 | 7.6 | 17.8 | 29.8 | 48.5 | 40.0 | 25.5 | 46.5 | 49.4 | 45.5 | 29.7 |
| 1972 | 26.7 | 16.6 | 10.2 | 6.7 | 8.2 | 38.6 | 156.3 | 121.4 | 76.1 | 44.1 | 32.3 | 22.2 | 46.6 |
| 1973 | 15.2 | 10.4 | 7.2 | 5.3 | 4.5 | 20.9 | 30.1 | 19.9 | 23.4 | 47.0 | 46.7 | 36.5 | 22.3 |
| 1977 | 14.1 | 11.1 | 7.8 | 5.6 | 4.3 | 6.0 | 29.6 | 50.6 | 59.2 | 32.6 | 39.0 | 23.7 | 23.6 |
| 1978 | 14.2 | 8.8 | 5.8 | 4.2 | 5.3 | 12.4 | 23.8 | 71.0 | 80.6 | 104.8 | 59.1 | 33.2 | 35.3 |
| 1984 | 12.5 | 8.9 | 6.0 | 4.4 | 4.6 | 27.3 | 28.0 | 58.8 | 41.1 | 64.6 | 41.9 | 23.3 | 26.8 |
| 1985 | 14.6 | 9.0 | 6.0 | 4.3 | 3.5 | 47.0 | 47.2 | 39.3 | 46.4 | 64.6 | 40.3 | 23.6 | 28.8 |
| 1986 | 15.5 | 9.8 | 6.4 | 4.4 | 7.7 | 10.9 | 40.1 | 61.2 | 62.8 | 68.7 | 57.5 | 32.9 | 31.5 |
| 1987 | 19.9 | 12.8 | 8.0 | 5.3 | 3.9 | 10.2 | 17.2 | 38.0 | 43.8 | 30.3 | 34.4 | 27.7 | 20.9 |
| 1988 | 20.5 | 14.3 | 9.5 | 6.1 | 5.7 | 25.5 | 29.6 | 19.4 | 22.2 | 79.8 | 68.7 | 34.4 | 28.0 |
| Max | 57.2 | 55.0 | 44.7 | 45.2 | 42.9 | 47.0 | 156.3 | 121.4 | 89.6 | 104.8 | 69.8 | 76.5 | 46.6 |
| Min | 8.9 | 6.0 | 4.3 | 3.6 | 3.3 | 4.0 | 11.9 | 9.9 | 12.0 | 16.1 | 19.2 | 14.8 | 19.4 |
| Mean | 25.2 | 18.9 | 13.5 | 10.0 | 10.6 | 20.3 | 33.1 | 38.0 | 43.2 | 46.0 | 41.7 | 34.3 | 27.9 |

## Table 3.1 Estimated Mean Monthly Discharge (3/5) - Kanan No.2 Damsite

Unit : $m^3/sec$

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 130.5 | 54.2 | 67.4 | 20.8 | 8.4 | 7.9 | 29.7 | 40.8 | 18.3 | 110.2 | 116.3 | 146.7 | 62.6 |
| 1951 | 109.9 | 63.3 | 16.5 | 16.8 | 58.3 | 26.7 | 21.2 | 94.5 | 26.5 | 38.0 | 230.3 | 217.3 | 76.6 |
| 1952 | 126.1 | 67.9 | 17.4 | 20.0 | 9.0 | 17.7 | 20.6 | 89.3 | 50.9 | 252.6 | 40.3 | 152.1 | 72.0 |
| 1953 | 84.6 | 103.7 | 20.1 | 22.9 | 6.0 | 26.2 | 6.7 | 57.6 | 24.2 | 88.2 | 86.2 | 209.8 | 61.3 |
| 1954 | 62.4 | 33.4 | 83.5 | 6.6 | 4.2 | 2.0 | 7.8 | 17.2 | 23.7 | 27.4 | 66.9 | 258.6 | 49.5 |
| 1955 | 191.9 | 27.1 | 17.3 | 24.9 | 14.7 | 19.6 | 16.7 | 9.5 | 31.9 | 64.3 | 127.8 | 86.6 | 52.7 |
| 1956 | 72.1 | 42.3 | 71.4 | 75.4 | 23.8 | 21.3 | 41.7 | 35.0 | 81.0 | 145.8 | 149.4 | 317.7 | 89.7 |
| 1957 | 120.6 | 22.3 | 6.6 | 6.0 | 3.4 | 8.2 | 13.9 | 40.3 | 29.6 | 40.5 | 50.7 | 31.2 | 31.1 |
| 1958 | 64.0 | 18.3 | 30.0 | 45.8 | 45.0 | 43.8 | 48.4 | 20.6 | 44.1 | 107.5 | 98.5 | 26.8 | 49.4 |
| 1959 | 72.1 | 37.2 | 75.9 | 10.0 | 1.0 | 6.9 | 10.8 | 27.1 | 29.0 | 33.0 | 112.3 | 96.9 | 42.7 |
| 1960 | 62.5 | 73.1 | 8.7 | 9.2 | 14.2 | 35.0 | 30.6 | 134.0 | 54.3 | 117.0 | 85.9 | 100.3 | 60.4 |
| 1961 | 115.9 | 93.9 | 73.2 | 46.0 | 61.2 | 12.7 | 1.7 | 18.1 | 26.8 | 86.8 | 157.6 | 54.1 | 62.3 |
| 1962 | 95.2 | 78.0 | 44.0 | 46.4 | 16.8 | 9.4 | 5.7 | 0.6 | 75.5 | 39.1 | 112.4 | 107.7 | 52.6 |
| 1963 | 84.7 | 100.1 | 46.6 | 42.1 | 12.1 | 3.2 | 5.8 | 23.2 | 45.1 | 40.1 | 48.9 | 103.7 | 46.3 |
| 1964 | 85.8 | 90.5 | 76.8 | 47.9 | 22.0 | 7.1 | 21.5 | 18.6 | 28.2 | 37.6 | 164.9 | 166.4 | 63.9 |
| 1965 | 107.3 | 61.0 | 37.2 | 13.8 | 7.3 | 3.4 | 2.1 | 17.1 | 6.6 | 69.7 | 123.2 | 187.0 | 53.0 |
| 1966 | 52.5 | 43.2 | 10.7 | 7.4 | 12.7 | 5.3 | 6.3 | 7.8 | 2.8 | 92.2 | 137.0 | 133.0 | 42.6 |
| 1967 | 110.5 | 38.4 | 38.8 | 30.2 | 25.3 | 20.2 | 13.8 | 24.8 | 4.3 | 9.3 | 125.9 | 105.4 | 45.6 |
| 1968 | 87.5 | 95.1 | 95.1 | 62.4 | 18.2 | 9.2 | 6.1 | 10.2 | 16.8 | 51.1 | 70.0 | 40.3 | 46.8 |
| 1969 | 47.7 | 19.3 | 25.1 | 15.2 | 7.3 | 4.8 | 9.6 | 4.2 | 2.4 | 10.7 | 48.2 | 176.2 | 30.9 |
| 1970 | 80.6 | 25.4 | 8.1 | 23.0 | 7.2 | 7.8 | 7.8 | 3.2 | 7.6 | 72.6 | 210.1 | 115.2 | 47.4 |
| 1971 | 63.5 | 103.4 | 96.4 | 22.4 | 109.8 | 132.0 | 137.2 | 36.0 | 11.8 | 115.5 | 124.2 | 183.1 | 94.6 |
| 1972 | 62.9 | 24.8 | 40.3 | 35.7 | 33.9 | 10.0 | 106.5 | 33.4 | 23.6 | 32.8 | 107.1 | 134.5 | 53.8 |
| 1973 | 45.4 | 60.3 | 28.7 | 23.6 | 23.3 | 22.7 | 17.6 | 9.5 | 14.5 | 84.6 | 169.3 | 235.3 | 61.2 |
| 1977 | 126.9 | 119.5 | 72.1 | 28.5 | 23.8 | 12.9 | 41.4 | 16.0 | 36.9 | 39.8 | 144.0 | 64.9 | 60.6 |
| 1978 | 51.7 | 39.9 | 20.3 | 6.1 | 13.2 | 13.8 | 6.0 | 28.6 | 31.8 | 125.4 | 97.4 | 159.7 | 49.5 |
| 1984 | 51.5 | 32.5 | 20.5 | 4.7 | 2.2 | 13.4 | 15.0 | 36.2 | 20.0 | 63.4 | 95.8 | 109.0 | 38.7 |
| 1985 | 51.5 | 29.9 | 18.4 | 5.0 | 1.5 | 29.0 | 27.7 | 20.2 | 31.2 | 70.8 | 99.6 | 119.6 | 42.0 |
| 1986 | 57.9 | 33.6 | 20.0 | 4.1 | 7.5 | 4.0 | 30.9 | 37.3 | 35.7 | 72.2 | 165.3 | 170.0 | 53.2 |
| 1987 | 74.7 | 43.7 | 25.7 | 5.3 | 2.7 | 4.7 | 13.8 | 26.7 | 30.5 | 28.5 | 106.5 | 176.3 | 44.9 |
| 1988 | 106.4 | 57.3 | 32.8 | 6.4 | 3.0 | 11.2 | 20.7 | 5.1 | 13.6 | 99.0 | 199.1 | 177.3 | 61.0 |
| Max | 191.9 | 119.5 | 96.4 | 75.4 | 109.8 | 132.0 | 137.2 | 134.0 | 81.0 | 252.6 | 230.3 | 317.7 | 94.6 |
| Min | 45.4 | 18.3 | 6.6 | 4.1 | 1.0 | 2.0 | 1.7 | 0.6 | 2.4 | 9.3 | 40.3 | 26.8 | 30.9 |
| Mean | 85.7 | 55.9 | 40.2 | 23.7 | 19.3 | 17.8 | 24.0 | 30.4 | 28.4 | 73.1 | 118.4 | 140.7 | 54.8 |

## Table 3.1 Estimated Mean Monthly Discharge (4/5) - Kanan Low Damsite

Unit : $m^3/sec$

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 160.7 | 66.8 | 83.1 | 25.6 | 10.3 | 9.7 | 36.6 | 50.3 | 22.6 | 135.7 | 143.2 | 180.8 | 77.1 |
| 1951 | 135.4 | 78.0 | 20.4 | 20.7 | 71.8 | 32.9 | 26.1 | 116.4 | 32.7 | 46.8 | 283.7 | 267.7 | 94.4 |
| 1952 | 155.3 | 83.7 | 21.4 | 24.6 | 11.1 | 21.8 | 25.4 | 110.0 | 62.7 | 311.1 | 49.7 | 187.4 | 88.7 |
| 1953 | 104.2 | 127.7 | 24.7 | 28.2 | 7.3 | 32.3 | 8.2 | 71.0 | 29.8 | 108.7 | 106.1 | 258.5 | 75.6 |
| 1954 | 76.9 | 41.2 | 102.8 | 8.1 | 5.2 | 2.4 | 9.6 | 21.2 | 29.1 | 33.7 | 82.4 | 318.5 | 60.9 |
| 1955 | 236.4 | 33.4 | 21.4 | 30.7 | 18.1 | 24.2 | 20.5 | 11.8 | 39.3 | 79.2 | 157.4 | 106.6 | 64.9 |
| 1956 | 88.8 | 52.1 | 87.9 | 92.8 | 29.3 | 26.3 | 51.4 | 43.1 | 99.7 | 179.6 | 184.1 | 391.3 | 110.5 |
| 1957 | 148.5 | 27.5 | 8.1 | 7.3 | 4.2 | 10.1 | 17.1 | 49.6 | 36.5 | 49.9 | 62.4 | 38.4 | 38.3 |
| 1958 | 78.8 | 22.6 | 37.0 | 56.4 | 55.4 | 53.9 | 59.7 | 25.4 | 54.3 | 132.4 | 121.3 | 33.0 | 60.8 |
| 1959 | 88.8 | 45.8 | 93.4 | 12.4 | 1.2 | 8.4 | 13.3 | 33.4 | 35.7 | 40.6 | 138.3 | 119.4 | 52.6 |
| 1960 | 76.9 | 90.1 | 10.7 | 11.3 | 17.5 | 43.2 | 37.7 | 165.1 | 66.8 | 144.1 | 105.9 | 123.5 | 74.4 |
| 1961 | 142.7 | 115.7 | 90.2 | 56.6 | 75.4 | 15.7 | 2.1 | 22.3 | 33.0 | 106.9 | 194.2 | 66.6 | 76.8 |
| 1962 | 117.3 | 96.1 | 54.2 | 57.1 | 20.7 | 11.6 | 7.0 | 0.7 | 93.1 | 48.2 | 138.5 | 132.6 | 64.8 |
| 1963 | 104.4 | 123.3 | 57.4 | 51.9 | 14.9 | 3.9 | 7.2 | 28.6 | 55.6 | 49.4 | 60.2 | 127.7 | 57.0 |
| 1964 | 105.7 | 111.5 | 94.6 | 59.0 | 27.1 | 8.8 | 26.5 | 22.9 | 34.7 | 46.3 | 203.1 | 204.9 | 78.7 |
| 1965 | 132.2 | 75.2 | 45.8 | 17.0 | 9.0 | 4.2 | 2.6 | 21.0 | 8.2 | 85.8 | 151.8 | 230.4 | 65.3 |
| 1966 | 64.6 | 53.3 | 13.2 | 9.1 | 15.7 | 6.5 | 7.8 | 9.6 | 3.4 | 113.6 | 168.8 | 163.8 | 52.4 |
| 1967 | 136.1 | 47.3 | 47.8 | 37.2 | 31.2 | 24.8 | 17.0 | 30.5 | 5.3 | 11.5 | 155.1 | 129.9 | 56.1 |
| 1968 | 107.8 | 117.1 | 117.1 | 76.9 | 22.4 | 11.3 | 7.5 | 12.6 | 20.8 | 63.0 | 86.2 | 49.6 | 57.7 |
| 1969 | 58.8 | 23.7 | 30.9 | 18.7 | 9.0 | 5.9 | 11.8 | 5.2 | 3.0 | 13.2 | 59.3 | 217.1 | 38.1 |
| 1970 | 99.3 | 31.3 | 10.0 | 28.3 | 8.9 | 9.6 | 9.6 | 4.0 | 9.3 | 89.5 | 258.8 | 142.0 | 58.4 |
| 1971 | 78.3 | 127.4 | 118.7 | 27.6 | 135.3 | 162.6 | 169.0 | 44.4 | 14.5 | 142.2 | 153.0 | 225.5 | 116.5 |
| 1972 | 77.4 | 30.5 | 49.7 | 43.9 | 41.7 | 12.4 | 131.2 | 41.2 | 29.0 | 40.5 | 132.0 | 165.7 | 66.3 |
| 1973 | 55.9 | 74.3 | 35.4 | 29.0 | 28.8 | 27.9 | 21.7 | 11.7 | 17.9 | 104.2 | 208.5 | 289.8 | 75.4 |
| 1977 | 156.4 | 147.2 | 88.8 | 35.1 | 29.3 | 15.9 | 51.1 | 19.6 | 45.4 | 49.1 | 177.4 | 80.0 | 74.6 |
| 1978 | 63.7 | 49.1 | 25.0 | 7.5 | 16.3 | 17.0 | 7.5 | 35.2 | 39.1 | 154.5 | 120.0 | 196.7 | 61.0 |
| 1984 | 63.4 | 40.1 | 25.2 | 5.8 | 2.8 | 16.5 | 18.4 | 44.7 | 24.7 | 78.1 | 118.0 | 134.3 | 47.7 |
| 1985 | 63.4 | 36.8 | 22.6 | 6.2 | 1.8 | 35.7 | 34.1 | 24.8 | 38.4 | 87.2 | 122.7 | 147.3 | 51.8 |
| 1986 | 71.3 | 41.4 | 24.7 | 5.0 | 9.2 | 5.0 | 38.1 | 46.0 | 44.0 | 88.9 | 203.7 | 209.4 | 65.5 |
| 1987 | 92.1 | 53.8 | 31.7 | 6.5 | 3.4 | 5.8 | 17.0 | 32.8 | 37.5 | 35.1 | 131.2 | 217.2 | 55.3 |
| 1988 | 131.1 | 70.5 | 40.4 | 7.9 | 3.7 | 13.8 | 25.4 | 6.3 | 16.8 | 121.9 | 245.2 | 218.4 | 75.1 |
| Max | 236.4 | 147.2 | 118.7 | 92.8 | 135.3 | 162.6 | 169.0 | 165.1 | 99.7 | 311.1 | 283.7 | 391.3 | 116.5 |
| Min | 55.9 | 22.6 | 8.1 | 5.0 | 1.2 | 2.4 | 2.1 | 0.7 | 3.0 | 11.5 | 49.7 | 33.0 | 38.1 |
| Mean | 105.6 | 68.9 | 49.5 | 29.2 | 23.8 | 21.9 | 29.6 | 37.5 | 34.9 | 90.0 | 145.9 | 173.4 | 67.5 |

## Table 3.1 Estimated Mean Monthly Discharge (5/5) - Agos Damsite

Unit : $m^3/sec$

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 227.0 | 113.8 | 129.5 | 53.6 | 29.7 | 28.8 | 57.1 | 70.0 | 52.9 | 201.9 | 208.1 | 263.0 | 119.6 |
| 1951 | 189.7 | 113.3 | 41.1 | 35.2 | 90.2 | 47.1 | 51.7 | 154.1 | 64.6 | 77.9 | 388.4 | 369.7 | 135.2 |
| 1952 | 229.9 | 129.6 | 47.7 | 45.4 | 31.2 | 52.9 | 48.1 | 153.5 | 103.6 | 416.0 | 104.8 | 285.4 | 137.3 |
| 1953 | 169.1 | 180.0 | 52.4 | 53.8 | 26.7 | 53.7 | 32.9 | 100.4 | 50.4 | 174.3 | 182.1 | 392.5 | 122.4 |
| 1954 | 153.6 | 101.8 | 175.6 | 43.3 | 30.7 | 25.4 | 31.3 | 43.2 | 48.9 | 59.9 | 118.5 | 396.1 | 102.4 |
| 1955 | 319.5 | 71.0 | 45.0 | 47.9 | 29.6 | 62.2 | 53.7 | 35.8 | 68.4 | 153.1 | 270.4 | 183.4 | 111.7 |
| 1956 | 156.5 | 113.2 | 144.9 | 165.3 | 72.8 | 72.6 | 93.7 | 95.4 | 147.6 | 249.5 | 266.9 | 526.5 | 175.4 |
| 1957 | 243.3 | 76.6 | 39.4 | 30.1 | 20.8 | 22.7 | 37.8 | 78.4 | 59.3 | 84.3 | 101.5 | 70.3 | 72.0 |
| 1958 | 139.7 | 75.2 | 70.7 | 82.3 | 74.8 | 72.5 | 87.5 | 63.4 | 86.5 | 195.0 | 182.3 | 66.0 | 99.7 |
| 1959 | 134.8 | 81.4 | 131.1 | 32.1 | 20.3 | 25.3 | 40.0 | 57.5 | 66.9 | 82.5 | 211.4 | 196.8 | 90.0 |
| 1960 | 147.5 | 175.3 | 53.0 | 44.8 | 66.9 | 85.3 | 73.9 | 219.1 | 134.4 | 236.9 | 181.6 | 184.0 | 133.6 |
| 1961 | 187.7 | 148.1 | 113.9 | 74.1 | 96.4 | 73.0 | 61.9 | 58.0 | 107.4 | 188.9 | 277.1 | 112.4 | 124.9 |
| 1962 | 158.2 | 127.3 | 74.4 | 73.4 | 33.3 | 33.3 | 96.7 | 75.6 | 194.8 | 107.9 | 198.6 | 177.8 | 112.6 |
| 1963 | 141.5 | 156.5 | 77.5 | 67.2 | 23.6 | 46.1 | 59.1 | 99.2 | 137.1 | 108.2 | 102.3 | 184.2 | 100.2 |
| 1964 | 147.4 | 145.1 | 120.8 | 76.6 | 43.5 | 63.1 | 92.1 | 108.8 | 110.7 | 114.4 | 302.8 | 285.0 | 134.2 |
| 1965 | 185.5 | 108.8 | 67.9 | 29.8 | 25.2 | 26.1 | 65.2 | 55.8 | 69.5 | 137.6 | 214.3 | 293.5 | 106.6 |
| 1966 | 95.7 | 77.5 | 28.8 | 20.0 | 70.8 | 30.2 | 32.5 | 35.6 | 80.0 | 187.1 | 271.8 | 250.5 | 98.4 |
| 1967 | 193.0 | 79.3 | 71.3 | 53.1 | 43.0 | 62.5 | 48.8 | 107.8 | 76.0 | 62.0 | 213.4 | 175.4 | 98.8 |
| 1968 | 143.3 | 148.0 | 142.7 | 94.2 | 31.5 | 28.0 | 46.4 | 86.7 | 89.7 | 122.4 | 127.6 | 75.5 | 94.7 |
| 1969 | 78.6 | 35.4 | 41.2 | 26.2 | 14.8 | 12.2 | 35.8 | 55.2 | 66.1 | 67.1 | 107.0 | 287.9 | 69.0 |
| 1970 | 140.3 | 54.1 | 23.5 | 39.7 | 15.8 | 22.6 | 35.9 | 25.8 | 113.7 | 200.8 | 374.7 | 218.8 | 105.5 |
| 1971 | 122.8 | 168.0 | 154.2 | 46.8 | 186.1 | 229.4 | 255.7 | 101.0 | 48.7 | 223.5 | 245.1 | 328.3 | 175.8 |
| 1972 | 131.7 | 61.0 | 72.5 | 61.3 | 60.0 | 60.4 | 324.9 | 184.9 | 123.9 | 103.6 | 194.6 | 221.5 | 133.4 |
| 1973 | 86.3 | 99.8 | 51.0 | 40.8 | 38.8 | 55.4 | 60.0 | 39.4 | 50.2 | 176.8 | 302.4 | 387.2 | 115.7 |
| 1977 | 199.9 | 183.4 | 113.1 | 48.8 | 39.8 | 27.1 | 94.5 | 80.3 | 117.4 | 93.9 | 251.1 | 122.0 | 114.3 |
| 1978 | 91.1 | 67.7 | 36.6 | 14.6 | 26.0 | 37.5 | 38.9 | 123.3 | 141.4 | 312.2 | 218.3 | 273.0 | 115.0 |
| 1984 | 92.1 | 60.5 | 38.8 | 13.7 | 10.6 | 53.7 | 56.2 | 118.9 | 76.4 | 181.4 | 194.2 | 185.6 | 90.2 |
| 1985 | 93.9 | 55.9 | 35.0 | 13.9 | 7.6 | 94.1 | 98.6 | 75.7 | 101.9 | 183.6 | 197.6 | 204.9 | 96.9 |
| 1986 | 105.3 | 63.7 | 39.1 | 13.4 | 20.1 | 20.0 | 92.7 | 127.5 | 126.5 | 188.0 | 305.3 | 279.8 | 115.1 |
| 1987 | 131.0 | 79.1 | 47.5 | 15.3 | 9.6 | 18.6 | 38.4 | 81.4 | 94.5 | 77.4 | 191.9 | 288.6 | 89.4 |
| 1988 | 181.8 | 102.0 | 61.1 | 19.0 | 13.9 | 49.9 | 66.7 | 32.5 | 47.1 | 242.8 | 368.6 | 291.9 | 123.1 |
| Max | 319.5 | 183.4 | 175.6 | 165.3 | 186.1 | 229.4 | 324.9 | 219.1 | 194.8 | 416.0 | 388.4 | 526.5 | 175.8 |
| Min | 78.6 | 35.4 | 23.5 | 13.4 | 7.6 | 12.2 | 31.3 | 25.8 | 47.1 | 59.9 | 101.5 | 66.0 | 69.0 |
| Mean | 155.4 | 104.9 | 75.5 | 47.6 | 42.1 | 51.3 | 74.5 | 88.5 | 92.2 | 161.6 | 221.8 | 244.4 | 113.3 |

## Table 3.2 Flow Duration Curve (1/3)

**Laiban Damsite**

| Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) |
|---|---|---|---|---|---|---|---|
| 1 | 88.62 | 26 | 33.52 | 51 | 17.80 | 76 | 8.39 |
| 2 | 70.85 | 27 | 32.52 | 52 | 17.17 | 77 | 7.98 |
| 3 | 69.37 | 28 | 31.50 | 53 | 16.47 | 78 | 7.25 |
| 4 | 63.50 | 29 | 30.73 | 54 | 16.13 | 79 | 7.03 |
| 5 | 60.13 | 30 | 30.21 | 55 | 15.72 | 80 | 6.70 |
| 6 | 58.72 | 31 | 29.13 | 56 | 15.44 | 81 | 6.41 |
| 7 | 57.43 | 32 | 28.28 | 57 | 15.06 | 82 | 5.92 |
| 8 | 55.01 | 33 | 28.06 | 58 | 14.87 | 83 | 5.57 |
| 9 | 51.23 | 34 | 26.76 | 59 | 14.70 | 84 | 5.46 |
| 10 | 49.76 | 35 | 25.69 | 60 | 14.29 | 85 | 5.34 |
| 11 | 48.34 | 36 | 24.97 | 61 | 13.97 | 86 | 5.24 |
| 12 | 46.93 | 37 | 24.77 | 62 | 13.35 | 87 | 4.74 |
| 13 | 45.51 | 38 | 24.35 | 63 | 13.09 | 88 | 4.43 |
| 14 | 44.44 | 39 | 23.69 | 64 | 12.61 | 89 | 4.24 |
| 15 | 43.96 | 40 | 22.77 | 65 | 12.43 | 90 | 3.88 |
| 16 | 41.99 | 41 | 22.05 | 66 | 12.18 | 91 | 3.63 |
| 17 | 40.85 | 42 | 21.56 | 67 | 11.55 | 92 | 3.51 |
| 18 | 40.45 | 43 | 21.20 | 68 | 11.09 | 93 | 3.45 |
| 19 | 39.52 | 44 | 20.59 | 69 | 10.66 | 94 | 3.32 |
| 20 | 38.23 | 45 | 20.27 | 70 | 10.12 | 95 | 3.08 |
| 21 | 37.77 | 46 | 20.04 | 71 | 9.99 | 96 | 2.92 |
| 22 | 37.70 | 47 | 19.42 | 72 | 9.54 | 97 | 2.74 |
| 23 | 36.29 | 48 | 19.20 | 73 | 9.26 | 98 | 2.54 |
| 24 | 35.25 | 49 | 18.28 | 74 | 9.03 | 99 | 2.32 |
| 25 | 34.14 | 50 | 17.97 | 75 | 8.77 | 100 | 1.73 |

**Kaliwa Low Damsite**

| Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) |
|---|---|---|---|---|---|---|---|
| 1 | 104.75 | 26 | 40.55 | 51 | 22.33 | 76 | 12.37 |
| 2 | 79.82 | 27 | 39.33 | 52 | 22.02 | 77 | 11.74 |
| 3 | 71.71 | 28 | 38.73 | 53 | 20.87 | 78 | 10.95 |
| 4 | 69.83 | 29 | 38.07 | 54 | 20.52 | 79 | 10.45 |
| 5 | 65.28 | 30 | 36.62 | 55 | 20.14 | 80 | 10.18 |
| 6 | 64.57 | 31 | 35.99 | 56 | 19.41 | 81 | 9.87 |
| 7 | 61.20 | 32 | 34.49 | 57 | 19.17 | 82 | 9.41 |
| 8 | 60.03 | 33 | 34.35 | 58 | 18.60 | 83 | 8.93 |
| 9 | 58.75 | 34 | 33.22 | 59 | 18.21 | 84 | 8.58 |
| 10 | 56.63 | 35 | 32.26 | 60 | 17.60 | 85 | 8.21 |
| 11 | 54.98 | 36 | 31.27 | 61 | 17.35 | 86 | 7.84 |
| 12 | 52.44 | 37 | 29.79 | 62 | 16.90 | 87 | 7.46 |
| 13 | 50.89 | 38 | 29.37 | 63 | 16.33 | 88 | 6.91 |
| 14 | 49.92 | 39 | 28.04 | 64 | 16.19 | 89 | 6.71 |
| 15 | 48.46 | 40 | 27.39 | 65 | 15.90 | 90 | 6.40 |
| 16 | 47.03 | 41 | 27.21 | 66 | 15.50 | 91 | 6.05 |
| 17 | 46.70 | 42 | 26.65 | 67 | 15.20 | 92 | 5.97 |
| 18 | 46.38 | 43 | 26.08 | 68 | 14.75 | 93 | 5.84 |
| 19 | 45.36 | 44 | 25.60 | 69 | 14.31 | 94 | 5.33 |
| 20 | 44.67 | 45 | 25.30 | 70 | 14.23 | 95 | 5.22 |
| 21 | 43.83 | 46 | 24.83 | 71 | 13.53 | 96 | 4.54 |
| 22 | 42.43 | 47 | 24.47 | 72 | 13.40 | 97 | 4.37 |
| 23 | 41.83 | 48 | 23.74 | 73 | 13.20 | 98 | 4.26 |
| 24 | 41.24 | 49 | 23.30 | 74 | 12.95 | 99 | 3.93 |
| 25 | 40.62 | 50 | 22.52 | 75 | 12.58 | 100 | 3.27 |

## Table 3.2 Flow Duration Curve (2/3)

**Kanan No.2 Damsite**

| Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) |
|---|---|---|---|---|---|---|---|
| 1 | 252.57 | 26 | 80.96 | 51 | 35.65 | 76 | 16.84 |
| 2 | 210.10 | 27 | 75.86 | 52 | 33.59 | 77 | 15.95 |
| 3 | 187.05 | 28 | 73.24 | 53 | 32.85 | 78 | 14.49 |
| 4 | 176.30 | 29 | 72.19 | 54 | 31.93 | 79 | 13.84 |
| 5 | 166.36 | 30 | 71.39 | 55 | 30.58 | 80 | 13.24 |
| 6 | 157.63 | 31 | 67.93 | 56 | 29.86 | 81 | 12.11 |
| 7 | 145.82 | 32 | 64.30 | 57 | 28.73 | 82 | 10.70 |
| 8 | 137.00 | 33 | 63.42 | 58 | 28.48 | 83 | 10.05 |
| 9 | 131.96 | 34 | 62.40 | 59 | 27.11 | 84 | 9.51 |
| 10 | 126.07 | 35 | 60.31 | 60 | 26.73 | 85 | 9.20 |
| 11 | 124.17 | 36 | 57.63 | 61 | 26.25 | 86 | 8.68 |
| 12 | 119.52 | 37 | 54.05 | 62 | 25.13 | 87 | 7.90 |
| 13 | 115.45 | 38 | 51.50 | 63 | 24.17 | 88 | 7.81 |
| 14 | 110.49 | 39 | 48.90 | 64 | 23.57 | 89 | 7.43 |
| 15 | 109.81 | 40 | 47.86 | 65 | 23.24 | 90 | 7.23 |
| 16 | 107.35 | 41 | 45.97 | 66 | 22.38 | 91 | 6.65 |
| 17 | 106.42 | 42 | 45.01 | 67 | 21.31 | 92 | 6.34 |
| 18 | 103.65 | 43 | 43.75 | 68 | 20.65 | 93 | 6.05 |
| 19 | 99.65 | 44 | 42.16 | 69 | 20.29 | 94 | 5.70 |
| 20 | 96.91 | 45 | 40.82 | 70 | 20.04 | 95 | 5.01 |
| 21 | 95.10 | 46 | 40.28 | 71 | 19.62 | 96 | 4.23 |
| 22 | 93.89 | 47 | 39.96 | 72 | 18.56 | 97 | 3.42 |
| 23 | 88.24 | 48 | 38.80 | 73 | 18.16 | 98 | 2.78 |
| 24 | 86.17 | 49 | 37.32 | 74 | 17.40 | 99 | 1.98 |
| 25 | 84.63 | 50 | 36.25 | 75 | 17.05 | 100 | 0.57 |

**Kanan Low Damsite**

| Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) |
|---|---|---|---|---|---|---|---|
| 1 | 311.13 | 26 | 99.73 | 51 | 43.92 | 76 | 20.75 |
| 2 | 258.81 | 27 | 93.44 | 52 | 41.37 | 77 | 19.65 |
| 3 | 230.41 | 28 | 90.22 | 53 | 40.46 | 78 | 17.85 |
| 4 | 217.17 | 29 | 88.93 | 54 | 39.33 | 79 | 17.05 |
| 5 | 204.93 | 30 | 87.94 | 55 | 37.67 | 80 | 16.31 |
| 6 | 194.18 | 31 | 83.68 | 56 | 36.78 | 81 | 14.92 |
| 7 | 179.63 | 32 | 79.21 | 57 | 35.40 | 82 | 13.18 |
| 8 | 168.76 | 33 | 78.12 | 58 | 35.08 | 83 | 12.38 |
| 9 | 162.56 | 34 | 76.87 | 59 | 33.39 | 84 | 11.71 |
| 10 | 155.29 | 35 | 74.29 | 60 | 32.93 | 85 | 11.33 |
| 11 | 152.95 | 36 | 70.99 | 61 | 32.33 | 86 | 10.70 |
| 12 | 147.23 | 37 | 66.58 | 62 | 30.95 | 87 | 9.73 |
| 13 | 142.22 | 38 | 63.44 | 63 | 29.77 | 88 | 9.62 |
| 14 | 136.11 | 39 | 60.23 | 64 | 29.03 | 89 | 9.15 |
| 15 | 135.26 | 40 | 58.96 | 65 | 28.62 | 90 | 8.91 |
| 16 | 132.23 | 41 | 56.62 | 66 | 27.56 | 91 | 8.19 |
| 17 | 131.09 | 42 | 55.44 | 67 | 26.25 | 92 | 7.82 |
| 18 | 127.68 | 43 | 53.89 | 68 | 25.44 | 93 | 7.45 |
| 19 | 122.75 | 44 | 51.94 | 69 | 25.00 | 94 | 7.02 |
| 20 | 119.37 | 45 | 50.29 | 70 | 24.69 | 95 | 6.17 |
| 21 | 117.14 | 46 | 49.61 | 71 | 24.17 | 96 | 5.21 |
| 22 | 115.66 | 47 | 49.22 | 72 | 22.86 | 97 | 4.21 |
| 23 | 108.70 | 48 | 47.80 | 73 | 22.37 | 98 | 3.43 |
| 24 | 106.15 | 49 | 45.97 | 74 | 21.44 | 99 | 2.44 |
| 25 | 104.25 | 50 | 44.65 | 75 | 21.01 | 100 | 0.71 |

## Table 3.2 Flow Duration Curve (3/3)

**Agos Damsite**

| Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) | Duration (%) | Discharge ($m^3$/sec) |
|---|---|---|---|---|---|---|---|
| 1 | 396.12 | 26 | 154.08 | 51 | 82.31 | 76 | 48.81 |
| 2 | 374.68 | 27 | 148.06 | 52 | 80.01 | 77 | 47.66 |
| 3 | 324.92 | 28 | 147.39 | 53 | 78.38 | 78 | 46.80 |
| 4 | 305.27 | 29 | 143.27 | 54 | 77.52 | 79 | 45.36 |
| 5 | 291.86 | 30 | 140.30 | 55 | 76.43 | 80 | 43.45 |
| 6 | 285.01 | 31 | 134.75 | 56 | 75.51 | 81 | 41.25 |
| 7 | 271.80 | 32 | 131.00 | 57 | 74.08 | 82 | 39.81 |
| 8 | 263.00 | 33 | 127.57 | 58 | 73.02 | 83 | 39.43 |
| 9 | 249.50 | 34 | 123.94 | 59 | 72.54 | 84 | 38.75 |
| 10 | 236.87 | 35 | 122.02 | 60 | 70.73 | 85 | 36.56 |
| 11 | 227.01 | 36 | 118.48 | 61 | 69.48 | 86 | 35.79 |
| 12 | 218.78 | 37 | 113.79 | 62 | 67.18 | 87 | 35.04 |
| 13 | 211.41 | 38 | 113.12 | 63 | 66.67 | 88 | 32.54 |
| 14 | 200.79 | 39 | 108.82 | 64 | 64.60 | 89 | 31.30 |
| 15 | 197.60 | 40 | 107.86 | 65 | 63.07 | 90 | 30.24 |
| 16 | 194.57 | 41 | 105.32 | 66 | 61.92 | 91 | 29.57 |
| 17 | 189.69 | 42 | 103.65 | 67 | 60.47 | 92 | 27.08 |
| 18 | 187.68 | 43 | 101.88 | 68 | 60.01 | 93 | 26.22 |
| 19 | 185.48 | 44 | 100.39 | 69 | 59.13 | 94 | 25.36 |
| 20 | 183.56 | 45 | 96.66 | 70 | 57.14 | 95 | 23.64 |
| 21 | 182.13 | 46 | 94.55 | 71 | 55.41 | 96 | 21.68 |
| 22 | 181.40 | 47 | 93.89 | 72 | 53.79 | 97 | 20.00 |
| 23 | 175.62 | 48 | 92.07 | 73 | 53.12 | 98 | 15.28 |
| 24 | 169.11 | 49 | 87.47 | 74 | 52.45 | 99 | 13.72 |
| 25 | 156.48 | 50 | 85.27 | 75 | 50.25 | 100 | 7.58 |

## Table 3.3 Result of River Water Quality Analysis

| Category | Laboratory Test Item | Unit | Standard Value/ Maximum Level | July 2001 | | | August 2000 | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Agos River | Kanan River | Kaliwa River | Agos River | Kanan River | Kaliwa River |
| Inorganic Constituents | Arsenic | mg/L | 0.01 mg/L | 0.00130 | 0.00150 | 0.00053 | 0.00210 | 0.00060 | 0.00150 |
| | Cadmium | mg/L | 0.003 mg/L | < 0.001 | < 0.001 | < 0.001 | < 0.002 | < 0.002 | < 0.002 |
| | Chromium | mg/L | 0.05 mg/L | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 |
| | Cyanide | mg/L | 0.07 mg/L | 0.002 | 0.002 | 0.002 | <0.001 | <0.001 | <0.001 |
| | Flouride | mg/L | 1 mg/L | < 0.02 | < 0.02 | < 0.02 | < 0.02 | 0.062 | < 0.28 |
| | Lead | mg/L | 0.01 mg/L | < 0.002 | < 0.002 | < 0.002 | <0.005 | < 0.005 | < 0.005 |
| | Mercury | mg/L | 0.001 mg/L | < 0.0002 | < 0.0002 | < 0.0002 | < 0.0002 | < 0.0002 | < 0.0002 |
| | Nitrate as $NO_3$- | mg/L | 50 mg/L | 0.851 | 1.060 | 0.287 | 0.51 | 0.45 | 0.49 |
| Physical and | Color | PCU | 5 PCU | 40 | 15 | 35 | 10 | 5 | 5 |
| | Turbidity | mg/L | 5 NTU | 43.0 | 0.6 | 25.0 | 11.3 | 0.3 | 9.2 |
| | Chloride | mg/L | 250 mg/L | 2.1 | 2.1 | 2.6 | 7.5 | 3.7 | 0.9 |
| | Copper | mg/L | 1.0 mg/L | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 |
| | Hardness | mg/L | 300 mg/L | 142 | 116 | 86 | 89 | 46 | 150 |
| | Iron | mg/L | 1.0 mg/L | 9.40 | 6.60 | 0.12 | 0.78 | <0.06 | 0.58 |
| | Manganese | mg/L | 0.5 mg/L | 0.18 | 0.12 | < 0.02 | 0.28 | 0.22 | 0.03 |
| | pH * | - | 6.5-8.5 | 7.6 | 8.0 | 7.8 | 6.8 | 7.1 | 6.8 |
| | Sodium | mg/L | 200 mg/L | 6.1 | 6.3 | 5.7 | 6.0 | 5.7 | 6.5 |
| | Sulfate | mg/L | 250 mg/L | 3.9 | 4.9 | 2.1 | 13.2 | 11.6 | 2.7 |
| | Zinc | mg/L | 5 mg/L | 0.038 | 0.120 | 0.046 | < 0.02 | 0.020 | < 0.02 |
| | Calcium | mg/L | N.S. | 47 | 38 | 28 | 31 | 17 | 42 |
| Others | Temperature * | $^{o}C$ | N.S. | 28.8 | 28.2 | 29.0 | 22.0 | 21.0 | 22.0 |
| | Alkalinity | mg/L | N.S. | 92.5 | 60.9 | 110.0 | 87.2 | 55.7 | 150.8 |
| | Electric Conductivity | $\mu\Omega^{-1}$/cm | N.S. | 215 | 150 | 252 | 200 | 100 | 200 |
| | Biocarbonate | mg/L | N.S. | 123 | 149 | 82 | 106 | 68 | 184 |
| | Phosphate | mg/L | N.S. | 0.23 | < 0.01 | 0.28 | 8.07 | < 9.81 | 6.95 |
| | $BOD_5$ | mg/L | N.S. | 2.4 | 1.0 | 2.5 | 3.0 | 5.0 | 4.0 |
| | COD | mg/L | N.S. | < 5.0 | < 5.0 | 5.0 | 19.0 | 30.0 | 17.0 |
| | $KMnO_4$ Consumption | mg/L | N.S. | 1.9 | 1.1 | 0.7 | 0.6 | 0.6 | 0.9 |
| | Anminia ($NH_3$) | mg/L | N.S. | 0.75 | < 0.01 | 0.57 | 0.06 | < 0.01 | 0.05 |

Note : N.S. ; No Standard Provided by the Department of Health (DOH)

* ; Measured on-site

**Table 3.4 Water Quality of Raw/Treated Water at La Mesa No.1 Water Treatment Plant**

| Item | | August 2000 | | | March 2001 | | |
|---|---|---|---|---|---|---|---|
| | | Average | Max. | Min. | Average | Max. | Min. |
| Tempareture ($^0$C) | Raw water | 23.5 | 25 | 21.7 | 24.1 | 25.9 | 23.1 |
| | Treated water | 24.5 | 26.7 | 22.4 | 25 | 26.4 | 23.4 |
| Turbidity (NTU) | Raw water | 29.3 | 101 | 8.01 | 8.95 | 73.7 | 1.68 |
| | Treated water | 1.72 | 2.26 | 1.21 | 0.96 | 2.19 | 0.59 |
| pH | Raw water | 7.62 | 7.78 | 7.47 | 7.53 | 7.87 | 7.37 |
| | Treated water | 7.07 | 7.34 | 6.9 | 7.22 | 7.49 | 7.02 |
| Color | Raw water | 29.2 | 99.1 | 10.8 | 9.97 | 41.2 | 5 |
| | Treated water | 5 | 5 | 5 | 5 | 5 | 5 |
| Iron (mg/l) | Raw water | 0.36 | 1.41 | 0.06 | 0.14 | 1.14 | 0.02 |
| | Treated water | 0.02 | 0.1 | 0 | 0.02 | 0.04 | 0.01 |
| Residual Clorine (mg/l) | Raw water | - | - | - | - | - | - |
| | Treated water | 1.28 | 1.35 | 1.17 | 1.19 | 1.36 | 0.98 |
| Alkalinity (mg/l) | Raw water | 46.7 | 54 | 40 | 43.1 | 56 | 24 |
| | Treated water | 36.3 | 48 | 28 | 36.5 | 46 | 22 |
| Bicarbonate (mg/l) | Raw water | 57 | 65.8 | 48.8 | 52.6 | 68.3 | 29.2 |
| | Treated water | 44.3 | 58.5 | 34.1 | 44.5 | 56.1 | 26.8 |
| Acidity (mg/l) | Raw water | 6 | 8 | 2 | 7.23 | 12 | 4 |
| | Treated water | 7.94 | 18 | 4 | 7.1 | 12 | 4 |
| Free Carbonic Acid (mg/l) | Raw water | 5.28 | 7.04 | 1.76 | 6.36 | 10.5 | 3.52 |
| | Treated water | 6.98 | 15.8 | 3.52 | 6.25 | 10.5 | 3.52 |
| Chloride ($Cl^-$) (mg/l) | Raw water | 4.39 | 6 | 3 | 4.23 | 8 | 2 |
| | Treated water | 5.77 | 9 | 2 | 4.48 | 9 | 2 |
| Total Hardness (mg/l) | Raw water | 59.8 | 74 | 44 | 66.4 | 78 | 54 |
| | Treated water | 60 | 70 | 44 | 63.9 | 76 | 46 |
| Calcium Hardness (mg/l) | Raw water | 39.4 | 46 | 26 | 43 | 54 | 28 |
| | Treated water | 38.1 | 48 | 25 | 40.9 | 52 | 30 |
| Total Manganese (mg/l) | Raw water | 0.26 | 0.93 | 0.04 | 0.1 | 0.63 | 0.02 |
| | Treated water | 0.02 | 0.04 | 0 | 0.01 | 0.05 | 0 |
| Dissolved Manganese (mg/l) | Raw water | 0.02 | 0.05 | 0 | 0.01 | 0.04 | 0 |
| | Treated water | - | - | - | - | - | - |
| Calcium ($Ca^{2+}$) (mg/l) | Raw water | 15.7 | 18.4 | 10.4 | 17.2 | 21.6 | 11.2 |
| | Treated water | 15.2 | 19.2 | 10.4 | 16.3 | 20.8 | 12 |
| Magnecium ($Mg^{2+}$) (mg/l) | Raw water | 4.97 | 8.26 | 1.94 | 5.69 | 7.78 | 2.92 |
| | Treated water | 5.3 | 8.26 | 2.43 | 5.58 | 7.78 | 3.4 |
| Electric Conductivity ($\mu\Omega^{-1}$/cm) | Raw water | 126 | 138 | 100 | 129 | 139 | 102 |
| | Treated water | 132 | 143 | 110 | 133 | 140 | 102 |
| Total Dissolved Solid (mg/l) | Raw water | 59.9 | 66 | 48 | 61.1 | 65 | 47 |
| | Treated water | 62.5 | 69 | 52 | 62.7 | 67 | 49 |

(Source) La Mesa No.1 Water Treatment Plant, MWSI

## Table 3.5 Table of Geological Formation

| Time | | Formation | Symbol | Explanation |
|---|---|---|---|---|
| Quaternary | Holocene | Quaternary Alluvium | Qal | Detrital deposits, mostly silt, sand, and gravel. |
| Quaternary | Pleistocene | Laguna Formation ≅ Guadalupe Formation | Qg or GF | Layers of thin to medium bedded, fine-grained tuffs, agglomerate, volcamic breccia and associated tuffaceous sediments. |
| Tertiary | Middle Miocene | Tignoan Formation | Nt or Ntf | Agglomerate, volcanic breccia and tuff with interbedded fine sedimentary clastic rocks and volcanic flows. |
| Tertiary | Middle Miocene | Madlum Formation | MF | Consist of upper, middle and lower members. Upper member is fairly fossiliferous, massive or obscurely bedded limestone. Middle includes the basalt. Lower clastic member is calcareous sandstone and shale with conglomerate at the base. |
| Tertiary | Early Miocene | Angat Formation | AF | Well bedded massive limestone with siliceous layers and limy sandstone, calcareous shale, clayey sandstone, sandy limestone and conglomerate. |
| Tertiary | Paleocene~Eocene | Maybangain Formation ≅Bayagas Formation | Pm | Equivalent to Bayabas, Masungi and Kanan formation; consists of andesitic to basaltic flows, agglomerate, volcanic breccia, lapili and lithic tuff with intercalated sedimentary rocks composed of siltstones, shaly sandstone conglomerate and limestone. |
| Cretaceous | | Kinabuan Formation | Kk or KF | Thinly interbedded silty shale and calcereous sandstone with tuffaceous and siliceous layers capped by thin beds of limestone. |
| Cretaceous | | Barenas-Baito Formation | Kbb | Pillow and massive basalt, red chert, red siliceous mudstone/shale and basaltic sedimentary rocks mostly sandstone and pyroclastics. |

# Table 3.6 Acceleration Value of Each Proposed Dam Site

| Reports | Type | Acceleration of Each Dam Site | | | | |
|---|---|---|---|---|---|---|
| | | Laiban | Agos | Kanan | | |
| | | | | Kanan No.1 | Kanan No.2 | Kanan B-1 |
| Manila Water Supply III Project, Appendix B, Geology and Geotechnics, Dec.1979, Electrowatt | Peak Acceleration | 0.15g (50years) 0.20g (100years) 0.40g (1000years) | - | - | - | - |
| | Design Accelerration | - | - | - | - | - |
| Feasibility Report on Agos River Hydropower Project, Data Book III , Geological Exploration, March 1981, JICA | Peak Acceleration | - | 0.58g | | | - |
| | Design Accelerration | - | 0.15~0.20g | | | - |
| Manila Water Supply III Project, Summary, Engineering Report, July.1984, Electrowatt & Renardet | Peak Acceleration | 0.50g (MDE) 0.40g (OBE) | - | - | - | - |
| | Design Accelerration | - | - | - | - | - |
| Feasibility Study - Agos Project, Main Report – Draft, Oct. 1991, ELC Electroconsult | Peak Acceleration | - | 0.58g | - | - | - |
| | Design Accelerration | - | 0.15~0.20g | - | - | - |
| Small Hydropower Projects, Feasibility Study, Draft, Volume IV : Kanan B1 Scheme, Nov. 1992, Nippon Koei-Lahmeyer | Peak Acceleration | - | - | - | - | 0.46g |
| | Design Accelerration | - | - | - | - | 0.26g |
| | Design Accelerration | - | - | - | - | 0.23g |
| Manila Water Supply III, Project Review, Volume 1 : Feasibility Review, Feb. 1997, Electrowatt & Renardet | Peak Acceleration | 0.50g (MDE) 0.30g (OBE) | - | - | - | - |
| | Design Accelerration | - | - | - | - | - |

Note
According to the guidelines of the ICOLD (International Committee on Large Dams), a total failure of the structure has to be avoided for the MDE (Maximum Design Earthquake), however major damage is accepted. For the OBE (Operating Basis Earthquake), minor damage may occur, but all major equipment has to remain operational.

## Table 3.7 List of Typhoon Records in the Agos River Basin (1974-2000)

| No. | Calendar Year | Name of Typhoon | Date | Maximum 24-hr Relative Rainfall (mm) | Recorded Place | Note |
|---|---|---|---|---|---|---|
| 1 | 1974 | TD Delang | Dec. 19-22 | 216.9 | Infanta | |
| | 1975 | | | | | No direct affected typhoon recorded |
| | 1976 | | | | | No direct affected typhoon recorded |
| 2 | 1977 | TD Tasing | Nov. 03-05 | 116.4 | Infanta | |
| 3 | | TD Walding | Dec.02-06 | 199.4 | Infanta | |
| 4 | 1978 | T. Kading | Oct. 25-27 | 304.4 | Infanta | |
| 5 | 1979 | TS Karing | May 10-16 | 89.7 | Infanta | Signal #1 |
| 6 | 1980 | TS Gloring | May 22-26 | 230.7 | Infanta | Signal #3 |
| 7 | | TS Yoning | Oct. 28-30 | 253.2 | Infanta | Signal #1 |
| 8 | | TS Dorang | Dec. 15-21 | 84.6 | Infanta | Singal #1 |
| 9 | 1981 | T. Kadiang | Dec. 18-21 | 12.5 | Infanta | |
| 10 | 1982 | TS Emang | July 12-16 | | | Signal #3 |
| | 1983 | | | | | No direct affected typhoon recorded |
| 11 | 1984 | TS Konsing | July 05-07 | 106.2 | Infanta | Signal #1 |
| 12 | | TD Paring | Oct. 19-20 | 261.9 | Infanta | Signal #1 |
| 13 | 1985 | T. Bining | May 21-25 | 39.4 | Infanta | |
| 14 | | TD Elang | July 04-07 | 281.4 | Infanta | Signal #1 |
| 15 | | T. Pining | Sept. 29-Oct.04 | 84.3 | Infanta | Signal #1 |
| | 1986 | | | | | No direct affected typhoon recorded |
| 16 | 1987 | T. Auring | Jan. 12-14 | 44.7 | Infanta | |
| 17 | 1988 | TS Reming | Oct. 08 | 138.2 | Infanta | |
| 18 | | T. Seniang | Oct. 11-15 | 171.1 | Infanta | |
| 19 | | T. Unsang | Oct. 21-26 | 282.7 | Infanta | Signal #1 |
| 20 | | TS Welpring | Nov. 01-02<br>Nov. 04-05 | 234.7 | Infanta | Signal #3 |
| | 1989 | | | | | No direct affected typhoon recorded |
| | 1990 | | | | | No direct affected typhoon recorded |
| 21 | 1991 | T. Diding | June 13-15 | 182.7 | Infanta | |
| 22 | | TS Yayang | Nov. 14-19 | 98.8 | Infanta | |
| 23 | 1992 | TD Edeng | July 26-27 | 59.0 | Infanta | |
| 24 | 1993 | T. Monang | Dec. 03-07 | 206.0 | Infanta | Signal #3 |
| 25 | | T. Oning | Dec. 14-17 | 281.8 | Infanta | |
| 26 | 1994 | T. Katring | Oct. 18-23 | | | Signal #3 |
| | 1995 | | | | | No direct affected typhoon recorded |
| | 1996 | | | | | No direct affected typhoon recorded |
| | 1997 | | | | | No direct affected typhoon recorded |
| | 1998 | | | | | No direct affected typhoon recorded |
| 27 | 1999 | TS Trining | Nov. 14-15 | 37.9 | Infanta | |
| 28 | 2000 | T. Seniang | Oct. 31-Nov. 05 | 238.5 | Daet | Signal #3 |

## Table 3.8 Record of the Flood Damage due to Typhoons in Infanta Municipality and General Nakar Municipality

| | 1994 | 1995 | | | 2000 | |
|---|---|---|---|---|---|---|
| | Katring | Mameng (Oct) | Rosing (Nov) | | Seniang | |
| | General Nakar [1] | General Nakar | Infanta | General Nakar [2] | Infanta | General Nakar [3] |
| **Casualities** | | | | | | |
| - No. of Barangays | 2 out of 19 | | | | 36 | |
| - No. of Families Affected | 248 | | 4,178 | 374 | 4,491 | |
| - No. of People Affected | 1,211 | | 20,886 | | 38,877 | |
| - Dead | 1 | 1 | | | 0 | |
| - Missing | 3 | | | | 0 | |
| - Heavily injured | | | | | 10 | |
| - No. Served in the Evacuation Center | | | | | | |
| - Families | | | | | 115 | |
| - People | | | | | 690 | |
| **Affected house/building** | | | | | | |
| - No. of Damaged House | | | | | 744 | |
| - Totally Damaged | 13 | 10 | 390 | 11 | | 13 |
| - Partially Damaged | 235 | 14 | 3,085 | 239 | | 241 |
| - No. of Damaged Goverment Infrastructure | | | 29 | | | |
| - Totally Damaged | | | | | 18 | |
| - Partially Damaged | | | | | 55 | |
| - No. of Private Infrastructure | | | 16 | | | |
| - Totally Damaged | | | | | 91 | |
| - Partially Damaged | | | | | 400 | |
| **Direct Damage (PHP)** | | | | | | |
| Agricultural Products | | | | | | |
| - Coconut Tree | | 58,000 | | | 1,000 | |
| - Fruit Bearing Tree | | 214,000 | | | 10,000 | |
| - Commercial Tree | | | | | 11,000 | |
| - Crops and Commercial Plants | | 627,000 | | | 8,000,000 | |
| - Livestock Animals | | | | | 146,000 | |
| Subtotal | | 899,000 | | | 8,168,000 | |
| Non-agricultural Products | | | | | | |
| - House | | | | | 5,572,000 | |
| - Damaged Goverment Infrastructure | | | | | 794,500 | |
| - Private Infrastructure | | | | | 1,509,300 | |
| - Vehicle | | | | | 67,200 | |
| Subtotal | | | | | 7,943,000 | |
| Total | | | 10,000,000 | | 16,111,000 | |

1) The number indicates the damage in Poblacion and Brgy. Banglos.
2) The number indicates the damage in Brgy. Anoling and Brgy. Banglos.
3) The number indicates the damage in Poblacion, Brgy. Anoling, and Brgy. Banglos.

Note: Above figures indicate all the damage from overflow of the Agos River as well as storm surge.
Above damage values are at the price level of each year.

Sources: Municipal Social Welfare and Development Office, Infanta, Quezon
Municipal Disaster Coordination Council, Infanta, Quezon
DILG

## Table 3.9 Result of Flood Damage Survey

***Infanta Municipality***

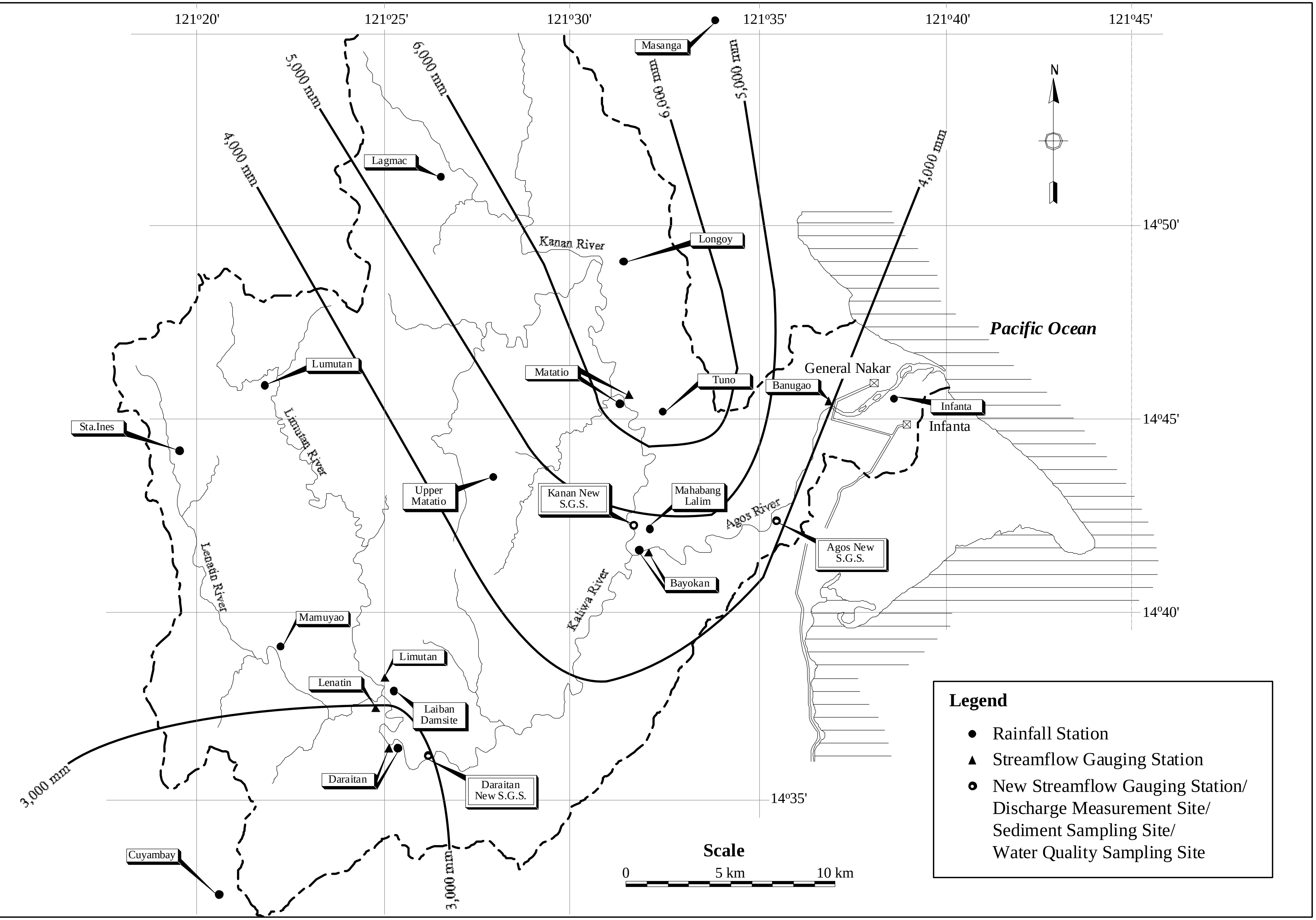
| | unit | Bubuin | Catambungan | Bantilan | Pob. 39 | Banugao | Ilog |
|---|---|---|---|---|---|---|---|
| Elevation | m | 5-6 | 5 | 6-7 | 7 | 10-20 | 5 |
| Annual Flood/Normal Flood | | | | | *1) | *2) | |
| Duration | hours. | 4 | 8 | 1 | | - | 2 |
| Inundation Depth | m | 0.3 | 1 | 0.9 | | - | 1.2 |
| Assumed WL | m | **5.8** | **6** | **7.4** | | | **6.2** |
| Major Flood | | | | | | | |
| Name of Typhoon | - | Rosing | Rosing | | | | |
| Year | - | 1989 | 1989 | 1996 | 1998 | | early '90s |
| Duration | hours. | 24 | 24 | 4 | 10 | | 3 |
| Inundation Depth | m | 1.2 | 1 | 0.9 | 0.9 | | 2.1 |

***General Nakar Municipality***

| | unit | Poblacion | Banglos |
|---|---|---|---|
| Elevation | m | 5-7 | 5-7 |
| Annual Flood/Normal Flood | | | |
| Duration | hours. | 9 | 8 |
| Inundation Depth | m | 0.6 | 0.5 |
| Assumed WL | m | **6.6** | **6.5** |
| Major Flood | | | |
| Name of Typhoon | - | | Rosing |
| Year | - | early '80s | 1989 |
| Duration | hours. | 8 | 8 |
| Inundation Depth | m | 0.9 | 0.9 |

*1) After the completion of drainage canals, floods subside easily.
*2) No damage from the annual floods
Note: All of the barangays choosen for the survey was recommended from the Municipal Office

**Figure 3.1**
**Location Map of Hydrological Stations**



**Rainfall**

| No. | Station Name | Location: Latitude | Location: Longitude | River Basin | Elevation (El.m) |
|---|---|---|---|---|---|
| 1 | Infanta | N 14°45'00" | E 121°39'00" | Agos | 7 |
| 2 | Bayokan | N 14°42'00" | E 121°33'00" | Agos | 140 |
| 3 | Mahabang Lalim | N 14°42'00" | E 121°32'00" | Agos | 60 |
| 4 | Matatio | N 14°46'00" | E 121°31'00" | Kanan | 130 |
| 5 | Upper Matatio | N 14°43'10" | E 121°28'00" | Kanan | 170 |
| 6 | Tuno | N 14°45'50" | E 121°32'30" | Kanan | 500 |
| 7 | Masanga | N 14°59'36" | E 121°32'06" | Kanan | 300 |
| 8 | Lagmac | N 14°51'24" | E 121°27'06" | Kanan | 260 |
| 9 | Longoy | N 14°49'10" | E 121°31'20" | Kanan | 610 |
| 10 | Sta. Ines | N 14°44'00" | E 121°19'00" | Kaliwa | 500 |
| 11 | Daraitan | N 14°36'30" | E 121°25'40" | Kaliwa | 170 |
| 12 | Lumutan | N 14°45'00" | E 121°21'00" | Kaliwa | 508 |
| 13 | Mamuyao | - | - | Kaliwa | - |
| 14 | Laiban Damiste | - | - | Kaliwa | - |
| 15 | Cuyambay | N 14°35'00" | E 121°21'00" | Kaliwa | 550 |
| 16 | Quezon | N 14°39'00" | E 121°03'00" | Pasig-Laguna | 43 |
| 17 | Bosoboso | N 14°38'00" | E 121°14'00" | Pasig-Laguna | 0 |
| 18 | Baguio | N 16°25'00" | E 120°36'00" | Agno | 1,500 |
| 19 | NAIA | N 14°31'00" | E 121°01'00" | Pasig-Laguna | 11 |

Year: 1939–2000

; Data Available ; Data Available (incl. Data deficit period)

**Discharge**

| No. | Station Name | Location: Latitude | Location: Longitude | River Basin | Drainage Area (km²) |
|---|---|---|---|---|---|
| 1 | Banugao | N 14°45'15" | E 121°36'45" | Agos | 879 |
| 2 | Bayokan | N 14°42'00" | E 121°32'00" | Agos | 869 |
| 3 | Daraitan | N 14°36'00" | E 121°26'00" | Kaliwa | 326 |
| 4 | Lenatin | N 14°37'40" | E 121°25'00" | Kaliwa | 131 |
| 5 | Limutan | N 14°38'00" | E 121°25'00" | Kaliwa | 145 |
| 6 | Matatio | N 14°46'00" | E 121°31'00" | Kanan | 361 |
| 7 | Sto. Nino | N 14°38'15" | E 121°05'30" | Marikina | 499 |
| 8 | San Rafael | N 14°44'00" | E 121°10'20" | Marikina | 282 |

Year: 1939–2000

; Data Available ; Data Available (incl. Data deficit period) ; only Water Level Data (incl. Data deficit period)

**Temperature**

| No. | Station Name | Location: Latitude | Location: Longitude | River Basin | Elevation (El.m) |
|---|---|---|---|---|---|
| 1 | Infanta | N 14°45'00" | E 121°39'00" | Agos | 7 |

Year: 1939–2000

; Data Available ; Data Available (incl. Data deficit period)

**Evaporation**

| No. | Station Name | Location: Latitude | Location: Longitude | River Basin | Elevation (El.m) |
|---|---|---|---|---|---|
| 1 | Cuyambay | N 14°35'00" | E 121°21'00" | Kaliwa | 550 |

Year: 1939–2000

; Data Available ; Data Available (incl. Data deficit period)

**Relative Humidity**

| No. | Station Name | Location: Latitude | Location: Longitude | River Basin | Elevation (El.m) |
|---|---|---|---|---|---|
| 1 | Infanta | N 14°45'00" | E 121°39'00" | Agos | 7 |

Year: 1939–2000

; Data Available ; Data Available (incl. Data deficit period)

**Wind Speed/Direction**

| No. | Station Name | Location: Latitude | Location: Longitude | River Basin | Elevation (El.m) |
|---|---|---|---|---|---|
| 1 | Infanta | N 14°45'00" | E 121°39'00" | Agos | 7 |

Year: 1939–2000

; Data Available ; Data Available (incl. Data deficit period)

# Figure 3.2 Available Hydrological Data

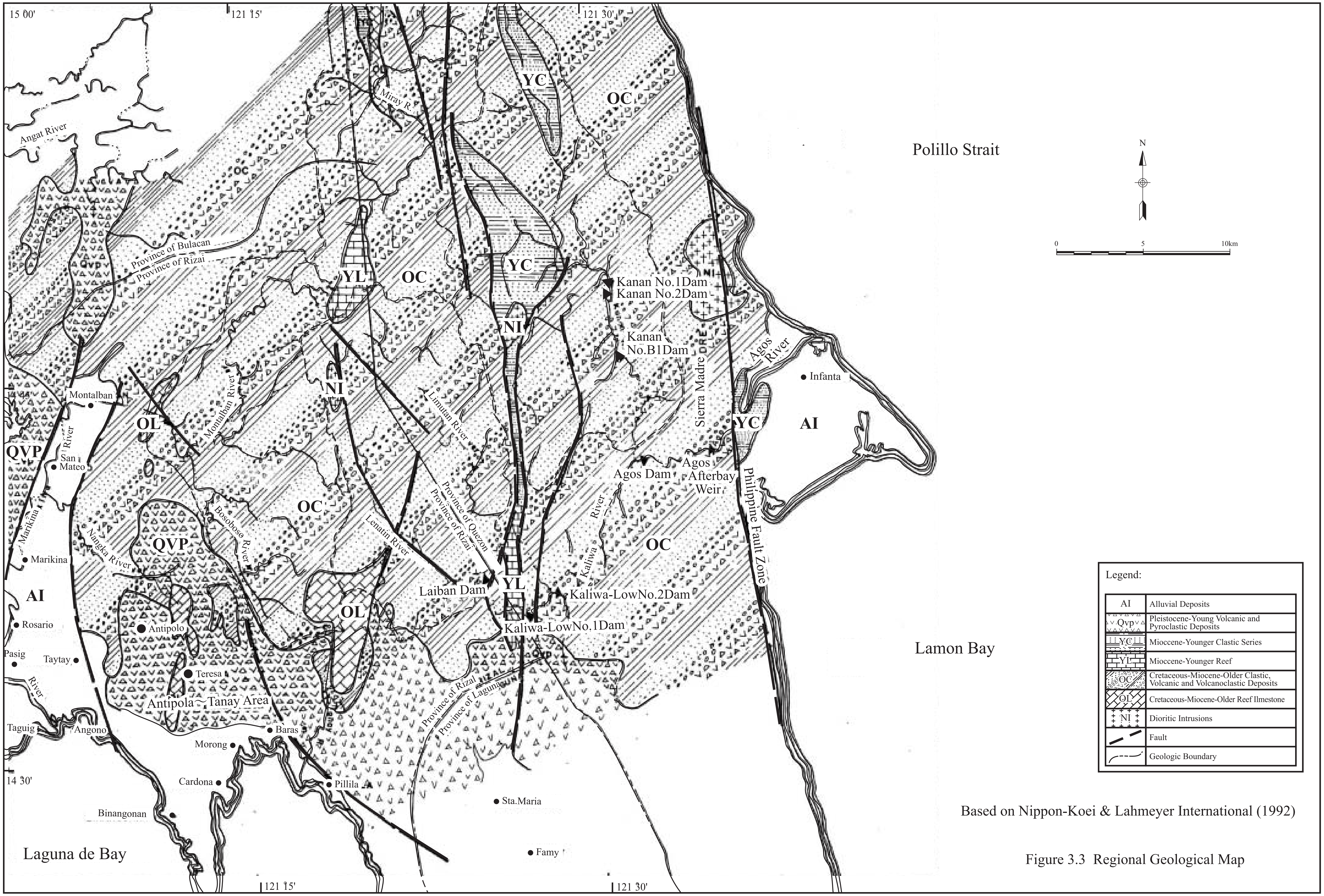


Figure 3.3 Regional Geological Map